Agricultural Technologies for Market-Led Development Opportunities in the 1990s

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Abstract

Agricultural Technologies for Market-Led Development Opportunities in the 1990s is a compilation of 19 articles written by experts in technology development, management, and application. Business executives and practitioners documented their experiences in the application of technology to small, medium and large enterprises, while researchers analyzed technology transfers and their impact on changing relationships between producers and consumers. The result is a set of chapters based on applied and theoretical experiences. The unique feature of this book is its focus on dynamic processes of technological change in agriculture, and the effects on production systems.

These processes of technological change have been structured for study in three forms. Authors examined the links between 1) technology and producers; 2) technology and consumers; and 3) technology and small business. Several important lessons are presented in each chapter, with the following underlying themes:

Traditionally, the process of technological change was only linked to producers; in this volume we learn that consumers play a major role in shaping the process;

Small/large agricultural enterprises were not historically involved in technology transfer; the authors report that now agroindustry plays the role of gate-keeper by signaling newly created opportunities to producers and consumers;

Field experiences suggest that impressive performances in technology generation and application can be achieved through successful coordination of public and private agencies.

The changing relationship between technology and producers, and the increasing dominance of agribusiness, has redefined the process of technological change to include several players. Supermarkets and retailers, patent rights and industrial pollution (created by packaging, shrimp and fish etc.), and continuously changing tastes and consumer preferences all influence technological change. Agriculture is therefore increasingly treated as an industrial sector deserving modern management, and incentives to accommodate rapid changes, rather than as a traditional sector of development.

Illustrating this concept are chapters describing Cyprus' growth in potato processing and consumers, and Chile's productive agroindustry sector. In both cases, private and public sectors played important roles in technological innovation. These experiences show us that successful agribusiness is possible when all partners have well defined roles, and when each accepts limits and responsibilities as the process of innovation becomes more complex. In Chile, for example, the public sector focused on its responsibilities for testing advanced genetic improvement technology, while the private sector concentrated its efforts on mastering the process for patent rights and commercial aspects of biotechnology. At the same time, the public sector worked to ease trade regulations and encourage competition, while private producers searched world markets for new opportunities and invested in data gathering. Chile has turned out to be the number one fresh fruit exporter compared to other fruit producing and exporting countries in the Southern Hemisphere.

The second lesson we learn is that there are always opportunities to meet the changing needs of consumers when the private sector is allowed to innovate and design new technologies in an environment with minimal restrictions and legal hurdles. The flourishing aquaculture industry in Taiwan demonstrates the importance of the private sector role in advancing production technology in nontraditional areas. It would not have been possible to create a multi-billion dollar aquaculture industry without large scale private
sector investment in adaptive research. This experience also demonstrates that if the private sector concentrates on improvements in production technology and processing, the public sector can more efficiently focus on the environmental consequences; in this case groundwater pollution, biodiversity and contamination control.

The Indian experience in oilseed production demonstrates that the public sector can set agendas through subsidies, preferential treatment and reward systems. Without a private sector counterbalance to provide technological innovation and extension, the chain of production does not ensure efficient development of the oilseed sector. Public intervention in the oilseed market may have crowded small businesses and prevented them from achieving optimal targets in specialization of processing and marketing. This was shown in different regions of India where oilseed production has traditionally been neglected.

During the 1990s, they will continue to be net importers of vegetable oil. This story, however, is incomplete because the economic cost of intervention to the public treasury has not been analyzed. It would be useful to compare the experiences of India's advanced oilseed processing to the Ghanian experience of advanced cocoa processing.

In Ghana, the public sector protected processing quality and maintained high industry standards, and created some desirable stability in cocoa markets regardless of seasonable variability. Industrial business dealings with cocoa were disturbed when the role of the government in quality control was challenged. The lesson we learn is that the role of the government agency should be protected only in those areas which provide security and assurance to investors.

Several chapters describe the role played by marketing chains in the European food industry. These marketing agencies, including chain supermarkets and food processing and packaging industries, are becoming increasingly important in determining the success or failure of production technology.
Foreword

The momentous changes in Eastern Europe and the emergence of commercial agriculture in some of the more advanced developing countries require an assessment by agencies providing development assistance. This assessment should include the available technology that could be applied to increase production and profitability of agriculture in countries that are moving rapidly towards a market-led economy.

Clearly the requirements will differ from the largely low-risk technologies that are often employed where subsistence is the farmers’ prime aim. There is considerable scope for improving the flow of information about technology developed in Western Europe and North America to the middle-income developing countries in Asia, Africa, Latin America, and the countries of Eastern Europe.

This conference was arranged to bring together experts in various aspects of production, food processing, and business management in order to create an international forum for an exchange of views and information on how aid and other official support mechanisms could improve technology transfer in the 1990s. The conference was held on April 13-16, 1992 at Wye, Kent, United Kingdom. It was sponsored by the World Bank and supported by the Technical Centre for Agricultural and Rural Cooperation (CTA), Ministere des Affaires Etrangeres, France, Know-How Fund, UK, Deutsche Gesellschaft Fur Technische Zusammenarbeit (GTZ) GmbH, Germany, and Overseas Development Administration, UK.

This document contains the edited versions of most of the papers presented at the conference. No manuscript was available for three presentations, and it was decided to postpone the publication of presentations on intellectual property, biosafety, and plant genetic resources until a later date.

Michel Petit
Director
Agriculture and Rural Development Department
Acknowledgments

The need for a review of agricultural technologies that could be applied in those countries entering a market-led agricultural economy was initially recognized by the World Bank.

Almost all the responsibility for the organization of the conference that eventuated and was sponsored by the World Bank fell to the staff of ODI, NRI, and the University of London's Wye College. Many individuals were involved, but special thanks are due to Dr. John Howell, Director of ODI; Dr. Rod Cooke, Deputy Director of NRI; Professor John Prescott, Principal of Wye College; and Dr. Jock Anderson of the World Bank.

The key role played by Virginia Ball of ODI in the organization of the conference is gratefully acknowledged.

Seth Beckerman prepared this document for publication.
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The concept of technology transfer has been defined, analyzed, and debated extensively in the agricultural literature and in many conferences and seminars over the past two decades. In light of this, why would we choose to initiate yet another conference on this subject? The reason is that we wish to focus specifically on technologies that fit the needs of developing countries which have a relatively modern agricultural sector. We are particularly interested in exploring why these technologies can be easily transferred to one country but not to another, or why the transfer of certain technologies seems to be more problematic than others.

While we observe great successes in the transfer of certain technologies, such as the modern cultivars of wheat and rice, we also observe other areas in which success has been harder to achieve. We have ahead of us the challenge of increasing the performance and efficiency of technologies in diverse areas such as water and soil management, high-value export-crop production, transportation and other post-harvest handling, packaging, storage, and marketing.

Dillon (1991) recently had occasion to list the players in international agricultural technology and research, each with their own roles and interrelationships. These players include the stage setters (politicians, policymakers, international and national aid agencies), the funders (international and national agricultural research centers in both less-developed and more-developed countries, and the various international agricultural research centers), the adoption facilitators (extension service, non-governmental agencies and national and international development agencies) and the users (farmers). We would add — as another funder, generator, and facilitator — the private sector, the sector that is key to our meeting together today.

Overview

The process of technology transfer has evolved as a pattern of technological, social, economic, and institutional factors linked in increasingly complex interrelationships. The green revolution, the most recent agricultural revolution in the history of man, consisted mainly of generalized technologies applied over a range of commodities, exclusively food grains at first, in order to achieve increasing yields. The achievement of higher yields was viewed by most developing countries as desirable in order to improve the likelihood that a country would be able to grow enough food to protect its poorest citizens from the threat of starvation.

As experience from the green revolution was collected, reviewed, and critiqued, an awareness developed of the process by which successively improved modern cultivars gave the best performance. However, the most impressive results achieved by the green revolution were from irrigated lands and from prime lands where soils were fertile and moisture available and reliable. Scientists and others who participated in these agricultural technology transfers were concerned that not enough attention was given to such practicalities as sub-optimal planting and growing conditions, and began emphasizing...
farmer risks and the constraints under which the farmer operated.

This mode of thinking itself evolved as agronomists and other natural scientists, working with economists and other social scientists, recognized that these constraints also included such things as poor resource endowment, labor shortages, the pattern of non-farm income-earning, adverse economic and policy conditions, and insufficient or inappropriate infrastructure. Farming systems research evolved, therefore, with the realization that a farmer's decision could not be made on a crop-by-crop basis in isolation, but rather as one part of a whole decision "domain" in which other crops, and for that matter non-crop elements, were factors.

Producer response to the scarcity of arable land and to the many other factors which are less than ideal circumstances for production has generally fallen into three broad categories: intensification, diversification, and mechanization. The technologies that are able to enhance these three processes are likely to be those that will succeed.

The trend of increasing cropping intensity is occurring both in the rainfed areas of the Middle East, North Africa, and the Indian subcontinent, as well as in the irrigated areas of North Africa, and East and South Asia. Higher intensity in the former area has been a result of the elimination of the fallow period, and cropping intensity increased with increasing areas planted to fruit trees, nut trees, and industrial crops.

Increases in the latter have resulted from the development of improved short-maturing, high-yielding varieties, and the increased use of fertilizers, pesticides, and more modern machinery.

The potential for diversification of production to reduce risk and increase profits from a more complex market has been increasingly recognized, and issues such as the linkages to processing and input supplies are in the forefront of current discussions regarding agricultural technology. Areas under high-value crops, mainly fruits and vegetables, have increased considerably in East Asia, the Middle East, and Latin America. Diversification into such crops is not limited to irrigated areas, but has been extended to dryland areas, both as a replacement and an addition to, traditional annual crops. And most recently we have seen the development of "protected" agriculture, the production of high-value crops by use of sophisticated irrigation methods, mulches, row covers, and greenhouses. These methods are ideally suited for, and indeed already enthusiastically embraced by, agroindustrial investors.

The rising cost of labor combined with a growing demand for specialized land services such as preparation, tillage, weeding, and harvesting, has induced rapid increases in the use of farm machinery. With increased diversification and intensification of production has come the need both for specialized machinery which can handle large quantities of an homogenous crop over vast areas, as well as machinery for processing, packaging, and storing the often highly-perishable, high-value crops. Food processing and packaging plants, when located in the rural areas, are providing employment and increasing incomes to the limited number of communities that are fortunate enough to be proximate.

Challenges Defined

In spite of generally increasing funds being expended on agricultural development throughout the world, gains have been made in some countries more rapidly than for others. As knowledge and experience have accumulated, we have reached a better understanding of the diversity among less-developed countries, regions within a single country, and even farms within a particular region. Thus, we are now seeking solutions and investments which address highly specialized needs.

What are the challenges confronting the more advanced and diversified developing countries that will help shape our decisions about aid and investments? The most fundamental challenge is the limitation on land and water resources. In a report recently
requires attention not only to the essential crop inputs and machinery, but also to rural infrastructure, market structure, and institutional environment.

There are also non-technical challenges which confound the process of technology transfer, and to which the private and public sectors both must respond. The benefits of transfers of technology can be neutralized or even have unintended negative effects if policy distortions are present. Government intervention, in both the farmer's production decisions and in prices and quantities, can stifle or prevent the adoption of new technologies. This has been and will continue to be a difficult issue, as governments often pursue the maintenance of low-priced and secure supplies of "strategic" commodities at the expense of the agricultural sector itself. Finally, even when the government has the will to correct these distortions through the maintenance of competitive exchange rates, interest rates, and relatively few quantitative restrictions, institutional rigidities can thwart the usefulness of technology transfer at any stage of its introduction, from the national research system, through the extension agents, right to the village structure itself.

Ensuring a Receptive Environment: The Developing-Country Role

Developing countries themselves are challenged with taking the necessary measures to ensure a receptive environment for the effective review and adoption of, and increased private-sector commitment to and profit-taking from, new technologies. Addressing some of the constraints of technology transfers referred to above will go a long way towards creating such an environment.

The first, if not the top priority, must be the establishment of a sound macroeconomic environment along with signals to both the domestic players (the producers, processors, marketing agents, and not least, investors), and to potential international players (aid agencies as well as private multinational investors) that this can be maintained credibly and
continuously over the long run. The removal of policies which distort prices not only of inputs and outputs but also of credit and foreign exchange will help that country determine more realistically what its own domestic needs are, as well as where its competitive advantage might lie. Secure and stable property rights are essential to allow the producers to respond freely to these changes, and to provide both them and other related domestic investors a degree of certainty concerning the long-range security of their holdings.

Second, expanding private-sector involvement will require the provision of an appropriate and reliable infrastructure, for example in the creation of transport and communications, and in the delivery and correct pricing of essential inputs such as water and electricity. Ultimately, the progress and competitiveness of the agricultural sector depend on factors outside the productive enterprise itself. Innovations in areas of post-harvest handling, distribution, and marketing, both domestically and for export, may require some level of government support and involvement, although eventually some of these endeavors might better be owned and operated by the private sector.

Third, the government must provide an educational system which prepares the labor force for the many roles in these functions, while at the same time not allowing its own size and functions to preempt labor’s incentive to work within the private sector. The education must be broad-based and address not only technical but also attitudinal changes which will help break down farmer resistance to change. Training and advice should be oriented to winning acceptance, not only of the technological package itself, but of the managerial and institutional changes necessary to ensure a productive use of these technologies in the field.

Fourth, the government must also provide a regulatory sector, with regard to licensing and patents, labor, and quality standards, which nurtures private-sector efforts.

Fifth, developing countries must themselves take primary responsibility for improving and making relevant their institutions for research and extension. Too often, research activities “. . . have produced innovations that farmers find variously unprofitable, too risky or impossible to implement in a timely and useful fashion” (Anderson 1991). The national research system should be on the front line in helping the farmers develop their ability to absorb, adapt and utilize new technologies, with the objective of reducing costs, improving the quality of the product, and developing the capacity to innovate new technologies of their own. Those who work in the research system must bear in mind that new technologies are not necessarily resource- or scale-neutral, and they must be willing to allow and encourage the extension workers to communicate back to the research programs the constraints and the actual needs of the farmers (Carr 1990).

Lastly, the developing countries that seek and accept transfers of technology must themselves take primary responsibility for overseeing the conservation of their own natural resources. They alone have the greatest interest in protecting these resources for the benefit of future generations. To do so may indeed require cooperation among a surprisingly diverse group of interests, including partners in nutrition and health, wildlife conservation, tourism, energy, education, and transportation (Bonte-Friedheim 1991). This should be one small part of an overall regulatory structure provided by the government that seeks to satisfy national goals and international standards while at the same time encouraging domestic and international investment.

Role of More-Developed Countries: Paternalism or Partnership?

It is our belief that, given a receptive environment as outlined above, the private sector (either domestic, international, or multinational) is well-equipped to seek out and take full advantage of the opportunities for technology transfer through its desire to invest on the basis of its belief in the profitability of a
given enterprise. In the more modern developing countries where intensive production has been achieved, there exists a budding entrepreneurial sector which has perhaps already identified, if not yet taken advantage of, marketing opportunities. Quite often, these private-sector producers are willing to innovate in their area of specialization, even in the face of relatively high investment costs, often cooperatively and sometimes in advance of the national research programs (Collins 1991).

We are not suggesting that there is no role for the public sector or donor agencies in technology transfer, but it would be appropriate here to highlight a few of the difficulties the public sector has in being the sole instigator in this process.

First, there are some experts within the bilateral and multilateral aid agencies who advocate the notion that "traditional is beautiful," and that any new techniques or machinery introduced into traditional agriculture are not only too complicated for the small farmer to manage efficiently, but are more than likely disruptive and harmful as well. Just as there are problems with farmers' resistance to change, so too are some development workers themselves slow to adapt to new strategies and techniques.

Second, these agencies are often not up-to-date concerning new technologies, nor are they typically motivated (nor encouraged) to educate themselves in this regard. Too often, the public sector is most interested in smooth and quick implementation of projects, and the time and added expense of experimentation with innovative techniques is disallowed on grounds of efficiency.

Thus, there is scope for the private sector of more-developed countries to join in partnership with the less-developed countries in a number of areas in which even the research systems themselves have not taken an interest or do not have a comparative advantage. This could occur either bilaterally or multilaterally, instigated by the private sector in more-developed countries, or through direct actions taken by the less-developed country governments themselves to provide the incentives necessary to stimulate cooperation between their fledgling private sector and external co-investors.

There is a growing need for technology and knowledge transfers to assist in developing environmentally desirable practices such as the minimization of agrochemical applications, the design of farm systems that minimize soil erosion, the integration of crop-livestock farming systems including improved feed grain production and feeding efficiency, and increasing the use of agricultural waste and by-products. Some of these technologies will be directly transferable from more-developed countries, while others (machinery, for example) will require adaptation before they can be applied in very different agroecological circumstances (Evenson 1991).

Building on the existing knowledge and institutions which have enabled some countries to increase production, biotechnology has become a growing field which promises to not only further increase production, but to seek out insect pest- and disease-resistant varieties and improve the ability of these new varieties to utilize existing water and climatic and soil resources. Cooperative efforts in this area exist between the international agricultural research community and the national research systems. More cooperation should now be encouraged between governments and the private national and international sectors, to seek "... collaborative research and implementation agreements... across country borders [in order to] facilitate the transfer of information and techniques and thus help the developing countries capture the benefits of the new technologies" (AGR and others 1991).

There are certain types of technology transfers, in particular the transfer of knowledge, that, by their public good nature, are best attained and developed through public bilateral or multilateral cooperative efforts. One good example is the provision of support for studies that improve the knowledge base regarding local agroecological resources (for example, soil mapping, aerial survey, hydrological survey, and climatological data...
Participating governments are best suited to direct the realignment of the research system, in particular the international agricultural research system, so that it can address the broader issues of natural resource management and human resource capitalization.

Finally, what may often be thought of as a purely technical problem, may in fact be a major undertaking from an institutional or managerial perspective. Rhoades makes this case articulately, by offering numerous examples of technologies which, while complete, appropriate, and needed, are nonetheless ineffective because too little attention was given to the institutional or managerial factors. He recommends three areas of improvement (Rhoades 1989, pp.177-179):

- A review of related experiences in management and technology transfer in the particular technology or subsector. He makes the suggestion that perhaps we would “... look differently at our technologies if we were required to extend a ‘warranty’ or ‘guarantee’ to our clients.”

- An interdisciplinary research approach which looks beyond adoption and impact analysis to actual long-term use and management of innovations.

- The IARCs should build management into their training programs, by incorporating management scientists into interdisciplinary teams alongside biological and social scientists. The goal should be to encourage technicians to acquire managerial skills, rather than encourage these technicians to aspire to management where their technical skills would no longer be fully utilized.

While endorsing the importance of the issues which these recommendations address, we must recognize that successful management remains more of an art than a science.

**Conclusion**

In this paper we have only hinted at the issues to be covered more thoroughly in the next few days. We have specified the numerous challenges we believe the global agricultural community faces. These include limitations on land resources, achieving the sustainability of agricultural practices through improved management of natural resources, overcoming technological shortcomings, addressing the problem of dwindling returns to agriculture, and rectifying policy distortions and institutional rigidities.

We have outlined what we believe should be the general response of these more modern and agriculturally-advanced developing countries to ensure an environment which is conducive to receiving ever more sophisticated technology transfers from the rest of the world. These include establishing a sound macroeconomic environment, one which is credible and stable over the long run; providing a reliable and appropriate infrastructure, sustained by an institutional structure capable of supporting ancillary services to the productive agricultural enterprises; and supporting and participating in cooperative efforts both in research and investment, domestically and in international partnership.

For their part, the more-developed, or industrialized, countries must continue to support and participate in international cooperative efforts. These countries have a wealth of often privately-developed advanced technologies and know-how which they can share or even sell, particularly in the more specialized areas of information collection and dissemination, environmentally sustainable practices, and biotechnology. These countries have a shared interest in helping their developing-country partners to improve the managerial and institutional capacity that will be required to maintain growth, progress, and prosperity in this vital sector.

**References**


Major Trends Driving Change in European Food Markets

Population Growth Rate
- Very slow population growth.
- But, nevertheless, huge market.

Age Profile of the Population
- Living longer.
- Elderly account for ever-increasing proportion of the population.

Changes in Household Numbers and Size
- Household size diminishing.
- Numbers of households increasing.
- Single parent families significant category.

Ethnic Diversity
- Ethnic minorities increasingly important.
- Ethnic minority population younger than white population.

Women in the Workforce Outside the Home
- Increasingly, women take paid employment outside the home.

Availability of Leisure Time
- Leisure time for men increasing.
- Leisure time for women decreasing.

Meal Eating Location and Behavior
- More meals being eaten away from home, particularly by younger, higher-income groups.
- In-home meal eating less formal.
- In-home convenience meals on the increase.

Consumer Concerns about Health, Welfare, and the Environment
- Consumers increasingly concerned about health and nutrition, although more interested in “looking good” than in balancing nutritional intake.
- Worried about pesticide residues and feed supplements.
- Concerned about the impact of modern farming practices on the environment and on the welfare of animals.
- Health concerns have contributed to a changing national diet (for example, less red meat).

Changes in Real Consumer Income
- Real income has grown substantially over the past twenty years.
- One-quarter of the population owns over 60 percent of the national wealth.
- Three-quarters of EC consumers or coping, or better, economically.
- Lowest income quintile has seen real incomes fall over the last decade — the appearance of a permanent “underclass.”
- Proportion of consumer expenditure spent on food, beverages, and tobacco declining over time.

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Education Level of Consumers

- Increasing number of young people undertaking college education.
- Number of women attending college/university, now similar to that for men.

Interest in Eating Foreign Foods

- Foreign holidays increasingly popular; accelerates contact with foreign cuisine
- Colonial heritage, media coverage of foreign lands and foods, bland indigenous culinary milieu, and social cachet of foreign foods encourages and legitimizes culinary experimentation
- Development of chilled ready meals, technology removes mystique and problems of preparing unfamiliar foods

New Food Product Market Development

- Rapid acceleration of new food product introductions during the 1980s.
- Supermarket chains major instigators of new product development in the U.K., launching own-label products.
- Nutritionally-modified (for example, fat-reduced, fiber added, salt-free) and ethnic foreign food products predominate new entries.
- High failure rate of new product introductions.
- Increasingly, new food products are targeted at specific markets, for example, children, working mothers, retired persons.

Technological Advancements in the Food Industry

- Increasing ownership of microwave ovens dramatically reduces food preparation time
- Biotechnical advances offer prospect of “consumer friendly” agricultural products (for example, improved post-harvest characteristics, disease free produce that requires lower usage of pesticides, increased yields)
- Food preservation and packaging technological advances change nature of new food products (for example, shelf-stable meals)
- Food ingredient substitutes (for example, sugar-free, fat-free) meet consumer concerns about food health and nutrition

Changes in Structure of Food Retailing and Food Manufacturing Industries in Europe

- Increasing concentration in food manufacturing and retailing
- Growth in importance of internationally-branded food products and supermarket-label products
- Growing supermarket chain concern about supply chain management and supply chain integrity.

Major Trends — What Are the Implications for Food Product Suppliers?

Food consumers in Europe, increasingly, are searching for convenience food products. In effect, they are willing to “buy” time.

- The mother working outside the home seeks to reduce or eliminate food preparation through purchasing pre-prepared food products and meals, eating out more, and using “take-out” and home-delivered foods. Value for money is a key concept for food buyers in this category.
- One- and two-person households, where household members are employed outside the home, will also seek convenient food items, are less price sensitive, and more food status conscious (for example, will try exotic/foreign foods as it promotes a cosmopolitan self-image). This group is a prime target for premium product suppliers and those in the “food away from home” business.
- The growing number of retired consumers will have time to shop for and prepare food. On fixed incomes, their concern will focus on nutritionally sound food products that are good value for money (ever trying to extend their life span!). Foods that are modified to meet the particular
requirements of older people will appeal to this group (for example, vitamin-enhanced, calcium-fortified food products).

- Kitchen technology will become increasingly sophisticated to shorten preparation time.

- Fresh and processed products will be presented in package sizes that satisfy small household requirements (for example, smaller melons, one-person ready meal portions), and in packages that can be stored efficiently and opened easily.

Ethnic diversity, growth in the overseas holiday market, and global communications will continue to increase awareness of and fuel demand for exotic/foreign food products.

- Consumer concern about health and nutrition, animal welfare, and the environment will have a significant impact on the production and marketing of food products.

- Demand for nutritionally-modified foods will continue to expand (for example, foods with fat analogues, added fiber, etc.)

- “Freshness” of food will become increasingly important. This is a complex notion that connotes naturalness, additive-free, “clean” food products that can be “freshly prepared”, as well as “fresh off the tree”.

- Increasingly, food retailers will insist that agricultural products are grown under specified conditions, with pre-agreed inputs, with constant communication between all participants in the food chain.

- Meat analogues will break out of their present minority mold and become a significant feature in the market. Consumers will express a preference for pre-prepared food items that are not easily associated with the live animal.

Supermarket chain concerns about food safety and the focus of some on differentiating their food products through establishing a strong quality reputation will act as a substantial barrier to entry for suppliers not conforming to stringent food production and processing standards. Satisfying ISO 9000/BS 5750 requirements on quality standards will be a prerequisite for growers and processors dealing with major manufacturers and retailers.

Growing concentration in the European food retail sector and continued growth in sales of supermarket chain own-label food products will necessitate suppliers understanding the exact requirements of the chains and developing closer commercial relationships with them (that is, developing the “supply partnership” concept. Concentrating on becoming a successful supplier of “own-label” products to the supermarket chains has strong commercial validity for smaller-scale, technologically sophisticated food firms.

Escalating costs and the high risk of failure of launching new branded food products will remove this market entry option for all but the major food manufacturers. Ingredient and processed product suppliers should develop linkages with “big league” manufacturers that have strong distribution networks and strong European branded food products.

In summary, European consumers, now and in the future, are looking for a choice of food products that are convenient to prepare and eat, fresh, healthy, with a distinct taste profile, and that complement their lifestyle and ability to pay. Successful new food products will be those that are developed in response to these consumer wants.

While the EC comprises a huge mass of, in general, affluent customers, food product suppliers must not be taken in by the term “Single Market”. The commercial reality is that it is a panoply of sub-markets, differentiated by variables such as geographic location, lifestyles, national and regional cultures, age, income group, and many others. The successful firm is the one that identifies and satisfies the wants of particular target groups and makes a profit doing so!
What Will Be Out?

• Daily home-cooked meals.
• Family dinner times.
• Long supermarket checkout lines.
• High-fat fast food.
• Kitchen-bound homemakers.
• Deep fat frying.
• Large expensive restaurants.
• Plastic and foam containers.
• Expense account dining.
• High-alcohol drinks.
• Medium-scale general food manufacturers.
• Small retail food chains.

What Will Be In?

• More nutritional labeling.
• More nutritionally-modified foods.
• Fresh vegetables and fruits.
• Exotic and foreign foods.
• Healthy fast food.
• Healthy breakfasts.
• Supermarket take-home foods.
• Value-for-money restaurants.
• Small, specialized restaurants.
• More supermarket own-label products.
• More government food regulation.
• Premium, indulgence food items.
• Drinking in moderation (less spirits, more wine).

Product Categories With High Market Potential

• Dried fruits (leathers, bits).
• Tropical and temperate juices and cordials.
• Purees, nectars.
• Fruit essences.
• Fruit chunks in natural juice.
• "Fresh" frozen gourmet vegetables and herbs.
• Exotic grains and pulses.
• Fish, shellfish, and processed fish.
• Exotic sauces and sauce ingredients.
• Natural spices and flavorings.
• Specialty coffees.
• Specialty teas (fruit, herbal, etc.).

United Kingdom Population

Age profile of U. K. population

<table>
<thead>
<tr>
<th>Year</th>
<th>&lt;16</th>
<th>16-39</th>
<th>40-64</th>
<th>65+</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961</td>
<td>24.8</td>
<td>31.4</td>
<td>32.0</td>
<td>11.7</td>
<td>52.8</td>
</tr>
<tr>
<td>1991*</td>
<td>20.3</td>
<td>35.2</td>
<td>28.6</td>
<td>15.8</td>
<td>57.6</td>
</tr>
<tr>
<td>2011*</td>
<td>20.2</td>
<td>30.0</td>
<td>33.7</td>
<td>16.2</td>
<td>60.0</td>
</tr>
</tbody>
</table>

*Projections based on 1989 data.


Changes in household numbers and size

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Average household size (no. of people)</td>
<td>3.1</td>
<td>2.9</td>
<td>2.7</td>
<td>2.5</td>
</tr>
<tr>
<td>Number of households</td>
<td>16.2</td>
<td>18.3</td>
<td>19.5</td>
<td>22.7</td>
</tr>
</tbody>
</table>


Ethnic Diversity

Ethnic mix of U. K. population, 1989 and 1983

<table>
<thead>
<tr>
<th></th>
<th>1989</th>
<th>1983</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total all ethnic minority groups (millions)</td>
<td>2.6</td>
<td>2.3</td>
</tr>
<tr>
<td>Total U.K. population (millions)</td>
<td>54.7</td>
<td>54.0</td>
</tr>
<tr>
<td>Ethnic minority as proportion of total population (percentage)</td>
<td>4.8</td>
<td>4.3</td>
</tr>
</tbody>
</table>

Population in the U. K. by age category and ethnicity, 1987 to 1989

<table>
<thead>
<tr>
<th>Ethic minority groups</th>
<th>0-15</th>
<th>16-29</th>
<th>30-44</th>
<th>45-59</th>
<th>60+</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>19</td>
<td>22</td>
<td>21</td>
<td>17</td>
<td>21</td>
</tr>
<tr>
<td>All ethnic groups</td>
<td>20</td>
<td>22</td>
<td>21</td>
<td>16</td>
<td>21</td>
</tr>
</tbody>
</table>


Meals eaten outside the home, 1990, selected U. K. demographic statistics

<table>
<thead>
<tr>
<th>Category</th>
<th>Average number of meals eaten outside the home per week</th>
</tr>
</thead>
<tbody>
<tr>
<td>All households</td>
<td>3.8</td>
</tr>
<tr>
<td>A and B income groups</td>
<td>4 +</td>
</tr>
<tr>
<td>E and old age pensioners</td>
<td>Less than 3</td>
</tr>
<tr>
<td>Under 25 years old</td>
<td>6 +</td>
</tr>
<tr>
<td>35 years old and over</td>
<td>Less than 4</td>
</tr>
</tbody>
</table>


Women in the Workforce

Outside the Home

Women ages 25-54 at work outside the home in the U. K., 1971 to 2001

<table>
<thead>
<tr>
<th>Year</th>
<th>Age group (percentage of total)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25-44</td>
</tr>
<tr>
<td></td>
<td>45-54</td>
</tr>
<tr>
<td>1971</td>
<td>52.4</td>
</tr>
<tr>
<td>1981</td>
<td>61.7</td>
</tr>
<tr>
<td>1990</td>
<td>73.1</td>
</tr>
<tr>
<td>2001</td>
<td>79.4</td>
</tr>
</tbody>
</table>

1. Projections

Source: Employment Department, U.K. Government

Meal Eating Location and Behavior

Expenditures for household food and meals away from home in the U. K. during select years (U. K. pounds per household per week)

<table>
<thead>
<tr>
<th>Expenditure</th>
<th>1979</th>
<th>1984</th>
<th>1989</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household food</td>
<td>21.8</td>
<td>26.1</td>
<td>33.0</td>
</tr>
<tr>
<td>Meals bought away</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>from home</td>
<td>3.6</td>
<td>5.4</td>
<td>8.7</td>
</tr>
<tr>
<td>Total</td>
<td>25.4</td>
<td>31.5</td>
<td>41.7</td>
</tr>
<tr>
<td>Away-from-home as percentage of total</td>
<td>14.2</td>
<td>17.1</td>
<td>20.9</td>
</tr>
</tbody>
</table>

Source: Family Expenditure Survey, U.K. Government

Consumer Concerns About Health, Welfare, and the Environment

- Household expenditure (at constant prices) on tobacco products declined by about 20 percent during the decade of the 1980s (source: U.K. National Accounts, Central Statistical Office).
- Over half of the population in the U.K. admit to being health-conscious — women are more aware of their health than men (A.C. Nielsen).
- In the U.K. per capita purchases of red meats, in particular beef and lamb, have declined, whereas poultry per capita purchases have increased more than threefold. Per capita butter consumption has fallen sharply, and purchases of milk have declined, with increasing preference shown by most consumers for fat-reduced milk. While fresh fruit per capita purchases have remained relatively stable over the past twenty years, fruit juice per capita consumption has increased eight-fold over the same period. Per capita sugar consumption in 1990 was one-third of its 1961 level (although consumption of sugar via confectionery is, still, relatively high in the U.K.). The traditional British beverage, tea, halved in per capita consumption from 1961 to 1990 (see chart).
• One-third of all new food products introduced onto the U.S. market in 1991 claimed health benefits, that is, no/low salt, sugar, fat, low calorie or high fiber (Marketing Intelligence, Inc., U.S.A.) Total “healthy” food and beverage sales in the U.S. were $27 billion in 1991. The “healthy” food market in the U.K. is proportionately much smaller but increasing at a significant rate.

• In the U.S., the Food Marketing Institute researched consumer concerns about food and found that the top five nutritional concerns of consumers are (percent of consumers surveyed):
  - Fat 42
  - Cholesterol 37
  - Salt 22
  - Calories 12
  - Sugar 12

• In the U.K. the above five are all considered important concerns, but the weightings are different — sugar, for example, is accorded a higher “concern” priority than in the U.S.

• The British public is more concerned about looking good than living longer. Over 60 percent of women are concerned about their weight and half this number are trying to lose weight.

• In Britain, the percentage of the adult population that is obese increased during the 1980s from 8 to 12 percent. The U.K. Government has established a health target to reduce present levels of obesity to the 1980 level by 2010.

• Close to three-quarters of the British population is concerned about the effects of fat and cholesterol on the nation’s health. Low fat/reduced calorie products in general, show double the sales growth rate of their “parent” products, and account for 20 percent or more of the category market share (A.C. Nielsen).

• In the EC, consumers express particular concern about climate change due to carbon dioxide/global warming, loss of natural resources, extinction of plant and animal species, air and seas pollution, but are much less concerned about loss of farm land or damage to the landscape (Eurostat). In the U.K., two-thirds of all consumers claim to use ozone-friendly aerosols, and over 40 percent do not use herbicides in their gardens. (Report of the Environment) Animal welfare issues (for example, use in testing safety/efficiency of products, intensive livestock production methods, etc.) have been of perennial concern to consumers and brought about substantial changes in livestock production practices in the U.K. (for pigs, poultry, in particular) and spawned livestock quality assurance schemes for beef cattle, pigs, and sheep.

**Changes in Real Consumer Income**

*Growth in real disposable income per head, U. K., 1971 to 1990. Index = 100 (1985)*

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1971</td>
<td>73</td>
<td>81</td>
<td>92</td>
<td>100</td>
<td>128</td>
</tr>
</tbody>
</table>


*Percentage of wealth (those over 18)*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Most wealthy 1%</td>
<td>13</td>
<td>11</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Most wealthy 5%</td>
<td>26</td>
<td>24</td>
<td>24</td>
<td>26</td>
</tr>
<tr>
<td>Most wealthy 10%</td>
<td>36</td>
<td>34</td>
<td>35</td>
<td>38</td>
</tr>
<tr>
<td>Most wealthy 50%</td>
<td>80</td>
<td>79</td>
<td>82</td>
<td>83</td>
</tr>
</tbody>
</table>

*Source: Inland Revenue, U.K. Government*

**Education Level of Consumers**

*Selected Statistics on Education — U. K., Europe, and Other Countries*

• The number of students on full-time higher education courses in the U.K. rose by nearly 30 percent between 1980-81 and 1989-90 to stand at 0.7 million in the latter year.
• Female students made up 47 percent of all students on full-time first degree courses in 1989-90 in the U.K., compared to only 41 percent in 1979-80.

• The percentage of 16 to 18 year olds in education and training was 70 percent of total in 1989. This figure is low relative to most EC countries (apart from Spain and Italy), and very low relative to the U.S. (81 percent).

**Interest in Eating Foreign Foods**

British consumers show increasing knowledge of, and interest in, foreign foods.

*Sampling different foods on foreign holidays*

<table>
<thead>
<tr>
<th>Year</th>
<th>U. K. residents taking foreign holidays (millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>11.7</td>
</tr>
<tr>
<td>1986</td>
<td>16.6</td>
</tr>
<tr>
<td>1990</td>
<td>20.2</td>
</tr>
</tbody>
</table>

Percentage change,
1981-1990 73

*Source: Employment Department, U.K. Government*

• Seeking more interesting taste experiences than those offered by British cuisine. One-third of British consumers surveyed expressed a preference for foreign foods over traditional U.K. national dishes (Mintel, *European Lifestyles*, 1989).

• Bringing a revolution in the range of food products presented to the consumer at retail. Marks & Spencer plc, the leading retailer of pre-prepared, chilled meals in the U.K., merchandises its products by national category, that is, Italian, Thai, Indian, Chinese, etc., and foreign food dishes regularly account for at least one-half of the retail food offerings in the chilled, ready-prepared category (the category with the fastest sales growth in the retail store).

**Market Development for New Food Products**

• In the U.S., there was explosive growth in the rate of new food product introductions at retail — increasing by a factor of six from 1980 to 1990. In this last year, new food products introduction peaked at 3,489, of which 80 percent failed to maintain retail shelf presence for more than one year. In 1991, new food product introductions declined by 10 percent to 3,148; of which 86 percent are projected to fail to maintain retail presence past one year.

• In the U.K., increased new food product introduction activity during the 1980s also showed marked buoyancy: the average number of items carried by major food retailers increased from less than 10,000 to more than 15,000 through the decade; the majority of new food products were merchandised under "own brand" labels, as the major chains sought to differentiate themselves from the competition by offering greater variety of food products.

• In both North America and Europe, characteristics shared by new food products were that many included exotic/foreign ingredients (for example, spices, juices); and were pre-prepared items that were suitable for cooking in a microwave; were modified nutritionally, that is, either subtracting fat, sugar, salt or adding vitamins, fiber, calcium, etc.

**Advancements in the Food Industry**

**Food Preparation**

In 1989-90, 47 percent of all households in the U.K. had a microwave oven (General Household Survey, U.K. Government), high relative to France (23 percent), but low relative to the U.S. (82 percent). Most businesses in the U.K. and North America provide their employees with microwave oven facilities for heating luncheon dishes.
**Food Production**

New biotechnological breakthroughs are beginning to change the nature of new food products entering the markets of Europe and North America. Genetic manipulation can build disease resistance into plants and remove the requirements for herbicides and pesticides — a critical factor for satisfying consumer concerns about food safety and the environment. Agricultural products can be constructed from the bottom up to satisfy the wants of discerning consumers (for example, for seedless water melon, or sweet, vine-ripe tomatoes that have excellent post-harvest characteristics).

**Food Production**

Food preservation technology has moved from drying, pickling, canning, or freezing through to more sophisticated chilling technology and, now, includes “shelf-stable” packaging that was used initially for U.H.T. milk and juices and progressed to providing shelf-life at ambient temperatures of up to 12 months for fully pre-prepared meals (for example, the Heinz range of “Lunch Bowl” ready meals in the U.K., and Dial “Lunchbucket” and Hormel “Health Selections” shelf-stable meals in the U.S.A.

**Food Ingredient Substitutes**

For example — fat analogues such as “Simplesse”; “Aspartame” as a sugar substitute; and, in the U.K., an alternative to meat in the form of a myco-protein with the brand name “Quorn.”

**Changes in the Structure of Food Retailing and Food Manufacturing Industries in Europe**

Over the past decade, major food retailing companies in each of the EC countries have consolidated their market presence and, increasingly, account for the majority of food product sales: for example, in all five of those European countries with the highest concentration of retail space, the share of the food market going to the top two retailers has continued to grow over the five years from 1984 to 1989 — the highest concentration is in France, followed by Germany and, then, the U.K. — in all three countries the top two companies account for about one-quarter of the overall food market. U.K. supermarket chains are stronger in own-label products than their European counterparts, that is, about 30 percent of items are branded with the supermarket chain label, as against 27 percent in Germany and 23 percent in France. Overall in Europe, own-brand merchandising practices by the supermarket chains is expected to flourish and grow through this decade.

In part in response to concentration in the food retail sector, there has been corresponding concentration in food manufacturing (see chart): all four largest companies Nestlé, Unilever, BSN, and the food arm of Philip Morris — dominate the European value-added food market and use considerable brand strength and high distribution power to combat the burgeoning supermarket chain stores.
Figure 3. European population trends, 1978 to 1990


Figure 4. Population trends in selected European countries, 1977 to 1990


Figure 5. Size of European food and beverage markets

Figure 6. Population of selected countries, aged 60 and over, as percent of total population


Figure 7. Decreasing European household size, 1978 to 1990, EC and EFTA averages

Figure 8. Single parent families in selected European countries


Figure 9. Women ages 25 to 54 who work outside the home

Source: U.S. Census Bureau.
Figure 10. Percentage of population in selected European countries which eats out each week, as percentage of total population


Figure 11. Percentage of all food shoppers in the U.K. who serve convenience meals at home

Figure 12. Percent of real income rise and fall in U.K, 1981 to 1988

Source: Family expenditure survey.

Figure 13. Consumer expenditures during 1976 and 1987 for food, beverages, and tobacco in selected European countries

Figure 14. Economic well-being in the European Community — of all living on present income

Finding it difficult 20%  Almost impossible 7%
Coping 50%
Living comfortably 23%


Figure 15. Growth of top ten European food manufacturers during 1984 to 1990

Source: Bain & Co.
Cyprus’ Experience with Identifying and Responding to New Export Market Opportunities

Andreas Savvides

Cyprus Potato Industry

Cyprus is a rather small island and small country, but has an interesting history in potatoes and a relatively large potato industry. When Cyprus became a British colony in 1878, potatoes were grown, but the exact time of introduction is unknown. At the beginning of this century, Cyprus was exporting potatoes in small quantities to the Middle East (Egypt), Far East (Ceylon), and Europe (Greece). Export of potatoes to U.K. started in 1932. After World War II and in particular in the 1950s, production increased slowly but steadily until 1960, when Cyprus became a republic. By 1963 potato production had doubled and reached 130,000 tons. The Cyprus Potato Marketing Board was established in 1964 and further increased potato production. (At the time U.K. was the most important market, followed by the Gulf countries and Scandinavia.) Since 1970 the potato acreage has been controlled, and it varies in accordance with market expectations.

Potato growing was and still is a very important source of income for a large number of Cypriot farmers (Table 1). Potato exports are over 40 percent of the agricultural and over 10 percent of the total exports of Cyprus. Traditionally, potatoes in Cyprus are grown twice a year, thus giving two crops, spring and winter. The spring crop is planted in November-January and is harvested from the middle of March to the middle of June. This crop is by far the most important and provides the main potato exports. The winter crop is planted in August and lifted in November/December. This crop is mainly used for local consumption (50 percent) and the rest is exported to the Arab countries and the U.K. Presently it is exported only to the EC. Since 1982, however, a third crop, the intermediate crop, has developed. This crop is planted in September/October with the aim of meeting the demand and covering the requirements for new potatoes in the European markets during February and early March. Potato growing in Cyprus depends entirely on irrigation. Production costs are very high, about £3,200 per hectare.

Scale of Production

Production is in the hands of numerous small family growers. There are nearly 4,000 growers who average 50 tons per year. About 500 grow potatoes for the local market and deliver for exports irregularly. About 300 growers produce over 120 tons annually, while hardly anyone grows over 500 tons per year.

Concentration of Production

Production, while it is scattered all over the island, is largely concentrated in a small area. Over 80 percent of potato exports are produced in the red soil area of the southeast region of Larnaca and Famagusta, villages known as Kokkinochoria (red soil villages).

Acreage, Production, and Exports

The total acreage, production, home usage, and exports by country of destination are shown in Table 2. The total acreage is controlled by the Cyprus Potato Marketing Board, and all changes are intentional. Total
production naturally depends also on yields, therefore its fluctuations are more violent. Total exports follow the pattern of production. Exports to Germany and Belgium have expanded steadily at the expense of U.K. Exports to Arab countries have now stopped. Presently, Cyprus is exporting potatoes on a regular basis to six EC and four other European countries. The breakdown of exports by crop and country of destination is given in Table 3. The level of production and the quantities exported are very small compared to the potato production of the Common Market to which Cyprus potatoes are primarily exported.

**EC Duties**

From 1977, when U.K. joined the Common Market, until 1987, the duty on Cyprus potatoes was:

<table>
<thead>
<tr>
<th>Period</th>
<th>Duty (percent)</th>
<th>Quota ('000 tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 1-May 15</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>May 16-June 30</td>
<td>9.4</td>
<td>60</td>
</tr>
<tr>
<td>July 1- Dec. 31</td>
<td>18</td>
<td>-</td>
</tr>
</tbody>
</table>

Since 1988, the duties have been annually reduced by 10 percent to become zero in ten years, and the quota has been increasing by 5,000 tons annually to reach 110,000 tons. However, duty reduction has been accelerated and the present position is:

<table>
<thead>
<tr>
<th>Period</th>
<th>Duty (percent)</th>
<th>Quota ('000 tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 1-</td>
<td>3.8</td>
<td>0</td>
</tr>
<tr>
<td>May 15</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>May 16-</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>June 30</td>
<td>0</td>
<td>80</td>
</tr>
<tr>
<td>July 1-</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Dec. 31</td>
<td>18</td>
<td>18</td>
</tr>
</tbody>
</table>

**The EC Potato Industry**

European production is over 100 million tons, and if the CIS is included then it is nearly 200 million tons. Community total potato production is around 40 million tons (Table 4). Early potato production in the Community is fluctuating around 3.5 million tons plus or minus 5 percent (Table 5). The early potatoes of the southern countries are available from late March through to July, with the peak in May and June. After very quickly covering home requirements, they are exported to the northern countries. The English new potatoes appear in late May and increase considerably in June and July. The German early crop is available after the middle of June and the Belgian crop after the beginning of July.

The intra-Community potato trade is nearly 3.5 million tons (Table 6). The exports from Belgium, Germany, and Holland refer to main crop potatoes, while the exports from Greece, Spain, and Italy refer primarily to new potatoes. French exports are in both categories. The imports of Greece, Spain, Portugal, and Italy are primarily main crop, while the imports of the other countries are both new and main crop potatoes.
The Community imports of new potatoes from third countries are also considerable (Table 7). The biggest importer is the U.K. with Egypt and Cyprus as the main suppliers. The second importer is France with Morocco as the main supplier, followed by Israel. The third importer is not Belgium, but Germany. A lot of Cyprus potatoes are customs cleared in Belgium but they are marketed in Germany. The figures should be reversed.

It is clearly evident from these figures that Cyprus, as a potato producer and exporter, is very small compared to her customers and some competitors. Furthermore, Cyprus has

- a relatively high cost of production,
- a geographical disadvantage,
- a duty disadvantage, and
- no direct or indirect subsidies.

Nonetheless, Cyprus potatoes usually fetch the highest prices in every market where they are consumed. No wonder they have been called ‘Champions’, which has gradually become their brand name. Out of all this comes the obvious question: ‘How do we cope with so many factors and what are the reasons for the high price of Cyprus potatoes?’ The answer can be found in:

- the Cyprus Potato Marketing Board,
- methods of marketing,
- management of quality,
- programming of production to meet effective demand, and
- the satisfaction of our customers.

Cyprus Potato Marketing Board

As has been mentioned, since 1964 the Cyprus potato industry has been centrally controlled by the CPMB. Why a marketing board? The answer can be found in the analysis of the marketing environment in Cyprus and the trading conditions in U.K. that prevailed during the years preceding 1964:

- Growers were faced with uncertainty which resulted in selling at lower prices, due to competition among them.
- Destructive competition among exporters arising from their uncoordinated selling policies resulted in lowering the price offered to producers in years of low or normal demand.
- The lack of advanced planning, regulation, or intraseasonal distribution of shipments resulted in seasonal local surplus and uneven geographical distribution of Cyprus supplies to U.K., thus affecting the prices in this market.
- Both producers and exporters were not always honoring their contractual obligations.
- Lack of confidence between U.K. importers and Cyprus exporters; their commercial integrity was not always up to the desired standard.
- Due to the fact that production was not planned or controlled, a great percentage of the crop was often left unsold in the hands of producers.
- Producers believed that they were consistently exploited in many respects by middlemen and exporters. They strongly believed that the margins between the prices they received and the actual prices realized in the U.K. market were considerably higher than justified.
- The potato trade within Cyprus could be described as showing characteristics of monopsony — a group of a few large buyers — plus atomistic selling (too many growers).

In summary, the commercial relations between the potato producers, the Cypriot exporters, and the English importers were not satisfactory. The lack of planning in production and marketing usually caused great problems not only for the growers but also for the exporters and the importers. This unsatisfactory and unhappy situation was
greatly exacerbated by the exceptional circumstances of 1962 and 1963, and led to the establishment of the Cyprus Potato Marketing Board in October 1964.

**Methods of Marketing**

In 1965, the CPMB decided to use the services of the Cypriot exporters on a principal to principal basis — not agents — by applying the method of forward sales by tenders. In 1972, the CPMB was forced to take over all marketing functions, because starting from 1970, the Cypriot exporters were faced with increasing difficulties in selling forward at fixed prices due to the change of attitude and the preference of U.K. importers to deal on consignment terms.

To the request of U.K. importers to appoint agents and form a panel, the CPMB decided to sell outright to any buyer on an ex quay basis with the following terms:

- For minimum 1000 tons Price X
- For minimum 500 tons X+2p
- For minimum 250 tons X+4p
- For minimum 125 tons X+6p

From the very beginning, experience showed very clearly the necessity of orderly distribution, the importance of confidence in promoting sales, the significance of correct pricing, and the value of market intelligence in decision making.

In 1974, the CPMB introduced the system of daily sales to primary buyers on an ex quay basis. Under this system, the U.K. is divided into four regions with a number of chosen 'primary buyers' for each region. The price is the same for every primary buyer, irrespective of the quantity they take ex quay. The CPMB regulates supplies to each region on the basis of anticipated demand and experience. The forwarding agent of each port in the U.K. informs the London office of the daily deliveries to the primary buyers. In this way the management is aware of the individual activities, and regional and national daily movement of quantities.

Pricing is a dynamic process. In deciding the price of Champions, due consideration is given to the quantity, quality, and timing of the local crop, other imported potatoes, local new potatoes, and of course the Champions. The importance of accurate and correct information can not be overemphasized. The main objective in pricing Champions is to have the highest probable price maintained for as long as possible, so that market stability is established and maximization of returns is achieved.
Table 2. Exports of Cyprus potatoes (winter, new, and spring) by country of destination (tons)

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<tr>
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<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
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<td>124,251</td>
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<td>111,711</td>
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<td>95,803</td>
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Table 3. Exports of Cyprus potatoes by country of destination, 1990-1991 (tons)

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<th>New crop</th>
<th>Spring crop</th>
<th>Total</th>
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<td>France</td>
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<td>-</td>
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<td>892</td>
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<td>960</td>
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1. Estimate

Source: OSCE - Potato Markets Suppl. Agra Europe.

Table 5. European Community early potato production ('000 tons)

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Table 6. Intra European Community potato imports and exports during 1990 (‘000 tons)

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<th>Germany</th>
<th>Greece</th>
<th>Spain</th>
<th>France</th>
<th>Ireland</th>
<th>Italy</th>
<th>Nether- lands</th>
<th>Portugal</th>
<th>Kingdom</th>
<th>Total</th>
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Total imports 316 54 741 41 232 377 50 816 485 147 142 3,401

* Less than 500 tons.
Source: Communication from member states.

Table 7. European Community imports of new potatoes from third Mediterranean countries (‘000 tons)

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Total 310¹ 455¹ 332¹ 308¹ 281 271 340 377

1. Includes imports from Spain.
* Less than 500 tons.
Source: Eurostat.

When market conditions favor price increases it is not unknown for the Board to give advance notice to all its primary buyers of the price increases it has decided to effect on certain dates in order to encourage uplifting from the ports. When market conditions impose a reduction of price, then the buyers are reasonably covered by re-invoicing certain quantities, which are calculated on an equal, fair, and objective basis. This practice has been instrumental in gaining the confidence of those dealing in Cyprus potatoes, so that even when the prices of Cyprus potatoes are significantly higher or there is a downward movement of the prices of potatoes from other sources, they continue to buy Cyprus potatoes since they know that they will not be left uncovered if the Board decides to reduce the price.
The market statistical information and the theoretical reasoning behind all pricing decisions are supplied to the market in order to help both our buyers and their customers to form their own opinion about our decisions.

From experience it was very obvious that orderly distribution, effective pricing based on accurate market intelligence, and market confidence were not helping much when Champions had quality problems on arrival. In fact quality is the most important factor that affects the price of potatoes. If the quality is bad, then the price will drop even under conditions of a supply shortfall.

**Management of Quality**

Research and experience show very clearly that quality matters to the European consumer more and more.

People would give different answers to the question of what is quality, depending on habits, culture, etc. For the CPMB the following aspects of quality are important:

First is appearance. It is obvious that people do buy 'with their eyes'. Cyprus potatoes are grown in areas with red soil which not only contributes towards higher yields and excellent taste, but it also imparts on the tubers the attractive outside color which has become synonymous with Cyprus potatoes.

Second comes freshness. This is becoming more important since most consumers are not shopping daily, which means that they stock up on fruits and vegetables. Consumers want the potatoes to be fresh after they buy them. The longer they stay fresh at home the better. Cyprus potatoes have longer life-span and lasting freshness.

Third comes taste. Potatoes must look good and taste good as well. Consumers will come back if they like the taste. Retailers want customers to come back and buy again. Taste means repeat sales, which result in successful selling and lead to market growth. Taste varies with countries and differs from one place to another and changes over time even within the same season.

Lastly comes value for money. Consumers are prepared to pay a certain premium for quality. As long as that premium does not affect consumption, the high price is beneficial to wholesalers and especially retailers. Cyprus potatoes command higher prices but they are of better quality, which the customers recognize as good value.

Cyprus potatoes are grown with utmost care and at great expense by thousands of small family producers. The lifting is still done with the traditional plow, and potatoes are hand picked, not because of lack of technological progress, but because of special concern for the quality of our scrapers. Potatoes are then selected, graded, and packed in a well-organized manner and under strict control, so that the final product is homogeneous and of very high standard.

**Programming of Production to Effective Demand**

The CPMB does not rely only on the intrinsic virtues of Champions, because this is not enough. We find out what our customers want and we produce it, in other words, we program our production to effective demand. Cyprus potatoes are produced to be exported, therefore production is planned with export markets in mind with regard to volume, timing, and varieties.

**VOLUME.** The total production and percentage of each variety of each crop is carefully planned in advance every season with the anticipated future demand in mind.

**TIMING.** The pattern of demand for Cyprus potatoes in the U.K. markets has changed dramatically the last twenty years. For many years Cyprus potatoes were covering the gap in English potatoes for late May, June, and July. Nearly 50 percent was going to the crisping industry and the balance to the wholesale markets. In the meantime, improved methods of growing in U.K. (use of irrigation and plastic) and the introduction of new varieties, coupled with more efficient methods of storage, meant that home-grown potatoes were available.
much earlier and longer. As a result, the consumers’ demand for Cyprus potatoes in July gradually diminished and the crispers’ demand was almost lost.

The CPMB reacted to the above changes and brought the spring crop forward by nearly two months. In order to promote earliness, new varieties were introduced and the price mechanism was used to expedite lifting. As a result about 1,000 hectares of non-fertile land along the coast were converted to potato land by adding red soil.

It has already been mentioned that a third crop was introduced between the winter and spring crops in order to meet the demand for new potatoes during the months of February and March, because consumers now expect new potatoes to be available throughout the year.

**VARIETIES.** In addition, the retailer structure of the U.K. market changed in favor of supermarkets, whose share rose in 1960 to 40 percent, increasing to 50 percent in the 1970s and 1980s. Presently, it is nearly 60 percent with an upward trend. The supermarkets have introduced and strengthened a lot of changes in consumption like potatoes for salads, frying, roasting, boiling, baking, etc. These changes in demand created special markets which are available only if the potatoes are of premium quality and of varieties with specific cooking and eating characteristics.

The varieties cultivated over the years changed in order to meet the changes in demand (Table 8). The white-flesh Scottish variety (1893) *Up-to-Date* was the only one during the first half of the 20th Century. The white-flesh Scottish variety (1927) *Arran Banner* was imported in 1935, but its production expanded after 1950, and it was the most important until 1978.

In the 1970s the CPMB and the Ministry of Agriculture, realizing that the intention of U.K. to join the Common Market was going to affect adversely the sales of Cyprus potatoes, decided to carry out experiments with the target of finding earlier varieties, including yellow-flesh ones for the potato market on the Continent.

Among many varieties, the Dutch light yellow-fleshed *Spunta* was the most successful, and it was rapidly adopted by the potato producers. *Spunta* was the main variety between 1979 and 1989, not only because it is early and productive, but especially because it is preferred in the English, German, Arab, and local markets. The varieties *Liseta* and *Lola* supplement *Spunta* since they are very similar.

The Dutch yellow-fleshed salad (firm cooking) variety *Nicola* is the only one selling in Belgium, and it is extremely popular in Germany and other European markets. Recently it has become very popular with the U.K. supermarkets. The *Diamant* is mainly marketed in Germany and Holland, but it is also liked by the U.K. supermarkets which do not like *Spunta*. The new Irish variety *Cara* replaced the traditional *Arran Banner*, because it has a good appearance due to its shallow pink eyes and is exceptionally suitable as a baking (potato in the jacket) potato. The market of bakers in U.K. has increased steadily. *Cara* bakers cover the demand in June and July. In order to cover the demand for bakers in May, the earlier variety *Marfona* was re-imported. Furthermore, the CPMB is importing the variety *Sieglinde* which is loved in Germany, the variety *Accent*, which is used by one supermarket in Holland, and the varieties *Tmate* and *Obelix*, which look promising with regard to appearance, flavor, and taste. At the moment CPMB is working on the *Royal Kidney* with the aim of offering this delicious variety in December and January. Finally, it must be mentioned that the research to discover new varieties is a continuous scientific process carried out both extensively and intensively.

**Satisfying the Customers**

The first rule in successful marketing is to satisfy the customer. This happens to be the last rule as well, for if business does not satisfy customers, they will soon be out of business. Who are the customers? First and foremost the consumers.

**CONSUMERS.** Consumers of today are not mere users of goods, but they are choosers.
with particular preferences. Because of tradition, material welfare and high taste they are sophisticated, discerning, and health conscious with an emphasis on better quality, appearance, freshness, and taste. We try to supply them with what they want at the best quality.

**RETAILERS.** The vast number of independent retailers, as well as the sophisticated supermarkets, are the capillaries of marketing distribution channels which bring potatoes to consumers’ attention for their choice and which feed back consumers’ preferences and reactions to the suppliers. Cyprus potatoes, because of varietal differences, consistency in quality and weight, high level of public awareness, and finally premium prices, offer choice, reliability, and profitability.

**WHOLESALEERS.** These are the people who bring the buyers and sellers together. They need to cover their constantly increasing costs and maintain their profits. The steady prices of Champions offer stability and the market support when prices have to drop offers confidence. Selling Champions does not earn fortunes, but at the same time the risk of loss is minimized, if not eliminated.

**PRIMARY BUYERS AND REPRESENTATIVES.** The primary buyers and representatives are the first link in the chain between the Board and the market. They have to work hard, intelligently, and above all efficiently to satisfy both the market and the Board. As long as they do that, they have our full support and protection. Our efforts to satisfy our customers will be strengthened, with the belief that they will continue supporting us, in order to stay in business for mutual benefit and satisfaction.

**Prospects for Cyprus Potatoes in the EC After 1992**

After 1992 there will be ‘The Single Market,’ which is officially defined as: ‘... an area without internal frontier in which free movements of goods, persons, services and capital is ensured.’ The ultimate goals of this single market are better market opportunities, increased competition, greater efficiency, economies of scale, reduction of costs, creation of jobs, and the improvement of wealth. It all sounds very good and looks very nice. How is this likely to affect Cyprus potatoes?

**Free Movement of Goods**

This is already happening. However, it will be at somewhat lower costs because of elimination of State customs. Also, transport will be cheaper as a result of liberalization.

**Economies of Scale**

The probable developments are:
- Many more intercommunity takeovers, mergers, and acquisitions.
- Grouping of wholesalers or distributors to offer Europe-wide distribution services.
- Grouping of supermarkets for common procurement offices.

All these will mean that we will operate under conditions of more severe competition, we will be confronted with more concentrated buying power, but at the same time, we will be negotiating larger volumes.

**‘The Single Market’**

In many respects there already exists a single market for fruits and vegetables — potatoes included. However, it is necessary to mention some points of importance.

It seems that the Commission is not prepared to introduce a reference price for new potatoes. The reference price system, if applied, would protect Cyprus potatoes because we can supply profitably at ‘minimum wholesale price’ against other third countries which might be prevented from engaging in price competition by having to respect the reference price. In addition:
- Pesticides residues — it will be harder, but harmonization will not be a problem.
- Phytosanitary regulations — the ‘Passport’ will help Cyprus potatoes.
• The EC will be more sympathetic to imports from Eastern European countries, and this could lead to greater competition.

• There might be increasing similarity of consumers tastes, and possible ‘Pan-European’ advertising.

• The expected increase in wealth will undoubtedly go to increased expenditures on holidays, personal transport, private housing, luxury items, etc. The smaller effect on the food budget will benefit most likely the so-called ‘luxury’ fresh produce — Champions included.

• Finally, environmental measures are most important — for example, Germany requires recyclable packaging and returnable pallets.

**How Should Cyprus React to These Developments?**

We will follow very closely the changes in consumer demand, continue meeting their requirements, and satisfying their preferences. In the past the emphasis was on quality. It will continue to be so, but with greater commitment and increased professionalism. Our goals will be the development of new varieties, the improvement of methods of growing and better selection, grading, and transport. With our commitment to impeccable appearance, natural freshness, and tantalizing taste, we shall make our potatoes more desirable, more needed, and more wanted by the consumers. The reputation of CPMB as a steady and reliable supplier of quality potatoes will be safeguarded, because it will attract the attention of those who are after value for money.

A lot of people, when the subject of the single market is raised, express doubts, pessimism, fears, and uncertainty. This is an interesting and exciting period. The developments are of profound significance to European history. The single market is a new challenge. I feel enthusiastic about it and strongly believe that the CPMB will continue with success for the following reasons:

• We have confidence in our potatoes and we are proud of what we are selling: they are fresh, nutritious, delicious, and healthy.

• We have confidence in the skills of our producers: they are efficient, market-oriented, and ready to adjust their production to changes in demand.

• We have confidence in the infrastructure of the trade: the retailers, supermarkets, wholesalers, and our representatives. We understand their demands and they appreciate our commitments. We cooperate fully because the objectives are in many respects identical.

• We invest not only in production, but in marketing as well. We support our customers in their efforts to educate consumers about the qualities of the potatoes in general and ours in particular.

In conclusion, we recognize that the CPMB will be only as good as the results it will continue to produce. However, it must be stressed out that there is no magic in a marketing board. It is simply an instrument which can become useful with expert management and purposeful direction. The Marketing Board has the power, the appropriate use of which may facilitate the achievement of the targeted objectives. As a marketing expert put it, the Marketing Board is a key that properly used may unlock the door to successful marketing, but it is not the door itself.
Table 8. Potato varieties grown on Cyprus (hectares), 1972 to 1992

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<td>8,310</td>
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<td>10,689</td>
<td>9,200</td>
<td>9,062</td>
<td>11,273</td>
<td>12,805</td>
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</table>
The food industry relies on a tremendous variety of processes, the most important of which are:

- **Mechanical processing**: milling, grinding, extraction, bolting, grading, and cleaning.
- **Thermal processing**: refrigeration, freezing, pasteurization, and sterilization.
- **Hydrothermal processing**: drying, dehydration, liquefaction, and concentration.
- **Processing using micro-organisms and yeasts**: alcoholic, lactic, and acetic fermentation.

The objective of these numerous processes, some of them known for a long time and others now being perfected, is the separation of food constituents, conditioning, preservation, preparation, and conversion of products to make them directly consumable or usable by other food processing industries or other industrial sectors. They must be innovative and constantly adapted to the various conditions specific to the extremely diverse raw materials that constitute agricultural and food products all over the world.

This first section will take up new technologies, which are appropriately named. Of course, one thinks immediately of biotechnology as applied to the food industry. But there are also other technologies, such as ionization, use of filtration membranes (microfiltration, ultrafiltration), dehydration/impregnation by immersion, cryogenic freeze-drying, long-term aseptic conditioning, and supercritical CO₂, treatment under very high pressures.

Some of these new technologies have experienced spectacular development and many applications in food industries, in particular micro-filtration, ultra-filtration, and aseptic processing. They are also being studied in industrialized nations, for example, the use of high pressures. They have a dual purpose: processing of basic agricultural products grown in those same countries or imported, and manufacture of products responding to market demands from industrial users or consumers in the developed nations.

The second section of this paper will take up appropriate technologies that represent real innovations. Current technologies already mastered in the industrialized nations must be adapted to agricultural raw materials from tropical nations. Rightly or wrongly, this research places priority on products that might find outlets as exports: palm oil, coffee, cacao, citrus juices, and cotton, for example.

But there are also traditional technologies specific to the food consumed by the inhabitants of the developing nations. In this area, there is much room for innovation and more efficient production of food that is easier to use and more competitive with products imported for urban populations. We must reiterate that innovation applied to traditional procedures for food processing in developing nations will have the same or an even greater impact on the economies of those countries than the new technologies mentioned above, over the next ten years at least.

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New Technologies

Biotechnologies

Modern biotechnology, molecular biology, and genetic engineering should not influence the development of food processing industries in the developing countries for a long time to come. By contrast, within ten years biotechnology will probably make it possible to significantly increase agricultural production, and thus food supplies.

It will be possible to improve plant resistance to drought, to insect or virus attack, and perhaps to improve the nutritional and organoleptic quality of products (Table 1). We can thus expect rapid short-term progress with genetic manipulation of potatoes, rape seed, and rice, whose genetic maps are already quite advanced; medium-term progress for plantains, manioc and coffee; and progress for coconut, oil palm, and wheat over the longer term (Persley 1990).

However, several observations are necessary:

When applied to tropical foodstuffs intended for export, biotechnology will make it possible to increase production and therefore exportable quantities. The selling price might then drop on the world market, requiring a significant offsetting effort in quality and market prospecting. Biotechnology applied to export products will therefore offer only a temporary advantage, benefiting the most developed of the developing nations, which will exploit it and thus increase their market share. But will the increased sales volume provide a parallel increase in value? What will happen is that the importing nations will derive a clear advantage, since they will get their supplies at lower prices.

When applied to food products intended for domestic consumption, biotechnology will make it possible to increase available supplies of manioc, plantains, rice, etc., at a rate higher than population growth. It is clear that agricultural nations already well integrated into the market economy will be the first to benefit from these new techniques, as was the case for the green revolution.

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Constraints</th>
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<tbody>
<tr>
<td>Banana/ plantain</td>
<td>Black Sigatoka disease, bunchy top virus, Fusarium wilt</td>
</tr>
<tr>
<td>Cassava</td>
<td>High cyanide, cassava mosaic virus</td>
</tr>
<tr>
<td>Coffee</td>
<td>Coffee rust, quality characteristics</td>
</tr>
<tr>
<td>Cocoa</td>
<td>Vegetative propagation</td>
</tr>
<tr>
<td>Coconut</td>
<td>Vegetative propagation, virus/viroid diseases, lethal yellow disease</td>
</tr>
<tr>
<td>Oil palm</td>
<td>Clonal propagation, flowering abnormalities, drought susceptibility, insect pests and diseases, oil quality</td>
</tr>
<tr>
<td>Potato</td>
<td>High temperature susceptibility, disease-free planting material, postharvest quality</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>Oil quality</td>
</tr>
<tr>
<td>Rice</td>
<td>Virus diseases</td>
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<tr>
<td>Wheat</td>
<td>Fungal diseases, virus diseases (barley yellow dwarf)</td>
</tr>
</tbody>
</table>

Will biotechnology be easier to use and more efficient than technological packages already well-known, which include cultural practices, selected seed, fertilizers, and phytosanitary treatment? Although the impact of these technological packages on the development of foodstuffs is still well below its potential in most African and South American nations, this is due to a lack of finance and organization hindering their dissemination, rather than to any shortage of these techniques. The same should be true for the diffusion of products derived from molecular biology and genetic engineering, in view of the resources required.

Before biotechnology can generate savings to be reinvested in agriculture or the food industry, the application of biotechnologies in developing nations will require increased financing from the developed nations. Bio-industry, which uses genetic engineering and requires rigorous controls on product quality and safety, requires heavy investment and extremely qualified staff trained in basic research. These conditions are often lacking in
the developing nations, with the exception of some that are economically more developed, such as India and Brazil. These two countries could take advantage of applications from research done in the industrialized nations, if assisted by a significant effort from donor agencies and countries.

If they are not able to manufacture them themselves, the developing nations can be supplied with materials genetically modified in the industrialized nations, which they would use in their industries; for example, modified baking yeasts (authorized for bread making in Great Britain a short while ago).

**Microorganisms and Enzymes**

Traditional biotechnology using microbial resources offers much more immediate benefit than genetic engineering for agribusiness in developed nations, and for certain applications in developing countries. Biotechnology allows the use of multiple fermentations in liquid and solid media, which could be carried out in industrial bioreactors. Examples are:

- Selection of micro-organisms capable of governing fermentation; development and manufacturing of starters to join these micro-organisms; mastery of the process for industrial applications in order to ensure a final product having the same organoleptic characteristics as the traditional product — fermented beverages or dishes. We know that the Japanese food industry has very successfully developed industrial manufacturing of traditional Japanese dishes.
- Use of industrial enzymes for conversion of starch in countries that are heavy producers of tubers.
- Composting and recycling of wastes, biogas fermentation, and decomposition of lignocellulose biomass and its conversion into fuel.

The following examples of applications to tropical products are the results of recent research done at the Center for International Cooperation in Agronomic Research for Development (CIRAD).

**Palm Oil.** Tests in pilot plants have shown that malaxation of palm nuts in the presence of enzymes that destroy cellulose and pectin produces an increase on the order of 5 percent in total oil from the palm cluster. These enzymes also improve the static and dynamic separation occurring after pressing. Lastly, this treatment could be applied to assisted recovery of oil in oil mill effluents. Full-scale tests using industrial enzyme juices are planned in an oil mill.

**Deacidification of Hyperacidic Oil.** Refining a highly acidic oil is cumbersome, requires a solvent, and losses are still high. This occurs with rice bran oil (10 to 15 percent free fatty acid) and palm kernel oil, which is often acid as a result of the method of nut storage (5 to 10 percent). The experience of the CIRAD Oilseeds Department (IRHO) in the field of industrial lipases and inter-esterification has made it possible to perfect a high-yield procedure for reducing acidity to 2 percent. Traditional refining can then be done with limited loss because of the reconversion of fatty acids in the oil.

**Production of Food Yeast from Palm Oil Mill Effluents.** The technical and economic feasibility of the procedure developed at the experimental pilot stage at CIRAD has been demonstrated, which makes possible simultaneous yeast production (*Candida rugosa*) and treatment of effluents to reduce the pollution potential.

**Microfiltration in Tangential Flux**

Microfiltration in tangential flux has made enormous progress since the appearance of mineral membranes. The recent development of new techniques for manufacturing these membranes has made it possible to use new metallic oxides, titanium and zirconium, for the filtering layer. This produces selectivity not only because of the pore diameter of that layer (0.2 microns), but also because of polarization and interaction between aromatic molecules.
present in the fruit juices close to the membranes.

Since these membranes are mineral, they can tolerate simultaneously the aggressive nature of some tropical juices caused by their acidity and the presence of enzymes, polyphenols, and essential oils, and their fragile nature, deriving from their aromas and colors.

This simple, low-cost technique eliminates several intermediate clarification stages in the manufacturing of juices, and can be used in developing nations after having been applied to temperate fruits such as grapes and apples, as well as kiwi. Its adaptation to lemon juice was achieved by the CIRAD Fruit and Citrus Department (IRFA) at the request of a group of citrus producers from Côte d’Ivoire (COCI). This group wishes to market a clarified lemon juice in response to a new demand from the European market. The product meets market standards, and industrial production can commence.

IRFA has also filtered orange juice through mineral membranes and derived a pulpy concentrate with clear juice, the latter rich in aromatic compounds. This can be used as a base for fruit juice mixtures or concentrated at low temperature by inverse osmosis for use in food industries.

**Dehydration/Impregnation by Immersion**

Dehydration/impregnation by immersion (still called osmotic dehydration or dehydration by direct osmosis) is a procedure based on placing whole products or products cut in pieces in contact with heavily concentrated solutions. In the industrial nations, pretreatment using partial drying and impregnation by immersion is restricted to traditional techniques, such as salting and pickling of meats, fish, cheeses, and vegetables.

In the case of fruits, the solution for immersing the cut products is usually a heavily concentrated sugar solution. A significant amount of water leaves the product to enter the solution at the same time as sugar is transferred from the solution to the product. One may thus obtain semi-crystallized fruits with particularly good organoleptic characteristics (aroma, color, and texture), whose basic nutritional qualities are preserved. Significant energy savings occur as well, since the water need not be evaporated in order to achieve this “dehydration.” This technique is widely used in Southeast Asia for the production of “dehydrated” tropical fruits and is tending to spread through Europe in the form of fruits for appetizers.

The CIRAD Department of Food and Rural Systems (SAR) is currently working on industrial control of the procedure (control of concentration and management of volume of syrups, automation and control of the procedure), as well as on developing specific equipment, in particular for the appropriate contact between the liquid and solid stages.

**Ionization**

Ionization is a physical process consisting of exposing products to the direct action of photonic gamma rays generated by a radioactive source such as cobalt 60 or to a source of beta electronic rays traveling at high speed in an accelerator. Their energy is too low to induce any radioactivity but sufficient to cause formation of ions in the material. Among other things, these rays make it possible to destroy bacteria, which are the main culprits which deteriorate product quality; delay ripening; inhibit germination; or remove insects from products. The effects of the treatment on technological and organoleptic characteristics should be evaluated on a case-by-case basis, but as a general rule are minimal.

Currently, agri-food processing on a commercial scale takes place in multipurpose facilities, since ionization entails extensive investment, which must be written off over a long period of time, and large product quantities. In 1990, the cost of treatment by ionization in a multipurpose station capable of handling 20,000 tons per year probably amounted to 0.5 to 1 franc per kilogram (£50 to 100 per ton) (Erhart 1990). The feasibility
of many applications is related to the cost-effectiveness of ionization by comparison with other procedures for preservation, pasteurization, and inhibition, as well as to domestic or international regulatory obstacles, consumer reaction, and the practicality of incorporating it into the production line and marketing system. It must be remembered that ionization does not prevent reinfestation by micro-organisms or insects after treatment, and thus airtight packaging is still required.

Ionization is theoretically an advantageous procedure for developing nations, both for reducing losses after harvest as well as for export of agricultural products, particularly those with high added value, but equipment is still too costly and regulations too restrictive internationally to allow commercial use. Its application as a quarantine treatment is a useful way of substituting for chemicals such as ethylene bromide, which is prohibited in some countries. Papayas from the Hawaiian Islands are authorized for entry on the U.S. continent if treated with ionization to combat fruit flies.

**Cryogenic Freeze Drying and Supercritical CO₂**

Liquid nitrogen at -198°C and liquid carbon dioxide at -80°C are used for freeze drying foodstuffs, but as yet account for no more than 10 percent of quantities freeze dried in France, by comparison with the 90 percent freeze dried by mechanical methods. The advantage of cryogenic freeze drying is that it is fast and affords optimum preservation of the product's organoleptic qualities, while reducing water loss. It is therefore of special interest to the meat and fish industries as long as it is more profitable than traditional mechanical refrigeration. For a long time to come, traditional mechanical refrigeration will satisfy the needs of industrial fishing fleets and shellfish and seafood packing and shipping operations in developing nations.

Use of supercritical CO₂ is a high-yield, clean technique, but an expensive one, which will remain so. The only industrial applications are in the extraction of high value-added aromas (coffee, hops).

**High Pressure Technology**

The application of high pressure in the food industry is already in evidence in Japan, where it is used by three agribusinesses, specifically for meat, fruit juices, and eggs, and for bacterial purification of various foodstuffs. In the last case, this means "pasteurization" or "sterilization," depending on operating conditions.

The principle of the procedure is to subject the food product, in solid or liquid state, to pressures ranging from 1,000 to 4,000 bar for a process time of 15 to 30 minutes, at room temperature for pasteurization and at approximately 80°C for sterilization. The treatment takes place in continuous or discontinuous hydrostatic pressure vessels.

High pressure has effects identical to high temperatures on proteins and micro-organisms, and produces products with organoleptic characteristics superior to the characteristics using traditional thermal processing. Product texture can also be modified by modulating treatment intensity, and thus its effect on proteins and their denaturation.

The introduction of high pressures on an industrial scale in agricultural or food industries is not expected for another four or five years in Europe, nor, as far as we know, in the United States. It is hard to see any commercial advantage that might be gained by applying this technology to tropical foodstuffs in developing nations. One exception within ten years might be the exotic fruit concentrates and juices industry, if the improvement of organoleptic qualities and preservation were such that the consumer market would be prepared to pay the price.

**Aseptic Processing Systems**

Aseptic processing and production systems have undergone spectacular development in recent years in industrialized nations. They are applied to liquid goods or products containing solid particles (juice, puree, soups, milk, or
yogurts). Tremendous progress has been made to guarantee heat sterilization of suspended particles in liquids and chemical-free sterilization of packaging to improve the physical properties of packaging and aseptic filling.

Large plastic packaging placed in rigid boxes (bag in box) filled aseptically is being developed and could be beneficial for countries that are large exporters of high-quality bulk fruit juices and pulp. Control of the production line and conditioning environment, and the extremely strict regulatory aspects of an aseptic system, call for specific infrastructures and proper mastery of the technology. Some food industries in developing nations already well established on the international market will be in a position to satisfy these operating conditions in close technical collaboration with equipment suppliers and their industrial associates in the north.

Appropriate Technologies

By way of information we will now describe some of these technologies, and take the opportunity to cite some of the results achieved by CIRAD.

Gossypol-Free Cottonseed Flours

Industrial grinding of regular cottonseed provides table oil and oilcakes, used only to feed livestock or poultry because of the presence of gossypol. Gossypol is a toxic polyphenol pigment present in cottonseed.

Selection work undertaken as of 1974 at the Savanna Institute — IDESSA — in Côte d'Ivoire, with the assistance of CIRAD's Department of Cotton and Textiles (IRCT), has led to the creation of new varieties without gossypol (glandless) with high fiber yields when ginned, which can compare with traditional varieties. The seed has oil yields that are 1.5 percent higher than those from regular seeds. With these gossypol-free varieties, the cotton plant can now be regarded as a food crop as well as a plant for textiles — a source of both oil and protein flour for humans and feed for monogastric animals. The CIRAD/IRCT lab has demonstrated that direct extraction of oil by using hexane after conditioning of seeds by cold extrusion is the most appropriate industrial process.

The procedure is industrial and yields a higher quality oil, clearer with less acid, and a clear, lipid-free flour, with more than 65 percent protein and a high solubility rate. This flour can be used in the production of various foods in the cereal industry, as well as sauces and baby food, and for animal food, in particular poultry, which offers the largest outlets. Approximately 100,000 hectares of gossypol-free cotton plants were sown in West Africa for the 1991-92 season.

Deacidification of Commercial Cacao

For roasters who buy acid commercial cacao, in particular from Southeast Asia, CIRAD's Department of Coffee and Cacao (IRCC) has perfected a team-based deacidification process, simple and quick, to be applied between hulling and roasting. This treatment is easy to incorporate into the manufacturing process, and makes it possible to lower free acidity by 10 to 25 percent depending on processing conditions, and volatile acidity by 20 to 60 percent, in less than 30 minutes. It does not affect the organoleptic quality of the cacao.

Industrial Hulling and Grinding of Sorghum and Millet

Direct grinding of sorghum and millet without prior hulling does not provide satisfactory results from the standpoint of the purity of milled products, semolina and flours. The pericarp surrounding the sorghum seed is unusually friable, and hard to separate from the flour by bolting. Industrial flour mills and corn mills have to be modified in order to handle tropical cereals profitably. Hulling with industrial equipment used for processing rice is not suitable either without modifications, because many varieties of sorghum are farinaceous or semi-vitreous and break when hulled, causing a significant decrease in yields in finished products.
Research over the last 20 years by research organizations and various equipment manufacturers in developing and developed countries has made it possible to perfect and make available, commencing in 1985-86, satisfactory processes and equipment adapted to the characteristics of the seeds, namely direct grinding with preliminary conditioning of seed to a certain moisture level or dry hulling by abrasion. The choice of equipment and settings depends on the characteristics of seed varieties and the types of finished goods traditionally demanded by consumers: flours, semolinas, crushed seeds, or hulled seeds.

Unfortunately, the grinding industries for millet and sorghum did not develop as anticipated after technical issues were resolved. The marketing policies used for cereals by producer developing countries do not encourage marketing of local cereals. The significant subsidies enjoyed by wheat sales on the world market enable importing countries to give urban populations breads, doughs, and wheat crackers at a very good price. Lastly, rural populations are quite happy when a mechanical mill is available in the village that mills to order to meet their needs.

Small Units for Fruit Processing

In conjunction with UNIDO, the Center for Industrial Development of the EEC, and a French manufacturer, IRFA has done preliminary studies on the installation of small multipurpose production units for tropical fruit juices, set formulas for beverages, and optimized production. In 1991, three operations of this type were completed: in Cameroon for guava, pineapple, and passion fruit juices, with a daily capacity of 5,000 bottles; in Togo for production of ginger, guava, mango, papaya, and passion fruit juices; and in Burundi for production of pineapple and passion fruit juices in aluminum cartons.

Controlled or Modified Atmospheres

Preservation in a controlled atmosphere means placing foodstuffs in an airtight vessel in which the various atmospheric components — $\text{H}_2\text{O}$, $\text{CO}_2$, $\text{O}_2$, $\text{N}_2$ — are maintained at concentrations that promote better preservation. Preservation in a modified atmosphere means injecting a specific gaseous mixture in the packaging at the time the product is packaged.

Applied to production from temperate countries, for example, apples and pears, and in banana ripening depots, these atmospheres are justified when large quantities of products are to be stored and marketed over a long period of time, basically for export. The major condition is the imperviousness of the storage location or the packaging itself. Adaptation to tropical products too sensitive to tolerate refrigeration has been attempted, for example on yams and bananas in Côte d'Ivoire, but this effort ran up against cost and marketing organization problems. Using these methods to ensure supply to an urban market in developing nations does not appear justified.

Adaptation of Traditional Technologies

The search for innovation in traditional technologies is based on a specific procedure:

- Analysis of all operations and operators participating in a subsector, for example, corn, from production to consumption.

- Technical analysis of local processing, often artisanal and manual.

- Identification of bottlenecks limiting the effectiveness of the procedure and competitiveness of the products from the standpoint of volume and quality.

- Possible creation of a small piece of equipment for mechanization of the most tedious operations and research into transferring the process to an industrial scale.

This methodology is the basis of a CIRAD program entitled "Consumer and Market-Driven Research and Development." Without attempting a complete listing, we can cite by way of example the study of the mechanization or modernization of the following processes in various CIRAD departments:
Conclusions

The green revolution made it possible to distribute high-yield varieties, and has been supported by the work of the International Centers for Agronomic Research (CIRA). This has led to a transfer of North/South and South/South varieties that have revolutionized agriculture, particularly in Asia, and have led to a capital-intensive, high labor productivity model.

The bio-revolution will accentuate the gaps between the North/South agri-food systems, and probably between southern agricultural systems with low and high levels of inputs, and will be reflected in a concentration of northern firms that master biotechnologies, leading to heavy competition between them and pharmaceutical and fine chemistry firms, and oil companies.

As a general rule, agricultural nations having the resources use modern methods and opt to grow products which can be sold on the world market. Brazil is an example, growing soybeans, wheat, citrus (oranges for freeze-dried concentrated juices), coffee, and sugar. Other farmers using a low level of inputs produce 70 percent of the food crops in Brazil, including rice, maize, cassava, and beans.

The same is true of the processing of foodstuffs. Industry in the developing countries will opt to manufacture products that have outlets on the world market, and may adopt the newest technologies in order to stay competitive on that market. However, we have seen that the choice is still constrained by the local industrial climate, the cost of equipment, and the technical assistance required. For the domestic market, on the other hand, companies will not be very much inclined towards industrial processing of local food crops.

The concerns of the agri-food industries in the North are very different from those of the South. Research and development are directed towards light, low-calorie, low-cholesterol products; easy to prepare and in individual portions, etc., for very specific consumer targets with a certain amount of purchasing power. They must be in a position to respond...
to the assumed or actual demands of these consumers: flavor, service, safety, and health.

To obtain these new product formulas, the food industry is studying the use of alternative products among foods themselves, in particular substitution of fatty mineral substances (butter) by vegetable substance (margarine) with 82 percent lipids, and now spreads containing only 41 percent and even 30 percent fat. The fats are being replaced by substances having the same technical and organoleptic properties, but lower in calories, since they have been greatly lightened (polydextrose); sugar is being replaced by sweeteners, such as aspertame, and animal proteins by textured vegetable proteins (such as filler products to replace meat in sausages and hamburgers). Thus, the agri-food industry in the northern nations is increasingly a business of cracking agricultural products and assembling ingredients.

Consequently, the new technologies are being developed in western nations to allow product manufacturing under the most profitable conditions. They require significant investment in equipment rather than labor, and are increasing processing capacities. They are mainly oriented toward manufacturing products for financially solvent markets. It is not clear just what advantages the developing nations could derive from them, apart from a few sectors limited to export products.

Overall, it is not so much the new technologies as the application of technologies already mastered or well adapted to local conditions that will enable industries processing tropical foodstuffs to participate actively in national economic development. What is still needed is for this development in the southern nations to be encouraged by a coherent economic and marketing policy that increases value added from processing within a domestic or international framework.

References


Chile's Experience in Adapting New Technologies for Agroindustry

Patricio Galeb

I would like to thank Wye College, the University of London, and the World Bank for the opportunity to be here and discuss some of our experience in technology transfer in Fundación Chile during the last 16 years.

I shall begin with the characterization of Chilean agroindustry in the 1970s. I will then explain what Fundación Chile is, its action areas, problems dealt with, its strategy in the transfer of technology, and end with the characterization of the present agroindustry and its evolution during this period.

As you know, Chile is a very long and narrow country with a dry, desert climate in the north, temperate climate in the central part, and rainy and cold down south.

If we begin analyzing the situation of agroindustry in the 1970s, we can say that it was a family-type enterprise with incipient knowledge of markets and their demands, low receptiveness to innovation, and low credibility from the private sector on the benefits that technological changes could produce.

Commercialization channels were not clear enough and changeable, and equipment and machinery were out-of-date. The concept of quality was very poor, with low productivity, and all business was oriented to the internal market — small with few demands.

Facing this deficient situation, various technical, economic, and political measures were taken. In relation to technical measures, Fundación Chile was created in 1976 thanks to an agreement between the Government of Chile and ITT (International Telephone and Telegraph) Corporation, each contributing 50 percent of its initial endowment of $50 million (all dollar amounts are U.S. dollars). By definition, our institution is a private, non-profit organization, totally autonomous in its administration, and oriented to the private sector.

The most important action areas of its work are centered in agribusiness, forestry, and marine resources, with a full-time staff of 175 and 30 part-time workers.

In analyzing the principal problems we faced with the private sector during our first year, we had to work hard to maintain our credibility. They argued, for example, “How can I believe what you are saying if you have no experience in my business? I was taught by my father, and my father by my grandfather.”

Similar situations were countless. Along with this credibility problem, there was a serious confidence problem. They said things like “How shall I allow you to come and see my industry, you will later tell the competition the kind of machinery I have, and how I work.”

As you can see, our task was not easy at all.

To these points we must add the traditional attitude of the group. An important sector believed in a state subsidy system, which resulted in a strong reluctance to any change by acquiring new technology.

Facing this situation, we had to formulate strategies to face this sector which resisted new technologies. Thus, we dealt with critical points such as how to obtain the client’s confidence by looking for mechanisms which gave credibility to our work. In the same way, we looked for various ways to demonstrate the economic benefits from a technological change or the application of a new technology. One of the clues was to participate with the private sector in the natural risk when a new technology was applied. Thus, for example, we
developed a series of new products or formulas which we transferred to the private sector with a very low down payment. Whether or not we received a percentage of sales depended on the commercial success of this product.

On the other hand, because one of the aims of Fundación Chile was to develop new technologies and implement them, we began to develop whole investment projects unknown in Chile. When we negotiated the first ones with the private sector they said “The project is very interesting but I am not prepared to invest in it because I want someone to show me that this is really good business. After this I will invest.” Facing this situation, we implemented the projects with our own money to create enterprises which demonstrated that they could be technically and commercially successful, so that private entities would copy the system by adapting new technologies. At this stage, we would sell our participation in the enterprises.

This mechanism proved very successful and to date we have created more than thirty enterprises in the agribusiness, forestry, and marine resources sectors. Four of them have already been sold to the private sector. Berry production and Pacific salmon are examples of the application of new technologies.

Before the introduction of new varieties and technologies, mainly blackberries and raspberries were cultivated. These species were known only in family-type orchards, but today about 1.5 million cases with a value of $30 million are exported from 3,000 hectares.

Ten years ago, Pacific salmon were totally unknown in Chile. Today we have more than fifty private enterprises dedicated to the production of salmon, with an export value of $110 million last season.

Identifying the requirements of the private sector and working with them was and still is fundamental in the selection and application of new technologies. Our philosophy is to create enterprises which somebody will be willing to buy. This makes it easier to demonstrate that technology is a good investment and not a major cost. All this has been possible because our institution decided to specialize in the three previously-analyzed production sectors. We believe that it is better to do a few things well.

The most important action area of Fundación Chile is introducing new technologies. The introduction and adaptability of new fruit varieties have been fundamental in this highly competitive business. We have tried, in general, to apply the concept of agricultural diversification. We looked for high-income species and varieties for each region of the country, orienting the production to export.

In this scheme, quality and quality control have been our main concern. The same has happened with the specialization and diversification of markets. For example, at present Chile sells its fruits and vegetables in more than forty countries. Training professionals and technicians has been a priority task because without the human element, the application of new technologies is more difficult. Finally, industrialization has also been a very important action area. As the fresh fruit business has grown, the total volume and exports have both increased.

If we analyze the present situation of agribusiness in Chile, we have a more rational and diversified industry with higher productivity. It is very competitive at a world level, with an aggressiveness from the private sector oriented to both short- and long-term outlooks. It is also an industry receptive to innovation that recognizes the economic benefits that technological changes produce with efficient channels of commercialization, and advanced equipment and machinery.

The concept of quality is also a priority in all processes, and the central orientation of business is the world market. In a parallel way, industry has a very qualified professional staff, and the relationship between growers and industry has improved greatly, which is very important in this business.

Between 1965 and 1990, the total planted area increased 325 percent, with annual growth rates of about 10 percent. For grapes, the increase was 1,000 percent during the 25-year period. Other species unknown until 1980, such as kiwis, are now in fourth place on the list of fresh fruits for export. There are about
17,500 growers, but many produce more than one fruit, for example, grapes, kiwis, and stone fruits.

Fruit exports have grown along with planted areas. Grape exports increased 2,500 percent between 1971 and 1990. For apples, the growth percentage was 950 during the same period. The total volume of fruit and vegetable exports between the 1970s and 1990 increased 1,700 percent. The total number of cases exported during the 1990-1991 season was 128.5 million. Apples were 29 percent of total exports in 1974, but are only 16.6 percent today. Grapes, however, were 30 percent of total exports in 1974, but 46.7 percent at present. We must mention again kiwis. Their growth has been dramatic during the last few years, reaching a share of almost 9 percent of total exports during the 1990-1991 season.

The destination of Chilean exports from 1986-86 to 1990-91 has changed: the European market share increased from 28 percent to 43.5 percent, and the North American market decreased to 41.8 percent from 53 percent.

In Chile, thirty-six varieties of grapes are grown, but six make up 90 percent of our exports. There are twenty varieties of apples grown in Chile but only three comprise 95 percent of exports. A similar situation can be noted for stone fruits and pears. It is also important to note the continuous rotation of varieties in the orchards, the addition of new ones, and the elimination of obsolete varieties. Two plum varieties grown during the 1975-76 season were no longer grown in 1989-90. Currently we grow 15 varieties that were unknown in the 1970s.

Peaches and nectarines have evolved even more. Eleven varieties of peaches and twelve of nectarines grown in the 1970s no longer exist, but sixteen and eighteen varieties, respectively, are now grown. This demonstrates the enormous evolution of varieties, which indirectly shows the evolution of markets. Fruit growing is nowadays a sign of evolution, great dynamism, and a high technological level.

If we compare Chile with other fruit producing and exporting countries in the Southern Hemisphere, Chile has turned out to be the number one fresh fruit exporter, with 31 percent of the apple market and 23 percent of the pear market. Chile also has 92 percent of the peach and nectarine markets, and 80 percent of the grape market. There is no doubt that technology has been one of the great factors in this transformation. Without the great technological changes experienced by this sector, the expansion of these export markets would not have been possible.

If we briefly analyze what has happened in the export of fruits and vegetables, in 1980 the total volume was $30 million, and today it is $155 million. This is more than a 500 percent increase, which includes tomato paste, wine, raisins, dried prunes, and frozen berries. To reach these figures, the number of fruit processing plants grew, but the problem at the moment is that we are running short of raw materials to make our equipment and machinery work at full capacity.

Finally, I wish to mention some of the conditions that influenced the spectacular growth of the export fruit industry in Chile. It is impossible to mention all aspects, however, in my opinion, these are some which are salient and worthy of note:

- Favorable economic conditions. I think this was the basis for the development of private enterprise, which grew by looking into business opportunities based on the natural resources offered by the country. When such an initiative exists and is supported by technology, development of different sectors starts.
- Incentives for free enterprise. This is an aspect closely related to the first: clear support by government policies, willingness by banks to financially support projects, and the commitment of the private sector to implement them.
- Guarantee of private property. This is a subject that cannot be argued even in the most centralized economies: Who is going to invest if such a right is not guaranteed?
- Natural resources. This is arguably a
privileged country in many regions for the development of the fruit business. But resources are not the only element needed; you must also have a human capital to technically exploit such resources — and it exists in Chile.

- Export orientation. This is something one cannot buy. It is a conviction; a great effort; going out and getting to know the world. It is also knowing how to solve many problems without falling apart when facing uncertainty. Such an export orientation exists in Chile, and is led by private businessmen. But it is not enough for private businessmen to be export oriented if the government is not. In such a case, bureaucracy could stop the strongest drive.

- Technology. This is a fundamental. Without it, it would have been impossible to achieve what we talking about.

- Knowledge about the markets. When we convinced ourselves that we should produce what the market was expecting, and not what we wanted, then the great evolution started.

   Markets must be lived, analyzed, and supplied. We must look at them with our eyes permanently open. Very dynamic and coherent decisions are necessary to ensure business for many years. Specific short-term deals are not the basis to develop this sector. Continuity, trust, and credibility between buyer and seller encourage the existence of permanent ties that facilitate all future operations.
Multinational Companies and Genetic Resources

Keith Pike

It appears that in today's world there can be no discussion of global agricultural development, biotechnology, or the conservation of biodiversity that is complete without reference to the "genetically rich South" as a hunting ground for multinational companies seeking raw materials to fuel their biological research.

Indeed this hypothesis has reached a stage of common currency where it goes unchallenged by governments, UN agencies, and other organizations so as to pervade the thought processes behind a multitude of activities. One consequence of this is that a number of governments appear to have come to believe that they are sitting on a veritable "crock of gold" in the form of genetic riches which can be exchanged for access to technology, finance, and other needs.

This paper examines the hypothesis and concludes that it is based on a false premise, which in turn may well lead to the very opposite of that which is required to secure the orderly development of technology and trade that will allow environmentally sound economic progress. This conclusion is reached through consideration of several factors.

Genetic Diversity

The world's genetic diversity very largely comprises wild plants of unknown provenance. The effort required to systematically analyze this resource in the hope of finding genetic constructs of value would be enormous. The financial risks are such that private industry could devote no more than a small amount of speculative investment to the task.

By way of contrast, the bulk of crop types of economic importance are widely dispersed around the world in the form of a multitude of genetically differentiated individual cultivars, many of which have been characterized to a useful degree. At the same time, these cultivars are individually adapted to meet particular demands within a complex of agricultural and environmental conditions, and cultural and economic needs.

Cost efficacy allied to market needs dictates that commercial plant breeding is based upon the use of characterized and adapted germplasm with development taking place within or close to the market that the crop varieties are intended to serve.

Thus there is no commercial pressure to develop a trade in the broad generality of genetic resources, although fortuitous discoveries have occasionally proved to be of great international value and interregional transfers of plant material regularly augment plant breeding programs around the world.

There is, therefore, the need to distinguish between the broad mass of wild plants and their conservation, and the very much smaller number of plant types upon which agriculture and other economic activities are based. Failure to make this distinction interferes with the proper consideration of conservation, which has a moral imperative of its own, and the separate consideration of how best to advance agriculture development and other industries without wreaking further damage to the environment, when population is destined to double over the next fifty to sixty years.

Thus the theory that success or failure of multinational companies is dependent on a flow of exotic material is based upon a false premise which takes the exception as the rule and can only lead to the opposite of that which is required.

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Second Green Revolution?

Concerns have been expressed that the involvement of multinational companies in plant breeding will lead to a re-run of the unforeseen consequences of the green revolution, particularly in terms of the replacement of traditional cultivars by high-yielding imported varieties.

A second green revolution is undoubtedly required if the world is to meet the demands of a burgeoning global population. This population increase poses a number of threats, among which are:

- The obvious threat of increased poverty and starvation.
- The threat to the environment, including the maintenance of biodiversity, as increasing amounts of land are brought into cultivation.

These threats dictate the need to pursue productivity gains in agriculture so as to both produce increased quantities of food and other agricultural materials at economic prices and to make as productive use as possible of the existing agricultural land base.

Plant breeding allied to bioscience can contribute to this effort through the delivery of new varieties of crops with increased yields, improved qualities, and greater tolerance of environmental stresses, insect pests, and diseases. Much of the field development of these varieties will have to take place within the communities they serve, but this should not be constrained by a refusal to countenance the introduction of useful novel material.

This will undoubtedly lead to a reduction in the planting of some traditional varieties (the so-called landraces) which are incapable of meeting the increased demand being placed upon agriculture. The suggestion that these varieties should be conserved en masse within the mainstream of agriculture can only condemn whole communities to increasing poverty and cause a greater threat to biodiversity through habitat loss than the possible loss of some crop varieties. Some other means of conserving these varieties needs to be found.

At the same time, the replacement of one variety by another with improved attributes need not cause an absolute diminution of crop types and varieties that has been associated with the first green revolution which is now seen to have resulted from centralized control exerted by governments on plant breeding and seed distribution.

Contrast this situation with that in the developed world where commercial plant breeding within competitive free-market economies has:

- Ensured a continual flow of new crop types and varieties to the market place.
- Contributed approximately 50 percent of the productivity and virtually 100 percent of the quality gains in agriculture, which in turn has produced a secure supply of produce and the luxury of choice in land use so that land can now be set aside for conservation, recreation, and other non-agricultural purposes.

The role of multinational companies within these advances has been relatively small and recent. Depending on the definition of multinational, they currently have a 10 to 30 percent share of the global seed market, largely confined to OECD countries. Their market share seems set to rise as research investment and research success discriminates between companies.

Much of this research will continue to be directed toward agriculture in the developed world as the restructuring of agriculture (for example, through GATT) and changes in consumer demands present new opportunities for product development. There is therefore no imperative for them to turn their attention to the developing world unless they are made welcome. If their ability to transfer technology, expertise, training, and investment is considered of value, then they will be attracted by a fairly regulated, market-led, climate for progress which will include recognition of intellectual property rights.

To expand on some of the above points:
A Starting Point

World agriculture is heavily dependent upon a relatively few crop species. Of the 200,000 species of flowering plants, 5,000 are utilized by man, but only about 500 species have been domesticated and fewer than 150 are significant in commerce — many in the diverse range of vegetables that are consumed throughout the world. If one then considers only those crops that are vital to survival by excluding those which simply add spice and variety to our diet, then the list is extremely short.

For example, eleven species account for the bulk of carbohydrate demand: sugarcane, wheat, rice, maize, sugar beet, potato, barley, cassava, sweet potato, sorghum, and millet. Equally short lists exist for sources of vegetable proteins, oils, and fats. Some of these crops remain close to their centers of origin, others are more widely distributed and some have become near universal in their cultivation.

The major influence on the distribution of crop plants has been human migration, starting with the early civilizations, expanding in the sixteenth century, and continuing to modern times. Thus plants traveled with man. When grown in new ecological and geographic locations, genetic diversity of plants could change because of new evolutionary opportunities. Novel environments provided evolutionary challenges so that new gene combinations were selected and new plant types emerged in response to different climates, soils, and a changing spectra of insect pests and diseases.

By these means, modern crop cultivars have come to comprise genes from a wide range of sources, and it is impossible to assign all the genes within a cultivar to a specific geographic origin. The notion that one part of the world somehow “owes” some other part of the world recompense for a genetic resource which results from an accident of history is therefore impractical. And even if it was practical and one was able to build some sort of international balance sheet, I suspect that the “winner” would be the USA for having contributed two major commercially valuable crops to world agriculture, maize and sunflowers.

Plant Breeding

The impact of man has also been substantial in ways other than his exploration of the world.

For at least 10,000 years farmers have been selecting crop plants suited to a wider range of environments, which give higher yields, have better insect pest and disease resistance, provide a range of cooking and processing qualities, and fulfill different taste, color, and aroma preferences. The physical protection and artificiality of the environment in which crop plants are grown encourage both further genetic change and the survival of desirable variants.

The result of these natural and directed evolutionary processes has been the subdivision of crop species into a multitude of cultivars, each suited to a particular need within an environmental complex. This adaptation and specialization has reached the stage where individual cultivars will underperform or even fail if transplanted to conditions that differ from those to which they are adapted. Indeed many cultivars would scarcely recognize their original home.

A major influence in these matters is the environment — particularly climate and day length. Crop cultivars tend to travel, when they travel at all, latitudinally rather than longitudinally, and it is only in a second phase that longitudinal extension becomes apparent. This, in turn, means that there are many useful “south-south” exchanges of crop germplasm and that they are not confined “south-north” as is commonly but wrongly alleged. The consequences for the plant breeder are two.

Specific Features

When a farmer buys a supply of seed, his decision to purchase one cultivar in preference to another will be conditioned by consideration of a number of specific features such as yield,
timeliness to harvest, various product qualities in relation to the end purpose, etc. Underlying the decision is the assumption that the plant will behave itself within the particular environment of his farm, that is, it is adapted.

The plant breeder seeks to capture a share of a particular market by improving on one or more of those special features of value to the customer. To save expense, he will generally work with germplasm whose genetic background is already adapted or nearly adapted to the market he serves rather than continually having to return to basics of working with unadapted material. An analogy is the race horse breeder. He keeps a stable of thoroughbreds rather than trying to breed a Derby winner from a stable of cart horses!

Fortunately, one result of the migration of crop species, followed by the work of generations of plant breeders, is that there exists a wealth of crop genetic diversity at national and regional levels. Much of it is already adapted such that the plant breeder has considerable resources available on the doorstep.

**Breeding in the Target Environment**

Plant breeders have to maintain breeding and field trial programs close to the agricultural economies and environmental conditions they wish to supply. For example, ICI Seeds in North America maintains some twenty breeding stations spread across the USA and Canada in order to capture conditions representative of the range of situations under which maize is grown within the corn belt.

This imposes a major logistical and managerial penalty upon the plant breeding industry, forcing large and small organizations to prioritize within a relatively narrow range of crops and markets. The possibility of any single company or even group of companies being able to take over and monopolize the world of plant breeding and food production — the conspiracy theory so beloved of some (so-called) public interest groups — must therefore lie in the realm of fantasy. The almost infinite complexity of agriculture is such that within a market economy the plant breeding industry is destined to remain fragmented, although this does not mean that the number and size of players is forever fixed.

An examination of the list of the “top ten” plant breeding/seed production companies in the world discloses that only three of these companies are multinationals by common definition — Sandoz, UpJohn, and ICI. The other seven companies all have plant breeding/seed distribution as a sole or major activity although, of course, they are multinational in the sense that they have sales and/or operations outside of their countries of domicile. They include a major farmers’ cooperative as well as conventional companies. If the list is extended to the top twenty companies, then the number of multinationals expands to five, hardly a basis for world dominance and control. Indeed the combined sales of the three multinational companies in the top ten amount to no more than 6 percent of the world traded-seeds market, although this may well increase as a result of research investment.

Genetic richness is therefore a comparative term. All countries outside the polar and desert regions contain a measure of plant types. The fact that some countries are wealthier in this respect than others is not necessarily an indicator of economic potential since the overwhelming bulk of these plant types are uncharacterized wild plants whose potential is totally unknown. The theory that this mass of material must contain something of economic value rests upon the occasional fortuitous discovery rather than on systematic analysis.

Nonetheless it is possible that within the global vastness of biodiversity there has to be some potentially valuable genetic constructs. The problem of identifying them within such a mass of largely uncharacterized material is so daunting as to make such an enterprise difficult to contemplate. Thus few if any companies are willing to commit resources to their identification and use because the whole process is difficult and unpredictable. These difficulties apply to all potential uses and not just plant breeding.
A commonly cited example is the potential value of biodiversity to the development of new therapeutic compounds, and yet the pharmaceutical industry believes that synthesizing and screening new compounds is a more productive route to new product development than the search for natural materials. This confidence in chemistry is enhanced by the increasing use of computer-aided drug design systems and increasing knowledge of site-specific modes of action of new molecules. Estimates vary of the use of natural materials in pharmaceutical research, but the general indication is that the screening of exotic plant material accounts for no more than 2 percent of total industry research in the U.K.

For all these reasons, the exchange of genetic resources, whether as raw material or the finished product in the form of a new plant variety, is largely confined to material proven and adapted to specific purposes within particular environments. Thus it tends to be regional rather than international, although breeding programs are augmented from time to time by the introduction of genetic constructs from further afield.

This augmentation is now being supplemented by the development of the biological sciences — biotechnology.

**Influence of Biotechnology**

Biotechnology (in the broad sense of the term) is likely to prove both a plus and a minus in relation to the use of genetic resources. It has significant potential value in the proper identification of plants and may well help aid their conservation.

On the other hand, plant breeders are beginning to use biotechnology to better assay material already lying on their doorsteps such as that within their own collections. One result of this activity is that poorly identified genetic traits of value are becoming better understood and brought into breeding programs. It is beginning to appear that a number of objectives which, until recently, were thought of as only attainable through the employment of r-DNA technology may well be more easily developed through bioscience-aided plant breeding. This should be of interest to the developing world since it implies a more modest investment in technology than is often supposed.

Nonetheless, the development of r-DNA technology also proceeds apace and it is now thought that real advantage may lie within the realm of true genetic engineering in the laboratory — techniques such as anti-sense RNA technology and protein engineering — rather than in any random search for exotic constructs.

**Trade in Genetic Resources**

None of the foregoing should be taken to suggest that genetic resources do not move around the world. Clearly they do, but in more limited quantities and on a more regional basis than is often suggested. There are of course exceptions to these general statements, for example:

- The wild relative of wheat from Turkey which has provided disease resistance genes to commercial wheat varieties.
- The semi-wild relative of barley from Ethiopia which has provided a gene giving some resistance to lethal yellow dwarf virus in commercial barley varieties.
- The semi-wild relative of the tomato which has provided processing tomato varieties with improved qualities.

Industry critics often point to these and other examples with estimates of their value to Western agriculture as if they are a daily occurrence. I do not doubt their value but I do query their frequency.

There is no pressure to systematically develop a global search for novel genetic constructs and it therefore follows that the value of trade in genetic resources will be governed by the same considerations that govern many other trades such as:

- The costs and financial risks of converting an amorphous raw material to something of utility and the ability to offset these risks.
through the availability of intellectual property protection and sensible regulation.

- The presence or absence of alternative sources of raw material supply and, increasingly, the presence of alternative technologies.

The belief that genetic richness equates to a monopolistic position that will allow interregional trade in genetic resources to be forced into some form of straight jacket may well result in uneconomic demands which will frustrate potentials to the detriment of rich and poor alike. The valuation and development of genetic resources can only take place within a flexible mechanism which allows fair bargains to be struck on a case-by-case basis between the supplier of the raw material, which may be presented at various stages of refinement, and those who accept the marketplace risks of its further development. Such mechanisms are commonplace within commerce, including plant breeding and the seed trade.

The bulk of the trade in genetic resources occurs between plant breeders and is far more prosaic than is often suggested. No individual plant breeder can hope to keep and maintain all the material he would ideally like. The maintenance of plant collections as the base for a breeding program is a significant item of capital and recurrent cost.

An exchange system has therefore developed over the years. Arrangements vary in their detail but a common basis is that two breeders/breeding organizations agree to exchange material on some defined basis. Normally there will be no question of payment (beyond incidental costs) at the point of exchange since at this point there is no way of estimating just how useful the exchanged material may prove to be, and the relevant intellectual property systems have no validity in the research mode.

However, exchange agreements can and do contain clauses to the effect that should a piece of material prove to be commercially valuable, then the parties will share the royalties or other income, according to the contribution each has made. Again, there is no way of forecasting how the income might be shared nor of fixing shares according to some predetermined view. The sharing can only result from sensible negotiations once all the costs and contributions are known in relation to an agreed view of the likely income.

While such arrangements appear to be confined to the private sector, I can see no reason in logic or law why they should not extend to the public sector in both the developed and developing world, so ensuring that those who provide the raw material in natural, semi-refined, or refined state can obtain a share of any reward. Nor does the private sector wish to be excused from paying its dues.

The obstacles to such an extension appear to be a commonly held view that genetic resources are, in some way, free or man's heritage.

I cannot believe that the word free means without economic value. Genetic resources in the form of the finished article — the food we eat, the crops and animals in the farmers' fields, and even household pets have long been a subject of commerce. Why then should the components of the finished article be free when they have a quantifiable economic purpose?

They do of course form part of man's heritage but so are the earth's minerals, air, and water, and yet none of these are considered free in an economic sense, and all have a cost in terms of their identification, maintenance, and use.

A further complication arises in some quarters from the belief that if genetic resources are not free, then the values attributed to them may deny access to some groups. However, a distinction has to be drawn between value and cost or charge. Again, I can see no reason why access should not be granted on negotiable commercial terms to those with commercial purpose, while at the same time providing more generous terms to others — the academic research worker or the development institute.

A second obstacle is the myth and misconception that surround the issue of applying the laws of intellectual property
protection to the biological area. Suffice to say that these laws can help underpin the commercial exchange of germplasm and the accompanying agreements. They can also assist in the assignment of value between the contribution made by nature in terms of the fundamental genetic resource and that made by man in terms of the human ingenuity used to convert a natural element to some industrial purpose.

Future Developments

Concerns have been expressed that the development of plant breeding with particular reference to multinationals will lead to a re-run of the alleged failure of the green revolution.

The green revolution was not a failure. It saved, and continues to save, millions from dying of starvation and has brought food security in place of uncertainty. Nonetheless, with all the benefit of hindsight, it has resulted in a number of unforeseen consequences. Some include within these consequences the replacement of local crop varieties by high-yielding imported cultivars.

The threats implied by the forecast doubling of world population over the next fifty to sixty years with 75 percent of this increased population in the developing world suggests that global agricultural productivity needs to increase rapidly and dramatically. Technological development has to be central to this effort if production is to be increased without wreaking further damage to the environment and greater loss of biodiversity through non-agricultural land being brought under the plow.

A second revolution is therefore required, but one which avoids the excesses of the first. Plant breeding could again play a major role.

OECD countries have reached a level of self-sufficiency in those crops which they can conveniently grow, providing the luxury of choice in land use to the extent that land can be taken out of agriculture to meet other desirable purposes such as reforestation, conservation, and recreation. This self-sufficiency results from the application of science and technology to provide major productivity gains per unit of land and major reductions in the real costs of production. Analysis by the National Institute of Agricultural Botany in the UK suggests that about 50 percent of these gains result from plant breeding; the balance being the result of the adoption of other technologies such as mechanization, crop protection, fertilizer use, irrigation, and improved agricultural education.

Gains of this sort are not confined to OECD. For example in India, thanks to the Green Revolution, wheat production increased from 12 million tons in 1965 to 55 million tons in 1990. This increase was accompanied by an increase in crop area of 9 million hectares — from 14 to 23 million hectares. But if yield per hectare had remained at the 1965 level, then 40 million hectares of additional land would have had to have been brought into production to provide for the increased national production. In other words, 40 million hectares of forest and other natural land would have succumbed to annual cropping if the yield improvement had not occurred.

No one pretends that the gains have been free of environmental problems. As a result there is now demand for agriculture to adopt greater environmental sensitivity while maintaining all the economic virtues of productivity. This, in itself, poses an interesting challenge to science and technology, since even organic farming can have an environmental as well as financial costs.

Nor does anyone pretend that there have been no changes, including losses, in the spectrum of varieties available to the farmer. However, these losses are nowhere near as dramatic as some suggest, as illustrated by the number of varieties shown on the national lists of registered varieties in Europe. The losses that have occurred have resulted from economic and consumer pressures rather than the work of the plant breeder, and have been counterbalanced by an increased range of crop types available to individual sectors of the market as exemplified by the spread of oilseed rape and sunflowers across Europe and the Americas. This is likely to be enhanced through the development of bioscience
resulting in the delivery of crop varieties better suited to a wider range of purposes, including new purposes such as the manufacture of industrial materials. Diversity will also be aided by the ability of bioscience to identify and use a much wider gene pool than has previously been possible. Thus one diversity may well be replaced by another.

Not all of the components of the productivity gains of developed agriculture will equally suit subsistence agriculture. Many of them demand a level of infrastructure development lacking in many rural areas of the world or have other implications which are currently beyond many farmers. The one component which is most widely applicable at least cost is plant breeding. However, its adoption has to recognize that many traditional crop varieties may disappear from mainstream agriculture.

It is sometimes argued that these varieties serve particular local needs and are a source of valuable diversity. This may be true, but if they do not yield at a level commensurate with population growth then how is the world to feed itself? Their replacement by varieties meeting the same needs but with improved yields and other qualities (for example, disease or insect pest resistance) does not mean that consumer and farmer needs have to be ignored. A free market competitive plant breeding industry has to be mindful of its customers in order to survive. This leads to choice coupled with technological progress as supply companies vie for their customers attention.

If the varieties that are supplanted are considered to be of value then some means needs to be developed to allow their preservation outside of economic agriculture. The multinational companies could clearly play a useful role in these affairs because of their ability to develop and transfer technology, investment, expertise, and training. Whether they do so or not will depend on the environment in which they will be expected to operate in relation to other opportunities. This environment has to include intellectual property protection systems if large-scale, long-term investment by private industry, large and small, is to be encouraged. Such an environment will also encourage the development of local industry, including its ability to acquire both genetic and technological resources.

Postscript

In summary:

- The trading of genetic resources in the form of characterized plant material representative of the major crop types has long been a feature of commercial plant breeding with benefit to all concerned, not least the consumer. It has also been of major environmental importance in many parts of the world by increasing the productivity of the agricultural land base, thus helping to preserve natural habitats.

- It is vital that agricultural science progresses if the world is to continue to feed itself without wreaking further damage on the environment. Plant breeding can play an important role in this process and thus it is equally important that the interchange of crop genetic resources continues within a sensibly managed framework. The imposition of unwarranted restrictions on the use of genetic resources may well cause more environmental harm and increased poverty than they resolve. This does not mean that those who utilize genetic resources should not pay their dues to those who provide them, nor that public sector institutions should be prevented from obtaining the commercial benefits of their work. Fully tested mechanisms exist to meet both of these requirements.

- The so-called multinationals already participate positively as players within a diverse industry. Their capacity to aid development could be of considerable benefit, but they will need the encouragement of well-established, sensible policies if they are to divert resources from opportunities elsewhere.

- Finally, much play has been made in some
quarters of a supposed relationship between conservation of genetic resources and trade in genetic resources. The relationship, if it exists at all, is tenuous in the extreme. It is therefore both a false trail and a lessening of moral authority to endeavor to market the undoubted need for conservation on alleged future value. Biodiversity needs to be considered separately and simply for its own sake as part of the history and culture of the world. ICI is happy to play its part in these matters on a non-commercial/no strings basis.
Responding to Consumer Food Quality Requirements —
The Experience of the British Retail Sector

John Love

We must be clear on two very important words: consumer and quality. In our case the consumer is the 7.5 million customers who shop with us each week. Quality is fitness for purpose and meeting the needs of the consumer.

Self-service as practiced in supermarkets over the last twenty-five years has given us a first hand opportunity to discover the needs of the consumer. For the last twenty years we have been able to go back to the farmer and grower and advise him what to grow, how much to grow, when to supply it, and in some instances, how to grow it.

This we do through three means: product specification, program of supply, and technical support. We have developed and established a close, direct relationship with our suppliers in the UK and with many of our larger suppliers abroad, but there are obvious limits to the resources we can afford to put into this on our own, so we largely work through approved importers when it comes to developing countries.

There should, however, be no major problems arising whether you deal directly or through an intermediary. The requirements of a supplier and the standards to be met remain the same:

- Technical ability of the grower to produce the product assuming all other cultural and climatic conditions are suitable.
- Adequate facilities for harvesting, packing, handling and transport of product — including such aspects as hygiene, refrigeration of stores and transport, and efficient handling.
- Good management of operation with particular reference to quality assurance, planning and scheduling of production, and good financial control.

So much for the quality of the operation, but what about the product? There are two excellent booklets published by the Commonwealth Secretariat’s Export Market Development Division: Guidelines for Exporters of Selected Vegetables to the UK Market, and Guidelines for Exporters of Avocados, Mangoes, Pineapples, Papayas and Passion Fruit to the UK Market. I do not intend to go into detail, but rather concentrate on the broad principles to be considered. A product specification is essential.

Visual Product Criteria

Three visual criteria influence the importer, wholesaler, and consumer: size, color of maturity, and blemishes.

Size

Larger sizes of product may mean high cost and make it uneconomic to transport and unattractive in price to consumers, for example, popular sizes for mangoes, avocados, and papayas are 250 to 450 grams. Pineapples and cantaloupe melons are 800 to 1,000 grams, but there are some markets which can sell smaller fruit (often suited to prepacking in twos, threes, or fours) or even larger individual fruit, thus giving the customer a choice of size within well-defined ranges.

John Love is Senior Product Manager, J. Sainsbury plc, London, U.K.
**Color of Maturity**

Most fruit is sold on visual appearance, so color, which is frequently linked with maturity in the customers’ eyes, becomes important. Green-skinned mango varieties will not sell as readily as those showing a red or orange tinge. Some fruit is packed under-ripe before it is fully mature and will not color, or if it does, there is no flavor. Carambola or star fruit is a common example of this. Fruit should be picked when fully mature but with some degree of ripening still to be achieved. This can be delayed by cool chain and ensuring ethylene levels are minimized. The controlled atmosphere storage, transport, and packaging of product is only now being implemented.

**Blemishes**

Slight natural blemishes such as scarring or russetting can normally be tolerated, but product showing rots, shrivel, breakdown, or mechanical bruising and damage is not acceptable. Where EC or OECD grading requirements are applicable, Class I is required. Extra Class is too demanding, and Class II may be acceptable from time to time in some products, provided the defects are not progressive nor likely to impair the edible quality of the product, for example, onions.

**Intrinsic Product Criteria**

Among the intrinsic criteria which affect products are taste, safety, packaging, and legal requirements.

**Taste**

Not only has the product to look good, but it must taste good and be safe. Choice of variety, picking time, cooling, and handling time will all affect flavor.

**Safety**

Safety is another matter, and this is where pesticide residues rear their ugly head. We must be able to give our customers assurance that the fruit and vegetables we offer are safe to eat. If a product is washed it must have a final rinse in chlorinated water. All suppliers must comply with our pesticides Code of Practice which, among other things, states that only approved chemicals may be used according to Good Agricultural Practices: at the correct rate, with a safety period between spraying and harvest, all growers must keep records of pesticides used in growing crops, and any post-harvest treatments are similarly recorded.

Talking of post-harvest treatments, we are against the use of polishes and waxes purely for cosmetic enhancements, and would like to encourage all post-harvest treatments. Analysis for pesticide residues has to be carried out on a programmed basis for each crop. We carry out residue analysis on produce supplied to us. On no account must any product be offered for sale with residues above the maximum permitted levels.

**Packaging**

There is now considerable pressure in the EC from environmentalists in particular regarding packaging. We do not like wooden boxes, metal staples, or wire. We prefer packaging to be of one material so that recycling is easier — no metal staples in cardboard. Our distribution system is based on the 1 x 1.2 meter pallet, and the majority of our products are carried in 400 x 600 millimeter crates. However, these may hold too large a quantity of product, especially of high value, very perishable product, so small packages, say, 300 x 400 millimeters, may be more practical.

Another aspect of packaging for Sainsbury’s is the increasing amount of loose produce displayed on the shelves in their original packaging. This reduces handling costs and damage and subsequent losses due to downgrading. The fact that such packages are filled in the area of production requires that premises must be clean and proper controls enforced. It cannot be stressed too strongly that cigarette ends, frogs, lizards, cockroaches, and even black widow spiders are unwelcome in the
contents of our produce receipts, particularly when they get through to the customer.

**Legal Requirements**

While the quality of many of the produce lines must comply with the European Community Grading Requirements, as well as our own specifications, we also have other legal requirements to meet. I have already mentioned the question of pesticides and pesticide residues, the usage of which are covered by the UK Food and Environment Protection Act (1984). But a more serious piece of legislation is the Food Safety Act by which we are required to show "due diligence" that we, J. Sainsbury, have taken all reasonable steps to ensure that the produce we offer our customers, no matter where it comes from, is safe, wholesome, and legal. It is for this reason that we are so fussy about who supplies us, and all suppliers must comply with our relevant Codes of Practice and be approved by us, or by proxy by our intermediary suppliers.

**Conclusion**

The production and marketing of produce for the UK market, and in particular for chains such as Sainsbury’s, is no longer something for the untrained, uninitiated, and uninformed grower or merchant. It requires knowledge, training, management, and discipline, which if lacking can have serious consequences.

The consumer lobby, especially with respect to safety and environmental matters, is increasingly vociferous. Pesticide residues, post-harvest treatments, for example, methyl bromide fumigation, storage conditions, aflatoxins in nuts, listeria and salmonella in salads, are all on our “hazard factor” warning list. The effect on consumption of Alar on apples or poison in grapes is considerable on an international scale, and is no longer a local problem. Fortunately the whole industry is now much more aware of these problems, and developing countries need to be particularly careful that they have adequate controls in place to ensure the safety of their products.

There is an expanding market for your produce, and this will increase as the recession with its limit on customer purchasing power, gives way, hopefully, to more balanced trading conditions. The opportunities are there for those who are willing to learn and put their learning into practice. However, there must be an acceptance of the disciplines and controls required to produce the quality — in the broadest sense of the word — to meet the consumers’ needs. I hope that today I have widened your concept of quality and given you a clear picture of the new responsibilities now being placed on food producers, handlers, distributors, and marketers if we are to meet the needs of the 1990’s consumer.

**Useful Reading**

*Guidelines for Exporters of Selected Vegetables to the UK Market,* and *Guidelines for Exporters of Avocados, Mangoes, Pineapples, Papayas and Passion Fruit to the UK Market.* Both publications prepared by and available from:

- Commonwealth Secretariat
- Marlborough House
- Pall Mall, London, SW1Y 5HX
- Phone: 071 839 3411
- Fax: 071 930 0827
- Telex: 27678

*EC Quality Standards for Horticultural Produce.* Four loose leaf binders published by MAFF: Fresh Fruit, Fresh Salads, Fresh Vegetables, and Fresh Cut Flowers and Bulbs. Available from MAFF Publications, London SE99 7TP

*The Code of Practice: Pesticide Control for Produce Marketing Organisations.* Second edition, 1992. Published by and available from:

- Produce Packaging and Marketing Association
- 103/107 Market Towers
- 1 Nine Elms Lane
- London SW8 5NQ
- Phone: 071 027 3391
- Fax: 071 498 1191

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Considerable improvements in food production have been made by application of modern technologies, but there has been a significant failure within developing countries to understand the interrelationship between food production and the marketing and distribution of products. Real added value is only achieved when the consumer has purchased, and continues to purchase the products.

It is recognized that the marketing and distribution supply chain of food is one of the most complex in the world, but if food producers are to benefit from their activities, it is essential that the right supply chain is identified and supported within the economies of developing countries. Figure 1 shows the major activities and participants.

I believe that it is possible to develop the correct supply chain if consumer needs and the options for processing, transport, and distribution are understood and integrated. These two key factors will drive the choice, and even the feasibility of the correct supply chain.

Consumer Needs

What does the consumer wish to buy? The answer must be based on the perceived value of the product offered. Value for money includes convenience, handleability, appearance, price, quality, and life. By understanding consumer needs and their relationship to price, there is a clear definition of the cost to market that can be incurred in the supply chain for a given processing technology and/or packaging method.

Processing and Packaging Technologies

Looking back through the history of Western economies when the supply chain was slow and fairly unsophisticated, processing techniques for satisfying consumer demand at a distance were, for example, salting or drying products. At a later stage, the novel technologies of canning and bottling were introduced. Other processes were developed to increase the life of products such as freezing, freeze drying, and vacuum packing, so that they could reach the market cost-effectively.

This is illustrated in Figure 2, showing how the life of a product is related to the process to which it has been subjected.

Time to Market

Time to market is critically dependent on the organization of the supply chain. At its simplest level, the supply chain could link from the farmer’s field to the farmer’s table; at a slightly more sophisticated level, it could link from the farmer’s field to the local market. However, once the supply chain requires a significant movement of product from the farmer’s field to the consumer, then the organization of the supply chain has to be far more sophisticated and products have to be processed to maintain quality, possibly to extend life, and to improve handleability. As illustrated in Figure 3, there is an interrelationship between life of the product, given the process, and the time to the market. If the life of the product is shorter than time to market, then it is not possible to reach that market.

H. R. Hoare is Associate Consultant, Touche Ross, UK.
## Figure 1. The production and market chain for agricultural products

<table>
<thead>
<tr>
<th>Continuous services at each activity stage</th>
<th>Major activities</th>
<th>Major participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification of consumer wants</td>
<td></td>
<td>Consumer</td>
</tr>
<tr>
<td>Production and marketing intelligence</td>
<td>Production</td>
<td>Market research agencies</td>
</tr>
<tr>
<td>Production and post-harvest</td>
<td>Harvesting</td>
<td>Technical and financial analysts</td>
</tr>
<tr>
<td>Technical procedures</td>
<td>Packing station</td>
<td>Growers and farm workers</td>
</tr>
<tr>
<td>Trade contracts (buying, selling, storage, etc.)</td>
<td>Storage, Processing</td>
<td>Extension officers</td>
</tr>
<tr>
<td>Documentation associated with handling, storage, transportation, buying and selling activities</td>
<td>Shipping, Ripening, Wholesale storage, Retail storage and display, Consumer storage and preparation</td>
<td>Government research officers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Farms input supplies</td>
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<td>Banks and credit agencies</td>
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<td></td>
<td></td>
<td>Crop insurance officers</td>
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<tr>
<td></td>
<td></td>
<td>Production and marketing intelligence units</td>
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<tr>
<td></td>
<td></td>
<td>Buyers' representatives</td>
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<td></td>
<td></td>
<td>Graders, packers, processors</td>
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<td></td>
<td></td>
<td>Quality control officers</td>
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<tr>
<td></td>
<td></td>
<td>Maintenance engineers</td>
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<tr>
<td></td>
<td></td>
<td>Warehouse/storage operators</td>
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<tr>
<td></td>
<td></td>
<td>Packaging companies</td>
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<tr>
<td></td>
<td></td>
<td>Utilities (water, electricity)</td>
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<tr>
<td></td>
<td></td>
<td>companies</td>
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<td></td>
<td></td>
<td>Transporters</td>
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<td></td>
<td></td>
<td>Phytosanitary inspectors</td>
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<td>Export/import dock employees</td>
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<td>Customs officials</td>
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<td>Final buyers' representatives</td>
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<td></td>
<td></td>
<td>Retail staff</td>
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<tr>
<td></td>
<td></td>
<td>Advertising agencies</td>
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<tr>
<td></td>
<td></td>
<td>Consumers</td>
</tr>
</tbody>
</table>

### Price

The next key parameter in defining the right supply chain is the price the consumer is willing to pay. In Figure 4, for a given product, we have illustrated the relationship between prices and the process. Thus, for this example, the consumer is willing to pay more for fresh product than canned or dried. There is also a quality dimension not illustrated; for each process, the quality could vary and the price consumers are willing to pay will also vary. However, in general terms, the quality has to match the expectation of the particular market.

Also illustrated in Figure 4 is a seasonal price differential. If a fresh product is available out of season in a given market, then the price paid is higher than the price in season.

### Cost

Finally, there is the cost of the supply chain to produce, process, deliver, and sell the product. According to the accessibility of the market, there will be different costs associated with different processes for a given market. As an example, Figures 5, 6, and 7 show three levels of cost according to the proximity of the market (local, overseas) and the method of transport (road, sea, air).
Figure 2. Product life versus time to market

Figure 3. Product life versus time to market, considering transportation

Figure 4. Price/cost strategy
Figure 5. Price/cost strategy considering local transportation

Figure 6. Price/cost strategy considering transportation by sea

Figure 7. Price/cost strategy considering transportation by air
This example would indicate that in the local market there are opportunities for added value, but for overseas markets, there would be time limitations (fresh and chill take too long to reach the market by sea) and the only opportunity would be to fly out of season where counter-seasonal pricing gives added value.

The Supply Chain

The supply chain that maximizes added value must integrate the processes to be applied, supported by the most cost-effective infrastructure to optimize between time to the market and costs. An illustration of the supply chain is given in Figure 8, and the decisions to be made are:

- What should be produced and where.
- What process(es) should be adopted, with number of facilities and locations (including packaging if separate from process).
- What methods of transport should be established and used.
- Where should stocks be held.
- What supply chain operating methods should be adopted.
- What organization(s) should be set up and used.

The structure of the appropriate supply chain is complex, but can be based on the concept of consolidating supplies at processors, subsequently transferring between processes and storage/handling locations, and finally dispersion to the ultimate consumer. In terms of technology, the key elements are the use of specialist vehicles and automated materials handling systems, supported by computer systems, with appropriate initiation of loads. Strategies to be considered include process, load utilization, vehicles, intermodal transportation, storage and handling facilities, and locations.

Process

Each process technology has a particular investment requirement and supply chain infrastructure requirement. Thus, given the size of the investment that is necessary to establish a cost-effective plant, it is important that sufficient products can be accessed by this plant. For example, the investment in a modern mill requires product from a significant number of major grain-producing farms, and thus, the mill may be at a distance from the farms. An appropriate supply chain must be established, and subprocessing might need to be done at a local level in order to optimize transfer between the farm and the major processing plants. The strategic decisions are where to site the processing plants, what capacity should be provided, and what supply chain should be used both to and from the processors.

Load Unitization

The unit for handling through the supply chain should be integrated with the process, transport, storage, and handling. Perhaps the most general unit load is the pallet, which can be associated with technologies ranging from high-bay storage in racks, handled by automated cranes, to bulk stock on the floor. Other unit loads include sacks, boxes, box pallets, tanks, and containers. The process for unitization must be considered as part of the supply chain.

Vehicles

The vehicles must be integrated in the supply chain and use of temperature control, bulk loads for powder and liquids (perhaps under pressure), etc. considered as part of the supply chain, with additional benefits of maintaining quality and extending life.

Intermodal Transportation

There are some significant developments in the road/rail and road/air interfaces which will have an impact on the cost and time to the market.
Storage and Handling Facilities

The interfaces between transport and facilities must be designed. For example, on transfer of bulk loads, the pipework must match or there is risk of cross-contamination. Use of dock-levels, tail lifts and conveyors might also be appropriate.

Locations

A key determinant of supply chain cost is the number and location of processing/storage facilities. Thus, the supply chain must be analyzed in detail to identify the most cost-effective infrastructure and operating methods.

Conclusion

There are many choices of processes and supply routes to the market. The identification of the best choice is complex but critical to achieving the highest added value for the producing countries. It cannot be set up by piecemeal developments such as building a processing plant without the appropriate supply and transport structure or without understanding the market needs.

I have outlined some of the technical issues to be addressed, although these alone are not enough; the forms of organization (private, public, cooperative, JV, brokerage, etc.), the management skills (forecasting, IT, quality control, profitability, etc.), and marketing skills must also be integrated into the supply chain (Figure 9). The total supply chain must be analyzed, first at a strategic level, then at an operational level, after which specific sections can be progressed, but in the appropriate sequence.

But the key driver is the consumer requirements, met by the appropriate supply chain to get the right goods to the right place at the right time in the right condition — and at the right price.
Figure 9. Optimizing the supply chain

- Production
- Processing
- Selling

Business skills
- Supply chain technologies
- Supply chain organization
- Supply chain management

<table>
<thead>
<tr>
<th>Business skills</th>
<th>Technologies</th>
<th>Organizations</th>
<th>Management</th>
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<tbody>
<tr>
<td>The right deals</td>
<td>Unitized loads</td>
<td>Joint ventures</td>
<td>Inventory forecasting</td>
</tr>
<tr>
<td>Profit focus</td>
<td>Temperature control</td>
<td>Export marketing</td>
<td>Information systems</td>
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<tr>
<td>Investment</td>
<td>Quality testing</td>
<td>boards</td>
<td>Transport planning</td>
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<tr>
<td>Making decisions</td>
<td>Packaging</td>
<td>Private traders</td>
<td>Quality control</td>
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<td></td>
<td></td>
<td>Trading brokers</td>
<td>procedures</td>
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Experience of the Shrimp Culture Industry in Taiwan

Peter Chiang and Ching-ming Kuo

The shrimp culture industry, tiger prawn culture in particular, has developed rapidly in Taiwan during the last two decades. This was made possible by an economically viable technique for producing stocking shrimp post-larvae in captivity first developed in 1968. The significant breakthroughs in the industry were the development of hatchery technology which makes a possible reliable supply of the stocking post-larvae in quantity, development of practical culture technology and management, availability of efficient formulated feed (which was developed in 1975 and commercialized in 1977), and the successful marketing of the products, international markets in particular.

The shrimp culture has progressed from an extensive polyculture system towards an intensive monoculture system under the progressive development of a peripheral industry relevant to the shrimp culture, including shrimp feed and processing industries, and aquaculture machinery. The total annual production of tiger prawns, *Penaeus monodon*, in Taiwan increased from 90 metric tons in 1968 to 278 metric tons in 1975, 1,122 metric tons in 1977 and 80,279 metric tons in 1987 (Taiwan Fisheries Bureau) (Figure 1). The production value of tiger prawns is shown in Figure 2.

During the same period, the number of shrimp hatcheries also increased from the very first one to more than 2,000 in 1987, while the number of feed mills increased from one in 1975 to 74 in 1987. The production quantity and value of kuruma prawns *Penaeus japonicus* remained at a rather constant level (Figures 1 and 2). In 1988, for the first time the industry faced serious problems being unable to sustain its growth. A sharp decline in tiger prawn production was experienced in 1988 with the production down to only 31,171 metric tons. Several factors have been suggested by the Fish Disease Prevention and Cure Taskforce for such a drastic reduction (Liao 1988). These factors are discussed in more detail later in this paper.

The content of this paper is a summary of Hanaqua’s understanding and experience in the development of the shrimp culture technology and industry in Taiwan and elsewhere, since its involvement in the aquaculture business began in 1976.

Hanaqua also began a business involvement through technology dissemination of shrimp culture in Indonesia and the Philippines in 1987, and Thailand in 1989. The discussion focuses on the industry development in Taiwan as a model, and then evaluates the success of the culture industry resulting from technology dissemination in Indonesia, Thailand, the Philippines, India, and China.

Technical Requirements for Shrimp Industry Development

The requirements of the shrimp culture industry include:

- Environmental conditions suitable for shrimp culture. These include climatic and meteorological conditions, and the availability of land and water resources.
- Development of culture technology and availability of peripheral industries essential to the culture industry growth.
Figure 1. Annual production of *Penaeus* prawns and *Kuruma* prawns in Taiwan, 1967 to 1990

![Graph showing annual production of Peaneus prawns and Kuruma prawns in Taiwan, 1967 to 1990.](image1)

Figure 2. Annual production value of *Penaeus* prawns and *Kuruma* prawns in Taiwan, 1967 to 1990

![Graph showing annual production value of Peaneus prawns and Kuruma prawns in Taiwan, 1967 to 1990.](image2)
Success in technology extension and transfer for the continued upgrading of culture skills.

Marketability of products — vital to industry development and sustained growth of the culture industry.

Government policy and promotion for increased foreign exchange, utilization of marginal land and food production through introduction of aquaculture technology, and constant efforts for extension. This was partly to decentralize the population.

The interaction of these factors is illustrated in Figure 3.

**Government Policy and Promotion**

FISHERIES. Through national economic development programs, significant growth in fisheries, both capture and culture, at an annual rate of 6.9 percent was achieved from 1953 to 1988. Notable growth in the aquaculture fisheries was also achieved. Total production increased from 57,092 metric tons in 1969 to 300,974 metric tons in 1988, equivalent to 10.2 percent and 22.1 percent of the total fisheries production, respectively, while the value increased from US$23.3 million in 1969 to 861.96 million in 1988, equivalent to 15.9 percent and 39.1 percent of the total fisheries value, respectively (All subsequent dollar amounts are U.S. dollars).

SHRIMP CULTURE. The development of the shrimp culture industry today was by no means originally intended, but it can be considered as the outcome of overall agricultural development.

However, it is true that the rapid growth of shrimp culture in Taiwan was triggered by the continued increase in market demand after the marketing of the commodity was successful and overwhelmingly well received.

**Factors Influencing Shrimp Industry Development**

The success of the aquaculture industry in Taiwan has been attributed to the following efforts and accomplishments:

- Government policy and promotion.
- Development of culture and feed technology.
- Technology extension and dissemination.
- Educational background and experience of shrimp farmers.
- Capital accessibility.
- Industry motivation.

Supporting/peripheral industry technology. The backup technologies facilitate culture practice and improve culture efficiency. These include aquaculture equipment and machinery, and aquaculture chemicals for maintaining the adequacy of culture environment conditions, and treatment for disease prevention and cure, if necessary.

**Development of Culture Technology**

HATCHERY TECHNIQUE. Experiments for the artificial propagation of tiger shrimp in captivity first succeeded in 1969. The maturation and subsequent spawning was induced by the method of unilateral eyestalk ablation. Only one spawning from each brood shrimp was obtainable because of unsatisfactory spawning performance in the subsequent spawning. The technique of
Figure 3. Technology development for the shrimp culture industry in Taiwan

GOVERNMENT R&D

Broodstock physiology and ecology
Reproductive physiology and endocrinology
Larval nutrition and environmental requirements
Environmental physiology
Disease diagnosis methodology
Vaccine development
Nutritional and dietary requirements
Feed technology
Genetics and stock improvement
Gamete cryopreservation
Gene manipulation & biotechnology

Basic and applied research

Culture technology

INDUSTRY R&D

Broodstock husbandry and management
Maturation and spawning manipulation
Hatchery technology
Culture technology and management
Feed formulation and technology
Improved culture stock and efficiency

Feed industry (credits)
Government (Grants and assistance)
Banks (Loans)
Credit unions (Cash)

FINANCE

Information dissemination and extension
Verification and feedback
controlled spawning was further improved until 1977, when the technique of artificial spermatophore transplantation was developed.

With this breakthrough in hatchery technology, the multiple use of valuable broodstock of up to eight sequential spawnings became possible. As a result, the cost of each brood shrimp has dropped sharply from $1,500 in 1970 to $35-70 in 1990. Through years of effort for continued upgrading of hatchery technology, the seed production sector has naturally developed an integrated operation network, which is characterized by skill specialization. The seed production sector is divided into the categories of broodstock husbandry and breeding, larval rearing, and nursery operation (Figure 4). The details of the operation are as follows:

- Broodstock husbandry — maintenance of broodstock and supply of newly-hatched nauplii.

- Larval rearing — the rearing of nauplii through post-larvae 14-16 (PL14-16) and functioning as seed suppliers to the growout farmers or nursery operations.

- Nursery operation — continuation of larval rearing from PL14-16 up to post-larvae 30 (PL30) or post-larvae 45 (PL45), and functioning as the fry suppliers directly to growout farmers.

DEVELOPMENT OF FORMULATED FEED.

Availability of nutritionally balanced formulated feed has stimulated the development of shrimp culture towards culture intensification, by which the unit production is greatly increased and the full utilization of the culture land becomes possible. Under the intensive monoculture system, the production of 12 to 14.4 metric tons per hectare per crop was often achieved, and as much as 19 metric tons per hectare per crop was also recorded. The formulated feed for tiger shrimp was first developed in Taiwan in 1975, followed by a two years of effort for continued improvement and verification of culture efficiency and economic viability. The stages in feed development were:

- The nutritional requirements of tiger shrimp were initially investigated by researchers at the research and academic institutions through government funding.

- Under the advice and information provided by the government institutions, the formulated feed was commercially produced and became available to farmers in 1977. The private sector played an important role in feed development, and feed formulation was later attempted mostly by the private sector with advice and information provided by the government institutions.

It has been a long process to develop a formulated feed, yet the extension and dissemination of the importance of formulated feed has been very effective because of the direct and wide contacts of the private sector with the shrimp farmers.

Technology Extension and Dissemination

Aquaculture has been practiced in Taiwan for a long time, starting with the polyculture of milkfish and shrimp dating back three centuries. The artificial propagation and culture of several important species have been intensively attempted in the carp species, mullet, milkfish, seabass, grouper, red porgy, black porgy, and others since the 1960s. Notable breakthroughs and accomplishments have been obtained since then. To date, more than seventy species are constantly under cultivation with the capability of producing the required stocking seed of more than forty species in captivity.

With respect to shrimp culture, extension and service have been primarily performed by:

- Government organizations, including Fisheries Research Institutes and University extension professors. In addition, 300 fisheries associations all over the island today are involved in technology extension, and also promote industry growth.

- The private sector, including more than 2,000 shrimp hatcheries, 74 feed
Figure 4. Shrimp culture in Taiwan

Traditional

Fishermen

Middlemen

Hatchery operators

Feed producers

Postlarva distributors

Growout farmers

Middlemen

Processing → Marketing

Present

Broodstock importers

Nauplii producers

Alga producers

Postlarva producers

Nursery operators

Feed producers

Supply of broodstock

Broodstock distribution

Supply of PLs 12-15

Supply of PLs 25

Supply of PLs 25
manufacturers, aquaculture machinery/equipment manufacturers, and aquaculture chemical suppliers.

- Farmers' organizations, including shrimp farming associations, shrimp development and export associations, and others. The updated progress in technology development is often transmitted very effectively among themselves.

The technology extension is performed in the following ways:

- Training programs — These are usually sponsored by government authority. The program duration is varied, ranging from several days up to a month. The program is implemented by lecturing, demonstrations, and field visits.

- Seminars — These are organized by private aquaculture corporations, quite frequently, according to needs and the local fisheries association's requests. The location is selected depending upon the association structure.

- Small-scale farmers gathering for constant discussions and information exchange.

The means of technology extension have varied with the purpose of the program. The training program and seminars are conducted with hand-out documents, which include a technical manual, product descriptions, and an operation/use manual, while the small-scale discussions are exclusively performed by conversation on topics which are not pre-determined.

Educational Background and Experience of Shrimp Farmers

The effectiveness of the technology extension exercise in Taiwan has proven to be successful because of the recipients' educational background and the farmers' long exposure and experience in aquaculture practices. Most importantly, the combination of farmer innovation and business consciousness and the motivating attitude of the industry sector have greatly facilitated aquaculture technology development and the continued verification of the potential of the aquaculture industry. Furthermore, close cooperation among has farmers, without any strong attitude as business competitors, has effectively translated experiments and technology breakthroughs into field practices. The technology extension and information dissemination through the extension channels and farmer associations have been a relatively easy task in this country.

Capital Accessibility

Sufficient fund availability certainly triggered the exploration and eventually the development of new enterprises. In the course of the pre-operational phase, evaluations of the possible success of new investment and availability of technology are required, and the evaluation process further promotes technology transfer. It is therefore believed that capital availability has contributed significantly to the success of the shrimp culture industry through technology extension and dissemination.

At present, financing policies and practices toward the fisheries industry from financing institutions are not different from those to other industries. The financing institutions include commercial banks, trust companies, and agriculture and fisheries associations, which are also involved in banking for the association members.

To implement national development programs on strategic industries or to relieve the loss from natural catastrophes, the government authority always establishes reserve funds, which through the commercial banks and fisheries associations are loaned to the farmers at an interest rate 3 percent below the prime rate at that time. In some special cases, financial assistance is provided free, directly to the farmers for the purpose of program promotion.

For research, the National Science Council and the Council of Agriculture under the Executive Yuan provide annual budgeted funds for basic and applied research relevant to industry development, respectively. The
Research programs are implemented through research projects applied to the individual scholar's interest, or the national development program identified by the government authority. The latter is always implemented as mission-oriented in the form of an integrated research program in which a group of the researchers participate.

Besides government funds for research, the commercial banks have not funded any research in the field of aquaculture development to date. Similarly, the government has not received any international financial assistance for at least two decades.

With regard to technology introduction and promotion, the Council of Agriculture also provided financial assistance rather than loans for implementation. Among the farmers, they are also able to obtain limited quantities of capital through private credit unions which are organized among farmers themselves or association farmers.

Industry Motivation

Motivation and business competition among corporations has further accelerated the growth of the industry. The corporations are very motivated for the success and continued growth of the business, and competition among them always exists. Under the limited market resources, the corporation gains popularity and business growth by offering technical assistance. For this purpose, the corporation is obliged to strengthen staff competence through the establishment of its own research and development capability and the continuous uptake of information and technical reports available elsewhere. Technical knowledge gained is immediately translated into the farmers' dialogue and extended to customers.

Since the shrimp culture industry in Taiwan is considered to be relatively young, whoever is able to transfer innovative technology quickly and effectively to the farmers would gain the advantage in market competition. Therefore, extension work performed by the private corporations is more effective than that of governmental agencies.

Technology extension is made flexible and information and advice are adapted to their needs. For example, the proper methodology of fry stocking is advised and demonstrated at the time of stocking, and assistance is provided when difficulties and problems in pond water management are encountered. In any case, technology assistance has been provided timely and effectively, which also strengthened its acceptability and accuracy.

The know-how in shrimp culture has been extended through training courses, discussion, seminars, and group meetings. All these extension works are shouldered by skilled sales staff who promote product sales at the one end, and also disseminate the information/know-how and offer technical service at the other. It is true that the corporations play the most important role in technology transfer and extension.

Problems Within a Rapidly Expanding Industry

The rate of growth of any industrial sector must at some time meet factors which will limit its expansion. As indicated earlier, the Taiwanese shrimp culture industry for the first time faced the serious problem of being unable to sustain its growth. A sharp decline of tiger prawn production was experienced in 1988 with the production down to only 31,171 metric tons. Several factors have been suggested by the Fish Disease Prevention and Cure Task Force for such a drastic reduction (Liao 1988). The major factors would appear to be non-pathenogenic and pathenogenic.

Non-Pathogenic Factors

The non-pathogenic factors include high-temperature-reared post-larva, deterioration of pond environment, overstocking, poor quality feed, misuse of chemicals and drugs, poor quality of water source, ignorance of growout techniques, and the absence of disease prevention practices.

Aging and deterioration of the culture environment resulting from overstocking (up to 120 post-larvae per meter in some cases) and
continued use of the culture system. Accumulation of recirculated pollutants, including infected organic materials, and lack of proper pond management have significant impact on the degradation of culture conditions.

Pathogenic Factors

The pathogenic factors consist of combinations of Monodon Baculovirus (MBV), Vibrio bacteria, and protozoa Epistylis sp. (Chiang and others 1990). Mortality is often the consequence of compound effects of pathogenic infection and environmental stress, high-temperature-reared post-larvae, and deterioration of rearing environment.

Corrective Action Promoted

Significant progress in hatchery technology has been made since 1987. Larval rearing is performed under a high constant temperature of 34-36°C and a sanitary environment. The duration of rearing in hatcheries can be shortened from 24 days under 28°C to 17 days under 34°C. By employing the high temperature technique, the risk is significantly reduced, the turn-over is hastened, and production is notably increased. However, low survival and slow growth of the high temperature reared fry after stocking into growout ponds have been reported by farmers (Chiang and others 1990).

Field observations indicate that satisfactory growth and survival are attainable if the water is conditioned and/or the farm is relatively isolated rather than if several farms are aggregated. This fragmentary evidence strongly suggests pollution as a cause of failure (Chiang and others 1990).

Improper management of pond conditions and discharged water in the aquaculture zone have been identified as important causes in the collapse of shrimp culture, and the optimal use of the culture system, proper management, and inspection of the culture environment should be emphasized.

Economic Problems Resulting from the Collapse of Shrimp Culture

The difficulty in sustaining the shrimp production in Taiwan experienced in 1988 resulted from the compound effects of biological, environmental, and pathogenic problems, but the shrimp culture industry has begun to show signs of recovery in recent years. However the economic problems associated with the declined shrimp culture industry still remain and in brief are as follows.

The hatchery operators and growout farmers are flexible in changing the culture commodity, and their efforts have been shifted to produce stocking seeds and marketable products of other economically valued marine fishes. These include black porgies (black seabream), red seabream, seabass, grouper, snapper, mullet, milkfish, and others. The impact is minimized through species diversification, and the business loss is reduced by the farmers' flexibility. However, the circumstances do make the hatchery operators and growout farmers search for business continuation through foreign investment elsewhere, mostly in southeast Asian countries.

The impact of the industry collapse on the feed manufacturers was vital, and the situation forced the manufacturers to discontinue the business of aquatic feed production, if they were also involved in the poultry and livestock feed industry. Otherwise, emigration of the feed industry elsewhere has significantly increased in recent years, and the internationalization of the feed industry obviously became essential. Meanwhile, the aquatic feed manufacturers have notably shifted their products toward fish feed, while the demand for shrimp feed still remains below production capacity.

The producers of aquaculture equipment have also been notably affected, production is lower, and some manufacturers have even been forced to close down their business operations.

In fact, the development and expansion of the shrimp culture industry in the past progressed much faster than the government
authority could have expected. Under the rapid mobilization of a fisheries force into the aquaculture industry, the government authority has been unable to keep pace with industry growth in developing management policies and regulations. The difficulties experienced from the collapse of the shrimp culture industry provided the opportunity for a re-evaluation of the development trend of the aquaculture industry. It is therefore concluded that the following measurements should be kept in mind in order to minimize the loss from similar incidents:

- Optimal utilization of biological production potential.
- Proper utilization and management of the culture system.
- Strengthening knowledge of disease prevention, diagnosis, and treatment.
- Enforcement of the zone management of aquaculture.
- Enforcement of the necessary environmental controls, inspection, and management.

**Future of Shrimp Culture Industry in Taiwan**

The constraints of land resource availability and high labor costs have forced the industry toward culture intensification, and excess inputs to meet environment protection requirements have significantly reduced the market competitiveness compared with neighboring countries in the ASEAN region. It is anticipated that the aquaculture industry in Taiwan will play a role as:

- Supplier of live aquatic products in the domestic market.
- Manipulators of culture technology, capital, and marketing overseas.
- Export opportunities for feed and equipment.
- Technology and industry transfer through overseas investment.

**Status of Shrimp Culture Industry in Asia**

**Indonesia**

Following Presidential Decree No. 39/1980 banning the use of trawler fisheries, shrimp production from sea catches was significantly reduced. Under the Government initiation of the INTAM program (Program Tambak Intensification) in 1984-85, there were efforts at technology introduction and the development of shrimp culture infrastructure with foreign aid from the Asian Development Bank (ADB). As a result of the government's efforts in Pelita IV (five-year development program), there was a continuous increase in shrimp production and export. The private investment in shrimp aquaculture as well as supporting industries such as hatcheries, shrimp feed manufacture, cold storage, etc. have since increased.

The development of the shrimp culture industry was indeed triggered by the incentive of tax exemption on shrimp feed imports. The hatchery and growout technologies from Taiwan were transferred along with the profit-motivated business investment of Taiwanese feed and machinery companies in Indonesia. Motivation and efficiency of private industry has played a significant role in the development of the shrimp culture industry. The technology transfer was facilitated through the Chinese communities in Indonesia. Indonesia possesses a great potential for continuing growth of the industry because of natural resources, a favorable environment of industry development and competition, and active support from the Government through ADB financing.

**Thailand**

The shrimp industry in Thailand is primarily promoted by two private companies with technology inputs from Taiwan, from which technical expertise and technology information are easily accessible. The technology extension seems effective because of similarities with Taiwan in terms of industry structure, capital accessibility, farmer experience and reception of aquaculture.
technology inputs, and social and ethnic background. Aquastar, a subsidiary of British Petroleum, is a well-organized entity, possessing systematic strategies for business development. Technology transfer is implemented systematically. The future of the culture industry in Thailand is considered very comparable with Indonesia when the natural resource is better utilized and competition among industries is established.

**Philippines**

The shrimp culture industry was first developed among the ASEAN countries. The culture technology was transferred from Taiwan dating back to 1979, and the technology extension is primarily implemented through the private sector, although fisheries extension agencies have been actively involved for a long time. The significance of technology transfer was not as effective as others, resulting from a lack of industry competition and insufficient accessible capital, so the peripheral and supporting industries were not established.

**India**

The extensive culture of Indian shrimp, *Penaeus indicus*, has been practiced for many years. Until recently, the culture of tiger shrimp has attracted tremendous interest in the country. The shrimp feed from Taiwan was first used by a subsidiary company of Unilever, until 1990. Transferability of the technology was tested on four demonstration ponds and the technology was verified through demonstrations and on-site supervision. The outcome of the technology transfer has proved very successful. Slow growth of the shrimp culture industry is anticipated, however, based on the seven important parameters determining the success of industry development.

**China**

Oriental shrimp culture has been practiced before the disaster of the shrimp culture industry encountered in 1988. Shrimp farmers have naturally explored new territory for continuing the culture practice in China. Under the drive to establish private businesses, contacts among farmers have facilitated technology extension. The culture technology is effectively upgraded at the same time. With the advantages of shrimp culture experience and exposure of the farmers in mainland China, the technologies developed in Taiwan have rapidly spread, and the future of the shrimp culture industry is tremendous.

**Conclusion**

The shrimp culture industry in Taiwan developed very rapidly, which is evident by the remarkable increase in the annual production. The success in the industry has been attributed to technology development and dissemination, capital accessibility, industry structure and integration, and product marketability. The technology developed in Taiwan has also been shown to be transferable, indicated by the recent increase in prawn production and a progressive development of the shrimp culture industry in ASEAN countries. However, in 1988 the prawn culture industry in Taiwan, for the first time, faced serious problems, and was unable to sustain previous production levels. Similar problems have recently surfaced in Indonesia and Thailand.

In prawn farming development, economic viability has been the major concern of technology advancement on fry and feed production. It is important to adopt ecological principles in management strategies and to recreate a stable and balanced growout system, especially under a deteriorating environment, so that the risk can be reduced. The gains in production of polycultured fish to compensate for reduced prawn production, which might have been obtained in intensified monoculture, make "ecological aquaculture" (Mackay and Lodge 1983) also economically feasible (Chiang and others 1990).

The effectiveness of technology transfer and extension attempted in the ASEAN countries is compared with those in Taiwan, and the findings are summarized in Table 1. The significance of the various parameters on the success of technology transfer are
represented by a scale of 0 to 5. The success of technology extension will be the determining factor in industry development and growth. The corporation has certainly played the most important role in technology extension and transfer, and Indonesia, Thailand, and China, among others, possess the greatest potential to develop the shrimp culture industry, and even for other aquaculture species in the years to come.

Table 1. Status of shrimp culture industry in Asia. The contribution of each parameter to the success of technology extension and transfer is scored on a 0 to 5 scale (5 is highest)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Taiwan</th>
<th>Indonesia</th>
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<th>Philippines</th>
<th>India</th>
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<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
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<td>1.5</td>
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<td>3</td>
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References


Economic and Technological Change —
Moving to Market-Led Development
and Its Implications for Agriculture

Carliene Brenner and Ian Goldin

Forces Influencing Technological Change and Innovation in Agriculture

In order to understand the forces influencing the pace and nature of technological changes in agriculture, it is useful to view the agriculture sector — and agricultural technology — within the global context of factors shaping technological change and innovation.

First, technological innovation is an essentially interactive process, involving linkages and networks (network relationships) among different organizations and actors, particularly industrial enterprises. Without these linkages, developing countries will be frozen technologically.

Second, the innovation and diffusion process is a reflection of technological learning (learning-by-doing, learning-by-using, and learning-by-interacting) which involves both users and producers. This combination of learning and experience is an essential element in the process which is termed “technological accumulation.” A base for technological change thus has to be established in developing countries. Education and infrastructure are vital components.

Third, an important trend has been the transition to globalization of economic activities. This means that an increasing share of worldwide production and distribution occurs within a system of interlinking private networks. The major actors in this new configuration are large multinational corporations (MNCs) which deploy their resources and activities on a world-wide basis. Within some industrial sectors, oligopolistic rivalry is giving rise to new types of long-term alliances and agreements with other firms (network corporations), including rivals. Whereas in the past, concentration was measured in terms of domestic market shares, but with globalization the only meaningful measure of concentration is the share in world markets, developed through cross-country mergers and takeovers. This is giving rise to what can be described as international oligopolies. This raises new questions of access to scientific and technological information, particularly for developing countries.

Technological Change and Growth

If it is agreed that technological change is central to long-term economic growth, continuing differences in output must be linked to variation in the ability of countries to acquire and diffuse new techniques. In light of the recent and widespread adoption of structural adjustment programs, not only in developing countries but also in the hitherto centrally-planned economies, it is useful to consider how far spontaneity could stimulate technological change in agriculture, and the ways in which — particularly in low-income countries — the increased emphasis on market
incentives may or may not be conducive to technological change.

The "catching-up" hypothesis developed in relation to industry would suggest that the greater the initial technological gap in the use of "best-practice" techniques, the greater the potential for catching-up. While in some situations the catching-up concept may be applicable (for example, wheat in the Punjab), in others catching-up can be inhibited by a combination of technological backwardness and lack of what has been described — but not defined — as social capability.

It can be argued that the success of late-industrializing countries is due to learning and imitation rather than to domestic innovation. (This would correspond to the notion of "cumulativeness"). Following this reasoning, technologically backward countries should devote more effort to development (rather than research) and to adapting technologies designed elsewhere.

Explanations of technological accumulation, innovation, and diffusion in industry may not be directly applicable to agriculture, however. Natural resource endowments (climatic and soil conditions) are still important in the production of food crops. In addition, technology transfer and imitation may be inhibited by the location-specific character of agricultural technology.

It is undeniable that a very wide technological gap exists between many developing countries — particularly Sub-Saharan Africa — and the rest of the world. Can this be accounted for in terms of technological backwardness and lack of a critical mass of scientists, technologists, and infrastructure? Can it be accounted for, at least in part, in terms of social capability and, if so, is it possible to begin to define and measure this?

In agriculture, producers could be expected to respond to market and price incentives by introducing minor, incremental technological change by introducing better seeds, improved implements, and better storage facilities which, if combined, would have considerable impact on output. Public participation is essential to provide roads, credit, agricultural research, and extension services. It should be expected that the public provision of agricultural services should result in a higher rate of growth than would result from spontaneity or laissez-faire.

The development of research capacity requires education and infrastructure, suggesting that market incentives have to be supplemented with public investments if the challenges of technological development are to be met.

New Biotechnology and Agriculture

New biotechnology lies at the center of the debate regarding the influence of economic and institutional policies on technological change and, conversely, the influence of technological change on the capacity for economic and institutional development. It is also an important element within the debate concerning sustainability, where expectations of environmentally friendly plant and animal nutrients and biological controls are seen as an appropriate response to growing concerns regarding fertilizers, pesticides, and other chemical compounds increasingly viewed as unsustainable pollutants. Can it be anticipated that environmental pressures are likely to stimulate the development and diffusion of biotechnologies for more sustainable agricultural production systems? Or will regulatory processes, problems related to the protection of intellectual property rights, and public fears over the new technologies in food and agriculture, inhibit their development? And, what are the implications for developing countries and their agricultural research systems?

It can be argued that the high prices and protected markets in OECD member countries stimulate biotechnology innovations which could further distort markets. However, it is at present unclear, particularly with respect to plant biotechnologies, which techniques will be profitable and how structural adjustment and liberalization might affect profitability. Environmental concerns are also expected to alter the criteria governing production, consumption, and trade, with non-tariff barriers
associated with chemical residues and food regulations increasingly acting as a form of non-tariff barrier to developing country exports. The extent to which these changes will occur and their global impact depends critically on the pace of technological change.

Except in the field of health care, few new products have yet reached the market. The first important wave of biotechnology products is expected from 1992 to the year 2000. In the longer-term (fifty years hence) biotechnology may be essential in helping to preserve the physical environment, coping with possible climatic change, and feeding growing populations.

In plant biotechnology, the major techniques currently being investigated involve genetic modification for various kinds of stress resistance, plant breeding, plant production, and enhancement of plant quality, in turn linked to food quality. Contrary to earlier expectations, developments have been more rapid in animal than plant biotechnology and relate to animal health (diagnostic tests and kits, vaccines, therapeutics), growth and lactation, animal feeds, embryo multiplication, and genetic engineering of animals.

In food processing, among the many new techniques being developed are monoclonal antibodies used to enhance food safety and prevent contamination, enzymes, bio-preservation, new foods, and new plant cell cultures for flavors, fragrances, etc. It is anticipated that consumer tastes, as well as food safety concerns and regulations, will be of overriding importance in the diffusion of new food-processing techniques.

For developing countries, biotechnology constitutes both opportunities and threats. The hopes relate to prospects for raising production, enhancing nutritional properties and quality, lowering dependence on agrochemical inputs, and helping to conserve biodiversity. The threats stem from the possibility of a widening technological gap, due on the one hand to an inability to develop the new technologies, and on the other, to constraints on application due to the lack of an appropriate legal framework, for example, for the environmental release of microorganisms or to the protection of intellectual property rights.

It is interesting to compare some of the essential characteristics of the new biotechnologies and their potential impact with those of the more traditional technologies. It is also worth noting that earlier predictions that biotechnologies, particularly plant biotechnologies, would be commercialized by 1990, have not been borne out.

Although plant biotechnologies being developed at present will control some stress factors, they will not have direct impact on increasing yields. This will require complex techniques of multiple gene transfers which have not yet been mastered.

The green revolution technological package was introduced at a time when there was considerable pent-up derived demand by farmers. At least with respect to crops, no such derived demand exists for the new biotechnologies, particularly as cheaper ways of coping with stress factors may be available. At present the early plant biotechnologies appears to offer little profit incentive for farmers. It can therefore be argued that incentives to the R & D and farm supplies industries may be required in order to diffuse the new technologies at the farm level.

As with earlier technologies, biopesticides, disease resistance, etc. will be mainly embodied in germplasm and will therefore pose no particular problem for adoption by developing country farmers. However, the situation is quite different with respect to animal biotechnologies. Apart from some of the animal vaccines and improved feedstuffs, the use of techniques such as bovine growth hormone and improved reproduction techniques for animals will require relatively sophisticated management capability on the part of farmers.

One positive aspect of the new biotechnologies for developing countries is that they would not have the same dramatic impact on labor utilization as the earlier mechanical technologies. The new biotechnologies are perceived as being less labor-saving, and if appropriately marketed, essentially size-neutral.

In contrast to the green revolution
technologies which were developed as a public good with the support of philanthropic foundations and the early international agricultural research centers (IARCs), a large share of R & D on the new biotechnologies is being carried out within private sector firms. As the research effort can be highly capital-intensive, firms will make more effort to appropriate research results. This raises questions of the potential for monopoly behavior on the part of private firms and of access and control for farmers.

The combination of privatization with respect to the development of the new biotechnologies and emphasis on market forces as an outcome of structural adjustment implies that the prospects for biotechnology will be most favorable in those developing countries where private involvement in innovation is already developed and/or where the private sector has incentives.

**Biotechnology and Industry**

Recent research for the OECD Development Centre focusing on the investment strategies of leading agrofood companies suggests that involvement in biotechnology is an essential aspect of competitive strategies. However, due to the high level of uncertainty among the major actors themselves, the uncontrollable nature of key scientific, economic, and other variables, and difficulties in establishing R & D priorities, network relationships have become a permanent feature of negotiations in assessing the costs of introducing and developing the new technologies. At the same time, there appears to be stronger emphasis on in-house competence. This is a result of a perceived need to control markets through intellectual property rights protection, and more specifically, through patenting.

Differences can be observed in the way biotechnology is perceived upstream and downstream. In the former case, biotechnology is an essential component of competitive restructuring in the seeds and agrochemicals industries. In the latter, biotechnology is one of a series of options dominated by the need to establish competitive strength in global markets, which are increasingly segmented along quality lines.

The interest of the major firms in developing countries is concentrated on those countries which already have a strong agroindustrial base. The impact of trade liberalization in the context of the GATT negotiations does not enter into their calculations. Liberalization would seem to favor markets where they are already present and operating where currency is stable, inflation is controlled, and where intellectual property rights are respected.

Breeding programs which incorporate research on modern biotechnology are increasingly concentrated in the industrialized countries. Nevertheless, many firms express interest in the direct transfer of research capacity to developing countries to conduct programs defined by governments or international bodies. This may open the way for new models of technology transfer, but may also imply privatization of important segments of biotechnology research in developing countries.

**Structural Adjustment and Technology**

The possible negative implications of structural adjustment on poor farmers, particularly in African countries, is a source of great concern. It is in these countries that the need to cushion small farmers — and consumers as well — from greater price variability during stabilization and adjustment is most pressing, but where the lack of cost-effective institutions to manage risks, particularly for small farmers, is most apparent.

In the past risk management was inherent in different public policy instruments. With adjustment, farmers are likely to be exposed to greater price variability and it is therefore important to investigate ways and means of risk management. In practice, whereas the public sector may continue to have an important role, a role for the private sector may also be nurtured, for example through drought and
In examining the impact of the structural adjustment and liberalization process, it is important to make a distinction between stabilization measures which are designed to address short-term imbalances in external trade and the internal budget account (which involves large-scale reductions in public expenditure, sharp increases in interest rates, and devaluation), and structural adjustment proper, which is longer-term and would involve a shift in production to tradable sectors, divestment of state resources, measures to encourage private sector involvement, liberalization of markets, deregulation of prices, and subsidy removal.

Whereas in the 1980s stabilization tended to dominate the policy arena, in the 1990s structural adjustment is expected to be manifest in a fundamental liberalization of markets and shift in the public/private balance. Thus farmers in developing countries, and not least in Africa, are increasingly to be faced by deregulation of prices, subsidy removals, and the privatization of public enterprises. Public investment in infrastructure and research is also expected to be severely curtailed.

The findings of research on the impact of stabilization and structural adjustment concur in some respects but diverge in others. Structural adjustment can have major effects on the structure of agricultural incentives and on price relativities between internationally tradable and non-tradable outputs. In general, the effects are pro-agriculture. In principle the broad impact on the use of resources in the agriculture sector would be to encourage the use of non-traded resources such as labor and land rather than fertilizer, chemicals, energy, and machinery. In aggregate, it might then be expected to be pro-poor.

Evidence also points to problems of transition which can have quite dramatic implications for technology in Africa. Improved varieties which produce high yields but which require storage and chemical treatment, may be abandoned. Mechanization and large-scale irrigation schemes may also be abandoned or reduced in intensity.

Another important effect of stabilization and structural adjustment programs is their inevitable impact on public research. Public sector agricultural research has been a sheltered area in adjustment because it has been argued, first, that this is a genuine area of market failure where private supply would be socially suboptimal and, second, that the inventory of "on-the-shelf" technology has been smaller than originally thought. In most countries, an inordinate proportion of funds is absorbed in salaries, and underfunding and management problems are endemic. In principle, institutions should be made more sensitive to cost-recovery and more accountable to client demand. However, there may be limited scope for divestment of public research institutions except in the seeds industry.

In Africa in particular, public sector agricultural research is likely to suffer from problems of donor fatigue and coordination failures. These problems are compounded by
the lack of domestic technical and managerial capacity to ensure implementation.

**Technical and Economic Change**

Proponents of structural adjustment and liberalization argue that it will result in better price signals and in stimulating competition. This will be conducive to the development of agricultural systems which will have true comparative advantage with respect to choice of crop, location, processed product, and technology. Proponents also stress the importance of links with international markets and of the role of foreign investment.

The hypothesis that widespread technical adoption by small farmers requires specific institutional interventions by the public sector, which should make major investments in extension, input supply, and credit, has also been challenged by the proponents of structural adjustment. Instead, they would advocate industry-based extension services and private suppliers of agrochemicals and seeds. Similarly, the proposition that price liberalization and the removal of subsidies would inhibit the adoption of new techniques by smaller farmers, who should therefore be provided with incentives to induce them to take the risk, has been questioned by advocates of structural adjustment. Ongoing work at the OECD Development Centre and elsewhere is assessing the impact of structural adjustment on agriculture and on agricultural technology, and will throw light on the validity of these different hypotheses.

A central issue concerns the conditions necessary for countries at different levels of development to stimulate technological change and diffusion. One important aspect of this issue is related to risk or at least to the perception of risk by farmers and the consequent need, first, to identify the groups most at risk and develop ways and means of managing the risk.

A second aspect is the availability of profitable technologies for small farmers. One view holds that there is a dearth of technologies which would be both appropriate and profitable for small farmers; the other argues that technologies are indeed available but the sets of policies in place do not provide incentives conducive to risk-taking by farmers.

An additional aspect, which is linked to developer/user questions, is that of the transfer of technology versus local development. To what extent does location-specificity inhibit the import of biological techniques, or at least necessitate a period of adaptation to local agroclimatic conditions? Clearly, the responses would differ for different techniques and for plant and animal technologies.

It can be argued that productivity gains in developing countries will, at least in the short term, continue to be gained from the diffusion of traditional techniques rather than from new biotechnologies. With respect to plant crops, the new techniques will complement but not supersede those of plant breeding, which implies the need for strong plant-breeding capability. However, apart from the benefits which might be gained from the new technologies in the future (in terms, for example, of accelerating the process of plant breeding or facilitating the characterization of genetic resources), if the catching-up hypothesis has any validity, biotechnology would be a necessary step in the process of accumulation of technological capability, particularly if countries are to be competitive in agriculture.

The agrofood system is one in which a number of actors (markets, firms, farmers, governments) are linked, through technology and information networks, at the farm, firm, national, and global levels. The essential question for developing countries is then whether the system is open or closed and where windows of opportunity are to be found.

**Conclusion**

The structural reform process implies an enhanced role for the market in the economy and diminished State intervention. Recent examination of investment trends in R & D in OECD member countries suggests that private firms are not prepared to assume the role,
earlier considered to be the responsibility of the public sector, of investing in long-term basic research. A strong case has therefore been made for a continuing role of the public sector in the basic sciences underpinning the new generic technologies. It is also argued that government intervention is necessary to stimulate interactive networks at national, regional, or local levels to stimulate technological innovation and as a countervailing force against the globalization trends, which to a large extent escape national control.

In some developing countries, the problems of striking an appropriate balance between the public and private sectors are compounded by states which are weak, vulnerable, and do not have the administrative capacity to implement structural reforms. It is also sometimes — but not always — in these countries that markets are so weak that the role of the state cannot easily be divested. The proper role of government in agriculture, agricultural research, technology development and dissemination, and in institutional infrastructure will, of course, depend on individual countries, on the social capability existing in that country, and on market structures already in place.

The ways and means of inducing the private sector to play a more active role both in agricultural research and in the provision of agricultural services to small farmers, is an important research issue. One of the problems lies in the fact that producer groups in developing countries are usually not organized as clients of research to the same extent they are in industrialized countries. Clearly, it is important to examine the potential for collaboration and complementarities in research between the public and private sectors.

The challenge in the coming decades will be to define the role of different actors in securing sustainable rural development in the economic context of liberalization and adjustment. This places an increased emphasis on the private sector and market forces. But, the private sector can be as imperfect as the state incapable. The comparative advantages of the state and private sector need therefore to be carefully analyzed and the role for international and non-profit institutions be identified as providing a public good. In developing countries, there appears to be no private shortcut to the provision by the state of a broad system of education, social welfare, and infrastructure. This capacity is vital for the adoption and diffusion of technological change and for the achievement of dynamic comparative advantage. In particular, the state, together with other non-profit national and international institutions, needs to ensure that research reaches small and poor farmers and that developing countries have the “network relationships” and the “technological accumulation” to grow. The aim should be to increase the effectiveness of the state and its symbiosis with the private sector. On this division of labor rests the success of any development strategy.
Czechoslovakian Agriculture in Transition — Economic, Technological, and Policy Implications

Examples from the Dairy Sector

Tomas Doucha

New Agricultural Policy of the Czech Republic

It is useful to analyze the present situation and outlook for dairy production and the dairy industry in the broader context of our economic reforms.

The economic reforms and transition to a more market-oriented economy began in Czechoslovakia during 1990. The process is based on the extremely extensive privatization and transformation of state enterprises and cooperatives. A new agricultural policy is now being introduced pursuing the common aims of our economic reform and specific aims in the agriculture and food industry sector. The new agricultural policy, as quickly as possible, struggles to eliminate all negative consequences of the previous policies of full food self-sufficiency and cheap food which prevailed during the centrally-controlled economy. We are faced with several negative issues from our past:

- Almost 100 percent of large-scale technologies and capacities are concentrated in extremely large state and cooperative farms. The share of smaller family farms is utterly insignificant.
- The unsuitable dislocation of both agricultural production and the food industry.
- The extremely high production costs in agriculture and the food industry.

- The absence of a real agricultural capital and land market, as well as the monopolistic behavior of input suppliers, processors, merchants, and dealers to farmers and food consumers.
- The significant participation of the agricultural sector in environmental and landscape damage.

The new agricultural policy aims to privatize and de-monopolize the agriculture and food industries, provide a defined level of food security, improve our environment, preserve adequate agricultural and rural development even in regions with the worst productive and living conditions, and preserve an adequate income for farmers.

Cattle Breeding and Dairy Production in Czech Agriculture

Cattle breeding in the CR has significantly developed during the last twenty years. During this period the number of cows has declined by 5.6 percent, but dairy production has increased by almost 50 percent. In 1970, the average annual yield per cow was 2,477 liters of milk and 302 kilograms of meat. In the last five years, production has increased up to 4,000 liters of milk and 415 to 430 kilograms of meat.

Cattle breeding forms the economic base of Czech agriculture. Its share in total cash receipts from all farm commodities accounts for 40 to 47 percent, and half of this amount comes from milk. In 1989, the average annual consumption per capita was almost 30 kilograms of beef, 260 liters of milk, and over

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9 kilograms of butter. The breeding of almost 1,250,000 cows corresponded to these figures. Evidently, any changes in cattle breeding, in the "heavy industry" of our agriculture, have extremely relevant effects on the whole agricultural sector.

As a result of our transition to a market economy and other factors, around 30 percent of cattle products cannot find a consumer in our domestic market at present. Having in mind the biological basis of cattle production and the processes deeply rooted in the past, a solution to this problem, for example, reducing the number of cows, is by no means simple.

Where is the starting point of our present problems? In the early 1970s, the problem of a substantial increase in cattle production without increasing the number of cows had been solved. The insemination of all capable heifers and at the same time the high percentage of negative selections of cows, especially in their first production years, started during this period. The normal five-year reproduction cycle of cows was gradually changed to a three or four year cycle, which was also the reason for the outstanding growth of fixed reproduction costs on final production. This breeding system was guaranteed by the State Breeding Board, a monopolistic institution providing centrally-controlled insemination according to a plan. The system was also supported by state bonuses on the market.

Our farmers received the first market signals in 1990, but they have not reacted adequately and have continued to apply the previous reproduction system. There are two contradictory processes in our farms today — on one hand, there is an effort to reduce production while preserving the number of cows as much as possible (which is linked with an effort to maintain employment in agriculture). On the other hand, there is an effort to get rid of cows no matter which way, regardless of the farm economy (which is the result of the lower responsibility of the present farm management for future farm development). As a joint consequence of these processes, there is a deep drop in milk yield by about 250 liters per cow per year (in the Slovak Republic even by about 600 liters per cow) in 1991.

It is necessary to consider that the reproduction cycle of the large cow herds also brings heavy surpluses of meat. About 1 million cows are bred in the CR at present. This number could be reduced to 700,000 to 800,000 dairy cows, with higher milk yields, and the transfer of part of the herd to production without milk.

Production capacity of our cattle breeding is substantially higher than the present demand for final products. Regardless of the present action by our farmers, it is almost impossible for them to quickly accommodate big changes in demand without external support. Farmers are now confronted with unsaleable products whose production was started three years ago.

The monopolistic attitude of input suppliers, processors, and dealers, coupled with the ineffectiveness of our agricultural exports, places the burden of surpluses solely on farmers. They are struggling to solve their market problems by processing and selling dairy products independent of the monopolistic chains, reestablishing dairy cooperatives, and sharing in privatized companies. However, the results so far have been poor, and the situation is complicated by the political and economic divisions between farmers, preventing them from gaining a more equitable share of the profits from agribusiness.

In every case, the CR is now confronted with the task of radically reducing its productive capacities in cattle breeding by reducing the number of cows and using the retarded reproduction cycle of herds. These processes should be realized, keeping in mind the links between cattle breeding and plant production, and also the links between cattle breeding and social and rural development, especially in those regions with the worst productive conditions. However, the main criteria of these processes should be market, economy, and lowered production costs.

Milk represents a raw material with characteristics which determine the methods and locations of its production, processing, and marketing. There is the question of the
importance of milk in human nutrition, together with the policy of adequate milk prices in all regions for the whole population, and also the question of the perishability of milk as a raw material, together with the high demands of milk on transport activities.

The Dairy Market in the CR During the Transitional Period

Selected indices of our history and some predictions for the future of our dairy market are shown in Table I and Figures 1 and 2.

The average balance of milk in the last years was: 52 to 54 percent on human nutrition, 24 percent as a fodder, and 12 to 14 percent on export. Some milk was transferred between republics (1 to 1.5 percent, transferred from the CR to the SR). The predicted balance of milk in the CR for 1992 is:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Liters (million)</th>
</tr>
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<tbody>
<tr>
<td>Milk production on farms</td>
<td>3,500</td>
</tr>
<tr>
<td>Milk for processing on dairy enterprises</td>
<td>3,300</td>
</tr>
<tr>
<td>Demand on domestic market (human nutrition, fodder)</td>
<td>2,450</td>
</tr>
<tr>
<td>Reserves for seasonal variations</td>
<td>350</td>
</tr>
<tr>
<td>Storage or export</td>
<td>500</td>
</tr>
<tr>
<td>Intervention purchases</td>
<td>650</td>
</tr>
</tbody>
</table>

These ratios vary according to region or dairy input-output area. For example, a shortage of milk in the big cities (Prague, Ostrava) is now signaled.

Domestic Dairy Market

The last year of the centrally-controlled economy was 1989, with fixed prices and high state subsidies for retail food prices in the form of “the negative turnover tax.” These subsidies were especially important in cattle products. The deformed markets were revealed immediately after triggering the first steps of the economic reforms of 1990 and 1991.

The removal of subsidies on retail food prices in the middle of 1990 resulted at first in soaring prices. From day to day retail food prices increased on average by 25 percent. Prices further soared after the price liberalization in January 1991—food prices increased by 30 percent in comparison with December 1990. Food prices were stabilized at approximately this level until the end of 1991, but then new prices increases began and still continue.

The repeated price increases revealed big discrepancies between supply and demand, especially on the dairy market. The domestic demand for dairy products dropped by about 30 percent in 1991 in comparison with the situation before the middle of 1990. In 1992-93, the domestic demand is predicted to stabilize at 75 to 80 percent of the 1989 level. The drop in demand will differ according to the kind of dairy products, of course. The biggest drop is predicted for fluid milk and butter (with a contribution of the substitution of vegetable oil for butter) and partially in cheese and curd.

An increase in demand is projected for yogurt, sour products, and new milk products with higher added value.

Under conditions of surpluses and monopolistic behavior of processors and dealers, these were the conditions during 1991:

- Farm prices remained approximately at the same level as in the last years, but an increase of farm prices (and as a consequence of retail prices, too) set in at the end of 1991. Since that time supply and demand on the domestic market have stabilized as a result of the export of surpluses. Demand even exceeds supply in some regions at present. For example, the retail price of fluid full-fat milk in January 1991 was 6.16 crowns per liter, 6.08 in June, but 7.7 in December.
- Processors and dealers realized both wholesale and retail prices were high and they did not realize an adequate profit.

Dairy Exports and Imports

The export of dairy products is unprofitable, a situation which is predicted to
Table 1. Basic indices of dairy production and milk consumption in the Czech republic

<table>
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<tr>
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<th></th>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Population (millions)</td>
<td>10.3</td>
<td>10.3</td>
<td>10.3</td>
<td>10.3</td>
<td>10.3</td>
</tr>
<tr>
<td>Consumption of milk products</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(no butter, kg/person/yr)</td>
<td>236</td>
<td>260</td>
<td>223</td>
<td>223</td>
<td>223</td>
</tr>
<tr>
<td>Fluid milk (liters/person/yr)</td>
<td>106.2</td>
<td>91.4</td>
<td>81.4</td>
<td>81.4</td>
<td>82.0</td>
</tr>
<tr>
<td>Butter (kg/person/year)</td>
<td>9.4</td>
<td>9.4</td>
<td>6.7</td>
<td>6.2</td>
<td>6.0</td>
</tr>
</tbody>
</table>

Milk production

| Cattle ('000)                | 3,429 | 3,506 | 3,359 | 2,951 | 2,900 |
| Cows ('000)                  | 1,319 | 1,247 | 1,195 | 1,036 | 933-990 |
| Average milk yield (liters/cow/year) | 3,122 | 3,982 | 3,712 | 3,740 | 3,840 |
| Average fat content (%)      | 3.9   | 3.9   | 4.0   | 4.0   | 4.0   |
| Calf births/100 cows         | 101   | 106   | 100   | 90    | 92    |
| Milk production (billion liters) | 4.0   | 4.8   | 4.1   | 3.7   | 3.5    |
| Milk supplied to dairy industry (billion liters) | 3.7   | 4.4   | 3.5   | 3.3   | 3.1    |

Dairy products

| Fluid milk (billion liters) | 1.04 | 0.92 | 0.69 | 0.67 | 0.67 |
| Cream (million liters)      | 44.0 | 45.7 | 29.4 | 30.1 | 30.0 |
| Yogurt and sour milk products (million liters) | 80   | 113  | 54   | 70   | 75    |
| Ice cream (million liters)  | 28   | 44   | 44   | 48   | 52    |
| Butter ('000 tons)          | 98   | 120  | 105  | 95   | 94    |
| Curd ('000 tons)            | 40   | 52   | 27   | 29   | 29    |
| Cheese ('000 tons)          | 80   | 105  | 90   | 86-90 | 92    |
| Dry milk ('000 tons)        | 87   | 140  | 148  | 120  | 115   |

Average prices (crowns/liter)

| Farm price, class I raw milk | 3.3 | 4.7 | 4.9 | 5.9 | 6.3 |
| Retail price, full-fat fluid milk | 3.1 | 3.1 | 7.2 | 8.0 | 9.0 |
| Retail price, butter         | 40  | 40  | 70  | 80  | 82   |

1. Last year of the centrally controlled economy.

Figure 1. Milk production in the Czech Republic, 1989 to 1991
continue. For example, export refunds for butter are up to 50 crowns per kilogram, but exports of dry milk and some special products such as cheese are more favorable. It is true that the volume of exports has increased since 1990, but these exports have been forced by high domestic surpluses of milk — about 500,000 to 1,000,000 liters — which had to be processed, stored, or exported in the form of butter or milk powder. In addition, the protective agricultural policy of the EC has negatively influenced our export possibilities to the EC countries. An expansion of our exports is also conditioned by the harmonization of our veterinary hygiene and technical standards with comparable standards of the EC.

The import of dairy products, oriented above all to higher quality yogurt and selected cheeses from the EC countries, has not been significant so far, and similar tendencies are predicted for the future. The import of vegetable oils and or margarine will have a growing importance for the domestic market of butter.

The agricultural policy of the CR supposes a gradual opening up of our dairy market towards world markets. The supposed import to export ratio is 1:1, provided dairy production would be 90 to 95 percent of the domestic demand. The enrichment of the domestic production and market is expected through products with better packaging and quite new products (yogurt, curd, and pudding desserts), and with regional specialties.

**Dairy Production**

**Dairy Production on Farms**

Dairy production today is based almost exclusively on big state or cooperative farms, while the contribution of family farms is utterly insignificant — 2 to 2.5 percent of cows — but it is growing. The shortage of capital and the necessity to use the present large-scale technologies will determine and limit the privatization and establishment of family dairy farms in the near future.

The present density of cows, 23 to 24 head per 100 hectares, is a typical average for the whole territory at present, with a higher density occurring in east and south Bohemia and south Moravia, and lower densities on the western borders. The average stocking rate on agricultural land (1989) was 82 per 100 hectares. With the exception of some urban areas, all regions are self sufficient, with large
surpluses in south Bohemia and the Czech-Moravian highlands (1,200 liters of milk per capita per annum).

Milk yield and quality vary according to production conditions, technologies, and the level of breeding. The level of breeding is a very important factor in our present dairy farms. There are farms with an annual average milk yield of 5,500 to 6,000 liters per cow, but there are also farms which average 2,500 liters.

Large-scale cowsheds with fixed stalls still prevail. About 90 percent of cows are placed in cowsheds with more than 96 stalls, 20 percent are in cowsheds with more than 400 stalls, and 7 percent are in cowsheds with more than 500 stalls. There are 400 large-scale cowsheds in the CSFR, some with capacities of 1,000, 1,200, 1,700, and up to 2,100 stalls! About 12 percent of cows (in some regions up to 40 percent) are placed in cowsheds without litter and with loose grating stalls.

The extensive and transport-costly cooperative links between farms in the plains and farms in mountainous areas have until recently been applied in young cattle breeding.

The large-scale cowsheds cannot be evaluated favorably for effectiveness and labor productivity. The majority are “big manufacturers,” although several are equipped with electronics. The large-scale technologies are connected not only with high costs of transport (animals, fodder, and excrement), but also with environmental and ethological problems. The number of cows per worker ranges between 40 and 50 in well-managed farms. The land necessary to feed one cow ranges from 0.65 to 1.0 hectare, depending on the region.

The most serious problem in cow breeding is infections (for example leucosis, about 20,000 head) and the contamination of dairy production with PCB elements that causes the elimination of whole herds in some localities (which is very expensive both for farmers and the government). The sources of this contamination are paint materials from silage pits, construction of sheds, etc.

The agricultural policy supposes that during privatization a relocation of dairy production will occur, together with a reduction in the number of cows, with an increase in milk yield and a decrease in production costs. Intensive dairy production would develop in the favorable regions, including urban areas, suppression of dairy production would occur in regions where there is insufficient grassland (for beef cattle breeding on pastures), and where there is a low local demand for milk. The prevailing breed would be the domestic red-spotted cattle (the breed for milk and meat), together with imported breeds and cross-breds.

The transition to small-scale technologies is seriously restricted by high capital requirements for new capacity (the cost of one cow stall is nearly 180,000 crowns, for example). There is an insufficient domestic supply of cheaper technologies, especially for cattle breeding on pastures. Under these conditions, it is necessary to make the best of the present large-scale capacities until their depreciation, or to reconstruct and modernize smaller installations.

The main goal for the future is to strengthen the competitiveness of our dairy farms by cutting high production costs and increasing milk yield. To meet this goal we will require:

- Relocation of production.
- Prolonging the productive life of cows from three to four or five years at least. (In 1990, the average herd structure was 1 cow: 0.45 calves: 0.7 heifers: 0.55 beef cattle. The slower reproduction cycle could restructure the herd to 1 cow: 0.4 calves: 0.55 heifers: 0.6 beef cattle. In this way fixed reproduction costs would be cut significantly. These costs are also negatively influenced by the low daily growth of young cattle, an average of 0.76 kilograms per day.)
- Improving the level of feeding.
- Cutting transport costs. The price of fuel compared to the price of milk is relatively much higher in the CSFR than in the surrounding countries.
• Rationalization of the consumption of other purchased materials. Input prices grew 50 to 80 percent during 1991, but farm prices almost didn’t move during this period.

Dairy Industry

The dairy industry is enormously concentrated, and the number of dairy plants significantly declined during the last forty years. As in the whole food industry sector, the dairy industry was stigmatized by the liquidation of medium and small enterprises and by the establishment of monopolistic state organizations. In 1931 there were 653 dairy plants in the CSFR, 366 in 1945 (about 75 percent cooperatives), 263 in 1955, and only 167 by 1985, all big state organizations. Although the big dairy organizations were gradually decentralized to regional and smaller plants during 1985 to 1989, regional monopolies still survive.

The relocation of dairy plants has developed approximately according to supply and demand areas. The average production capacity is about 104,000 liters of milk per day (six dairy plants have capacity of more than 100 million liters per year). The average transport distance from dairy farms is about 30 kilometers (in urban areas about 50 kilometers). The processing capability of plants depends on the local demand for fluid milk — plants in surplus areas are more oriented to dry or condensed milk products. However, the effects of location were not taken into account when dairy plants were founded. The necessity to transfer up to 40 percent of milk among regions is the consequence of this imperfect location of capacities.

The dairy industry in the CR has a high percentage of out-of-date plants. Almost 50 percent of plants (58 percent of machinery and 37 percent of buildings) are depreciated. There is also an urgent need to obtain capital for environmental purposes, especially equipment for water cleaning.

One of the main tasks is therefore modernization of our dairy technologies. Participation of foreign capital will be invited, not only for modern dairy equipment (for example, technologies for membrane processes), but also for modern technologies for handling materials, packaging, preparation of cartons, and so on. An enlargement of cold stores, renovation of truck parks, and introduction of automation are also in high demand.

Since 1990 several farms have been equipped with small-scale dairy technologies. Small-scale mobile dairies are now available and some farms sell a part of their milk production in their own shops or directly to their workers.

The majority of small-scale dairies have imported relatively expensive equipment (2 to 6 million crowns), and very few need domestic suppliers. The capacities of these small dairies range from 10,000 to 40,000 liters of milk per day. There is a sufficient supply of dairy equipment on our market, with short delivery terms (three to six months), with training and guarantee and post-guarantee service. The use of credit or leasing services or paying foreign suppliers in products is also possible. The more significant suppliers are the following firms: Alfa-Laval (Sweden), Packo (Belgium), AVP (UK), Arten (Germany), Geere (France), and firms from Denmark and Italy. Beside technologies for primary milk processing, small technologies for production of condensed milk, sour milk products, and cheese are also imported. However, the importers (excluding Alfa-Laval) so far do not offer further desirable equipment. This is a question of technologies for reproduction of pure dairy cultures, laboratories, cleaning technologies (in circle-CIP), cold storage, and water cleaning equipment.

New technologies for milk processing as part of bio-organic (alternative) agriculture have recently been introduced. Some small-scale dairies process milk only from a given farm (with capacity of 500 to 600 liters per day) or from a small number of farms (with capacity of 1,000 to 1,200 liters per day). However, new standards differing from those for conventional agriculture must be respected. These new standards concern fodder
production, breeding, milking, milk preserving, and processing. Processed milk should be of high quality corresponding with elite grade of the Czechoslovak standard for raw milk as a minimum. The full exploitation of small-scale dairies with the capacity of 1,000 to 1,200 liters is reached by production of milk specialties or by processing mixtures from cow milk and goat milk (sour milk products, cheese). The assortment of products includes pasteurized full-fat milk, standard milk, flavored milk, yogurt, curd cheese, soft cheese with mold, and so on. Of course, the technologies are more simple in correspondence with the small-scale character of production and with the higher proportion of manual work.

There is also a small-scale technology for the pasteurization of milk for direct sale. The technology (Agropaster U 200) enables milk and cream pasteurization from amounts of 25 liters, with a pasteurization time of 20 minutes. The technology is designed for use on small family farms or cooperatives. A separate part of the technology involves filling equipment that enables the manual filling of any vessel, located very near to a milk store, using the natural temperature of milk to reduce energy demands on the pasteurization and to heat water for cows.

The establishment of small-scale dairies on farms is a part of desirable diversification processes in our agriculture and a part of the struggle to eliminate the present monopoly in the dairy industry. The small-scale dairies are also important for reestablishing local and regional markets and for the formation of reasonably competitive conditions. However, there is no expectation that the new capacities will significantly affect the position of big dairy plants, especially in the main centers of milk consumption. However the dairy industry in the CR has excess capacity that will have to be reduced in the near future.

The following criteria should be followed in relocation of new capacity:

- Capacity for primary milk processing should correspond with raw milk supply from the shortest distances possible, and have reserves of about 15 percent for seasonal swings. Dairy plants should be located in the middle of areas of consumption (the transport of final products is more complicated than the transport of raw milk). However, the possible expansion of the number of small dairy farms will have the opposite problem: the transfer of raw milk from many small points of supply.

- In regions with a high density of consumers only fluid milk and other quickly perishable milk products (for example, ice cream) should be produced.

- An assortment of liquid milk products should be produced in regions with small surpluses.

- Capacities in regions with large surpluses should be oriented to production of condensed milk or dry milk.

- Small-scale dairies should be used to process milk from mountain pastures and from environmentally uncorrupted localities, and for separate processing of milk of extremely high quality, with the flexible accommodation of the assortment.

- Butter should be produced in every region (as a technological necessity).

In principle, markets at the local, regional, and republic levels should be renewed and the distribution of profits in dairy chains should be improved. The latter need is linked with the reestablishment of previous dairy cooperatives or with the establishment of dairy shareholder companies, in which farmers could be shareholders. There is also a need to increase the quality of purchased milk to the comparable European level.

State Interference with Dairy Production and Marketing

The market and privatization of dairy farms and the dairy industry will be decisive factors in achieving objectives mentioned in the earlier
part of this article. Owing to specific features of milk, the government will have to interfere to a certain extent in dairy production and marketing. The state influence will be most important during the transitional period, and will need to apply the following mechanisms and instruments:

**Legislation and Institutional Measurements**

Besides common restitution, privatization, and transformation laws that would also enable direct participation of farmers in the dairy industry, there is a question of further legislation, such as the Agriculture Chambers and Union Act and legislative support to new associations of producers.

**State Subsidy Policy**

State subsidies supported the transfer of breeding cattle to meat production in 1991. These subsidies were stopped in the middle of 1991 since they supported the growth of meat surpluses. Partial compensation for the reduction of agricultural production (including milk production) in selected regions is proposed in 1992.

Since 1991 the state has directly supported the establishment of new private enterprises in the agriculture and food industry sector and the diversification of agricultural production, including the establishment of small-scale dairies. The state also participates in costs connected with the liquidation of infections and PCB from the food chain.

**Market Regulation**

Until 1990 milk was sold for fixed prices. Since 1991 only market prices have been used. Owing to the market situation, the difficulties in the accommodation of milk supply, the soaring drop in demand, and the natural seasonal swings, milk is a commodity with a federal regulation system. The regulation system is still in a stage of development, but in principle it is now based on the following rules:

- The state fixes a guaranteed farm price for Class I milk with 3.6 percent fat (in 1992, 5.40 crowns per liter. The average market price is predicted to be about 6 crowns per liter).
- By means of a special institution (the Fund of Market Regulation), the state provides intervention purchases (for butter, non-fat dry milk, condensed milk, and hard cheese) to draw surpluses from the market by way of state reserves or a direct export; or the state provides export refunds directly to exporters of milk products. So the surpluses are drawn from the domestic market in the following ways: farm-dairy plant-Fund of Market Regulation-reserves-export, or farm-dairy plant-wholesale dealer-export.
- Depending on the amount of the released state finance (in 1991, about 2 billion crowns in the CSFR), the dairy plants purchase from farms a limited percentage of milk production for the guaranteed price (in 1991, 50 to 60 percent of the level of purchases for the corresponding months in 1990). The state provides an export refund or an intervention purchase only on the condition that milk is purchased by a dairy plant for the guaranteed price, as a minimum.

As a whole, the regulation system is relatively simple. However, the export refunds are provided only to plants that own technologies for the production of storable milk products. In this way, the state gives preference to selected dairies and farms in the respective supply areas and thus interferes in natural competition.

A permanent tendency toward overproduction of milk is predicted. To eliminate this burden, a new regulation system is now being worked out. The introduction of tender mechanisms for subsidized exports and regional unified “pooling” prices are now being considered.

At present the most serious questions are connected with methods for the quantitative
restriction of milk supply by means of quotas. The quotas are demanded by farmers, but the government does not want to apply this method because of the present unsuitable location of production and the current privatization and transformation processes (which causes problems with the determination of the starting amounts of quotas).

The regulation of retail prices protecting consumers was temporarily applied in 1991 (maximum retail prices for basic milk products and maximum business profit in retail). In November 1991 all these non-market instruments were canceled.

**Foreign Trade Regulation**

The foreign trade instruments (apart from export refunds, which were described previously) have recently been stated to give high protection to domestic producers during the transitional period. These instruments are justified especially by arguments that the surrounding countries also apply the high protection of agriculture and that high export refunds to foreign exporters are provided. In the case of milk products, the protection system consists of custom and non-custom instruments:

- Customs tariff. Since January 1, 1992 a new customs tariff has been applied. Customs rates have increased for food and agricultural products from the previous 5 percent on average to the present 20 to 30 percent (for example, the customs tariff for butter has been raised from 7.5 percent to 30 percent and rape oil from 1.7 percent to 20 percent).

- Import levies. Since January 1, 1992 import levies, a quite new instrument of the non-customs protection, have been introduced. These levies are stated either as a percentage of a customs price or absolutely in crowns per unit of a product. The import levies represent the difference between a threshold price and an import price. As an example, the following levies are now applied: cows, 7 crowns per kilogram; and butter and other fats, 38 to 39 percent.

- Additional 10 percent charge on imports. This charge is applied on goods for further production or for sale.

- Export and import licenses for our entrepreneurs.

- Concessions agreed in the frame of the Association Treaty between the EC and the CSFR. The gradually increased customs and non-customs abatements on the agreed (and gradually increased) amount of the selected products will be reciprocally applied.

**Milk Grading, Standards, and Norms**

The state standard 570529 "Raw cow milk" is in operation in the CSFR. This standard has the following limits:

<table>
<thead>
<tr>
<th>Milk class</th>
<th>Microorganisms ('000 units)</th>
<th>Somatic cells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elite</td>
<td>&lt;200</td>
<td>&lt;300</td>
</tr>
<tr>
<td>Class I</td>
<td>201-500</td>
<td>301-500</td>
</tr>
<tr>
<td>Class II</td>
<td>501-2,500</td>
<td>301-500</td>
</tr>
<tr>
<td>Class III</td>
<td>2,501-25,000</td>
<td>301-500</td>
</tr>
<tr>
<td>Non-standard</td>
<td>&gt;25,000</td>
<td>&gt;500</td>
</tr>
</tbody>
</table>

*Note:* Non-standard milk has additional criteria, for example, acidity below pH 6.2 and temperature above 10°C.

As a whole, the present state standard roughly corresponds with health and hygiene demands stated in the EC regulations dated April 5, 1985. Unfortunately, the big problem is to conform with standards and norms in reality. The majority of our dairy plants have relevant hygiene defects. During the next period, broader harmonization with the EC standards is projected, including the transition to different milk classification and evaluation according to fat content and protein elements. All these demands should be included in market orders agreed between producers and processors, while the state standard should include only the basic parameters and their
limiting values. Veterinarians will have until 1993 meet the EC standards.

State interference also exists in the reproduction activities and the inspection of products. This interference is provided by the State Breeding Board and the State Veterinary Board. All commercial activities should be excluded from both institutions and these activities should be privatized.

Other special standards and norms, connected for example with cattle breeding, are not applied. However, the introduction of limited numbers of animals per hectare in the frame of environmental programs and in protected regions is proposed.

**Conclusion**

In short, the problems facing the dairy sector in the Czech Republic are intransigent — large-scale milk production and processing facilities that are high-cost and not well located relative to the major consuming centers. However, the need is for smaller-scale herds and dairy plants that are flexible and responsive to the needs of the consuming public. By any measure, it will be a challenge for the Czech government to accelerate the transformation of the dairy sector to meet the rigorous competition challenges of an open-market economy.
Environmental Aspects of Technological Developments in Agriculture

G. Weststeijn

In every market-led economy, individual entrepreneurs and commercial societies pursue mainly their own interests. Science and technology are applied wherever useful to achieve that aim. This organization of society has resulted in the Netherlands — and in all Western countries — in a tremendous development of agriculture, agricultural output, and agricultural technologies during the last century, and even more so during the last forty years. Total production value increased almost ten-fold and total export value nearly twenty-fold (Figure 1). Some of these increases, however, are due to inflation.

In the 1960s and early 1970s everyone in our country was satisfied with these developments and quoted proudly the increase in production levels and exports, and mentioned with satisfaction that Dutch agriculture proved able to keep more or less pace with income development for the general public. Agriculture was considered to be green, natural, and healthy.

From the end of the 1960s onwards, doubts were gradually arising on the correctness of this satisfaction. Action groups, concerned with the deterioration of the environment, began to point at agriculture as one of the main polluters. The first problems were encountered on the use of pesticides. In a later stage the emission of minerals to soil, water, and air, the expenditure of energy, the use of groundwater, the acidification of rainwater, and other aspects became apparent. Consequently, instead of being considered green, natural, and healthy, agriculture in the Netherlands in the 1980s acquired an image among a considerable part of the population as an industrialized, polluting economic sector.

Western Europe was dependent on food imports to nourish its people before and during the first decades after World War II. Since the 1970s it has become a net exporter of agricultural produce. Moreover due to subsidies on certain important basic foodstuffs, agriculture has become a big burden to the EC budget. This economic change has accelerated the changing image of agriculture in society.

To substantiate these developments, some examples will be given below and some lessons for the future in our country and elsewhere will be drawn.

Crop Husbandry

In crop husbandry, the main emphasis of farmers since the 1960s was to increase their net incomes by increasing the acreage of crops giving the highest value added. In their annual farming plans, therefore, they went for crops giving a high gross yield and the culture of which could be easily mechanized (labor saving). Consequently more potatoes were grown and less cereals, pulse crops, and minor crops. Crop rotation was limited to a large extent to potatoes, sugar beets, and cereals. Cereals were included mainly for rotation, because the value added was relatively low.

A narrow crop rotation of potatoes increased the population density of potato root pathogens. This stimulated farmers to disinfect their soils because the net from potato crops was still better than that from cereals or minor crops.

Besides, farmers were aiming to maximize production, and thus fertilizer levels were high.
Although this situation still exists to a large extent, the disadvantages of this management regime gradually became apparent in the 1980s. The use of metham-sodium as a soil disinfectant causes leakage of the active ingredient and its metabolites to the groundwater. It also evaporates into the air, resulting in deposition of the product in non-target fields. Moreover, the efficacy of the disinfection decreased due to bacterial breakdown in the soil. The use of dithiocarbamate fungicides appeared to cause an increase of ethylenthiourea (ETU) in the field, which is a highly toxic component. In Dutch agriculture, the consumption of pesticides per hectare is much higher than in surrounding countries (Table 1).

**Table 1. Pesticide use on arable and horticultural crops in selected European countries**

<table>
<thead>
<tr>
<th>Country</th>
<th>Pesticide volume (mean kg active ingredient per ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>4</td>
</tr>
<tr>
<td>France</td>
<td>6</td>
</tr>
<tr>
<td>Switzerland</td>
<td>6</td>
</tr>
<tr>
<td>Belgium</td>
<td>12</td>
</tr>
<tr>
<td>Netherlands</td>
<td>20</td>
</tr>
</tbody>
</table>

The high levels of nitrogen-fertilizers increased the nitrate concentration in shallow groundwater, and in wintertime also in deeper groundwater, endangering its quality. Deep groundwater is often used as a source of drinking water in the Netherlands.

**Protected Cultivation**

Horticultural products grown in greenhouses are marketed to a large extent in free competition with similar products from other countries and other cropping systems. The capital needs for the construction and management of greenhouses are high. Therefore, the annual gross income from the cropping activities has to be high too.

Between the mid-1970s and the early 1980s, the price of natural gas for use in greenhouses rose from 5 cents to nearly 45 cents per cubic meter, that is, the price of gas increased nine-fold. Growers had to make a choice between:

- Decreasing gas consumption by reducing greenhouse temperatures and/or stopping cultivation in wintertime, or
- Increasing the production per cubic meter of gas used without reducing greenhouse temperatures.

![Figure 1. Production and export in Dutch agriculture, 1950 to 1990](image-url)
The latter system was chosen, which included more technological inputs into the greenhouse industry (thermal screens, better greenhouse climate control equipment, soil-less culture systems, etc.). It also meant breeding new varieties, developing better regimes for watering, fertilizing, and insect pest and disease control, and introducing methods to register and compare cultural and economic data between holdings. Moreover, more emphasis was laid on the quality of produce in order to satisfy the buyers and to enhance competitiveness.

This development required a higher level of knowledge by the growers, numerous special courses, adaptation of the advisory system, and last but not least, a tremendous increase in research.

Greenhouse cropping systems changed swiftly, too swiftly for part of the growers, but the competition level was maintained.

In the course of these developments the disadvantages became apparent as well:

- Leakage of excess nutrient solution and pesticides and/or their metabolites through the soil and drainage system to the surface water and soil water.
- Increased vulnerability of the highly technological cropping system.
- A growing feeling among groups of consumers that greenhouse products are acquiring more of an industrial than a natural image.
- Increase of the acreage under glass and its conflicting aspects with the attractiveness of the countryside.

Some favorable consequences may also be mentioned, such as the possibility of recirculating and reusing the excess nutrient-solution, thus avoiding environmental pollution and economizing on raw materials. The improvement of insect pest and disease control regimes led to consequences as described above for crop husbandry. This stimulated the development of biological control systems.

**Animal Husbandry**

The developments in pig husbandry are a good example of intensification in animal production. During the last thirty years a piggery has changed from keeping pigs outdoors (in summertime) in relatively small numbers per farm to year-round indoor operations with large numbers (several hundred) under climate-controlled conditions with well-defined nutritional regimes. Consequently, the pig population of the Netherlands has increased from 2 million in 1950 to 14 million in 1990 (Figure 2).

The forage industry expanded vastly and the meat export industry was able to conquer a fair part of the markets abroad.

The mainly sandy soil regions, where most of these piggeries were started, changed from economically poor to economically well-developed regions.

However, all that glitters is not gold. The dense pig population in one barn or on one farm increases the danger of epidemics. The consequences were and still are at times dramatic for the pig farmer, because large investments and the costs to finance these do not allow him much financial scope to meet great losses. Consequently, the consumption of preventive medicines increased, which sometimes had an adverse effect on the quality of meat.

Besides, huge amounts of pig manure are produced in such piggeries. Pig farmers tend to spread that onto their own fields (grassland, maize fields, and the like), which caused too high concentrations of nitrogen, phosphate, and heavy metals in the soils. The nitrogen leached into groundwater in wintertime, polluting the sources of drinking water, and the phosphate is building up in the soil to saturation levels. This point has been reached on approximately 15 percent of our agricultural land. The NH₃ partly evaporates to the air and precipitates with rain water, thus creating an overdose of nitrogen and acidification, which is especially deleterious in forest soils.

To solve the manure problems, industrial processes are being developed to dry and
pelletize the manure for transport and use elsewhere, but so far they are costly in both capital and energy requirements. Systems are also being developed to distribute the liquid manure to agricultural regions which have a shortage of nutrients. However, transport is expensive, and nutrients in an organic form are insufficiently available to the plants in early spring and are still leaching to deeper ground layers in late autumn and winter.

In order to solve these problems, feeding systems to reduce the mineral content of the manure are being developed, and farmers have to invest in equipment to incorporate manure into the soil instead of spreading on top.

**Political Consequences**

The above mentioned and other similar developments in agriculture, the intensification of industry, transport, recreation, and the strongly increased population density in the Netherlands have moved the government to embark on a policy to protect nature and the environment in such a way that the physical environment and the natural resources are not irrevocably damaged. At the same time, agriculture should become a safe, sustainable, and competitive economic activity.

In recent years a number of policy plans have been adopted by Parliament which require agriculture to greatly reduce emissions to the environment by the year 2000, with an intermediate goal in 1995.

As an example, the following requirements can be mentioned:

- Emission of nitrates to groundwater should be reduced in order to maintain the concentration below 50 milligrams per liter.
- Concentration of nitrogen and phosphorous in surface water may not exceed 2.2 milligrams and 0.15 milligrams per liter respectively.
- In the year 2000, the emission of NH₃ should be less than 30 percent of the amount emitted in 1980.

*Figure 2. Growth in number of pigs in the Netherlands, 1950 to 1990*
- Phosphate inputs into agricultural soils should not exceed output of phosphate through harvested produce.

- Use of pesticides should be reduced by 30 to 35 percent in 1995 and by 50 percent in 2000 compared to the average of the 1984-88 period (measured in kilograms of active ingredient).

- Use of soil disinfectants should be reduced by 80 to 90 percent in the same period, and the emission of pesticides to surface water by 90 percent.

- Concentration of pesticides in groundwater is not allowed to exceed 0.1 micrograms per liter per active ingredient and 0.5 micrograms for all active ingredients.

- Pesticides which are too toxic to specific test organisms, those which are too persistent, and those which leach out too easily, will be banned from the market.

- Energy consumption per unit of produce in greenhouse crops will have to be reduced by half in 2000 in comparison with 1980.

The above-mentioned policy plans and regulations are putting Dutch agriculture under great stress in order to meet these requirements. For agricultural sectors using high investments in their production systems at present, there is no way back. Solutions will have to be found, mainly by means of more advanced technology, more knowledge, and improved management. For the agricultural sector with lower levels of investments, integrated cropping systems and/or extensification may offer solutions. A lot of research, education, and extension work is still to be done.

Conclusions

- Developments in Dutch agriculture have taken place with insufficient knowledge of important side effects.

- Human beings are in general reluctant to reduce their existing levels of material welfare in order to protect nature and the environment in such a way that all present generations and future generations can have there needs fulfilled.

- In most sectors more technology will be needed to redress what developed in a wrong direction in the past.

- In all sectors more knowledge will be required by growers, farmers, advisors, wholesalers, and many others in order to produce and trade at high levels of development without polluting the environment beyond recall.

- Legislation to indicate the limits of pressure on the environment should be decided upon before such limits are exceeded. Incentives and prescriptions to influence social behavior in agriculture should already be available.

- Much research is to be done to assess the stability and health of ecosystems in order to provide a sound scientific base to the legislative limits mentioned above.

- Inevitably, our society will become more complex, more controlled, and more subdued to rules and regulations in order to protect the environment and maintain or create an acceptable level of material welfare for now and the future.

- Such rules and regulations should preferably be drawn up in close cooperation between legislators and agricultural producers. Motivation among producers and their involvement in the search for solutions are a precondition for success of any drastic operation in which they are involved.
The processing of cocoa at origin, especially in Sub-Saharan Africa, has often come up for debate between the consuming countries and the countries of origin. Cocoa producers strongly feel that processing adds value, thus increasing earning power in the face of ever-falling prices of the primary commodity.

In all, four processing factories have been set up in Ghana, two in the western region, and two in the greater Accra region.

The factories are identified by their brand names: CPC (Cocoa Processing Company)-Wam, Takoradi; CPC-Taksi, Takoradi; CPC-Portem-Cocoa, Tema; and CPC-Portem-Confectionery, Tema. The confectionery factory uses the brand name Golden Tree.

Historical Background

Cocoa processing in Ghana was started in 1947 by Gill and Duffus of London, England, with the establishment of West African Mills, Ltd. in Takoradi. Between 1962 and 1964, two other factories were built in Tema and Takoradi to increase the volume of processed cocoa.

CPC-Taksi, Takoradi was wholly owned by the government of Ghana, while the CPC (Portem) was a joint venture between the government and the Drevici Group of companies in Germany. The Portem factory was taken over by the government in 1972, while the Wam factory was fully owned by the government in 1982.

In 1990, the Portem factory was divided into Portem (Cocoa) for primary processing and Portem (Confectionery) to manufacture chocolate and other confectionery items.

By 1978, most of the machinery had become obsolete and very difficult to maintain. Throughput of the factories dropped below break-even points, and rehabilitation was the only remedy. Funding for a project of such magnitude became difficult because of other more pressing national priorities.

Visits to Western cocoa processing machinery manufacturers afforded us the opportunity to select the best and most cost-effective machinery to suit our peculiar operations. Rehabilitation of the factories started in 1984 in phases, and is about 70 percent complete at Portem and Taksi. The Wam factory is being fully rehabilitated. Part of the foreign exchange component is being financed by Messrs. Schroeder of the Hosta Group in Germany. We have, in fact, acquired new machinery with advanced technology from Germany, Italy, Switzerland, and the United Kingdom for our rehabilitation program.

Cocoa Processing Factories in Ghana

There are three cocoa processing factories and one confectionery factory in Ghana. Two factories are in the port city of Takoradi in the western region, and the other cocoa processing factory and the confectionery factory are sited at Tema in the greater Accra region.

For ease of control and effective management, these four factories are grouped to form the Cocoa Processing Company, headed by a managing director. Each factory is headed by a general manager. The company is fully owned by the government of Ghana, with the Ghana Cocoa Board as the sole shareholder.

Isaac K. O. Abbiw is General Manager, Cocoa Processing Company Ltd. (Portem), Tema, Ghana.
Processing Technologies in Ghana

The technologies employed in cocoa processing in Ghana in all four factories have changed over the years.

CPC (Wam)

The objective of building this factory in the 1940s was to process subgrade beans. This therefore influenced the selection of appropriate machinery. Wam used the expeller process to extract cocoa butter, but the by-product (cocoa cake with shells) was not edible by humans.

The process involved steam heating the whole bean at a specified temperature and time, andsubjecting the treated beans to the expeller press process. The extracted cocoa butter contained impurities, and was filtered by means of a filter press. The filtered cocoa butter was of good quality, close to that of prime-pressed butter.

At the moment, the factory has been shut down and rehabilitation is in progress. The new machinery is quite different from the old. There were no bean cleaning machines in the old system, but they are being installed in the new system. The new machinery has been selected such that other oil seeds could be processed. In addition, there will be a refinery and a margarine plant. Unlike the old system, after rehabilitation this factory will process mainly light-crop beans and other oils seeds.

CPC (Taksi) and CPC (Portem-Cocoa)

When these two factories were initially established, the types of machinery chosen were quite different even though they both produced prime-pressed cocoa butter by the hydraulic method, and the by-product of cocoa cake/powder was edible.

The experience and problems encountered in the use of that machinery influenced the selection of the present machinery installed during rehabilitation. At present the two factories use almost the same type of machinery for processing.

In each case the raw beans are cleaned by Buhler (Portem) and Baurmeister (Taksi) cleaning machines, and then stored in silos. Taksi has twelve steel silos, each with a capacity of 100 tonnes, while Portem has nine concrete silos, each with a capacity of 350 tonnes. The cleaned beans are roasted at a specified temperature and time by using a Lehmann KRD continuous roaster. The roasted beans are winnowed to separate the nib (kernel) from the shell. The nibs are then subjected to a three-stage milling process:

- Buhler SCS4 impact breaker and cutting mill which gives a coarse mass of about 10 to 15 percent residue on a 200 mesh sieve.
- Lehmann triple stone mill, which gives a mass of about 4 to 6 percent residue on a 200 mesh sieve.
- Attritor ball mill refiner, which achieves a fineness of between 0.5 to 1.5 percent residue on a 200 mesh sieve.

At Taksi, natural cocoa mass is produced, while at Portem a proportion of the cocoa mass is alkalized. In each case the cocoa mass is stored in tanks and subjected to further heat treatment to reduce the microbial load.

The cocoa mass can either be tempered and packed as liquor or subjected to hydraulic pressing at about 5 atmospheres to release the cocoa butter, leaving a residual cake as the by-product. The butter, which contains some cocoa solids, is centrifuged and filtered.

Portem uses a Carle & Montanari 22-pot press, while Taksi uses 12-pot Baurmeister presses fitted with a Duyvis filling and hydraulic system. The butter is subsequently tempered and packed in 25 kilogram cartons for export. The residual cake is broken into pebble-sized (kibbled cake) and packed in 40 kilogram multiwall paper sacks for export or pulverized into cocoa powder.

CPC (Portem-Confectionery)

It is well known all over the world that Ghana is a major producer of cocoa. Unfortunately, it is a minor consumer of cocoa products. The government of Ghana therefore thought it wise to establish a confectionery
factory at Portem in 1965. The products of this factory have the brand name Golden Tree. The products are chocolate, couverture, and confectionery products like pebbles, instant cocoa powder, and milk and nut chocolate.

COUVERTURE AND CHOCOLATE MANUFACTURE. The plants for the manufacture of the confectionery products were old and obsolete, manual and labor-intensive. With the rehabilitation, automated plants with modern technologies were installed. Unlike the previous years, handling of raw, intermediate, and finished products has been eliminated from the system.

Formulations are made solely from premium Ghana cocoa liquor, cocoa butter, milk powder, sugar, lecithin, and flavoring agents mixed in the right proportions, depending on the recipe. They are then milled and refined on two- and five-roller refiners. They are then conched with a double back-overthrow system. This has reduced the conching time considerably, about six hours.

Liquid couverture so prepared is tempered and cast into 25-kilogram cartons. Plans are afoot to mold the couverture into smaller weight sizes such as 1, 2.5, and 5 kilograms. The chocolate passes through the same processes as the couverture, and after tempering is molded into sizes of 17.5, 37.5, 20, 50, and 80 grams.

CONFECTIONERY PRODUCTION. This is a process whereby roasted groundnuts (peanuts) are coated with chocolate, bound together by food-grade corn starch, and coated with sugar syrup. The groundnuts are colored and polished. The ultimate mixture of the colors has a good aesthetic appeal, especially to children. Much handling is encountered in the production of pebbles, but there are plans to improve this system by automation.

INSTANTIZING COCOA. After processing the raw cocoa beans into cocoa butter, the by-product of cocoa cake/powder is obtained. The marketability of this product is a problem, and every effort is being made to find alternative uses.

An instant cocoa powder plant has been installed during the rehabilitation, at least to reduce the back-log of cocoa cake/powder. Alkalized cocoa powder is formulated with sugar, milk powder, vanillin, and lecithin, and subjected to the instantizing process. It is then packed in 125-, 250-, and 500-gram containers.

Experience, Problems, and Solutions Using Advanced Processing Technologies

A number of different factors all affect the processing of cocoa beans.

Cleaning

When Wam was first established, it was thought that cleaning the beans before the expeller process was unnecessary. The frequent wear and tear and replacement of parts led to the inclusion of bean cleaning machines in the rehabilitation program.

Storage Silos

No problem has been encountered by Taksi during the 28 years it used the steel silos. However, during the same period, Portem used concrete silos, but only three of the nine silos can now be used. The others are cracked, and moisture from the outside raises the moisture content of the beans and promotes mold growth. It has also been noted that for beans in the silos to maintain their quality for long periods, cold air should be circulated to maintain the beans at the correct temperature and humidity.

Roasting

Much experience has been gained in the roasting process. At Taksi, the first roasters used were Sirocco batch roasters which were manually controlled. This was labor intensive, and the roasting parameters were difficult to control. This often led to over- or under-roasting, which resulted in non-uniform product. This problem has been solved by the acquisition of Lehmann continuous hot air roasters.
Portem also used continuous steam roasting. In this process nibs were roasted, which meant that raw beans were winnowed before getting the nibs. Experience has shown that winnowing of raw beans is not as efficient as winnowing roasted beans. We get high losses of nibs into the shell, that is, losing product in the process. Again, we get more shell mixed with the nibs resulting in a high microbial content in the cocoa liquor and cake.

With time, it was observed that steam roasting resulted in high production costs. This has been solved by using the new technology of hot air and continuous roasting, which is also less labor intensive.

**Milling**

The old milling system used two stages for milling, pre-grinders and refiners. The old refiners used four rollers, which needed considerable expertise to adjust for fineness. It tended to give the resulting mass much higher residual content than expected. This meant higher retention of fat in the cake, with a lower butter yield. It also affected the quality of the powder pulverized from the cake. The selection of the present milling system also has its problems. Superfine mass is produced, which tends to block the press filter sieves, resulting in high fat content of the cake and leakage of mass from the sieves.

Three-stage milling is ideal for liquor production for chocolate manufacture. However, for butter production, a two-stage milling system involving a coarse grinder and a stone mill produces no superfine mass which could be pressed without blocking the press sieves. Two lines are therefore envisaged to utilize the inherent properties of the ball mills for the superfine mass and the stone mills for press mass.

**Pressing**

The pressing cycle for the old hydraulic system of the Bauermeister presses could take 30 to 35 minutes. Both Duyvis of Holland and Bauermesister of Germany have developed new hydraulic pumps which attain three pressing cycles per hour. The Taksi factory has availed itself of this new development and has installed the Duyvis hydraulic system.

**Packaging**

Packaging poses a big problem in the producer countries. At present both butter and liquor are tempered, packed in cartons, and stored in air conditioned rooms at about 18 to 22°C. For effective cooling and solidifying after tempering, cooling tunnels have to be provided, especially for liquor. This is extra cost to the company. Processors in temperate countries do not encounter this problem.

Even though we are blocking our cocoa butter and liquor in 25-kilogram polythene-lined cartons, we are aware of the gradual shift from this method to deliveries by tankers. Since we sell our products far and wide, it would be impractical to consider this method now.

Up to the mid-1980s, we had the problem of obtaining the packaging materials like multiwall paper sacks for the cake and powder, and cartons for butter and liquor packing, because they were all imported. The government has encouraged local investment in this direction and all our packaging material is now obtained locally.

**Spare Parts**

With the use of cocoa processing machinery in a basically agricultural country like Ghana, there are bound to be problems of acquisition of spare parts and capital items. Ghana has balance of payments problems and its scarce foreign exchange resources have to be controlled and critically monitored. Until recently, one had to obtain import license before letters of credit could be established for even a minor item. This could take months and even years, resulting in a complete breakdown of machinery, thus adversely affecting both quality and quantity of products produced. Since both spare parts and capital items are also imported from developed countries, they tend to be more expensive.
**After-Sales Service**

The suppliers of our processing machinery are all based in developed countries. We do not benefit from quick after-sales service. Maintenance of the machinery is done by our technical staff. We are therefore forced to invest in large stocks of spare parts, thereby locking up capital.

**Quality Problems**

The hot and humid weather of Ghana is favorable for microbial growth. This results in mold growing on products when they are stored for long periods in the warehouse under normal atmospheric conditions, especially cocoa cake/powder and cocoa liquor. This problem was overcome by the installation of an air conditioning system at the warehouses which reduces the ambient temperature to about 18 to 20°C.

Hygiene classes were introduced to all the factory staff, including the Engineering Department. This brought a sense of awareness to the workers and a high standard of personal hygiene was kept at the factory. The workers also realized the importance of producing high-quality products since their job security depended on it.

When the factories were initially set up, only physical and chemical analyses of the raw materials, and intermediate and finished products were conducted. There was no facility for microbial examination of the products.

When we started getting complaints from our overseas customers, we realized the importance of setting up the microbiological laboratories. This has gone a long way in solving our microbiological problems.

**Marketing**

Marketing of our products has also posed a problem. Due to the distances between us (the producers) and buyers of our products, forward sales are made which invariably attract lower prices than spot sales. In addition, we have to store the products for a period of time, thus incurring storage, handling, and insurance costs.

**By-Products**

While there is a ready market for the main products, cocoa butter and liquor, there is a glut of cocoa cake/powder and cocoa cake with shell on the world market. This problem is being solved with the establishment of Portem (Confectionery) to develop and encourage the local consumption of cocoa powder and confectionery products. Research work is also being conducted into alternative uses of cocoa cake with shell for local uses.

**Training**

When the factories started operating, all sorts of problems were encountered in both plant operation and general performance of the workers. A crash training program was drawn in which all workers were involved, both in-service and external training programs. Some members of staff were sent to other cocoa processing factories, cocoa processing machinery manufacturers, conferences, seminars, workshops, and even to pursue post-graduate studies. This transformed the performance of the workers within a short period of time. Since then much emphasis has been placed on training to ensure high productivity.

**Quality Assurance of Processed Cocoa**

All the cocoa processing factories in Ghana are backed by first-class, well-equipped quality control laboratories with highly trained, qualified technical staff. Physical, chemical, and microbiological checks and analyses are conducted on the raw material and intermediate products to ensure high-quality end products. Our standards and specifications are based on the joint FAO/WHO Food Standards Programme of the Codex Alimentarius Commission.

In addition, measures have been taken to ensure effective monitoring of our products by engaging the services of internationally
recognized organizations like the Ghana Food Research Institute and the Ghana Standards Board to cross-check the quality of our products in addition to using our own laboratory facilities. This is also an indirect check on our own quality control personnel to produce true and reliable reports.

**World Bank Policies**

The World Bank’s negative stand on the rehabilitation of our processing factories (because they were not viable) almost collapsed the industry but for the courage and foresight of the government of Ghana.

The government provided funds in phases to complete about 70 percent of the rehabilitation program. Ironically, with the remaining 30 percent of the rehabilitation, the World Bank is insisting that unless CPC is privatized, it cannot avail itself of the EEC’s Stabex Fund.

**Conclusions**

Raw cocoa beans have been produced by Ghana since the early 1940s for export to developed countries. Cocoa is the life-blood of Ghana’s economy. The government has formulated plans and programs to safeguard this major cash crop.

A further step has been taken to process part of the crop to increase earnings. Ghana is in a position to make available on the world market high-quality, semi-finished products like cocoa butter, cocoa liquor, and cocoa cake and powder, as well as confectionery products and high cocoa content couverture. Due to the high quality of our products, CPC has three times won medals in the international Monde Selection competition at Brussels, Belgium for its chocolate and confectionery products, taking first position each time it entered.

In 1980, CPC won four gold medals and one silver. In 1982 it again won four gold medals and two silver. In 1989, CPC won five gold medals and one silver. It continues to win medals at international trade fairs organized in the USA, Bulgaria, Japan, etc.

We have come a long way in the processing of cocoa and cocoa products. We once encountered problems of hygiene and microbial contamination and lack of technical know-how. Some of the problems have been traced to old and obsolete machinery.

Investments have been made for the acquisition of advanced technologies from developed countries for the industry. Technical know-how and experience have been acquired after 40 years of cocoa processing. The industry has therefore come to stay and must be further encouraged to improve its performance.
Factories in cocoa-producing countries process cocoa beans into mass, butter, and cake, and operate with a view to export. They must therefore be in a position to compete with factories in consuming countries, and have the flexibility to respond effectively to market opportunities. They have a definite role to play to benefit the economy of the countries in which they are located. Nevertheless, they face a number of serious difficulties.

Role of Factories in the Economy of Producing Countries

Factories affect the economies of producing countries in several different ways.

Industrial Activity Significantly Adds Value

This consists first of the direct value-added as generally defined in national accounting systems: wages, taxes, duties, and financial charges, together with the net result obtained by the undertaking.

Besides this direct value-added, there is the indirect value acquired through the work and services of subcontractors or suppliers. This includes foreign supplies and services, transport, and the cost of packaging, which will be supplied mostly by national firms.

Contributions to the Development of Industrial Centers

Subcontracting, including civil engineering, electrical and mechanical work, general or specific services, phytosanitary treatment, etc., all benefit an industrial center.

In addition, the transfer of advanced technology for sufficiently large units enables the most appropriate process to be used for a given type of cocoa.

Wherever their location, cocoa factories must produce at a quality level consistent with the most stringent standards imposed by international customers and with uniform quality, regardless of the raw material used, to assure trade outlets. Furthermore, constant efforts must be made to find ways of achieving the best possible yields from the raw material, together with the lowest processing costs, in order to ensure that the operation is financially viable. This calls for a process involving, in particular:

- Thorough cleaning of beans to reduce the proportion of insect fragments.
- Pre-roasting beans to ensure better separation of shell and bean (a quality factor) and to reduce the insect fragments, which also improves processing of substandard cocoas.
- Constant roasting to develop the organoleptic properties of products, whatever the state of the processed beans (fresh or otherwise).
- Sterilization of products which does not affect the quality of cocoa butter.
- Refining to improve the grain size of products.

Production management and organization must also determine in advance the quality of the goods produced on the basis of the raw material in stock, at the same time monitoring the warehouse.

All of these objectives call for substantial investment and the introduction of suitable

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production techniques which will enrich the industrial experience of the countries concerned.

**Social Role**

The social role of factories takes the form of:

- Substantial recruitment programs for managerial staff, supervisors, and skilled and unskilled workers at the national level.
- Employment of a large work force not only for production and maintenance, but also for administration and commercial aspects, which is a significant total wage bill.
- Development of numerous technical, administrative, and commercial training programs, together with in-service courses for a wide range of disciplines.

**Utilization of Poorer-Quality Cocoa**

In all producing countries there is a proportion of substandard beans, defective beans falling outside the international classifications “good fermented” and “fair fermented,” and small beans, those with a count of more than 105 per 100 grams. Such proportions vary from one country to another.

By absorbing such cocoa, factories actively promote the policy of improving the quality of exported beans and obtain a premium on such cocoa. Furthermore, if poorer quality beans were put on the market, they would be purchased only after application of a quality discount, which would be that much larger, given the fact there has been a cocoa surplus for the last sixty years.

**Extend the Range of Exported Products**

The tonnage processed by these factories is sold as semi-finished products. This means that the volume of unprocessed beans exported is reduced and, because less of the raw material is sold, its price can be raised.

**Difficulties Currently Facing Factories**

Cocoa-processing factories face five disadvantages:

**Tied to One Origin**

Unlike their European competitors, they are unable to:

- Mix origins according to the taste and color specifications of their customers, which prevents them from obtaining the most profitable selling price.
- Draw supplies from the cheapest sources or from those with the best quality/price ratio. Being tied to their local origin, they are inevitably affected by any problems arising in connection with that origin.
- Become more involved downstream by engaging in further processing, producing chocolate powders and coatings with a higher value-added.

**More Expensive Processing Costs Compared to European Factories**

Higher processing costs are caused by:

- Distance from customers, which means having a more complete manufacturing process, necessarily involving solidification to guarantee delivery of products, and higher distribution costs.
- Distance from suppliers, which increases investment and maintenance costs, if only in terms of transport and assembly expenses.
- Administrative constraints and formalities, for example, in connection with customs clearance of imports and exports.

As a result, costs are higher for packaging, maintenance, services, subcontracting, and amortization. Factories more geared to export feel this handicap more keenly.
Distance from Customers

In addition to higher costs for solidification and distribution, distance from customers means:

- Less effective service since deliveries to customers cannot be as punctual from factories in producing countries as they are from European factories, plus the fact that because products are solidified, customers are obliged to melt them again, thereby incurring an additional expense.
- Less commercial flexibility since factories in the country of origin lose opportunities for both nearby and very forward sales.

Use of Substandard Beans

For factories which process substandard beans:

- Productivity is lost because the manufacturing process takes longer when defective beans are used.
- Additional costs occur because the process has to be adapted to the type of beans used, or more elaborate processes such as butter deodorizing must be employed.
- Waste may be very extensive, especially in the case of small beans, and primarily affects cocoa butter, the semi-finished product with the highest commercial value.
- Greater difficulty in meeting the quality standards of international customers.

Supply of Beans

The supply of beans affects the overall operation because:

- European factories are in a position to obtain supplies at any time and of practically any origin from places such as Amsterdam, and therefore have greater flexibility.
- Factories in producing countries, however, are dependent for their supplies on the cocoa policy of national authorities and may, therefore, be subject to restrictions.

Specific Constraints Affecting Individual Producing Countries

Producing countries are affected by higher costs for certain operational factors such as energy (the kilowatt is twice as expensive in some French-speaking countries as it is in Europe), and by interest rates and customs duties on imports of equipment or spare parts. In this case, exemptions under preferential taxation arrangements (priority agreements or free zone) would constitute only a return to normal practice rather than any advantage. Factories may carry much larger stocks than their European competitors unless corrective measures are taken because the bean harvest is often concentrated into a few months of the year, for example, on the coast of West Africa (unlike Malaysia or Brazil).

These peculiarities demonstrate that it is possible to generalize about the constraints on the processing industry in producing countries.

Conclusion

If processing factories in producing countries are to operate satisfactorily at a competitive level, they must have a number of guarantees, including:

- Offsetting additional operating costs and the constraints resulting from the use of substandard cocoa.
- Assured supplies of beans and exports of products, with the possibility of releases on both nearby and forward positions so as to operate at full capacity and develop trade flows.
- The possibility of increasing activity in relation to the market in order to cover fixed operating costs more effectively and increase productivity to levels comparable with those of competing factories.
- Durable and stable conditions.

It can be concluded, on the basis of the previous considerations, that the development of a primary processing industry in a producing country represents a considerable cost in terms
both of investment, together with associated financing problems, and of operational assistance.

Over-development of the processing industry would be reflected in the selling price of the semi-finished products in that it would increase the grinding over-capacity at a world level. It is reasonable, therefore, for cocoa-producing countries to maintain a fair balance between domestic processing and export of the unprocessed raw material.
International edible and non-edible oil markets continue to be speculative, with large swings in prices. Such swings become more pronounced in South Asian countries, where domestic production has to be augmented by imports which fluctuate due to the poor balance of payments position.

In most South Asian countries, vegetable oil is predominantly produced from annual crops cultivated on rainfed lands. Farmers use limited inputs, and often rely on obsolete production systems. Oil production is generally considered in isolation rather than as an integrated oil-oil meal-protein system. Technology transfer mechanisms are generally slow, and the limited resources available for research and development are mostly directed to food crops. The protection, processing, storage, and marketing facilities in production areas also lack development. The result is that progress is slow in vegetable oil production in the region.

During the 1990s, population growth is expected to slow while growth in income continues to rise. Because oil consumption is much more income elastic and demand is more responsive to faster income growth, oil production and availability would be required to grow faster to keep pace with consumption requirements. In this endeavor, competition among commodities, the relative levels of technology available, and national policies commensurate with the priorities would be the determinants.

In simple terms, agriculture relies on the ability of plants to convert solar energy into products useful to mankind. During the process, the interaction of the biological system with the environment determines the final production per unit of area, input, and time. Crops and tailor-made varieties need to be chosen to make the best of the environment prevailing in the region. Subsequently, processing and value additions should be made to match the demands of the market. The farmer should get a price that provides him with an incentive to produce more. This would call for an effective flow of market forces, with free flow of technology through the end-product chain.

**Oil-Yielding Crops of the Region**

In the South Asian countries, groundnut (*Arachis hypogaea*), rapeseed-mustard (*Brassica juncea*, *Brassica campestris* var brown sarson, yellow sarson, and toria, *Brassica napus*, *Eruca sativa*), sesame (*Sesamum indicum* syn *Sesamum orientale*), soyabean (*Glycine max* syn *glycine soya*), sunflower (*Helianthus annuus*), safflower (*Carthamus tinctorius*), niger (*Guizotia abyssinica*), linseed (*Linum sitatissimum*), and castor (*Ricinus communis*) predominate. All except linseed and castor are used primarily for edible purposes.

Besides these nine oilseeds, coconut (*Cocos nucifera*) cultivation has long been important. Recently oil palm (*Elaeis guineensis*) plantations have been initiated in some pockets. There are also over 100 oil-yielding forest tree species, and a few of them are used for oil production. Apart from these primarily oil-bearing annuals and perennials, cotton, paddy, maize, etc. are also available for augmenting the vegetable oil supply.

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*Mangal Rai is Assistant Director General (Oilseeds), Indian Council for Agricultural Research, New Delhi.*
Table 1. Area, production, and yield of nine oilseed crops

<table>
<thead>
<tr>
<th>Year</th>
<th>Area (million ha)</th>
<th>Production (million tonnes)</th>
<th>Yield (kg/ha)</th>
<th>Percent under irrigation</th>
</tr>
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<td>5.23</td>
<td>519</td>
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<tr>
<td>1950-51</td>
<td>10.73</td>
<td>5.16</td>
<td>481</td>
<td>-</td>
</tr>
<tr>
<td>1951-52</td>
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<td>5.03</td>
<td>430</td>
<td>-</td>
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<td>11.18</td>
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<td>502</td>
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<td>493</td>
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<td>6.85</td>
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<td>4.8</td>
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<td>1969-70</td>
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<td>7.73</td>
<td>522</td>
<td>6.1</td>
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<td>16.64</td>
<td>9.63</td>
<td>579</td>
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<td>17.27</td>
<td>9.08</td>
<td>526</td>
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<td>15.79</td>
<td>7.14</td>
<td>452</td>
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<td>1973-74</td>
<td>16.90</td>
<td>9.39</td>
<td>555</td>
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<td>17.31</td>
<td>9.15</td>
<td>529</td>
<td>9.2</td>
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<td>16.92</td>
<td>10.61</td>
<td>627</td>
<td>7.9</td>
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<td>1977-78</td>
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<td>1979-80</td>
<td>16.94</td>
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<td>1981-82</td>
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<td>639</td>
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<td>1982-83</td>
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<td>563</td>
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<td>1983-84</td>
<td>18.69</td>
<td>12.69</td>
<td>679</td>
<td>16.7</td>
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<td>1984-85</td>
<td>18.92</td>
<td>12.95</td>
<td>684</td>
<td>18.3</td>
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<td>1985-86</td>
<td>19.02</td>
<td>10.83</td>
<td>570</td>
<td>16.0</td>
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<td>1986-87</td>
<td>18.63</td>
<td>11.27</td>
<td>605</td>
<td>18.8</td>
</tr>
<tr>
<td>1987-88</td>
<td>20.13</td>
<td>12.65</td>
<td>629</td>
<td>NA</td>
</tr>
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<td>1988-89</td>
<td>21.89</td>
<td>18.03</td>
<td>824</td>
<td>NA</td>
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<td>1989-90</td>
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<tr>
<td>1990-91</td>
<td>24.01</td>
<td>18.46</td>
<td>767</td>
<td>NA</td>
</tr>
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Note: Data for 1949-50 to 1969-70 are for only groundnut, castor, sesame, rapeseed-mustard, and linseed.

Indian Scenario

During the period 1949-50 to 1988-89, the annual growth rate of oilseed production was 2.04 percent, while the growth rate of cereals was 2.97 percent. However, the increase in seed yield was only 0.82 percent and that of cereals 1.91 percent. With the setting up of the Technology Mission on Oilseeds (TMO), production went up to 18.46 million tonnes during 1990-91 compared with 11.27 million tonnes in 1986-1987 (Table 1). The major gains were due to enhanced yields rather than area expansion as in the previous three decades. During the 1980s, the compound growth rate of area and yield of nine annual oilseeds was 2.48 and 2.58 percent respectively, reflecting an annual growth in production of 5.4 percent. Such a spectacular achievement was widely acknowledged, especially as 80 percent of oilseeds were grown as rainfed crops.

In India over 200 varieties and hybrids of different crops are available for commercial exploitation. Demonstrations conducted on farmers' fields showed that untapped yield reservoirs are large (Table 2). The benefit to cost ratio under rainfed situations was as high as 8.21 for safflower and 9.27 for groundnut (Table 3). The genetic potential of the available varieties is two to four times the current national and state average yields.

During the 1980s, the availability of vegetable oils was higher than ever before, but the demand outpaced supply, with the result that prices rose sharply (Tables 4 and 5). After TMO was established with an integrated approach, there was a decrease in the imports of edible oils, while the exports of oil meals, oilseeds and minor oils had more than offset the value of the imports (Table 6).

The export of hand-picked and selected (HPS) groundnut will not make headway until the high aflatoxin content is taken care of. Similarly, the export of rapeseed-mustard seed meal is not likely to pick up unless its glucosinolates are removed. In the solvent extraction of oil from soyabean, the hexane left in the soya meal, which contains 50 to 55 percent protein, would restrict the diversification of its products. As a result, the farmer quite often gets only the value of the by-product rather than the main product. The case of linseed is similar, where valuable dry stalk goes to waste, and as a result, fiber worth Rs.500 million is imported every year. Further, linseed pulp could effectively be used for currency-grade papermaking. Nevertheless, for want of industrial back-up, this sector remains unexploited and the country continues to resort to importing high-quality paper to meet its domestic requirements.

Among oil-bearing plantation crops, oil palm can yield an average of 4 tonnes of oil per hectare every year. Suitable oil palm material should be identified and potential pockets need to be explored for its cultivation on a long-term sustainable basis. In view of the slow progress in the production of oilseeds in the country, the government instituted a Technology Mission on Oilseeds in May 1986, as a task force of all concerned government agencies. On the recommendations of this mission, the government has approved an integrated policy on oilseeds production, import, distribution, and pricing to accelerate self-reliance.

The basic objective of the mission was set in February 1986, when the Prime Minister, defined the scope and strategy of the mission:

One of our biggest problems today in the agricultural sector is oilseeds. We are setting up a thrust mission for oilseeds production. When we talk of a mission, we mean an exercise starting from the engineering of the seeds and finishing with the finished products of the vegetable oil which could be delivered to the consumer. We would like to put one person in charge of such a mission, with full funding, with no restrictions on him, whether bureaucratic or otherwise. The only limits will be certain achievements which must come within a certain time frame. This will cut across a number of Ministries where we find a lot of hassles and projects getting stalled because the interaction is not smooth enough.
Table 2. Untapped oilseed yield reservoir available with currently recommended improved production and protection technologies

<table>
<thead>
<tr>
<th>Crop</th>
<th>State</th>
<th>Untapped yield reservoir</th>
<th>At farmer level</th>
<th>At state/district level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Groundnut</td>
<td>Gujarat</td>
<td></td>
<td>413</td>
<td>407</td>
</tr>
<tr>
<td>(kharif rainfed)</td>
<td>Maharashtra</td>
<td></td>
<td>45</td>
<td>330</td>
</tr>
<tr>
<td></td>
<td>Karnataka</td>
<td></td>
<td>350</td>
<td>420</td>
</tr>
<tr>
<td></td>
<td>Tamil Nadu</td>
<td></td>
<td>572</td>
<td>526</td>
</tr>
<tr>
<td></td>
<td>Andhra Pradesh</td>
<td></td>
<td>333</td>
<td>318</td>
</tr>
<tr>
<td>Groundnut</td>
<td>Tamil Nadu</td>
<td></td>
<td>1,250</td>
<td>584</td>
</tr>
<tr>
<td>(rabi/summer</td>
<td>Andhra Pradesh</td>
<td></td>
<td>500</td>
<td>511</td>
</tr>
<tr>
<td>irrigated)</td>
<td>Karnataka</td>
<td></td>
<td>500</td>
<td>617</td>
</tr>
<tr>
<td></td>
<td>Maharashtra</td>
<td></td>
<td>1,350</td>
<td>783</td>
</tr>
<tr>
<td></td>
<td>Gujarat</td>
<td></td>
<td>475</td>
<td>335</td>
</tr>
<tr>
<td></td>
<td>Orissa</td>
<td></td>
<td>500</td>
<td>523</td>
</tr>
<tr>
<td>Sesame</td>
<td>Madhya Pradesh</td>
<td></td>
<td>337</td>
<td>250</td>
</tr>
<tr>
<td>(kharif rainfed)</td>
<td>Rajasthan</td>
<td></td>
<td>175</td>
<td>112</td>
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<td></td>
<td>Maharashtra</td>
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<td>Gujarat</td>
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<td></td>
<td>Orissa</td>
<td></td>
<td>238</td>
<td>187</td>
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<tr>
<td></td>
<td>Tamil Nadu</td>
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<td>208</td>
<td>86</td>
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<tr>
<td>Sesame</td>
<td>Andhra Pradesh</td>
<td></td>
<td>450</td>
<td>181</td>
</tr>
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<td>(rabi/summer</td>
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<td>373</td>
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<td>Orissa</td>
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<td>1,090</td>
<td>990</td>
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<tr>
<td>(kharif rainfed)</td>
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<tr>
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<td>Rajasthan</td>
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<td>Castor</td>
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<td>323</td>
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<td>(kharif irrigated)</td>
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<td></td>
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Table 2 (continued)

<table>
<thead>
<tr>
<th>Crop</th>
<th>State</th>
<th>Untapped yield reservoir</th>
<th>At farmer level</th>
<th>At state/district level</th>
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<tr>
<td></td>
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<td></td>
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<td>1  2</td>
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<tr>
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<td>227</td>
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<tr>
<td></td>
<td>Maharashtra</td>
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<td>194</td>
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<td>Madhya Pradesh</td>
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<td>182</td>
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<tr>
<td></td>
<td>Orissa</td>
<td>175</td>
<td>400</td>
<td>131</td>
</tr>
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<td>Niger (kharif rainfed)</td>
<td>Maharashtra</td>
<td>195</td>
<td>194</td>
<td>264</td>
</tr>
<tr>
<td></td>
<td>Madhya Pradesh</td>
<td>290</td>
<td>182</td>
<td>231</td>
</tr>
<tr>
<td></td>
<td>Orissa</td>
<td>175</td>
<td>400</td>
<td>131</td>
</tr>
<tr>
<td>Rapeseed-mustard (irrigated)</td>
<td>Rajasthan</td>
<td>500</td>
<td>468</td>
<td>2,670</td>
</tr>
<tr>
<td></td>
<td>Madhya Pradesh</td>
<td>525</td>
<td>443</td>
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</tr>
<tr>
<td></td>
<td>Uttar Pradesh</td>
<td>980</td>
<td>462</td>
<td>2,131</td>
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<td>Punjab</td>
<td>400</td>
<td>293</td>
<td>1,031</td>
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<td></td>
<td>Haryana</td>
<td>800</td>
<td>363</td>
<td>2,225</td>
</tr>
<tr>
<td>Rapeseed-mustard (irrigated)</td>
<td>Uttar Pradesh</td>
<td>620</td>
<td>485</td>
<td>1,006</td>
</tr>
<tr>
<td></td>
<td>Himachal Pradesh</td>
<td>367</td>
<td>352</td>
<td>450</td>
</tr>
<tr>
<td></td>
<td>Madhya Pradesh</td>
<td>187</td>
<td>219</td>
<td>367</td>
</tr>
<tr>
<td></td>
<td>West Bengal</td>
<td>420</td>
<td>340</td>
<td>555</td>
</tr>
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<td></td>
<td>Assam</td>
<td>338</td>
<td>265</td>
<td>562</td>
</tr>
<tr>
<td>Rapeseed-mustard (irrigated)</td>
<td>Uttar Pradesh</td>
<td>620</td>
<td>485</td>
<td>1,006</td>
</tr>
<tr>
<td></td>
<td>Himachal Pradesh</td>
<td>367</td>
<td>352</td>
<td>450</td>
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<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td>West Bengal</td>
<td>420</td>
<td>340</td>
<td>555</td>
</tr>
<tr>
<td></td>
<td>Assam</td>
<td>338</td>
<td>265</td>
<td>562</td>
</tr>
<tr>
<td>Safflower (rainfed)</td>
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<td>340</td>
<td>325</td>
<td>782</td>
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<tr>
<td></td>
<td>Andhra Pradesh</td>
<td>350</td>
<td>443</td>
<td>550</td>
</tr>
<tr>
<td>Linseed (irrigated)</td>
<td>Uttar Pradesh</td>
<td>655</td>
<td>298</td>
<td>1,753</td>
</tr>
<tr>
<td></td>
<td>Himachal Pradesh</td>
<td>613</td>
<td>472</td>
<td>616</td>
</tr>
<tr>
<td></td>
<td>Rajasthan</td>
<td>360</td>
<td>330</td>
<td>379</td>
</tr>
<tr>
<td></td>
<td>Punjab</td>
<td>155</td>
<td>226</td>
<td>718</td>
</tr>
<tr>
<td>Linseed (irrigated)</td>
<td>Uttar Pradesh</td>
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<td>308</td>
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<td>401</td>
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<td></td>
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<td>169</td>
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<tr>
<td></td>
<td>Punjab</td>
<td>200</td>
<td>246</td>
<td>644</td>
</tr>
</tbody>
</table>

1. Maximum realizable yield gap equals maximum yields achieved with improved technologies on farmers' fields minus maximum yields obtained with prevailing farmer practices.

2. Mean realizable yield gap equals mean yields realizable with improved technologies minus mean yields obtained with prevailing farmer practices.

Source: Indian Council on Agricultural Research.
Table 3. Economics of improved technologies in various annual oilseed crops under farmer conditions

<table>
<thead>
<tr>
<th>Crop</th>
<th>Rainfed Additional investment (Rs/ha)</th>
<th>Irrigated Incremental benefit-cost ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>farmer practice</td>
<td>Rainfed</td>
</tr>
<tr>
<td>Groundnut</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kharif</td>
<td>420-2,080</td>
<td></td>
</tr>
<tr>
<td>Rabi/summer</td>
<td>-</td>
<td>668-1,998</td>
</tr>
<tr>
<td>Sesame</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kharif</td>
<td>225-1,048</td>
<td></td>
</tr>
<tr>
<td>Rabi/summer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soybean</td>
<td>512-1,815</td>
<td></td>
</tr>
<tr>
<td>Castor</td>
<td>276-966</td>
<td></td>
</tr>
<tr>
<td>Niger</td>
<td>399-803</td>
<td></td>
</tr>
<tr>
<td>Sunflower</td>
<td>215-1,523</td>
<td></td>
</tr>
<tr>
<td>Rapeseed-mustard</td>
<td>455-1,063</td>
<td></td>
</tr>
<tr>
<td>Linseed</td>
<td>396-1,344</td>
<td></td>
</tr>
</tbody>
</table>

Source: Indian Council of Agricultural Research

Table 4. Minimum support prices of oilseeds as recommended by Commission for Agricultural Costs and Prices (R), and as announced by the Government of India (A). All figures are rupees per 100 kilograms

<table>
<thead>
<tr>
<th>Crop year</th>
<th>Groundnut</th>
<th>Soyabean</th>
<th>Soyabean</th>
<th>Sunflower</th>
<th>Rapeseed-mustard</th>
<th>Toria</th>
<th>Safflower</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R</td>
<td>A</td>
<td>R</td>
<td>A</td>
<td>R</td>
<td>A</td>
<td>R</td>
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<tr>
<td>1976-77</td>
<td>140</td>
<td>140</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>150</td>
</tr>
<tr>
<td>1977-78</td>
<td>155</td>
<td>160</td>
<td>145</td>
<td>145</td>
<td>-</td>
<td>-</td>
<td>165</td>
</tr>
<tr>
<td>1978-79</td>
<td>170</td>
<td>175</td>
<td>155</td>
<td>175</td>
<td>-</td>
<td>-</td>
<td>175</td>
</tr>
<tr>
<td>1979-80</td>
<td>175</td>
<td>190</td>
<td>175</td>
<td>175</td>
<td>-</td>
<td>-</td>
<td>175</td>
</tr>
<tr>
<td>1980-81</td>
<td>206</td>
<td>206</td>
<td>183</td>
<td>183</td>
<td>-</td>
<td>-</td>
<td>183</td>
</tr>
<tr>
<td>1981-82</td>
<td>273</td>
<td>270</td>
<td>213</td>
<td>210</td>
<td>234</td>
<td>230</td>
<td>253</td>
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<tr>
<td>1982-83</td>
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<td>295</td>
<td>220</td>
<td>220</td>
<td>245</td>
<td>245</td>
<td>250</td>
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<tr>
<td>1983-84</td>
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<td>315</td>
<td>230</td>
<td>230</td>
<td>255</td>
<td>255</td>
<td>275</td>
</tr>
<tr>
<td>1984-85</td>
<td>340</td>
<td>340</td>
<td>240</td>
<td>240</td>
<td>265</td>
<td>265</td>
<td>325</td>
</tr>
<tr>
<td>1985-86</td>
<td>350</td>
<td>350</td>
<td>240</td>
<td>250</td>
<td>265</td>
<td>275</td>
<td>325</td>
</tr>
<tr>
<td>1986-87</td>
<td>370</td>
<td>370</td>
<td>250</td>
<td>255</td>
<td>275</td>
<td>290</td>
<td>350</td>
</tr>
<tr>
<td>1987-88</td>
<td>390</td>
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<td>390</td>
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<tr>
<td>1988-89</td>
<td>430</td>
<td>430</td>
<td>275</td>
<td>275</td>
<td>320</td>
<td>320</td>
<td>450</td>
</tr>
<tr>
<td>1989-90</td>
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<td>500</td>
<td>305</td>
<td>325</td>
<td>350</td>
<td>370</td>
<td>500</td>
</tr>
<tr>
<td>1990-91</td>
<td>580</td>
<td>580</td>
<td>350</td>
<td>350</td>
<td>400</td>
<td>400</td>
<td>600</td>
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</table>

Source: Technology Mission on Oilseeds.
Table 5. Index of wholesale prices for edible oils and other selected food items, 1973-74 to 1988-89 (1970-71 = 100, average of weekly prices)

<table>
<thead>
<tr>
<th>Year</th>
<th>Edible oils</th>
<th>Rice</th>
<th>Wheat</th>
<th>Pulses</th>
<th>Tea</th>
<th>Sugar, khandarsi, and gur</th>
<th>Total food articles</th>
<th>Total commodities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973-74</td>
<td>148</td>
<td>140</td>
<td>108</td>
<td>177</td>
<td>111</td>
<td>192</td>
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<td>1974-75</td>
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<td>1975-76</td>
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<td>182</td>
<td>175</td>
<td>214</td>
<td>164</td>
<td>173</td>
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<tr>
<td>1976-77</td>
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<td>157</td>
<td>152</td>
<td>146</td>
<td>214</td>
<td>218</td>
<td>155</td>
<td>177</td>
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<td>1977-78</td>
<td>176</td>
<td>162</td>
<td>157</td>
<td>215</td>
<td>252</td>
<td>185</td>
<td>174</td>
<td>186</td>
</tr>
<tr>
<td>1978-79</td>
<td>135</td>
<td>161</td>
<td>154</td>
<td>247</td>
<td>212</td>
<td>147</td>
<td>172</td>
<td>186</td>
</tr>
<tr>
<td>1979-80</td>
<td>193</td>
<td>184</td>
<td>161</td>
<td>244</td>
<td>233</td>
<td>231</td>
<td>187</td>
<td>218</td>
</tr>
<tr>
<td>1980-81</td>
<td>228</td>
<td>206</td>
<td>176</td>
<td>323</td>
<td>227</td>
<td>377</td>
<td>208</td>
<td>256</td>
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<tr>
<td>1981-82</td>
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<td>339</td>
<td>243</td>
<td>336</td>
<td>235</td>
<td>281</td>
</tr>
<tr>
<td>1982-83</td>
<td>263</td>
<td>257</td>
<td>214</td>
<td>302</td>
<td>288</td>
<td>259</td>
<td>250</td>
<td>289</td>
</tr>
<tr>
<td>1983-84</td>
<td>304</td>
<td>292</td>
<td>218</td>
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<td>431</td>
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<td>335</td>
<td>318</td>
<td>338</td>
</tr>
<tr>
<td>1985-86</td>
<td>288</td>
<td>284</td>
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<td>463</td>
<td>413</td>
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<td>358</td>
</tr>
<tr>
<td>1986-87</td>
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<td>302</td>
<td>239</td>
<td>408</td>
<td>424</td>
<td>401</td>
<td>339</td>
<td>377</td>
</tr>
<tr>
<td>1987-88</td>
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<td>259</td>
<td>494</td>
<td>421</td>
<td>393</td>
<td>367</td>
<td>405</td>
</tr>
<tr>
<td>1988-89</td>
<td>423</td>
<td>364</td>
<td>282</td>
<td>670</td>
<td>439</td>
<td>430</td>
<td>408</td>
<td>435</td>
</tr>
</tbody>
</table>


The mission basically adopted a four-pronged strategy:

- Improvement of crop technology for stepping up yields and profits to farmers.
- Improvement of processing and post-harvest technology since at present about 500,000 tonnes of oil are annually lost due to inefficient processing.
- Strengthening services to the farmers, particularly in the areas of technology transfer and input supply.
- Improving the price support to farmers and financial and other support to the processing industry. The four important areas of concern and targets in the sub-sectors are each headed by a chairman:

**Crop Production Technology (Mini-Mission I)**

- Increasing yield potential by 20 percent to 50 percent.
- Reducing crop growing duration by 5 to 25 days.
- Breeding disease- and insect pest-resistant varieties.
- Increasing oil content by 6 to 25 percent.
- Exploiting the tissue-culture technique in coconut and oil palm.
- Producing nucleus and breeder seeds for subsequent large-scale multiplication.
- Developing appropriate production and protection technologies.

**Post-Harvest Technology (Mini-Mission II)**

- Modern integrated processing technology.
- Technology for minor and unconventional oil-bearing materials.
- Technology for better oil recovery.
- Improvement for ghanis and oil expeller units.
Table 6. Exports of oil meals, oilseeds, and minor oils, 1985-86 to 1989-90, and projections for 1990-91, by currency area (quantities in '000 tonnes, value in 10 million rupees)

<table>
<thead>
<tr>
<th>Year</th>
<th>Rupee payment area</th>
<th>General currency area</th>
<th>Grand total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quantity</td>
<td>Value</td>
<td>Quantity</td>
</tr>
<tr>
<td></td>
<td>('000)</td>
<td>(10 million rupees)</td>
<td>('000)</td>
</tr>
<tr>
<td>1985-86</td>
<td>441.8</td>
<td>45.47</td>
<td>106.5</td>
</tr>
<tr>
<td></td>
<td>(64.82%)</td>
<td></td>
<td>(9.06%)</td>
</tr>
<tr>
<td>1986-87</td>
<td>1,013.4</td>
<td>192.98</td>
<td>231.9</td>
</tr>
<tr>
<td></td>
<td>(63.05%)</td>
<td></td>
<td>(12.96%)</td>
</tr>
<tr>
<td>1987-88</td>
<td>803.7</td>
<td>148.32</td>
<td>69.3</td>
</tr>
<tr>
<td></td>
<td>(66.45%)</td>
<td></td>
<td>(6.38%)</td>
</tr>
<tr>
<td>1988-89</td>
<td>1,225.3</td>
<td>327.29</td>
<td>78.6</td>
</tr>
<tr>
<td></td>
<td>(66.0%)</td>
<td></td>
<td>(7.0%)</td>
</tr>
<tr>
<td>1989-90</td>
<td>1,225.3</td>
<td>591.88</td>
<td>67.1</td>
</tr>
<tr>
<td></td>
<td>(69.9%)</td>
<td></td>
<td>(4.5%)</td>
</tr>
<tr>
<td>1990-91</td>
<td>710</td>
<td>45</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td>(70.0%)</td>
<td></td>
<td>(4.5%)</td>
</tr>
</tbody>
</table>

Note: the breakdown between rupee payment area and general currency area is not available for niger seed and sesame seed, however the figures for these two oil seeds are included in the grand totals.

Input and Service Support to Farmers (Mini-Mission III)

- Strengthening the extension system for transfer of technology to farmers.
- Streamlining the production and distribution of seeds.
- Streamlining the supply and distribution of fertilizers, pesticides, and implements.
- Arranging for distribution of credit.

Price Support, Storage, Processing, and Marketing (Mini-Mission IV)

- Timely declaration of prices.
- Efficient procurement operations.
- Expansion and modernization of storage facilities.
- Creation and expansion of integrated modern processing facilities in the cooperative sector.
- Modernization of existing processing facilities in the private sector.
- Modernization of the marketing system.
- Fair prices to consumers.
- Introduction of packaging systems.

Mission Organization

The Mission is headed by a senior official of Special Secretary status who reports to the Minister for Agriculture and Cooperation. Since one of the critical functions of TMO is coordination, a policymaking and communication network has been established with the following principal elements:

EMPOWERED COMMITTEE ON OILSEEDS POLICY. This is a policymaking body consisting of the Secretary to the Prime Minister, the Cabinet Secretary (who acts as Chairman), and the Secretaries of the principal government agencies with interest in the vegetable oil industry from the production of oilseeds to marketing and trade in the finished product. Among others, the membership of the Committee includes the Secretaries of Finance, Commerce, the Planning Commission, Agricultural Research and Education, and Civil Supplies. It meets as the occasion demands.

STANDING COMMITTEE. Set up to supervise the work of the mini-missions. Among its members are the Secretaries of several important departments who also serve on the Empowered Committee. Chaired by the Secretary of the Department of Agriculture and Cooperation, it usually meets quarterly.

MINI-MISSION. TMO has adopted a strategy which successfully achieved self-reliance for the country in food grains, cotton, jute, and dairy products. This covers improved processing and post-harvest technology, strengthening of services to farmers, and improving institutions for post-harvest services. Four so-called mini-missions have been established to supervise activities in the four identified thrust areas, each with a very wide representation of related interests, including non-governmental organizations. Mini-Mission I is chaired by the Deputy-Director General of ICAR, Mini-Mission II by the Additional Director General of CSIR, and Mini-Mission III and Mini-Mission IV by the Director of TMO. The mini-missions usually meet once in two or three months.

STATE-LEVEL MISSIONS: To complete the picture, eighteen important oilseed-growing states have also established Oilseeds Missions, similarly divided into mini-missions.

With this organization and research and development objectives, TMO hopes to produce 26 million tonnes of oilseeds to make the country self-reliant in vegetable oils by 1995. Looking to the increase in area, production, and yield by 26, 69, and 35 percent, respectively, between 1985-86 and 1990-91, such a target appears to have been well conceived. Interestingly, during the on-going year, all the previous records of production are likely to be exceeded, thanks to an on-going bumper rapeseed-mustard crop. Further, due to the modernization of 350 huller units, chemical stabilization facilities extended to 100 units in 1990-91 alone, and introduction
of double chamber modern oil expellers, the total oil availability would be further augmented. Provisions of special lines of credit, existence of a network of 4,600 oilseeds cooperatives, and efficient market intervention machinery for ensuring adequate supply at a reasonable cost would ensure healthy development of the oilseed sector.

Issues and Strategies

Production

There is limited scope to expand the area under the nine annual oilseeds crops, but there is considerable scope for stepping up productivity in South Asia. In rapeseed-mustard, sunflower, and soyabean, considerable expansion in area is expected. There is a good potential to exploit hybrids in sunflower and castor, so large-scale replacement of varieties is often advocated. Stress should be put on intercropping and relay cropping, which would increase the oilseeds area, minimize risks, and increase the net monetary returns under rainfed farming systems.

Since irrigation is vital, emphasis may be placed on minimal irrigation at critical stages through better water management and efficient usage. The availability of quality seed of improved varieties is of vital importance and so is need-based plant protection.

Breeding varieties tolerant to diseases and insect pests is a top research priority. Rapeseed-mustard, sunflower, safflower, and sesame are most vulnerable. Other research priorities include the development of varieties tolerant to drought stress and salinity, increasing oil content in sunflower and safflower, decreasing erucic acid and glucosinolate in rapeseed-mustard, and development of edible-grade linseed and shatter-tolerant groundnut. To overcome coconut root wilt, adequate quantities of good planting material are required. In areas suited to oil palm cultivation, adaptable materials should be introduced and location-specific production and protection technologies should be developed before undertaking large-scale commercial plantations. The existing potential of the oil-yielding forest trees should be tapped. Planting of mahua and neem in saline/alkaline-degraded lands appears promising.

Soft options that merit consideration are the spread of rapeseed-mustard, safflower, sunflower, groundnut, sesame, and soyabean in rice fallow; cultivation of toria as a catch crop in between predominant pulses, millets, and early rice-wheat rotations; sunflower as a spring crop after the harvest of potato, field pea, toria, and sugarcane in irrigated areas; and rapeseed-mustard and safflower in salt-affected areas. Toria and sunflower have a great potential because they need not replace any crop, but can be raised as pure crops in the irrigated belt. This can also be used as an effective strategy to compensate for the poor production of an oilseed due to weather vagaries in the rainy season.

Intercropping of oilseeds in pulses, cereals, and millets, with effective crop geometry, holds good promise in rainfed areas. Some of the promising intercrop combinations are: pigeonpea-groundnut, sorghum-soybean, maize-soybean, pigeonpea-soybean, finger millet-soybean, chickpea-mustard, lentil-mustard, field pea-mustard, chickpea-linseed, lentil-linseed, sorghum-sesame, winter sorghum-safflower, chickpea-safflower, and coriander-safflower. Relay cropping of rice-linseed (uteru) on rainfed lands and potato-mustard in irrigated regions merits consideration. Intercropping and relay cropping not only increase the oilseed area and production, but minimize the risks in rainfed farming.

Limited irrigation at critical stages is crucial for all crops, and more so for groundnut, rapeseed-mustard, safflower, linseed, sunflower, and castor. Other aspects that need attention are the production of rhizobium culture for groundnut and soyabean, use of nitrogenous fertilizers in all oilseeds and phosphatic fertilizers in leguminous oilseeds, surveillance of diseases and insect pests and timely integrated pest management, transfer of location-specific technologies, development of
farm implements for irrigated and rainfed lands, diversification of product development, and supply of inputs, credit, and marketing facilities at the farmer's doorstep.

Oilseeds need less water than rice and wheat. In canal-irrigated areas, therefore, a policy decision should be taken to ensure that the irrigation charges are proportional to the water used. In drought-prone areas, available wells and tanks should be recharged, and sprinkler sets and drip irrigation should be introduced to provide critical life-saving irrigation. Water should be stored within the field with the help of mulches and contour-tillage. Safflower, linseed, rapeseed-mustard, and sesame should be sown early in the winter season to exploit the available moisture and help the crop escape from the attacks of *Alternaria*, aphids, and linseed budfly.

About 25 percent increase in yield can be realized by replacing the oil varieties with quality seeds of new varieties. Effective seed plans on a rolling concept must be implemented to bring the maximum area under improved varieties. Arrangements to produce adequate quantities of stock seed immediately after the identification of varieties for distribution in mini-kits and large-scale cultivation should also form an integral part of the overall strategy.

Centers of excellence around competent scientists and centers would be desirable to tackle unsolved complicated problems. This would help generate information in specific areas for developing location-specific varieties. Available sunflower and castor hybrids and those in the offing in rapeseed-mustard and safflower are going to play a crucial role, cutting across regions and seasons in years to come. Contrary to earlier beliefs, hybrids are likely to play an important role under rainfed conditions as well.

It is desirable to remove coconut plants affected by root wilt to provide a safe disease-free zone. It would be essential to enhance existing coconut gardens to meet the ever-growing demand for seedlings. As a long-term strategy, it would be essential to intensify research and breed resistant varieties.

Delineation of irrigated areas, motivation of farmers of contiguous areas for the oil palm plantation, and creation of processing facilities commensurate with the creation of processing capability are prerequisites for effective palm oil production. It is also essential to assess the potential of imported materials before undertaking large-scale commercial plantations of oil palm. If less-productive oil palm material is planted, the losses would be tremendous over the thirty-year period that palms normally occupy the land. Drought stress leads to the formation of male flowers instead of female ones and such effects are manifest in subsequent years too. As such, planting on hills and shallow soils having poor water-holding capacity needs to be discouraged. It would be desirable to introduce germplasm from Costa Rica and African countries where drought is a perpetual problem.

Devising a well organized seed collection system for the efficient collection of tree-based forest oilseeds holds the key to the realization of a vast potential. It would be desirable to have an apex body represented by all related departments. The body could be vested with the responsibility and authority to formulate and implement the time targeted collection programs.

The private sector is generally interested in the production and marketing of hybrid seeds. In the interest of rapid spread of varieties, incentives to private sectors as well as strict quality control measures would be desirable. Further, appropriate agencies should be identified to provide buffer stocking of certified, foundation, and breeder seeds as an *ex ante* decision to meet unforeseen eventualities.

The extension system is fairly well conceived, but due to operational problems, the desired results are not being achieved. Periodically, the subject matter specialists should be given training in the finer details of the latest technology, and require more precise transfer to location-specific technologies compared to wheat or rice. The extension programs should be so monitored as to ensure feedback, including impediments and
bottlenecks from the farm level, so that research priorities can be reoriented and corrective measures taken.

**Processing**

The diversity of oilseeds; their geographical spread, availability, and preferential use; status of available technology; and capacity to invest in the processing sector determine the processing approaches in the form of ghanis, expeller units, extraction plants, and refining and modification plants in the region. Impurities in seeds, frequent power cuts, mechanical breakdowns, low yields, and high consumption of energy quite often lead to the low efficiency of the system. Situations which need to be tackled in the region are the feasibility of penetration by improved technology to the villages where traditional ghanis are in use; small expeller use where production is widely dispersed; demand for oilcake with a high oil content as livestock feed; collection problems associated with rice bran; and the false notion that cotton seed is more useful for livestock feeding.

As expeller oils have a premium in the market compared to solvent-extracted oil, the efficiency of oil recovery should be considered at two general levels of expelling and extraction. Presently, the expeller industry aims for about 8 percent oil content in cake and the extraction industry processes about 20 to 25 percent of the available oil cake. Improving the efficiency of the expeller industry by decreasing energy consumption and minimizing the residual oil in the cake could be considered. An optimum balance of expeller and extraction systems could lead to greater efficiency. In this endeavor, small-scale minipresses may be encouraged to replace ghanis, and improved expellers which increase pressing efficiency by seed preparation and cooking prior to pressing might be introduced. To reduce the operational cost of large expellers, ensuring availability of the cake over a longer period would be desirable.

In rice bran, modernization of the milling industry, timely collection of bran, stabilization of the bran from the milling process, and availability of solvent extraction capacity at a reasonable distance are essential. As such, immediate conversion of hullers into hullers-cum-shellers is desirable. For stabilizing rice bran, mixing the bran with hydrochloric acid has already been tried, or use of expander technology combining mechanical friction and steam as heat sources would be of help.

**Marketing**

Marketing, consumption, and trade are much more complex and often quite sensitive. Timely declaration of procurement prices, efficient procurement operations with effective market intervention mechanisms right in the area of production, expansion and modernization of storage and marketing facilities, fair prices to consumers, introduction of blending and packaging, and need-based vanaspati production are some of the important issues. In the region, oil prices are much higher than the international market levels, whereas oil meal prices are quite close to prices prevailing in the world market. Oil prices remain high because of the urge to conserve imports due to limited foreign exchange. If such a situation is allowed to continue, this would lead to production of oilseeds with high oil content, and solvent extraction of oilseeds/oilcake. In fact, in a region where protein malnutrition is quite serious, this would further aggravate the situation and prices of pulses would continue to rise, but with limited protein content compared to oil meal.

Crops like soyabean, safflower, sunflower, castor, and linseed require marketing systems right in the area of production or it is not possible for them to expand to new areas. Industrial back-up would be essential if soya meal is to be used for human consumption through diversified production development and its popularization. Similarly, double purpose linseed varieties (suitable for both seed and fiber production) would not be able to make much progress unless dry stalk collection, its retting, fiber extraction, and use,
are standardized and popularized. This would obviously call for an integrated approach cutting across departments, both public and private, farmers, and consumers.

Available data suggest that consumption of edible oil by the poorest sections of society is comparatively quite low and well below adequate nutritional standards. Increased intake of oils would give a beneficial boost to diets which are heavily dependent on cereals and to a lesser extent on pulses. There is no sign of any government intervention in the oilseed market specifically oriented to increasing the supply for the poor.

In India, support prices are declared, often well before the sowing season. This obviously gives confidence to the growers about the minimum prices which they are assured of. Nevertheless, in the last six years market prices always ruled above the support prices. This acted as an incentive to the growers for increasing the production of oilseed. Hence the declaration of support prices coupled with the presence of market intervention machinery provided a congenial environment for developing the oilseed sector on a sound footing. Imported oil released through the public distribution system also provided some relief to the consumers, particularly when prices were roaring.

Looking to needs and trends, it is obvious that blended oil in the region would compete freely with vanaspati, which meets widespread consumer acceptance and is expected to remain a powerful tool in influencing the market in years to come. It appears that there is a very thin layer between the edible and non-edible oil sectors, and depending on price, each category changes its use, both directly and indirectly, including adulteration. Consequently effective packaging and legalized trademarks, enabling the adoption of strict quality control measures, are needed now more than ever.

Perspective

During the 1990s, the region will continue to be a net importer of vegetable oil.
Nevertheless, regional production could go up, and the gap between demand and availability due to enhanced local production would be considerably bridged. In addition, several other factors should be considered:

- Varieties available with low glucosinolate would provide opportunities by the end of the century for export of rapeseed meal. This would be in addition to, soya, groundnut, and sesame meal. Due to slow progress on the industrial front, value addition and diversified product development and use are bound to be far below the available potential.

- Rice bran, cotton seed, and oilseeds of tree and forest origin could be exploited much more widely, but there would still be a vast gap between realistic potential and actual production.

- Area, production, and productivity of rapeseed-mustard, sunflower, and soyabean could substantially increase. The private sector could play a vital role, particularly where hybrids are available or likely to be available.

- The most rewarding input sector would be quality seed. Unless concerted efforts on seed production and its distribution are made, the situation will not substantially change.

- From the technology generation and technology transfer sectors, greater efforts and investments should be accorded to extension to harness the vast available technology which is still in store. Nevertheless, basic, strategic, and applied research to sustain the pace of progress must go hand-in-hand with developmental approaches.

- Varietal improvement programs are likely to pay much greater dividends compared to any other research sectors. Emphasis on hybrid research, improvement of varieties for tolerance to biotic and abiotic stresses, and quality would be much more rewarding.
• On a long-term basis, the future of the sector would depend on how it has tuned itself to an integrated oil-protein system.

• Research in isolation, as in the past, would be of no real consequence in terms of practical translation unless policies are tuned to meet the requirements of adoption in each of the sectors in terms of production, processing, and value addition. Integration is essential not only at the technology transfer and adoption stages, but also at the technology generation stage.
I am most grateful to the sponsors of this conference on Agricultural Technology for Market-Led Development Opportunities in the 1990s for having invited me to share my experience in increasing vegetable oil production in a developing country like India. In all humility, I submit that I feel inadequate talking to an august audience of agricultural technologists from different parts of the world, as I am only a practicing manager and not a technologist. My experience is borne out of the need for a country like India to evolve and develop technologies to bridge the gap between demand and supply of vegetable oils, and more particularly, of the commitment of a company like Unilever to evolve new technologies for maximizing vegetable oil production in India. We in Unilever India are fortunate to have one of the five research labs of Unilever worldwide, in Bombay, and for the last twenty-five years we have committed a large research effort to evolving new technologies for maximizing both edible and industrial vegetable oil production and use.

I propose to cover my presentation in four parts: vegetable oil demand and supply in India, new technological developments in annual agricultural crops, wasteland/land utilization for oil plantation crops, and unconventional sources of oil.

Vegetable Oil Demand and Supply

India, with its population of more than 850 million people, has a very large demand for vegetable oils, both edible and inedible. The gap between demand and domestic supply of oils has been largely bridged by using innovative technologies and unconventional oils because with its shortage of foreign exchange, India can ill afford to import large quantities of vegetable oils. Between 1987-88 and 1991-92, the demand has been restricted by allowing very high prices for edible oils, thus reducing demand. In the meantime, the supply has substantially improved (Table 1).

Up to 1986, production of quality seed was almost entirely carried out by central and state government seed corporations, and research was carried out by central and state governments and agricultural universities. In 1986, the government permitted large foreign companies to take on research in the private sector, and in 1988, a new seeds policy was introduced which encouraged production of quality seeds in the private sector. Government policies have therefore also helped in the last few years to maximize vegetable oil production.

Annual Agricultural Crops — New Technological Developments

In the last thirty years, the irrigated area in India has increased from 21 million to 68 million hectares, however most agriculture is still monsoon dependent. The challenge for oilseed production is to produce high-yielding oilseeds for rainfed conditions and to introduce new seeds which can be grown on marginal and sub-marginal lands. Efforts are on to develop new hybrids of oilseeds, introducing a genetic base with wide adaptation and resistance to diseases, insect pests, drought, and frost.

Oilseed production in India was somewhat static for almost fifteen years until 1986-87. The formation of the Oil Technology Mission in 1986, and simultaneous permission for large private companies to enter the seeds business because hybrids seeds were included on the list of core sector activities, resulted in the
Table 1. Gap between domestic supply and demand for vegetable oils in India (million tonnes)

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>Edible oils</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demand</td>
<td>5.40</td>
<td>5.60</td>
<td>5.70</td>
<td>5.70</td>
<td>5.82</td>
</tr>
<tr>
<td>Domestic supply</td>
<td>3.28</td>
<td>4.77</td>
<td>4.36</td>
<td>5.42</td>
<td>5.65</td>
</tr>
<tr>
<td>Gap</td>
<td>2.12</td>
<td>0.83</td>
<td>1.34</td>
<td>0.28</td>
<td>0.17</td>
</tr>
<tr>
<td><strong>Inedible oils</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demand</td>
<td>0.68</td>
<td>0.67</td>
<td>0.70</td>
<td>0.71</td>
<td>0.74</td>
</tr>
<tr>
<td>Domestic supply</td>
<td>0.55</td>
<td>0.56</td>
<td>0.58</td>
<td>0.63</td>
<td>0.66</td>
</tr>
<tr>
<td>Gap</td>
<td>0.13</td>
<td>0.11</td>
<td>0.12</td>
<td>0.08</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Thus there is substantial room to improve yields through new hybrids and high-yielding varieties, and better agronomic practices. Even in India, where high-quality seeds and correct agricultural practices are used, particularly in irrigated areas, the potential yield of these seeds per hectare as indicated above, has been achieved. High-quality hybrid sunflower seeds, for instance, provide yields of up to 2,000 to 2,200 kilograms per hectare in a good farmer's field. Efforts are on, both by government and the private sector seed industry, to maximize availability of quality hybrids and high-yielding varieties of seeds to the farmers. Extension services of both the central and state governments, as well as the sales and technical teams of the private companies, are providing technical assistance and packages of practices to farmers for different seeds. It is estimated that in the next few years much higher average yields per hectare could be achieved in oilseed production in the country.

Farmers in India have traditionally used their own seeds. However, in the last five years, purchase of quality seeds, including high-yielding varieties, has become an accepted practice. The major role that the seed industry is playing is to educate farmers through extension work on the new research hybrids and varieties developed, and the need for a shift from using their own seeds to using quality seeds from the central and state government seed corporations or from private industry.

Table 2. Area in India planted to oilseed crops, oilseed production, and yield

<table>
<thead>
<tr>
<th>Year</th>
<th>Area (million ha)</th>
<th>Oilseed production (million tonnes)</th>
<th>Yield (tonnes/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970-71</td>
<td>16.7</td>
<td>9.6</td>
<td>0.58</td>
</tr>
<tr>
<td>1980-81</td>
<td>17.6</td>
<td>9.4</td>
<td>0.53</td>
</tr>
<tr>
<td>1990-91</td>
<td>(est.)</td>
<td>21.6</td>
<td>18.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.80</td>
</tr>
</tbody>
</table>
Table 3. Oilseed production in India

<table>
<thead>
<tr>
<th>Area (‘000 ha)</th>
<th>Production (‘000 tonnes)</th>
<th>Average yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundnut</td>
<td>6,844.0</td>
<td>8,297.2</td>
</tr>
<tr>
<td>Castorseed</td>
<td>479.5</td>
<td>807.4</td>
</tr>
<tr>
<td>Sesame</td>
<td>2,153.3</td>
<td>2,594.6</td>
</tr>
<tr>
<td>Nigress seed</td>
<td>639.1</td>
<td>615.6</td>
</tr>
<tr>
<td>Rapeseed, mustard</td>
<td>4,619.2</td>
<td>5,722.4</td>
</tr>
<tr>
<td>Linseed</td>
<td>1,150.7</td>
<td>1,148.3</td>
</tr>
<tr>
<td>Safflower</td>
<td>1,051.9</td>
<td>821.2</td>
</tr>
<tr>
<td>Sunflower</td>
<td>1,651.3</td>
<td>2,365.3</td>
</tr>
<tr>
<td>Soyabean</td>
<td>1,542.6</td>
<td>2,418.9</td>
</tr>
<tr>
<td>Total</td>
<td>20,131.6</td>
<td>24,013.7</td>
</tr>
</tbody>
</table>


Sunflower

Hindustan Lever, a subsidiary of Unilever, first introduced Morden variety of sunflower in the 1970s, establishing its wide adaptability, which has been the base for sunflower cultivation in the country. In the last four years, there has been a massive expansion of sunflower cultivation in the country. Area has increased from 1.1 million hectares in 1987 to over 2 million in 1991, and production of sunflower increased from 437,000 tonnes to almost 900,000 tonnes over the same period. The yield per hectare has risen from 382 to 550 kilograms in 1991, as per the latest estimates.

Several private sector seed companies have reported that hybrid seeds introduced by them are yielding, on an average, between 1,500 and 2,400 kilograms per hectare. Our own hybrid sunflower seed, which is particularly for rainfed conditions, and the earliest hybrid, provides a yield of 1,200 to 2,000 kilograms per hectare on non-irrigated land. Several new hybrids which have been testing are giving yield results in multilocational trials varying between 2,000 and 2,800 kilograms per hectare. Two of these are being launched this year. Sunflower appears to be a very promising oilseed crop for the future in India, where there still exists a large gap between Indian average yields and the potential which can be achieved through use of better quality seeds, improved agricultural practices, and planting in the right season.

Rapeseed and Mustard

This is the second largest oilseed crop produced in the country, and in the last five years the production has increased by nearly 80 percent. The area has also expanded by over 40 percent over the same period. The yield has increased on average from 700 to 900 kilograms per hectare.

While over 17,000 tonnes of seed are required for sowing on 5.7 million hectares, farmers are currently buying only 3,000 tonnes of seed, and primarily using their own seed for sowing. However, several good high-yielding varieties have been developed in the country. Our company has developed a yellow mustard with high oil content, which is doing well.

We have also developed a new high-yielding variety which grows well on saline land. India has 7.04 million hectares of saline

Table 4. Average and potential yields of selected oilseed crops in India

<table>
<thead>
<tr>
<th>Crop</th>
<th>Average 1991 yield (kg/ha)</th>
<th>Potential (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundnut</td>
<td>919</td>
<td>1,600-2,000</td>
</tr>
<tr>
<td>Sunflower</td>
<td>541</td>
<td>1,400-2,000</td>
</tr>
<tr>
<td>Mustard</td>
<td>900</td>
<td>1,700-2,400</td>
</tr>
<tr>
<td>Soyabean</td>
<td>1023</td>
<td>1,900-2,400</td>
</tr>
</tbody>
</table>
land, where nothing grows. Our research breeders in the company have developed a saline-resistant variety of mustard which grows well in totally saline areas, yielding 1.8 tonnes per hectare of oilseeds annually. Another high-yielding variety which is drought resistant has been developed for the drought areas and is giving excellent results. Rapeseed and mustard are crops for the future. We are working towards producing a hybrid for rapeseed/mustard and feel confident of success in the future.

**Groundnut**

The largest oilseed production area is planted to groundnut, over 7.6 million hectares. However, this crop is characterized by unstable production, mainly due to the productivity of the monsoon crop because of unpredictable drought spells, together with diverse biotic factors. In recent years, the winter/early summer groundnut crop area has increased by 1.5 million hectares. Productivity is much higher at almost 1,500 kilograms per hectare, hence increasing the overall groundnut seed production in the country, with the average yield increasing from 800 to almost 920 kilograms per hectare.

**Soyabean**

In the recent years, the largest area increase has been in this crop, increasing from 1.5 million hectares to almost 2.4 million hectares, with the yield increasing from 637 to almost 1,025 kilograms per hectare. New varieties have been developed and introduced, and several parts of northern India are switching to soyabean production.

**Castor**

This is an oilseed grown on marginal land, and requires very little water. New uses of castor oil have been developed through intensive use of new technologies. Castor oil is now being used on a large scale by our company for manufacturing high-quality toilet soaps. In 1991, we consumed almost 10 percent of the entire castor oil production in the country for soap manufacture. We have developed two new technologies to hydrogenate and dehydroxylate this oil, and it is now possible to use this oil at a level of almost 60 percent of the total fat charge for making toilet soap, and produce laundry soap from only castor oil.

Gujarat Agricultural University has developed two very successful hybrids of castor which are now being extended in different regions in the country, thus substantially increasing the oilseed production from 0.5 million to almost 0.9 million tonnes of seed. Castor oil also has large export potential, and 35 to 50 percent of the oil is exported to Russia and other European countries.

The new Seeds Policy announced by the government in 1988 permitted import of oilseeds for initial trials for a period of two years. It was envisaged that during this two-year period the supplier of seeds would transfer the technology for seed production in India. Several hybrid sunflowers have been imported from Australia, acclimatized, adapted to Indian conditions, and are now doing well.

There is still much room for expanding annual oil crops in the country by increasing yields through supply of good quality seeds. The government’s policy on fair prices for oilseeds has substantially helped the farmer to shift his land to oilseed production, and the increased oilseed production has substantially reduced the imports of edible oils by almost 70 percent. With our population increase, it is estimated that our oil demand will continue to increase oilseed production in the country if we are to keep the gap between demand and supply at the current levels.

**Application of Biotechnology to Increase Annual Oil Crop Production**

A number of business houses in India have equipped themselves with sophisticated laboratories capable of conducting research in molecular genetics, tissue culture, and other biotechnology areas, with a view to producing high-yielding varieties of oilseeds. Our
company is using protoplast fusion and \textit{in vitro} culture techniques to develop new hybrids. This is not only valuable for transfer of nuclear genetic information across sexually incompatible barriers, but also for the rapid development of new cytoplasmic male sterile lines.

We have been using the embryo culture techniques to reduce breeding time with good results in oilseed crops (sunflower and mustard), and for transfer of CMS in diverse genetic backgrounds. Anther culture technique is being used for generation of pure lines. Using anther culture and embryo scooping technologies, we are able to reduce breeding time for developing new hybrids to about three years. Our company has also used somaclonal variation techniques for inducing genetic variability, thus helping our seed breeding program. Use of biotechnology holds great promise for increasing annual oilseed crop production in the country.

**Wasteland/Land Utilization for Oil Plantation Crops**

**Pilu** (Salvadora oleoides and S. persica)

In India, we have 40 million hectares of arid wasteland where nothing grows. Several trials have been conducted to grow oilseed-bearing trees on such lands. The Central Salt and Marine Research Institute has done considerable work in developing seeds capable of producing high-yielding oilseed from pilu trees. It has been established that plantations based on 450 trees per hectare give optimal results. The trees start yielding fruits from the fifth year onwards, and achieve maturity after the tenth year. The fruit-bearing life of the tree is estimated to be over 300 years. The tree needs attention only during the first four to five years. The estimated output of fruit per tree is around 30 kilograms per year.

High-yielding varieties of pilu strains have been developed to give oil yields of 35 percent of dried seed. A 400-hectare plantation can yield up to 5,400 tonnes of seed per year, equivalent to between 1,000 and 1,200 tonnes of oil. The oil has high lauric content and hence is suitable to substitute for coconut oil, which is necessary for soap making, to provide lather. Our company is attempting to get land for pilu plantations. We expect that in the next five years or so, at least 10,000 hectares of land should be under pilu plantations.

**Ratanjyot** (Jatropha Curcas)

This is a semi-wild shrub and a native of South America which has been propagated by the Portuguese in Africa and Asia. It is grown in semi-arid zones, and also withstands saline/sodic soils well. It bears fruit in the second year during the dry season between September and December. The seeds resemble castor, and kernels constitute 66 percent of the seed. The oil content of the kernel is 46 to 58 percent. However, double crushing in expellers yields 28.5 percent oil. While jatropha bushes grow wild in different parts of the country, efforts are on to persuade the government to allocate wasteland for organized plantations by the private sector.

This is a soft oil, superior to rice bran, and after hardening can be used for high-quality toilet soap. It has excellent color, unlike rice bran. Here again, we expect that in the next five years at least 20,000 hectares will be put under plantations. Our company and a few other large companies are taking the lead in promoting such plantations.

**Oil palm** (Elaeis quineensis jacq)

The Andaman and Nicobar Islands have the ideal climatic conditions for producing oil palm, and an experimental plantation has been planted on the Little Andamans since 1973. The total land area of the Andaman and Nicobar Islands is 9.8 million hectares. A study team set up by our company has identified 60,000 hectares which would be ideal for oil palms and is not under tropical tree cover. We have been trying to persuade the government to allow palm plantations in this region. The Andaman and Nicobar Islands are very close to Malaysia and hence have similar climatic conditions.
The Government of India has also been carrying out experiments on oil palm plantations under irrigated conditions since 1986 in four major states, and the initial results seem promising. However, land in these states is not available for large plantations. The production will have to be organized on private farmers' land, and as the size of holdings are very small, this will require massive extension services. A project is in the process of being worked out, where the farmers will be supported in the first five to six years, during which time there will be no yield. We need to await the results of this experiment.

**Unconventional Sources of Oil**

**Cottonseed Oil**

Traditionally, Indians are used to eating butter oil (ghee). Almost fifty years ago, hydrogenated vegetable fats resembling ghee were introduced in the country. One of the primary reasons was that a large quantity of cottonseed oil was produced as a by-product of cotton, but could not be eaten unless mixed with other oils to make it palatable. Hence, the first non-conventional oil introduced in the country, using technology of refining and odor removal, etc., was cottonseed oil. The country now produces about 350,000 tonnes per year of cottonseed oil.

**Rice Bran Oil**

The country produces over 10 million tonnes per year of paddy, and in the early 1970s processes were developed for extracting oil from rice bran. The country now produces over 380,000 tonnes per year of rice bran oil, of which 200,000 tonnes is edible and the balance (inedible) is used for soap production. There still exists potential for an additional 0.3 to 0.4 million tonnes of rice bran oil, provided that while polishing the paddy, the bran and husk are separately removed, thus allowing extraction of oil from the grain. The government is encouraging installation of new, modern rice mills, thus making available good quality bran for extraction. Edible rice bran oil is mainly used by the hydrogenated fats (vanaspati) industry.

The Unilever group in India was the first to develop the technology for use of rice bran oil in soap production and for hydrogenating rice bran oil, as this is a soft oil. We have also developed a catalyst for hydrogenation of rice bran oil. A process has been developed to reduce the wax content and improve the color, thus making it possible to use rice bran oil in much larger quantities for edible purposes. We use the chlorate bleaching technology developed by our R & D to improve the color and make it suitable for use in toilet soap. We have also developed a process for fractionating it to produce a fatty acid for production of very high-grade toilet soaps. The Unilever group is the largest user of inedible rice bran oil in India, using 130,000 tonnes each year.

We have also been very actively involved in developing technologies for a small, low-priced mills in order to generate larger quantities of raw materials for oil extraction processes. Our research center in India has obtained two patents for new technologies developed for use of rice bran oil, and one more is pending.

Thus, unconventional oils like cottonseed oil and rice bran oil are major raw materials in the production of around 900,000 tonnes per year of hydrogenated fats (vanaspati). Unilever India's large research center has contributed very substantially to developing technologies for the use of these unconventional oils.

**Oilseeds of Forest Tree Origin**

SAL (SHOREA ROBUSTA). Here again, the research center of the Unilever group in India was the first to recognize the potential of a forest seed, sal, which is wasted as it falls to the ground and has no useful purpose. The seed contains 13 percent oil. The oil has a very dark color and a disagreeable odor. A chemical bleaching process has been developed which removes color and odor, enabling its use in toilet soaps. We have also developed a process of specific de-gumming for removal of ellagic tannins and other impurities, enabling its use as
a confectionary fat after further processing. It is very similar to cocoa butter and is extensively used in India, and exported as a cocoa butter substitute. We have also developed an in-house technology for plant-scale chromatographic purification of sal fat for higher incorporation in chocolates.

The seed is collected by poor people, mostly tribals, living around forest regions. Thus, collection of seed is also an employment generating activity. Approximately 20,000 tonnes of this oil is made available through collection of over 150,000 tonnes of seed each year. The gross potential of collection of this seed is over 5 million tonnes. However, organizing collection is a difficult task in dense forests. Planting sal trees therefore serves an economic purpose as well, and is being promoted by forest departments of state governments.

KARANJA (PONGOMIA GLABRA). This is again a forest seed, mainly found in southern India, which grows on dry wasteland, even on saline soils. The yield of kernels per tree varies from 10 to 25 kilograms, and the kernels contain 27 to 39 percent oil. About 8,000 tonnes of oil are currently being produced each year, however, the potential is in excess of 100,000 tonnes. Here again, a chemical bleaching process has been developed and a process to harden the soft oil evolved, enabling its use in toilet soaps. The oil is also used for leather tanning, and the cake is used as a fertilizer.

KUSUM (SCHLEICHERA TRUUGA). This is a forest tree which is found in sub-Himalayan tracks of north and northeastern India. The fruit has a high oil content of between 50 and 60 percent. This is a good oil for soap making. A chemical process has been developed to remove some cyano compounds and make it safe for use in soaps. Each year 5,000 tonnes of oil are generated, while the potential is over 50,000 tonnes.

OTHER FOREST TREE OILS. There are a host of other forest seeds which are being collected for oil extraction, including pisa (Actiondaphne hookeri), thumba (Citrulus colosynthis), palash (Butea frondosa), undi (Calaphyllum inophyllum L.), nahor (Mesua ferrea L.), etc. In the tree planting program, oil-bearing trees are being promoted and plantations developed in areas where access for collection of seeds is easy.

Conclusion

Both government and private sector laboratories and breeding stations are working hard to develop new technologies for oil seed production and use. Our company has twenty-two technologies patented for use of difficult, unconventional oils for edible/industrial purposes, which include patents for rice bran
oil, castor, sal fat, neem oil, karanja oil, and kusum oil. Patents for five more processes are pending.

In recent years, India has successfully increased production of oilseeds through increased area, improved productivity, and better prices for growers. With limitations on further increases in area for annual crops, the future strategy consists of three major elements: improved productivity through high-yielding seeds in a liberalized environment, converting land from other crops to oilseeds, and plantations on wasteland and irrigated areas.
The Impact of Technology from the Private Sector in the Development of Agriculture in Central America

H. Eugene Ostmark

The original plan for this paper was to present the role of the private sector in introducing improved technology for some important commodity group into the agriculture of Central America. In researching the data, the impact of market and technology-led development of commodities ranging from bananas to melons by multinational agricultural companies was overwhelming. As Wilson Popenoe, the grand old man of tropical agriculture, once said, "A man's judgement is no better than his information." This paper will therefore present the impact that information, based on the infusion of many millions of dollars of privately funded research, has had on Central American agriculture. In so doing, both the benefits and liabilities of research designed primarily to make money for the multinational companies will be presented.

The term "Banana Republic" is often used as a derisive term for underdeveloped Central American countries. However, the banana is the most ideal tropical agricultural crop and will serve as the major case history and as an example of the results of the technology of the private sector. Bananas are in demand year round, a renewable resource, require a high level of hand labor, and most important, are profitable enough to support research, not only on bananas, but on a variety of other crops. The banana's rapid perishability is in itself an advantage since when it reaches a certain age on the plant, it must be harvested and shipped within 24 hours. Coffee, another major commodity, can be stored, causing

oversupplies to build up with a subsequent plummeting of prices. These price fellouts have far-reaching effects down to field laborers and peripheral suppliers.

This paper will emphasize the effects of technology developed strictly within the boundaries of Latin America by multinational banana companies. Almost no technology for tropical crops is available from the developed or industrialized nations, and almost all technology had to be originated, perfected, and transferred within the boundaries of Latin American countries. However, some basic technology such as irrigation systems, pesticides, and existing cultivars needed only modifications to be usable in the tropical environment.

Background

Research on bananas was begun by the United Fruit Company in Panamá in 1910 when the Fusarium soil fungus called Panamá disease began to kill the Gros Michel banana, the only banana of commerce at the time. [The United Fruit Company changed its name to United Brands Company in 1970, to Chiquita Brands International in 1990]. Limited research continued until 1926 when a wide range of research programs were begun on the agronomy, handling, agricultural engineering, food value, and by-products of bananas.

In 1930, the United Fruit Company began a banana breeding program which was subsequently abandoned, reinstated in 1958, and continues to this day.

In 1934, the entire research program was halted because the new owner of the United Fruit Company felt that research was too expensive and that Panamá disease kept competition out of the banana business. The

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United Fruit Company owned virgin land that could be planted to bananas when Panama disease made existing plantations uneconomical.

From 1935 to 1938 a leaf fungus called Sigatoka, from the valley in Fiji where it was discovered, began to kill banana leaves in Central American banana plantations. A young pathologist, Dr. Vining Dunlop, was one of the three remaining members of the depleted research staff. Dr. Dunlop proved that Bordeaux mixture (copper sulfate-lime-water) would protect banana leaves from Sigatoka. This protection required the construction of thousands of miles of piping and hundreds of pumps throughout the banana plantations, an expenditure unequalled in plant protection in the tropical agricultural world. But the banana industry was saved and the importance of research to the bottom line profitability of tropical agriculture was proven.

From 1939 to the present, new fungicides were tested for Sigatoka control to be applied by aircraft, which reduced costs from the unwieldy hose-applied Bordeaux sprays. In addition, major insect pests such as red rust thrips and red scale were controlled by the innovation of covering developing fruit with thin plastic sleeves.

In the 1940s the Standard Fruit Company began a research program mainly on bananas, but with a sizable effort in pineapples and grapefruit. In the 1950s Standard Fruit’s research department designed and perfected methods for boxing and transporting the tender skinned Cavendish banana, a technology quickly adapted by all banana growers and exporters. In addition, tests were conducted on fungicides to control rots that, if left untreated, reduced salability of fruit.

The importance of a technological base having been demonstrated by successes in disease control, the research departments of the multinational banana companies expanded rapidly. Operational costs and staffing of the United Fruit Company rose from a tropical professional staff of sixteen in 1940 with an annual budget of $95,000 to sixty-nine in 1960 with an operational cost of over $3 million. Of the professional staff, twenty-eight held PhD degrees, with an additional sixteen PhDs in an affiliated laboratory in the USA.

By 1984 the combined annual budget for both United Brands and Standard Fruit exceeded $6 million, mainly for research on bananas. An entire complex of tropical research facilities had been built in Honduras, including departments of agronomy, pathology, nematology, entomology, and post-harvest studies. In addition, there existed an active diversified crops program, experimental farms, research substations in Costa Rica, Panamá, Guatemala, and Colombia, foliar and soil analysis laboratories, and a world-class library on tropical agriculture. Meanwhile, the Del Monte Corporation established a research department in Guatemala to work exclusively on banana production problems.

Poor profits in the banana industry in 1983-1984 impelled the multinational banana companies to cut costs. Research was among the first casualties of the United Brands Company. The entire complex of United Brands’s Division of Tropical Research — buildings, laboratories, and facilities — was turned over to a new USAID-Honduran government sponsored, independent research foundation, the Fundación Hondureña de Investigacion Agrícola (FHIA). United Brands continued limited research, particularly on reducing costs of Sigatoka control.

Impact

There is little doubt that the modern banana export business owes its existence to the technology generated by research from the private sector. While the major research efforts were on the banana, the various departments within the research group also used their expertise on the development of other crops. In addition, the profitability of the banana made funds available for the establishment of institutions with long-term benefits to tropical agriculture in all of Central America.
Table 1. Banana exports from Central America, 1984 to 1989

<table>
<thead>
<tr>
<th>Year</th>
<th>Costa Rica</th>
<th>Guatemala</th>
<th>Honduras</th>
<th>Panama</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Volume (metric tonnes)</td>
<td>Value ('000 U.S. dollars)</td>
<td>Volume (metric tonnes)</td>
<td>Value ('000 U.S. dollars)</td>
</tr>
<tr>
<td>1984</td>
<td>1,039,569</td>
<td>254,754</td>
<td>323,034</td>
<td>57,493</td>
</tr>
<tr>
<td>1985</td>
<td>841,245</td>
<td>195,452</td>
<td>365,834</td>
<td>60,747</td>
</tr>
<tr>
<td>1986</td>
<td>890,090</td>
<td>218,795</td>
<td>342,712</td>
<td>73,910</td>
</tr>
<tr>
<td>1987</td>
<td>991,240</td>
<td>230,372</td>
<td>363,499</td>
<td>77,110</td>
</tr>
<tr>
<td>1988</td>
<td>1,060,817</td>
<td>257,110</td>
<td>332,810</td>
<td>78,400</td>
</tr>
<tr>
<td>1989</td>
<td>1,275,693</td>
<td>309,180</td>
<td>384,476</td>
<td>88,923</td>
</tr>
</tbody>
</table>

The Banana

Bananas are important to the economy of Latin America (Table 1). With approximately 120,000 hectares of bananas planted as a monoculture throughout Central America, pest problems became the limiting factor in profitable banana production.

Diseases

Between 1900 and 1960, the *Fusarium oxysporum* soil fungus called Panamá disease decimated the Gros Michel banana plantations. When the multinational banana companies ran out of *Fusarium*-free lands, they sent teams of pathologists to devise ways of eliminating or at best, reducing the effects of Panamá disease. Technologies had to be developed on site. Every conceivable possibility was tried, including the conversion of entire farms into lakes (flood fallowing) and the application of fungicides. Even a soil-dwelling bug, *Scaptocorus talpi*, whose secretions killed *Fusarium* in the lab was evaluated in an attempt to stem the losses. After millions of dollars were spent in a fruitless search for a control method, the multinationals replanted their banana farms with one of the *Fusarium*-resistant Cavendish bananas, the last naturally occurring banana clone in the world.

In the meantime, several other major diseases were intensely studied and brought under control. These were Moko disease caused by the bacterium *Pseudomonas solanacearum*, and Sigatoka, *Mycosphaerella musicola*. Moko was found to be a problem of farm practices, especially the lack of sanitation of farm tools and the quarantining of infected plants and their immediate environs. Before Moko was brought under control, entire plantations in Costa Rica were almost wiped out.

Sigatoka, which mutated into the more virulent strain called black Sigatoka, required emergency clearance of new fungicides by regulatory organizations in the United States and Europe to save the industry. Control costs soared, however, until studies of spray timing originating with French government scientists were adapted by the multinationals and the banana again became more profitable.

Insects

Spraying of plantations with insecticides was abruptly halted in the early 1970s by a long and costly series of experiments conducted by the United Fruit Company to determine the effects of defoliating insects. The discovery that the banana plant could lose 20 percent of its leaf area before fruit was lost, combined with field studies that showed that 100 caterpillars per leaf of the most common defoliating insect were necessary to consume 20 percent of the leaves, led to the virtual elimination of aerial application of insecticides.

Similar studies on the effects of the banana corn weevil, *Cosmopolites sordides*, reduced the importance of that pest throughout Latin America with a subsequent reduction in use of the long residual insecticides formerly required to control the pest.
Insect pests that fed on the fruit peel (only one or two insect species worldwide actually penetrate the peel) were controlled by the invention of an insecticide-impregnated plastic sleeve originated and tested by United Fruit's research department in cooperation with the Dow Chemical Company. The hazards to workers of the insecticide-dusted sleeve that had been used up to then were eliminated with no reduction in fruit protection.

**Nematodes**

Long-term studies on the effects of nematodes in Honduras allowed entire banana areas to withhold the application of a ground-contaminating nematicide which also presented a health hazard to banana workers.

**Wind Losses**

The single greatest source of losses up through the 1960s was wind damage. Winds of only 25 miles per hour were capable of blowing down thousands of hectares of bananas. The agronomic testing from planting through marketing of dwarf varieties of Cavendish, namely Gran Nain, eliminated the threat of massive wind-caused losses.

**Other Crops and Products**

In addition to the technology developed to sustain the export banana market, research funded by banana companies developed banana by-products such as banana puree, exported in drums to the United States. The plants refined basic technology from industrialized plants outside Latin America to use waste bananas that did not meet export quality standards, mainly size and peel appearance.

There have been many examples of the multinational banana companies attempts to diversify into other crops in order to reduce their dependency on bananas. Many were failures, such as catfish and fresh water shrimp farming. Others were successful, but were left for small-scale entrepreneurs since the income generated did not justify the profit minimums of the major multinational banana companies (plantains, vegetables, tropical fruits, soybeans, rice, and ornamental plants). Several examples will serve as examples of technology introduced, than abandoned.

In 1982, the Standard Fruit Company began a project to raise cucumbers in Honduras. Adapting varieties developed in temperate countries required extensive studies, especially on disease and insect control, two limiting factors of most attempts to acclimatize a temperate crop to the tropics. By 1990, cucumbers had been abandoned as producing insufficient and unstable profits, but had been taken over by a smaller exporting company which has been increasing production in recent years (Table 2).

In 1974, the United Fruit Company (now renamed United Brands) organized a subsidiary company (PATSA) to develop the cantaloupe and honeydew melon exporting business in Honduras. The scientists from the banana research group, together with hired managers, tested varieties, spacing, fertilizers, pest control methods, boxing, and shipping, and organized independent growers together with United Brands' own fields into a successful export business. Paradoxically, in recent years United Brands (now renamed Chiquita Brands) has ceased expenditures on technology and now purchases melons only on a consignment.

<table>
<thead>
<tr>
<th>Year</th>
<th>Pounds ('000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983</td>
<td>1,500</td>
</tr>
<tr>
<td>1984</td>
<td>1,300</td>
</tr>
<tr>
<td>1985</td>
<td>4,500</td>
</tr>
<tr>
<td>1986</td>
<td>2,500</td>
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<tr>
<td>1988</td>
<td>5,400</td>
</tr>
<tr>
<td>1989</td>
<td>12,300</td>
</tr>
<tr>
<td>1990</td>
<td>19,000</td>
</tr>
<tr>
<td>Total</td>
<td>48,200</td>
</tr>
</tbody>
</table>

Source: USDA Summary Report
Fresh Fruit and Vegetable Shipments,
FVAS-4 Calendar Year/PROEXAG.
basis. The business has attracted many new melon exporters and appears to be a solid export crop from Honduras (Figure 1). The value of melons imported into the United States from Central America reached $27.5 million in 1989. No new organization has taken up the slack in research created when the United Brands Company withdrew its support. Private growers, have proven amenable to adapting and testing new melon varieties produced by seed companies. However, new threats from viruses may require additional assistance in the near future.

While cucumbers and melons are examples of crops begun then largely abandoned to competitors, there are other examples of agricultural successes based on the development locally or adaption of outside technologies by multinational companies. A partial list follows:

- **Pineapples** Over 2.5 million boxes per year exported from Honduras.
- **Oil palm** The basis for local cooking oil and margarine manufacture. Over 28,000 hectares in production.
- **Grapefruit** One million boxes exported annually from Honduras.
- **Soybeans** A tropic-adapted variety developed (Siatsa 194).
- **Rice** A new variety developed (Chiquita Alisia).
- **Cattle** Imported prize Brahman and Santa Gertrudis stock, and selectively bred them to improve Honduran livestock.
- **Peanuts** A total of 2,000 hectares of peanut farms were established to provide cooking oil for a factory in Nicaragua.

One criticism frequently aimed at the research conducted by multinational companies is that the results remain in company archives and little technology emerges to assist in the development of the host-country agriculture. With the recognition by multinational companies that contracting with independent banana (and other crops) growers was as profitable as maintaining their own plantations, technology was disseminated as soon it was
produced. Again, the stimulus of profits provided the basis for transfer of technology.

Nor was the technology generated by the multinationals kept within the boundaries of the countries where they operated. Between 1925 and 1978 the staff of the United Brands Division of Tropical Research published 415 papers, mainly in international journals.

Institutions

In addition to the technology introduced directly into Central American agriculture, the private sector founded and financed to varying degrees three institutions that have had profound effects on Central American agriculture. They were the Lancetilla Experiment Station, the Escuela Agrícola Panamericana (Zamorano School) and Honduran Foundation for Agricultural Research (FHIA). A brief description of each follows:

**Lancetilla Experiment Station (Wilson Popenoe Botanical Garden)**

In 1926, the president of the United Fruit Company, Victor Cutter, pointed out the mutual advantages to be gained by cooperation in the development of Central American agriculture. To this end he commissioned the establishment of an experiment station near the north coast of Honduras to intensify diversification into tropical fruits and trees collected from all over the world. The Lancetilla Experiment Station was born. Its first director was Dr. Wilson Popenoe, the renowned tropical botanist.

Entirely funded and maintained by the United Fruit Company, Lancetilla planted trees on an experimental scale. In its first thirty years, plantings included approximately 1,000 varieties of citrus, coffee, African oil palm, tung oil trees, rubber, and an Asiatic fruit collection judged from a horticultural standpoint to be the best in Latin America. Although the Lancetilla Station is too rainy to produce good mango crops, the station collected, grafted, and distributed the best fiberless mangos from all over the world. The station serves as a major source of grafted mango, citrus, and other tropical fruit seedlings to this day.

The station established a serpentarium in 1928 in cooperation with Harvard University and the Mulford Drug Company to produce antivenom from the fer-de-lance (*Bothrops atrox*) and the Central American rattlesnake (*Crotalus durissus*), the two most dreaded poisonous snakes of Central America.

Foreign plants that were first introduced into Central America through Lancetilla included the African oil palm (*Elaeis guineensis*). Today there are more than 25,800 hectares of this palm in Honduras and Costa Rica.

By 1965, the cost of maintaining the Lancetilla Experiment Station had risen to a level that the United Fruit Company found excessive and they began to look for a university or foundation to take over operations. Between 1965 and 1974, with no institution willing to take over operations, the plantings and grounds deteriorated. In 1974, when the garden was turned over to the Honduran government’s Secretary of Natural Resources, a total of 342 varieties of plants had been lost. Between 1974 and the present the garden was reassigned to the forestry department of Honduras (COHDEFOR). Most records of accessions have been lost, but Lancetilla still remains a prime source of plant material for experimentation and commercialization.

**Escuela Agrícola Panamericana (Zamorano School)**

In early 1941 Sam (the banana man) Zemurray, a Russian immigrant who became chief stockholder and president of the United Fruit Company, decided to “give something back to the region that had brought the United Fruit Company considerable profits.” Zemurray contacted Wilson Popenoe and told him to establish a practical agricultural school to train young Central Americans.

Wilson Popenoe and Doris Stone, Zemurray’s daughter (a famous archeologist),
searched the Central American highlands and finally selected a 3,500-acre property in Zamorano, Honduras. The Escuela Agrícola Panamericana was born.

The United Fruit Company donated $3 million dollars in 1942 to start the school and another $3 million over 20 years to defray expenses. The policy of the United Fruit Company was not to employ graduates of Zamorano so that Zamorano’s graduates would benefit Central American agriculture and not United Fruit’s own money-making banana enterprise.

The Zamorano School grew and eventually covered 15,000 acres. Although agricultural education is the primary purpose, the school also conducts research and extension programs to benefit Latin America. Today the school has an international student body of 650, an international teaching staff of approximately 100, and a total payroll of 700.

The Zamorano School conducts studies in horticulture, fruit crops, agronomy, basic grains, natural history, aquaculture, livestock, biological control, and silviculture. The original investment by a multinational company has paid off many times over in new technologies developed by the Zamorano School.

Fundación Hondureña De Investigación Agrícola (FHIA)

The latest addition to Central American institutions was the formation in 1984 of the Honduran Foundation for Agricultural Research. Again, a decision to save money by the United Brands Company by reducing its Research Division was made in 1984. The entire infrastructure that housed departments of agronomy, pathology, entomology, nematology, post-harvest, and genetics that had contributed technology vital to the banana (and other crops) industry of Central America was dismantled. All programs except the important banana genetics program, which received bridge funding from the Food and Agriculture Organization of the United Nations until FHIA took over, were either reduced to a fraction of their former status or dropped entirely.

FHIA is an independent, non-political research organization whose operations are currently funded primarily by USAID and the Honduran government, and by donations from other governments. In addition, small agricultural companies contract with FHIA for services.

FHIA has taken a commodity approach to its organization and conducts studies on vegetables, soybeans, cacao, banana, and plantains, as well as a diversified crops section to test and encourage the development of new or little grown crops such as palm hearts, black pepper, and mangos.

If we agree that the banana is one, if not the most important tropical export crop, then the scientific work with the most potentially important impact on Latin America is the program to develop a disease-resistant banana currently underway at FHIA. The Gros Michel banana, once the only banana of commerce, was replaced by the Cavendish group when the Fusarium fungus (Panama disease) killed out the Gros Michel plantations. The fungus remains like a time bomb in the soils of Latin America. If and when new mutations of the fungus begin to attack the currently resistant Cavendish banana, there is no resistant banana to replace Cavendish.

Also, the Sigatoka leaf fungus has been replaced into the more virulent black Sigatoka, which has not only driven up costs of control, but is infecting plantains that are normally resistant to Sigatoka. Plantains are traditionally a small landowner’s crop and the devastation by black Sigatoka has severely reduced incomes of the farmers least able to afford any losses.

The FHIA program on banana and plantain improvement has had several successes. A black Sigatoka-resistant cooking banana (FHIA 3) could replace the cooking and beer bananas of East Africa where over 1 million hectares produce this basic food crop. Black Sigatoka is already making inroads on African banana production, and FHIA 3 may be arriving just in time to avoid massive food losses. In addition,
new plantain hybrids promise to triple plantain production.

The banana breeding program, begun with such foresight by the United Fruit Company, was abandoned when the company found that they could not patent a new banana. With the spectre of new races of both Panama disease and Sigatoka posing grave dangers to the banana industry — a single generation of banana crosses requires three years — the policies of the multinational banana companies in not funding the banana genetics program seem strangely shortsighted.

Conclusion

This paper has attempted to briefly describe the impact of technology from the private sector, namely the multinational banana companies, in the development of agriculture in Central America. With bottom line profits as an incentive, the private sector, in particular the United Fruit Company, developed technologies for agriculture within the boundaries of the Central American countries where it operated.

The limits of subject matter and space do not allow for the inclusion of other major side benefits to Central American agriculture, such as the construction of railroads, the Tropical Radio system, seaports, and townsites.

In summary, the impact of technology by the private sector in the development of agriculture in Central America has been vital not only to the multinational banana companies, but to agricultural industries and institutions that, without the effect of this technology, would probably not exist in their present form. By necessity, some technology had to be imported and adapted to the tropical environment in order for sustainable, profitable agriculture to continue.

References


There are innumerable ways in which dairy cattle are managed for milk production in emerging economies, and these systems reflect not only the resources available for production, but also different government policies toward the import or export of milk solids.

For instance, a large percentage of Mexico's milk is produced as a by-product of seasonally calving beef cattle, whereas virtually all of Puerto Rico's milk comes from large commercial herds. Both these systems contrast sharply with systems such as those in India, where organized milk collection from subsistence farms is prevalent.

In order to discuss appropriate technologies for milk production in emerging economies, it is perhaps useful to start by defining the type of situation within which dairy farming is likely to exhibit long-term sustained viability.

One of the first essentials for milk production is that it should be perceived to be in the national interest and/or to be politically important. If these requirements are not met, then the long-term viability of any sort of milk production, in the face of freely imported milk solids, is questionable.

This is because the majority (Table 1) of the dairy products in world trade are produced by moderately to heavily subsidized industries (Table 2) and are virtually “dumped” products.

Where governments do not exercise some control over the relationship between imports and local production, then local production will at best stagnate (for example, Jamaica and Guyana), or at worst drop sharply (Dominican Republic).

If local milk producers are given some form of protection from imports, then milk production at the farm level becomes largely a question of persuading cows to eat enough feed of sufficiently low cost to produce milk at a price which consumers can afford. Such a system of feeding should also provide the farmer with sufficient returns to make dairy production as viable an enterprise as any other which his circumstances allow him to undertake.

In many cases dairy production is attractive because of its ability to generate a more or less steady flow of cash, and this, coupled with low opportunity costs, is often reason enough to make it attractive to small or subsistence farmers.

Animal Constraints

The native cattle of the tropics are well adapted to their environment with its generally low levels of nutrition and management, high incidence of parasites, and difficult climatic conditions. These cattle produce small volumes of milk, have long calving intervals, and an elevated age at first calving (McDowell 1972).

Productivity is normally increased by crossing with breeds from temperate areas except under the harshest of environments (Mason 1974). As the proportion of Bos taurus blood increases in the crossbreds, so too does milk production with maximum production being reached at around the 50 percent level (Table 3), although it can continue to increase until the purebred Bos Taurus level is reached (Table 4).

Similarly, both reproductive efficiency and survival tend to be better in crossbreds than in the temperate breeds, although there are an increasing number of cases where both of these
Table 1. Dairy production and exports from four regions as percentage of world exports and production, 1988

<table>
<thead>
<tr>
<th>Region</th>
<th>Production (percent of world production)</th>
<th>Exports (percent of world exports)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Butter</td>
<td>Cheese</td>
</tr>
<tr>
<td>EC</td>
<td>27.8</td>
<td>40.8</td>
</tr>
<tr>
<td>U.S.</td>
<td>7.8</td>
<td>24.3</td>
</tr>
<tr>
<td>Australia</td>
<td>1.5</td>
<td>1.8</td>
</tr>
<tr>
<td>New Zealand</td>
<td>4.4</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Source: Cornell University 1990.

Table 2. Percentage of equivalent producer dairy subsidies

<table>
<thead>
<tr>
<th>Country or region</th>
<th>1980</th>
<th>1983</th>
<th>1986</th>
<th>1987</th>
<th>19881</th>
<th>19902</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>84</td>
<td>80</td>
<td>98</td>
<td>94</td>
<td>90</td>
<td>84</td>
</tr>
<tr>
<td>Norway</td>
<td>80</td>
<td>73</td>
<td>85</td>
<td>82</td>
<td>80</td>
<td>79</td>
</tr>
<tr>
<td>Switzerland</td>
<td>72</td>
<td>71</td>
<td>89</td>
<td>87</td>
<td>82</td>
<td>76</td>
</tr>
<tr>
<td>Finland</td>
<td>70</td>
<td>61</td>
<td>72</td>
<td>77</td>
<td>76</td>
<td>73</td>
</tr>
<tr>
<td>Canada</td>
<td>54</td>
<td>62</td>
<td>87</td>
<td>81</td>
<td>72</td>
<td>68</td>
</tr>
<tr>
<td>Sweden</td>
<td>66</td>
<td>55</td>
<td>75</td>
<td>72</td>
<td>68</td>
<td>62</td>
</tr>
<tr>
<td>EC</td>
<td>59</td>
<td>47</td>
<td>73</td>
<td>68</td>
<td>60</td>
<td>52</td>
</tr>
<tr>
<td>U.S.</td>
<td>57</td>
<td>57</td>
<td>81</td>
<td>71</td>
<td>56</td>
<td>51</td>
</tr>
<tr>
<td>Australia</td>
<td>27</td>
<td>20</td>
<td>54</td>
<td>43</td>
<td>34</td>
<td>29</td>
</tr>
<tr>
<td>New Zealand</td>
<td>20</td>
<td>46</td>
<td>18</td>
<td>14</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Austria</td>
<td>50</td>
<td>40</td>
<td>69</td>
<td>62</td>
<td>55</td>
<td>47</td>
</tr>
</tbody>
</table>

1. Estimates.
2. Preliminary.
Source: Cornell University 1990.

Table 3. Lactation yields in Cuba

<table>
<thead>
<tr>
<th>Holstein (fraction)</th>
<th>Yield (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/8</td>
<td>2,199.5</td>
</tr>
<tr>
<td>1/4</td>
<td>2,179.1</td>
</tr>
<tr>
<td>1/2</td>
<td>3,171.4</td>
</tr>
<tr>
<td>5/8</td>
<td>3,175.0</td>
</tr>
<tr>
<td>3/4</td>
<td>3,029.1</td>
</tr>
<tr>
<td>7/8</td>
<td>2,809.0</td>
</tr>
</tbody>
</table>

Source: De La Fuente 1978.

Table 4. Lactation yields in Venezuela

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Lactation length (days)</th>
<th>Milk yield (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holstein</td>
<td>287</td>
<td>4.0</td>
</tr>
<tr>
<td>7/8 Holstein-Criollo</td>
<td>290</td>
<td>3.6</td>
</tr>
<tr>
<td>3/4 Holstein-Criollo</td>
<td>285</td>
<td>3.6</td>
</tr>
<tr>
<td>1/2 Holstein-Criollo</td>
<td>274</td>
<td>3.1</td>
</tr>
</tbody>
</table>

Source: McDowell 1972

largely a function of management, and more specifically of the level of nutrition to which they are subjected, the extent to which they are protected from the sun, and the degree to which animal health measures are implemented. In many instances developing countries are not in a position to provide the necessary infrastructure to support high levels of Bos taurus-based milk production, but there is sufficient knowledge to quantify the levels of nutrition required to support animals with different levels of cross breeding (Tables 5 and 6).

To summarize, current knowledge indicates that to make the best use of a certain feed supply we require particular genotypes, or put another way, to make the best use of a certain type of animal we must feed at a certain level (Figure 1).

Forage Constraints

In other words, the ability of cattle with a high level of Bos taurus blood to produce is largely a function of management, and more specifically of the level of nutrition to which they are subjected, the extent to which they are protected from the sun, and the degree to which animal health measures are implemented. In many instances developing countries are not in a position to provide the necessary infrastructure to support high levels of Bos taurus-based milk production, but there is sufficient knowledge to quantify the levels of nutrition required to support animals with different levels of cross breeding (Tables 5 and 6).

To summarize, current knowledge indicates that to make the best use of a certain feed supply we require particular genotypes, or put another way, to make the best use of a certain type of animal we must feed at a certain level (Figure 1).

Forage Constraints

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To summarize, current knowledge indicates that to make the best use of a certain feed supply we require particular genotypes, or put another way, to make the best use of a certain type of animal we must feed at a certain level (Figure 1).
Figure 1. Milk yield in relation to feeding
Table 5. Estimated milk yield and feed requirements for native and crosses with Friesian

<table>
<thead>
<tr>
<th>Breed group</th>
<th>Cow weight (kg)</th>
<th>Expected milk (kg)</th>
<th>TDN (kg/day)</th>
<th>Multiples maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>8/8 native</td>
<td>350</td>
<td>850</td>
<td>4.2</td>
<td>1.46</td>
</tr>
<tr>
<td>1/8 Friesian</td>
<td>370</td>
<td>1,345</td>
<td>5.2</td>
<td>1.60</td>
</tr>
<tr>
<td>2/8 Friesian</td>
<td>400</td>
<td>1,840</td>
<td>6.2</td>
<td>1.74</td>
</tr>
<tr>
<td>3/8 Friesian</td>
<td>425</td>
<td>2,335</td>
<td>7.0</td>
<td>1.86</td>
</tr>
<tr>
<td>4/8 Friesian</td>
<td>450</td>
<td>2,830</td>
<td>8.0</td>
<td>2.08</td>
</tr>
<tr>
<td>5/8 Friesian</td>
<td>502</td>
<td>4,015</td>
<td>9.0</td>
<td>2.12</td>
</tr>
<tr>
<td>6/8 Friesian</td>
<td>575</td>
<td>5,090</td>
<td>9.8</td>
<td>2.38</td>
</tr>
<tr>
<td>7/8 Friesian</td>
<td>612</td>
<td>5,900</td>
<td>10.2</td>
<td>2.45</td>
</tr>
<tr>
<td>8/8 Friesian</td>
<td>650</td>
<td>7,000</td>
<td>11.2</td>
<td>2.80</td>
</tr>
</tbody>
</table>


Table 6. Milk yield from different breeds

<table>
<thead>
<tr>
<th>Resources will support milk yield (kg)</th>
<th>Breed</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 4,000</td>
<td>Pure Holstein or 3/4 Holstein cross</td>
</tr>
<tr>
<td>3,000</td>
<td>Dairy cross 50-65%</td>
</tr>
<tr>
<td>2,000</td>
<td>Dairy cross 25-50%</td>
</tr>
<tr>
<td>&lt; 1,500</td>
<td>Dairy cross 25% or native</td>
</tr>
</tbody>
</table>


the main component of the diet, supplemented with varying amounts of grain, by-products, and crop residue.

In general terms, tropical forages produce more dry matter than do those of temperate areas (Vicente Chandler et al. 1974), but conversely they generally have a lower nutritive value (Figure 2). This relative drop in value is probably due to the higher temperature at which forages are grown, as well as to their greater stem to leaf ratio. These effects will be further exaggerated in the case of C4 grasses which have increased proportions of lignin and cellulose relative to C3 grasses (Table 7).

This drop in nutritive value is associated with a decrease in voluntary intake, and this is the main reason for the lowered levels of animal production in the tropics, although lack of protein may be more important in some specific instances (Stobbs 1971).

Based on these considerations, the level of animal production in the tropics would be very low were it not for the ability of the animal to graze selectively and to mobilize its body reserves during periods of nutritional stress (Stobbs and Thompson 1975).

Under good management conditions, milk yields of 8 to 9 kilograms per cow per day have been obtained with small cows, while 12 to 14 kilograms per cow per day have been obtained with larger animals (Stobbs 1976). These figures are similar to those suggested by McDowell (1983), who estimates that lactating cows will average 11 kilograms of milk on excellent quality grazing or grazing plus supplements (ration with a digestibility of 55 percent).

Feeding Systems

Reviews covering much of the knowledge available on feeding systems for both the humid (Archibald 1984) and seasonal rainfall tropics (Topps 1984) are available, while the potential of pasture-based systems has been summarized recently (Humphries 1991).

In the humid tropics where grass growth continues for most of the year, high levels of production per hectare have been achieved in many countries. For example, in Australia, per cow productions of 3,250 liters per cow per year and over 25,000 liters per hectare per year have been obtained with minimal supplementation under experimental conditions (Chopping et al. 1976).
Figure 2. Digestibility of grasses, crop residue, by-products, and grains

Grasses

Grains, by-products

Digestibility

Temporaty

Mature

Young

Bloom

69

64

58

54

45

38

Maize
Cottonseed meal
Sorghum
Cassava
Peanut screenings
Cupra meal
Cottonseed cake
Wheat bran
Banana (whole, dried)
Molasses
Rice bran
Maize stover (improved)
Wheat straw (native)
Rice straw
Wheat straw (improved)
Sugarcane tops
Sugarcane bagasse
Peanut hulls
Rice hulls
Coffee hulls
Table 7. Chemical composition of plant material, grouped by plant function

<table>
<thead>
<tr>
<th>Functional Structural tissue</th>
<th>Cell wall</th>
<th>Hemicellulose</th>
<th>Cellulose</th>
<th>Lignin</th>
<th>Nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood (trees)(^1)</td>
<td>88.1</td>
<td>22.5</td>
<td>45.4</td>
<td>20.2</td>
<td>6</td>
</tr>
<tr>
<td>Bark (trees)(^2)</td>
<td>76.1</td>
<td>10.9</td>
<td>44.0</td>
<td>20.1</td>
<td>3</td>
</tr>
<tr>
<td>Stem (trees and shrubs)(^3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring</td>
<td>35.8</td>
<td>7.7</td>
<td>18.9</td>
<td>9.2</td>
<td>20</td>
</tr>
<tr>
<td>Winter</td>
<td>61.9</td>
<td>13.1</td>
<td>29.1</td>
<td>19.8</td>
<td>20</td>
</tr>
<tr>
<td>Stems</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tropical grass(^4)</td>
<td>74.3</td>
<td>29.6</td>
<td>35.3</td>
<td>10.1</td>
<td>9</td>
</tr>
<tr>
<td>Temperate grass(^5)</td>
<td>60.7</td>
<td>28.4</td>
<td>29.5</td>
<td>2.8</td>
<td>2</td>
</tr>
<tr>
<td>Stems (legume)(^6)</td>
<td>54.0</td>
<td>9.8</td>
<td>34.6</td>
<td>10.4</td>
<td>22</td>
</tr>
<tr>
<td>Photosynthetic surfaces</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaves (trees and shrubs)(^7)</td>
<td>57.1</td>
<td>16.5</td>
<td>23.5</td>
<td>14.6</td>
<td>18</td>
</tr>
<tr>
<td>Leaves</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tropical grass(^4)</td>
<td>66.3</td>
<td>32.7</td>
<td>27.4</td>
<td>5.8</td>
<td>9</td>
</tr>
<tr>
<td>Temperate grass(^5)</td>
<td>55.4</td>
<td>29.0</td>
<td>23.6</td>
<td>2.8</td>
<td>2</td>
</tr>
<tr>
<td>Leaves and stems (temperate annual grass)(^8)</td>
<td>59.0</td>
<td>23</td>
<td>29.8</td>
<td>6.2</td>
<td>15</td>
</tr>
<tr>
<td>Storage organs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underground storage (domestic)(^2)</td>
<td>10.0</td>
<td>3.5</td>
<td>5.1</td>
<td>0.8</td>
<td>5</td>
</tr>
<tr>
<td>Reproductive organs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seed hulls(^2)</td>
<td>76.0</td>
<td>15.3</td>
<td>47.9</td>
<td>13.5</td>
<td>6</td>
</tr>
<tr>
<td>Seed with hulls(^9)</td>
<td>52.5</td>
<td>13.7</td>
<td>19.5</td>
<td>19.4</td>
<td>20</td>
</tr>
<tr>
<td>Seeds without hulls(^9)</td>
<td>17.8</td>
<td>7.1</td>
<td>5.4</td>
<td>9.9</td>
<td>5</td>
</tr>
<tr>
<td>Seeds (legume)(^9)</td>
<td>40.4</td>
<td>20.0</td>
<td>16.3</td>
<td>4.2</td>
<td>9</td>
</tr>
<tr>
<td>Fruits (fleshy, including seeds)(^9)</td>
<td>40.9</td>
<td>10.9</td>
<td>15.2</td>
<td>14.8</td>
<td>47</td>
</tr>
<tr>
<td>Fruits (domestic, no covering)(^2)</td>
<td>14.4</td>
<td>3.6</td>
<td>8.8</td>
<td>2.0</td>
<td>4</td>
</tr>
</tbody>
</table>

5. Laredo and Minson 1975.

Source: Demment and Von Soest 1983.

In Puerto Rico, lactation averages of 3,840 kilograms have been reported for 19,000 cows receiving supplementary feed (Camoens et al. 1976), while 3,300 liters per cow have been achieved under commercial conditions with no supplementary feeding and with a stocking rate of close to 2.5 cows per hectare (Caro Costas and Vicente Chandler 1979). In Costa Rica yields of 2,800 liters per cow per year have been reported at stocking rates of 5.5 cows per hectare (Deaton 1979).

These levels of production are based on high stocking rates coupled with intermediate levels of production per cow. The interrelationships involved are indicated in Tables 8 and 9.

Quite clearly, as stocking rates increase so too do the risks involved in the system. It is also more likely that such practices as supplementary feeding, increased fertilization of pastures, and irrigation will give better returns as stocking rates rise.
Table 8. Milk production per cow and per hectare on fertilized tropical pastures

<table>
<thead>
<tr>
<th>Pasture</th>
<th>Stocking rate (cows/ha)</th>
<th>Milk production (kg/cow/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyparrhenia rufa</td>
<td>1.9</td>
<td>10.7</td>
</tr>
<tr>
<td>decumbens</td>
<td>1.2</td>
<td>10.2</td>
</tr>
<tr>
<td>Bracharia</td>
<td>3.3</td>
<td>8.6</td>
</tr>
<tr>
<td>Pennisetum</td>
<td>2.8</td>
<td>7.8</td>
</tr>
<tr>
<td>Clandestinum</td>
<td>3.3</td>
<td>7.1</td>
</tr>
<tr>
<td></td>
<td>4.7</td>
<td>6.9</td>
</tr>
</tbody>
</table>

Source: Stobbs 1976.

Table 9. Carrying capacity of pasture and milk production of dairy cows on various tropical pasture regimes

<table>
<thead>
<tr>
<th>Pasture</th>
<th>Stocking rate (cows/ha/yr)</th>
<th>Milk production (kg/ha/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unfertilized grass</td>
<td>0.8-1.5</td>
<td>1,000-2,500</td>
</tr>
<tr>
<td>Grass-legume mixtures</td>
<td>1.3-2.5</td>
<td>3,000-8,000</td>
</tr>
<tr>
<td>N-fertilized grass pastures (plus P &amp; K)</td>
<td>2.5-5.0</td>
<td>4,500-9,500</td>
</tr>
</tbody>
</table>

Source: Stobbs and Thompson 1975.

Work on supplementation of grazing animals has given variable results in terms of yield response. This is not unexpected given the different levels of substitution which are likely to occur with varying pasture, animal, and weather conditions both during and between experiments. It is important when evaluating such responses to bear in mind other factors such as reproductive performance, ratio of feed costs to milk price, carry-over effects, stocking rates, and farmers peace of mind (Table 10).

Pasture fertilization, and more so nitrogen fertilization, will often boost milk yields at high stocking rates, as will irrigation. However, as with supplementary feeding, short-term evaluations of these practices may well give conflicting results. It is only when the “insurance” value of these practices is taken into account that their true value to the farmer can be appreciated. Conversely, these practices are unlikely to yield reasonable returns unless high stocking rates are used.

Having established the possibilities for dairy production in the tropics, we will now turn to the Jamaica/Serge Island situation to illustrate its application.

Jamaican Dairy Industry

Jamaica has many of the conditions for a successful dairy industry — it has benefited from good basic research in forage production and animal breeding and has a moderate tropical climate and reasonable soils. In addition, its rural population has some tradition of cattle keeping.

However, Jamaica still imports over 80 percent of its dairy requirements, and the dairy industry has only shown sporadic periods of growth. Such periods have had little to do with changes in technology, but rather reflect changes in government policy relative to imported milk products.

Thus production increased slowly through the decades of the 1950s and 1960s until the mid-1970s. At around this time it became far more profitable for processors to reconstitute milk from imported solids rather than to buy farmers’ milk. As a result, milk production declined rapidly.

In early 1987 the government implemented a policy controlling the use of imported solids, effectively “piggy backing” development of the local industry on such imports. Following this, production increased dramatically (Figure 3), although the effects of very recent changes in government policy (brought about by structural adjustment and liberalization of the economy) are not clear.

Serge Island Dairies (SID)

Originally Serge Island was a sugar estate, and conversion to dairy started in 1974-75. As in most other cases where growing sugar has been replaced by large scale dairying, the
Table 10. Effects of supplementing Holstein cows grazing on African star grass in Puerto Rico

<table>
<thead>
<tr>
<th></th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>T5</th>
<th>T6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lactation length (days)</td>
<td>271</td>
<td>284</td>
<td>281</td>
<td>291</td>
<td>290</td>
<td>290</td>
</tr>
<tr>
<td>Lactation yield (kg)</td>
<td>3,070</td>
<td>3,560</td>
<td>3,590</td>
<td>4,380</td>
<td>4,130</td>
<td>3,740</td>
</tr>
<tr>
<td>Supplement (kg)</td>
<td>516</td>
<td>580</td>
<td>2,016</td>
<td>819</td>
<td>544</td>
<td></td>
</tr>
<tr>
<td>Liveweight charge</td>
<td>-12</td>
<td>+3</td>
<td>-3</td>
<td>-6</td>
<td>-8</td>
<td>-22</td>
</tr>
</tbody>
</table>

**Reproduction**

<table>
<thead>
<tr>
<th></th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>T5</th>
<th>T6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days to first heat</td>
<td>60</td>
<td>52</td>
<td>49</td>
<td>57</td>
<td>52</td>
<td>50</td>
</tr>
<tr>
<td>Calving interval (days)</td>
<td>407</td>
<td>392</td>
<td>392</td>
<td>409</td>
<td>394</td>
<td>387</td>
</tr>
<tr>
<td>Percent failing to conceive</td>
<td>300 days post partum</td>
<td>11.2</td>
<td>8.3</td>
<td>7.0</td>
<td>7.6</td>
<td>6.0</td>
</tr>
<tr>
<td>Milk yield/cow/yr (kg)</td>
<td>2,750</td>
<td>3,310</td>
<td>3,340</td>
<td>3,910</td>
<td>3,830</td>
<td>3,670</td>
</tr>
<tr>
<td>Marginal return from supplements (U.S. dollars)</td>
<td>126</td>
<td>81</td>
<td>-25</td>
<td>167</td>
<td>218</td>
<td></td>
</tr>
</tbody>
</table>

T1. Grazing alone, 1kg supplement per 2 kg milk above yields of 10 kg.
T2. Grazing plus molasses, 1kg supplement per 2 kg milk above yields of 10 kg.
T3. Grazing plus ground corn, 1kg supplement per 2 kg milk above yields of 10 kg.
T4. Grazing plus concentrate (1 kg/2kg milk).
T5. Grazing plus concentrate mix, 1kg supplement per 2 kg milk above yields of 10 kg.
T6. Grazing plus molasses-urea, 1kg supplement per 2 kg milk above yields of 10 kg.


Table 11. Production at Serge Island Dairies Limited, 1991

<table>
<thead>
<tr>
<th>Farm</th>
<th>Breed</th>
<th>Cows</th>
<th>Hectares</th>
<th>Cows/ha</th>
<th>Liters sold/cow</th>
<th>Liters sold/ha</th>
<th>Tonnes of concentrate/cow</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F1 H/F</td>
<td>397</td>
<td>104</td>
<td>3.8</td>
<td>3,555</td>
<td>13,580</td>
<td>1.78</td>
</tr>
<tr>
<td>2</td>
<td>F2 JH</td>
<td>440</td>
<td>86</td>
<td>5.1</td>
<td>3,149</td>
<td>16,100</td>
<td>1.40</td>
</tr>
<tr>
<td>3</td>
<td>FE H/F</td>
<td>387</td>
<td>78</td>
<td>5.0</td>
<td>3,834</td>
<td>19,000</td>
<td>1.91</td>
</tr>
<tr>
<td>4</td>
<td>F4 JH</td>
<td>467</td>
<td>93</td>
<td>5.0</td>
<td>2,757</td>
<td>13,840</td>
<td>1.22</td>
</tr>
<tr>
<td>5</td>
<td>F5 crossbred</td>
<td>411</td>
<td>71</td>
<td>5.8</td>
<td>3,417</td>
<td>19,790</td>
<td>1.46</td>
</tr>
</tbody>
</table>

process of conversion has been slow and more costly than expected. By 1983 many lessons had been learned, and since that time there has been steady progress in milk production (Figure 4), as well as the development of a fully integrated dairying operation. SID operations now cover milk production, milk processing and marketing, as well as a small farmers dairy scheme. Serge Island is situated in the southeast of Jamaica, and has a humid climate with essentially one dry season. Rainfall averages 2.146 millimeters, with the dry period between December and April. Mean maximum temperatures vary by only a small amount (28.1 to 31.2°C), as do mean minimum temperatures (20.6 to 23.9°C). The soils are mainly sandy loams, moderately acidic (pH 6.8 to 5.6), and characterized by a high gravel content, which makes them very free draining. Main fertilizer requirement is nitrogen.
The current operation covers 610 hectares, of which 432 are utilized by five milking farms, with the balance used for calf and heifer rearing. Stocking rates on the milking farms vary from 3.8 to 5.8 cows per hectare, and milk production varies from 2,750 to 3,830 liters per cow and 13,500 to 19,750 liters per hectare (Table III).

**Animal Factors**

Three different genetic groups of cattle are farmed on Serge — Jamaica Hopes, Friesian/Holsteins, and crossbreds. The reasons for this are mainly historical. When SID commenced operations there were not enough Jamaica Hopes available to stock the farm, and a group of Canadian Holsteins were
imported. The crossbreds are mainly the result of crosses of F/H cows with J.Hope bulls.

Our experience with these breed groups generally falls in line with expectations — the greater productive potential of the F/H animals must be matched by better feeding and management if it is to be realized.

Since 1985 all F/H replacements have been bred from New Zealand sires on the basis that this particular strain of black and white cattle have been shown to have a smaller mature size than other strains, while there are also indications that it is the most efficient producer of milk solids per kilogram of body weight. It is also pertinent that the conditions under which NZ selection is carried out are closer to those on Serge than those in other temperate areas offering similar semen. This might well reduce the possible effects of genotype-environment interactions.

Assuming reasonable levels of feeding, the main constraint of F/H cattle is the poor levels of conception obtained in the hotter months of the year. The result of this is that calving tends to be seasonal with those animals that calve so that they are served in the cooler months having the shortest calving intervals.

In contrast, calving intervals for the J.Hopes are less affected by season (Figure 5) although their milk production is also lower.

We are now adopting a policy of reinforcing nature — we aim to calve all our F/H animals between August and January in order to ensure good calving intervals. Our figures indicate that this could result in an increase in milk production of the order of 10 to 15 percent simply as a result of reduced calving intervals. However, it should be realized that in order to achieve this potential gain in productivity, nutrition at the time of calving must be improved since it will coincide with the slowest period of grass growth.

Milk production varies according to breed (Table 11), although it should be noted that there are also large differences from farm to farm.

**Forage Factors**

Practically all pastures on SID are of African Star grass — *Cynodon nlemfuensis* — which is a very hardy, stoloniferous grass capable of withstanding considerable mismanagement, particularly due to overgrazing during dry periods. It requires heavy grazing in order to provide feed of even
moderate nutritional value, and must therefore be subjected to high grazing pressures for most of the year.

In order to achieve this a high degree of subdivision is necessary, with each farm having well over fifty paddocks with their own water trough so that grazing pressures of about 250 cows per hectare are achieved. Rotation lengths vary from as little as five or six days to as many as three or four weeks.

Grazing management not only attempts to improve the nutritional value of the forage on offer but also attempts to provide those animals with the highest demands with the best feed available at any time. Thus the milkers are grouped according to production as are the dry animals according to body condition. Compared to temperate areas, the proportion of dry animals required to keep pastures under control is much higher with tropical grasses.

Heavy use is made of fertilizer with up to 300 kilograms per hectare of nitrogen being applied to the more productive pastures with annual maintenance doses of phosphorus and potash also required. This fertilizer regime is based on extensive soil analyses which have proved very cost effective.

Irrigation is used during the dry period — response in terms of dry matter production is limited for the winter months, but becomes much better after the middle of February. Up to now no conservation either as hay or silage has been attempted.

Feeding System

Essentially the grazing system depends on a high stocking rate which ensures relatively good nutritional value of the grass. At the same time, heavy fertilization and some irrigation ensure that the system does not “crash.”

As stocking rates have risen over the years, the winter feed gap has become more noticeable, and this has been further compounded by the fact that calving has tended to be concentrated in the cooler months of the year.

Supplementary feeds have been an essential part of the system at SID, with the milking herds receiving feed (commercial 16 percent protein dairy ration) at around the rate of 400 to 500 grams per liter of milk. While the use of supplements will depend on the milk production response, it should be clear that the level of use will be a function of the relative cost of feed to the price of milk. Changes in this relationship will mean changes in the amount of supplementary feed utilized.

Young stock are reared on two separate units, either until they are ready for breeding or have been bred, depending on forage availability over the farm.

Calves are reared outside on nurse cows which are culls from the milking herds. Reasons for culling include reproductive disorders, slow or awkward milking, poor udder conformation, chronic mastitis, and low production.

Most bull calves are sold within a week of birth, while up to now all heifer calves have been reared at least to weaning at 7 to 10 weeks. Calves have access to concentrates and hay almost from birth.

Animals are penned in groups of about ten according to breed and size, and are kept on hay and concentrates until 6 to 8 months, when they are put out to pasture. This is a function of pasture availability rather than a requirement of the system.

Internal and external parasites are controlled (but not eliminated) from an early age and kept in check thereafter.

The opportunity cost of this system is minimal; it eliminates the foreign exchange requirement of milk substitutes and reduces the risk of human error.

Compared to other systems of rearing it has a relatively high land-use requirement while the main difficulties encountered are unevenness of calf growth, increased mortality, and lowered growth rates due to lack of shelter during prolonged rainy periods.

Once heifers leave the calf unit they are reared on grass with supplementary feed with the objective of reaching breeding weight to calve down at around 27 months of age.

Up to this point, it is clear that SID has found it much easier to achieve its objectives
with Jamaica Hope and crossbred animals rather than with Friesian/Holsteins.

Essentially this has resulted from feeding all groups of cattle in virtually the same way as is adequate for the smaller-sized Jamaica Hopes. Over the last year efforts to address this problem by feeding more to the Friesians have resulted in cost effective increases in growth rates, which should result in first calving within 30 months of age.

The relationships between supplementary feed levels, pasture production (both in terms of quality and quantity), stocking rate, and economic returns are complex. Over the last six or seven years the balance between these factors at SID has afforded the farming operation good operational profits.

The Future

Current changes in economic policy in Jamaica will have profound effects on the dairy industry, perhaps similar to those following the imposition of quotas in Britain. In order to survive, dairy farmers will have to become more efficient in all aspects of their operations, and especially so in terms of reproductive performance and nutrition.

Farmers in the tropics are faced with reduced reproductive efficiencies due to heat-related reductions in conception rates. Basic knowledge of the factors involved is increasing, and there are indications that farmers will have techniques available within the next five to ten years which will help to increase conception rates.

Similarly, embryo technology is of direct relevance to tropical dairy farmers since it will allow more rapid multiplication of such breeds as the Jamaica Hope and Australian Friesian Sahiwal, which are currently limited by their small numbers. In fact, it could be argued that embryo technology has more to offer such breeds in terms of genetic progress than those breeds which already have well-structured genetic improvement programs.

In terms of nutrition, increasing emphasis will have to be placed on forages, recognizing that per cow production will be lowered when high energy concentrate use is decreased. This need not necessarily happen if indigenous sources of energy such as cassava are developed.

In the short term, there is ample scope for increasing the efficiency of forage utilization not only by making better use of the dry matter available, but also by manipulating growth to produce forages of higher nutritive value.

Whatever the outcome it seems clear that dairy farmers will have to place increasing reliance on indigenous sources of feed — the main technical factor to be overcome is the generally lower levels of per cow production obtained with such feeds.

Conclusions

There is abundant potential for increased milk production in many tropical countries, and the multiplier effect on rural development can be considerable.

However, due to the prevailing conditions in world trade of dairy products, production will only increase if governments in countries wishing to develop a dairy industry exercise control over the relationship between imports and local production.

Similarly, developed countries exporting dairy products must recognize the irony of dumping heavily subsidized products on developing countries while at the same time offering these same countries all types of assistance, including food aid.

References


Commodity Perspectives — Dairying

David Leaver

World milk production increased by 1.5 percent in 1990 to 534 million tonnes, and is expected to reach 585 million tonnes by the year 2000. Approximately 400 million tonnes will be from developed and 185 million tonnes from developing countries. Nevertheless, due to population differences, and in spite of net imports of about 15 million tonnes, per caput availability in developing countries will be only 42 kilograms per year compared with 290 kilograms per year for developed countries.

Thus it can be concluded that there is ample scope for the expansion of dairy production in developing countries. However, this will only occur if the dumping of surpluses from the developed world is curtailed. The greatest priority for the world dairy industry is the removal of subsidies. These encourage over-production of milk in developed countries, often using unsustainable production methods which lead to environmental damage. The surpluses undermine the dairy industries in developing countries through the dumping of low-priced dairy surpluses, in particular skim milk powder.

Appropriate Technology

It is generally accepted that a “bottom-up” approach to development is required. Technology to be transferred from developed countries must therefore be in keeping with this approach.

Increasingly, a farming systems research perspective is practiced in developing countries, to ensure that farmers’ needs and motivations are identified. Too often, however, packages of technology are developed and attempts are made by research and extension groups to introduce these onto farms. This package approach invariably fails, as each farmer is different, and each may prefer to adapt individual parts of the package to the farm system.

The transfer of technology, therefore, requires:

- Deep understanding of the individual farmer and his system,
- Realization that different farmers will utilize the same technology in different ways, and
- Consideration of the economic, environmental, and social implications of the technology (a systems approach).

Change can only occur if the political and economic framework in the country allows technology transfer to happen. It is the government’s role to provide this framework, including the infrastructure for marketing and the education to allow the rural population to be more adaptable to change.

Dairy Technology

Dairy technology encompasses several different considerations, including genetic improvement, nutrition, health, reproduction, milking, and milk storage and processing.

Genetic Improvement

The quickest method of increasing the genetic merit for milk production of local breeds is to import genes through bulls, embryos, or semen. The importation of bulls and embryos is, however, expensive, and their genetic influence on the population is small. The use of semen from superior bulls is the
most economic and influential method of changing genetic merit.

The problems with this approach, however, are that it is dependent on artificial insemination services being available for the local cattle population, and that the crossbred genotype produced may not be well-adapted to local conditions. Thus when crossing *Bos taurus* (European) with *Bos indicus* cattle in tropical areas, the F₁ crossbred is not as well-adapted to heat stress and local disease problems as the local cattle. Its success will be very dependent on the level of management on the individual farm. Also, on small farms, cattle are often not single purpose. They may be dual purpose (produce milk and suckle a calf) or multipurpose if also used for traction or transport, and imported genes may be inappropriate for these objectives.

The appropriateness of the new genotype therefore requires great consideration.

The technology of group breeding schemes would also be a desirable introduction especially where an artificial insemination scheme is inappropriate. Such schemes involve groups of farmers in developing selection programs within a jointly owned nucleus herd to produce superior sires.

**Nutrition**

Much knowledge has been accumulated in developed countries in ruminant nutrition, both in relation to their energy, protein, mineral, and vitamin requirements, and to the analyses of feeds for these constituents. Specific problems in tropical countries relate to the lower quality of the feeds available, and the greater importance of supplementation of basal grass, hay, or straw diets with local energy and protein sources.

High tech supplements such as rumen additives, hormones, protected fats, and proteins are likely to be of benefit only when other aspects of management are optimized.

**Health**

A major problem in developing countries can be diseases of farm animals.

The new technologies of developed countries in disease diagnosis, prevention, and treatment have an important role in developing countries. Diagnostic kits such as ELISA, biotechnology methods applied to vaccine production, and modern therapy techniques are appropriate for transfer. However, they are dependent on the necessary resources being made available such as laboratories, transport, field and laboratory staff, and above all, the financial input to run the system.

**Reproduction**

Low reproduction rates lead to inefficiency and are common in developing countries due to climate, local genotype of cattle, poor nutrition, disease, and management.

Considerable research has been carried out on aspects of reproduction which could be applied to developing countries, in particular, aspects of nutrition and disease prevention. In most circumstances the technologies of hormonal therapy, induced twinning, embryo transfer, and embryo sexing would not be appropriate due to their high costs.

**Milking**

The principles of mechanical milking have remained relatively unchanged over a long period of time. The need to produce clean milk is a high priority in all dairy systems. Also most mastitis is contracted during the milking process.

Milking technologies which produce milk of low total bacterial count and somatic cell count (low mastitis) are very appropriate for transfer.

**Milk Storage and Processing**

The equipment for milk storage, milk pasteurization, and production of cheese and other dairy products is well-developed. It requires, however, a source of electricity, and has a high capital cost for individual farmers.

In small farm systems, a farmer cooperative approach to storage, processing, and marketing of milk and dairy products requires encouragement and support.
Milk Production Systems

The bottom-up approach envisages that the production systems in a particular region should be appropriate for the local socioeconomic system. The level of technology required and the complexity of management will therefore vary enormously from small to middle income to large farms.

For a large proportion of the developing world, small farming systems will be the most appropriate, utilizing local resources to produce milk which will be marketed locally as liquid milk or processed milk. The appropriate technology for these systems will have low capital cost, will lead to increased efficiency of production, and will result in a hygienic product in demand by the local community. Such systems will require cooperation between farmers if a successful processing and marketing system is to be developed.

Transfer of Technology

Some of the main factors constraining technology transfer in dairying are:

- Infrastructure — lack of a satisfactory road system, provision of electrical power, and an organized marketing system.
- Farm size — small farms lack capital input for new technologies and lack organizational involvement.
- Financial — low output of milk at low prices leads to low-cost systems unless a system of credit is available to incorporate new technologies.

- Social — social position, social events, and religious beliefs influence the cattle population and the direction and rate of change.
- Education and training — receptiveness to new ideas and motivation for change are developed through education, and skills are required for maintaining machines and equipment.
- Environmental — climate influences productivity through direct effects on animals and indirect effects on the feed supply.

Conclusions

The developing world has a deficit in milk and dairy products, and there is scope for technological developments.

These include genetic improvement, better nutrition and health, improvements in reproductive rates, and developments in milk storage and processing.

Appropriate technology for the individual farmer is required, not a package approach. This requires a full understanding of economic, environmental, and social constraints.

The appropriate technology will differ for farms of different sizes and resources, and for farmers of different abilities and motivations.

The most important priority for developed countries is the removal of subsidies which lead to the dumping of dairy products in developing countries, preventing their own industry from evolving.
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