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COLD CHAIN FOOD SYSTEMS DEVELOPMENT FOR BRAZIL

A Preliminary Assessment

Report to

Ministerio do Planejamento e Coordenação Geral

Instituto de Planejamento Economico e Social (IPEA)

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CHAPTER I

EXECUTIVE SUMMARY

A. The Nature and Function of a Cold Foods Handling System

The rational processing, storage, and transport of foods of animal origin, such as meats, fish, eggs, and milk products, which are highly perishable, requires an adequate cold foods handling system. Moreover, highly perishable foods of vegetable origin, such as many fruits and vegetables and some moderately perishable foods, such as onions and potatoes, keep better and much longer when cooled during storage and transportation. An effective foods handling system, which should include facilities for controlled low temperature storage and transport, must be efficiently operated, must be capable of maintaining necessary quality standards and must be able to extend the shelf life of perishable foods from the sources of production to final consumption.

The adequacy of such a system depends on how well it extends uninterrupted from the place of production to final consumption; how effectively it reduces food losses due to deterioration; the extent to which it serves the industrial and commercial producers of foods requiring cold handling; and the way it upgrades the nutrition and health of the consumers. If these conditions are not satisfactorily met, large losses to the economy are inevitable.

The cold foods handling system should be initiated at the source of food production, i.e., in slaughter houses, on fishing boats, at dairy and poultry farms and at receiving and packing centers for fruits and vegetables.

Furthermore, the system should be integrated, with links between ice makers, shippers, truckers, other transporters having equipment for conservation of cold foods, cold storage facilities, processors, distributors and marketers of perishable products requiring cold storage and/or handling. Wholesalers, retailers and large institutional feeding operations, such as hotels, restaurants, luncheonettes, bars, and universities, must be equipped with refrigerators and freezers to handle cold foods. In addition, if the system is to be fully successful, single family units should be equipped with refrigerators and freezers as well.

B. The Scope, Objectives and Approach of this Study

Recognizing that Brazil must ultimately develop a cold foods handling system capable of processing, storing, conserving and transporting perishable food products at a technically high level of performance, the Ministry of Planning in early 1972 contracted with Arthur D. Little, Limitada, to make a preliminary assessment of the existing system in Brazil and to outline a work program for producing an implementable plan for expanding and improving it.

The conclusions and recommendations of the assessment are presented in this report.

The field work of the study was carried out in Brazil in July, 1972, by an interdisciplinary team of five members of the ADL professional staff who interviewed a wide array of knowledgeable people in the public and private sectors, studied the technical and economic features of existing units in the various cold food handling systems, analyzed the overall systems in the context of total supply, demand, and relevant public economic development goals, and gathered and reviewed relevant data. The same team, while in Brazil, designed a work plan for improving and expanding the cold food handling systems for meat, fish, fruits and vegetables.

C. Principal Findings

- There is a substantial, but quantitatively and qualitatively inadequate amount of cold storage capacity in Brazil. A small amount of low temperature processing facilities exists. Relative to the need and to cold storage capacity, the number of refrigerated transportation facilities is insufficient. Thus, it can be said that there is no cold chain food system[1] for handling meats, fish, and fruits and vegetables in Brazil. However, isolated components of a cold chain food system for these commodities, including a few cold chain segments (especially for meats), do exist. As a result, at the present time, these commodities do not move through a cold chain system from immediately after harvest, slaughter or catch to the final consumer.

- The existing cold chain food system is inadequate as an overall system because it handles so little of present production. Much more of the meat, fish, and fruits and vegetables produced in Brazil should benefit from a cold chain. This would reduce losses of already produced commodities, would sustain quality, and would contribute to the attainment of other important government objectives such as price control, evening out of income distribution, agricultural development, and efficient food distribution. A well developed cold chain food system would also significantly reduce public health hazards stemming from improper control of the temperature of meat, fish, fruits and vegetables and would raise the nutritional level of the diet of much of the Brazilian population.

[1] See Chapter II for definition of a Cold Chain Food System (CCFS)

- With a few exceptions, most of the cold chain units in Brazil are small and are not able to realize available economies of scale.

- Many public cold storage units are old and some are partly or entirely closed down; some private cold chain units are new, but many of them are also old and some are also partly or entirely closed down. Considering their age, the state of maintenance of some of the very old units is quite remarkable.

- The existing cold chain food system is generally inadequate to enable efficient and effective utilization of existing supplies of meat, fish, fruits and vegetables. Serious fruit and vegetables losses have occurred, for example, because no cold chain capacity was available to handle bumber crops. Some fish losses also have occurred because of inadequate cold chain capacity. Finally, the recent requirement for beef stocks to be developed from quantities intended for export are likely to put serious pressure on available chilling and freezing storage capacity. For example, the largest public sector frozen storage facility in Rio de Janeiro (built in 1911) is nearly filled with beef alone, and during our inspection visit in late July, officials were attempting to make room for additional 2,000 metric tons of beef seeking frozen storage. Moreover, a day or so after we visited, all beef exports from Brazil were halted, suspenso creating an even greater need for chilled and frozen storage areas for beef.

- The existing cold chain food system is not adequate to provide many of the kinds of form, place and time utility that consumers desire. The general inadequacy of the system, as it exists, results in many sales to consumers of low quality meat, fish, fruit and vegetable products, both those that have been chilled or frozen, as well as those that have not. An expanded and improved system would improve quality, new food product development and expand the place and time utility of many chilled and frozen meat, fish, fruit and vegetable products. This would enable expansion of production, processing and marketing activities for these products and would contribute to consumer satisfaction.

- The general state of maintenance and operational adequacy of a large portion of the existing cold chain food system is poor. Adequate temperature control is sometimes not attained in these facilities. Control equipment is often not operational or does not exist. For example, meat products requiring temperatures of at least -18°C are being stored at -10°C or higher in many facilities. Such temperature conditions allow product deterioration, e.g., through mold growth. Other factors reflecting this general condition include freezer doors that do not close completely, deteriorated insulation, small evaporators compared to storage room size, and frozen compressor suction lines.

- There are large gaps in the cold chain food system in Brazil for meats, fish, and fruits and vegetables. For example, a large proportion of meats do not move through any kind of cold chain unit during the processing and distribution phases. Fish may enter a cold chain unit at the catching end of the system, but exit the cold chain when peddlers for the most part purchase them for distribution from house to house. Only a very limited portion of fruits and vegetables for domestic consumption enter any cold chain unit, but a significant portion of those being imported and exported do enter a cold chain unit at dockside.

- The transportation links in the existing cold chain food system are severely inadequate. Partially thawed meats, for example, were observed entering frozen storage units. This results in quality deterioration that cannot be recovered. Despite this general finding, a few larger, very modern, and highly effective mechanical refrigeration trucks are operating in Brazil. Large and technically very sophisticated trucks are operated to haul fruits and vegetables between Brazil and Argentina. Smaller vehicles of various types and with differing degrees of effectiveness are also used throughout Brazil to handle cold and frozen foods.

- The existing cold chain food system is not adequate at the retail and consumer levels. Much of the meat, fish, fruits and vegetables purchased by consumers has not passed through any cold chain unit. Many retailers have no chilling or freezing capacity. Most consumers do not have refrigeration or freezer capacity to maintain the quality of food products and to retard them from spoiling. As a consequence, they do not demand frozen or other food products with characteristics that can best be enjoyed if they are refrigerated or frozen in the home, or they demand them only for immediate consumption.

- The cold storage capacity in Brazil is highly concentrated in certain regions, especially the Sudeste and Sul regions. This concentration tends to spur agricultural development of commodities requiring or benefitting from a cold-chain in the Sudeste and Sul regions, but to constrain such development in the other regions. As such, this concentration conflicts with agricultural production and other development goals for regions other than the Sudeste and Sul. In the north, where temperatures are highest and the need for cold storage is greatest, there is, in fact, the smallest cold storage capacity.

- The existing cold chain food system is inadequate to handle even the export requirements of the future. Realization, for example, of the goal of 500,000 metric tons per annum of beef exports will substantially increase the proportion of the existing cold chain food system used for beef exports. Additional exports of other meat, such as horse meat, and of fish, fruits and vegetables, would take up even more of existing capacity. Moreover, the present cold chain food system is not adequately located, organized, and technically capable of handling future exports efficiently and maintaining the high quality and sanitary condition of exported products necessary to permit Brazil to compete effectively with other nations in international markets.

- A maintenance capability and supply of technicians necessary to operate the existing cold chain food system effectively does not exist. Much of the equipment in existing cold-chain units is old and of foreign manufacture, thus being difficult to maintain. Moreover, the equipment, especially the control facilities, is complex and not easily mastered by maintenance personnel without substantial experience or training. To date, this type of experience and training of personnel has not reached the level necessary to assure that existing and future cold-chain units will be well maintained and operated.

- A substantial effort is required to educate future and current users of cold chain facilities on the concepts and benefits of properly used refrigeration systems. Many misconceptions and misunderstandings exist at all levels of users of cold chain facilities, from the farmer up to the final consumer. Care should be taken not to establish mistrust and a bad image for refrigerated and frozen food with the final consumer.

D. How Developing a Cold Chain Food System Would Contribute to Brazil's Development Program

- It would increase productivity in agriculture
  - .. by increasing capacity to store surplus products until market conditions are favorable;
  - .. by extending the geographical boundaries of markets;
  - .. by increasing the demand for goods and services required for building and operating a cold chain food system;
  - .. by reducing waste in storage and transit;
  - .. by demonstrating to producers the value of improved technology and efficient management of resources.
- It would improve the national balance of trade
  - .. by facilitating the entry of Brazilian agricultural products (especially meat, fish, and processed fruits) into wider export markets;
  - .. by reducing domestic demand for imported food products.
- It would contribute to price stabilization in an important sector of the economy
  - .. by levelling off supply peaks and valleys;
  - .. probably also by effecting long term price reduction in some foods through more efficient handling.
- It would stimulate wide distribution of income and other other economic and social benefits
  - .. by bringing regions of Brazil now virtually outside the market economy directly into the economy;
  - .. by enlarging the opportunities of farm people to sell their products in distant markets;
  - .. by improving nutrition in the national diet;
  - .. by reducing public health hazards posed by spoiled or infested foodstuffs.

E. The Scope of a Work Program for Developing an Implementable CCFS Plan

Development of an implementable plan for an expanded cold chain food system will require 12 to 14 months of effort by a team competent in development planning, familiar with the technology and economics of the food industry, and knowledgeable about Brazil. The analysis should proceed through three successive cycles, each of which makes adjustments in and adds to the overall concept, thus converging on the ultimate detailed system design and cost/benefit analysis. An additional step would design the detailed program of implementation of the plan. This program is outlined schematically in Figure 7 and is described more fully in Chapter V.

CHAPTER II

KEY TERMS AND CONCEPTS

A. The Cold Chain

Broadly speaking, the refrigerated and frozen food industry is made up of cold chains which include two basic operations, temperature reduction and temperature maintenance. Temperature reduction, which should normally occur as soon as possible after harvest, slaughter, or catch, may be to a chilling or to a freezing temperature. Once the temperature of a product is so reduced, the remainder of the cold-chain is designed to maintain the reduced temperature during transport, storage, marketing, and other activities until it is finally consumed (Figure 1).

B. The Cold Chain Food System

In analyzing and developing the refrigerated and frozen food industry, it is helpful to view it as a system. There are two primary reasons for this.

First, the industry is, in fact, composed of: (1) units, (2) networks, and (3) flows. The units are items such as freezing tunnels, chilled storage warehouses, refrigerated trucks, transport links, and so on. The simplest network is the cold-chain. To adequately reduce the temperature of a product and to maintain such a temperature from post-harvest/slaughter/catch to consumer requires a complete cold-chain, one that connects farm production to the consumer. A complete cold-chain for one specific food product such as beef roasts, for example, would be composed of a series of units, such as chilled wholesale storage areas, refrigerated trucks, and chilled retail display counters. The next most complex network would be the commodity cold-chains system, such as for all beef products. Finally, when all perishable commodity cold-chain systems are simultaneously considered, an overall cold-chain food system (CCFS) emerges.

The flows in each network are from producer to consumer. Such flows will be over varying distances and at different rates, depending on the geographical locations, supply and demand, market conditions, the capacity of the cold-chain system, and other factors.

C. The Agribusiness System

A second reason for viewing the development of the frozen and refrigerated food infrastructure as a system is the fact that it is a subsystem in the larger agribusiness (or agri-industrial) system. As such, it represents a vital component (or subsystem) that must be developed and expanded if the entire agribusiness system is to expand. Thus, it is a subsystem which can

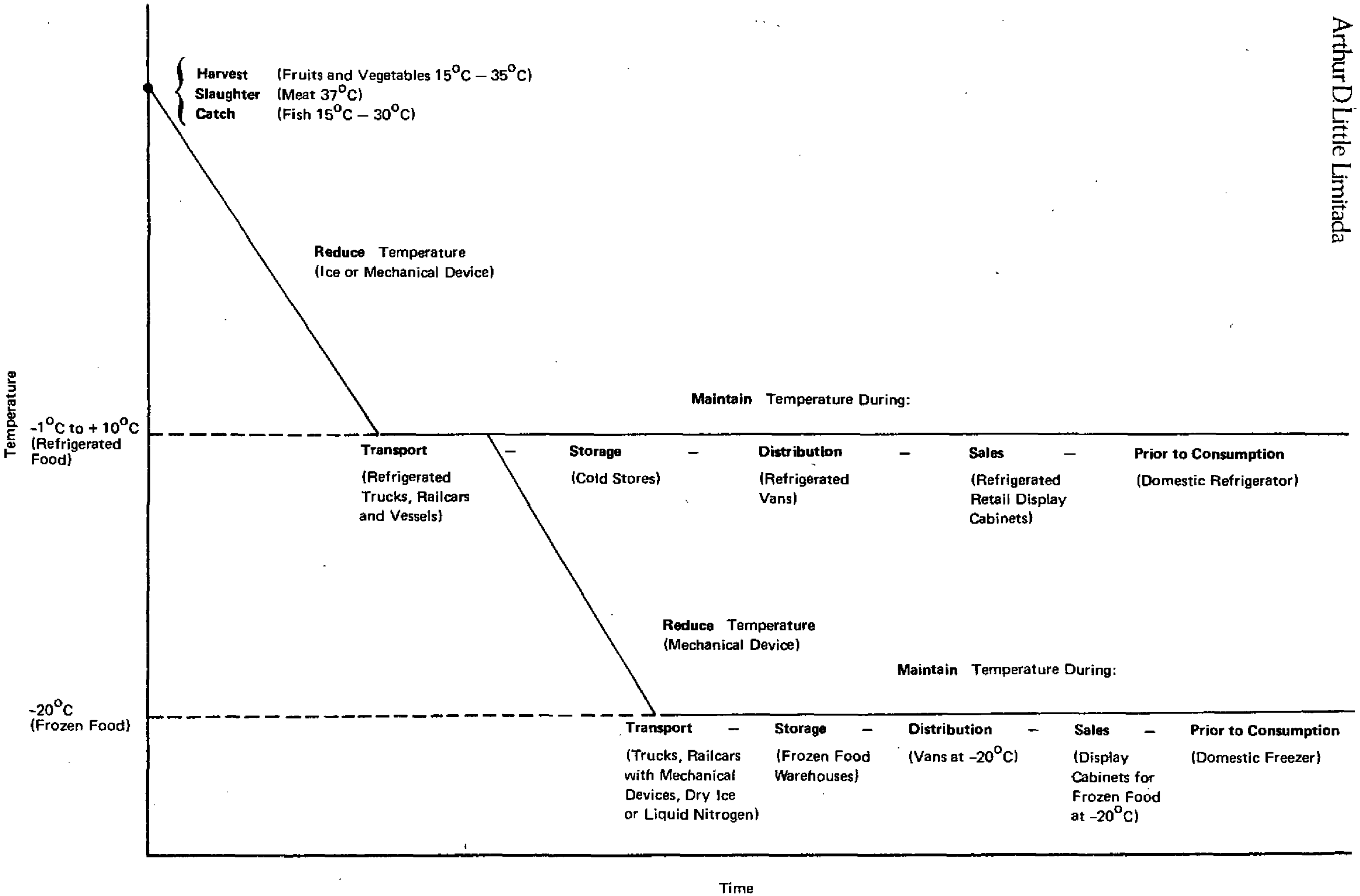

FIGURE 1 FOOD COLD CHAIN IN A TIME-TEMPERATURE FRAME

be utilized as an effective planning tool by the government in support of many of Brazil's major social and economic goals (e.g., growth of the agribusiness sector, increased exports, regional development).

The concept of agribusiness as a system is shown in the diagram in Figure 2. In broad terms this system is composed of production, processing, and marketing segments, each of which is supported by input supply industries and infrastructure capacity. The CCFS is basically a part of the processing and marketing blocks of the agribusiness system. The efficient production, processing, and marketing of food products requires that all aspects of this agribusiness system be meshed together, that the links be sized adequately to eliminate critical constraints, and that the system be highly flexible so as to grow and/or adapt to a wide range of changes and conditions.

When one of the segments in the agribusiness system, or a linkage between two segments, is inadequate the outputs of the system are not sufficient and the system is less than optimum for meeting consumer demands, for attaining desired rates of growth of productivity or production, or for meeting other selected objectives.

When one segment of a balanced agribusiness system expands, it is necessary for many other segments of the system to expand also. Otherwise, the expansion of the one segment soon meets bottlenecks in other parts of the system so that its growth is not effective in terms of efficiency or additional output from the system as a whole, and much of the effort spent in expanding the one segment is lost. For example, in order to increase beef production in a particular underdeveloped region, it may be a necessary but not sufficient requirement to improve, forage, breeding, disease control, and management practices. However, in considering the entire beef production, processing and marketing system, one might find that improved local slaughtering facilities and an adequate cold-chain were also required to enable the increased beef production to be of maximum benefit to producers, distributors, and consumers. Also, if the system is not balanced, even more work on the weak segments and linkages in the system must be done to enable the growth in other, stronger segments to be effective.

The conceptual characteristics of each cold chain and the overall CCFS are the same as those for the overall agribusiness system. The segments in each system are tightly woven together so that changes in one part of the system affect many other parts of the system. Gaps anywhere in the system cause the performance of the rest of the system to be less than optimum. Growth in any part of the system usually requires growth in many other parts of the system. Moreover, Cold Chain Food Systems tend to parallel the entire agribusiness system as a part of the infrastructure and to act to support or constrain the overall growth of the entire system or significant sectors of the agribusiness system, such as livestock production, processing and marketing.

As part of the agribusiness system, the CCFS must be integrated into a broad range of activities concerned with the efficient movement of products

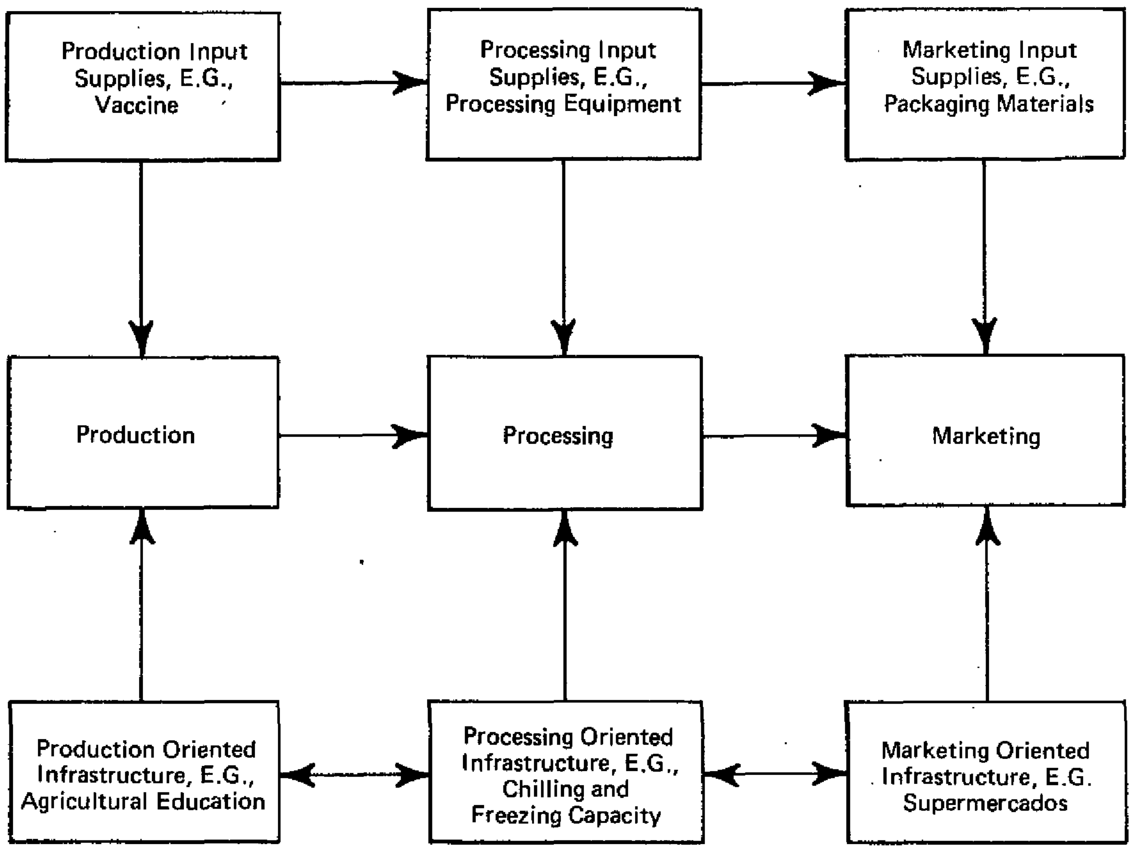

FIGURE 2 A SIMPLE SCHEMATIC OF THE AGRIBUSINESS SYSTEM

from the end of the production line to the consumers and/or the movement of raw materials from the source of supply to the beginning of the production line. This is usually referred to as physical distribution, the objective of physical distribution being to provide good form, time, and place utility; that is to provide the right product for the right price, at the right place and time. Physical distribution includes protective packaging, inventory control, warehouse site selection, market forecasting, order processing, customer service, material handling, warehousing and freight transportation. Physical distribution also includes timely and accurate dissemination and feedback of distribution related information. Thus, it is the key link between growing and marketing. By definition, then, physical distribution is far more than the refrigeration or freezing of foods; rather, it is an integrated coherent whole of which the CCFS is only a part. Only a totally optimized physical distribution system from grower to consumer can best serve an expanding agribusiness system.

In addition to being a part of the agribusiness system, the overall CCFS is a part of other larger systems. It particularly interfaces with the international market, and with the durable and non-durable service sectors of the general economy. For example, imported refrigerated and frozen food items enter the CCFS at many points in the system and exported refrigerated and frozen foods leave the CCFS from many points in the system. It also absorbs compressors and refrigerated trucks from the industrial sector as well as maintenance supplies. It takes in truck driving, legal, accounting, and other services from the service sector.

An understanding of the CCFS concept and the relationships between the overall CCFS, the agribusiness system, and the rest of the economy is necessary to effectively assess the existing refrigerated and frozen food industry and to adequately plan for its future development. For example, the CCFS concept, when well defined, enables the ready identification of inadequacies, such as missing units which cause products to leave the cold-chain, only to reenter it later as they move further toward the consumer. More specifically, in order to appraise the adequacy of a cold-chain in the CCFS, one would begin by determining the capacity of the nodes (i.e., facilities) and links (i.e., transportation) and then estimate the expected demand called for at the end of the system as well as the supply available at the beginning of it. The next step would be to test whether the system could physically and economically carry the load called for. In this way, bottlenecks within the system would be identified. This type of analysis is most effectively performed through the application of a simulation model, an abstract representation of the nodes and links making up the system. A model of this kind can vary in form from a map with pegs and strings representing the system to a set of mathematical or symbolic statements programmed for an electronic computer.

In order to plan for the development of a well-balanced, efficient and effective refrigerated and frozen food industry, a systems approach is necessary. Thus, by identifying the geographical location and the quantities of commodities to be supplied that require temperature reduction and maintenance, the demand for such commodities, and the geographical flows of these commodities, one can set out the scale and location of the complete cold-chains and commodity cold-chain food systems necessary to complete or expand the existing facilities so as to adequately handle the commodity loads from post-harvest/slaughter/catch to the consumer.

D. Key Working Definitions

To effectively use the systems approach, boundaries must be set for the cold-chains and for the cold-chain food system concepts. Consequently, the following working definitions have been adopted for use in this report:

1. A cold-chain food system (CCFS); that portion of the food distribution process and infrastructure which reduces and maintains perishable commodities at lower than ambient temperatures from production up to and including storage with the final consumer. A CCFS can theoretically exist for each commodity, and an overall CCFS can theoretically exist for all perishable commodities.

2. The cold-chain; that portion of a CCFS which reduces and maintains the temperature of a specific food product below ambient temperature during the movement of the products from producer to consumer. For example, a cold-chain would be the geographical array of freezing tunnels, wholesale frozen storage warehouses, retail frozen storage areas, and frozen transport means used to move half beef carcasses (a single beef product). Another cold-chain would move beef viscera, and another would move kosher beef quarters. The beef CCFS would include all of these, and other individual beef product cold-chains. Finally, the overall CCFS includes the beef CCFS and other commodity CCFS's, such as the pork CCFS, the chicken CCFS, the strawberry CCFS, the shrimp CCFS, and so on.

E. Cold Chain Food Systems for Meat, Fish, Fruits, and Vegetables

Very simple concepts of cold-chain food systems for meat, fish, and fruits and vegetables are presented and discussed below. These systems, as schematically presented, include most of the steps that would occur in a complex cold chain for each commodity type. However, the cold chain food system for poultry will be somewhat different from that for beef. Moreover, the simple schematic presented, even if for beef alone, would be replicated many times in Brazil. Finally, a significant amount of interaction between all the individual units in the replicated cold chain schematic would occur, making the total system for each commodity very complex indeed. The total CCFS would be even more complex.

Despite this complexity in reality, the explanation of the various elements and linkages in each commodity cold chain food system is helpful for understanding the method of analysis and the type of integrated planning that must be carried forward to support and accelerate the development of a modern cold chain food system for meat, fish, fruits and vegetables.

The schematic for the meat cold chain food system and the steps before and after are presented in Figure 3. This schematic basically represents a cold-chain for beef, but is very similar to the cold chain food system that would be required for pork, mutton, goats, rabbits, and poultry. The flow of beef from the farm to the consumer begins with several pre-cold chain steps:

(a) Beef cattle, produced at the farm level, is transported live to a slaughtering facility. This transport haul may be long or short, depending on several factors. If a terminal market concept is being developed, the haul may be from a distant producing area to the terminal market where all the processing and marketing activities take place. In many developed countries, this concept has given way to the location of slaughtering facilities in the producing areas to save transport costs and to preserve weight and meat quality.

(b) After slaughter, the animal is dressed and halved or quartered.

(c) The carcasses are then transported to either a chilling or a freezing unit.

(d) They may be further stored in chilling or freezing storage units or transported (after cooling) without being chilled or frozen to a breaking facility. Stored chilled or frozen beef can also be moved into the breaking facility for further processing.

From the breaking unit, the meat portions can move in several directions:

(a) Most prominent would be movements down the cold chain toward the consumer and into a further processing step. This further processing would include making steaks, roasts, sausage and other meat cuts or products from larger portions. These cuts would then be chilled or frozen, perhaps stored, and sold to the consumer directly or through a hotel, restaurant or institution (HRI) outlet.

(b) Alternately, the meat portions could move into a chilling or freezing cold chain unit, then into the appropriate cold chain storage unit and finally on to the consumer or an HRI outlet.

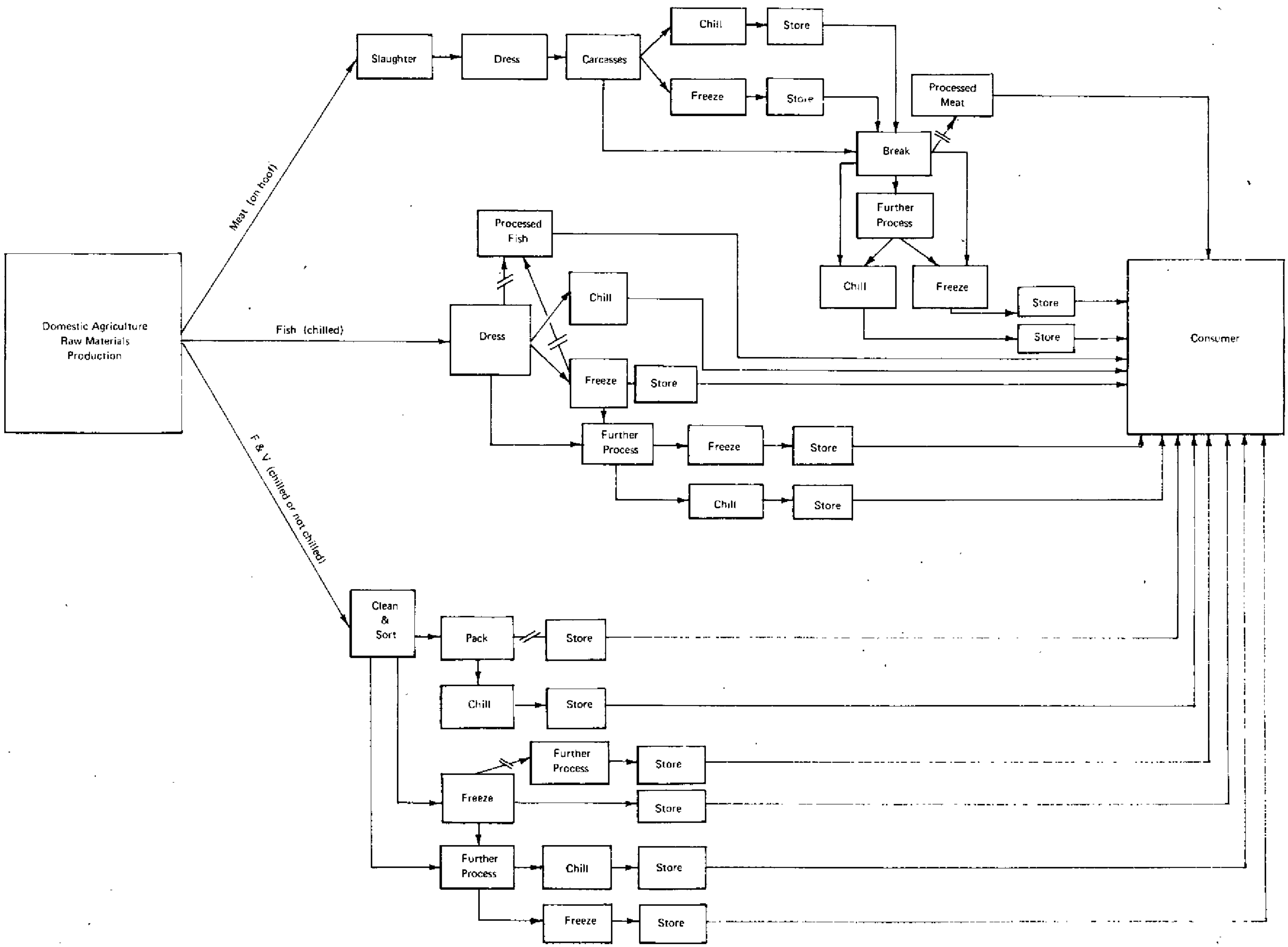

FIGURE 3 SCHEMATIC REPRESENTATION OF COLD CHAIN FOOD SYSTEM (CCSF) FOR MEAT, FISH, FRUITS AND VEGETABLES

(c) Finally, the meat portions could move into a processed meat facility to be canned, smoked, dried, etc., and sold to a consumer or an HRI outlet. These products do not require refrigeration and are therefore no longer within the CCFS.

A simple schematic of the fish cold chain food system is also indicated in Figure 3. In this system, the pre-cold chain step is the catch of the fish. Once caught, the fish enters the cold chain immediately by being chilled on the fishing vessel until it arrives at a processing factory, shipbound or at dockside. Once dressed, the fish moves in several directions:

(a) Mostly, it is chilled and moves directly to the consumer or an HRI outlet, or

(b) It may be frozen, then stored until it is sold to the consumer or an HRI outlet in frozen form.

(c) Dressed fish can move into a further processing facility and then be:

i. Chilled, stored, and sold, or

ii. Frozen, stored, and sold. Fish frozen directly after being dressed, can also move into this further processing unit and be chilled, stored, and then sold.

(d) Finally, dressed fish can move into a processed fish unit to be canned, smoked, dried, etc. Fish frozen immediately after being dressed can also be moved into the processed fish unit. The end products of these processes, because they require no cold chain facilities, leave the cold chain upon movement into the processing unit. Such products also are sold to consumers or HRI outlets.

A simple schematic of the cold chain food system for fruits and vegetables is also set out in Figure 3. The pre-cold chain step for fruits and vegetables, is their harvest. Once harvested, fruits and vegetables may or may not be chilled during their transport to a cleaning and sorting facility. If so, they enter the cold chain food system at that point. If not, once cleaned and sorted, fruits and vegetables customarily move as follows:

(a) They are packed in appropriate containers and either stored and sold to consumers or HRI outlets (in which case they leave the cold chain) or, once packed, they are chilled, stored, and sold to consumers or HRI outlets.

(b) Other fruits and vegetables are frozen, stored, and sold to consumers or HRI outlets. Once frozen, they can also be moved into further processing (such as canning) stored and sold to consumers. In this case, they also leave the cold chain food system. Or, frozen fruits and vegetables may be further processed, chilled or frozen and stored, then sold to consumers or HRI outlets.

(d) Finally, cleaned and sorted fruits and vegetables may move directly into further processing, after which they are either chilled or frozen, stored, and sold to consumers or HRI outlets.

CHAPTER III

PRELIMINARY ASSESSMENT OF COLD CHAIN FOOD SYSTEMS IN BRAZIL

A. MEAT

I. Conclusions

(a) Brazil does not have commodity CCFS's for meat as such. There are storage capacity units, transport units, and some other cold-chain segments, but these are scattered and do not compose a system.

(b) Brazil's cold storage capacity for meat is not adequate. Even today, it should handle a much larger proportion of the meat and meat products consumed domestically.

(c) Brazil's cold storage for meat and meat products is rudimentary, and has many gaps.

(d) Brazil's cold storage for meat and meat products has insufficient capacity to serve adequately for storing meat as a means of damping supply and price fluctuations.

(e) Brazil's cold storage for meat is not adequate to handle even the export requirements in the future. To compete, large, more modern facilities will be required, as well as more total capacity.

(f) Brazil's cold storage is highly regional and as such, hinders the development of meat production (especially for export) in regions with a minimal cold-chain infrastructure.

(g) Brazil's cold-chain system for meat and meat products is not adequate to provide form, place and time utility desired by consumers. Much of what moves through existing capacity now is of low quality.

2. Location

The bulk of the cold-chain facilities for meat and meat products is located in the Sudeste and Sul regions. These are the regions where livestock production is most concentrated in Brazil and where most livestock slaughtering and further processing as well as marketing occurs. For example, approximately 50% of the total beef slaughtering capacity in

Brazil is in the Sudeste region and about 25% is in the Sul region. Not only is most of the livestock raised and slaughtered in these regions, but most export and domestic consumption of livestock products is also concentrated in these same regions. As a result, cold-chain capacity supporting the slaughtering, further processing, and wholesale and retail marketing of meat and meat products can be mostly found in Southern Brazil. Of course, cold-chain capacity for meat also exists in the Norte, Nordeste and Centro-Oeste regions. However, the extent of this capacity is much less than that of the Sudeste and Sul regions. For example, studies of slaughtering facilities carried out by CONDEPE for the 1967/69 period in the states of São Paulo and Bahia indicate that the São Paulo slaughtering industry has over 30 times as much freezing capacity and 100 times as much frozen storage capacity as the Bahia slaughtering industry. This ratio is probably even more disproportionate for other states which have significant potential as livestock producing areas.

3. Capacity

Total cold-chain capacity in Brazil is about 100,000 metric tons. Approximately 70% of this total capacity is used for meats and meat products, most of the rest being used for fish, with a very small amount being used for fruits and vegetables.

The cold-chain for meat and meat products is composed mostly of small captive[1] refrigeration and freezing units in the private sector. However, some large cold-chain capacity is operated by private meat processors, especially in major producing and marketing areas. Most of the large and small units of cold-chain capacity are owned and operated by private entrepreneurs as an adjunct to a slaughtering and breaking business or other further processing enterprises.

Public cold-chain capacity of approximately 18,000 metric tons static storage capacity is operated by CIBRAZEM. Much of this capacity is used for meats and meat products. For example, the largest public cold-chain facility, which is located in Rio with a capacity of 14,000 metric tons, is used almost exclusively to store meat. (A small amount of fish and some other products, such as cheese, is customarily also stored in this facility). Most of the meat is beef, but some mutton and other meats are also stored. This public cold-chain capacity constitutes only a small portion of the total cold-chain capacity in Brazil, approximately 20%. Much of the capacity operated by CIBRAZEM is in very small units, 15 to 60 tons. However, these units are not captive, as are most private units, but are available to entrepreneurs in the distribution system. Consequently, this capacity fills a special role for entrepreneurs who operate without

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[1] Captive - the units are part of a larger integrated meat handling or processing facility

the use of substantial amounts of fixed capital by making cold-chain capacity available to them at rates reflecting economies of scale, and provides a means of accomplishing public economic objectives such as damping the effects of supply fluctuations, enabling stockpiling of certain commodities, and increasing flexibility of fixed processing and cold storage capacity.

The cold-chain capacity is especially important for the export of meat and meat products. Most of these products that are exported without substantial further processing must be chilled or frozen and thus require use of existing cold-chain capacity. At present, about 5-10% of total cold-chain capacity is utilized for meat exports. Figure 4 sets out the estimated flow of 1969 beef production through fresh, chilled, and frozen distribution channels to export and domestic markets.

The largest part of the cold-chain capacity for meat is used for beef; the next largest shares are used for poultry and pork products. A smaller portion of the total cold-chain capacity for meat and meat products is used, in order of magnitude, for horse, mutton, rabbit, and goat meat.

Additional capacity for meat products is planned as a part of regional economic development programs (e.g., PRODOESTE) and as part of the National Central Market Terminal development program. Some of this terminal market cold-chain capacity is under construction (e.g., Brasilia) at the present time.

4. Volume

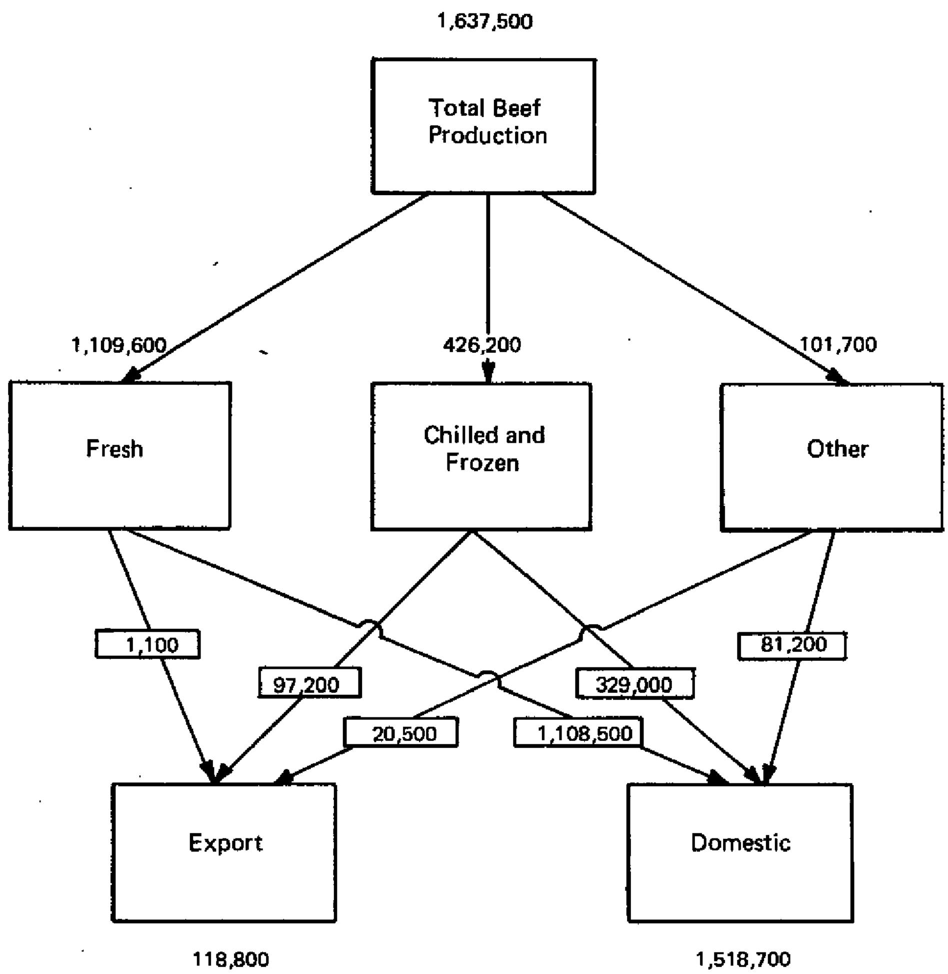
The total volume of meat that moved through the Brazilian cold-chain in 1969 was about 500,000 metric tons (Figure 5).* Of this total, beef constituted about 85%, poultry 8%, and pork 7%.

5. Exports and Imports

Meat exports for the 1968-1970 period are set out in Table 1. Total meat exports were 75,309 metric tons in 1968 and 142,987 metric tons in 1970. Fresh, frozen and refrigerated meat exports were 54,937 metric tons in 1968 and 125,210 metric tons in 1970. Of this total, frozen beef accounted for 26,031 metric tons in 1968 and 92,908 metric tons in 1970, and chilled beef for 2,037 metric tons in 1968 and 4,336 metric tons in 1970. About 19,600 metric tons of horse meat was exported in 1969.

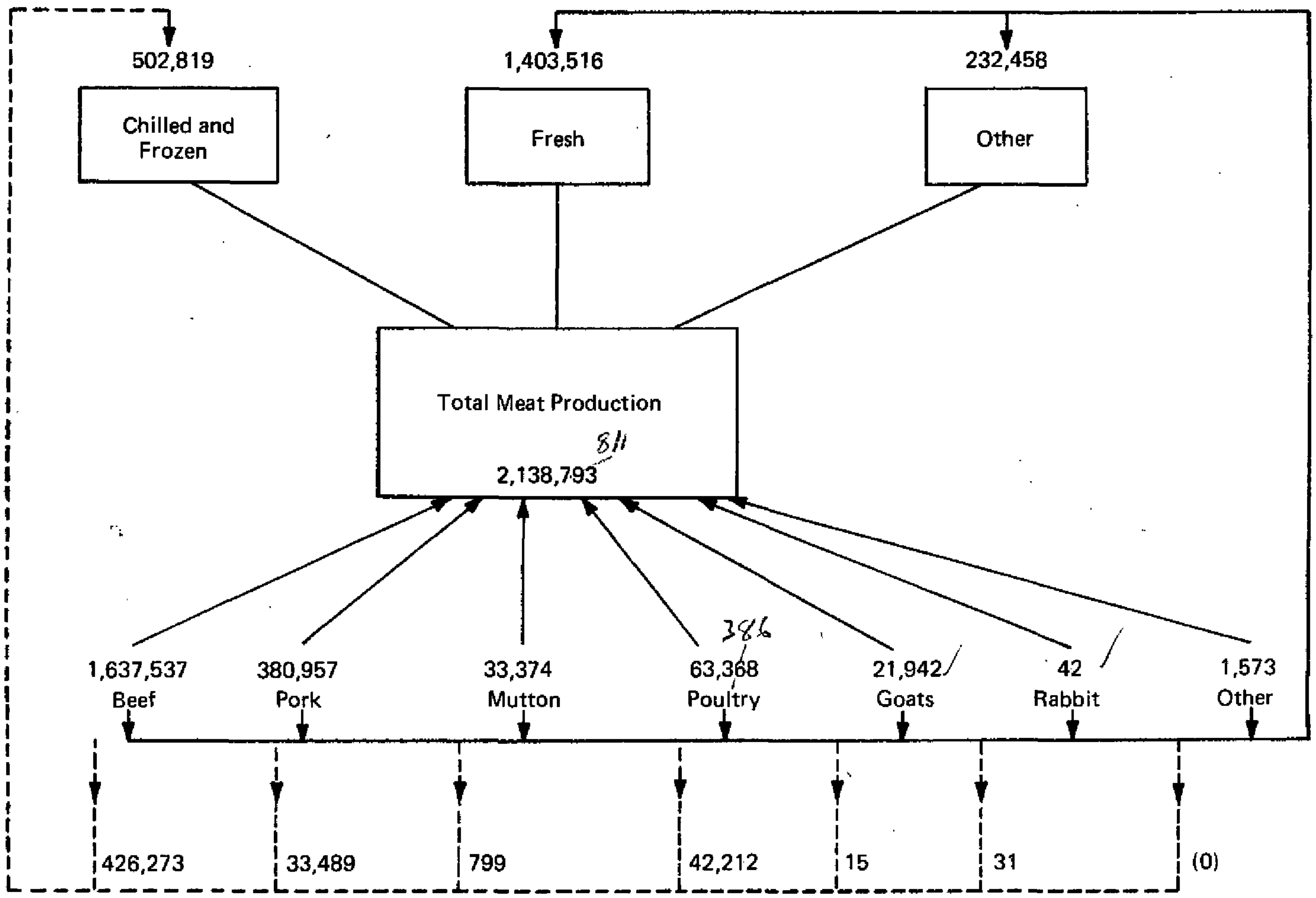
The quantity of meat and meat products imported into Brazil is small compared to the amounts exported and consists mostly of low value animal products, such as intestines and other primary materials of animal origin.

* Excluding horse meat



Source: Arthur D. Little, Inc. estimates based on data from *Anuário Estatístico do Brasil, 1971.*

FIGURE 4 ESTIMATED DISPOSITION OF BEEF PRODUCED IN BRAZIL, 1969 (METRIC TONS)



Source: *Anuário Estatístico do Brasil, 1971.*

FIGURE 5 MEAT PRODUCTION IN BRAZIL BY TYPE OF MEAT AND METHOD OF HANDLING, 1969 (METRIC TONS)

TABLE 1

BRAZIL: MEAT EXPORTS, 1968-1970
(Metric Tons)

	1968	1969	1970
Slaughtered and Hunted	75,309	123,404	142,983
1. Fresh, chilled or frozen meat	54,937	102,833	125,210
a. Beef, frozen	26,031	50,686	92,908
b. Beef, chilled	2,037	6,732	4,336
c. Veal	11,178	20,146	1,065
d. Mutton	-	26	218
e. Pork	243	789	2,129
f. Horse and Mule	12,566	18,644	19,583
g. Viscera and other intestines, excluding domesticated birds	2,866	5,809	4,728
h. Other meat, fresh, chilled, or frozen	16	1	189
2. Dried, salted, or smoked meat	5,079	4,453	476
3. Canned meat and meat preparations	14,720	15,400	16,704
4. Extracts and meat juices	573	718	593

Source: Anuário Estatístico do Brasil, 1971

6. Assessment of Cold Storage for Meat

At present in Brazil there is not a complete CCFS for any meat commodity. There are segments of cold-chains for specific meat products, such as beef carcasses intended for export, but even these, as complete cold-chains, are limited. Thus, there is not a cold-chain food system as such for meat.

There is, however, a substantial amount of chilled and frozen meat storage capacity. There is also some chilled and frozen meat transport capacity. However, even this total capacity is inadequate to meet the requirements of the normal flow of meats and meat products to consumers. In 1969, for example, about 80% of the meat produced in Brazil was consumed without going through any cold chain unit. Even under the most carefully controlled conditions, this results in deterioration in meat quality, unsanitary meat and meat products, inability to store meat, losses of meat through spoilage and shrinkage, and public health problems. When conditions, such as distance to market, sanitation of the further breaking, storage, and display areas, and other factors cannot be carefully controlled, these problems become even more severe. As a result, farmers and ranchers, wholesalers, retailers, and consumers all suffer. Ranchers who work to develop a high quality hog, for example, cannot sell it for a premium because the distribution system cannot carry the premium quality forward to the consumer with certainty, because of lack of an adequate cold chain food system. The wholesaler and retailer suffer losses because incoming product has been subject to variable temperatures resulting in deterioration of color and texture, or even spoilage. The consumer must pay more for even the low quality meat to offset the losses suffered by those in the distribution system who paid for 100 kilos but can sell only 80 or 85 kilos due to the lack of an adequate cold chain food system. Moreover, the consumer has difficulty in obtaining a high quality meat at a reasonable price, especially when meat supplies are seasonally or abnormally low. He is also constantly subject to public health problems because of the unsanitary and uncontrolled environment for meat and meat products in the classical physical distribution chain.

A substantial portion of existing slaughtering and further processing operations has a limited cold storage capacity. For example, frigorificos and many general and special matadouros have cold storage areas. Some other types of enterprises have cold storage capacity too, and others moved their product into or through existing cold storage capacity. These cold storage operations, however, are often rudimentary and not well-managed. Sometimes they are not sufficient even for the needs of the enterprise operating them. Many of these units are old, but some are modernized and others are relatively new.

Many meat slaughtering and processing establishments do not have cold-chain facilities at the present time, although strenuous efforts are being made by a substantial number of firms to add these facilities. A recent study of over 1,000 beef slaughtering houses indicated that less than 10% had refrigeration and other modern facilities. Such findings are not surprising; the average size of these slaughtering units was 22 head per day, and over 56% of the units slaughtered less than 10 head per day. Only 12% had the capacity to slaughter over 100 animals per day. Such small businesses cannot readily afford the fixed investment necessary to provide adequate chilling or freezing facilities; in the absence of legal action by the governments, they would seldom consider such an investment.

The technical and management aspects of much of the meat cold storage capacity in Brazil are rudimentary compared to the need. This situation reduces the effectiveness and efficiency of the existing capacity, so that it does not realize its complete potential in contributing cold storage services for meat and meat products. There are also many geographical and capacity gaps in the cold storage capacity which now exists. Some geographical areas along a potential product cold-chain have no cold storage capacity, while other areas have some capacity but not enough to meet the needs. In some areas existing capacity is not fully utilized because of mechanical failures.

The existing meat cold storage capacity in Brazil is not only inadequate to meet requirements for a normal flow of product. It is also inadequate to provide emergency capacity to store meat and meat products as a means of damping supply fluctuations. At times, all meat cold storage capacity in major consuming centers is utilized and there is still need for additional area to stockpile meat for periods of decreased supply. This lack of cold storage capacity requires other, often less desirable, policy means for controlling meat prices and regulating supplies. It also has the effect of creating pressures to disregard certain regulations by meat handlers and others. Finally, it reduces the ability of produced meat supplies to meet consumer demand and public policy goals over time.

Existing meat cold storage capacity is not adequate to handle future export requirements. The goal for near future beef exports is 300,000 metric tons and this is expected to increase to 500,000 metric tons shortly thereafter. At present, somewhat over 100,000 metric tons of chilled and frozen beef is being exported. If the export goal of 300,000 metric tons of beef is reached, a significant proportion of the available cold storage capacity will be taken up by exports. As a result, without significant expansion of existing capacity, more and more domestic beef will be excluded from cold storage facilities with attendant sanitation, public health, and quality problems for consumers.

Moreover, existing cold storage capacity is not adequate to enable Brazil to go forward with a well organized export program that provides world markets with high quality beef. Particularly, it is not properly located or organized to do so. To compete in the best markets in the future, Brazil should have a complete beef CCFS that maintains quality from producer to the international consumer and enables high sanitation, temperature and environmental control standards and fast product flows. Such a system is not now possible, given existing facilities.

Brazil's existing cold storage capacity is highly regional, centered mostly in the Sudeste and Sul regions. Traditionally, such locations were adequate because they contained major supply and market areas. The rapidly changing conditions in Brazil, however, and the development needs of the nation now require changes in this traditional pattern. As regionally concentrated, the existing cold storage capacity hinders the expansion of livestock production (especially for export) in regions with a minimal cold storage capacity.

As Brazil expands its livestock production, especially in the PRODOESTE, SUDENE and SUDAM areas, but also in the traditional producing areas, an adequate cold-chain will become more and more critical. Improved production practices will enhance meat quality. This quality will need to be protected by an adequate distribution system, including a CCFS. Moreover, the movement and expansion of livestock production away from major consuming centers will also require an adequate cold chain to allow long distance movement to these centers. This interaction also works in reverse, because, as cold-chains are established that enable, for example, beef produced in the Amazon region to be easily exported or sold in Recife or Rio, it will provide a strong impetus for high technology cattle production in areas more removed from consuming centers.

Further, because a CCFS does not exist, there are very few complete cold chains for meats produced in these new production areas. Thus, meat produced in such regions, if not marketed locally, is now subject to significant environmental hazards in moving to major market areas. If substantial livestock production is to occur in these regions destined for markets outside the regions, a CCFS for such production areas will be necessary both as an incentive to such production efforts and to assure that the results of such efforts are fully captured by producers, wholesalers, consumers and the entire economy.

The existing meat cold storage capacity in Brazil is not adequate to provide many of the kinds of form, place, and time utility that consumers desire. The relatively simple nature of existing storage and lack of a complete CCFS with its attendant capability to expedite physical distribution of new high quality chilled and frozen products to appropriate market outlets and at appropriate times, hinders new food product development and the exploitation of latent demand for agricultural products. As such, the CCFS bottleneck has significant repercussions on much of the agribusiness system. Producers cannot realize increased demand for their raw materials; processors do not expand as fast as they could otherwise and remain focused on primary processing operations; input suppliers such as package manufacturers are not able to realize additional business; marketing remains simple, and even supermercados cannot become attractive to many consumers because they cannot offer a wide array of high quality, attractively priced, new chilled and frozen food items.

B. FISH

1. Conclusions

(a) Freezing techniques are adequate for shrimp and lobster.

(b) There is substantial lack of adequate refrigeration for handling the fish catch. This condition, plus poor handling, results in substantial fish losses and very poor quality fish being regularly sold to consumers. Sharply increased fish consumption would result if high quality fish were offered to consumers.

(c) Fish is customarily sold to consumers in the round (without viscera removed). This traditional practice results in much more rapid bacterial and enzymatic deterioration of fish and makes adequate refrigeration and handling of the catch even more crucial.

(d) Icing and/or refrigeration of fish on many fishing vessels is not adequate. Only some artesanal fishermen use ice. However, some industrial fishing vessels have very good refrigeration capacity and others even process and freeze on board.

2. Production

Fish production depends upon the availability of fish in accessible waters as well as on the demand for fish. In Brazil, fish production results from harvesting operations in both sea and fresh waters, including brackish estuaries. Over 80% of the total catch is from the sea.

The total catch has been increasing rapidly. It was about 500,000 tons in 1968 and has increased to over 600,000 tons today. This rapid rise can be expected to increase even further as a result of the priority access given to Brazilian fishermen for the 200 mile offshore fishing area. The total value of the fish catch is indicated in Table 2.

3. Consumption

The market for fish harvested in Brazil is made up of domestic and export components. Fish destined for the domestic market is usually iced or refrigerated, but very little is frozen. The average annual consumption of fish in Brazil is only 3.7 kg. per capita. It ranged from a maximum of 14.2 kg. per capita in the north to a minimum of 2.2 kg. in the south. The difference in per capita consumption between the north and south may in part be due to the fact that so much beef is raised in the south and hence available to the consumer in lieu of fish. It is also highly probable that

Arthur D. Little Limitada

TABLE 2

BRAZIL: FISHERY PRODUCTION 1968/1970
(Value in 1,000 Cr.)

Product Description	Year	Total	Sea	Fresh Water
Fish	1968	219,575	160,851	58,724
	1969	297,970	223,991	73,979
	1970	349,878	267,370	82,508
Crustaceans	1968	76,321	69,062	7,259
	1969	116,686	106,511	10,175
	1970	140,973	128,050	12,923
Whales	1968	2,065	2,015	50
	1969	2,953	2,900	53
	1970	3,260	3,208	52
Shellfish	1968	2,555	2,555	-
	1969	2,036	2,036	-
	1970	2,861	2,861	-
Turtles	1968	234	73	161
	1969	293	76	217
	1970	638	88	550
Not specified	1968	2,079	...	...
	1969	1,537	...	...
	1970	1,001	...	...
TOTAL	1968	302,829 (2)	234,556 (2)	66,194
	1969	421,475 (2)	335,514 (2)	84,424
	1970	498,611 (2)	401,577 (2)	96,033

Source: Anuário Estatístico

fish consumption is low throughout the country because of its low quality due to poor handling techniques and lack of adequate refrigeration.

Sharply higher consumption of fish is to be expected if a product of consistently high quality is made available to the consumer. This underlines the urgent need to improve the handling and distribution facilities.

Because it is highly perishable, fish is nearly always frozen if it is to be exported. Since export demand is related to species, the present export market is almost entirely limited to shrimp and lobster. However, for Brazilian marine products, the world demand for shrimp and lobster appears to be almost insatiable; since 1971, Brazil has exported almost $24 million of these products alone. The cold chain facilities for these products have been adequate in light of the huge unsatisfied demand, but it is not clear what effect additional and more efficient facilities would have on the expansion of exports of these items.

4. Exports and Imports

In 1970, Brazil exported about $19 million of marine products, of which about $16 million were accounted for by shrimp and lobster (Table 3). Brazil imported about $33 million of marine products in 1970, of which about $31 million was accounted for by dried cod fish (Table 4). The trade balance for all marine products for the 1968/1970 period is shown in Table 5, which indicates that imports of fishery products customarily exceed exports by $10 - 20 million per year in Brazil.

5. Assessment of Cold Storage for Fish

A typical Brazilian system for the handling of fresh fish is described below. Fish first enters the system when it is brought aboard a fishing vessel. At this point, it is necessary to immediately take precautions to preserve the quality of the fish and the value of the catch. However, good operational practices prevail on only a limited number of vessels. Consequently, a large portion of the catch is not properly iced or refrigerated on the vessel. In addition to the lack of proper refrigeration, many fish are not adequately handled aboard the vessel. For example, almost without exception, fish destined for domestic consumption in Brazil are handled in the round (without the removal of viscera). This is a very poor practice, since the microorganisms and the enzymes in the viscera are extremely active in deteriorating the quality of the fish. The importance of adequate refrigeration under these conditions is crucial. The best practice, of course, would be to remove the viscera at sea and to properly refrigerate.

The importance of adequate handling and refrigeration aboard the vessel, as well as later in the distribution system, cannot be overemphasized. Fish begin to spoil immediately after death. The rate of spoilage is largely a function of temperature. Chilling a fish to a temperature of about 0°C, just above the freezing point for fish, does not stop the spoilage, but greatly retards it. This is because it reduces the bacterial and enzymatic activity that are the major sources of spoilage in fish.

TABLE 3

BRAZIL: EXPORTS OF SELECTED MARINE PRODUCTS 1968/1970

Product Description	1968		1969		1970	
	Tons	1,000 US$	Tons	1,000 US$	Tons	1,000 US$
Fish: fresh, frozen, salted and live	2,741	1,167	3,631	1,634	4,215	2,233
Shrimp: fresh, frozen salted	1,656	3,525	2,707	6,771	3,058	6,339
Lobster: fresh, frozen, salted	1,683	5,487	2,473	10,234	2,794	10,043
Other crustaceans	1	1	541	944	31	11
Other fish products	3	2	9	6	37	33
TOTAL VALUE		10,182		19,589		18,659

Source: Anuário Estatístico 1971
Min Plan - Brazil
JBGE

TABLE 4

BRAZIL: IMPORTS OF SELECTED MARINE PRODUCTS 1968/1970

Product Description	1968		1969		1970	
	Tons	1,000 US$	Tons	1,000 US$	Tons	1,000 US$
Dried cod fish (bacalhau)	40,240	25,588	45,071	24,370	47,222	31,081
Inkfish, fresh, frozen and salted	721	261	771	281	468	193
Fish conserves and other preparations	722	790	578	601	742	875
Other marine products	3,286	527	4,650	473	6,044	761
TOTAL VALUE		27,174		25,725		32,910

Source: Anuário Estatistico 1971
Min Plan - Brazil
JBGE

TABLE 5

BRAZIL: TOTAL VALUE OF REPORTED IMPORTS AND EXPORTS OF MARINE FISHERY PRODUCTS 1967-1970

Year	Exports	Imports	Exports-Imports
1968	10,182	27,174	- 16,992
1969	19,589	25,725	- 6,136
1970	18,659	32,910	- 14,251

Source: Anuário Estatístico do Brazil, 1971

Consequently, even in chilled fish, there is a certain amount of spoilage caused by bacterial, enzymatic and oxydative changes.

Enzymes are substances present in the flesh and intestines of the fish. They cause chemical changes which, during the life but not after death, are in the gut of the fish when it is caught and powerful digestive enzymes are present. The wall of the gut and the neighboring flesh are rapidly penetrated and softened by the enzymes after death, even in chilled fish, and thus easily invaded by spoilage bacteria. Hence, it is good practice for fish to be gutted and washed immediately after catching. Enzymatic activity is probably largely responsible for the flavor changes that take place in gutted fish during the early period of storage when there is no marked bacterial spoilage.

Bacterial action spurred by the changes caused by enzymes is by far the main cause of spoilage in chilled fish. Bacteria in large numbers are confined to the surface of the gills and intestines of the fish. These bacteria, often together with other bacteria introduced from external sources, increase in number after death and eventually penetrate through the skin and invade the fish.

Bad odors and flavors are also produced when oxygen in the atmosphere combines with the fat in the fish. Oxidation does not have as marked an effect in lean fish, but it can cause a significant part of the spoilage of fatty fish. Figure 6 shows a typical deterioration pattern for fish at various temperatures.

The capture of fish in Brazil is carried out by industrial fishermen and artesanal fishermen. The industrial fishermen operate offshore in large more or less well equipped vessels. They usually use adequate ice or mechanical refrigeration. Indeed, some vessels fishing for shrimp off Belem actually process and freeze the product aboard. These fishermen have large investments in equipment and therefore attempt to protect their catch the best way possible to assure an adequate return on their investment.

The artesanal fishermen, on the other hand, use small boats usually propelled by oar or sail (less than 10% of the total Brazilian fishing fleet is equipped with motors) and fish close to shore (see Table 7). These fishermen sometimes use ice in an attempt to comply with good operating practices, but usually mishandle the fish aboard their boats. As a result, large quality losses occur at this stage that cannot be corrected in later stages of distribution. The fish are then brought ashore and repacked with ice in boxes of either wooden or plastic construction. The cooling operation at this point is often inadequate as indicated by the high losses (for example, 40% at the São Paulo entrepostos) reported when the fish are handled at the next operation. At this subsequent operation, the fish are again repacked in boxes and the ice is replaced.* This re-

*In Rio de Janeiro, the fish are landed directly at the entrepostos, so that the dockside icing operation is not required.

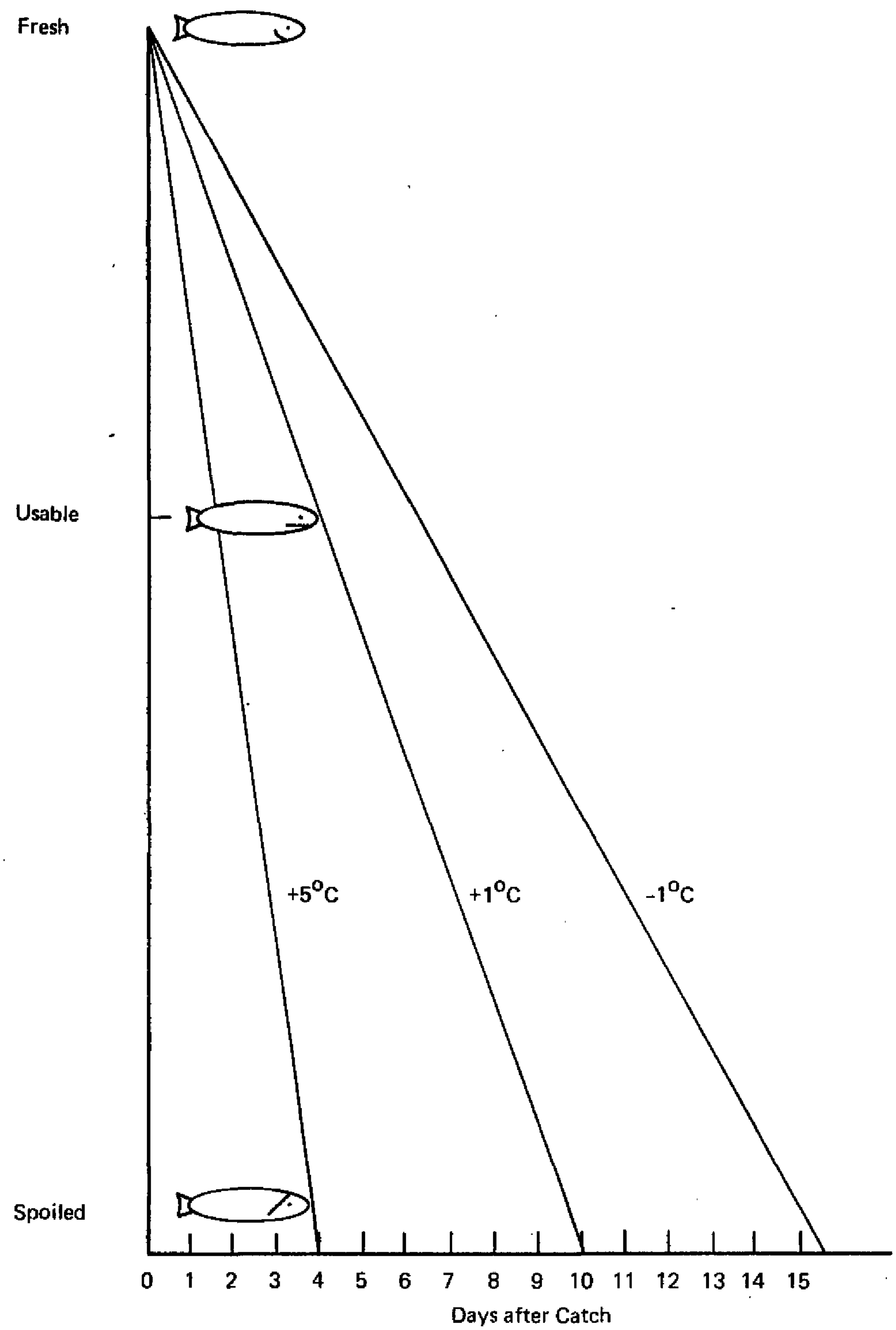


FIGURE 6 FISH QUALITY AS A FUNCTION OF STORAGE TIME AND TEMPERATURE

TABLE 6

APPROXIMATE COMPOSITION OF
BRAZILIAN FISHING FLEET (1971)
(Number of Vessels)

Industrial Fleet	600
Artisanal - Oar Propelled	26,000
Artisanal - Sail Propelled	19,000
Artisanal - Motor Propelled	3,400
TOTAL	49,000

Source: Arthur D. Little, Inc. estimates.

handling and inspection operation usually takes place in large urban centers. As a result, the cooling is frequently better than that done at the dock, but probably is inadequate because of lack of cold storage and ice capacities at the entrepostos. From this point on, the distribution of fish is done in a rudimentary way. For example, 80% of the fish in São Paulo are sold to the consumer by individual peddlers or very small stores. Much of the product is mistreated during this period. Even at large modern supermarkets, presently the most sophisticated level of retailing, considerable improvements in the handling of fish can be accomplished.

In excess of 60,000 tons of fish per year move from Rio de Janeiro, Guanabara, São Paulo, Paraná, Santa Catarina and Rio Grande do Sul to the Northeast as well as between these states. Much of this transport is carried out in inadequately refrigerated trucks. Very few mechanically refrigerated vehicles are used and icing is most often inadequate. This situation results in serious deterioration of the fish and in great losses. The truck trip from Rio Grande do Sul to Recife takes almost a week. Much of the fish is certainly lost during this journey, and the remainder is of poor quality. This poor quality probably is a significant factor in determining Brazil's present low per capita fish consumption. In turn, this problem of quality is mainly due to inadequate refrigeration and handling during distribution and perhaps to the peculiar infrastructure organization of the industry. The present fish production in Brazil overloads the existing port refrigeration facilities and the facilities available as a part of the larger distribution system. Together with improper handling practices, this largely accounts for the poor quality of the fish sold in the domestic market. The impact of the inadequate refrigerated infrastructure will become even more serious if attempts are made to increase fish consumption to provide additional protein in the diet, especially in the northeast.

C. FRUITS AND VEGETABLES

1. Conclusions

(a) Facilities for handling fresh fruits and vegetables at reduced temperature are almost completely lacking.

(b) The only significant facility for processing or handling frozen fruit products are those of the frozen, concentrated citrus juice industry.

(c) The few facilities existing for storage and transport of fruits and vegetables are either geared to exports, e.g., citrus juices and bananas, or geared to imports, e.g., apples and pears. Little benefit is derived for entirely domestic production and distribution.

2. Production

Fruit and vegetable production has shown the largest increase of all Brazilian crop production in the last 15 years. This is true for absolute volume produced as well as for the value of the products. The total value of the 1970 crop production was approximately 15 billion cruzeiros. Fruits and vegetables accounted for slightly more than 15% of this total crop value. Fruit crops make up more than 75% of the category fruits and vegetables. Hence, a preliminary estimate of the current value of Brazil's fruit and vegetable crop at the farm level is approximately two and one half billion cruzeiros.

Brazil's fruit and vegetable production, with respect to appropriateness and need for refrigerated storage, is divided among three geographic areas. The extreme south, Rio Grande do Sul, is the area of deciduous fruits with an existing production of peaches, figs, strawberries, and a potential for increased apple and pear production. Rio Grande do Sul's production is harvested at a time that makes it profitable to look at European export markets. The development of a profitable export market, though, requires the guarantee of a constant quantity and a constant high quality of products. The development of long-term stable conditions in these export markets cannot be brought about without an appropriate Brazilian system which includes capacity for storage and handling of refrigerated products.

The second major area is the states of Paraná and São Paulo, where a large number of relatively small farmers are engaged in intensive fruit and vegetable cultivation. The overall distribution system in these states, for large part geared to the provision of the São Paulo market, is probably the best developed system in Brazil.

The third production area of fruits and vegetables is the tropical northeastern part of the country where typical tropical fruits are produced that are not well known in many markets in temperate zones, mainly due to lack of proper refrigerated storage and handling capabilities.

The three production zones of fruits and vegetables in Brazil display different products, different production methods, and different markets, in general terms. Hence, from the standpoint of product requirement, as well as from the standpoint of distribution systems, it appears logical to regard these three areas as separate but interrelated in a total system for fruit and vegetable refrigerated storage and handling in Brazil.

Scattered plantings, and the tendency for surplus production to be wasted because of lack of adequate marketing and refrigeration facilities, limit the accuracy and the usefulness of production statistics. Fruit is raised both in large commercial orchards, mostly in the south and east regions, and on small farms and garden patches throughout the country. A general lack of standardization and efficient wholesale marketing facilities, with refrigerated storage capacity, restrains expansion of production, consumption, and exports of fresh fruits and vegetables.

A large number of tropical fruits exists, mainly produced in the northeastern part of the country, that might beneficially be marketed in the frozen state. The Food Technology Institute in Campinas, ITAL, has done substantial development work on tropical fruits. Unfortunately, commercialization of these developments has been limited. Table 7 lists three-year production volumes of major fruit and vegetable crops. Frozen products have been developed for such fruits as avocado, cashew fruit pulp, mango, and various other fruits not listed in Table 7 since production volumes are not reported yet.

The three most important vegetable crops continue to be onions, tomatoes, and garlic.

3. Distribution and Consumption

One of the most efficient distribution systems for fruits and vegetables in Brazil, the COTIA operation, reports an average loss of 30% between the product received from the farmer and handed over to the wholesaler. On the basis of this figure, it appears reasonable to assume an average loss of 50% of all fruits and vegetables produced in Brazil in the total commercialization system from the farm up to the final consumer. Incidentally, this figure is approximately 30% for the United States of America.

The proper management and control of the total commercialization system for fruits and vegetables, which would include cold storage and handling facilities, could possibly reduce these losses to a level below that from the United States, mainly due to shorter overall transport distances.

Consequently, the potential gains of proper system control and management, including refrigeration, are of the order of magnitude of 250 million cruzeiros* for each 10% improvement in the amount of product wasted.

*Based on an approximate production value of two and one half billion cruzeiros.

TABLE 7

BRAZIL: PRODUCTION OF SELECTED FRUITS AND VEGETABLES

1968-1970

FRUITS	UNIT	1968	1969	1970
Grapes	tons	539,036	483,443	598,016
Oranges	tons	2,717,346	2,896,811	3,099,440
Lemons	tons	50,355	53,258	54,233
Tangerines	tons	215,718	229,331	244,485
Avocados	tons	112,199	115,082	122,539
Bananas	tons	8,437,140	9,266,480	9,858,000
Cashew	1,000 fruits	4,540,038	4,477,173	4,057,622
Figs	tons	16,464	17,593	17,679
Apples	tons	13,035	14,432	15,425
Mangoes	tons	653,003	669,224	651,062
Pears	tons	54,202	55,602	56,972
Peaches	tons	90,518	97,434	119,736
Persimmons (caki)	tons	20,428	20,849	21,659
Pineapples	tons	321,630	370,803	403,555
VEGETABLES				
Sweet Potatoes	tons	2,120,450	2,175,143	2,133,983
Garlic	tons	37,321	37,563	36,377
Onions	tons	272,577	275,147	284,603
Tomatoes	tons	775,262	700,438	764,119

Source: Anuário Estatístico do Brazil, 1971 - IBGE.

It should be noted, however, that refrigeration alone is not the crucial factor in attaining drastic increases in the efficiency of fruits and vegetable distribution. It is the improvement of the entire system, including refrigeration, that eventually will bring about the substantial savings to the economy as indicated above.

As illustration of the current losses of mainly fruits, due to insufficiently developed commercialization infrastructure, we can cite the 40% loss of the grape harvest this year, amounting to approximately Cr.80 million for that crop alone. Substantial losses were experienced for peaches and figs in Rio Grande do Sul, as well as for strawberries produced in the central and southern part of the country. These losses are mainly due to the fact that the current system has no capability to cope with production peaks occurring as a result of unusually favorable agricultural circumstances. Even relatively short storage periods of two to four weeks in refrigerated storage houses, can greatly even out these supply peaks, can make the products available over longer time periods, and can even out prices at the farm level as well as on the retail level, due to more orderly market conditions, as a result of a more continuous supply.

A notable exception to the limited use of refrigerated or frozen fruits and vegetables is the domestic use of frozen citrus juices with institutional users for reasons of convenience. A widespread use of frozen fruit juices by the Brazilian consumer has so far been severely restricted by the absence of domestic freezers in Brazilian households.

4. Imports and Exports

Tables 9, 10 and 11 present import and export figures of the most important fruits and vegetables crossing Brazilian borders.

Imports are largely deciduous fruits of temperate zones destined for the larger urban markets. Apples head the list with a strong lead over the combined other fruits. The bulk of apple imports is from Argentina in refrigerated transport means that take bananas and some pineapples as return cargo. The refrigeration facilities handling these products are by and large the only controlled temperature facilities in Brazil specifically built for the handling of fruits and vegetables. As we noted earlier, these facilities benefit, almost exclusively, the import/export trade.

The substantial imports of garlic are noteworthy. This product lends itself very well for long term refrigerated storage. A combination of concentrated domestic production and proper refrigerated warehouses could conceivably reduce imports of these vegetables alone, now amounting to approximately 40 million cruzeiros yearly.

Fruit and vegetable exports are currently led by citrus juices, with Brazil nuts and bananas as a close second and third. A large part of the banana exports go to Argentina. The current economic situation of this major banana market may have unfavorable repercussions on the domestic banana producer.

TABLE 8

BRAZIL: IMPORTS OF SELECTED FRESH FRUITS AND VEGETABLES 1968-1970

Product Description	1968		1969		1970	
	Tons	1000 US$	Tons	1000 US$	Tons	1000 US$
Apples	113,958	25,377	113,924	26,230	108,994	26,915
Pears	19,530	4,354	21,486	5,723	24,202	6,803
Grapes	4,727	1,914	6,015	2,654	5,474	2,450
Prunes	1,785	677	2,047	857	2,219	960
Melons	2,378	562	2,934	703	2,494	600
Peaches	---	---	---	---	953	405
Edible Nuts	8,240	3,505	8,922	3,563	7,962	3,455
Olives	11,599	5,230	14,128	5,745	15,280	6,226
Garlic	12,493	9,978	14,928	5,796	16,525	6,691
TOTAL VALUE		51,597		51,271		54,505

Source: Anuário Estatístico, 1971
Min Plan - Brazil
IBGE, p. 319.

TABLE 9

BRAZIL: EXPORTS OF SELECTED FRESH FRUITS AND VEGETABLES AND ORANGE JUICE 1968-1970

Product Description	1968		1969		1970	
	Tons	1000 US$	Tons	1000 US$	Tons	1000 US$
Oranges - Fresh	2,072,526[1]	3,104	1,627,189[1]	3,553	2,095,490[1]	2,490
Bananas	8,006,131[2]	5,615	8,138,764[3]	9,769	8,052,230[3]	10,657
Pineapple	22,138	1,583	21,781	2,314	14,283	1,517
Brazil Nuts	36,172	14,969	24,115	12,076	32,267	13,638
Cashew Nuts	3,342	3,377	503	517	24	25
Orange Juice	30,096	11,631	23,245	10,910	33,468	14,736
Other Fruits	4,512	1,029	4,181	1,476	20,215	2,727
Tomatoes	1,953	239	13,181	2,750	11,493	1,856
TOTAL VALUE		41,547		43,365		47,646

[1] In boxes, not tons.

[2] Sacks.

[3] Bunches.

Source: <u>Anuário Estatístico, 1971</u>
Min Plan - Brazil
JBGE, p. 308-309.

TABLE 10

BRAZIL: TOTAL VALUE OF REPORTED IMPORTS AND EXPORTS OF FRUITS AND VEGETABLES, FRESH AND CONSERVED 1968-1970
(1,000 U. S. $)

Year	Exports	Imports	Exports-Imports
1968	46,553	75,615	- 29,062
1969	55,396	72,405	- 17,009
1970	60,706	79,254	- 18,548

Source: Anuário Estatístico do Brazil, 1971

This is the more noteworthy in view of the figures presented in Table 10. For each year, 1968, 1969 and 1970, the fruit and vegetable imports exceeded the exports, creating a partial balance of payments' deficit. A partial deficit, on one commodity class, is not alarming at all, were it not for the fact that it concerns an agricultural commodity class in which Brazil, without any doubt, has substantial production potential.

5. Assessment of the Cold Chain for Fruits and Vegetables

The absence of refrigerated storage capacity for Brazilian fruits and vegetables on the one hand and the sizeable economic value of these crops on the other hand, appear to make a development effort for refrigerated fruits and vegetables' storage most opportune.

Even the relatively well developed distribution system in the states of São Paulo and Paraná has no capability for the storage and handling of refrigerated fruits and vegetables. This means that in times of oversupply, such as is the case with the current oversupply of strawberries, the farmer cannot get his products off the land. It also means that the distribution system between the farmer and wholesaler has no capability for storing produce for very short periods, for instance, from one day to the next marketing day. Products held over in the wholesale market areas, such as in the CEASA market in São Paulo, from one night to the next, because they could not be sold, deteriorate very rapidly in the heat of the day. Daytime storage of these fruits and vegetables is economically attractive and could greatly reduce the 30% loss of produce within that part of the overall produce distribution system.

As we have noted elsewhere, the necessity for refrigerated storage and transport of fruits and vegetables arises out of the fact that we deal with living products, whose deterioration is partly due to their own metabolism. This metabolism now can be greatly reduced by lowering the temperature of the products. Owing to this necessity of a slowdown of the metabolism, proper refrigerated storage and handling requires a continuous system between the producer and the final consumer. Specifically, it should be noted that refrigeration is not some type of a cure that can be applied somewhere in the distribution system in order to heal damages done previously. Once fruits and vegetables are damaged as a result of prolonged exposure to high temperatures, the damage is irreversible and subsequent short or long term refrigerated storage cannot repair it. The only thing one can then hope for is to slow the damaging processes down.

This absence of frozen storage capacity at the household level, in other words, the non-existence of the last link in the frozen cold storage chain, is a major impediment for the development of a frozen fruit industry, catering to the ultimate consumer, in a frozen state. If worldwide experience can serve as a yardstick, we expect that refrigerated and frozen storage and handling will first be developed in the distribution chain up to and including wholesalers and institutional big users. Ultimately, a frozen fruit industry freezing retail packages of fruit will develop once household freezers are in widespread use.

The major thrust in fruit and vegetable refrigerated and frozen storage and handling will initially be in the refrigerated state in large warehouses, so as to preserve the quality of the fruits and hence their economic value for a period of time substantially longer than they could be preserved at ambient temperatures. This does not exclude the possible development of some specialized industries, for the bulk freezing of fruits for the institutional market, mainly in the period of top supply, the harvesting period. An example of this could be strawberries, which are this year in oversupply, to the extent that the farmer lets them rot in the field and cannot get them delivered to the distribution system. Reportedly, a French mission is interested in buying large quantities of frozen strawberries for delivery in October. Frozen strawberries are used by the jam and jelly factories and by such institutional users as large bakeries. The diversion of excess supply of these types of fruit into freezing for institutional use is perfectly feasible, a market exists and an early development of these freezing capabilities in Brazil appears to be called for.

The vegetable crops, such as lettuce, will benefit substantially by relatively cheap and efficient evaporative cooling just before they are transported over long distances. The relatively wet lettuce when already packed and stacked on the truck or railroad car is subjected to a vacuum in large vacuum chambers. This vacuum provokes the rapid evaporation of part of the water adhering to the produce. This evaporation of part of the water results in a substantial reduction in temperature of the entire load, often sufficient to keep the produce at acceptable temperatures for long-time transport.

In relation to tomatoes, it can be noted that this crop can benefit substantially from refrigeration immediately after harvesting. Quick removal of the so-called field heat can substantially increase the keeping quality of tomatoes and many other fruits and vegetables. In major tomato producing areas, such as northern Mexico, this is routinely done with the entire harvest.

D. FROZEN FOODS

1. Conclusions

(a) A CCFS for frozen foods exists to a limited degree for export products such as citrus juice, shellfish and beef.

(b) The domestic market demand for frozen foods is just beginning to require a CCFS.

2. Assessment of the Cold Chain for Frozen Foods

Frozen food can include practically everything we eat: vegetables, fruits, juices, poultry, meats, seafoods, and a number of prepared specialties. These product categories, though, are not of equal importance in the daily diet, nor will they be of equal economic importance in the frozen form. The major product categories already have started to make their appearance in the marketplace; frozen chickens and turkeys are being produced by a number of manufacturers. Prepared meals such as frozen juices and seafoods, are now appearing in the Brazilian economy. The initial introduction of these products into the institutional field, with hotels, hospitals, etc., will pave the way for other foods to follow when the institutional user recognizes their economic and convenience advantages. It can be expected that when the manufacturing of frozen foods becomes profitable, the manufacturers will tend to explore the possibilities of increasing the domestic consumer market. This market is now limited by a number of constraints, such as the lack of domestic freezer space and the limited consumer acceptance. Both the increase in the use of home freezers and the increase in the use of frozen foods will stimulate each other. In addition to the domestic market for frozen foods, there exists a very great export market, part of which already is accessible to Brazil, namely the market for frozen citrus concentrate and the market for frozen beef and seafood. Large markets exist for frozen products that are currently produced in Brazil but not yet frozen; for example, for frozen strawberries. This year in particular, there is a great surplus of strawberries in Brazil that will go to waste in the fields because there are no facilities to handle them. This, in spite of specific export demand demonstrated for frozen strawberries.

Comments have been made before on the success that Brazil has had in entering the frozen shrimp and lobster markets of the world. The world market demand is large for other frozen fishery products as well, and in the event that sufficient quantities of fish are available, this industry could expand to supply not only the international market but an increasing domestic demand too.

The coordinated effort of many industries will be required to produce, process, package, store, transport, distribute, display and sell frozen foods in Brazil. New varieties of field crops will have to be developed for freezing. Equipment and methods for quick freezing, packaging materials for meeting specific product and marketing requirements for frozen products, storage and transportation facilities for handling frozen foods all the way from the packer to the consumer will have to be developed and constantly improved. It can be expected that, as a result of these developments, important changes will occur in location of production of some commodities, and changes in the marketing system between the farmer and the consumer can be predicted. Some of these changes have already begun, related to other food items, for instance, the growing importance of the supermarket in Brazil. It is also conceivable that changes in location and production of some fruits and vegetables may take place from farming areas near the point of consumption to points farther away from major markets, where these crops can be grown more efficiently. If production of certain fruits and vegetables moves away from present locations, it can be expected that frozen food processing plants will be located near the source of supply because of the importance of receiving fresh products for freezing, and it can be seen from this chain of events that new agribusiness centers could develop where they do not now exist.

Frozen foods have become established products in many countries of the world. North American market statistics indicate that well over $6 billion per year of frozen foods are used by consumers and by the hotel, the restaurant and institutional trades. These figures do not include ice-cream, a separate category amounting to more that a billion and a half dollars. Conservatively, one can infer that the Brazilian frozen food business might approximate 10% of this within the next 20 years and it is prudent to plan now for the integration of a useful system and to avoid the errors committed by other countries while developing their CCFS.

The frozen food industry has been a commercial success in developed countries for over 20 years; however, the industry is still relatively new compared to other food industries and has been beset by problems common to infant industries. In addition to the usual problems, the frozen food industry, at the outset, also faced problems of entering a rapidly changing retail market system and attempting to operate in a system which had no facilities for the industry's unique requirements. As a result, the frozen food industry in the then developing countries attempted to apply and augment what was available; a rudimentary ice-cream distribution system. At the time of frozen food introduction, though, ice-cream was not a major retail grocery item, and was distributed in insulated trucks, sometimes cooled with a little solid carbon dioxide or "dry ice." In the retail grocery store, ice-cream was sold from crude home chest freezers. Frozen foods followed much the same pattern, being distributed in insulated trucks from the various warehouses to the grocery store, dry ice being used as the refrigerant. Mechanical refrigeration was virtually unused for small scale storage and transport when frozen foods were introduced at the retail level.

In the early days of the frozen food industry, there was fear that the deterioration processes might lead to spoilage which would be harmful to the consumer. This fear dated from initial experiences with refrigerated perishable commodities, such as beef, and with canned foods. Both of these product categories had exhibited a propensity to spoil and to become toxic if processing and distribution were not performed under adequate conditions. This experience, when scientists examined it more closely, appeared to be the result of deteriorative processes in frozen and processed foods. Fortunately, it soon became apparent that spoilage leading to toxicity was not a consequence of freezing, but rather a delayed process that develops the more rapidly the higher the temperature of the food is. As a by-product of research, scientists and technologists were able to make qualitative measurements of the deteriorative processes, and their time/temperature dependence, that occur both in processing and distribution. In the 1950's the advent of the supermarket in Canada and in the United States led to more widespread acceptance of frozen foods. Coupled with the introduction of the domestic refrigerator/freezer and the domestic freezer, the sale of frozen foods rose dramatically. This situation is now in the initial phase of its realization in Brazil. It should be recognized that frozen foods will become a significant part of the Brazilian diet as a logical consequence of current development and expansion. With this recognition in mind, industry and government leaders should now develop systems to protect the product, its processors and its distribution cycle so that they will gain on the basis of other countries' experiences.

What is to be avoided in Brazil is the confusion of the 1950's about the frozen food business in some developed countries.

The future growth of the frozen food industry in Brazil will be influenced by a number of economic and technological factors. Among those will be a growth in population, changes in its composition and location, growth in personal income, relative costs of frozen foods versus other forms of food, changes in food taste and preference, technology and methods of freezing as well as other methods of food preservation and consumer acceptance of new products. Intensive study and careful forecasting will be necessary to foresee what is likely to develop with respect to some of these factors, but trends in other countries can provide a guide to future developments regarding some of them and some logical assumptions can be made for guiding the impact of these developments on the future of the industry.

E. REFRIGERATION FACILITIES

The total refrigerated storage capacity in Brazil does not surpass 80,000 to 100,000 metric tons of storage. Of this total, CIBRAZEM accounts for approximately 20%. We estimate that approximately 60% is dedicated to meat storage, of which the storage facilities in Guanabara and Rio Grande do Sul take the major portion. Fish and dairy storage take by far the major part of the rest, with no specialized storage for fruits and vegetables existing.

The general state of maintenance and operational adequacy of the storage facilities can only be termed primitive. Most facilities indeed provide their basic service, cold storage. However, adequate temperature control is absent and control equipment is either non-existant or not operational. Although manual control of storage temperature is possible, especially with large warehouses, this procedure was abandoned approximately 40 years ago, in favor of the more satisfactorily operating automatic control. The maintenance of the constant low temperature over prolonged periods of time by manual control is not really possible. On the other hand, currently available automatic control equipment is very reliable and operates to complete satisfaction.

We have the impression that many misconceptions exist, even among the operators of large storage houses such as the large CIBRAZEM meat storage in Guanabara, as to operational details of their storage facilities. The necessity of a maintenance of frozen meat storage at at least -18°C is not well understood. We observed storage temperatures of only -10°C and even higher. These temperature ranges are favorable for the growth of certain types of mold, and hence the product can deteriorate very rapidly. Cold room doors do not close completely, which gives easy access to rats, and also to ambient air, taxing the refrigeration system with excess heat loads as well as with excess water vapor and forming ice on the cooling units in the cold rooms. The water vapor barrier of the insulation is often partially broken down, creating the possibility of penetration of humidity in the insulation and freezing of the insulation. This results in cracking and breakdown of the insulation, and increased heat flow into the room and hence an extra burden on the refrigeration system. This extra burden may eventually be larger than the total capacity of the installation, and hence correct temperature maintenance at desired low levels becomes impossible to reach.

We also observed renovation work that was not always carried out with a complete understanding of the function of modern refrigeration equipment. Specifically, liquid refrigerant lines in cold storage rooms were not insulated. The evaporators in the cold rooms, the equipment where the cold is actually generated, appeared very small in the renovated installations. For reasons of investment, a cheap small evaporator is often chosen instead of a larger and more expensive one. This appears a reasonable economy, but it is detrimental for the satisfactory operation of the equipment. A small evaporator requires a lower surface temperature in order to maintain a certain room, and hence product temperature. The lower the surface temperature of the evaporator is, though, the faster the product dries out, the faster ice accumulation on the evaporator occurs, and hence the more complicated and more often the defrosting of the evaporator. In other words, initial savings in installation will have to be paid for continuously later with high operating costs, and insufficient quality of the product stored. The suction lines of many compressors we observed were frozen up to a point very near to the compressor. This again indicates incorrect control of the entire installation. Unevaporated drops of liquid refrigerant are sucked by the compressor out of the evaporators. This is an inefficient operation as well as dangerous, since excess liquid cannot be compressed by the compressor and it may cause severe damage to the compressor units.

It should be noted that design and operation of refrigeration units, ~~be it~~ for freezing operations or for cold storage rooms, requires a combination of complicated technical as well as economic understanding of the installations in question. A correct design, and even a satisfactory operation, require the consideration of a large number of interrelated factors and their relative importance has to be judged. It occurred to us that many decisions as to new equipment were made on the basis of single criteria. An example of this is the fact that Sulzer compressors are chosen because they are oil-free. Indeed, this can be an important consideration in certain installations. However, an oil-free compressor is not the panacea for all installations and should not be the overriding criterion of choice.

Another factor that appears to be a misunderstanding is the fact that cold storage should not be seen as a medicine to repair some harm done to the product as a result of excessively high temperature somewhere in the distribution channel. Any product entering a storage room under low temperature, will come out of that room at maximally the same quality it entered, never better. In other words, one should never expect that cold storage can have a quality-increasing effect, but to the contrary. Much of the bad quality image that the Brazilian consumer has of products that have been stored in a refrigerated or frozen state, such as beef, can be related to the fact that the product was already in precarious quality conditions when it entered the warehouse. Often, excessive time elapses before the product actually moves into cold storage or the product that moves into cold storage is the product that could not be sold in a certain marketing period. For quality products to come out of refrigerated storage, it is imperative that quality products enter. The necessity for a closed cold chain is directly coupled with this same criterion. If products are held at elevated temperatures between the slaughter house and the cold storage room, rapid irreversible quality deterioration occurs. Partial thawing and re-freezing of meat should be prevented at all cost.

In 1969, Brazil had reported approximately 800 so-called caminhões frigoríficos. It is not clear whether this is a combination of insulated trucks, as well as trucks with their own mechanical regrigeration. It is not clear either what the average size of these transport units is. We observed a number of cold transport means, small insulated pick-up trucks for city delivery, as well as large 24 ton trucks that hauled apples from Buenos Aires to São Paulo and bananas as return cargo. The latter trucks, built in Porto Alegre, are of an advanced design, but employ a rather experimental cooling unit on the basis of liquid carbon dioxide. It appears not wise to experiment, under current Brazilian conditions, with these kinds of sophisticated installations, not having proven themselves yet in other parts of the world. Specifically, the control equipment that has to maintain the temperature in these trucks is still deficient. As a matter of fact, the operator of these trucks had to agree that under summer conditions it was not possible to maintain desired temperatures during apple transport between Buenos Aires and São Paulo. A proven mechanically operated refrigeration unit would do this job in a most satisfactory way.

These and other experiences again point to the fact that basic misconceptions and lack of understanding have to be overcome as far as cold storage and handling of perishable food products in Brazil is concerned. This is nothing exceptional or unexpected. Rather, it is indicative for a state of development of this particular technology, at a level reached approximately 40 to 45 years ago in Europe and in the United States. If we are able to learn from the experiences gained elsewhere in the world in the development of cold and frozen storage food handling, the learning, and hence development time, in Brazil could be drastically reduced. This, however, requires a combined effort of education, government incentive, willingness of private industry to cooperate, and proper government action to alleviate bottlenecks in the system.

The current equipment manufacturers in the country have sufficient capacity and knowledge to satisfy domestic demand. Several companies produce compressors, the most complicated part of the refrigeration system, up to the highest capacities that the domestic market requires. All other parts of refrigeration systems -- hence also much auxilliary equipment such as freezing tunnels, plate freezers, water coolers, etc. -- is domestically produced. The major equipment not domestically produced is the complete control equipment for the installation. This again is a normal situation, since only a few companies in the world are the major producers of this type of equipment. It appears not attractive for Brazil to invest now the substantial sums and professional effort in the research necessary to develop this control equipment domestically. The amount and hence total value of control equipment required in Brazil for the foreseeable future are small, and do not justify build up of a domestic industry in this sector. The availability and product quality of the domestic machine industry provide a sufficient basis for an expectation that refrigeration equipment supply will not be the bottleneck in the development of a domestic frozen and refrigerated storage and handling system. What is required, though, is a proper understanding of the technology and the economics of a cold and frozen storage and handling system, so as to provide a correct basis for judgment as to what is domestically offered by different equipment suppliers.

A major user of ice in Brazil is the fishing industry. The 17 entrepostos of Cibrazem all have ice-producing capability. However, these capabilities with a few exceptions, such as the on in Fortaleza, have freezing tanks where blocks of ice of 25 kg nominal weight are produced. Subsequently, these blocks of ice are chopped up and the ice chips are delivered aboard the fishing vessels. The production of ice blocks for ice chips is a rather inefficient way of producing these chips. Currently, equipment exists that produces chips immediately, without first producing ice blocks. This produces chips at a lower cost per ton of ice than when ice blocks are produced. It is noteworthy that these advanced ice chip producing machines are already manufactured in Brazil.

CHAPTER IV

IMPLICATIONS OF IMPROVING AND EXPANDING THE CCFS

A. Technical Implications

1. Contribution to Orderly Development

The cold chain food system in Brazil is developing and will continue to develop if there is a formal plan for that development or not. At this time, a number of entrepreneurs are planning the construction of segments of a CCFS. These individuals are to be commended for their aggressive business activities. It should be kept in mind, though, that their prime interest is the financial future of their enterprises; they have limited reason for concern about the technological coherence of the system as a whole.

The improvement and expansion of the CCFS under a well designed implementable plan will allow for sequential additions to the system of the right size, at the right place, and at the right time. The establishment of a sound implementable plan will allow for the selection of optimum technical solutions for components of the system, in line with its overall layout. Such a plan will lead to the establishment of standards for facilities and uniform operating conditions. In short, planned improvement and expansion of the CCFS in Brazil will lead and guide the infant frozen and refrigerated food industry to grow in the most orderly way.

2. Nutritional Improvement

While it can be expected that the supply of all nutrients will be increased as a result of an improved and expanded cold chain, the most dramatic impact will be the more plentiful supply of protein.

It is reasonable to expect that per capita consumption of fish might double from the present 3.7 kg. to 7.5 kg., if high quality refrigerated fish were available to large parts of the population. If this increase were to benefit that part of the population that is presently undernourished, great improvements in health can be expected. This reasoning can also be applied to meat. Although meat consumption is relatively high in Brazil, meat is not always available to large parts of the population, partly due to the absence of a complete and adequate meat CCFS.

3. Public Health Improvement

One of the severe problems in Brazil is high mortality due to enteric diseases. The problem is due in part to the consumption of severely contaminated food. Although no food item is completely sterile, if properly handled and refrigerated, the level of contamination can be held low enough so as not to cause disease in man. However, the higher the temperature to which food is exposed and the poorer the CCFS through which it passes, the higher the level of contamination and the greater the tendency to food poisoning.

It is interesting to note that the locations with the highest ambient temperatures (and therefore highest food temperatures andhighest level of contamination in food) experience the highest mortality rate (see Table 11).

TABLE 11

BRAZIL: MORTALITY DUE TO ENTERIC DISEASES

	Deaths per 100,000
Manaus	185
Belem	85
Rio	25
Porto Alegre	15

Enteric diseases are not usually fatal, and probably 100 to 1,000 times as many people are debilitated for a day or more for every death recorded.

It is certainly not true that adequate CCFS's will prevent all enteric diseases, but the existence of such a system will greatly reduce the incidence of these diseases.

4. Effect on Imports and Exports

The world food markets are increasingly demanding food that meets rigorous sanitation standards. International organizations, particularly F.A.O. and W.H.O. establish standards that are being adopted by many countries. Compliance with these specifications depends in large part upon the existence of an adequate CCFS. A well-planned, expanded and improved CCFS would thus greatly assist the promotion of export of Brazilian food products.

It should also be considered that non-compliance with international standards, though not always prohibiting exports, will nevertheless put the Brazilian exporter at a competitive disadvantage and may close the most profitable and sophisticated markets to him in a way similar to the export position of Brazilian beef from foot and mouth disease infested areas.

B. Economic Implications

There are many positive economic benefits to be obtained from a well-planned and well-executed expansion of Brazil's cold chain food system The scale and scope of these benefits can best be understood, however, in the broad context of present trends and policies in Brazil's economic development. Therefore, before discussing the economic implications of expanding its cold chain food system, we will briefly summarize those aspects of Brazil's economic development which we believe are most likely to be affected by expansion of the CCFS.

1. Achievements and Problems of Brazil's Economic Development Program Relevant to Expansion of the CCFS

Brazil's economic progress in macro-economic measures has been spectacular since 1967: Gross Domestic Product in real terms has been increasing between 8.5% and 11.3% annually, one of the fastest rates in the world; industrial output which has been the leading contributor to Brazil's rapid growth, has been growing at rates of between 10% and 13%; agriculture, the largest sector, which has suffered some bad years has, nevertheless, grown at an average rate of around 5%; and the service sector, one of the fastest growing, has averaged about a 10% annual increase. (See Table 12). Export earnings grew at a rate of nearly 20% between 1967 and 1970, while imports grew at a slightly lower rate thereby resulting in trade surpluses and a build-up in foreign exchange reserves. In 1971, however, exports were surpassed by imports, largely as a result of a price drop for coffee.

Other notable strides made by Brazil during the recent development period, include a doubling of electric energy capacity between 1964 and 1971 (another 50% increase over present capacity is planned for the next two years); substantial improvements in the country's infrastructure, including the beginning in 1970 of the 3,000 km Trans-Amazon Highway and the 1,600 km Curabá-Santarém Highway; and improvements in telecommunications and education.

Finally, one of the greatest economic achievements in the last five years has been a sharp reduction from the high inflation rates of the early and mid 1960's. Furthermore, new economic policies adopted in recent years have minimized the deleterious effects of inflation.

The formula used by Brazil for accomplishing these remarkable economic gains was not derived overnight, but has evolved over the last eight years, largely depending on experimentation. It began in 1964, with a program directed at monetary correction under which virtually every element of the macro-economic system is adjusted at least once a year to keep pace with increases in the wholesale price index. In late 1968, the same theory of monetary correction was applied to foreign exchange with the introduction of the system of flexible exchange rates with frequent mini-devaluations.

The concepts of living with inflation and monetary correction have been accompanied by programs for stimulating economic development in particularly backward sections of the country, such as the Amazon Basin and the Northeast Region.

Finally, the recent development program has been stimulated as a result of Brazil's favorable policies regarding foreign investment which permit foreign capital participation in all but a few sectors of the economy. The result has been sizeable inflows of capital, amounting to $2.55 billion as of mid-1971.

TABLE 12

BRAZIL: NATIONAL ECONOMIC INDICATORS

	1968	1969	Preliminary 1970	Estimate 1971
Gross Domestic Product (Cr. Millions, at current prices)	99,270	131,682	172,742	227,412
Population (1,000 inhabitants)	87,003	89,317	91,693	94,007
GDP per capita (Cr., at current prices)	1,141	1,474	1,884	2,417
Implicit Deflator (percent variation)	28.1%	21.7%	19.6%	21.0%
Increase in GDP per capita (percent increase, in real terms)	5.7%	6.2%	6.8%	6.2%
GDP per capita (U.S.$, using av. annual exch. rate)	336.56	361.35	403.45	456.10
Exports (U.S.$ Million, F.O.B.)	1,881	2,311	2,711	2,900
Imports (U.S.$ Million, C.I.F.	2,132	2,265	2,866	3,440

Source: F. G. V. and Central Bank.

A more critical look at Brazil's recent economic developments, however, indicates that in spite of the rapid progress made on a macro level, a number of traditional social welfare indicators have not reflected as much progress since 1967. A recent study of income distribution in Brazil by Albert Fishlow[1] indicates that the inequalities in income which existed in 1960 have not improved. For example, the upper 3.2% of the labor force received 33.1% of the national income in 1970, compared to 27% in 1960, (note that this considers only the economically active population which is less than one-third of the total population). Comparisons between 1960 and 1970 are shown in Table 13. Fishlow's study points out that since the concentration of income in 1970 was less in agriculture than in 1960, it has not meant greater welfare in rural areas. Rather, the sectoral differential appears to have widened. Even within the industrial sector, the leading participants in the expansion were producers of consumer durables such as automobiles, rather than non-durables, such as foodstuffs.

Fishlow's study also points out that the distribution of educational opportunities within the labor force were uneven in the past decade, with those persons receiving higher levels of education being responsible for the increases in the average years of schooling.

Another important measurement to be looked at more closely is the cost-of-living index. Although there, indeed, has been a highly significant reduction from previous rates of inflation, and in spite of the fact that Brazil's "economic development formula" has made it easier to live with inflation, the constant quarterly increases in cost-of-living of 5 - 7% tend to diminish the country's economic progress. While it has not been documented, it would appear that inflation has a more severe effect on lower income groups. For example, food, which constitutes a disproportionate share of a family's budget in lower income groups (as opposed to housing which is fairly proportionate to family income) has generally experienced more rapid price rises than the total index. (See Table 14). The lower income earner whose adjustments are based on total cost-of-living indexes is, therefore, squeezed more than the higher income earner. Furthermore, those people who derive a part or all of their income from other than wages and salaries (i.e., interest, dividends, rents, etc.) are generally less affected by inflation, due to the nature of those earnings and tax "breaks" for other forms of income.

Regional differences in cost-of-living provide another example of the disparity in the effects of inflation. For example, as shown in Table 15, prices have increased at a substantially higher rate in Porto Alegre than in São Paulo. Measures have been taken in an attempt to halt inflation, particularly with regard to food, which constitutes a major component of the basket of goods used in determining the price index. For example, in 1970 the Government adopted certain restrictive policies regarding beef, including setting price ceilings on fat cattle, limitations on monthly

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[1] "Brazilian Size Distribution of Income" Albert Fishlow, American Economic Review, May 1972, pp. 391-462.

TABLE 13

BRAZIL: DISTRIBUTION OF INCOME OF ECONOMICALLY ACTIVE POPULATION

1960			1970						
				TOTAL		AGR.		NON-AGR.	
Monthly Inc. In NCr$	% of Popul.	% of Income	Monthly Inc. In NCr$	% of Popul.	% of Income	% of Popul.	% of Income	% of Popul.	% of Income
None	14.7	0.0	None	11.7	0.0	20.1	0.0	5.1	0.0
0-2.1	22.3	5.2	0-100	31.7	8.0	46.8	28.4	19.7	3.4
2.1-3.3	14.4	7.0	101-150	12.8	6.2	15.3	17.8	10.7	3.6
3.3-4.5	10.5	7.4	151-200	15.6	10.6	10.0	16.3	20.0	9.3
4.5-6.0	13.1	12.3	201-250	4.5	3.9	1.7	3.7	6.6	3.9
6.0-10.0	13.8	20.0	251-500	14.6	21.2	4.6	16.0	22.7	22.6
10.0-20.0	8.2	22.2	501-1000	5.9	17.1	1.0	7.2	9.7	19.3
20.0-50.0	2.6	16.4	1001-2000	2.2	13.0	0.3	4.3	3.8	14.9
50.0	0.5	9.4	2001+	1.0	20.1	0.1	6.4	1.7	23.0
MEAN:	5.52		MEAN:	679		282		992	

Source: Fishlow (Ibid.).

TABLE 14

BRAZIL: COST OF LIVING INDEX

	1968	1969	1970	(1st Quar.) 1971
Food	17.7	30.9	20.9	7.0
Clothing	24.2	16.8	15.3	3.8
Housing	31.4	22.2	18.5	1.2
Household Goods	27.1	15.3	16.2	4.1
Health	30.1	16.6	26.1	3.6
Personal Services	32.9	19.3	22.3	7.5
Public Services	21.1	30.5	30.3	0.8
TOTAL	24.0	24.2	20.9	4.8

Source: F.G.V.

TABLE 15

BRAZIL: COST OF LIVING INDEX (PERCENT INCREASE)

	Total Increase			Food Prices		
City	1968	1969	1970	1968	1969	1970
Belo Horizonte	27.4	22.2	21.9	25.7	31.4	23.3
Curitiba	24.5	24.3	22.3	31.9	34.4	20.8
Rio de Janeiro	24.0	24.2	20.9	17.7	30.9	20.9
Pôrto Alegre	21.0	19.6	23.0	16.9	22.9	27.4
São Paulo	25.2	22.6	17.5	24.9	27.5	11.9

Source: Economics Departments at Universities of Minas Gerais, Paraná, and Rio Grande do Sul; Getulio Vargas Foundation; São Paulo City Government.

slaughtering by packing plants, application of fines and plant closures for non-compliance, and imports of frozen beef, mainly for the Rio de Janeiro market. In 1971, wholesale price ceilings were set on forequarters and hindquarters of beef sold in the Rio de Janeiro market and prohibitions were placed on products from packers who failed to comply with price measures. More recently, it was announced that all essential foodstuffs would be exempted from the tax on industrial products.

Another effort to control inflation has been in the field of monetary policy. Expansion in the money supply has declined steadily, from increases of 43% in 1968, to 33% in 1969 and, as estimated, 25% in 1970.

In short, Brazil's economic success in the past seven or eight years can be characterized as achievement of dual goals: rapid economic growth, and gradual reduction in inflation. While greater social welfare and wider regional distribution of economic prosperity have also been sought during this period, these objectives have, by necessity, had to receive lower priority as the nation turned its major attention and directed its principal resources in the direction of industrial expansion. The achievements of this effort are now capturing attention around the world and Brazil is in an excellent position to consolidate its diverse industrial programs and aim at achieving a more balanced development, including engaging a larger number of people in the economy, both as producers and consumers. As we shall show, expansion of the CCFS can make substantial contributions to these goals.

2. Goals of National Development Plan, 1972-1974

The goals of the First National Development Plan of Brazil, 1972-1974, include, among others:

- Attainment of the rank of eighth place, in terms of GNP, among the leading world economic powers and surpassing US$500 annual per capita income;
- Achievement of national objectives of development and social transformation by means of a competitive process capable of ensuring international efficiency levels at the public and private sectors;
- Harmonious cooperation between the Government and the private sector, as well as the Federation and the States; between the developed and developing regions; between business and labor;
- Introduction of new instruments for modernizing the national enterprise, strengthening its competitive capability and eliminating the inequality of conditions under which it operates vis-a-vis the foreign enterprise;

- Implementation of a national technological policy, which will permit acceleration and direction of transfer of foreign technology to the nation, associated with a strong component of creation of domestic technology;

- Expansion of employment opportunities over and above those in the increase in skilled labor supply and at income and productivity levels above those of subsistence. Such opportunities are to be opened through accelerated growth with an adequate technological policy and sectoral and regional priorities definition.

- Fulfillment of several large investment programs, each over one billion U.S. dollars, in accordance with the purpose of consolidating the economic infrastructure and the basic industries;

- Implementation of a regional strategy aimed at bringing about national integration. While the Central-Southern developed nucleus becomes consolidated, new regional poles will be established, notably the agro-industrial region in the South, the industrial-agricultural region in the Northeast, and the agricultural and cattle raising region in the Central Plateau and Amazônia. The transfer of federal funds to the Northeast and Amazônia -- through the PIN, PROTERRA, Fiscal Incentives, Participation Fund, Special Fund and Committed Funds, are a part of this strategy;

- Participation of all social levels in the results of development as well as decentralization of economic power, with the creation of capitalism-for-the-many and the diffusion of opportunities; and

- Growth in export revenue of above 10% a year; and creation of two categories of exports (manufactured goods and mineral ores/non-traditional agricultural products) capable of competing with coffee, and further enhancing the nation's active participation in the general preferences system established by certain developed areas.

The specific targets set forth for 1974 are summarized in Table 16. While the time frame of a proposed cold-chain system extends beyond this date, the targets are important in that they reflect the direction and magnitude of goals that can be expected in the remainder of the 1970's.

In the remainder of this section we indicate how expansion of the CCFS can support the foregoing targets of development.

TABLE 16

BRAZIL: TARGETS OF FIRST NATIONAL DEVELOPMENT PLAN 1972/74

	1972	1974	Increase in the Period - %
GNP (Cr $Million)*	222,857	314,581	41
Population (Thousands)	93,204	104,130	12
Per Capita Income (Cr $)*	2,391	3,021	26
Industrial Product (Cr $Million)*	53,384	78,160	46
Gross Fixed Investment (Cr $Million)*	37,885	59,770	58
Rate of Gross Fixed Investment (%)	17	19	--
Consumption (Cr $Million)*	185,015	251,224	36
Economically Active Population (Thousands)	29,195	32,987	13

*1972 Cruzeiros

3. How an Expanded and Improved CCFS Will Support the National Development Plan

Expansion of Brazil's cold-chain system, as described in the earlier sections of this report represents a potential program for helping the nation achieve its development goals. Very briefly, if properly planned and executed the creation of a major integrated cold-chain system could yield the following benefits:

Increased Production: This would result from a number of trends. To begin with, production would not be limited to supplying immediate demand as cold storage and freezing facilities would allow agricultural goods with short growing seasons or goods subject to unfavorable growing seasons to be produced for storage and later consumption. Second, demand would not be limited to markets near production centers. Thus, output from traditional production areas could be moved over a larger market area and production for exports and domestic consumption could increase in areas further removed from traditional large Brazilian markets. Third, production of other industries, both as suppliers to and as further processors of agricultural production would increase and, in turn, create a chain of increased inter-industry output. For example, with increased beef production through the cold-chain system, sales would increase of other agricultural products such as feed, transportation, construction, machinery manufacturing, steel, services, wholesale and retail trade, etc. As a consequence of these increased sales and employment, the increased beef sales would actually result in a multiple increase in national product. Fourth, productivity would be increased. Improved handling and storage of foodstuffs would reduce wastage and have a cost-reducing effect. Also, productivity would be increased through the "demonstration effect" which, by virtue of carrying modern technology further back in the production chain, would expose people to efficient handling techniques to which they are not now accustomed. Generally, technological exposure of this type tends to increase the productivity of other operations that tie into the part of the system which has been improved -- a technological chain reaction. All of these trends could help Brazil in achieving its targeted agricultural growth rate of 7% per annum.

Improved Balance of Trade: This would be the result of both an increase in exports of agricultural products and a decrease in food imports. At present, exports of frozen or refrigerated foods are primarily beef, which already constitutes a respectable share of the country's exports, but is small compared to its potential. Furthermore, with expanded cold storage facilities, Brazil could cut down its imports of some food items which are projected to increase on the basis of existing capacity and demand. Both of these trends would help reduce the country's dependence on the movement of world coffee prices and in improving the trade deficit, which the IBRD recently projects would rise to $600 million annually by 1975.

Stabilization and Possible Reduction of Food Prices: Stabilization of food prices would result primarily from the fact that production could be stored and, consequently, the "peaks and valleys" in supply would be levelled off. While it is possible that this could result in some prices being higher than they are now at certain times, the long run aggregate effect would be a reduction in prices as increased efficiency in handling and increased supply would most likely offset higher handling costs. However, this question would have to be studied further before a conclusive answer could be reached.

Wider Distribution of Income and of Other Economic and Social Benefits: An important characteristic of the CCFS is its potential as a development tool, which can be used by the Government for achieving both economic and social welfare goals, particularly as they relate to the distribution of benefits. For example, by extending the cold-chain system into the North and Northeast of Brazil, it would be possible to tie this part of the country into the economy and provide the people of that region with both markets for their agricultural products and goods and services from the rest of the country. Such a step would fit very well into the long range development program outlined in PROTERRA. Other benefits from a CCFS include an increase, nationally, of average per capita nutritional intake and improved public health.

What we have just described, however, are only the gross benefits that a cold-chain system would yield in Brazil. In order to assess the net benefits of such a system or any project that formed a part of it, one would also have to examine the costs these projects would impose on the national or regional economics. For example, it was mentioned that increased national product (or income) arising from a cold-chain system would be made up of increased sales of agricultural goods; increased sales of other directly or indirectly related industries; reduction of food losses; and increased productivity in input factors. However, these benefits would have to be measured against the "opportunity" costs Brazil would be incurring by employing its resources of capital, labor, land and foreign exchange to produce, or purchase abroad, the equipment, power, materials and technical expertise required to create the system or components to effectuate the benefits.

It appears quite obvious that because a well-planned cold-chain food system could offer many more benefits in addition to increased production (i.e., improved balance of trade, price stabilization, and regional development) that, in general, it would have a very favorable benefit-cost ratio. However, since the system is composed of many sub-systems (i.e., projects) numerous variations of components, the permutations and combinations must be studied in an orderly fashion so as to maximize the total effectiveness of the system.

The need for such analysis is particularly important because of the magnitude of effort being considered here. Traditionally, the development of a CCFS has occurred through an evolutionary process taking place over a long period of time as a country develops economically. Brazil, it seems, does not care to wait the years or decades usually required for such a system to evolve. The country has made tremendous economic progress on many fronts in recent years, and its planners recognize the need for making equally rapid progress in the areas which have had to be delegated lower priority initially. Thus, development of a nationwide CCFS will take place in Brazil through a revolutionary process. Nowhere in the world has such a significant program been undertaken in expanding the food industry and never, to our knowledge, have the potential opportunities for achieving other economic and social objectives from such a system been as broad or as great.

CHAPTER V

WORK PROGRAM

A. Objectives

The objective of the work program set out in Figure 7, is to develop an implementable plan for an improved and expanded CCFS in Brazil. This implementable plan would supply the types of projects necessary, their geographical locations, expected supply to and demand upon the system, commodity flows between the system components, technical and economic requirements, and the system's economic impact on other parts of the economy. The plan would be accompanied by a detailed program for implementing the improved and expanded CCFS, including priority project selection, investment phasing, a critical scheduling path for implementing the entire set of projects, and identification of exogenous constraints that must be dealt with to enable implementation to proceed, (e.g., international financing).

B. Method

The overall method used in the work program is to carry out several cycles of effort. Each cycle makes adjustments in and adds more precision to the overall system, to project specifications, to project locations, and to understanding of the economic impacts of the system, thus converging more and more upon the ultimate detailed system design and outputs. An additional phase, following the cycle that finalizes the detailed implementable plan, would design the detailed program of implementation for the plan.

Throughout the successive cycles, the technical and economic aspects of the existing and planned CCFS would be simultaneously considered, thus guaranteeing to mesh the technical and economic considerations throughout the work program and making them a consolidated and integral part of the final detailed implementable plan. This constant interaction of technical and economic expertise is critical to the design of an appropriate CCFS and assures the development of a practical implementation program for the detailed CCFS.

A program designed so as to pass through successive cycles also assists in identifying and further specifying the relationships between the planned CCFS and the remainder of the economic, social, and political environment. In particular, such a procedure allows the team to converge upon the specific constraints exogenous to the CCFS that would affect its efficient, effective operation or implementation. They also enable the team to specify more clearly the impacts of the CCFS on other economic sectors, such as the heavy machinery subsector, and upon the social and political environment, such as the effect of opening interior regions to increased agricultural production for distant markets with such corollary effects as the diffusion of new ideas and values to such regions.

Finally, this methodology generates timely decisions and useful outputs much earlier in the study period than most other approaches. At the end of the first cycle, decisions about the overall system design and other factors must be made to develop the first approximation of the CCFS. These decisions tend to point up problem areas early and allow time for corrective research or other relevant activity. This effectively limits errors that could, if other approaches were used, be carried throughout the study period and discovered only near or at the end of the research effort.

Equally important, the cycle methodology forces early decisions that produce useable outputs relatively early in the study period. These early decisions, for example, may clearly indicate the scale of a certain facility so that subsequent detailed design and financial analysis, as well as specific planning by the client, can proceed for that facility with dispatch and even be completed well before the total research effort is finished.

C. Major Steps

With reference to Figure 7, the work program is designed in two phases. The first phase lasting approximately 48 weeks, is devoted to the design and analysis of the implementable CCFS. The subsequent phase, of approximately 12 weeks elapsed time, is devoted to the detailed planning of the entire program as designed in the previous phase. The ultimate planning effort will specifically consider external factors and constraints pertinent to the implementation of the program.

It should be stressed that the work program as presented here has been elaborated on the basis of one overriding concern, viz., to be pragmatic and realistic, and hence to generate ultimately a truly implementable plan within the framework of present-day Brazilian reality.

Cycle 1 is a detailed stocktaking and inventorization effort of all existing components of controlled low temperature food handling in Brazil, as well as an in-depth analysis of domestic and foreign supply to and demand upon the future CCFS. Apart from identification and evaluation of existing system components and the major system interfaces, cycle 1 will also evaluate and identify projects, programs and plans within the larger Brazilian economy that are directly relevant to the design of a CCFS. Finally, in cycle 1 we will gain an understanding of exogenous constraints upon the implementation or operation of the CCFS. Before entering the second cycle, the separate results of the major activities of cycle 1 will be synthesized and critically reviewed, so as to build a coherent and complete basis of factual information for the subsequent design activities.

Guided by preliminary design criteria established as a result of the critical review of the first cycle activities, a strategy will be developed for the initial design of the actual system. The system's design will then be carried out as a major program activity partially parallel with three other activities: (1) a demand and supply analysis of relevant agriculture commodities, specific to the proposed system; (2) the design of economic methodology to measure the costs and benefits to society of the proposed system as well as its expected regional impact; (3) a further analysis of constraints that might hamper implementation or operation of the system as initially proposed. Cycle 2 will then be concluded with a consolidation effort of its major design activities, coupled with a critical evaluation of the feasibility and desirability of the system as proposed. If the system passes this test, we will immediately enter the third cycle of design and methodology refinement and identification studies on the major components of the system. In the event the entire initially proposed system does not pass the crucial test of feasibility and desirability, we will make adjustments and improve upon the system. If the latter activity is necessary, it should be regarded as a partial redesign effort that can be performed effectively and efficiently at that stage of the program development, on the basis of the detailed knowledge and information gained while performing the major activities of cycle 2. Specifically, it is not a complete redesign of cycle 2, but it could introduce a further time involvement of several weeks that will either have to be recovered later in the program or may cause the work to be extended.

It should be noted that the result of cycle 2, once the critical test of feasibility and desirability has been passed, will indicate specifics of the final plan in a form allowing for initial action on the implementation of major components of the final CCFS.

In cycle 3, then, the actual system is refined and its major components are identified in substantial detail. Again, three parallel activities will be carried out on the system's demand and supply, on the final version of the economic costs and benefits methodology, and on the quantification of the system's external constraints.

Cycle 3 will be concluded with the final system evaluation of its feasibility for private as well as for government financing. The final program will be drawn up and a final benefit/cost analysis, as well as regional economic impact analysis will be made.

This phase of the work will yield a detailed report on the proposed system, identifying all of its components, and giving detailed justification for the whole system as well as for its main components.

The last phase of the work, the planning phase, uses three different types of inputs. First, the information as to the physical characteristics of the proposed system components in a way and a format so as to allow the use of pre-programmed computer planning models. Second, additional information is put into the planning effort, such as required method of financing of different stages of development of the CCFS. Finally, external constraints are entered, such as trained manpower availability, maximum available refrigerated truck sizes, consumer image of frozen foods, and similar information.

The product of this planning phase, then, is a detailed schedule for the realization of the CCFS as developed in the previous phase, put into the reality of the Brazilian social and economic environment.

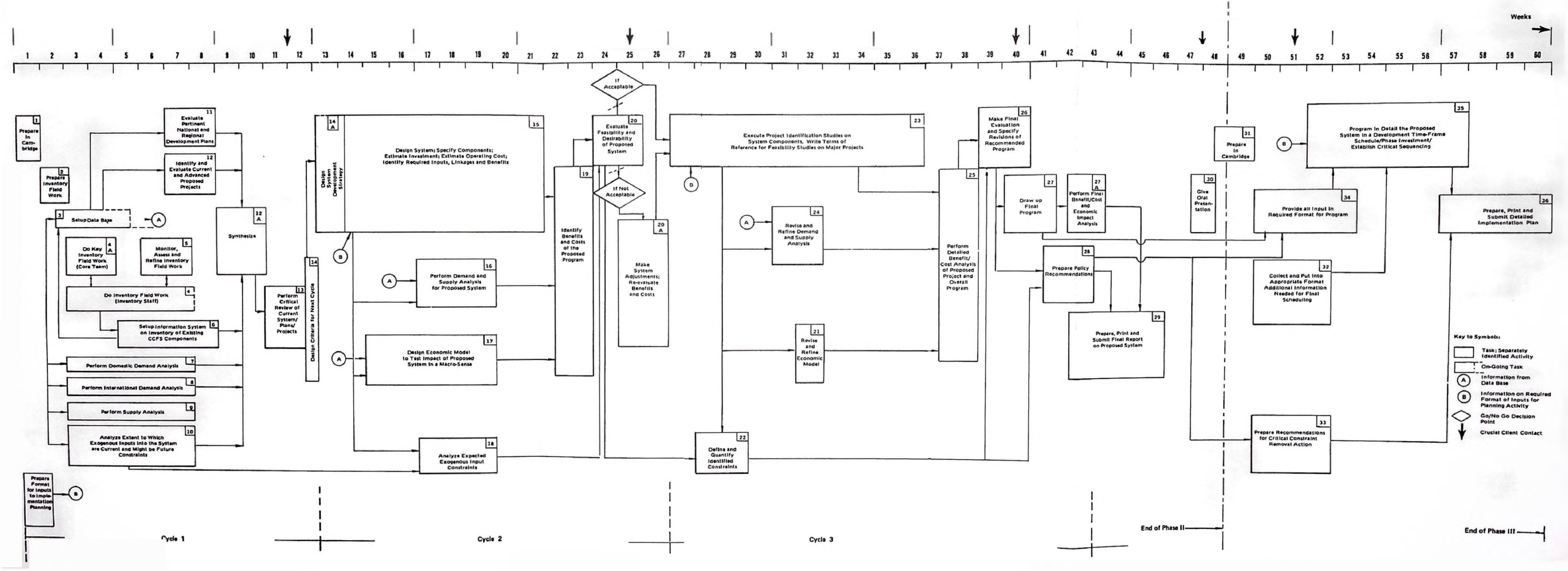

FIGURE 7 BRAZIL: WORK PROGRAM – IMPLEMENTABLE PLAN (Phases II and III)
COLD CHAIN FOOD SYSTEM