UNITED NATIONS

ECONOMIC
AND
SOCIAL COUNCIL

LIMITED

ST/ECLA/Conf.23/L.21
TE:ECLA/SID/66/III
January 1966

ORIGINAL: ENGLISH

LATIN AMERICAN SYMPOSIUM ON
INDUSTRIAL DEVELOPMENT

Organized jointly by the Economic
Commission for Latin America and
the United Nations Centre for
Industrial Development

Santiago, Chile, 14 to 25 March 1966

FOOD AND FOOD PRODUCTS INDUSTRIES

Submitted by the Food and Agriculture Organization
of the United Nations (FAO)

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
ORGANISATION DES NATIONS UNIES POUR L'ALIMENTATION ET L'AGRICULTURE
ORGANIZACION DE LAS NACIONES UNIDAS PARA LA AGRICULTURA Y LA ALIMENTACION

SYMPOSIUM ON INDUSTRIAL DEVELOPMENT
COLLOQUE SUR LE DEVELOPPEMENT INDUSTRIEL
SIMPOSIO SOBRE EL DESARROLLO INDUSTRIAL

ST/ECLA/CONF.23/L.21
TE: ECLA/SID/66/III
Paper No. III
31 Enero 1966

This Symposium on Industrial Development in Latin America

is organised by the

UNITED NATIONS ECONOMIC COMMISSION FOR LATIN AMERICA
(Comisión Económica para América Latina)

and will be held in

Santiago, Chile, from 14 - 25 March 1966

P A P E R No. III

FOOD AND FOOD PRODUCTS INDUSTRIES

The FAO Contribution to this Symposium includes in addition to the one mentioned above five other papers entitled:

I: ST/ECLA/CONF.23/L.19 "The Economic Significance and Contribution of Industries based on Renewable Natural Resources and the Policies and Institutions Required for their Development"

II: ST/ECLA/CONF.23/L.20 "Some Essential Requisites for Industrial Development of Renewable Natural Resources"

IV: ST/ECLA/CONF.23/L.22 "Industries Processing Agricultural Products other than Food"

V: ST/ECLA/CONF.23/L.23 "Fisheries Industries"

VI: TE/ECLA/SID/66/VI "FAO's Relations with Industry through the Freedom from Hunger Campaign"

In addition, FAO has collaborated with ECLA in the preparation of all the papers relating to the joint ECLA/FAO Interim Review Consultation on Pulp and Paper Development in Latin America, which is scheduled to form a part of the Symposium.

FOOD AND FOOD PRODUCTS INDUSTRIES

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FOOD AND FOOD PRODUCTS INDUSTRIES

1. General Considerations

During the last 20 years the food processing industry has expanded rapidly in the developed countries in response to increased demand, and similarly, in the developing countries, an increasing awareness of institutional needs, the introduction of new tastes, and above all the greater convenience in handling, storage and preparation, all backed by rising personal incomes, are resulting in an increased demand which may be expected to continue. At the same time, governments, aware of the needs for industrialization, appreciate the opportunity that this trend offers. Thus all factors point to a continuing expansion of this industry in these countries.

Economists have forecast a 154 percent increase in the food processing industries in developing countries between 1958 and 1975, a few selected figures being: Middle East - 319 percent, Africa - 224 percent, Asia - 209 percent, Latin America - 102 percent(*).

A good example of the food industries in the national economy of some developing countries is that of Chile, which produces some 2,330,000 metric tons of processed foods per annum, i.e. about 290 kg per capita. The growth rate of the food industry was 5.2 percent per annum during the period 1959-64.

Efforts are already being made by the developing countries to replace purchases of processed food from abroad, and hence reduce their expenditure on foreign exchange, by producing these goods locally. The major proportion of imported processed foods is in the form of canned foods.

This new trend in demand is also linked with the growth of urbanization, which usually means a change in attitudes towards food preparation, and a change in tasks. Urban women are less willing, and when employed unable, to spend the time involved in preparing unprocessed foods in the traditional manner.

The principal determining factor, however, is the rise in the standard of living, which is usually accompanied by a growing preference not only for better quality foods such as meat and milk, but for processed products.

(i) Benefits resulting from a well developed food industry

Parallel with import substitution goes the export drive. Certain of these industries, once established, find it possible to build up an export trade, particularly to their neighbours. It is essential, if the new industry is to succeed, for the cost and quality of the product to be competitive. This is indispensable so far as exports are concerned, though for internal sales some measure of protection is usually given.

The advantages of an expanding food processing industry, however, are not confined to an improvement in the balance of payments(**). They include

(*) These figures include food, beverages and tobacco manufacturing. The latter is a relatively small factor. Taking the USA as an example, tobacco represents only 7.67 percent of the total figure. Source: Peterson and Tressler, Food Technology the World Over. Avi Publishing Company Inc., Westport, Conn., USA, 1963.

(**) See Paper No. I: "The Economic Significance and Contribution of Industries based on Renewable Natural Resources and the Policies and Institutions Required for their Development".

employment in the industries themselves and in other related industries, and a general contribution to the economic growth of the country. In addition, there are reduced losses of food (once processed) during storage, transportation and distribution, and a better utilisation of by-products or waste products which otherwise tend to be lost. Another advantage lies in the contribution which processed products can make (since more easily stored and transported) to evening out seasonal fluctuations in prices of unprocessed or partly processed foods, reducing geographic maldistribution of food, and helping to lessen the food shortage in years of bad harvest. Lastly, they can contribute to an improvement in the health of the population by providing a wider range of nutrition throughout the year, especially if stress is laid on increasing protein supplies.

Naturally, the problem of building up a food processing industry is different in developing countries from that in developed areas. On the marketing side not only are personal cash incomes lower but concentrations of the population represent a smaller proportion of the total population. This tends to raise the marketing and promotion costs. There is no question but that in many countries the small, scattered internal demand has been the major handicap to introducing a good processing industry.

The major differences, however, consist of the far more formidable difficulties which have to be encountered by developing countries in setting up the industries. The lack of managerial and technical skills is a well-recognized impediment in the development of food industries in most developing nations, but it is possible if resolute government action is taken as was done in Kenya which has built up a sizeable export trade in canned foods. Training abroad in modern industries is useful, but the requirements and facilities are usually so different from those in the developing nations that more often than not such exposure does not quite accomplish the desired results. Therefore, in establishing food and food products industries, it is essential to provide local or regional training facilities. FAO is active in the creation of such regional food technology training centres, as, for instance, the International Training Centre in India, supported by the Canadian Freedom from Hunger Committee, the Tropical Centre of Food Research and Technology in Sao Paulo, Brazil, and the Institute of Food Science and Technology in Santiago, Chile, supported by the Special Fund, and several other centres in Africa, the Near East, and Latin America. Help is also provided by staff sent to the country in the case of foreign-owned plants, by the owners.

However, there are serious material complications as well. It is not sufficient, for example, merely to note and to set up a factory to process a seasonal glut of produce in a particular commodity. A successful operation is usually much more complex. The basis for a commercial processing plant is the regular availability of raw material. The security of supply at a reasonable price in relation to the end value of the product, and the quantity and quality of the deliveries for an extended period are the most important factors, but, under present conditions of agricultural production in the developing countries, these preconditions are often not fulfilled. Variation in yield due to poor quality seed, adverse weather conditions, diseases, etc., often restrict the availability of the produce even for the fresh market. The absence of regular supplies and failure to conform to standards can lead to high production costs. In order to assure a dependable supply of raw materials, the processor may contract with farmers or establish his own production units where he can grow the produce specifically designed for processing. Raw product requirements for the production of optimum quality processed products have been established during the last twenty-five years. For each product, and for each type of process, such as canning, freezing or dehydration, specific requirements have been formulated and must be met. Shape, size, texture, colour, flavour, odour, acidity, viscosity, maturity, specific gravity, soluble solids, total solids, vitamin content, etc., are all factors for which standards have been established. It requires careful planning in plant breeding and cultural practices to produce a raw fruit or vegetable suitable for canning, freezing, dehydration or concentration. Considering the great potential, only a small beginning has been made at experimental stations or universities to develop and evaluate varieties suitable for processing, in Latin America.

In this connection, for some commodities the improvement of storage facilities is vital, especially in tropical climates. Such an improvement is, of course, useful in other connections such as price stabilization, but it also facilitates the smooth flow both over time and in quality and amount of raw materials to the factory (see for further details on storage the next Chapter, Section xii).

A number of other infrastructural requisites is needed. These may be summarised as follows:

(a) An adequate transport system to bring raw products, raw materials, machinery, equipment, packaging material, etc., to the factories, and to carry the finished products to the markets;

(b) Fuel, power and water supplies in adequate quantities and at economically suitable cost;

(c) Adequate chains for marketing and retail outlets for the distribution of the products;

(d) A banking or credit system to provide working capital;

(e) Facilities for the building of industrial premises, storage facilities, laboratories, offices, housing, etc.;

(f) A reasonably efficient government providing adequate support for managerial, technical and sales personnel.

(ii) Marketing

Finally, we must again stress the marketing problems, and the fierce competition that characterizes this complex of industries. It is not enough to have a good product at a competitive price - it has still to be sold. Examples of costly failures abound where this has been forgotten. Almost invariably government assistance in the form of tariff protection is necessary, at least for an initial period which may extend to several years, and the possibility of at least a temporary increase in consumer prices has to be faced. Even with such government assistance, if the company concerned is not one that has already established a brand name then expension promotion is essential. These are not insurmountable problems, but their resolution is as important as solving the physical problems of production.

(iii) Research

Applied research in food processing and storage is expensive and often can only be carried out in developing countries by Governments with assistance from international organizations, through bi-lateral aid programs, or by Foundations. Several Governments have taken the initiative with UN Special Fund/FAO support to establish such applied research institutes or pilot plants in Brazil, Chile, Ecuador, Ghana, Jordan, Peru, Philippines, Poland, Senegal, Sudan, Syrian Arab Republic, Turkey, and in some other countries. These organizations will pave the way for the development of food industries in many countries, especially when carried out in pilot plant operations. These offer great opportunities for the planning of food industries, and the demonstration and operation of suitable modern equipment and machinery. They also provide opportunities to train local personnel, technicians, engineers, technologists, at the working as well as the managerial level.

Pilot plant operations can also be used to test out the markets and systems of marketing the product. They can also be used as a "test bed" for related industries such as packaging and transportation.

The establishment or expansion of a processing plant, or of research, costs money. Such investment can be public or private, or both. Private investment may be either by producers' organizations or by individual firms or investors. Public investment in this field is not ruled out since the improvement of nutritional levels in developing countries is recognized by many of them as a problem of the first importance.

Running costs have also to be met. In the case of a factory adequate working capital has to be available, though the annual costs will of course be met out of receipts from sales. The running costs of a research station are normally met by the government, with or without outside aid as the case may be, but in many instances the industry contributes towards the cost of research through a special research levy or other similar means.

In planning such investments, account has to be taken of the economic basis of the operation in terms of volume of production, capital, plant investment, market studies, supplies of manpower.

(iv) Labour intensity

Another vital consideration is the degree of labour intensity. Unskilled labour is relatively plentiful in many African countries, whereas capital is very scarce. It is therefore vital in many cases to choose a labour-intensive technique, even though much progress is unlikely with an out-of-date technique in the long run. Flexibility, as emphasized below, is important.

As shown in Table 1, a relatively small capital investment is sufficient to provide significant levels of employment for non-agricultural workers. It is difficult to define precisely the labor requirements for various sizes of canning installations because this figure is dependent on the nature of the foods to be processed and even more so upon the labor costs of the area. In a developing country, where wages are usually low, a very small plant with a capacity of fifty to a hundred kilograms per hour of processed food may cost only $56,000 for capital expense requirements while employing between 50 and 60 people. In regions where wages are high, equipment is available to reduce the manpower requirements so that fewer than 30 people may be able to operate such a plant.

In a somewhat larger installation such as Plant B in Table 1, one hundred people or more may be employed to process approximately 500 kilograms per hour of food in a plant which costs approximately $180,000. Alternatively, more equipment may be purchased and labor requirements may be reduced to as low as 42 people.

In a plant with a capacity of 5,000 kilograms of food processed per hour, minimum capital requirements will be about $600,000 with a relatively high manpower requirement of 300 people. Again, the use of more processing equipment can reduce these manpower requirements to as low as 60 to 70 men. As can be seen from the table, the larger the plant, the greater are the savings both on labor and on capital per unit of output.

Table 1

CHARACTERISTICS OF TYPICAL FOOD CANNING PLANTS
(values in US dollars)

	Plant A	Plant B	Plant C
Capacity, pounds/hr.	100 - 200	1,000	10,000
Capital Costs	56,000 - 90,000	180,000 - 290,000	600,000 - 850,000
Labor requirements, man-years	28 - 56	100 - 42	300 - 66
Capital per man employed	2,000 - 1,600	1,800 - 6,900	2,000 - 12,900
Capital per pounds/hr.	560 - 450	180 - 290	60 - 85
Labor per pounds/hr. man-years	.280	.100 - .042	.030 - .007

This great flexibility in the choice to be made between capital investment and labor requirements occurs primarily in the area of food crop handling and preparation. The functions of weighing, cleaning, trimming, grading, sorting, cutting, slicing, coring, etc., can be performed in an entirely satisfactory manner by hand labor. However, where the situation warrants their use, highly sophisticated equipment is available to carry out the functions with only a minimal amount of hand labor.

However, it must be appreciated that often the choice between a capital or labor intensive industry is more apparent than real. The factory, whether privately or government owned, will always seek to use the method that results in the lowest cost per unit of output, and where (as is normally the case) it has to meet competition, it may have little choice if it is to survive. Where, however, the economics of the firm show that more capital should be used, this may conflict with the balance of payments position of the country and the need to maximise employment.

2. Technological Aspects for the Planning of Food Products Industries

Food spoilage or deterioration are due to a variety of causes. Fresh plant and animal tissues are living organisms and therefore many of the metabolic processes continue after harvest or slaughter. The enzymes naturally present in such tissues can cause a variety of changes, mostly undesirable. In addition, microorganisms are present in or invade all such tissues, again causing changes which are, as a rule, detrimental. Therefore, the control of enzyme action and the prevention of proliferation and action of microorganisms is one of the major objects of food preservation.

This desired control of enzymes and microorganisms can be achieved by a number of means. Conditions can be created when enzymes and microorganisms can not function as at deep freeze temperatures. The enzymes can be inactivated by heat or chemicals. The microorganisms can be eliminated by thermal treatment or by the application of chemicals or antibiotics. Removing water from food products will also prevent both enzyme action and the growth or microorganisms. Ionizing radiation can also accomplish some of these desirable conditions. Thus the food processor has a wide choice of methods which, jointly with proper packaging, will produce preserved, attractive, wholesome, and economical foods. Some of these methods will be discussed below.

Planning food and food products industries must take into account the selection of or another technological process. Factors affecting the choice are the raw materi- o be processed, the facilities which are available, the quality and storage re- ements of the finished product and, naturally, the economical aspects.

(i) Dehydration

In dehydration the water content of a food is reduced to such an extent that enzymes are unable to act and microorganisms are unable to grow. In addition, deteriorative changes due to other factors are also usually retarded by a low moisture content. The amount of permissible residual water will vary from product to product according to specific requirements and the length of storage and temperature range to which the product will be exposed between processing and consumption. In general, the moisture content of dehydrated food products is in the range of 1-10%, but many products are now manufactured with moisture contents below 1%.

In addition to providing fruits and vegetable products out of season, dehydration has been extensively used in order to compensate for the variation in the seasonal production of some commodities, such as milk and eggs.

Quality, cost, and storage behaviour are the major factors determining the usefulness of dehydrated products and, therefore, the choice of the method of preservation used for a given product will depend mainly on these considerations. However, there are many other new methods in addition to those cited below as examples, which show promise of usefulness.

(a) Sun drying

Some fruits, like peaches, apricots, figs, dates and various raisin grapes, are still sun-dried on a very large scale. However, even with these products there is a definite tendency towards the use of more controllable artificial means. Sun-drying requires several days and is followed by "curing" in sweating bins where the moisture in the various pieces equalizes. The water content of most dried fruits is in the range of 5-20% with different requirements for various products.

(b) Artificial drying

The basis of successful drying is the transfer of water vapour into a stream of air or other gases that are not saturated with water vapour. Therefore, the volume, temperature, and the relative humidity of the drying gas and the surface of moist material exposed to heat will govern the drying efficiency. Every fruit particle has a definite attraction for moisture, which at a given temperature and pressure will be in equilibrium with the moisture content of the drying atmosphere. This attraction to moisture, as well as the size (surface) of the particles to be dried, vary greatly, and, therefore, most types of dehydrating equipment will be suitable for a limited number of products only.

With foods, the effect of the drying on flavour, colour, physical condition, and nutritional value are further factors that must be taken into consideration. There are several methods to dry artificially fruits and vegetables; among them the cabinet dryer, the kiln dryer or "evaporator", the tunnel dryer, the vacuum shelf dryer, the drum dryer, the rotary dryer and the spray dryer are noted here.

Often it is expedient to use combinations of various procedures for dehydration. There are some vegetables that can be most economically dehydrated with the maximum retention of desirable properties by first using a tunnel dryer to remove the bulk of the water followed by drying in cabinet dryers and lastly by removing some more moisture in bins through which air dried by silica gel is circulated.

(c) Freeze-drying

The food to be dried is first submitted to quick freezing, effected by the application of vacuum causing rapid evaporation of water and loss of heat. Drying operation is then carried out in a high vacuum, the process permitting rapid conversion of the water from the frozen into the vapour state without going through the liquid phase. Moisture is lost from the surface of the food leaving a porous product which greatly facilitates rehydration when the food is prepared for consumption.

Drying foods at low temperatures minimizes bacterial growth, enzyme activity and undesirable chemical changes, whilst damage to colour, flavour, and texture is low. Freeze-dried foods do not have to thaw but merely be rehydrated before cooking or serving. Freeze-drying is still an expensive procedure and therefore it is used mostly for specialty products or important ingredients of dehydrated soup mixes, etc. The volume of freeze-dried foods on the market is rapidly increasing.

(d) Foam-mat drying

This method involves making a still foam by whipping air or an inert gas into a concentrated foodstuff in the presence of an edible foam stabilizer. The stabilized foam is deposited as a uniform layer on to perforated trays; the trays pass over an air blast to perforate the foam and thus greatly increase the surface available for heat transfer and evaporation of water. This perforated mat of foamed food concentrate then passes through a dryer which decreases product moisture to 2 to 2.5%. Materials that have been foam-mat dried include water infusions of tea and coffee, fruit purees, and extracts of beef and chicken. Flavour and colour of these foam-mat products are superior to those dried by other methods. The process obviously is limited to liquids and concentrates as foaming is required. It is not suited to products sensitive to oxygen in the drying air. Volume and weight reduction of the dried food is approximately the same as with spray and drum dried foods.

(ii) Canning (thermal processing)

Fresh fruits almost invariably carry or will eventually acquire microorganisms that cause spoilage. The principle of preservation of foods in hermetically sealed containers rests on the destruction by heat of such organisms in a closed container, which prevents reinfection. Suitable containers may be made of metal, glass, plastics, or other materials.

It is clear that in addition to the destruction of microorganisms, the enzymes present in the food will also be entirely or mostly inactivated. While properly prepared canned food will keep indefinitely as far as putrefaction is concerned, deterioration of quality and nutritive value will occur during the prolonged storage of many products.

The term "processing" as used in the canning industry means the cooking of the product in a sealed container; it is designated in terms of temperature and time of the thermal treatment required. The processing of the canned products must destroy all organisms that are injurious to health and may cause spoilage. Complete bacteriological sterility, while sometimes attained, is not always essential in canned products, providing that conditions in the can are such that no growth of such residual organisms will occur.

(iii) Aseptic canning

This treatment of foods that have been sterilized by a high-temperature, short-time process is receiving a great deal of attention in several countries. The high-temperature, short-time sterilizing process in conjunction with aseptic canning minimizes the heat damage that accompanies traditional long-time processing of food. The new method retains more of the desirable properties of foods. In addition, large containers - even 210 liter drums - can be sterilized and filled aseptically. Milk, evaporated milk, processed cheese, fruit juices, and similar products processed by this method provide a more nutritious and natural tasting product than the same foods processed by conventional canning methods. Canning is still the most important and most extensively used method of food preservation and is likely to remain so for some years to come.

(iv) Fruit juices production

Although canned (heat-preserved) fruit juices were prepared from a variety of fruits in many countries for over a century, their large-scale production did not commence until the 1930's. The heat-preserved fruit juices constitute the highest proportion of the fruit juices produced. Large quantities of citrus juices are preserved by a combination of heat and freezing. Yet other juices are used in the canned form straight or in concentrates of all sorts, including a variety of products like tomato puree, sauces, paste, etc.

While the fruit juice industry originally utilized mostly surplus fruits and such as were unsuitable for the fresh market or processing, now most fruit juices are produced from fruits specifically cultivated for such purposes.

In producing fruit juices, the expressed juice flows through screening equipment to remove seeds and undesired suspended particles. This is usually followed by de-aeration and filling into cans, which are then quickly sterilized under hot water with rotation to insure rapid heat penetration. Cooling follows the processing. Tubular flash heaters are also used for some juices.

(v) Cold storage

When the storage temperature is lowered, most foods will keep longer. The multiplication and growth of most microorganisms is thereby retarded, and enzyme actions and other processes in living tissues as well as nonenzymic reactions leading to deterioration and spoilage progress more slowly. However, as a rule, cold storage does not stop such changes. As temperatures are again elevated, all types of reactions will again progress at increased rates. Although cold storage has been used for thousands of years, the intercontinental shipping of food, especially from New Zealand and Australia to England, provided a major impetus for the development of modern cold-storage technology.

Cold storages are extensively used with a wide variety of products and under a great variety of conditions. Fruits, vegetables, dairy products, eggs, meat, meat products, fish and many other foods are held in cold storages from periods ranging from a few days to a year or more.

Although icing is still extensively used, artificial refrigeration is being increasingly applied. The art of heat removal or refrigeration is a highly specialized branch of engineering. In addition to the initial cooling and heat losses, calculations of refrigeration loads and capacities must also take into account the heat generated by living tissues. For instance, 1 ton of sour cherries at 10.6° C (60° F) will evolve 11,000-13,200 B.T.U. of heat per ton per day. A number of other factors will also enter into the calculations of refrigeration requirements and thus into the design of refrigeration equipment. A considerable variety of different types of mechanical refrigeration and refrigerants are now in use. Capacities of refrigerating equipment are usually expressed in terms of "ton refrigeration". A ton refrigeration is equivalent to the removal of 288,000 B.T.U. per day or 200 B.T.U. per minute.

An interesting example of cooling of produce for transport is practised in the USA with lettuce. The loaded truck or railroad car is put into a huge chamber where sufficient vacuum is created to cause rapid evaporation of the water on the surface of lettuce leaves. The dissipation of heat by the heat of evaporation is sufficient to reduce the temperature of the lettuce throughout the load effectively to the level required for long-range shipment.

For best storage, most products require a specific, often narrow, temperature range, a given humidity, and perhaps also atmosphere control. The variations in all these requirements are great. Atmosphere control is important from the standpoint of odors as well as the presence of gases. Some products emanate gases, which influence the storage behaviour of the same product as well as that of other commodities. Artificially introduced gas atmosphere is often used for the storage of foods. At times such desired gases are produced by the food and then kept at specific concentrations.

Most fruits and vegetables keep best at 0° C (32° F), but the optimum storage temperatures for some products like lemons, grapefruits, cucumbers, tomatoes, and potatoes are somewhat higher. Often the optimum storage temperature (and other conditions) for a given crop (like bananas) will change with the maturity.

Milk and cream must be held under refrigeration at all times and are usually kept near 0° C (32°F). Even at this temperature these products will keep only for a few days unless they are pasteurized and cooled before being put into cold storage. In pasteurization, the number of microorganisms in the milk is greatly reduced and the pathogenic organisms are killed.

Fresh meats are highly perishable and therefore must be cooled immediately after slaughter and kept just above the freezing point until used. Some meats become more tender during aging. Cold and freezing storages of all sorts are extensively used with meats and meat products.

Fresh fish is even more perishable than meat, and the present tendency is to ice or refrigerate fish immediately upon catching. Salted and smoked fish will also keep better at lower temperatures and are often kept under refrigeration.

Eggs are usually kept at 0° C (32° F) where, under proper conditions of humidity and control of air movement, they will keep for many months.

A great variety of other foods and food products are kept in cool storage. Of these, wine, various chocolate products, yeast, and nut meats may be mentioned.

(vi) <u>Freezing and frozen storage</u>

Whereas cold storage will only retard the three major types of detrimental changes in foods, those of microbial, enzymic, and nonenzymic origin, freezing will often arrest these changes, and in some cases slow them down to such an extent as to allow storage of the product. However, in order to assure better storage behaviour of plant foods, it is often desirable to inactivate some of the enzymes present in the tissues. It is clear now that such thermal inactivation of the enzymes by "blanching" will usually destroy only certain enzymes while others will survive. The roles played by different enzymes in the deterioration of frozen foods is not clearly understood at the present time.

In many cases, the freezing of a food, such as meat, will cause no objectionable physical changes or will be even beneficial in certain respects. In other instances, the alterations resulting from freezing and thawing will be objectionable. Most such changes seem to be caused by the formation of ice crystals in the tissue and by the irreversible disturbance of colloidal tissue components. Quicker freezing will result in the formation of smaller ice crystals and thus in less disturbance of tissue organization. As far as flavour, odour and colour are concerned, the changes caused by freezing are usually less marked than when the same foods are canned. On the other hand, there are many products, which, by their very nature, must be prepared by a given method. Tomato juice, for instance, usually lacks the typical flavour associated with this product if it is prepared without heat treatment and then frozen, rather than processed by heat in the usual manner.

Siruping or mixing with sugar is used with many fruits in order to assure better quality in the frozen product. This is the case with apples, strawberries, raspberries, peaches, apricots, and cherries, which make up the bulk of frozen-fruit pack. In order to prevent oxidative discoloration of sliced peaches, addition of ascorbic acid to the sirup is now common practice. Most vegetables are blanched before freezing; sulfuring is used only with fruits and to a very limited extent.

The rate of freezing will depend on the efficiency with which heat is removed from the product to be frozen. The first phase of the freezing process consists of chilling the product to its freezing point. During the second phase, the actual freezing, the temperature of the commodity remains practically constant. The third phase is the lowering of the temperature of the frozen product to that required for its storage, which is usually considerably below the freezing point. The first phase is usually easily accomplished because of the relatively large temperature difference between the warm food and the refrigerating medium. The amount of heat (plus latent heat of fusion) that will have to be removed during the freezing process will vary from as low as 22 B.T.U./lb. for dried beef to 124 B.T.U./lb. for milk and 144 B.T.U./lb. for water. Fruits and vegetables are in the range of 100-134 and fresh meats in the range of 66-100 B.T.U./lb. Thus the rate of freezing of different products will vary considerably when the same equipment is used for various foods. Although for some time it was believed that quick freezing generally results in products of higher quality, it is now clear that this is seldom the case. However, under certain conditions, rapid methods of freezing have advantages over slow freezing. First, quality deterioration might occur in a product during the first phase of the freezing process during which the temperature of the product is reduced. Second, the output per unit investment is usually higher in equipment capable of quick freezing.

There are three main direct-contact freezing methods, with many variations: freezing in still air, blast freezing and immersion freezing. There are also several indirect-contact freezing methods, among which is quoted the multiple-plate freezer. There are additional freezing methods as for instance by floating the product in a blast of cold air. New techniques are continuously proposed to meet special product requirements and to attain greater production economy.

(vii) Dehydrofreezing

This is a process in which the product is partially dehydrated before or during freezing. This procedure has certain advantages over both dehydration and freezing. For instance, the rehydration and thawing processes can be combined by placing the dehydrofrozen product in boiling water. The storage space required for dehydrofrozen products is less than that needed for the directly frozen commodity. The practical possibilities of this new method seem to be limited as yet because of the higher cost of processing.

The methods used for the preparation of fruits and vegetables for freezing are essentially the same as those applied in canning. Blanching is required for most vegetables in order to ensure sufficiently long storage life.

(viii) Preservation by salting and fermentation

The proportion of salt present in a food product will determine to a great extent the type of microorganisms that will grow in it. In addition, the presence of salt will also influence the extent of the changes that the microorganisms will be capable of producing. Although salt has been used in food preservation for hundreds of years, its action is not clearly understood. Among the suggested explanations are that salt exerts a poisonous action on certain organisms, that it makes moisture unavailable to microorganisms, that it will prevent bacterial growth by plasmolysis of the cells, and that it destroys bacterial protoplasm. Whatever may be the mechanism of salt action, the fact remains that salt, especially in combination with acids, has a selective action on microorganisms. This effect is extensively used in the manufacture of pickles, sauerkraut, and many other products. Dairy products like butter and cheese and a great variety of fish and meat products are also salted.

There is little doubt that most fermented foods were discovered by accident and there seems to be even somewhat more uncertainty concerning the mechanisms involved in their production than in the case of the preservation methods discussed previously.

(ix) Preservation by chemicals

Sugar and salt have been utilized since old times as chemical food preservatives. In general, we qualify as chemical preservative any substance capable of inhibiting, delaying, or stopping the fermentation, acidification or other forms of deterioration of foods, and substances which are able to mask any sign of putrefaction in food. But the possibility of masking with the preservative the unsafe condition of the food has obliged the public health services in various countries to control in the most drastic way the utilization of chemical preservatives.

As examples of such preservatives, one may note the use of sodium nitrate, potassium nitrate, acetic acid, lactic acid, vinegar, glycerine, alcohol, benzoic acid, sorbic acid, sulphur dioxide. There are many other chemical preservatives used for a variety of products.

(x) Preservation by antibiotics

Even though the use of antibiotics could be theoretically effective for the control of the spoilage agents of foods, the health authorities in several countries have objected to its utilization due to the secondary effects which the antibiotics can produce on the eventual consumers of the foods. For instance, the use of Subtilin has been suggested in the canning food industry as a supplementary means to weaken the bacterial resistance to heat. It would be possible to get a sterilized food with a relatively short heat treatment. At the present time such processes are not allowed in commercial practice.

During recent years antibiotics have been utilized to delay deterioration of fish. For instance, 1 to 4 parts per million of aureomicin have been incorporated in the ice with which the fish is preserved. Also 2 parts per million have been incorporated in the sea water in which the fish is kept while still in the boat. The fish is also dipped for a minute in solutions which contain 50 parts per million of aureomicin before making use of ice preservation. These methods have shown very good preservative effects and are used now in commercial practice.

(xi) Preservation by irradiation

In order to be useful as a practical technique of food preservation, any new method must have some definite advantages. It will have to provide a cheaper procedure, or a better product, or be useful in instances where other ways of preservation can not be used. Whereas these requirements are clear, their assessment is not always easy and can be usually accomplished only by systematic development work followed by extensive testing under practical conditions. This certainly is the case with the use of ionizing radiations for food preservation.

The principles of preserving foods by exposing them to ionizing radiations are now fairly well understood. As expected, there is a great variation in the response of raw food materials to radiation. Even within a certain type of food, as fish, for instance, the effects of irradiation, beneficial or objectionable, vary greatly. This is not surprising since a strictly analogous situation existed in the development of canning, freezing, dehydration, etc. and led first to the selection of foods for which a certain technique was applicable and later to the testing and production of new varieties of plants and strains and breeds of animals and fish. Generally speaking, very little of this selection has been done with preservation by irradiation, the work thus far having been mostly restricted to the kinds of foods where irradiation shows practical promise of usefulness.

The radiation preservation of foods, as we understand it today, is based mostly on three modes of action. First are the physiological influences on plant foods as, for instance, the prevention of sprouting of potatoes and onions. Second, are the benefits of the irradiation in inhibiting the growth of microorganisms or destroying them altogether. Unfortunately, there is great variation in the susceptibility of microorganisms to radiation. Enzymes, viruses and toxins seem to be comparatively resistant to radiations and their destruction or inactivation often requires radiation dosages of such magnitude that undesirable side-effects on flavour, colour, etc. make the practical use of irradiation difficult or impossible. The third group of major useful influences is the killing or sterilization of insects, leading to the great promise of food desinfestation by ionizing radiations. There are many other isolated instances when preservation of foods or their desirable modification can be accomplished by radiation.

There are two major types of sources of ionizing radiations which are today considered as useful for food preservation. These are the electron accelerators of various kinds and the radioactive isotopes; the latter being usually derived as by-products of reactor operations. Both types have advantages and disadvantages. Electron accelerators are expensive and intricate machines and are able to deliver radiation of low penetrating power. Therefore, in their use the food or food container must not be more than a few centimeters thick and even so, irradiation may have to be done from two sides. As a result, it is difficult to attain a uniform dosage delivered throughout the package or product. On the other hand, the machine can be turned on and off, and does not need extensive shielding during transport or when not in use. Further, there are instances when shallow penetration is an advantage as for instance in the irradiation of some fruit for the destruction of mold spores or spoilage organisms occurring on the outer surface.

In the use of radioactive isotopes, - usually Co^{60}, - extensive shielding is necessary and the power of the source is continuously decreasing due to the comparatively short half-life of this isotope. On the other hand, the gamma rays produced have substantial penetrating power, making the irradiation of large packages, whole hams, etc. possible.

There are some foods where sufficient background information is on hand to allow practical testing. Important promising products are: potatoes, dehydrated fruits, fresh fruits, marine products, meat and meat products.

Two important points must be strongly emphasized. First, food preserved by radiation dosages now used or thought of for this purpose will not make the food radioactive. All foods possess some natural radioactivity of exceedingly low levels which, however, are now often higher than before on account of atmospheric atomic explosions. The second important point is that thus far there is no indication that irradiated foods are in any way "cancerogenic" or that they contain new harmful constituents. The "wholesomeness" of irradiated foods have been more thoroughly investigated during the past 20 years than that of any other type of food. The use of some irradiated food products has now been permitted in a few countries but it is likely to take a few more years before this new method of food preservation is used on a large scale in commercial practice. There are several possible applications as for instance the desinfection of cereals, dried fish and dried fruit which provide methods of great potential use to the developing countries.

(xii) <u>Storage</u>

It is only during the last twenty or twenty-five years that serious attempts have been made in the developed areas of the world to handle and store crops and processed produce in ways which minimize deterioration. There is, therefore, a tremendous challenge to ensure that also in the less developed areas of the world storage facilities are improved. It is often not sufficiently realized how great the damage can be in the form of high losses, including decrease of quality and other important drawbacks such as loss of nutritive value, all caused by faulty storage. The little information available on the quantitative aspects of food losses was already mentioned previously.

In dealing with storage problems in developing countries, it should not be forgotten that most of the knowledge on modern storage techniques and facilities derives from countries in temperate zones and has, therefore, only limited application under the climatic conditions prevailing in tropical countries, especially in the monsoon areas.

For the right application of modern storage techniques, it is necessary to understand the main causes of losses and quality deterioration during storage. They can be divided into two main groups:

A. moisture and temperature;

B. insects and rodents.

While the damage done by insects and rodents is more or less obvious, the influence of too high moisture and temperature on deterioration during storage is an indirect one leading to:

(a) biological changes like respiration and germination of seeds;

(b) chemical changes by oxidation and hydrolysis;

(c) microbiological spoilage by moulds and bacteria.

High humidity during storage and too high moisture content in the stored produce can also lead to a combination of microbiological and chemical processes resulting in spontaneous heating and at times combustion. In addition, excessive moisture and temperature of the stored produce create favourable conditions for insect activity.

Two methods of storage are used: in sacks or loose in bulk in a variety of containers. Advantages and disadvantages of sack and bulk storage may be summarized as follows: Storage in sacks provides flexibility of storage, is partially mechanizable, allows only slow handling with much spillage; demands low capital cost, but high running costs; rodent loss potentially important. On the other hand, bulk storage is inflexible, mechanizable, allows rapid handling but little spillage; requires high capital cost but low running costs; no rodent losses need to occur.

From the main causes of losses and deterioration follow automatically the main essential features of storage buildings: they must be water tight, they must not allow the entry of rats and mice, and they must assist rather than hamper the control of insect pests.

The building design should also specifically control the entry of moisture, as

(a) moisture introduced during construction;

(b) moisture entering the store from outside by rain penetrating the walls and through the roof, or by water or water vapour rising from the ground through floor and walls, and

(c) moisture condensed from water vapour in the air at night. The design of a storage building should also take into consideration the temperature conditions which will be obtained under the prevailing climatic conditions.

The scope of this paper does not permit to go into constructional details, but a few important points might be mentioned shortly, viz., importance of selecting a good site and having good foundations; careful selection of damp-proof materials for damp-proof courses and vapour barriers; floors of well-cured concrete, the surface treated with a hardener. There is a wide variety of materials suitable for walls and roofs which will give satisfactory results if carefully selected and properly applied.

Storage of produce in bulk is carried out in a range of types of containers and buildings, but commonly takes the form of storage in baskets or bins, especially constructed for the purpose. Above ground bins are usually constructed on a plinth and consist of wicker work and mud, metal (aluminium being popular), local brick or concrete. The efficiency of these bins depends upon the effectiveness with which insect infestation can be controlled, the degree of water damage which occurs, and the ease with which they can be erected efficiently under local conditions. The principles of construction are more or less the same as already mentioned for sack storage buildings. If of suitable construction, a bin is automatically rodent- and weather-proof and insect pests are readily controlled. It is now generally agreed that by concentrated efforts of improving storage conditions for foods, the world supply of food could be significantly increased within a matter of years.

3. Selected Food and Food Products Industries

(i) General

In the previous chapters, some of the economic factors and technological aspects relating to the food processing industry have been briefly described. What now is the actual purpose of food processing? Disregarding the final preparation of food for eating, i.e. stewing, grilling, baking, etc., the purpose of food processing can be broadly divided into the following three categories:

(a) Conversion of raw materials into more edible or semi-processed produce

The most important process in this category is the milling of food grains. Although the grain itself can be used as human food, its nutritional properties can be utilized much better if the grain is converted into flour and the outer shell removed. Processing of this kind also includes the extraction of sugar from sugar cane or sugar beet, extraction of oil from oilseeds and the pounding of cassava and other tubers. In all these cases, wastage is reduced and, at the same time, by-products for other utilisation as food or feed can be obtained.

(b) Food processing as a means of preservation

Since most perishable products are harvested during a very short period during the year but are confronted with a more or less continuous demand throughout the year, the food processing industry has the task of preserving these products. Numerous ways of doing this are available, from primitive methods such as salting and smoking, to the most advanced types such as food radiation preservation and accelerated deep freezing. The method to be used will depend largely on economic factors, the basic principle being that the cost of processing should be more than balanced by the reduction in losses. Preservation is of particular importance for fruits, vegetables and milk. Closely related to preservation, although not by itself a processing method, is proper storage of food products.

(c) Food processing as a means of meeting consumer demand

This category is directly related to the standard of living of the consumer population. The higher the standard, the higher the demand for further processing. For example, the butchery trade aids in utilizing the carcass in the best way to meet consumer demand by separating the various cuts and qualities of meat which, incidentally, also leads to highest returns from the market. Preparation of food mixes also falls into this category.

Obviously, it is very difficult to give any clear-cut distinction of food processing for the various types of food since the third category often overlaps with the first and the second. However, an attempt has been made to group the various commodities under the above headings.

(ii) Wheat and bread

The major economic trends in the field of commercial flour milling in recent years have been the tendency towards surplus milling capacity in developed countries, and the spread of modern mills in developing countries in the last decade or so, especially in tropical countries which produce no wheat, or only very little. As the mills in those areas have been frequently established with the active encouragement and support of governments, protective measures were introduced to safeguard their operations. As a result several countries, hitherto flour importers, have switched permanently their purchases from flour to wheat grain, with adverse effects on the level of world trade in wheat flour.

The main reason behind the spread of commercial flour mills in developing countries in recent years has been the desire: (a) to stimulate the economic growth by diversifying and modernizing the local industry, and providing new employment opportunities; (b) to meet the rapidly rising consumption requirements for wheat products out of domestic production, thus saving the foreign exchange expenditure on flour imports in the first place, and on wheat imports in the longer-run; and(c) to meet the problems of storage and transport of imported flour under tropical conditions.

These objectives, however, must be carefully weighed against the following general considerations: (a) Modern automatic flour mills are highly capital intensive, with modest requirements particularly for unskilled labour (e.g. the ratio of capital investment per man employed in the United States milling industry is around $110,000 or more, which is one of the highest ratios in any industry); (b) There may be problems for developing markets for by-products of milling which account for 25 to 30 percent of the volume of wheat milled; (c) Because of the low general productivity levels in most developing countries, almost any new industrial undertaking requires special measures of government protection which tend to perpetuate themselves, and flour mills have been no exception in this respect. This has led to the closing down of the mills, through their inability to compete with low cost imports; (d) Flour mills require a continuity in the supply of wheat - hence the necessity for adequate storage facilities; and (e) The scarcity of capital in developing countries, which generally handicaps industrial development, has been an impediment also to the flour milling in some countries.

The existing commercial flour milling capacity is utilized at below one half of their annual capacity (e.g. Brazil, Colombia, Mexico, Honduras). Substantial excess capacity exists also in developed countries (both among exporters and importers) because of the stagnant consumption of wheat as food and the shrinking export outlets for wheat flour, but in contrast to this position the underutilization of capacity in developing countries reflects primarily the supply bottlenecks (i.e. shortage of wheat and the scarcity of working capital).

Moreover, the information relating to commercial mills does not give the full picture of the overall milling capacity in existence in developing countries. In wheat producing countries there has always been a traditional milling industry, and although some of the primitive mills (usually cottage sized units using stone grinders and located in villages) are being progressively modernized, small primitive mills still represent a substantial share of the total milling capacity in many countries.

The large majority of commercial mills in developing countries are privately owned and controlled, and they are often financed fully or partly from abroad. In non-wheat producing countries, newly established mills are generally concentrated near the main population centres (i.e. near towns), while in wheat producing countries their location is more widely diffused, with a fair proportion of the total capacity placed in or near the main wheat growing areas.

An important corollary of the expansion of the flour milling industry in developing countries has been the creation (or extension) of wheat food and food products processing industries (e.g. bakeries, paste plants and other specialty manufacturing enterprises) in a large number of countries, associated with a declining use of flour in individual households, the setting up of livestock feed plants in some countries and the creation of a profitable export trade in by-products of milling, such as the steady increasing shipments of bran from the Philippines to Japan, Senegal's exports to the U.K., Denmark and Guinea, and Nigeria's exports to the U.K.

Two most significant technological developments in wheat utilization during recent years include:

(a) turbo milling or air-classification of flour;

(b) mechanical dough development.

Turbo milling or air-classification of flour is in principle the separation of flour into fractions of different protein content by means of a vortex classifier using centrifugal force in an air medium. During normal milling of flour, the endosperm cells are broken apart. Upon further milling of the endosperm pieces some of the starch and protein are separated into discrete pieces; the protein chunks are irregular in shape and small in size (mostly below 20 microns), while the starch pieces are round and usually larger. The flow-dynamics properties (size, shape and specific gravity) of the different particles permit separating into size ranges where protein matter is enhanced or depleted in the material. Since turbo milling is new, the limits of its possibilities are not known but at present flours rich in protein (above 20 percent) and flours low in protein (below 6 percent) are beginning to appear on the market. On a laboratory scale flours of more than 35 percent protein have been produced. At present research is under way to determine the effect of other particular materials than protein, such as enzymatic activity (primarily diastase) and colour, which appear in higher concentration in the below 20 micron particle size fraction after air-classification, on bread making. In view of existing knowledge of enrichment of flour with selected amino acids and vitamins, flours prepared by turbo milling may be enriched with amino acids and vitamins to produce high protein food suitable for infant and child feeding. These possibilities, however, require further investigation.

Mechanical dough development might be defined as the expenditure of sufficient mechanical energy within a mass of dough to bring about, within a few minutes, such structural changes as would otherwise occur only after several hours fermentation. Mechanical dough development can be achieved by one- and two-stage continuous mixers, batch mixers and continuous sponge plus development units.

It is recognized that some of the above mentioned new developments in cereal technology have their widest application in the technologically advanced countries. To assist member nations, FAO is now preparing to embark on a comprehensive bread improvement program. At present surveys of the individual countries are being made to assess the magnitude of the needs regarding bread improvement. Based on the results of these surveys it is expected that plans will be defined and implemented regarding:

(a) the establishment of regional grain, flour, and bread laboratories to provide the required chemical analysis and technological evaluation;

(b) the establishment of model commercial bakeries to introduce improved, but locally applicable methods of bread making; and

(c) the establishment of training courses, on a regional basis to train bakers, technicians, mill operators, analysts and foremen.

(iii) <u>Rice</u>

There are two conflicting issues underlying the decisions as to expanding rice processing in developing countries. First, most of the traditional rice producing countries appear to have a theoretical excess of milling capacity in physical terms; second, much of this capacity consists of crude or out-dated machinery on a small scale which may or may not require replacement, depending on the economic circumstances of particular countries and localities. In India, for example, the Government policy is to protect the handpounding industry which gives more nutritious undermilled rice and provides 10 times more employment for the same quantity processed. At the same time, the larger commercial mills play a crucial role in the marketing and distribution of rice, and the Government has decided to try to dominate the industry by establishing a large number of publicly owned modern mills during the Fourth Plan. Here, the main motive is to give the Government a firmer grip on the entire marketing system. In many countries, for example Korea, the processing facilities are very small and require modernization but the Government prohibits new construction because the present capacity is considered excessive. Similarly, Madagascar is closing down several of its obsolete rice mills, even though production is rising. At the same time, Ceylon wishes to erect more modern typesof mills but lacks the capital resources, whilst Burma is establishing quite a number of modern mills.

In short, there is no simple relationship between a given increase in production and the extra milling capacity which will be required. This has to be assessed very carefully, country by country, and will depend on the structure of the market, and the capital resources of the country.

As regards international trade, virtually all rice exports are in the form of milled rice or husked rice. This contrasts with the pre-war position when there was a substantial proportion of paddy exported from the Far East to Europe. Today European processing of imported rice is limited to the final polishing stage of husked rice. Husked rice receives preferential tariff advantages so as to protect the European milling industry in Germany and the United Kingdom, but only about 5% of world trade is in this form and this is not an important policy issue. In any event, a large part of such exports originate from the United States of America.

Processing at commercial level through medium or large scale mills is only justified when there is enough concentration of paddy production to keep a large installation running throughout the year. The setting-up of such mills usually involves high capital investment but it does not really involve great technical problems, since modern processing equipment and the relative techniques developed in the industrialized countries can easily be transferred with minor adaptations into any area.

As rice is the only food grain consumed in the whole state, modern milling facilities are of great advantage, especially if such mills have paddy drying and storage facilities, so that the moisture level of the paddy can be adjusted when necessary, thus reducing the amount of broken grains. Furthermore, such mills will separate the bran from husk and brokens so that this valuable by-product can be further utilized.

By considering this commodity in greater detail, losses appear to be severe at various levels. They start when the crop is still standing in the field, and continue until the product has reached the table of the consumer. Some countries are reporting 30% losses of the total production, other countries are reporting even higher figures, up to 50%, but in general the figures are unreliable and very rough since no attempt has ever been made to assess in a scientific way the amount of rice which is actually wasted, including a heavy loss in quality from a nutritional point of view.

A good part of the grain may go to waste during milling, and this may be determined by two different factors. The bad quality and poor adjustment of the milling machinery, and the previous infestations or deterioration which made the grain unfit for milling. A proper moisture content prior to milling also has considerable influence on the quality and quantity of the end products.

The reduction of rice wastage during the pre-processing stage does not require any appreciable capital investment. As pointed out on several occasions by the International Rice Commission, it requires applied research activities on a pilot basis to be conducted under the leadership of experienced experts. The purpose is to determine simple measures such as the opportune harvesting time, good harvesting techniques, proper threshing and improved methods of drying, which can be both natural or artificial. Once the improved techniques have been developed the program must be extended through training and demonstration in order to divulgate the improved methods among the farmers.

The storage, also requires some applied research work, since the current knowledge of modern techniques is derived from industrial countries, which are mainly in the temperate regions of the world. This knowledge has only limited application under the tropical conditions, particularly in the monsoon areas, and it is therefore necessary to conduct experimental research activities within such areas to ascertain local requirements.

Central storage involves less research work since there are various examples of modern, large and efficient storage facilities installed under tropical conditions which provide enough data for similar initiatives. On the other hand central storage requires organizational effort because a large installation must be operated by skilled personnel, and it also requires appreciable capital investment.

(iv) Sugar

All mainland countries of Latin America and most of the insular countries and territories of the Caribbean produce sugar. Except with respect to Chile and most of the output of Uruguay, all centrifugal and non-centrifugal sugar produced is from sugar cane. In 1964/65 the total output of centrifugal sugar amounted to 18.85 million tons raw value, a record volume and 28 percent of the world total. Output has increased by over 40 percent over the past ten years but the Latin American share in total world production of centrifugal sugar has tended to decline. In addition Latin America produces about 1.25 million tons of non-centrifugal sugars - panela, piloncillo, papelon and chancaca - roughly equivalent in sucrose content to about 750,000 tons, raw value, of centrifugal sugar. The main producers of these sugars are Colombia, Brazil and Mexico.

The main producers of centrifugal sugar are as follows:

	Production in 1964/65
	Million metric tons, v.v.
Cuba	6.05
Brazil	3.83
Mexico	2.08
Argentina	1.00
Puerto Rico	.81
Peru	.78
Dominican Rep.	.64
Colombia	.51
Others	3.14 1/
Total	18.85 1/

1/ Including 0.15 million tons of beet sugar.

The region as a whole and most individual countries are net sugar exporters. Only Chile and Uruguay import significant quantities to supplement domestic beet sugar production, although most countries import small quantities of refined sugar. In 1964, for instance, total imports into the region amounted to 220,000 tons raw value, including 184,000 tons for Chile and Uruguay. Total exports in 1964, including shipments from Puerto Rico and the Virgin Islands to the United States' mainland, amounted to about 8.6 million tons, Cuba accounting for nearly half of the total in spite of its small 1963/64 crop.

	Exports 1964
	Million metric tons r.v.
Cuba	4.18
Dominican Rep.	.67
Mexico	.52
Jamaica	.42
Peru	.42
Brazil	.25
British Guiana	.24
Trinidad and Tobago	.23
Other exports	.86
Total	7.79
Shipments from Puerto Rico (1963)	0.79

The bulk of the export trade is in raw sugar. Argentina, Nicaragua, and Venezuela export mainly refined sugar, but Cuba is the only country exporting substantial quantities. In 1964 total exports of refined sugar from the region amounted to 0.55 million tons, 7 percent of total sugar shipments; Cuba accounted for 0.35 million tons of this total. The main import demand for refined sugar comes from developing countries which are not producers of sugar, whereas most developed countries prefer to import raws and apply various measures to this end, such as quantitative restrictions and differential tariffs.

All regular exporting countries and territories of the region benefit, however, from preferential treatment for a large proportion of their sugar exports, receiving prices for shipments to particular markets usually much higher than the world market price. As the result of the large increase in world production in the 1964/65 season, prices on the free world market averaged only 2 cents per lb in 1965 and although they are now beginning to rise they remain substantially below the costs of efficient production. Under the Commonwealth Sugar Agreement, British Honduras, British Guiana and Commonwealth countries and territories in the West Indies have negotiated price quotas totalling 0.76 million metric tons for their exports to the United Kingdom; currently the negotiated price is nearly 6 cents per lb., fobs. Martinique and Guadeloupe receive the equivalent of French ex-factory prices for their exports to France. Under the recently amended United States Sugar Act, Puerto Rico and the Virgin Islands have quotas for shipment to the U.S. mainland totalling 1.05 million metric tons, while foreign countries and territories (including the above mentioned Commonwealth and French areas) have quotas totalling 1.73 million metric tons in 1966, for which they will receive the equivalent of U.S. domestic prices of well over 6 cents per lb. Under the U.S.S.R./Cuba trade agreement, the arrangements for 1965 provided for shipments of 2.1 million tons at an agreed price of 6 cents per lb.

Domestic consumption continues to account for about 40 percent of production in the region as a whole. Per caput consumption has gradually improved and at an average of 34 kg. per year is much higher than in other developing regions, but is still some 10 to 15 kg. below the levels of most of the high income developed countries.

The essential difference between the simple method of making non-centrifugal sugar and the modern methods of processing centrifugal sugar is that in the latter case the juice is concentrated under vacuum, therefore at a much lower temperature, and that crystals and molasses are separated in centrifugals. For the rest, the various stages are performed much more carefully and on a much larger scale.

A modern sugar factory with its expensive equipment is only economic for higher capacities of many hundreds and even thousands of tons of cane per day. This requires a good organization of cane transport to the factory, by car or by rail, and good roads. In some developing countries, such a regular cane transport is difficult because of lack of good roads or rail facilities. Sometimes, the chosen solution is then sugar manufacture in two stages. Juice extraction from cane takes place in various local mills, and only the juice is transported to the central boiling station. Sometimes the juice is concentrated in open pans to syrup or to non-centrifugal sugar; in the latter case, the crude sugar is dissolved again in the central plant and recrystallized. Such a central plant is then called a refinery, but it usually differs in methods and also in the quality of the final product from the proper refineries that refine centrifugal raw sugar.

While such a system might be a temporary solution for transport problems over greater distances, it is less efficient from a technical point of view than a modern central sugar factory.

From a technical point of view, the sugar industry is rather an "old" industry, as the basic principles of "modern" sugar manufacture, as extraction by a mill-train, clarification methods, use of filter presses, multiple effect evaporation, sugar boiling in vacuum, etc., were invented long ago and are partly more than a hundred years ago.

Machinery is, of course, steadily improving and being made more efficient, with a general trend to make all processes continuous. Juice extraction from cane has in the mill-streets always been a continuous process, but extraction from beets in diffusion batteries was originally done batchwise and has only in recent years been developed into a continuous process. Continuous processes have also been introduced for the clarification of the juice, for its subsidation and filtering. Juice evaporation in multiple effects has always been continuous, also sugar drying. Centrifugals are usually still working batchwise, but the trend here is also to continuously working separators. Continuous and automatic sugar boiling from syrup to massecuite, the dream of many a sugar technologist, is in spite of many attempts still an unsolved problem.

In the chemical field, the modern plastic ion-exchangers have introduced a new principle which by the removal of "molasses forming" Na and K cations makes it possible to drastically reduce losses in molasses. Other trends are the introduction of automatic control instruments, with the ultimate aim of complete automation.

(v) <u>Fruits and vegetables</u>

In determining whether to establish processing plants for fruit and vegetables (or for any other commodity) governments must have some knowledge of the market outlook both domestic and foreign. Generally speaking, consumption of processed fruit and vegetables is at present mainly confined to high income countries. In many of the countries of the African and Near-East regions, even fresh fruit and vegetable production is geared to the export market and there is ample room for expansion of domestic consumption of the fresh product before cultivating a taste for the more expensive processed items. It would seem therefore, as experience in North and West Africa would appear to indicate, that processing establishments in developing countries would have to aim primarily at the export market.

Data on trade in processed products are extremely limited but available statistics indicate that demand for processed fruit and vegetables in the high income countries of Western Europe in particular, has been expanding rapidly and at a considerably higher rate than trade in fresh fruit and vegetables. For example, imports of orange juice expressed in terms of fresh fruit equivalent have more than doubled (from about 350,000 tons to 700,000 tons) during the past four to five years and it is estimated that the demand for citrus juices will be sharply accelerated. Similarly, trade in canned peaches, canned pineapples and processed tomatoes has shown a steadily increasing trend and no doubt there is a potential outlet although probably more limited, for the other tropical fruits such as canned mangoes, lychees, papaws, passion fruit, tropical fruit salads, etc. Blending of tropical fruit juices with more common types of juice may however show further outlets especially for sophisticated markets. This subject however requires further investigation.

The first prerequisite for any processing establishment is of course an adequate supply of the fresh product.

The question of varieties needs some elaboration, as varieties suitable for the fresh market are often not suitable for processing purposes, particularly for juicing. For manufacture of citrus juice, for example, suitability depends generally on juice content of the fruit combined with the sugar content. In the case of oranges, bitterness can be a problem and for this reason, as well as for their low juice content, navel oranges are generally unsuitable for processing. Another undesirable quality is the formation of precipitate in the juice which is largely a characteristic of juice from blood oranges. Oranges of the common "blonde" or the "shamouti" varieties are also unsuitable because of low sugar content, lower juice yield and flat flavor. On the other hand, the "Valencia" variety generally possess the ideal requirements for processing. Similar considerations apply to other fruits and vegetables.

Labour supply, fuel and power facilities, etc. are also limiting factors. For obvious reasons (shortage of capital and skilled labour for example), processing techniques must be simple. For instance, developing countries may not be in a position to manufacture frozen concentrates but could produce hot pack fruit juices. However, even for a hot pack plant, establishment costs are fairly high (the machinery would have to be imported) and for this reason the importance of operating at full capacity needs again to be stressed. Cans and other components would also most probably have to be imported.

The establishment of efficient marketing channels is another obvious prerequisite. Although global prospects for processed fruits and vegetables are favourable, the market is nevertheless highly competitive and it is important to know where the market is and how to obtain a share of it. In this connection, developing countries might encourage firms with experience in the production and marketing of processed fruit and vegetables to invest capital and help supply the necessary technical and commercial knowledge.

The final determinant of profitability depends of course on the price obtained balanced against costs of production and marketing. It should be possible to estimate prices or a range of prices likely to be obtained on any given market and work back from there to production point. Proximity to markets is obviously not as important for processed products as there is no question of deterioration en route. Nevertheless, transport costs are still significant. This sector of industry is a good example of the close relation that has to be created between agriculture and industry as otherwise a profitable operation will not be the result (See in this respect also Paper No. I: "The Economic Significance and Contribution of Industries based on Renewable Natural Resources and the Policies and Institutions Required for this Development".)

(vi) Nuts

The most important edible nuts of the trade (not considering here coconuts and cocoa beans) are, in alphabetical order: Sweet Almonds; Brazilnuts (Paranuts, Butternuts, Castaneas); Cashew nuts; Sweet chestnuts, Maroons; Filberts and hazelnuts; Hickory nut, Pecan nut; Kolanuts, Colanut and other spp.; Macadamia nut, Queensland nut; Pistachio nut (Pistache, Green Almond) and Walnut.

Edible nuts are marketed either "unshelled" or "shelled" ("kernels"), and are graded according to country of origin, to size (large, midgets, medium, chipped, etc.) and to damage (wholes, halves, splits, pieces, broken, etc.).

For unshelled nuts, processing consists of cleaning and grading. For the production of kernels, the nuts have to be shelled which is usually not an easy processing operation, as damaging of kernels has to be avoided. Quite a number of very specialized machines are on the market. For example, for almonds, the green hulls are removed with almond huskers while the hard shell is cracked with special almond hullers. Almonds are further blanched by removing the skins in a blanching machine after scalding. Similar machines exist for peanuts, brazil nuts and other nuts. Further processing depends on the use of the nuts and can consist of slicing or stripping, splitting, nibbing, grinding, etc., also of roasting, dipping, coating and similar confectionery treatments. For all such treatments, suitable modern equipment is available.

Some nuts pose special processing problems, as e.g. the removal of the husks of the macadamia nuts for which special equipment has been developed. Extremely difficult is the cracking of some palm nuts, such as babassu nuts and cohune nuts which are too hard for direct eating (just like palm kernels) and are used for oil extraction. They have, however, no significance for Africa.

(vii) Cassava food products

There are a number of products that can be produced from cassava tubers, food as well as food products, and others for technical applications. These products have the advantage that they are durable and can be stored, while cassava tubers in unprocessed form have to be consumed within a day. A durable product from cassava is garri, usually processed by housewives in their kitchen. The large producers of durable cassava products (more commonly called tapioca products), for local consumption as well as for export, are in Asia, viz. Indonesia and Thailand.

The more common cassava products are:

(a) Products utilizing portions of, or the whole root:
Food products (usually for local consumption)
- Cooked roots; cooked and fermented roots (Indonesia);
- Farinha, a garri-like granular, slightly fermented and slightly roasted product (South America);
- Garri, a fermented and gelatinized product (Nigeria, Ghana);
- Couac or cassava bread, similar to farinha, but more intensively roasted (South America);
- Landang or cassava rice, also similar to garri, but coarser, consisting of pellets (Philippines).

(b) Products utilizing only the starch from the roots:
Food products (for export and local consumption)
- Tapioca Flour, pure cassava starch;
- Baked Products like Seeds ("Sago"), Pearl, Flake, etc.;
- Starch Syrup or Glucose, made from Tapioca Flour;
- Mixed Food Products, such as "Tapioca Macaroni".

For the local market durable food products are most important. Processes have been worked out for a mechanical garri manufacture, especially in Nigeria. Next to garri, the manufacture of tapioca flour in small-scale and medium factories should be considered the flour to be used for products such as "sago", tapioca macaroni, tapioca biscuits, as an admixture to baker's flour and for various other food products.

For export, tapioca chips, tapioca meal and tapioca flour may be considered, but competition with countries like Thailand is only possible if such export products can be manufactured sufficiently cheap. To this end, in the first instance the production methods in the field have to be improved, better varieties should be introduced and other cultivation measures be taken in order to increase the yield of starch per acre.

Once a sufficiently cheap raw material is available, tapioca flour for export and according to American standards should be produced in modern factories, while chips and meal can be produced with simple equipment and small investment.

(viii) Oilseeds

Practically all commercially important oilseeds are grown in Latin America, such as cottonseed, groundnuts, linseed, sunflowerseed, sesame, soybean, palm kernels, coconut and even rapeseed, the latter only in relatively small amounts in Chile and Mexico. However the share of Latin America in the world production of oilseeds is still rather a modest one. Of a world production of some 86 million tons of above mentioned oilseeds, Latin America produces about 7 million tons, therefore only 8 percent. As to trade the significance of Latin America for the supply of the rest of the world is also rather moderate: only about 9 percent of world total indigenous exports of vegetable oils and oilseeds (in terms of oil) originate in Latin America.

The various oilseeds are of widely differing significance for Latin America. The major oilseed produced is cottonseed, output of which accounts for over 40 percent of the toal volume of oilseeds produced in the region and for 15 percent of world total output of that commodity. It is followed in order of importance by groundnuts, linseed and sunflowerseed. Though still of minor significance, output of soybeans has been expanding rapidly in recent years, and is likely to assume an increasing importance in the future.

Production of oilseeds varies of course greatly within the region. The major producers are Argentina (mainly of linseed, sunflowerseed and groundnuts), Brazil (groundnuts, cottonseed, castorseed) and Mexico (chiefly copra, cottonseed and sesame). Together, these three countries account for over 80 percent of the total output of the area in terms of oil.

The proportion of the output of the region which is exported as seed or as oil varies also widely. The major part of the output of cottonseed, sunflowerseed, copra and palm kernels, for example is consumed within the producing countries whereas a relatively high proportion of the output of groundnut, soybeans, and particularly linseed is exported, often in the form of oil. The region is also a sizable importer of some oilseeds and oils, mainly soybean oil and copra.

Fat consumption per caput per annum in Latin America is low (10 Kg) when compared with consumption in North America (31 Kg) and Western Europe (28 Kg); it consists for 55 percent of vegetable oils, the remainder being mostly slaughter fats (lard and tallow).

Apart from the small share of oilseeds consumed as such, all oilseeds must be processed. This is a technically fairly simple process of extraction of the oil by pressure or by use of solvents and its subsequent refining if meant for human consumption. More advanced forms of processing include the improving of the oilcake for human consumption. This is not yet commercially important. Oils (and fats such as tallow) also become the main ingredients of soap and of margarine.

Since both oilseeds and their processed forms of oil and cake or meal can be stored or shipped quite satisfactorily and because their weight and bulk is approximately the same in both processed or unprocessed forms, there is technical freedom of choice as to the location of processing. (The fruit of oil palm and olives are exceptions).

When oilseeds are to provide food or feedingstuffs for local consumption they must normally be processed within the producing area. There is, however, a large export of oilseeds from developing countries chiefly to Western Europe and Japan. Some developing countries already process substantial quantities of oilseeds but the bulk of exports from developing countries in this commodity group are exported as raw materials.

Problems encountered in processing more of these raw materials within the exporting country include:

(a) Competition from industries in importing countries protected by tariffs on processed imports, e.g. EEC tariffs for oil imports from third countries are to be from 3-15 percent while oilseeds enter duty free;

(b) Unstable world market price which processors in importing countries can offset more easily (by blending or switching between different kinds of seeds) than is possible in developing, exporting countries;

(c) The processing machinery is fairly expensive, must be mostly imported and the processing tends to be capital rather than labour intensive;

(d) Need for a high level of technical and organisational skill in management;

(e) Substantial capital is required.

Advantages of processing in producing countries include:

(a) Export income is increased by the value added in processing;

(b) It provides more flexibility in choice of markets, e.g. the oil and the cake may go to different markets;

(c) In addition to the processing itself adding to the industrial base and employment of the country, it allows the establishment of associated industries, particularly soap and margarine, based in large part on local raw materials;

(d) The availability of oilcake is useful in the development of a livestock industry.

Concerning the advisability of developing countries processing more of their oilseeds for export - there is at present absolutely no consensus. Data are lacking on the comparative costs of processing in producing as against importing countries. The typical rates of return on the investments are not known. It is not clear whether a viable processing industry whose products are exported is generally possible in a developing country without direct or indirect Government support.

Because no comparative study is available, FAO has undertaken an investigation. The FAO Study Group on Oilseeds, Oils and Fats has asked that it be given a high priority. The International Association of Seed Crushers is expected to contribute information. The scope of the study comprises the economic aspects of the location of oilseed processing and it will include both general analysis and case studies. It will be presented to the session of the Group by approximately May 1966.

(ix) Meat

A. Current availability

Meat consumption levels. Among the developing regions, Latin America has the highest average per caput consumption of meat, estimated at about 35 kilograms (all meats including offals). Beef accounts for around 70 percent of total meat consumption. It appears that the share of pigmeat has increased in the postwar period and that consumption of poultry meat has been increasing also.

In Argentina and Uruguay, where natural conditions for cattle raising are very favourable, around 100 kilograms of meat are consumed per caput and per year, which is far above the consumption levels in other countries of the region, as demonstrated by the following data:

Paraguay	44	kilograms
Chile	35	"
Colombia	32	"
Brazil	27	"
Mexico	24	"
Peru	18	"
Ecuador	14	"
Honduras	13	"
Haiti	6	"

Considering the region as a whole, present average per caput consumption is estimated to be nearly ten percent less than at the beginning of the fifties because production has not kept pace with the fast growth of population. Over the above period, per caput consumption has declined in Argentina, Brazil and Uruguay, and very likely also in Chile and Colombia. The imbalance between demand and supply has been reflected in frequent meat shortages in many markets of the region. Mexico and Venezuela are among the few countries where consumption has improved.

Trends in production. Latin America is rich in livestock and the ratio between human population and livestock numbers - in terms of livestock units, excluding poultry - is 1.05 compared with 0.54 in North America and 0.33 in Europe. Only in Oceania the ratio is higher, namely 2.53. However, production is conducted prevailingly in an extensive way and its growth has been relatively slow. In the first years of the sixties, the region's total production of meat is estimated to have been about 20 percent larger then during 1948-52, whereas at the same time population has increased by more than 30 percent.

Production has grown in almost all countries in the region, with Mexico and Venezuela recording the highest rates of increase; in both countries total meat production in recent years was about 70-75 percent above 1948-52.

International trade. In view of the large exportable supplies in the River Plate countries, Latin America is one of the main suppliers of meat to world markets, largely to Europe and the United States. The Caribbean area, on the other hand, imports relatively large quantities of meat from the United States, Europe and also Oceania. The main importers in this area are Cuba, Jamaica, the Netherlands Antilles, and Trinidad and Tobago. During 1961-63, Latin America's net exports were about 570,000 tons of fresh, chilled and frozen meat, 70,000 tons of canned and prepared meat, and 500,000 head of cattle.

Compared with trade with other regions, intra-regional trade is small.

Programs of international assistance. International assistance has been concentrated mainly on helping in the development of domestic resources and intensification of livestock production. Technical assistance has been provided in most of the countries, to raise the standards of animal husbandry and feeding, mainly by improving the pastures, to eradicate animal diseases, and to introduce efficient marketing methods. In certain areas, credits were granted by the International Bank for Reconstruction and Development to facilitate the execution of government programs for improved livestock production, as in the case of Paraguay in 1960. (Bilateral assistance, particularly on the part of the United States, also has been of considerable importance)

B. Possibilities for expanding availabilities

Possibilities for expanding production. In view of the wealth in livestock, there are good possibilities in most countries of the region to expand production at higher rates then in the past.

The solution must be sought in intensifying livestock production. In Latin America as a whole, output of beef per head of the existing cattle herd is 28 kilograms per year, compared with 63 kilograms in Europe and 72 kilograms in North America. These figures indicate that there is ample room for improvement, but future growth will depend on many factors among which higher consumer incomes, efficient marketing systems, including good transport facilities, and far-sighted government policies are of great importance. Well organized extension services, moderate taxation and cheap credits are some of the ways in which governments can speed up the process of intensification and modernization of their livestock industries.

Possibilities of increasing international trade. The River Plate countries are significant exporters of meat (mainly beef), but the bulk of these exports are directed to the high-income countries of the Northern Hemisphere. Also exports from Mexico, Costa Rica and Honduras to the United States have been increasing.

On the other hand, intra-regional trade is small because most of the countries where consumption levels are low, are economically not in a position to step up imports which would improve meat consumption levels. As the latter group of countries will endeavour to meet the growing requirements by larger domestic production, it is unlikely that there will be any major expansion in intra-regional trade.

Possibilities for expanding international assistance. International assistance can have a very significant part in the development of Latin America's livestock production. Action should concentrate on helping the various countries to make the best possible use of their own resources which in the case of livestock are considerable. FAO will continue to have a major role in the assistance activities which cover a very broad field, from pasture management and animal husbandry to economics of livestock production, marketing problems and the establishment of solid livestock statistics. Assistance in the form of expert advice should be supplemented with financial help for the major development projects, with the Bank for Reconstruction and Development as a major source for providing such assistance.

(x) Eggs

A. Current situation

In Latin America as a whole, average per caput consumption is estimated to be around 85 eggs per year. In contrast to meat, production of eggs has expanded at higher rates than population, raising per caput consumption by more than 20 percent above 1948-52. However, consumption has remained far below the levels prevailing in the developed regions, which are more than 300 eggs in North America and nearly 200 eggs in Western Europe.

Countrywise, consumption is highest in Argentina and Uruguay (120-130 eggs per caput). Estimates for Mexico indicate around 90 eggs per caput and per year, and arount 70 eggs for Brazil and Venezuela. With around 15-20 eggs per caput, consumption is lowest in Peru and Paraguay. (It has to be noted that for meat countries in the region statistics on poultry numbers and egg production are either incomplete or not existing, and that therefore the above data are largely estimates.)

The only major exporter of eggs in the region is Argentina, with European countries as the main buyers, but in recent years this trade was severely reduced. Venezuela and some countries in the Caribbean are importers, with the United States and Canada the main suppliers, but also these imports have been shrinking, largely because domestic production has increased. Intra-regional trade is insignificant.

B. Posibilities for expanding availabilities

Larger supplies should come principally from expanded domestic production, and international assistance should aim at helping the countries to modernize their production and distribution methods.

Poultry production can be expanded much quicker than production of other livestock, particularly with the help of large-scale production methods developed first in the United States and introduced afterwards in many countries around the world. It appears that in a number of Latin American countries, successful starts toward specialized poultry and egg production have been made.

In emergency or famine situations, dried eggs are one of the most suitable means to improve the intake of animal proteins. Developed countries where the potential for egg production is great, may in such cases contribute to food aid programs, provided that this was considered desirable from the point of view of national and international policies.

(xi) Dairy Products

A. General problems

The economic growth of developing countries requires the development of dairy industries in order to supply safe milk as a protein-rich food primarily for the populations of fast-growing cities and new industrial settlements. The governments of such countries are faced with various problems in their decisions for making a sound economic basis for efficient milk schemes. At the present stage of economic growth in developing countries the following issues have to be solved:

(a) The dairy industry should receive a higher importance in the allocation systems of economic planning policy of developing countries than occurs at present. The dairy industry has often been treated as being of low significance in that it works for the domestic consumer market without earning additional foreign exchange from the world market as do many other industrial and agricultural products.

(b) The expected market conditions will provide indications of the type of plant and its product pattern. Roughly there are three types of plant: the urban milk plant; the plant in a rural area supplying surplus milk to an urban center; and the plant located in an area - a so-called "milk pocket" - having big surpluses. The question is to choose the right machinery for the throughput.

(c) The location of the plant is another very important factor, particularly in connection with transport costs. On the one hand, it must be within easy reach of the producer, due to the perishable nature of milk; while on the other hand, the urban plant should be placed fairly close to the consumer. Thus, the distance from the plant to its market also depends on the type of plant.

(d) The labour force must be adequately qualified. The most modern techniques can only be applied if the labour force is trained in the handling of dairy plants.

(e) The quality of the raw milk is important. The technological problems of processing must be studied on the background of the composition and stability of the raw milk, bearing in mind that the industry should promote those milk products which have heaviest local demand, i.e. yoghourt, ghee, and various types of cheese.

(f) The foreign trade policy. The development of the domestic dairy industry should be promoted, but without undue protection, i.e. imports of cheaper dairy products should not be prevented.

There is no doubt that the most advanced industrial milk processing techniques can be adapted to developing countries. However, it is important, from an economic point of view, to select the technique and plant best suited to local conditions, rather than to adopt the most advanced industrial technique which may not in many cases be economically justifiable.

Because of the shortage of domestic capital and technical inexperience, the assistance of foreign capital and the training of experts should be sought through international agencies and bilateral agreements with either governments and private foreign dairy firms.

B. Current Availability

The consumption of milk and milk products in Latin America is rather low in comparison with the advanced dairying regions, as the following data show 1/:

	Annual per caput consumption of milk products in terms of milk equivalent - cow and buffalo milk - 1955-59 average
Latin America (excl. Argentina)	82
(Argentina)	183
Western Europe	337
Eastern Europe (excl. U.S.S.R.)	261
(U.S.S.R.)	266
North America	321
Oceania	487

Milk consumption in Latin America is, however, higher than in the Far East (41 kg. per caput excluding Japan) and in Africa (45 kg. per caput excluding South Africa).

There were enormous differences among countries in the level of milk consumption depending on production and levels of national income. Table 1 (Appendix) shows milk consumption per caput in a number of countries in 1959-61. This table shows that the countries with the highest milk consumption were Uruguay (248.3 kg. per caput per annum), Argentina (183.1 kg.), Chile (140.1 kg.) and Colombia (110.3 kg.) in South America; Nicaragua (194.0 kg.), Costa Rica (144.4 kg.) and Cuba (116.2 kg.) in Central America. Milk consumption in those countries was at a similar level as in some developed dairy countries in Europe, but consumption was extremely low in Bolivia (30 kg.), Guatemala (38.2 kg.), Jamaica (43.5 kg.) and even in Brazil (69.6 kg.).

1/ Means of Adjustment of Dairy Supply and Demand, FAO Commodity Bulletin Series No. 37, Rome 1963, p. 81.

Indications of trends in milk consumption may be seen in Table 1 which shows the percentage changes in milk production between 1950-52 and 1960-62. Domestic production is the main sources of supply. The increasing trend in production and consumption was most pronounced in Puerto Rico, Cuba, Mexico and Panama in Central America and in Ecuador, Surinam, Uruguay and Brazil in South America. But in a number of countries, milk production showed a downward trend, as in Costa Rica, Nicaragua, El Salvador, Jamaica, Guatemala and Honduras in Central America, and in Argentina, Bolivia, Chile and Paraguay in South America. This was also reflected in milk consumption, as imports did not increase enough to offset the fall in production. The exception was Venezuela, where imports of milk powder and condensed milk were nearly three times larger than the domestic supply of fresh liquid milk. The domestic milk powder industry has developed in Venezuela, which has the highest income level in Latin America (around US$ 800 per caput per annum). It is followed by Puerto Rico (US$ 626) and Chile (US$ 500). The remaining countries have income levels of between US$ 200 and 300 per caput. and some have even less than US$ 160, i.e. Bolivia and Surinam.

Production trends. Between 1950-52 and 1960-61, milk production in Latin America increased by 53 percent, but milk suppliers per caput increased by only 16 percent (see Table 1). The upward trend in milk production was more marked in Central America than in South America.

There are a number of reasons for the inadequacy of production 1/. One of the main factors is the low yields per cow due to inadequate fodder supply and poor breeds. Some countries - such as El Salvador, Jamaica, Surinam, British Guiana and Peru - have animals with milk yields of between 500 and 900 kg. per annum. Milk production, however, has not increased adequately both in countries with relatively high-yielding animals, such as Argentina and Chile (average about 2,500 kg.) and Guatemala (1,000 kg.) owing to unsuitable pricing and marketing systems, lack of transportation between low-cost remote producing areas and consuming centers, and various other reasons.

Trends in international trade. Production has not been able to meet the demand for milk products in rapidly growing cities, particularly in countries where the production trends were almost at a standstill. These countries have consequently imported large quantities of condensed and evaporated milk and milk powder.

Latin America shared about 13 percent of the world imports of condensed and evaporated milk and 23 percent of milk powder (whole and skim) in 1962 63 as the following Table shows:

Imports of preserved milk products in Latin America *

	1958-59	1962-63
	thousand metric tons	
Condensed and evaporated milk	69.0	56.0
Milk powder (whole and skim)	122.0	140.0
	percentage	
Share of world total:		
Imports of:		
Condensed and evaporated milk	17	13
Milk powder (whole and skim)	27	23

* Source: FAO Trade Yearbook.

1/ See "General Review of Economic Aspects of Dairy Development in Latin America" by Mirko Lamer, FAO Regional Meeting on Dairy Problems in Latin America, Sao Paolo, Brazil, 11-20 April 1961 (CCP Working Paper No. 61/1).

Total imports of condensed and evaporated milk showed a downward tendency because some of these countries, particularly in Central America, developed their own industry, but an upward trend is noticeable in South America (see Table 2). Imports of milk powder are continuously rising - they were 22,000 tons in 1948-52 and reached over 150,000 tons in 1963. This happened in spite of import restrictions and the growth of domestic dry milk industries in some countries. But the domestic milk supply cannot meet domestic demand. Imports of butter and cheese are small, but they also increased in the postwar period. Exports of milk products consist mainly of butter and casein shipments from Argentina.

Policies for dairy products impose high ad valorem duties, specific tariffs, quota controls, import licences, unfavourable foreign exchange rates, small allotments of foreign exchange for imports, etc. These measures are not only a consequence of unfavourable balance of payments, but also have the aim of protecting the established domestic dairy industries. In several countries, imports of certain milk products were almost excluded. However, they were not able to check the upward trend of imports of milk products in general due to insufficient domestic supply.

In Latin America, the population increased 31 percent and milk production 53 percent between 1952 and 1962, while during approximately the same period (1948-52 to 1963) imports of whole and skim milk powder increased by 560 percent, butter 140 percent and cheese 122 percent. Imports of condensed and evaporated milk rose by 89 percent in South America while in Central America they increased only slightly, by 2 percent. Exports of butter increased much less (30 percent) than imports, while exports of cheese even declined (17 percent) (see Table 2).

Program of international assistance. Suppliers of milk products on concessional terms have been contributed by the United States Government. The following Table shows concessional and commercial shipments of skim milk powder from the United States to Latin America (excluding Argentina):

Year	Government programs	Commercial shipments	TOTAL	% of Government shipments to total shipments
	(....... thousand tons		.............)	(..... percentage .....)
1960	18.4	9.8	28.2	65
1961	55.0	11.7	66.7	82
1962	78.4	14.9	93.3	84
1963	121.8	16.7	142.0	86
1964	104.5	20.2	124.7	84

Source: Foreign Agricultural Circular, FAS:USDA, Nos. FD 7-63 (September 1963), FD 6-64 (July 1964) and FD 6-65 (June 1965).

Years 1960 and 1961: Commercial shipments included products moved into export under weekly sales programs LD 33 and LD 35 and under PIE Program.

Years 1962 onwards: Commercial shipments, in addition to dollar sales, include exports under Title I (sales for foreign currencies), barter agreements; Title IV (long-term credit); government-to-government sales mainly for school lunch programs; and products sold for exports under special sales programs.

Government shipments of skim powder increased very much between 1960 and 1963, while commercial sales remained practically unchanged. There was a decline in Government shipments in 1964 and 1965 due to lower support purchases following an improvement in commercial demand.

In some Latin American countries, United States surplus products were not allowed to enter (Uruguay) or only in small quantities (Argentina, Venezuela) as it was feared that surplus products would compete with the domestic industry on commercial markets. But Brazil, like some other countries, has been a large recipient of United States surplus skim milk powder and has been able to establish 15 milk plants in the last decade due to the enormous demand for this product 1/.

International assistance is also given, through both multilateral and bilateral programs, for the development of domestic dairy industries. A prominent role in dairy development is played by foreign firms, particularly Nestlé. UNICEF assisted in the establishment of milk plants with allocations totalling US$ 3.5 million spread over 12 countries. Through UNICEF's assistance 11 dry milk plants and 2 pasteurized milk plants have been established in Latin America. Since 1962, an FAO Dairy Training Center is functioning in Chile with the assistance of UNICEF and experts from Denmark. The Government of the Netherlands has also assisted in the development of a milk scheme in Surinam.

C. Possibilities for Expanding Current Availabilities

Possibilities for increasing international trade. There are good prospects for exports of milk products to Latin America since domestic production is not increasing at the same rate as the demand for these products. This will be much more evident if the economic growth and urbanization of Latin American countries continues. Latin American governments may thus be led to re-examine their present trade policies, especially if domestic production does not increase at a faster rate.

Possibilities for new or expanded international assistance. Except for that provided by the United States, very little assistance in dairy supplies is provided under bilateral arrangements and multilateral arrangements have not developed to the same extent as in the Far East. UNICEF has provided some assistance but this has been limited to the dry milk field, and its allocations to Latin America have been small in comparison with those to other regions 2/. There is wide scope for the development of the dairy industry and for increased milk consumption, particularly by low-income groups.

4. Protein-rich Food Processing

Because of the vast needs for additional low-priced sources of protein, much attention has been focused in recent years on the development and production of inexpensive protein concentrates from products, which up to now have been inadequately exploited, but which could be used as human food if carefully processed. Such protein concentrates have recently been developed in a number of countries from indigenous products such as oilseed meals, presscakes and also fish flour.

1/ Characteristics and Problems of Foreign Trade of Dairy Products in Latin America, CCP Working Paper No. 61/2, Rome, 1961.

2/ UNICEF allocations amounted to US$ 22.8 million between 1951 and 1964, of which Latin America received US$ 3.5 million - or 15.4 percent of the total.

Most oilseeds are rich in protein of good quality. Some of them, such as soybeans, contribute significant amounts of protein to the diets eaten in some countries. Protein-rich foods made from soybeans by traditional fermentation and other treatments have been used for many centuries in China, Japan, and other countries of the Far East, and commercial production of such traditional domestic products is now being carried out with some success in Japan.

In Indonesia a spray-dried extract of soybean and sesame is now commercially produced and widely used. In Brazil a new protein-rich product based on heat-processed full-fat soybeans is being introduced in the market with the support of the government. Cottonseed flour, processed either from presscake or from solvent-extracted meal, has been used in food mixtures in Central and South America for some years.

Many of the main oilseeds are grown chiefly in the tropical and subtropical areas where protein deficiency is most serious. However, although part of the production of such crops as coconuts, groundnuts, soybeans, and sesame seed is consumed in the producing countries, the bulk of these potential protein supplies for human and animal use is exported in the form of whole oilseeds or oilcakes. In those few countries where a significant amount of these crops is processed locally to meet the growing domestic demand for fats and oils, the protein-rich presscake is generally used as fertilizer, animal feed, or fuel, or even wasted altogether, while it could be processed for human nutrition.

A number of difficulties have had to be overcome in the development of such products. It is essential that they should appeal to the consumer, that they should be nutritionally satisfactory supplements to existing dietary patterns, and also that they can be introduced into existing marketing channels in such a way as to reach consumers who are not otherwise getting enough protein. In the case of oilseed presscakes another difficulty is that commercial feed-grade oilcake is not usually suitable as a raw material from which to produce human food. Special processing equipment is often necessary and also careful selection of the raw material. Consequently, edible protein concentrates from oilseeds tend to cost several times as much as commercial feed-grade oilcake though they remain a relatively cheap source of protein.

Groundnut flour, processed from defatted groundnuts, is also being introduced in human feeding, though a recent setback has been the discovery that, as a result of infection by the mold Aspergillus flavus, groundnut crops and products frequently contain toxic substances known as aflatoxins. How to eliminate or minimize infection during harvesting, transport, and storage is now being investigated. Such products should not be used as human food until they have satisfactorily passed certain biological tests which have been devised.

Much research has also been carried out in the development of processes for the production of low-cost fish protein concentrates suitable for human feeding. Commercial-scale plants for the production of edible fish protein concentrates have been installed in Chile, Morocco, Sweden, and the United States, though most are not yet in full operation. Fish sausages are a good and cheap source of protein and are in commercial production in Japan and other countries in the Far East.

The protein concentrates that have been brought into use in recent years have been developed in line with a set of principles for the establishment of their safety and nutritional suitability for human feeding drawn up under the joint FAO/WHO/UNICEF program on protein-rich food which guided the early research. It was recommended that the production process should not be kept secret, and that it should be not only commercially feasible but also suitable for use in developing countries. Prior to testing on human subjects the products should be fed to more than one species of animal to establish their safety and nutritional value. They must have a high protein content and the quality of the protein must be such as to provide a useful supplement to protein-deficient diets. Finally, the nutritional value of the product must be confirmed by actual feeding to human subjects.

To guide producers of such protein concentrates and ensure the safety and nutritional suitability of these new foods, "Processing and Quality Control Guidelines" have been proposed for each type of product by the FAO/WHO/UNICEF Protein Advisory Group. These guidelines cover such questions as the quality of the raw material, processing conditions, chemical composition, protein quality and its assessment, sanitary conditions (microbiological status and insect and rodent contamination), physical form, and packaging. They have been accepted by both government and private concerns involved in the production, development, and promotion of protein concentrates.

Protein concentrates from such sources may be treated so that they are flavorless and odorless for inclusion in staple foods in order to augment the protein consumption of needy populations. In countries where major staple foods are processed on a large scale before they are marketed, government legislation could go a long way to increase protein consumption and prevent protein malnutrition by insisting on the inclusion of a suitable amount of such tasteless products. Alternatively, protein concentrates may be so processed that they retain their distinctive flavor and sometimes odor, and as such they are often attractive to the consumer who uses them as a form of "relish" to be added to his food.

5. Processed Food Marketing

The trend of food marketing in the last twenty years is moving toward consolidation, with fewer and larger individual concerns, and toward greater integration of the different stages of marketing, and broadly speaking, toward a more direct flow of food products from the farm to the consumer.

This marketing evolution has given a tremendous stimulus to the improvement of processing and packaging of food products. Hundreds of new products have shown up in the market, the convenience processed foods appeared, and new types of package designs, labelling and materials are now ensuring the protection of processed and fresh foods.

The most important change in retailing of food products has been the rise of the supermarket as the modern method of selling foods to the consumer. Pre-packaging, self-service and one-stop shopping have been displacing gradually in the developed countries other sorts of food retailing.

A supermarket is a large, departmentalized one-stop food center with relatively complete lines of dry groceries, fresh produce, fresh meats, dairy products, frozen foods and canned foods. It carries a large variety of brands and foods in each line. The groceries, at least, are dispensed by self-service but all other departments tend in the same direction.

The swing toward self-service could not have occurred without corresponding developments in the industries that deal with the pre-packaging and processing of foods. Moreover, the processed food industries have been obliged to modify and adapt their products to the requirements of the self-service principle ruling the supermarkets. In other words, there is a substantial link between the food industries and the chain of supermarkets.

Consequently, the development trends of food industries in Africa must ultimately be matched by the establishment of modern and efficient chains of markets, containing the essential elements that created the "supermarket system" for the purpose of a suitable marketing of processed food products.

6. Utilization of Wastage and By-products

There are very few agricultural products which can be completely consumed without leaving some wastage or by-products behind. A characteristic sign of highly developed food processing industries is the optimum utilization of these residues. In less developed countries, however, by-products and waste of agricultural products processing are often not yet sufficiently utilized.

For the industry, the major reason for such action is an economic one; practically all waste materials and by-products have some market value. The major problem for the industry is to find the break-even point between cost of assembly, further processing, storage, and marketing of these products and their returns. This complex is generally of decisive influence upon the economies of scale of a food processing unit. For example, economies of scale in rice mills is practically non-existent. It is, however, only in the larger mills that separation of rice bran and its further processing into bran oil is economic and feasible. Similarly, drying of liquid skim milk after butter production pays only after minimum quantities necessary for economic utilization of equipment have been reached. Processing and overhead costs for small capacity roller or spray driers are higher than for larger equipment.

A particularly important example and one of specific relevance is the utilization of the "fifth quarter" in the butchery trade. In small-scale conventional slaughtering processes, blood, tail, some intestines and glands, hoofs and hide are either thrown away or used in an uneconomic way, e.g. use of hides for human consumption. When fully utilized these parts are of considerable value and allow for lower pricing of these portions of the animal which are of greater use for human consumption.

A second aspect of utilization of waste and by-products is the conversion for human consumption or feed of presently underutilized products. By far the most important aspect in this field is the production of unconventional vegetable protein food primarily from the residues of oil extraction, i.e. oil cakes. There are numerous other examples in the processing of fruits and vegetables where by-products, such as peelings, cores, pomace, stems, etc., can be used for the manufacture of a wide variety of products like pectin, jelly, juice, confectionery, vinegar and essential oils. In rice processing, the bran before being used for animal feed can be extracted by solvents, yielding and excellent oil suitable for human consumption.

Animal Feed Contributing Indirectly to Human Nutrition

There are various agricultural by- and waste products already in use, but much more of such raw material could be converted if animal feed and fodder industries were given more serious attention. For example, oil cakes can be used for chicken feed and the fresh pulp from cassava processing is fed to pigs. Rice bran is such a valuable feedstuff that some countries have prohibited its export. Some apparently wasteful processing techniques in developing countries are only economic if combined with chicken or pig farms, like the primitive extraction of coconut oil from fresh coconuts by rasping the meat, pressing it out and boiling and settling the obtained "cream". Another example is the mechanical oil extraction from soybeans which without firstclass equipment and proper chemical control leads to a loss of oil in cake of about half of the total oil in beans, but which is often economic because of the high value of the cake for feed (and also food) purposes.

The modern trend is the establishment of mixed feed plants also in developing countries producing valuable feed from all kinds of by-products in modern installations where they are automatically cleaned, disintegrated, mixed, formed into pellets, etc.

Not all the waste product problems of developing countries have been solved yet; up to now no profitable utilization has been found for the shells of groundnuts, or for the husks of rice or date culls, pineapple bran, etc.

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General

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Table 1 - Latin America: Changes in Population and Milk Production, and the Levels of Milk Consumption and National Income Per Caput

	POPULATION (Mid-year estimates)			MILK PRODUCTION			PER CAPUT MILK PRODUCTION			Per Caput Consumption of Milk and Dairy Products - Milk Equivalent	Per Caput National Income at 1960 Prices	
	1952	1962	% in-crease	1950-52	1960-62	% in-crease	1950-52	1960-62	% in-crease	1959-61	1950	1960
	thousand		%	000 m. tons		%	kg. per year		%	kg. per year	US$ per year	
CENTRAL AMERICA 1/	53,841	71,157	32	3,250	6,135	89	60	86	43			
Costa Rica	853	1,275	49	118	*120	2	138	94	-32	144.4	306	342
Cuba	5,755	7.068	23	473	*1,000	111	82	141	78	116.2	...	...
Dominican Rep.	2,274	3,220	42	57	*68	19	25	21	-16	53.1	2/169	3/219
El Salvador	1,955	2,570	31	124	*200	61	64	78	22	56.3	236	3/271
Guatemala	2,981	4,017	35	190	*220	16	64	55	-13	38.2	144	156
Honduras	1,452	1,950	34	105	125	19	72	64	-11	62.8	153	4/176
Jamaica	1,457	1,641	13	35	33	-6	24	20	-17	43.5	194	354
Mexico	27,415	37,233	36	1,632	3,500	114	60	94	57	80.4	238	375
Nicaragua	1,128	1,578	40	174	*175	1	154	111	-28	194.0	...	...
Panama	872	1,139	31	33	60	82	38	53	39	68.2	5/279	3/341
Puerto Rico	2,227	2,458	10	154	340	121	69	138	100	...	439	626
SOUTH AMERICA 1/	116,599	152,760	31	11,250	16,065	43	96	105	9			
Argentina	17,937	21,418	19	4,310	4,483	4	240	209	-13	183.1	424	365
Bolivia	3,095	3,549	15	249	*250	-	80	70	-12	29.9	111	6/105
Brazil	55,095	75,271	37	2,809	5,460	94	51	73	43	69.6	141	3/136
British Guiana	447	598	34	10	17	70	22	28	27	...	5/215	4/223
Chile	6,295	8,001	27	695	762	10	110	95	-14	140.1	427	501
Colombia	11,847	14,769	25	1,756	*2,200	25	148	149	1	110.3	179	238
Ecuador	3,350	4,596	37	173	685	296	52	149	187	80.0	133	167
Paraguay	1,462	1,857	27	126	133	6	86	72	-16	72.2	101	102
Peru	8,864	11,511	30	248	421	70	28	37	32	48.5	112	3/126
Surinam	221	307	39	3	8	167	14	26	86	...	...	...
Uruguay	2,487	2,914	17	449	751	67	180	258	43	248.3	...	...
Venezuela	5,472	7,398	35	356	497	40	65	67	3	87.5	615	805
LATIN AMERICA: TOTAL	170,440	223,917	31	14,500	22,200	53	85	99	16			

1/ Including also countries not listed in the table.
2/ 1951
3/ 1959
4/ 1958
5/ 1952
6/ 1955

* Partly estimated.

SOURCES: Population: UN Demographic Yearbook.

Milk Production: FAO Production Yearbook and other FAO information.

Consumption: Food Balance Sheets for 24 countries of Western Hemisphere; 1959-61 ERS Foreign 86, Foreign Regional Analysis Division, USDA.

Per Caput Income: FAO computations based on data published in the UN Yearbook of National Account Statistics.

Table 2 - Latin America: International Trade of Milk Products

	IMPORTS				EXPORTS			
	1948/52	1958	1963	Variation 1948/52-1963	1948/52	1958	1963	Variation 1948/52-1963
	thousand m. tons			percent	thousand m. tons			percent
CONDENSED and EVAPORATED MILK:								
Central America	36.0	30.0	*37.0	2.8	0.4	0.1	*0.2	-50.0
South America	9.0	15.0	*17.0	88.9	-	1.0	*1.2	...
Latin America:	45.0	45.0	*54.0	20.0	0.4	1.1	*1.4	250.0
WHOLE and SKIM MILK POWDER 1/:								
Central America	17.0	27.0	56.2	230.6	-	-	-	...
South America	5.0	69.0	89.1	1,682.0	-	0.5	0.2	...
Latin America	22.0	96.0	145.3	560.5	-	0.5	0.2	...
BUTTER:								
Central America	4.5	6.6	8.9	97.5	5.7	-	-	...
South America	5.0	7.0	14.0	180.0	6.0	9.6	15.2	153.3
Latin America:	9.5	13.0	22.9	141.1	11.7	9.6	15.2	29.9
CHEESE:								
Central America	4.3	7.6	8.1	88.4	0.3	0.4	0.5	66.7
South America	4.0	22.0	10.3	157.5	6.8	3.0	5.4	-20.6
Latin America:	8.3	29.6	18.4	121.7	7.1	3.4	5.9	-16.9

SOURCE: FAO Trade Yearbook, 1962, 1963 and 1964.

1/ Not all the milk powder imported from the United States under Government programs is recorded.

* Partly estimated.