DOCUMENT RESUME

ED 367 502 PS 022 192

AUTHOR	Gerbouin-Rerolle, Pascale
TITLE	Food Processing: Technology and Nutritive Value.
INSTITUTION	International Children's Centre, Paris (France).
REPORT NO	ISSN-0379-2269
PUB DATE	93
NOTE	55p.
AVAILABLE FROM	Children in the Tropics, International Children's Centre, Chateau de Longchamp, Boise de Boulogne, 75016 Paris, France ($10; annual subscription, $40).
PUB TYPE	Collected Works - Serials (022)
JOURNAL CIT	Children in the Tropics; n207 1993
EDRS PRICE	MF01/PC03 Plus Postage.
DESCRIPTORS	*Agriculture; *Food; Food Handling Facilities; *Food Service; Foods Instruction; Foreign Countries; Grains (Food); Meat; *Nutrition
IDENTIFIERS	Food Deterioration; Food Preparation; *Food Processing; *Food Storage

ABSTRACT

This booklet examines the principles of food preservation, food preservation techniques, and nutrition-related consequences of food processing. All foodstuffs in their natural state will deteriorate and become unfit for human consumption due to internal factors, such as enzyme activity, or external factors, such as insects, rodents, and microorganisms. Food preservation techniques have relied on: (1) a reduction of water activity through drying and smoking; (2) a modification of the acidic level, through fermentation or the addition of an acid; (3) heat, through blanching, heat sterilization, and pasteurization; and (4) cold, through refrigeration and freezing. Various techniques for the preparation, storage, and conditioning of food, as well as the nutrition-related consequences of food processing, such as vitamin, mineral, and protein loss, are examined in detail. (MDM)

CHILDREN
IN THE TROPICS

FOOD PROCESSING : TECHNOLOGY AND NUTRITIVE VALUE

1993 - N° 207

INTERNATIONAL CHILDREN'S CENTRE - PARIS

The International Children's Centre was created by the French government in 1949, on the initiative of Professor Robert Debré in particular, following negociations between France and the United Nations. Its purpose was to furnish those international and national agencies dealing specifically with child care with training facilities and educational and informational tools in the field of chid health and development, viewing children within their family and surroundings.

ICC soon turned essentially toward Third World children and devoted its activities to the training and education of personnel with social, educational and administrative responsibilities as well as medical and paramedical workers. The desire for greater efficiency has led it to work increasingly with trainers and to concentrate its efforts on the methodological and educational aspects of mother and child care programmes.

ICC is also engaged in an attempt to further study - and - action on some aspects of the life and health of children and their family, so as to contribute to practical improvement, particularly in the fields of growth, nutrition, planned parenthood, the control of transmissible and nutritional diseases, preschool and school education, the needs of disabled and underprivileged children, etc.

The documentation centre of the ICC has been collecting, processing and circulating invaluable information on children and their environment for the past forty years. In the last decade the centre has also developed the Robert Debré Database (BIRD) ; with its current 110,000 references, it can meet your bibliographic research needs either by correspondence or by visiting the centre's library. Furthermore the ICC also produces the BIRD CD-ROM, updated yearly with the latest database references; it is a user-friendly compact disc operated on any IBM compatible PC equiped with a standard CD-ROM drive. ICC also publishes books, proceedings of symposia and educational documents, as well as comprehensive analyses and bibliographic bulletins.

As for its legal status, the International Children's Centre is a foundation under french law of recognized public utility, administered by an executive board with broad international membership.

CHILDREN
IN THE TROPICS

REVIEW OF THE INTERNATIONAL CHILDREN'S CENTRE

FOOD PROCESSING : TECHNOLOGY AND NUTRITIVE VALUE

PASCALE GERBOUIN-REROLLE

1993 - N° 207

Pascale GERBOUIN-REROLLE	Food and agricultural technician, recently arrived at the International Children's Centre. Worked in Nicaragua for nine years as technical consultant to the Managua municipality for food and agricultural activities, and later at the National University School for Food Sciences. Coordinated the PRODESSA (Promotion and Counselling for Research, Development and Training in Agriculture) Post-Harvest programme in Nicaragua.
SECRETARIAL WORK	SYLVIANE LE BIHAN
TRANSLATION	HELEN ARNOLD

5

FOOD PROCESSING : TECHNOLOGY AND NUTRITIVE VALUE

6

INTRODUCTION

A little history and geography

Throughout its history, mankind has had to cope with the need to store food so that it would be more readily available.

People's first concern was to ensure their survival during that part of the year when farming is practically impossible (the dry season in tropical and subtropical countries, the cold season in temperate areas) as well as during any periods of shortage caused by weather conditions, wars, etc. In every case, staple foods were the first to be stored : these included cereal grains, legumes, roots and tubers as well as meat and fish.

Secondly, there has always been an attempt to procure a variety of food, both out of biological necessity and for pleasure, as well as for security, since a wider range of edible goods made groups less dependent, thus reducing the risk of famine.

The techniques developed within a given culture for the production and storage of foodstuffs, and also for exchanging and processing them, are closely intertwined. In those regions where roots and tubers are the staple food, for instance, storage meant leaving these in the ground, and only harvesting them when needed. Conversely, those groups that depended on cereal grains were obliged to develop more elaborate storage techniques, since cereal grasses cannot remain standing too long ; the sahelian peoples usually used earthen granaries, while aerated constructions were preferred in wet areas. These included granaries made of bamboo and straw, log platforms with a thatched roof, sometimes located over a hearth, because drying and smoking made the grains easier to preserve.

All food with a seasonal harvesting period (such as fruit) or a periodical one (products of fishing and hunting) have yielded preservation techniques aimed at making storage feasible. These include drying, outdoors or with protection against birds and insects, fermentation, salting, smoking, etc. The desire to keep meat, and especially large game animals obtained by a collective hunt, and fish, for later consumption or for exporting to other regions has been a concern for many peoples over the centuries.

At the same time, methods for preparing food have gradually been refined, to make it edible, easier to digest or tastier. Some naturally inedible species and varieties were made fit to eat, by eliminating their toxic elements : the hydrocyanic acid contained in the bitter varieties of cassava was eliminated by retting, the alkaloids in bitter potatoes were destroyed by soaking followed by fermentation (moraya in the Andes). The different cooking techniques developed in the course of history may also improve digestibility through gelatinization of the starch or denaturing of the proteins.

The flavour, texture and attractiveness of food are also usually improved by cooking, and there is no known human group that does not cook over a fire. In fact, the control of fire was a decisive factor in the development of a number of cultures.

Variety of techniques

Any one raw material may yield a number of different processed goods, depending on the context. Cassava, for instance, is eaten boiled in some regions, in flour form (farinha de mandioca, gari) elsewhere, or again as sour starch (in Colombia). The cultural and social features of the particular group and the tools and resources at its disposal contribute enormously to the adoption of any particular solution.

It is easy to understand, then, that the adoption of a new crop or type of animal husbandry depends to a large extent on the ease with which the food involved may be integrated in eating habits. Pellagra wrought such destruction in 17th century Europe because maize had simply been imported without any attention being paid to the peculiar aspects of its preparation (nixtamalization) and its consumption (in combination with legumes) by the Meso-American peoples.

Gradually, through learning and experimentation, preparation and preservation techniques were diversified, and more was learned about the physical, chemical and microbiological processes involved, fostering the development of new or more appropriate techniques ; UHT (Ultra High Temperature) sterilization, for instance, preserves the vitamins in milk and its taste, while combating germs just as effectively as the earlier sterilization techniques.

This issue is one of a series devoted to food, diet and nutrition. Readers are advised to consult the following earlier issues :

199/200 :	Rural agrobusiness
201:	Social approaches to infant feeding in urban African settings
205 :	Origin and nutritive value of food
202/203 :	Feeding babies : from breast milk to the family dish
192 :	Nutrition education
181/182 :	Nutritional status : the interpretation of indicators
204 :	Putting an end to diarrhoeal diseases
186 :	Nutritional anaemia
175/176 :	Strategies for combating endemic goitre
165 :	Xerophthalmia and blindness of nutritional origin in the third world

Coming soon : Nutritional rehabilitation for severely malnourished children.

PRINCIPLES OF FOOD PRESERVATION

Food can rarely be kept in its natural state. A number of factors - both internal and external - causes it to deteriorate.

Internal factors

Many foods contain enzymes, the activity of which generates negative reactions more or less rapidly : peroxidases, lipoxigenases, lipases and proteases, for instance, may produce unpleasant organoleptic modifications affecting the taste, smell or colour of the food. In addition, plants (grains, fruit, leaves, etc.) continue to breathe even after they are picked, releasing heat, water and carbon dioxide, conducive to germ proliferation and enzyme reactions.

External factors

Farm products are very frequently contaminated by bacteria, yeasts or moulds, or infested by insects (fruit flies, weevils in grain, etc.) even before harvesting. These germs and insects will continue to be active after harvesting, and if external conditions permit, other contaminations occur during storage and handling, and will rapidly cause spoilage of the product, with rotting, fermentation, the development of mould or toxins, losses of the food through its consumption by insects and larvae and soiling by the urine and excrements of rodents.

Environmental conditions, and especially temperature, moisture, light and the presence or absence of oxygen, affect these processes and the speed at which they develop. The composition of the food - its water and enzyme content, the presence of certain nutrients - also determines the type of spoilage that may occur.

If the quality of a foodstuff is to be protected, then, it is important :

- to determine its ingredients and physical/chemical properties ;

- to obtain information about the environment in which it is placed ;

- to know which agents (insects, germs, enzymes) are susceptible of developing under specific ecological conditions.

AGENTS CAUSING SPOILAGE

Insects

A great many insects may cause damage to farm products, and especially to cereal grains and legumes, during their storage. The most common ones belong to two orders : coleoptera, whose membranous wings, protected by elytra, or wing covers, are very sturdy and enable them to move through masses of grain (weevils, or sitophilus spp, for instance) and lepidoptera, or butterflies, which have fragile wings and can therefore only infest the surface layer of grain (this is the case of the corn-moth, or sitotroga cerealella).

Most insects are able to develop between temperatures of 15 and 35°C, with an optimum at around 25-30°C, which are common temperatures in tropical areas. Grain with even a very low moisture level may be attacked : the minimum is 11 % in the case of maize, which is usually stored at a moisture level of about 13-14 %. They die when the oxygen available drops below 2 %.

Often the albumen and occasionally the germ of the grains is eaten - usually by the larvae living inside the grain itself - causing great damage. Their waste products, secretions, etc. also deteriorate the grain, and create an environment in which micro-organisms thrive.

Insects also attack other foodstuffs, but grains and grain-based goods (flour, semolina, biscuits, etc.) are the most seriously affected.

Most of the time, insect control involves :

- protection of the food by adequate packaging or storage in hermetically closed warehouses ;

- use of insecticides in all storage and handling facilities, and if necessary on the grain itself, either preventively or for curative purposes.

Rodents

Rodents too cause losses, generally during the storage of food. These are quantitative losses, since they eat some of the food, but they are qualitative as well, since their urine and excrements soil it, and they may contaminate it by introducing the parasites which they sometimes carry (rabies, the plague, etc.). Rodent control is a question of prevention (strict cleanliness of warehouses, workshops and kitchens, effective closing of entry points, elimination of potential hiding-places), but curative measures may also be necessary (traps, poison, etc.).

Micro-organisms

Types of micro-organisms

While the presence of certain micro-organisms in food may be useful, and is in fact utilized (lactic bacteria for yoghurt, yeast for alcoholic beverages, etc.), many others may be harmful. Bacteria are divided into enterobacteria (Salmonella, Shigella), which are extremely widespread and often cause faecal contamination of food, gram-negative bacilli (pseudomonas, acetobacter), vibrios, present in water and plants, brucellas, found in meat and milk, spore-producing bacteria including certain toxigenic species such as Clostridium, lactic bacteria with highly complex nutritive requirements, that are occasionally pathogenic (Streptococci), gram-positive, non-lactic cocci hosted by animals and man, and susceptible of causing health problems (Staphylococci) and gram-positive actino-bacteria (Listeria, a pathogen found in meat and dairy products).

Yeasts include the saccharomycetes. used in alcoholic fermentation. The most important moulds are the Aspergillus and Penicillium families, some of which produce toxins capable of severely damaging cells, especially the liver cells, or which contribute to the development of primary liver cancer, after a latency period of several years (1). Other moulds are appreciated for their metabolic activity, valuable in cheese-making in particular (Penicillium roqueforti, for example).

---

(1) The mycotoxins produced on legume grains (including peanuts) and cereal grains by Aspergillus are called aflatoxins, and are conducive to primary cancer of the liver ; islandicine, found in yellow rice, is toxic for the liver, like the other toxins secreted by Penicillium islandicum.

There are also some viral pathogens transmitted by food, and some protozoans such as amoebas, the main vector of which is water and watered fresh vegetables.

Metabolism

The fact that micro-organisms develop in a great variety of places is connected with their extremely different types of metabolism. Food may suffer microbial spoilage if it offers an appropriate substratum for a specific germ : in other words, the nutrients required by it. Further, the food must have the right pH (below a pH of 4.5, bacteria are no longer pathogenic), and the proper temperature (cryobacteria subsist when the thermometer drops below 15°C, while the spores of certain bacteria may withstand temperatures exceeding 90°C !). Moisture, and above all "water activity" - Aw - (1) is also a factor : below an Aw of 0.75, no bacteria can develop ; some yeasts, as well as certain moulds, are capable of surviving below an Aw of 0.65 provided sugar is present, but most micro-organisms require a figure of 0.95-0.80 (cf. table 1).

Table 1
Aw of some foods

Aw	Food
1	Water, fruit and vegetables
0.95	Bread, meat
0.9	Ham, cheese
0.85	Pork butchery products, hard cheeses
0.8	Pastry, jellies and jams
0.75	Salt fish
0.7	Dry cereals (M = 13 %)
0.65	Dried fruit, sweets

Different micro-organisms prefer differing oxygen contents (present in gas form or as oxidative substances) which make the food more or less receptive to them.

Other agents

As mentioned above, there are other agents of spoilage. These are essentially the enzymes contained in the food itself : peroxidases, lipases, proteases and lipoxygenases.

Last, certain factors (temperature, light, oxygen) may also cause deterioration of food. One example is the process by which the lipids in oily grains, as well as in cereal grains, oils and fats, become rancid. The taste, smell and even the colour of the product is changed, owing to the oxidation of non-saturated fatty acids ; linoleic or linolenic acid, which are essential to diet, are then destroyed.

---

(1) The water activity, or Aw, is the relation between the steam pressure of the product and that of pure water, and indicates the amount of "free water" contained in the particular item. The higher the Aw of a food, the more easily the water it contains may be used by micro-organisms or for chemical reactions ; however, since this water is "free" it may be eliminated relatively easily by evaporation.

At first the oxygen saturates the anti-oxygen substances intrinsic to the food (the tocopherols, or vitamin E), then it binds itself to the non-saturated fatty acids, which become peroxides and in turn contribute to the destruction of the retinol present in the food.

For instance, storage of peanut flour for five months at temperatures ranging from 22 to 36°C not only causes the loss of 15 to 25 % of its thiamine content, but it also induces a rise in the free fatty acid and peroxide content, and causes rancidity in the flour .

FACTORS CONDUCIVE TO PRESERVATION

If the mechanisms involved in the deterioration of food are to be limited or eliminated, action must be aimed at the factors at work either directly or indirectly, through germ proliferation, for instance. These include the temperature, pH, water activity and oxygen (or redox potential).

All of the techniques developed by mankind over the centuries for the preservation of food modify these very same factors, through empirical processes. The techniques described below will therefore not be classified as more or less modern, but on the basis of the factors modified by them.

Industrial, cottage industry or household procedures may be classified as "simple" (only one factor is involved) or "composite" (several factors are affected). They are summarized in table 2.

Dried, salted, smoked fish combines the reduction of water activity through drying and salting with the addition of antiseptic smoke, which introduces phenols. A combination of techniques is safer, and is utilized very often, as in the case of blanching and deep-freezing of vegetables, or pasteurization and lactic fermentation of yoghurt.

Table 2
Preservation procedures

Factors	Level	Procedures
Temperature	High	Pasteurization, sterilization, cooking, blanching
	Low	Refrigeration, deep-freezing
Aw	Low	Drying, candying, lyophilization, concentration, salting
pH	Low	Acidification by fermentation or addition of acid (vinegar, etc.)
Redox potential	Low	Air-tight packaging or storage
Stabilization through additives or microbiological competition		Smoking (phenols),alcoholic and acetic fermentations

FOOD PRESERVATION TECHNIQUES

Traditional methods (drying, fermentation, etc.) will be discussed first, followed by procedures using more modern techniques (cold, etc.):

- reduction of water activity ;
- modification of pH ;
- heat ;
- cold ;
- other techniques.

For each technique, the principle at work will be reviewed, followed by several examples illustrating domestic, cottage industry and industrial applications.

REDUCTION OF WATER ACTIVITY

PRINCIPLE

As mentioned above, the water content of food is a decisive factor in its preservation, since micro-organisms cannot develop in the absence of water. Even more than the moisture content, it is the amount of water available in the food - the water activity, or Aw (figure 1) - which should be taken into account. Indeed, some of the water contained in any food is "bound" by polarized bonds with the solutes present. In a saline solution of sodium chloride, for instance, a fraction of the water molecules is bound to chloride and sodium molecules and therefore cannot be used by micro-organisms.

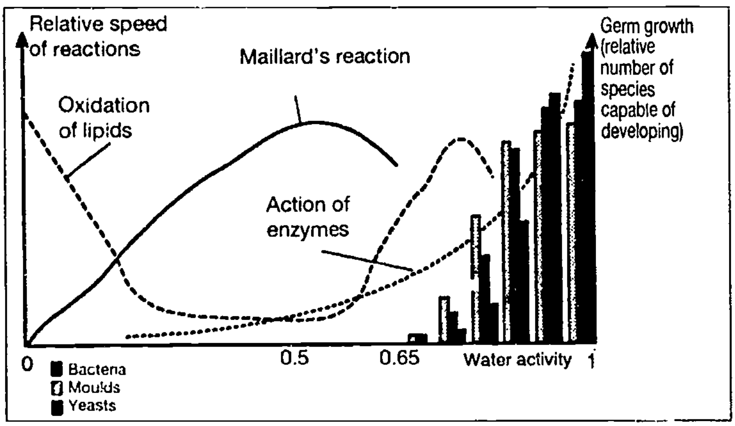

Figure 1 : Variations in the relative speed of several types of food spoilage and in the relative number of germ species that are able to develop, depending on the water activity.
Source : CU JL, GUILBERT S. In DUPIN H et al. Alimentation et Nutrition humaines. Paris : ESF éditeur, 1992.

By reducing the amount of available water in a food - that is, by lowering its Aw - its preservation is improved. There are two ways of doing this :

- by eliminating part of the unbound water : drying or dehydration, concentration ;
- by increasing the concentration of solutes : salt, sugar, etc.

DRYING

The technique

Drying is one of the oldest, most common preservation techniques : primitive hunting and fishing societies used it to preserve what they caught, after which the development of agriculture was linked to the drying and storage of cereal grains. The traditional method involves solar or outdoor drying. For drying to occur, the relative moisture (RM) of the atmosphere must simply be lower than the water activity (Aw) of the food. The latest dehydration techniques use artificially heated air (or a surface), occasionally in a vacuum, but the underlying principle remains the same as for cottage industry-type techniques : the elimination of the available water in the food, in the form of water vapour.

Many factors are at work in drying, and determine its speed and the quality of the final product :

- the temperature of the food and of the air (or of the heated surface) in contact with it ;
- the moisture content of the air ;
- the air flow, through which the water vapour is evacuated ;
- the characteristics of the foodstuff (its composition, texture, etc.) ;
- the size and shape of the foodstuff (thickness, etc.).

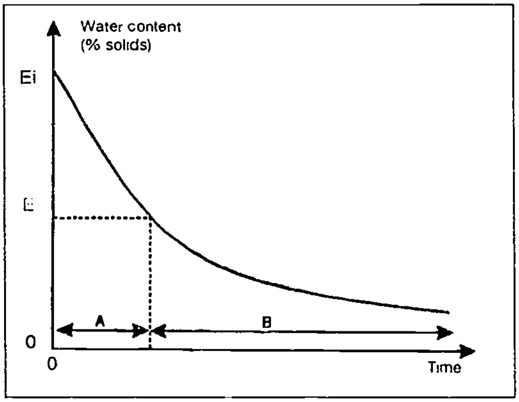

Figure 2 : Variations in water content of a food during drying.
Ei : initial water content, A : constant pace phase, B : 2nd phase, decreasing pace.
Source : CUQ JL, GUILBERT S. In DUPIN H et al. Alimentation et Nutrition humaines. Paris : ESF éditeur, 1992.

As a rule, water is eliminated rapidly at first, then more slowly, and if the operation continues, there is a point when the food no longer contains any free water, and dehydration can therefore go no further (cf. figure 2).

A great many foodstuffs may be dried, including fruit, vegetables, cereal grains, legumes, meat, fish, cheese, etc. In some cases drying may be combined with another technique. Fish, for instance, may first be salted, fermented or smoked : drying is then only one of the factors contributing to its preservation.

Parameters involved in drying

To obtain high-quality products, several parameters must be taken into consideration. When drying takes place too fast, because of over-heating, a crust may form on the surface : this makes subsequent rehydration more difficult, but also prevents pieces from sticking together.

Over-heating, especially at the end of the operation, when the food is almost dry, may impair its taste and appearance, causing it to turn brown, in particular (1).

(1) This browning, also called caramelization or Maillard's reaction, designates a complex series of reactions between reducing sugars, some vitamins and amino acids, resulting in the formation of brown or black pigments. This causes a drop in the availability and/or digestibility of certain nutrients (proteins and vitamins), and consequently, a loss of nutritive value.

Quality of the initial product

The initial quality of the product to be dried - and its microbiological features in particular - is important, of course : while germs can no longer develop in a dried food, any toxins contained in the food prior to drying may not be destroyed by the dehydration process. This is the case for peanuts, for instance : when harvested, the seeds are about 40 % water. In humid growing areas, the pods are first dried on the field, until their moisture content is reduced to 20 %, after which the pods are dry enough to be threshed. The peanut seeds are then dried to 7-8 %. If the first phase of drying of the pod does not go fast enough (because of a rainy period, for instance), or if threshing is not immediately followed by drying of the seeds, moulds, and Aspergillus in particular, develop and produce aflatoxins which are not eliminated by subsequent drying.

Different types of drying

Solar drying

The most common procedure for drying involves air heated either by the sun (solar drying) or by other means (burning wood, natural gas, fuel oil, etc.). Natural or artificial heating of air reduces its relative moisture, and enables it to "capture" the water in the food to be dried ; this heating of the air also heats the food, thus facilitating the evaporation of the water contained in it. If drying by hot air is to be homogeneous and not take too long, the food must be placed in thin layers around which the air is able to circulate. There are many types of driers. All solar driers are based exclusively on this principle, from the crudest ones (a mud floor, a piece of cloth or a cement terrace on which the food - cereal grains or legumes, coffee, cacao beans, etc. - are spread) to the most elaborate ones, with solar captors and forced air circulation, and including drying trays with mobile shelves and a roof for protection in case of rain (cf. figure 3).

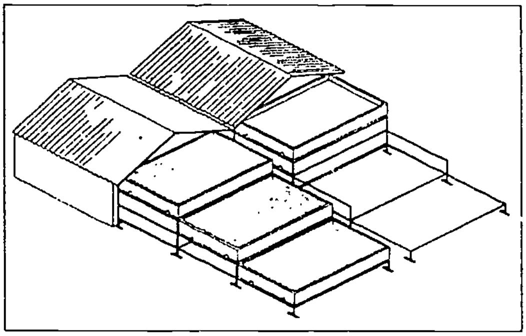

Figure 3 : "Truck" drier for coffee, maize, cacao beans.

Source : CIRAD-CEEMAT. Conservation des graines en régions chaudes. "Techniques rurales en Afrique". Paris : Ministère de la Coopération et du Développement, 1988.

Industrial machines

The simplest types of industrial machines are chests, ovens or steam cabinets that function discontinuously (cf. figure 4), and must be loaded and unloaded. In continuous devices, the food moves through a tunnel in which hot air - often a counterdraught - is circulated.

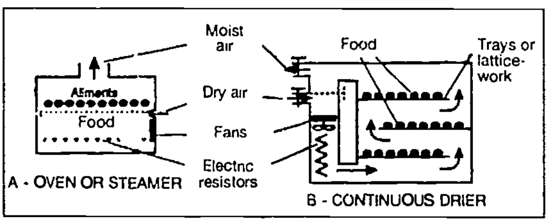

Figure 4 : Oven or steamer.

Source : CUQ JL, GUILBERT S. In DUPIN H et al. Alimentation et Nutrition humaines. Paris : ESF éditeur, 1992.

Sprayers	Sprayers are a type of drier specifically designed for fluids (milk, coffee, etc.) in which tiny droplets of the liquid are projected into a tower, in contact with hot air, and are instantly dried (cf. figure 5).

The other type of drying places the product in contact with a hot metal surface on which it slides, after which it is scraped off (cf. figure 6).

Lyophilization

In the most sophisticated heating technique, lyophilization, the product, previously deep-frozen, is placed on heated plates in a vacuum ; the water contained in the food then goes directly from the state of ice to water vapour, thus preserving the structure of the product and facilitating its rehydration when it is to be eaten. Furthermore, the low temperature maintains its organoleptic qualities most effectively. This is a very costly procedure, since it requires deep-freezing and use of a vacuum : it is reserved for foods with a high added value (lyophilized coffee powder, pharmaceuticals, etc.).

Grain and seeds

Post-harvesting techniques

In quantitative terms, cereals and other grains and seeds (legumes, coffee, cacao beans, etc.) are the main foods involved, since they can only be preserved and stored after drying. For ages, peasants everywhere have developed drying techniques appropriate to their particular crops, resources and weather conditions. Despite this, drying remains a critical post-harvest phase, and one which generates considerable losses, especially when no artificial means of drying are available, and weather conditions are not favourable.

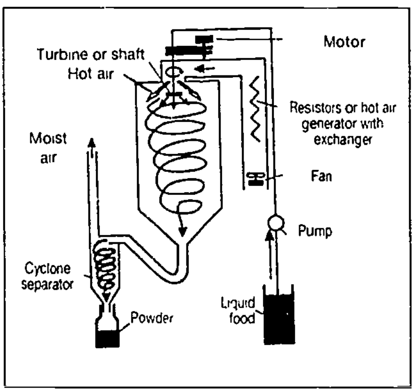

Figure 5 : Spray tower.
Source : CUQ JL, GUILBERT S. In Dupin H et al. Alimentation et Nutrition humaines. Paris : ESF éditeur, 1992.

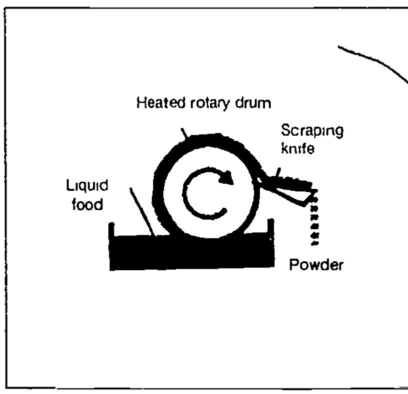

Figure 6 : Rotary drum drier.
Source : CUQ JL, GUILBERT S. In Dupin H et al. Alimentation et Nutrition humaines. Paris : ESF éditeur, 1992.

Moisture

Ripe grains and seeds have a high moisture content : as high as 30 or even 40 %. Since they are plant organs, they continue to breathe after harvesting, and the more moisture they contain the more intensely they do so, and the more heat they release. When they are stored while moist, the temperature rises rapidly, moulds and fermentation develop, and the grain is massively deteriorated. Insects cannot thrive in grain with a moisture content below 10-11 %. Sprouting only occurs above a certain water content (18 to 25 %). All of these problems are furthered by relatively high temperatures (20 to 35°C), and the conditions in most developing countries are therefore conducive to them.

Length of storage

For this reason, the length of storage of grain depends on the prevailing temperature and on the moisture of the grain. At a temperature of 25°C, seed maize with a 22 % moisture content may be stored for 7 days at most, and with 12 % moisture for several months. The water content of the grain balances out with the relative humidity of the air in which it is stored : if the air is saturated with water, the grain reabsorbs some moisture. Conversely, when the environment is very dry it may lose some water during storage. Table 3 shows some reference figures for tropical climates.

Other farm products

Other raw or processed farm products are commonly dried for storage. This is the case of cassava, for instance : gari, farinha, sour starch, sticks and tapioca, all made of cassava processed in different ways, are dried either in the sun or industrially. In many areas where people fish, the fish are dried after salting or fermentation.

SMOKING

Smoking, mostly used to preserve meat and fish, is actually drying in a smoke-filled draught. Surface, and to a lesser extent internal exposure to smoke is added to drying : its action is antiseptic, through the production of phenols, and antioxidant, and it gives the smoked food a special taste and colour.

There are two sorts of smoking.

Hot smoke

The fish is exposed to a smoke-filled draught heated to 60 to 100°C, which cooks the flesh. This relatively rapid technique causes a 20 to 30 % loss of water, which is more than is obtained with cold smoking, but the length of preservation is limited by the radical change in the texture of the flesh. This technique denatures the proteins somewhat, and destroys those vitamins which are sensitive to such conditions.

Table 3
Conditions for drying grain in tropical areas

Grain	Maximum moisture for storage (safety level)	Traditional drying method
Rice	14 %	Drying of panicles in shade before threshing, since overheating causes grains to split open during hulling.
Maize	13 %	Drying of ears standing, loose, in granaries, cribs, etc. Drying of kernels on sheets, in piles. Risk of great losses because of slow drying.
Millet and sorghum	13 to 13.5 %	Drying of ears in stacks or bales, in the sun, on trays or on drying areas. No particular difficulty, losses generally slight.
Legumes : beans, soyabeans, peanuts	 14 % 11 % 7 - 8 %	Drying difficult. First drying of pods standing, in the field or after reaping, then drying of seed after threshing, on trays or drying areas. Risk of development of toxins if drying is too slow or insufficient.
Cacao beans	7 to 7.5 %	Major risk of mould and insects (mites), since grown in moist areas. Natural drying of beans on mats, on the ground or on trestles. "Truck" drier on large plantations.
Coffee	8 % robusta 10 % arabica	Solar drying on trays, mud or cemented floor. Artificial drying required when harvested in rainy season, but risk of loss of flavour.

Cold smoke

The temperature of the smoke does not exceed 30°C here, water losses are lesser and the food cannot be kept for more than one week. This technique avoids crust formation and smokes the fish thoroughly.

Often smoking is combined with salting, to ensure better preservation.

OTHER TECHNIQUES FOR REDUCING AW

Many techniques based on the principle of reducing the water activity in food have been developed.

Concentration

Fluids such as fruit juices and milk are concentrated by boiling, to evaporate part of their water content. This evaporation may be done in a partial air vacuum, to lower the boiling point and thus protect the organoleptic qualities of the end product.

This operation is done in evaporators, which are exchangers of heat between the food and water vapour, often in several phases so as to make the best use of the energy (multiplier effect).

Concentration of milk raises its solids content from 13 % to 25 %, which does not suffice for preservation. Concentration is therefore generally combined with another method : the addition of sugar (sweetened condensed milk) or sterilization (evaporated milk), to avoid spoilage.

In the case of fruit juices, concentration raises the sugar content from 10-15 % to close to 65 %, which is quite sufficient for storage provided it is done hygienically. This operation also reduces the volume and weight of the juice, thus lowering the cost of handling, storage and transportation. At present, most factory-made juices are made of concentrates in the developed countries. Frozen citrus fruit juice concentrates for direct sale to consumers have become very popular there.

Osmotic dehydration

Osmotic dehydration is a well-known, century-old technique, consisting of causing loss of water in the food, along with enrichment with solutes through contact with a medium heavily loaded with solutes such as salt or sugar.

Salting

Salting is used for meat and fish, and is particularly recommended for the preservation of meat, which does not lend itself well to sun-drying. A 15 % salt content inhibits the development of pathogenic bacteria and prevents decay. A few bacteria are still able to grow in this environment, however, and they cause the slow deterioration of the product, through the breakdown of proteins.

Contact with a very salty medium (dry salt or brine) produces a two-way flow through which the concentration of salt is balanced out : water leaves the food to enter the salty medium, and salt enters the food. This occurs more or less rapidly depending on the thickness of the food and the type of tissue.

There are two methods for salting :

Dry salting

The meat is cut into strips and rolled in salt (300 g for 5 kg of meat), then placed in a container, with alternating layers of meat and salt, and left there for two days. It is then hung up in a moisture, light and fly-free environment, salted again 3 days later, and then dried for 3 to 4 weeks. At this point it keeps well, and may be eaten dried or rehydrated and cooked. As for fish, it is placed in direct contact with salt (3 kg for 10 kg of fish) for 10-15 days or more, after removal of the head, gutting and cleaning. The water contained in the tissues is then exuded, and a brine forms, which may be kept so as to eliminate the risk of oxidation of the fat and of proliferation of halophilic aerobic germs (in the case of fatty fish), or it may be poured off, as is usually the case for lean fish.

Salting in brine

In this case, the fish or meat is completely soaked in salted water. Meat may be placed in 500 g of salt for 5 l of water, for instance, left there for 3 days and then hung up to dry. The final salt content depends on how concentrated the brine is and how long the meat is left to soak in it. This technique is often preferred for fish that are subsequently smoked.

In south-east Asia a special preparation known as nuoc mam is used : it involves the autolytic fermentation of tiny whole fish in a highly salted environment for three and one half months. This produces a brown, salty solution, rich in short-chain peptides and free amino acids.

Candying

The principle is the same as for salting, but it is mostly used for fruit, and involves the immersion of pieces of fruit in a sweet syrup: the sugar concentration of the fruit and syrup balance out, as water leaves the fruit and sugar enters it. This occurs more or less rapidly, more so as the temperature of the syrup and its sugar content (which may be 40, 60 or even 75 %) rise, and also varies with the type of sugar (saccharose or polysaccharides), the size of the pieces of fruit and the texture of its tissue (prior blanching facilitates the exchange of sugar and water).

Use of several increasingly sweet solutions produces candied fruit with a sugar content exceeding 65 %, which may be kept in this state, following draining off of the excess syrup and, sometimes, drying. Semi-candied fruit (snack fruit), mostly made in Asia (in Thailand, in particular) contains less sugar but is dried afterward to a moisture content below 40 % and an Aw of about 0.84.

The addition of solutes

By mixing a solute such as sugar with the food in sufficient proportions, and then cooking it to soften the tissues, facilitate penetration of the sugar and eliminate any germs, a stable product is obtained. This is the case for marmalade, jams and jellies, the Aw of which ranges from 0.82 to 0.94 (at which there is no risk of development of pathogens).

This is a long-known technique, and is practiced both at the household and the cottage industry and factory levels, to keep fruit, a seasonal product, since jam-making requires only a modicum of equipment. However, it is essential to have a regular supply of sugar (about 1 kg of sugar per kg of fruit), adequate packaging... and a market... which may be a problem in countries where no sugar is grown, and where this type of food is not habitually consumed.

MODIFICATION OF THE PH

As seen above, most germs cannot survive in an excessively acid environment. There are two ways of acidifying a food to preserve it: the addition of an organic acid, or the use of acid-producing micro-organisms to induce fermentation.

---

(1) Halophilic : flourishing in a salty environment.

21 20

ADDITION OF AN ACID

Home recipes very often include an ingredient that is rich in an organic acid, such as vinegar (acetic acid), lemon (citric acid), etc., for the preservation of a highly perishable food. This is the case of meat which is marinated for a day or two in a vinegar solution, pickles, relishes and hot peppers, seeped in vinegar. Factory-scale production is infrequent, and when it does exist it is very much of the cottage industry type.

FERMENTATION

The different kinds of fermentation are age-old traditional techniques which may be classified as methods for preserving food, but they induce changes in taste and texture which actually change the nature of the food. Last, they improve the food value of many products by destroying some substances that are toxic or hard to digest and producing some vitamins and amino acids. A whole series of modifications occur, then, and not only simply a lowering of the pH. The most frequently used food fermentations use carbohydrates as a substratum, to yield ethyl alcohol (ethanol), lactic acid or acetic acid.

The development of these selected micro-organisms (yeasts, moulds or bacteria) inhibits the occurrence of other parasitic ones, and especially of pathogens, through microbiological competition. The acidification resulting from lactic fermentation deters pathogenic bacteria from implanting themselves, but simultaneously fosters the development of moulds and yeasts.

Alcoholic fermentation

Alcoholic fermentation transforms fermentable sugars (oses, diholosides and starch following the action of enzymes which release the oses) into alcohol and carbon dioxide, through the action of yeasts (such as saccharomyces cerevisiae). It is used for the preparation of alcoholic beverages (wine, beer, chicha, kefir) as well as for the preparation of bread dough. These yeasts are most active at about 25°C.

Lactic fermentation

Lactic fermentation is the process by which lactic bacteria transform oses into lactic acid. It is used to turn milk into yoghurt (the lactose is transformed into lactic acid, sufficient amounts of which (6 to 7 g/l) cause the casein, or cow's milk protein, to coagulate), but also to transform other foods such as sauerkraut, olives and pickles.

Lactic fermentation is also involved in the making of gari (cassava flour) and in the retting phase by which the toxic ingredients in bitter cassava are dissolved. Similarly, hulled néré seeds may be fermented to produce a relish - soumbala - which is eaten in the sahelian region. The seeds are placed in an earthenware pot, covered with water and boiled until almost no water is left. This operation is done three times. The cooked seeds are again covered with cold water ; the hulls are eliminated by hand rubbing. Once rinsed, the seeds are sun-dried then boiled again for one half-hour. They are then placed in a basket, the sides of which are lined with leaves, and covered with leaves held in place by stones. Micro-organisms cause fermentation, which is allowed to continue for two days, after which the seeds are ground and mixed with wood ash of the shea tree. The resulting dough is left for 24 hours, then cut into pieces and dried in the sun. The end product, rolled into balls or cut into strips, is black and has a strong odour ; it is then ready for use as a relish, or for seasoning all sorts of dishes (1). Soumbala, prepared in this way, is up to 50 % protein.

Acetic fermentation

Acetic fermentation is produced by acetobacter bacteria which convert ethanol into acetic acid. A sweetened fruit juice, containing 18 to 20 % sugar, may be transformed into a vinegar with an 8-9 % acid content by alcoholic fermentation followed by acetic fermentation. Vinegar is stable, because of its very low pH, and is in fact used as a preserving agent for vegetables, meat, etc.

Other types of fermentation

Soya sauce is also fermented. The soyabeans are boiled for 4 to 6 hours and left to cool for 18 hours. They are mixed with an equal amount of roasted, ground wheat. The mixture is seeded with spores of aspergillus oryzae and placed in a warm, humid room (at 36°C). The fermentation is continued until the moulds have invaded the entire mass, which is then placed in salt-saturated water (as much salt as soya) in containers in which the fermentation goes on for 6 months to 5 years. The mixture is churned twice a day in summer and once every two to four days in winter (in far-east Asia). When it reaches maturity, the mixture is pressure-filtered. A kilo of soyabeans produces 3 litres of sauce, and a by-product, "sorghu", which may be used as fertilizer.

In Indonesia, peanut press-cakes are left to ferment with rhizopus oryzae or neurospora, to make "ontjam". "Tempeh", prepared similarly but using soyabeans, contains proteins with a biological value similar to that of skimmed, powdered milk.

Certain population groups also preserve breadfruit, bananas or taro by allowing a dough made from them to ferment. This makes it possible to keep these foods for about 1 month. Others, in the polar regions, eat the plants - partly digested by fermentation - contained in the stomachs of killed reindeer (which they have partially domesticated). Once emptied, these stomachs may be used as containers in which plants may be preserved by acid fermentation following gathering.

Nutritive value of fermented foods

Some foods do not undergo any considerable modification of their nutritive value during fermentation. Curdled milk and yoghurt are quite similar to milk, but have an antiseptic action on the intestines, thanks to the lactic acid produced by fermentation.

The fermentation of bread dough hardly affects the nutritive value of flour. It is during cooking that some nutrients are modified.

While fermentation causes a loss of carbohydrates (converted into acids or alcohol) and sometimes of vitamins, it also improves the nutritive value of some foods. In the case of nuoc mam, for instance, the salt present operates a selection among the specific fish enzymes, of those which will hydrolyse the fish proteins. This

(1) *Seeds in the human diet. FAO, 1964.*

produces a proteolysate with a high biological value, easily assimilated and which also keeps well, because of the salt. Nuoc mam contains 12.8 g of protein for 100 g.

The controlled, organized fermentation by which milk is turned into cheese using a series of selected flora not only improves its organoleptic qualities, but also improves its nutritive value by predigesting it, converting the proteins into peptides and soluble nitrogen, and hydrolysing the lipids. This improves the digestion of these dairy products. In addition to this nutritional upgrading, cheese is a way of keeping milk in a condensed form, which is why pastoral peoples have made it for centuries.

Retting

Retting is a popularly used type of fermentation for the detoxification of certain roots (the bitter varieties of cassava) and tubers (bitter potatoes). When cassava roots are soaked in water for several days, fermentation eliminates the cyanogenic compounds, which are toxic substances present in them. These are broken down, and the hydrocyanic acid released then evaporates during drying or cooking. In the case of bitter potatoes in the Andes, the substances eliminated are glycoalkaloids. When cassava is made into gari, the grating of the root precipitates detoxification. Retting itself is not a preservation technique, and must be followed by drying or some other process that ensures the microbiological stability of the end product.

HEAT

Two types of deterioration processes may be halted by the action of heat : enzymatic reactions and the action of harmful microorganisms. The former are usually combated by blanching, and the latter by pasteurization and sterilization.

BLANCHING

Many enzymes naturally present in certain foods catalyse reactions that induce negative modifications in quality, as mentioned above. These reactions begin at a very early phase : at picking, for leafy green vegetables, for instance. Blanching is a heat-processing technique used on food prior to deep-freezing, dehydration or pasteurization, to inactivate the enzymes by plunging the item in a hot water or steam bath for a short lapse of time (less than five minutes), at a moderate temperature (between 60 and 100°C).

Blanching may be valuable for other reasons as well, and particularly for texture improvement : blanching of tomatoes, for instance, maintains their red colour and softens their tissues, thus facilitating subsequent operations (for making tomato sauce, concentrate or juice) while producing a product with the colour of a fresh tomato.

When green beans are blanched before deep-freezing they retain their pleasant green colour and are more tender. For foods that will subsequently be dried, blanching offers the further advantage of increasing the permeability of the plant's cell walls, thus facilitating both drying and later rehydration. Last, this operation helps to eliminate the air and other gases present in the food, thus reducing oxidation, especially in tinned food.

HEAT STERILIZATION

Principles

In 1810, Nicolas Appert developed a procedure for preserving fruit juices by heating them in hermetically sealed bottles. Later, in 1863, Pasteur did his work on wine, thus founding the science of microbiology.

Appert's method is a preservation procedure usually known as tinning or canning in which food is placed in a hermetically sealed container and heated, to ensure the destruction or inactivation of any micro-organisms or enzymes susceptible of deteriorating it.

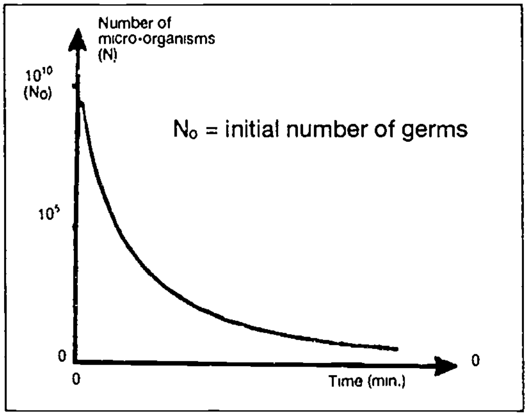

Figure 7 : Time-linked variation in the number of micro-organisms at a given temperature.
According to CUQ JL, GUILBERT S. In DUPIN H et al. Alimentation et Nutrition humaines. Paris : ESF éditeur, 1992.

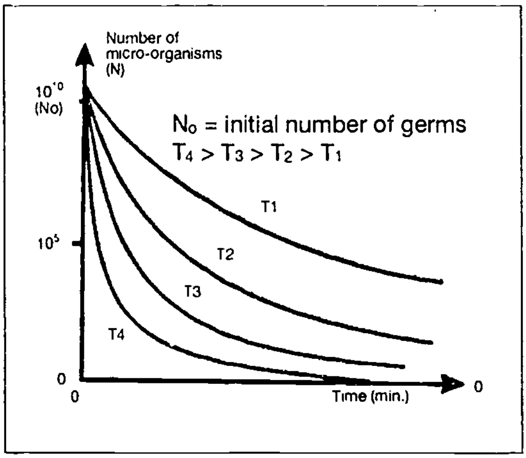

Figure 8 : Time and temperature-linked variation in the number of micro-organisms.
According to CUQ JL, GUILBERT S. In DUPIN H et al. Alimentation et Nutrition humaines. Paris : ESF éditeur, 1992.

The study of the physical and microbiological processes at work has shown that the destruction of these micro-organisms is directly proportionate to the number of micro-organisms present : in other words, the greater the contamination, the greater the number of germs destroyed in a given lapse of time (cf. figure 7). A further deduction is that as the population of micro-organisms grows smaller, it becomes increasingly difficult to destroy the remaining live germs, and that in theory, a food can never be made perfectly sterile. In practice, prolonged heat-processing succeeds in reducing the germ load, or germ content, to a point where the probability of having a single live germ per tin or per litre of milk is extremely low. Another fact : the higher the temperature, the faster the rate of destruction of micro-organisms (cf. figure 8).

Last, germs are more or less sensitive to heat. Two main parameters are used to describe the behaviour of micro-organisms :

- D = the decimal reduction time : this is the time required to reduce the number of live germs present by 90 % at a given temperature and for a given micro-organism ;
- F = the thermal death time : this is the amount of time required to achieve a predefined level of germ reduction (N_o/N) at 121°C (250F).

Let us take some examples to illustrate these parameters.

Clostridium Botulinum : value of D at 121°C = 0.2 minute. This means that at a temperature of 121°C, 90 % of the germs present at the start (N_o) will be destroyed in 0.2 minute, or 12 seconds. At the end of 12 seconds, then, there are only $\frac{N_o}{10}$ live germs.

24

If the contaminated food is left at the same temperature - 121°C - for another 12 seconds, only $\frac{N_O}{100}$ Clostridium B germs will remain.

Bacillus slearothermophilus : value of D at 121°C = 5 minutes. A 5-minute treatment at 121°C will be needed to destroy 90 % of the bacilli, and 10 minutes will be necessary to bring their concentration down to $\frac{N_O}{100}$ live germs.
This micro-organism is much more heat-resistant that Clostridium, then.

As shown in figure 8, when the temperature rises, the treatment time drops. For Clostridium Botulinum, for instance, a 10°C increment results in a 90 % reduction in time.

Practically speaking, this calculation is complicated by the fact that for most products, it is impossible to heat all points instantly to a given temperature. When a tin of beans with sauce is placed in an autoclave steamer, the sauce will heat up more quickly, and the first part to be heated will be the layer in direct contact with the tin. Different methods have been developed to calculate the time/temperature required to achieve the desired degree of destruction.

Other factors are also at work, such as the acidity of the food to be treated. When the pH is above 4.5, micro-organisms are more resistant to heat. For a substance contaminated with spore-forming Clostridium with a pH of 7.0, 25 minutes at 115°C will be required to achieve the same result as with 9 minutes at 115°C for a food with a pH of 5.0. In practice, food with a high pH (meat, milk, fish) should receive a more serious heat treatment, particularly since one of the most dangerous germs, Clostridium botulinum, develops in a pH exceeding 4.5.

It should be remembered that the amount of heat-processing required, defined by time/temperature, depends on which micro-organisms are susceptible of growing in that particular food, along with the initial germ load, the pH of the food and its texture (solid, fluid, solid in fluid, etc.) the type of packaging, etc.

Two applications of Appert's method - pasteurization and sterilization - are discussed in greater detail below.

PASTEURIZATION

Pasteurization is selective and aims at the destruction of the bacteria present in a food. It is done at moderate temperatures, usually lower than 100°C and the spore forms of micro-organisms are generally not destroyed. Because of this, pasteurization is only preferred in certain cases : when the bacteriological risk is low because of the specific features of the food involved (the acidity of fruit juices, for instance), when longer processing, or at a higher temperature would impair its organoleptic qualities (semi-preserved pâté, for instance), or when only certain micro-organisms are to be eliminated either because they are pathogens (such as the tubercle bacillus and salmonella in milk) or because they compete with controlled fermentation (pasteurization of milk prior to lactic fermentation for yoghurt-making).

Pasteurization must frequently be combined with another preservation technique so as to reduce the risk of proliferation of the remaining germs and of recontamination. Pasteurized milk must be refrigerated, ham is packaged, sometimes vacuum-packed and refrigerated, etc. Such articles require a continuous cold chain from producer to consumer, and their shelf life, restricted to several days or several weeks, makes their distribution more complicated and costly. Different heat-penetration schedules are used (cf. table 4), depending on the food (its heat-sensitivity and initial extent of contamination).

Table 4
Heat-penetration schedule for some foods

Foodstuff	Time	Temperature
Milk	30 min. 15 sec.	62°C 72°C
Beer	1 to 2 min.	87 - 88°C
Bottled apple juice	30 min.	77°C
Loose apple juice	30-60 sec.	88°C

According to Cheftel et al. Introduction à la biochimie et à la technologie des aliments. Paris : Technique et Documentation/Entreprise moderne d'édition, volume 2, 1978.

STERILIZATION

This is a more thorough treatment than pasteurization, since the higher time/temperature destroys practically all micro-organisms, including spores.

Once sterilized and placed in a sealed wrapping, food may be kept for several months and even for several years without deteriorating, provided it is protected against excessive heat. Sterilization schedules depend on the characteristics of the food (its composition, pH, initial germ load, etc.) ; they may range from 15 minutes at 120°C and several seconds at 140°C. The principle is the same as for any other heat-processing : the higher the temperature, the less time is required to achieve the same result.

Until quite recently, sterilization was usually done at a moderate temperature/long time, but this deprived certain foods, and milk in particular, of much of their food value and organoleptic qualities. Research into this subject has shown that the adverse reactions occurring during heating - loss of vitamins, Maillard's reaction (cooked taste), etc. - are not affected by temperature in the same way as the micro-organisms ; in the case of milk, for instance, beyond 135-140°C, the loss of quality is slighter than the destruction of pathogens.

Equipment for pasteurization and sterilization

The development of a technique known as UHT (Ultra High Temperature), which consists of heating the food (usually a fluid) for only a few seconds to a very high temperature (140°C or even 150°C) and then cooling it immediately, has led to a change in equipment, with continuous bulk sterilization (of the plate-exchanger type) followed by sealed packaging.

Two types of technique have been developed : heat-processing of pre-packaged food (jars, tins, etc.) and heat-processing of loose food before packaging ("packs", plastic bags, etc.). For the former (cf. figure 9), there are machines of the autoclave type that treat batches and continuous sterilizers in which the tins travel along a circuit at different temperatures. Whereas there are autoclaves for processing small quantities, the continuous machines are designed for a large input and represent a considerable investment.

For loose, or bulk processing (cf. figure 10), heat exchangers are utilized, in which the product is heated then cooled, using water and steam. The Tetra Pak assembly lines for packaging UHT-processed fluids (such as milk) use this technique.

Tins

Although factory sterilization occasionally uses glass jars, most food is placed in tins (made of a thin sheet of mild steel covered on both sides with a layer of tin or black iron, or a sheet of chrome or aluminium-covered steel). In addition, to avoid corrosion, which may modify the appearance of the food, and even the perforation of the tins and the entry of germs, the inside of the tins is given a protective covering of natural or synthetic resin.

Once the tin is filled, sealing is done along with preheating by pressured steam, which evacuates the air from the empty space, creating a vacuum following sealing, through condensation of the steam. The sealed tin is sterilized in an autoclave, at a temperature and time lapse determined by a number of factors : the nature of the bacteria, their form (spores, vegetative), concentration and acidity of the product, rate of transmission of heat to the centre of the tin. Schedules for sterilization are established : increasingly, there is a tendency to increase the temperature (140°C) and to cut the time down, to avoid excessive cooking.

Tins with swollen lids should be discarded, since they contain potentially pathogenic proliferating germs ; open tins must be

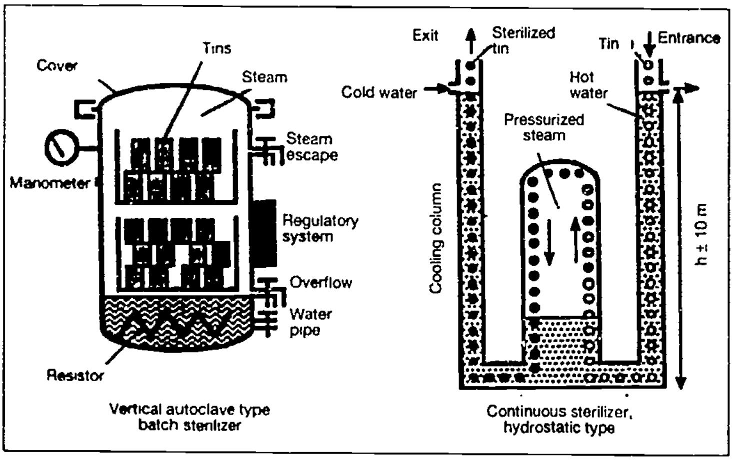

Figure 9 : Diagrams of sterilizers.
Source : CUQ JL, GUILBERT S. In DUPIN H et al. Alimentation et Nutrition humaines. Paris : ESF éditeur, 1992.

shielded from outside contaminants, refrigerated and the contents eaten rapidly.

Intoxications caused by tinned food have now practically disappeared, and the nutritive value of the food is excellent : rapid cooking in an air-free environment is often less destructive of vitamins than home-made preparations. However, the juice of tinned fruit and vegetables should not be discarded, since it contains vitamins and minerals that have seeped out into it.

Other types of conditioning

Other types of conditioning have been developed in recent years, including aluminium tins with an easy-to-open lid, mostly used for drinks (beer and soda) and for pork butchery or fish products. They are more expensive and require more sophisticated equipment than ordinary tins.

Complex packaging resulting from the juxtaposition and gluing of several films of different materials : "packs" of milk or of fruit juices contain - from inside out - a layer of polyethylene, two layers of laminate carton, another layer of polyethylene, a multicoloured printed paper (for labelling and decoration) and last, a transparent protective coating (made of polyethylene or polypropylene) (1). More will be said about these techniques in the chapter on packaging.

The qualities of the different layers (air and water-tightness, flexibility, etc.) may thus be combined, and they may be shaped in an antiseptic atmosphere. This technique is therefore widely used for foods that are pasteurized or sterilized in loose form and packaged afterwards (as in the Tetra Pak assembly lines).

COLD

PRINCIPLES

All chemical reactions, either enzyme-produced or microbiological, involved in food spoilage are slowed down when the temperature of the substance is lowered. By maintaining a food at a low temperature, then, the extent of these adverse reactions is limited, and its storage time is increased.

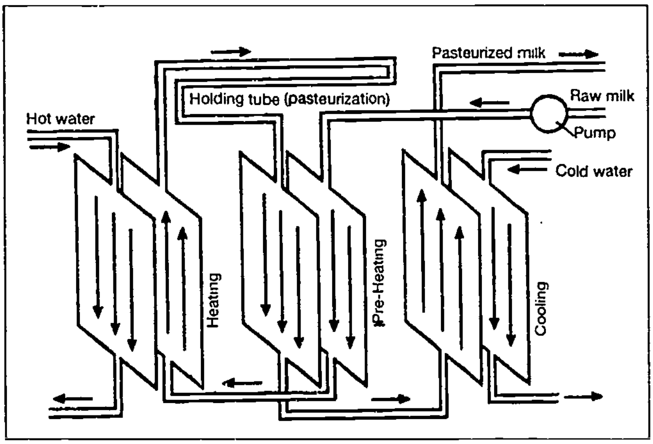

Figure 10 : Diagram of a continuous plate-exchanger pasteurizer. Source : CUQ JL, GUILBERT S. In DUPIN H et al. Alimentation et Nutrition humaines. Paris : ESF éditeur, 1992.

Micro-organisms are more or less resistant to cold, but none is able to develop below 10°C. In table 5, micro-organisms are classified as cryophiles (capable of developing below 15-20°C) (2), mesophiles (between 15 and 45°C) and thermophiles (capable of developing above 45°C, and up to 80°C).

---

(1) Manchon P. In : Dupin H et al. Alimentation et Nutrition humaines. Paris : ESF éditeur, 1992.

(2) Practically speaking, these micro-organisms are therefore able to survive in cold storage and household refrigerators, and may then cause contamination, possibly serious : recently, in Europe, there have been several incidents in which listeria was incriminated in pork butchery products.

Table 5
Classification of micro-organisms according to their optimum temperature

Cryophiles	Mesophiles	Thermophiles
Bacteria	Bacteria	Bacteria
Pseudomonas	Salmonella	Clostridium
Achaomobacter	Staphylococcus	Lactobacillus
Listeria		thermobacterium
Yersinia		Proprioni
Flavobacterium		bacterium
Moulds		
Cladosporium		
Sporotrichum		

This is a long-known phenomenon, but techniques for producing cold have not always been available. For centuries, people were obliged to rely on seasonal changes of weather and those tied to different altitudes. In Europe, for instance, an organized system supplied ice to the cities from some mountainous regions (in the Alps), with blocks of ice packed in on mules or carted in.

The natural ventilation techniques developed by different groups do not lower temperatures sufficiently, but they do at least avoid overheating caused by food being piled up. Traditionally, storage of yams in west Africa generally involves placing them on vertical wood trays in a shady, well aired place.

The invention of the refrigeration machine, which generates cold by the expansion of a previously compressed fluid, ammonia or freon, has made it possible to use cold to preserve food at both the household and the industrial levels.

There are two types of techniques : refrigeration, using temperatures ranging from +10 to -1°C and deep-freezing, between -1 and - 30°C. The main difference is the formation of ice crystals in the latter ; spoilage cannot occur in the water contained in the food, since much of it is then unavailable. Quick-freezing is simply rapid deep-freezing of sealed packages, which are strictly maintained at a temperature of or below -18°C.

REFRIGERATION

Food stored in a cold place will keep longer. For this operation to be satisfactory, some rules must be respected :

- refrigeration, like deep-freezing, is a preservation technique requiring that the raw materials be of excellent quality, since it simply slows down decay. It is important, then, to refrigerate only fresh food in good condition. Furthermore, it is essential to refrigerate food as soon as possible after harvesting or slaughtering, to avoid modifications and spoilage ;

- when food, which is generally moist, is stored in a refrigerator, a rebalancing of the water activity may occur, causing the product to dry, at least superficially. This may be avoided either by placing the food in a water-tight wrapping or by maintaining a certain degree of humidity in the air ;

- the storage temperature chosen depends on the item of food and it should be maintained as constant as possible until the food is distributed to consumers ;

- avoid storage of different foods in a same warehouse, since odours are occasionally communicated from one to another : melons, butter and white cheese, for instance, are easily impregnated with the odours of other food stored in close proximity.

Food that is dead (meat, fish, etc.), the tissues of which may host major germ proliferation, reacts differently from live food such as fruit and vegetables, the metabolic activity of which continues after picking.

Animal products

At room temperature (15 to 25°C), meat rapidly becomes unfit for consumption, because of the development of anaerobic germs which cause internal proteolysis. The refrigeration of meat avoids internal rotting, while enabling the biochemical phenomena of rigor mortis and maturation to proceed normally. However, at the usual temperatures (0 to 3°C), prolonged preservation is impossible, since an unpleasant smell and a slimy coating on the surface of the meat develop after a few days, owing to the multiplication of cryophilic surface germs. Only deep-freezing or a controlled atmosphere can prevent this evolution.

When left at room temperature, fish deteriorates extremely rapidly after death : the development of proteolytic micro-organisms and of endogenous enzyme reactions result in the release of compounds which may be evil-smelling (ammonia, trimethylamine, hydrogen sulphide, etc.) or even toxic (amines). Several factors contribute to this : a relatively high pH in the flesh and the large proportion of substrata with a low molecular weight, such as amino acids and amines, which are rapidly attacked. Last, the proteolytic tissue enzymes and bacterial proteases produce rapid softening of the muscle, while oxidation of the lipids soon takes place.

To slow down this decay, it is preferable to gut and bleed the fish immediately after it is caught, and to cool it rapidly to -1°C. It may then be kept in a refrigerator for one to two weeks, depending on the species.

Cold storage of eggs is a frequent procedure, and as in the case of other animal products, should be applied to fresh unadulterated eggs, and high-quality egg products (made of egg whites, yolk or whole eggs removed from their shell, possibly with additives such as salt or sugar).

When these rules are respected, a whole egg can be kept for ten days at 8°C and for six to seven months at -1°C or 0°C in a relatively moist atmosphere (80-85 % relative humidity), to avoid dehydration. Egg products cannot be kept in this way for more than a few days, and rapidly require deep-freezing or dehydration for further preservation.

Plants

Refrigeration of fruit and vegetables slows down their maturation, and more specifically their respiratory activity, and this effect is more pronounced when they are less ripe. For preservation to be satisfactory, the fruit and vegetables must be clean and healthy, and cooled very soon after picking. The optimum temperature for storage depends on the species, and even on the variety considered. As a rule, the lower the temperature the longer the preservation ; apples, for instance, may be kept for one and a half times as long at 4°C as at 15°C. The risk of decay limits the use of low temperatures : enzymes cause some fruit to turn brown (superficial or deep spotting) and deteriorate the flavour. Fruit from hot climates, and particularly tropical fruit, are particularly sensitive to low temperatures. If bananas, for instance, are stored for more than a few days at temperatures below 12-13°C, their maturation process is stopped definitively. Potatoes have poor tolerance of temperatures below 5°C, which cause partial hydrolysis of their starch, and development of a sweet taste.

Controlled atmosphere

The duration of preservation of fruit and vegetables also depends on the moisture content of the air around them : green beans are best preserved at a relative humidity of 80 %, and lettuce at 90 %. A high, steady level of humidity in a warehouse reduces dehydration and losses of turgor, but also increases the risk of mould production. In general, the exhalation of the fruit or vegetables themselves suffices to maintain proper humidity, but artificial humidification of the air is occasionally necessary. Table 6 shows refrigeration conditions for many foodstuffs.

As pointed out above, the combination of several techniques is often helpful in achieving optimum preservation of food. Based on this predicate, techniques based on modified or controlled atmospheric conditions for refrigerated warehouses - modifying the composition of the air (nitrogen, oxygen, carbon dioxide (CO_2) content · have been developed over the last few decades. When the proportion of oxygen (O_2) is reduced from 21 % (normal level) to 4 or even 1 %, most maturation reactions are slowed down. By raising the CO_2 content to 5 or even 10 % (whereas the normal content is 0.3 %), the intensity of breathing is reduced, and some enzyme reactions involved in maturation seem to be inhibited. This may prolong storage time considerably, up to nearly one year for certain types of fruit (citrus fruit, apples, etc.). Eggs may be kept for over a year in an oxygen-free atmosphere with 88 % CO_2 and 12 % nitrogen. Vacuum storage is an effective method for meat and fish : the carcasses may then be refrigerated for one to two weeks, as opposed to a maximum of one to two days in a normal atmosphere.

Other factors

To be effective, storage in a refrigerated warehouse requires not only adequate equipment, but also that the cold chain be respected. The cost of this option therefore includes sorting, preparation and packaging of products prior to storage, along with

Table 6
Storage conditions for perishable products

Products not, or only slightly, sensitive to cold

Fruits	°C	R.H. %	P.S.L.
Apricots	0	90	2-4 w
Lemons (coloured)	0 to 4.5	85-90	2-6 m
Dates (fresh)	0	85	1-2 m
Strawberries	0	90-95	1-5 d
Kiwis	-0.5	90-95	8-14 w
Coconuts	0	80-90	1-2 m
Oranges (a.o.v.)	0 to 4	85-90	3-4 m
Peaches	0	90	2-4 w
Pears (a.o.v.)	0	90-95	2-5 m
Apples (a.o.v.)	0 to 4	90-95	2-5 m
Plums	0	90-95	2-4 w
Grapes (a.o.v.)	-1 to 0	90-95	1-4 m

Vegetables	°C	R.H. %	P.S.L.
Garlic	0	65-70	6-7 m
Carrots (without leaves)	0	95	5-6 m
Celery	0	95	4-12 w
Mushrooms	0	90-95	5-7 d
Cabbage (a.o.v.)	0	95	1-3 m
Cauliflower	0	95	2-3 w
Lettuce	0	95	1-2 w
Sweet corn	0	95	1 w
Turnips	0	95	4-5 m
Onions (dry)	0	65-70	6-8 m
Potatoes (bulbs)	2 to 3	90-95	5-8 m
Radishes	0	90-95	1-2 w

Animal products	°C	R.H.%	P.S.L.
Variety meat	-1.5 to 0	85-95	7 d
Lamb	-1.5 to 0	85-95	3-4 w
Butter	0 to 4		2-4 w
Beef	- 1.5 to 0	85-95	3-5 w
Cream	- 2 to 0		15 d
Crustaceans	0		4-6 d
Cheese	5		1-2 w
cottage (d.c.)	0 to 2	85-90	2 m
soft (d.c.)	0 to 5	85-90	2 m
hard (d.c.)	-1 to 1	70-75	12 m
Raw milk	0 to 4		2 d
Milk (pasteurized)	4 to 6		7 d
Eggs (in their shells)	-1 to 0	90	6-7 m
Fish (d.c.)	0		6-14 d
Pork	- 1.5 to 0	85-95	3 w
Veal	-1.5 to 0	85-95	3 w
Chopped meat	4	85-95	1 d
Eviscerated poultry	- 1 to 0	85-95	1-2 w
Non-eviscerated poultry	0	60-70	3 w
Yogurt	2 to 5		2-3 w

Products somewhat sensitive to cold

Fruits	°C	R.H. %	P.S.L.
Mandarins	4 to 6	85-90	4-6 w
Mangosteens	4 to 5.5	85-90	6-7 w
Watermelons	5 to 10	85-90	2-3 w

Vegetables	°C	R.H. %	P.S.L.
Green beans	7 to 8	92-95	1-2 w
Potatoes			
(ware)	4 to 6	90-95	4-8 m
(industrial)	7 to 10	90-95	2-5 m

Products very sensitive to cold

Fruits	°C	R.H. %	P.S.L.
Pineaples (green)	10 to 13	85-90	2-4 w
(ripe)	7 to 8	90	2-4 w
Avocadoes	7 to 12	85-90	1-2 w
Bananas (green)	12 to 13	85-90	10-20 d
(coloured)	13 to 16	85-90	5-10 d
Green lemon (a.o.v.)	10 to 14	85-90	1-4 m
Guava	8 to 10	90	2-3 w
Limes	8.5 to 10	85-90	3-6 w
Mangoes (a.o.v.)	7 to 12	90	3-7 w
Melons (a.o.v.)	7 to 10	85-90	1-12 w
Grapefruits	10	85-90	2-3 m
Papaws	7 to 10		1-3 w

Vegetables	°C	R.H. %	P.S.L.
Eggplants	7 to 10	90-95	10 d
Cucumbers (a.o.v.)	9 to 12	95	1-2 w
Ginger	13	65	6 m
Okra	7.5 to 10	90-95	1-2 w
Yams	16	85-90	3-5 m
Sweet potatoes	13 to 16	85-90	4-7 m
Sweet peppers	7 to 10	90-95	1-3 w
Pumpkins	10 to 13	50-75	2-5 m
Tomatoes (green)	12 to 13	85-90	1-2 w
(ripe)	8 to 10	85-90	1 w

R.H. : Relative humidity ; P.S.L. : Practical storage life ; d.c. : Depending on the class ; a.o.v. : According to origin and variety ; d : day ; w : week ; m : month.

Source : International Institute of Refrigeration, 1990.

correct temperature and timing of distribution, in addition to the functioning of the cold storage facilities themselves.

DEEP-FREEZING

Technique

This is a technique for long-term preservation at a low temperature, based on the fact that at -18, the most frequently used temperature, all of the causes of spoilage of food are considerably inhibited, and that the solidification of much of the water, which forms crystals, restricts reactions between the solutes. However, at -18°C, preservation does not exceed three months to two years, depending on the food, since modifications continue to occur, albeit extremely slowly. This is because the residual water in fluid form, which may represent 5 to 15 % of the total water, then has an extremely high solute content, which facilitates interactions between solutes , as well as increased denaturing of proteins.

When deep-freezing takes place slowly, only a small number of crystals is formed, and these are mostly located outside of the tissue cells, are large in size and are often elongated ; these crystals are extremely pure, and consequently the residual fluid is highly concentrated. Furthermore, the development of these large crystals causes gradual dehydration of the cells. These facts account for many of the problems encountered in thawed products, including softening of the tissues and exudation (cf. figure 11).

When deep-freezing is done rapidly, crystallization takes place both inside and outside of the cells, the crystals are not pure ice, and there is therefore less deterioration of quality caused by modifications in texture during thawing. As a rule, quick-freezing of food is recommended. In the case of meat, however, freezing should not take place before full maturation, and in the case of previously blanched vegetables, quick-freezing is not necessary since the cell walls have already been damaged by blanching.

Equipment

Deep-freezing techniques vary with the desired speed of freezing and with the type of food. The simplest, least expensive equipment consists of a closed chamber at a temperature of about -20°C in which batches of food are placed, producing relatively slow freezing.

Other types of equipment achieve deep-freezing more rapidly, by circulating cold air (between -20 and -50°C). Fluidized bed freezers are sometimes used for small-sized items of food (such as green peas), which are suspended in air by the strong stream of cold air

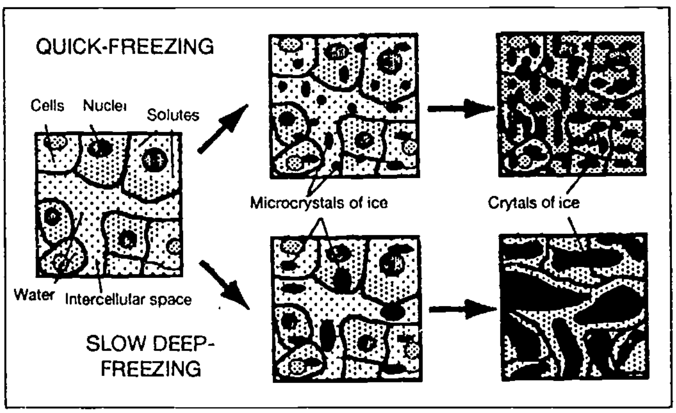

Figure 11 : A general representation of the microscopic formation of microcrystals then of crystals of ice during deep-freezing.
Source : CUQ JL, GUILBERT S. In DUPIN H et al. Alimentation et Nutrition humaines. Paris : ESF éditeur, 1992.

(cf. figure 12). Deep-freezing may also be achieved by contact with a solid (cold plates) or a fluid (liquid nitrogen, brine, etc.).

Duration of preservation

Theoretically, deep-frozen foods may be kept for long periods of time (24 months at -18°C for concentrated citrus fruit juices, 6 months at the same temperature for shrimp, from 4 to 8 months for fish) if the rules have been respected : freezing done soon enough, excellent quality of original product, cold chain maintained continuously with unfluctuating temperature constantly below -18°C.

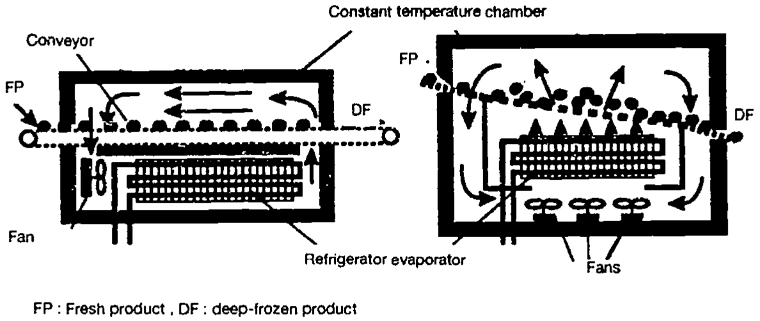

Figure 12 : Diagrams of industrial tunnel and fluidized bed type deep-freezing machines.
Source : CUQ JL, GUILBERT S. In DUPIN H et al. Alimentation et Nutrition humaines. Paris : ESF éditeur, 1992.

In practice, consumers are generally unable to determine whether these rules have been respected, especially when local conditions (frequent electricity failures, for instance) make this difficult.

Thawing

Thawing is also a delicate operation, and an important one which may impair the taste of the product and its healthfulness, if done improperly. The phase during which it is heated above 0°C is crucial in maintaining the quality of the food. It should be as short as possible.

For plants, the risk is mostly for their organoleptic qualities (taste, colour, consistency), whereas for animal tissues, the exudation occurring at that point may diminish their nutritive value (elimination of minerals, peptides and vitamins).

Furthermore, there is a considerable risk of germ proliferation during thawing, since deep-freezing did not destroy all of the germs present in the food. For a number of reasons, thawing food is particularly propitious to the multiplication of germs, which may cause food poisoning.

If thawing is not followed by cooking (for food eaten cold, such as pastry, pâté, fruit, etc.) it should take place in a refrigerator, in its original wrapping, to avoid the risk of microbiological and chemical deterioration of the article.

Thawing should not be done in water, since the nutritious components would be washed away, and germ proliferation would be stimulated. It is acceptable in some cases, but the food should then be left in its wrapping, and consumed rapidly once thawed.

Food should be eaten within 24 hours of thawing. Frozen food should never be refrozen, unless it has been cooked in the interval, in which case refreezing should be done immediately.

OTHER PRESERVATION TECHNIQUES

Sterilization by ionization

There are other methods for preserving food : these will be reviewed briefly here, either because they have been discussed in one way or another in other chapters, or because they are generally not in use in developing countries. This is the case of sterilization techniques based on irradiation or ionization, for example. The application of x and y-rays, otherwise called ionizing rays, to some foods such as potatoes, in very low doses, reduces sprouting ; in other items such as fruit and vegetables, it destroys potentially destructive micro-organisms. Ionization is rarely used, however, because of restrictive rulings for health reasons. Numerous nutrition-related and toxicological studies have been conducted, and no adverse effects have been uncovered at the doses used ; the World Health Organization, in collaboration with other United Nations agencies, has published several documents on this subject.

Chemical additives

The use of chemical additives is a well-known, time-tested method. Many compounds have an antimicrobial action (through their effect on the metabolism of germs) : sulphites and metabisulphites, benzoates and sorbates of sodium, potassium or calcium, nitrites (for salting meat) may be authorized by the local legislation, and are sometimes used illegally or in excessively large doses in a great many food products. Since close control of their use is difficult, there is a tendency for cottage-industry and factory producers to abuse of them, occasionally causing real public health problems, for two reasons : they are often used to cover up the mediocre quality of the merchandise, and secondly, they are used at doses which may induce intoxications.

Antioxidants such as sulphur dioxide and ascorbic acid are substances that reduce oxidation, and especially prevent rancidity in lipids.

Other additives

Other additives act in different ways, principally for the improvement of texture and of the organoleptic characteristics of the food: these are thickeners (starch, gelatin), emulsifiers (lecithin), flavourings and flavour-enhancers (such as sodium glutamate), acidifying agents (citric acid, tartaric acid), etc.

Each of these additives has been studied for toxicity, but while some governments are able to enforce restrictions and prohibitions, in many other countries illegal products (such as mineral acids, etc.) are in use, and legal additives are used at excessively high doses (for example : addition of 0.5 % or even 1 % of benzoate, whereas the generally accepted dose is 0.1 %). It is important that the official national agencies in charge of controlling the use of additives by the food industry dispose of sufficient means to be effective. The Codex Alimentarius is an extremely valuable tool for the international standardization of criteria, in terms of the quality, composition and healthiness of food.

Packaging

The packaging of food has several functions, including preservation. This important subject will be discussed in the next chapter.

As shown above for other types of techniques - smoking/salting, blanching/deep-freezing, UHT sterilization/aseptic "packs" - different methods are often combined to ensure proper preservation of food.

TECHNIQUES FOR THE PREPARATION, STORAGE AND CONDITIONING OF FOOD

The stabilization of articles of food for their preservation has been discussed at length in the previous chapter. For many foods other operations are required before and after this, in order :

- to extract the edible portion : the juice of sugar cane (by milling of the stalks), the grain from rice (by hulling and elimination of the husk), the root of cassava (peeling), etc. ;

- to achieve stability, through adequate storage and conditioning ;

- to make the food easy to digest and appetizing, through cooking.

EXTRACTION AND SEPARATION

A great many farm products are not consumed in their natural state, either because the edible portion is surrounded by a skin or a hard, indigestible envelope (this is the case of grain, tubers, etc.), or because there is a desire to concentrate a naturally diffuse substance (as in cane or beet sugar, fruit juice, cream, etc.). Last, it is often necessary to remove some undesirable parts (the seeds and skin of fruit for juice-making).

The techniques for performing these operations - some chemical, others physical - are too numerous to be discussed here : table 7 contains a non-exhaustive list of these.

Effects on nutritive value

It goes without saying that the efficiency of all of these separation and extraction techniques is imperfect and variable, since the shape, texture, physical features and composition of the natural animal or plant foods to which they are applied cannot easily be standardized : some fraction of the edible portion is discarded and lost, and some undesirable substances are only partially eliminated. Thorough hulling of millet and sorghum results in the elimination of part of the aleurone grain layer, which is particularly nutritious (it is rich in protein and vitamins) and in a lower percentage of extraction ; conversely, partial hulling does not remove all of the pericarp, making the grain difficult to digest and causing its rejection by consumers.

In the case of rice, a rather similar problem arises. The most efficient hullers, using rubber rollers, are more productive in terms of weight (total elimination of the pericarp but few grains broken or eliminated with the bran), but the aleurone grain layer is also partially eliminated, and at the same time their cost - and particularly the cost of maintenance - is much higher than for conventional hullers.

Table 7
Techniques for separation and extraction

OPERATION	FOOD INVOLVED	OBJECTIVE	TYPE OF EQUIPMENT
Shelling, threshing	Cereal grasses (maize, rice, millet, sorghum) Legumes in pods	Removal of the grain from the ear, separation of the seeds from the pods	Threshing using a club, hand or motor-run shelling and threshing machines
Hulling	Millet and sorghum : always Maize : occasionally Rice : with or without prior steaming Coffee, cacao, beans, etc.	Removal of the pericarp (the hard, cellulose covering) from the grain	Mortar and pestle (for dry or moist grain), hullers using mill-stones, metal cylinders or rubber rollers
Grinding, pulp removal	Fruit, cereal grains, legumes, coffee, cacao beans Sugar cane	Reduction of the pulp or the grain (dry or moist) to more or less fine particles, to facilitate subsequent preparation Grains (semolina, flour, dough, etc.) Fruit (juice, sauce, nectar) Crushing of the cane stalk to extract the juice	Mortar and pestle Grinders or mills : - using mill-stones - using hammers Fruit pulper Cane mill with vertical or horizontal cylinders
Grating	Roots, tubers, coconuts, sugar beets	Reduction of the pulp to small pieces to facilitate a subsequent operation (drying, extraction, fermentation, etc.)	Hand grater (a flat device with holes) Grating machine
Pressing	Oily seeds and fruit (peanuts, cotton, sunflower, palm, etc.) Secondary processing : cassava, cheese, etc.	Exertion of pressure on the substance to eject a fluid (water or oil-based)	Weight Screw-press Hydraulic press
Filtering	All fluids (fruit juices, cane juice, vinegar, etc.)	Separation of the solid particles from a fluid by passing it through a filter	Cloth, cellulose, sand, active coal filter, etc. (filtering substance = particles deposited during filtering)
Diffusion	Beet sugar (solvent = water) Soyabean, peanut, rapeseed oils, etc. (solvent = hexane)	Extraction of a substance (sugar, oil) from a solid by placing it in contact with a fluid (water or a solvent)	Diffuser
Centrifugation	Milk/cream, citrus fruit juices/essential oils, sugar crystals, etc.	Separation of two ingredients using their different densities by subjecting them to a centrifugal force	Centrifugal separator
Distillation	From juices containing alcohol (wine, chicha, cane juice) to spirits, rum, sake, etc. Essential oils from fruit juices (citrus fruit, etc.)	Extraction of the most volatile components of a fluid (alcohol, essential oils) by heating it : evaporation of the substances more volatile than water, and condensation	Still Distilling column
Decanting, sedimentation	Cassava starch, waste water, cane juice (panela)	Separation of ingredients of differing density on the basis of their speed of decantation in water, air, etc., following sedimentation	Filter-bed
Sifting	Flour, semolina etc. Fruit pulp	Separation of particles on the basis of their size, using a more or less closely meshed sieve	Perforated metal or meshed sieve
Peeling	Cassava Numerous roots and tubers Fruit and vegetables	Physical removal of the soft outer layer surrounding a root or fruit	By hand : machete, peeling knife, peeling machine using rubbing or abrasion

In a previous issue of this journal entitled "Food, its origin and nutritive value" (n° 205, 1993), the case of wheat flour with an excessively high extraction rate was discussed, with the ensuing loss of vitamins. The extraction of oil from many oily seed, proceeds by crushing followed by diffusion, using a solvent such as hexane, of the resulting press-cake, which still has a 10 to 25 % oil content : these successive operations arrive at a percentage of oil extraction of 98 or even 99 % without increasing the cost too much.

In the case of spirits, when wine containing methanol or propanol is improperly distilled, the end product may be rich in these two kinds of alcohol, and consequently highly toxic.

From the nutrition standpoint, two factors must be considered, then : the loss of nutritionally valuable substances through excessive extraction and the non-elimination of indigestible or toxic substances.

STORAGE

Because of the seasonal or cyclic production of many foods, and also because of eating habits, which put them on the menu regularly or exceptionally, articles of food must be stored for varying lengths of time, and at several points along the chain. Refrigeration and deep-freezing storage techniques for fresh and pasteurized products, which temporarily stabilize these, have already been discussed. There is no need to deal at any length with the storage of factory-produced items with a long shelf life, such as tins and UHT milk, for which the main precautions required are clean, dry facilities maintained at a moderate temperature, storage on pallets, tightly closing doors and windows, etc.

It is important to take a closer look at the storage of grains and seeds (cereal grains and legumes, but also coffee and cacao beans), which not only represent an extremely large portion of the world agricultural production, but are also capital for food security in developing countries. In addition, this storage takes place at all levels : by farmers, wholesale and retail sellers, government agencies in charge of regulating stocks, import-export agents, factories and consumers.

The basic rule for proper preservation is that only dry, healthy grain should be stored, in packaging or in facilities that protect them from moisture and from being attacked by rodents or insects, and at a moderate temperature.

In a great many developing countries, storage is first done on the farm, both for home consumption and for subsequent sale. This storage phase may last for varying lengths of time (ranging from several weeks to several months, or even years), depending on the need to constitute reserves (because of uncertain weather conditions), the need for money, the extent of home consumption and storage capacity.

Traditional storage methods vary from one region to another, depending on the climate, the building materials available, the grain itself and the sociocultural characteristics of the rural population. There are granaries made of mud, thatching or braided straw, as well as grating or platforms, a corner of a room in the dwelling place, earthenware jars, bunches of ear-bearing grass hung under a roof, etc. Grain may be kept on the ear (with or without the spathes in the case of maize) or piled up loose, alone or mixed with ashes, lime or sand to avoid massive infestation by insects.

In the past few decades some agencies for agricultural research and development have proposed many alternatives for the improvement of on-the-farm storage and the reduction of losses. Some of these have been enormously successful, while others have been only moderately popular :

- cribs (well-ventilated structures with wood pillars and bamboo or meshed cross-bars) are good for drying but do not afford protection against insects ;

- silos, made of various materials (bricks, mud, cement, sheet metal) and of varying capacity (from several hundredweights to several tons of grain) ;

- reused metal drums, etc.

Storage in silos

Use of a silo or drum requires that the grain be sufficiently dry (humidity 13-14 %) and free of insects. When the silo or drum is air-tight, a curative treatment with phostoxin (fumigation with phosphorus) may be delivered once it is filled. For larger scale storage (by cooperatives, specialized agencies, merchants, etc.) the most widely used method in developing countries is still storage in sacks, although loose storage is gaining ground.

Sacks made of burlap or woven polypropylene must be in good condition, clean and treated with an insecticide if reused, piles of sacks should be placed on pallets if there is a risk of moisture rising from the ground. The warehouse or storage facility itself should meet a number of conditions : easy access, absence of health hazards in the area, protection against infiltration of water, floor and walls easy to clean, water-tight roof, doors that close tightly, ventilation (in hot climates), etc.

In sacks

Warehouse storage requires cleaning and monitoring operations that must be performed with care if the quality and quantity of the food stored is to be maintained. The facility should be thoroughly cleaned and sprayed with an insecticide before being filled, the sacks of grain strictly checked upon arrival to avoid contamination of the entire batch by a defective article, piles of sacks given a curative insecticidal treatment by fumigation with phosphorus, rat traps set, sweeping and inspection performed at regular intervals.

Loose

There are many types of facilities for storage of loose goods, ranging from sheet metal or cement block units housing several tons to large 500-ton silos and even to some huge silos with a capacity of over 100,000 tons. These vertical silos, made of corrugated or flat galvanized sheet-metal or aluminium, which may be up to 20 metres high, are quite advantageous in that they are built rapidly and are inexpensive.

There is a risk of condensation inside the silo, however, because of variations in temperature between day and night, and occasionally because of excessive moisture in the stored grain : the consequences of this (oxidation of the inner side of the sheet metal, deterioration of the grain) may be disastrous. This risk may be reduced by use of fans, thorough drying of grain and insulation of the silo. Reinforced concrete silos are more complicated to build, but they last longer : fumigation of grain by an insecticidal gas is not feasible in them, however, because they are porous.

Permanent ventilation is required, in any case, to eliminate the heat produced by the respiration of the grain.

PACKAGING

Throughout their travels, during transportation, storage and commercialization, goods are usually protected by packaging or wrapping that protects them from shocks, contamination by germs, sometimes from air, heat, light, etc, and also makes them look appealing.

Materials

The materials used to package food vary enormously depending on the problem to be solved, the article of food itself and local constraints. Wooden boxes or woven baskets for carrying fruit, earthenware jars for storing olives, banana or maize leaves for wrapping cheese or cassava dough, glass jars, etc., are effective, time-tested solutions. The more recent development of tins, followed by plastics and other complex materials has gone hand in hand with technical advances, producing heat sterilization, UHT milk packs, tin-plate soft drink cans, etc.

The choice of the type of packaging depends on the material available and on cost, as well as on the objectives : the choice of materials is often limited in developing countries. When the package is in direct contact with food, it is essential to make sure it is safe. In the case of metal containers, the application of a lacquer on the inside avoids corrosion and thus prevents tin and lead from crossing into the food, especially when the latter is corrosive (contains nitrates, sulphur compounds, caramel, etc.).

In the case of plastics, monomers such as vinyl chloride should be eliminated, and the cross-over of certain adjuvants used in making plastics avoided, since they may be toxic.

Even in countries where the legislation is very strict about packaging materials, certain potentially toxic or unsanitary packages are sometimes used. On the streets of some cities food may be wrapped in paper from old bags of cement, and in some parts of Asia there are informal recycling shops where used plastic bags are washed and dried, to be resold.

In many countries, the plastics industry is particularly developed, and bags, packets and films are sold at an extremely low price, whereas glass and metal containers are rare and costly. This raises environmental problems. The recycling of glass bottles may reduce both costs and environmental hazards in some cases.

COOKING

One of the last phases in the transformation of food is cooking : heat facilitates digestion and improves taste ; when several foods are mixed, and other ingredients (sugar, salt, spices, etc.) are added, the end product is more pleasant to the palate. Cooking usually improves nutritive value as well. There are many techniques, most of which have been in existence for ages : they are summarized below.

Boiling and steaming

The temperature of cooking water is moderately high (about 100°C), and some substances cross over between the water and the food : dry goods (rice, beans, corn, etc.) absorb water, while moist ones (meat, fresh tubers) loose some. For this reason, nutritive value should be calculated for the cooked food rather than for the raw one, since nutritive density, and energy density in particular, per 100 grammes, may either be increased (as in the case of tubers) or decreased (for rice) by cooking. If the water is very salty or sweet, the food absorbs salt or sugar : part of the flavoursome substances of the food (meat, vegetables, etc.) cross over into the water, which then becomes a broth with some nutritive value of its own. In homes, steaming is done in autoclaves (pressure cookers), at temperatures that easily reach 110°C, thus ensuring rapid cooking and reducing losses of certain nutrients.

Cooking in hot air

This is one of the oldest cooking methods : in ancient times, hunters cooked their game over open fires. Later, ovens were developed, first fuelled by wood, then by coal, gas and electricity.

Microwave cooking is a similar method, but one which is based on the rapid movement of the water molecules contained in the article of food, caused by electromagnetic radiation ; since the temperature does not exceed 100°C, its effects are more moderate than in the case of cooking over a fire or in a stove, where the temperature may be as high as 200 or even 300°C.

Frying in fat or oil

This technique is frequently used for potatoes, fritters and a great variety of other foods. For deep-frying, a vegetable oil - preferably a saturated one - is used, to reduce oxidation, otherwise caused by unsaturated fats, and which affects nutritive value negatively. For pan-frying, animal fat is often used. Frying temperatures range from 130 to 170°C.

Effects of cooking on nutritive value

Cooking, the last step in the transformation of food, generally takes place in homes shortly before food is eaten. It is necessary to improve the taste, consistency and digestibility of certain items : for instance, raw egg white cannot be modified by the gastric juices, whereas once coagulated by heat it is completely absorbed by the intestine ; the raw starch in starchy foods cannot be assimilated without cooking.

It is also important to ensure a degree of healthfulness, since adequate cooking destroys the germs responsible for food poisoning. However, it may also considerably modify the nutritive value of food. Maillard's reaction, mentioned above, impairs the nutritive value of food to varying extents. This reaction, which peaks at a relative humidity of 70-80 %, is greatly stimulated by heat and especially affects food during roasting or broiling. In this reaction, the free sugars act on the amino acids, making them useless for the organism. Losses mostly involve lysine, thus creating an imbalance in the dietary amino acid ration, and reducing its ability to cover requirements.

Lactose-rich dairy products and roasted cereal grains are most seriously threatened. Dry legumes and meat are more resistant. Maillard's reaction may also be deliberately sought, to improve the organoleptic properties of some substances such as bread crust, roasted peanuts, biscuits, etc.

The intense or repeated heating of fatty acids, and particularly of frying oils containing unsaturated essential fatty acids results in a transformation of their linear structure. They are then more difficult to digest, disturb the utilization of several nutrients and are toxic. The same is true for certain end products of heat breakdown, such as acrolein, which gives its acrid smell to oils that have been overheated for too long : it is important to change oils used for frying often. In addition to this direct effect of frying, the oil may turn rancid, and the combination of the two may result in a lower nutritive value or even make food toxic.

Sugars, on the other hand, are very stable when cooked. Only caramelization (heating when very little water is present) deteriorates them.

Vitamins, which are extremely sensitive to exposure to high temperatures, may also be directly or indirectly destroyed by other influences : light, oxidation, pH (acidity or alkalinity).

Losses during transportation prior to distribution to consumers (sometimes as much as 50 % of the ascorbic acid content for fruit and vegetables having travelled for considerable lengths of time) and those induced by the initial preparation (as in grinding of grain) are further compounded by losses caused by cooking, with deterioration of thiamine, pyridoxine (vitamin B_6), vitamin B_{12} and ascorbic acid, while heat also causes oxidation which destroys retinol, carotenes, folic acid, vitamin E and ascorbic acid.

An alkaline cooking medium will tend to destroy thiamine. Generally speaking, vitamins resist better in an acid environment. Vitamin D and niacin are most resistant to cooking.

Practically speaking, loss of vitamins may be limited by respecting several rules : cook the food with its skin in as little boiling water as possible, for as short a time as possible, avoid cutting it into small pieces, and if possible use pressure cooking, consume the cooking water.

When food is cooked in water, the water-soluble minerals tend to cross over into the cooking water : for vegetables, up to 60 % of the potassium, 40 % of the iron, 30 % of the calcium and 50 % of the copper may be lost to the water ; for fish, 80 % of the iodine. Heat sterilization causes the minerals in the food to dissolve in the covering liquid. It is important to consume the liquid contained in cans and tins or in which food has been cooked, to keep losses to a minimum.

NUTRITION-RELATED CONSEQUENCES OF FOOD PROCESSING

The preservation and preparation of the products of farming, animal husbandry and fishing - be it at the household, cottage industry or industrial level - produce organoleptic and nutritional modifications. Most are positive, and some are actively sought, but others may lower the nutritive value of the final product eaten by the consumer. Understanding of the nutrition-related effects of various treatments may be helpful in foreseeing the nutritive value of the processed food, but may also be used in attempts to reduce losses of nutritive value, either by improving the technique or by replacing it by a less destructive one. This is illustrated by the replacement of sterilization of milk at a low temperature for a long lapse of time by the UHT method (high temperature, short time), which retains the original taste and nutritive qualities of milk.

Some of these changes have already been mentioned in the part devoted to the different techniques. They are discussed more systematically below, and for convenience of use, are grouped according to the nutrient involved.

Carbohydrates

Fibre

The fibre contained in plant foods (cereal grains, tubers, fruit and vegetables) is composed mainly of cellulose, hemicellulose and lignin, and is not used during digestion, even following cooking.

Consumption of fibre-rich food accelerates intestinal transit and therefore reduces the uptake of other nutrients, and especially of proteins, by the body. Extraction techniques eliminate some of the fibre contained in the envelope of cereal grains (polishing of rice, bolting of wheat, etc.), but the price is a loss of vitamins, and of thiamine in particular.

The choice of an extraction rate therefore involves a compromise between a high vitamin content and a low availability of these same vitamins as well as of minerals, because of the presence of fibre, or the reverse. Cooking softens fibres and facilitates their consumption.

Starch

Starch is one of the most abundant carbohydrates present in food. Its characteristics (shape and size of the grains, amylose content) vary with the food (rice, cassava, maize, potato, etc.).

Starch is insoluble in cold water but forms a gel when heated in a large volume of water : the grains incorporate water and swell, and the mixture thickens. This gelatinization enhances the digestibility of starch. When little water is present during cooking (as in the case of frying), gelatinization is incomplete. During the cooling following cooking, a reversal may occur which then reduces the digestibility of the starch.

Sugar

Saccharose is not significantly modified during processing, except in the case of caramelization. When saccharose is heated in an acid medium, as is the case in the making of fruit marmalade, it is hydrolysed into simple sugars ; its nutritive value is not affected.

Simple sugars - glucose and fructose - are present in many breads, biscuits, sweets and fruit-based foodstuffs. When heated in the presence of amino acids, these reducing sugars may cause Maillard's reaction to occur, thus making the former unavailable for use by the body. Maillard's reaction may occur during the storage of dry cereal grains if the temperature is too high, but its effect is mostly observed during cooking.

Protein

Denaturing

Cooking of protein-rich food denatures the protein ; that is, it causes modifications in the shape of the protein molecules, which do not affect the amino acid chain itself. This denaturation puts an end to the biological activity of the protein and improves its nutritive value in several ways :

- increased digestibility of collagen (meat requiring prolonged cooking) and of ovalbumin (egg white) ;

- inactivation of antinutritional proteins, or phytohaemagglutinins, contained in certain legumes (soya, peanuts, beans, etc.) ;

- inactivation of another category of proteins - enzymes - with many detrimental effects on nutrients (lipases, proteases, etc.).

Proteins may also be denatured by acidification (whence the "cooking" of fish and shellfish in lemon juice for Latin American "ceviches").

Maillard's reaction

When a protein-rich food is heated in the presence of reducing sugars such as glucose, lactose or fructose, it is browned by Maillard's reaction, which has been discussed above. This has many nutritional consequences : loss of availability of lysine, development of antinutritional substances.

This reaction is reinforced as the temperature rises, and it occurs essentially in semi-moist food. Furthermore, it should be pointed out that Maillard's reaction also induces modifications in the taste and colour of many foods, which are appreciated and even sought, as in the case of biscuits, broiled meat, etc. Use of high heat (between 100 and 200°C) as in the case of sterilization, cooking in an oven or over an open fire, causes the destruction of amino acids, whence a drop in the nutritive value of the protein.

Decomposition

When protein-rich food is exposed to a very high temperature (when meat or fish is broiled over an open fire, for instance), the amino acids are decomposed into mutagens, which are therefore potentially cancerous. Many other reactions may take place under specific conditions, but they are less important.

Lipids

The main phenomena affecting the nutritive value of lipids are oxidation, hydrolysis (or lipolysis) and decomposition by heat.

Oxidation

The oxidation of lipids - that is, rancidity - occurs spontaneously when the lipid is in contact with air. Lipids turn rancid rapidly and massively when they are rich in polyunsaturated fatty acids : that is, in acids with several double bonds.

This takes place during storage at room temperature or refrigeration, and even in deep-frozen foods, and may be limited by protecting the foodstuff from contact with air, using an air-tight wrapping. The main consequence of oxidation is the development of a rancid odour and taste, which may make the food unfit for eating ; this may be accompanied by a slight loss of nutritive value. Often antioxidant agents are added to food to limit the risk of its becoming rancid.

Hydrolysis

Heating of fat to a high temperature (170-200°C) may cause hydrolysis, especially in the case of frying, since the food fried (potato, plantain, etc.) contributes its water. This is all the more patent when heat-unstable oils such as soyabean and rapeseed oil are used, and leads to the destruction of essential fatty acids (linoleic and linolenic acids) with a consequent significant decrease in the nutritive value of the oil. Furthermore, high temperatures also cause the breakdown of the fatty acids into a great many substances, some of which are toxic.

Last, heating hastens oxidation, yielding other harmful substances (peroxides). To avoid all of these hazards, only very heat-stable oils such as peanut oil should be used for frying, they should not be heated to temperatures exceeding 180°C, frying time should be short and above all the oil should not be reused too often. Indeed, the elimination of essential fatty acids and the accumulation of toxic substances are the outcome of repeated, haphazard reuse of frying oil.

Vitamins

The vitamin content of food varies enormously, even before any transformation : it depends, among other factors, on ripeness in the case of vegetables, and may drop extremely rapidly immediately after harvesting (or slaughtering in the case of animal products).

Sensitivity

The sensitivity of vitamins to various types of processing varies : vitamins C (ascorbic acid) and B_1 (thiamine) are reputedly very fragile. Furthermore, they have differing sensitivity to a number of factors, including temperature, oxygen, pH, humidity, length of storage, light, presence of enzymes.

For this reason, certain vitamins are viewed as stable for a given type of treatment : for instance, fat-soluble vitamins (A and D) are quite resistant to heat, and therefore to techniques involving heating. Another illustration : blanching of vegetables causes immediate destruction of some vitamin C, but stops subsequent losses during storage by inactivating the enzymes responsible for the breakdown of this vitamin. Overall, then, blanching limits losses of vitamin C in vegetables that are intended for storage.

Elimination

Aside from the vitamin-destructive elements (heat, light, etc.), one major cause of losses is their elimination during extraction (the envelopes of some cereals are rich in thiamine, biotine, etc.), peeling (fruit) and boiling (vegetables).

During boiling of vegetables as well as of meat of the boiled beef type, a large proportion of the water-soluble vitamins (vitamin C, thiamine (B_1), etc.) crosses over into the cooking water and is therefore lost if the broth is not consumed. As an example, figure 13 illustrates the different extents of loss of vitamin C in a vegetable, depending on the technique used.

In conclusion, table 8 shows the main modifications occurring in vitamins during different types of treatment.

Minerals

Some techniques lower the mineral content of food. This is particularly true of hulling of cereal grains (the envelopes are rich in minerals) and boiling of meat, fish and vegetables (diffusion in the cooking water). In the latter case, losses may be reduced by recovering the cooking water. The uptake of certain minerals may be improved by some processing methods. Alkali maize cooking techniques in central American countries increases the calcium content of maize dough. This is also the case of iron, zinc and calcium in fibre-rich foods (legumes, cereal grains), the uptake of which is combated by the presence of phytates (antinutritional factors for minerals). Pasteurization, different types of fermentation (bread, porridges made of cereal grains, etc.) break these phytates down, thus improving the bioavailability of minerals.

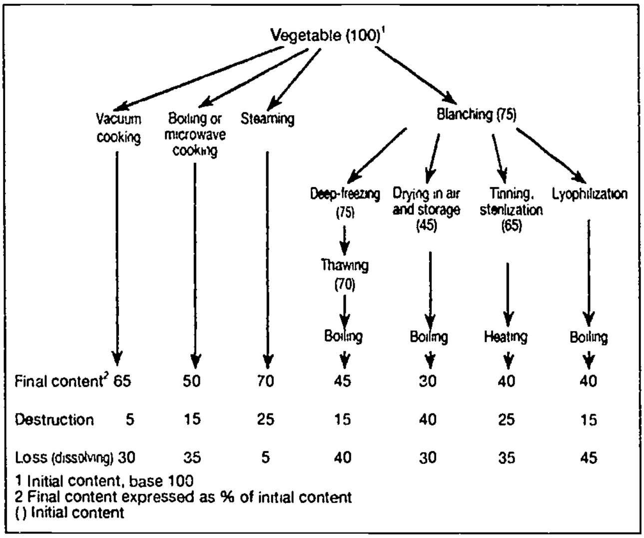

Figure 13 : Changes in the vitamin C content of a vegetable-type food with different home or industrial preparation techniques.
Source : CUQ JL. In DUPIN H et al. Alimentation et Nutrition humaines. Paris : ESF éditeur, 1992.

In developing countries where large amounts of cereals and legumes are eaten, mineral deficiencies may be observed when other foods do not provide compensation : the incidence of transformations undergone by cereal grains and legumes on the bioavailability of minerals is therefore particularly important.

The example of cassava

Few sorts of farm produce have been studied to determine the effects on nutritive value of various treatments done at the household and cottage industry level : the ORSTOM (1) has conducted research on cassava and sorghum. Table 9 summarizes the findings for various ways of preparing cassava in Africa.

(1) Favier J.C. Valeur alimentaire de deux aliments de base africains : le manioc et le sorgho. Paris : ORSTOM. Travaux et documents de l'ORSTOM, 1977.

Table 8
Modifications in vitamins during home or industrial cooking

Treatment	Water-soluble vitamins									Fat-soluble vitamins		
	Vit C	Vit B_1	Vit B_2	Vit B_5	Vit B_6	Vit B_{12}	niacin	folate	biotin	Vit A	Vit D	Vit E
Post-mortem or after harvesting	D						D					
Peeling, paring	LL						LL					
Grinding, milling*		LLL	LL	L	LLL	LL	LLL	LL			L	
Washing	L	l	l	l	l	l	l	L				
Heating in water**	LL,D	L,D	L, d	L, d	L, d	L	L, P	l, d, P		D		
Steam	l, d	l, d	l, d	l, d	l, d	l	L, p	l, d, P		D		
Maillard's reaction	DD											
Oxidation***	D							d	d	D	D	D
Sulphites	P	D				d		d				
Nitrites	d (pH4)	D						d		d		
Ethylene oxide		D										
Alkaline treatment	d	D	d	d	D	d		d	d			
Drying in air	d				d					D	d	
Light			D		D	d			d		D	
Irradiation	D	d	d			d				D	d	D
Cysteine					D	P						
Carboxyle compounds		d		d	d							

** with elimination of the germ, bolting*
***negative effects of heating mostly increase as temperature rises*
**** lipid peroxides, hydrogen peroxide, etc.*
L : major or minor (l) loss through physical elimination or diffusion, usually in water
D : major or minor (d) destruction
P : positive effect, an active form is generated
Source : CUQ JL, GUILBERT S. In DUPIN H et al. Alimentation et Nutrition humaines. Paris : ESF éditeur, 1992.

Table 9
Effects of the type of preparation of cassava on its nutritive value

Cassava-based food / Nutritional efficiency (1)	Boiled root	Stick	Gari	Retted, dried flour	Retted, dried, smoked flour	Dried flour smoked following retting after peeling
Calories	95 %	70 %	95 %	75 %	75 %	65 %
Proteins	86 %	47 %	77 %	78 %	70 %	50 %
Vitamins						
• C	7 %	7 %	11 %	0	0	0
• Thiamine (B_1)	70 %	35 %	58 %	62 %	40 %	28 %
• Riboflavin (B_2)(2)	98 %	>100 %	80 %	100 %	>100 %	80 %
Mineral						
• Iron (3)	100 %	50 %	300 %	150 %	---	30 %
• Calcium	96 %	50 %	76 %	76 %	50 %	45 %

(1) Percentage of nutritive value of the raw, peeled root.
(2) Bacterial fermentation causes enrichment of cassava with riboflavin.
(3) The iron content of certain end products is extremely high, owing to the incorporation of dust and the contact with iron cooking utensils ; this iron cannot necessarily be assimilated by the organism.

CONCLUSION

From food to nutritional status

This issue has dealt essentially with the principles and techniques by which food is prepared and preserved, as well as their consequences in terms of nutritive value.

One important point pertains to the sequence of operations ; that is, the successive techniques applied to an item of food from the moment it is harvested (or slaughtered in the case of animals) to its consumption. The sequence of phases, the conditions prevailing during each of these, the time factor, etc., all affect the nutritiousness and healthfulness of the final product. The best-equipped factory for the deep-freezing of shellfish may produce an excellent article, but an insufficiently low temperature during refrigerated transportation and/or storage in the refrigerated compartments of stores is enough to impair this quality. The cleanest cheese-making factory with the most qualified workers will be unable to make good cheese if the quality of the milk is not satisfactory because of contamination by pathogens introduced during milk-collecting, by too much handling under unsanitary conditions. When poorly dried following harvesting, peanuts contain aflatoxins which cannot be eliminated totally during subsequent processing.

The itinerary

In short, to be sure of the nutritiousness and cleanliness of the final product, we must be sure that the raw material is sound and that each of the operations has been performed under acceptable conditions.

Other points must be taken into consideration in assessing the nutritiousness of any foodstuff. First of all, the particular item must be situated in an overall picture :

- the amount of the food actually consumed ;

- the dish, composed of different foods intended to be eaten together ;

- the meal, a series of dishes and beverages, often accompanied by bread, flatbread, etc. ;

- the sequence and variations in meals in the course of a day, a week, a season.

Nutritional requirements

Within this whole, each particular food may cover certain nutritional requirements. The extremely seasonal consumption of mangoes in the two-month period during which they are ripe suffices for the local population, including its children, to constitute sufficient reserves of vitamin A (which is stored in the liver) to cover much of their annual requirements. Conversely, water-soluble vitamins (including vitamin C) must be eaten regularly, since the human body is incapable of storing them. The consumption of two foods containing protein (cereal grains and legumes for instance) with different limiting amino acids may amply cover protein requirements, provided the two are eaten simultaneously, but this will not be the case if the two foods are not eaten during a same meal.

In addition, there are the conditions under which the food is eaten : in the street, at home or in a canteen, by a person alone or in a group. Each individual's share, the amount remaining in the dish or on the plate may make a great difference in estimations of the actual consumption of each person.

Purchasing

More generally speaking, we cannot confine ourselves strictly to considering nutritive value when establishing recommendations with respect to food. The act of deciding what food to purchase involves a number of financial, social, ideological, psychological and other criteria, and the appearance, packaging, size, price, place of sale, etc. are all taken into account by consumers, be they adults, small children or adolescents. In doing so, they very rarely act on the basis of "rational nutrition".

The amount of income, but also its regularity, dictate choices ; the type of occupation as well as related constraints linked with free time and place of work also play a role. Last, eating habits are strongly influenced by the positive or negative religious, ethical and social (urban/rural, rich/poor, traditional/modern, etc.) connotations attached to food.

To be effective, activities aimed at improving nutritional status must take these different points into consideration, and they should do so dynamically rather than statically, since patterns of consumption and eating habits change, reflecting the trends in the societies of which they are a part.

DID YOU KNOW...

Other documents on food may help you :

ASIEDU JJ. Processing Tropical Crop. A technological approach. London : Macmillan publishers Ltd., 1989.

International Institute of Refrigeration. Manual of refrigerated storage in the warmer developing countries. Paris : International Institute of Refrigeration, 1990.

AVAILABLE ISSUES

*Double issue.

TO BE PUBLISHED

- Tiny development projects and the economy
- The ANDES programme in Ecuador

SUBSCRIPTION OR ORDER FORM

LAST NAME : ....

FIRST NAME : ....

PROFESSION : ....

ADDRESS : ....
(Street or P.O. Box)

TOWN : .... POST CODE : ....

COUNTRY : ....

I order issues numbers : ....

....

.... simple issue(s) x US$ 10 (50FF) ☐

.... double issue(s) x US$ 14 (75 FF) ☐

I subscribe (1) to the journal for US$ 40 (220FF) ☐

ENCLOSED FIND THE TOTAL AMOUNT OF ☐

by bank transfert to Banque Transatlantique
RIB 30568 00000 0061254574239 ☐

by check (FF) ☐

by money order ☐

to the order of CENTRE INTERNATIONAL DE L'ENFANCE

RETURN TO : CHILDREN IN THE TROPICS
INTERNATIONAL CHILDREN'S CENTRE
Château de Longchamp
Bois de Boulogne
75016 PARIS (FRANCE)

(1) 6 issues per year

NB : A special price could be allowed for an important order.

Founder · Prof. J. SÉNÉCAL
Managing Director : Prof. H. DUPIN
Editor in Chief : Dr. A.-M. MASSE-RAIMBAULT
Imprimerie Rosay, 47, avenue de Paris, 94300 Vincennes - Dépôt légal : 4e trimestre 1993 - 23030
N° de commission paritaire : AD 1622 - N° ISSN : 0379-2269

FOOD PROCESSING :
TECHNOLOGY AND NUTRITIVE VALUE

1993 - N 207

Everywhere around the world, to varying extents, families no longer confine their consumption to the produce of their own farming or animal-raising activities, but increasingly rely on processed food. Following the analysis, in a recent issue, of the different foods and their value as nutriture, the author now describes the ways in which food is prepared and preserved both traditionally, by cottage industries and in factories, and the impact of these methods on nutritive value.

Techniques relying on reduced water activity (drying, smoking, dehydration), on modifications of pH, use of heat or cold and storage systems are described simply.

In conclusion, the author stresses the great many factors to be taken into consideration when assessing the actual nutritional impact of any food. These include the quality of the raw material, the cleanliness observed during handling at various points in the processing, the amount, variety and complementarity of the different foods eaten, the succession and variety of meals over the weeks and seasons. As she clearly points out, "rational nutrition" is not in the forefront of eating habits: family choices are guided by economic, social, cultural, religious, ideological and psychological factors, as well as by the availability of food on the market.

"Sowing seeds in the school garden". Picture by Doctor Edmundo ESTEVEZ. The ANDES programme in Ecuador.

CENTRE INTERNATIONAL DE L'ENFANCE

BEST COPY AVAILABLE

INTERNATIONAL CHILDREN'S CENTRE
Château de Longchamp
75016 Paris - France
Tél. : (33-1) 45.20.79.92 • Télex 648 379 F
Fax : (33-1) 45.25.73.67