Food Preservation[a]

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Food processing, to a large extent, embraces techniques of food preservation, as in addition to producing modified products spoilage is also reduced. The main distinction between preservation and processing lies in the fact that processing may be carried out solely for the purpose of extending product lines and variety and not necessarily to extend shelf life as in preservation. The production of soft drinks, fruit syrups, glazes, and some snack products among many others, are examples of "value-added" products produced primarily to provide convenience foods, increased profits and the enjoyment of the consumer.

Methods of preservation used to extend shelf life include the following:

- Removal of moisture
- Temperature control
- pH control
- Use of chemical preservatives
- Irradiation

Figure 1 outlines the main operational exercises involved in preservation.

Figure 1: Methods of Food Preservation

COLD	HEAT	DRYING	FERMENTATION	CHEMICAL	PHYSICAL
Freezing Chilling	Cooking Pasteurization Canning	Tunnel Solar Spray Vaccum Freeze Drying	Alcoholic Acetic Lactic	Sugar, salt, spices, acid Preservatives e.g. benzoates, nitrites Additives e.g. antioxidants	Filtration/ Separation Distillation Irradiation Concentration Modified/ controlled atmosphere packaing

[a]*Adapted from: FAO/CFNI Publication "Food and Nutrition Resource Manual for the Small-scale Food Processor in the Caribbean".*

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CAUSES OF FOOD DETERIORATION

Preservation techniques are designed to counteract or slow the changes which cause deterioration by:

- Microorganisms
- Enzymatic Reactions
- Chemical Reactions

Microorganisms

Microbial spoilage may result from excessive numbers of bacteria, yeast and moulds in foods.

Factors affecting microbial spoilage of food include:

- The number and type of contaminating microorganisms
- Moisture (and water activity)
- pH (level of acidity or alkalinity)
- Presence or absence of oxygen
- Type and availability of nutrients
- Temperature
- Physical state of the food

Enzymatic Reactions

This phenomenon occurs mostly in fruits and vegetables as a result of certain enzyme catalysing reactions on components in the food. A typical example is an unappealing brown discoloration, which is seen when peeled ripe bananas or sliced apples, pears or some vegetables are exposed to the air. This discoloration is unappealing to the consumer. Enzymatic spoilage also causes the production of off-odours and off-flavours in foods such as meats and meat products. In order to prevent this type of spoilage the enzyme in the food has to be inactivated before storage.

Chemical Degradation

There are two common types of chemical deterioration of foods:

- Oxidative Rancidity due to breakdown of fats occurs in fatty foods, fats and oils, especially those with high levels of unsaturation. This is evident in fatty fish such as mackerel. This also results in production of off-flavours and off-odours.
- Non-enzymatic Browning – This occurs when sugars and amino acids present in the food go through a series of reactions producing a brown colour in the food. This is referred to as Maillard Reaction. The development of a brown colour and the accompanying flavour in the baking of bread, brewing of beer and roasting of coffee are desirable attributes of this reaction. However the browning of dried milk in storage is a highly undesirable effect.

Carmelization of products which are high in sugar due to direct or excessive exposure to heat as may occur in syrups, candied fruits, jams and jellies are examples of this. There is also the oxidation of ascorbic acid on exposure to oxygen that may occur in foods high in this nutrient.

PRESERVATION TECHNOLOGIES

Methods of preserving an array of local products for use throughout the year have been based on traditional methods. More sophisticated techniques such as irradiation may also extend shelf life mainly by the destruction of enzymes and the inactivation of microorganisms. This technique is often used on fruits and vegetables, meats, potatoes, onions and dried spices. This technology is expensive and is not applicable to small-scale processing.

Drying

Drying or dehydration involves the removal of water from the food by controlled processes. This may be done by:

- Evaporation due to heating of the product, e.g., drying of fruits.
- Osmotic dehydration, e.g. brining of fish.
- Sublimation, or freeze drying e.g. in the drying of coffee.

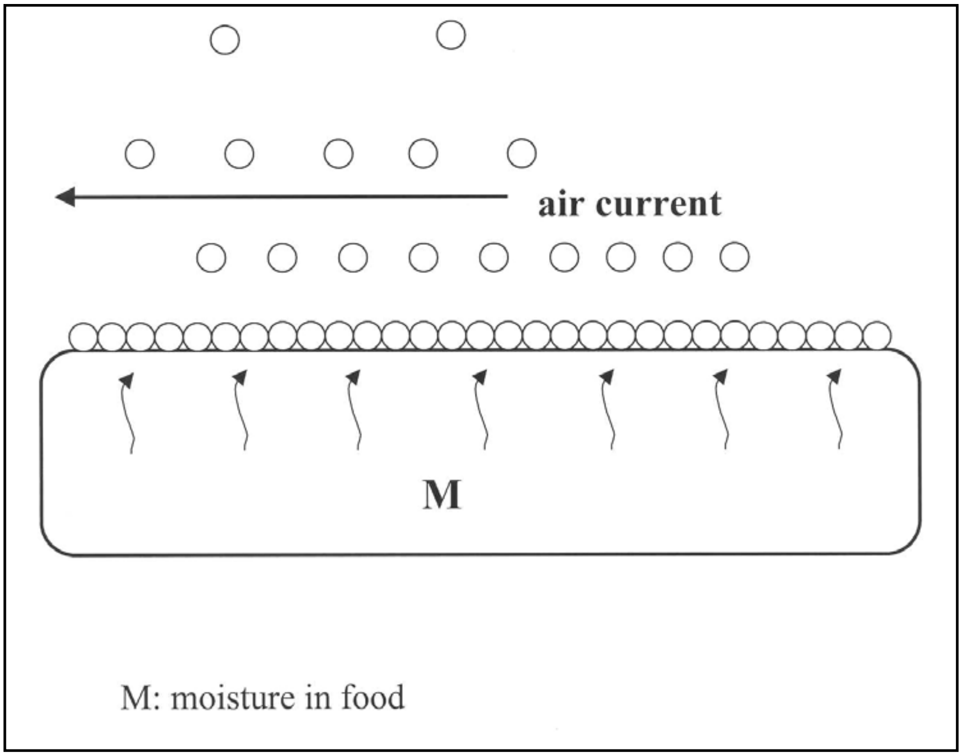
There are two distinct stages in this technology. In the first stage, the removal of surface water depends solely on the state of the air surrounding the food, such as its temperature, relative humidity and speed. In the second phase of drying, the moisture within the food moves to the surface. As the air is heated, its relative humidity decreases, resulting in more absorption of water. Here the rate of drying is dependent on the time the moisture takes to get to the surface. The heating of the air around a food product can therefore cause it to dry more quickly. By the same token, as the food loses moisture, the time the moisture takes to get to the surface becomes increasingly longer and drying therefore becomes slower as shown in Figure 2.

It should be noted however, that although the shortest drying time may be preferred, in the case of starchy foods, the common change of "case hardening" may result. In such an event, water removal from the surface is much faster than the rate at which water migrates from the interior. The surface, therefore, dries into a hard layer, which actually prevents the migrating water from reaching the surface.

Types of Dryers

With this method of preservation, most flavours are retained, there is a less bulky product (reduced shipping costs) and the shelf life is extended. Drying is an excellent way of preserving several of the Caribbean's seasonal fruits for use during the off-season. There are several types of dryers which are used. These include:

Figure 2: Removal of Water Vapour



Adapted from: Technical Manual – Basic Food Processing, FAO, 1985.

- Drum Dryer
- Cabinet Dryer
- Tunnel Dryer
- Drum/Rotary Dryer
- Spray Dryer
- Solar Dryer

There are four basic methods of drying. They are as follows:

- *Air and contact drying under atmospheric pressure* – In this case, the heat is transferred through the food either from heated air or heated surfaces, and the resulting water vapour is removed with the air current (Figure 2). Solar drying, sun drying, drum and spray drying all use this technique.

- *Vacuum drying* – Since evaporation of water takes place more readily at lower pressures, drying under vacuum is faster. This method is more expensive than air-drying and is reserved for specialised products.

- *Freeze-drying* – Water is removed by sublimation from frozen foods. Although the food structure is better conserved, the equipment and its maintenance are costly.

- *Solar Drying/Sun Drying* – Sun drying and solar drying are obvious alternatives for this region due to the abundance of natural sunlight. Although the two terms are sometimes used interchangeably, for the purpose of this manual, sun drying refers to the removal of moisture by merely placing the commodity in the sun, e.g., on a barbecue, rack, etc.

Limitations of traditional sun drying include the following:

- Moisture loss is intermittent, as it is largely dependent on the weather.
- Drying rates are usually slow and do not result in high quality products.
- Moisture levels are too high for prolonged storage.
- Insect infestation.

Solar drying, however, involves capturing and concentrating solar energy for the purpose of removing water. This method has increased in popularity, although commercial solar dryers with high rates of efficiency are often quite expensive.

The advantages of solar drying over sun drying include:

- Faster drying rates as higher air temperatures are generated.
- Lower final moisture content of the finished product.
- Greater protection of the product from rain, dust, pests.
- Low insect and mould infestation due to higher temperatures.

Essentially, there are two types of solar dryers – direct and indirect. Regardless of which type is used, it is important to have information on the seasonal and daily variation of sunshine, humidity, temperature, wind speed and direction during drying.

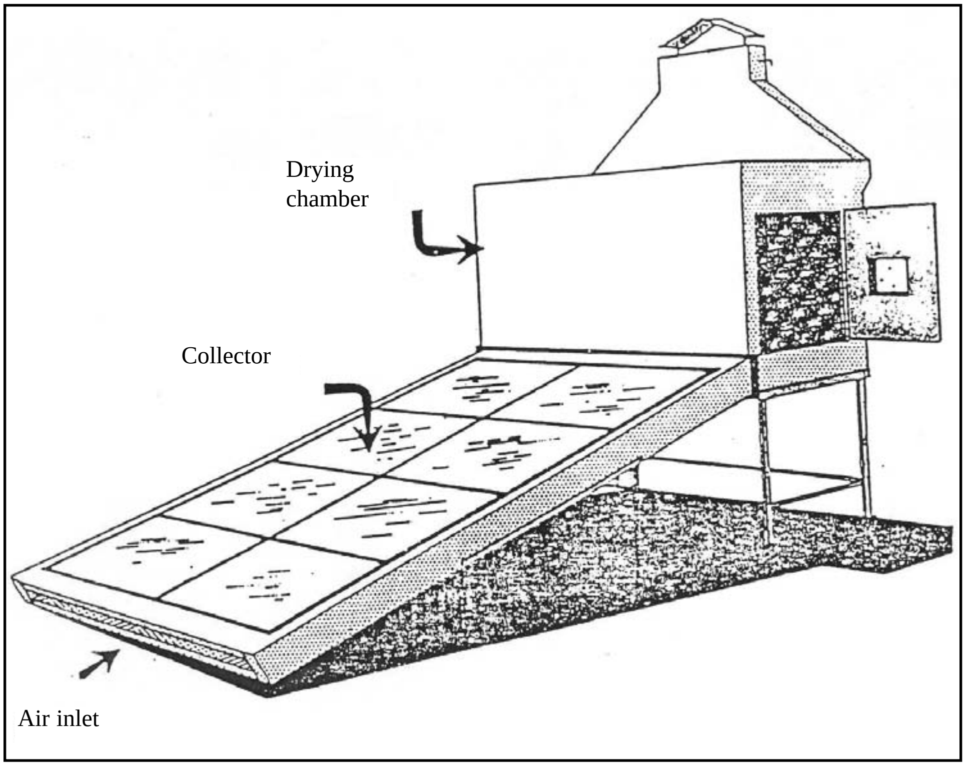
When the direct solar dryer is used, air is heated in the drying chamber, which acts both as the solar collector and drier. The indirect dryer on the other hand comprises of two parts – a solar collector, and a drying chamber for the crop. Air enters the collector where it is heated and its humidity decreases.

When selecting a solar dryer, consideration of the following factors aid in assuring success:

- The mixed mode dryer maximises the utilisation factor of the capital investment. Design may allow the dryer to be also used for heating water for domestic purposes.

- An additional heat source is recommended to ensure continuous drying even when there is no sunshine, also to handle peak loads and improve efficiency. Forced convection indirect dryers have the advantages of providing better control, more uniform drying and smaller collector areas.
- Small dryers allow for diversity in terms of crops dried. However, due to the high fresh weight to dry weight ratio, the dryer should be large enough to provide feasible throughput. Figure 3 shows a simple solar dryer.

Figure 3: Simple Solar Dryer



Source: Technical Manual – Basic Food Processing, FAO, 1985.

Advantages of Drying

Long Shelf Life – Since most microorganisms responsible for food spoilage are unable to grow and multiply in the absence of moisture, spoilage due to microbial degradation is limited in dried foods. Furthermore, enzymes which catalyse undesirable changes in foods need moisture to be effective.

Reduced Weight – This results in reduced transportation, storage and shipping costs.

Convenience – The production of convenience items with novelty appeal for niche markets makes drying an attractive option.

Concentration of nutrients – The removal of most of the water from a food results in a highly concentrated source of nutrients.

No refrigeration is required for dried products – Savings in energy and storage costs together with the long shelf life provide a lucrative processing alternative for tropical countries.

Disadvantages of Drying

Disadvantages of drying are few, and mainly relate to oxidation, which usually accompanies drying. This results in losses of micronutrients such as carotene and ascorbic acid, and minimal loss in protein as a result of browning reactions. Reduced consumer appeal is often linked with the latter.

There might also be changes in flavour and texture if drying is not properly controlled, particularly with regard to maximum temperatures.

Preservation by the Use of Chemicals

Salt and sugar have long been used as effective means of extending shelf life of various products as these solutes bind water, leaving less water available for the growth of micro-organisms. Essentially the water activity (a_w) of the product is reduced, and since most microorganisms require a high water activity, they are unable to survive.

Acids such as citric acid, acetic acid (vinegar) and ascorbic acid are also known to confer protection against product deterioration. In these cases, the pH of the product is shifted to being low, that is, more acidic, where very few moulds, yeast and bacteria are able to grow and multiply.

Food additives such as benzoate and sorbate are quite commonly used in the fruit drink industry to protect against microbial spoilage, while nitrites are used in meat processing. These chemicals work best at acidic pH ranges and when the products are pasteurised. A combination of heat and chemicals where applicable is usually more effective than either one on its own.

Preservation by Control of Temperature

The relationship between the temperature of food (for example, in preservation and storage) and its shelf life is evident in several food operations. For example, spoilage in foods held at 0°C and below is quite slow compared with spoilage of the same product stored at room temperature. At temperatures experienced in a household freezer (about -10°C), microbial growth is minimal, and chemical reactions proceed slowly, thereby enabling the food product to remain wholesome for an extended period. In commercial freezers, where temperatures of -40°C and below are maintained, freezing of the product takes place quickly, and the shelf-life is even longer. It should be noted that once the food thaws, deterioration may proceed, as microbes are able to multiply and thrive once more. Damage to tissue may also result from ice crystals, particularly in the case where slow freezing occurred, for example, in a domestic freezer.

Sometimes bacterial cells are damaged but they do not die during freezing. These bacteria are able to recover and repair themselves during thawing. Some bacteria may produce poisonous substances (toxins) at normal temperature. Freezing does not destroy such toxins and if this food is thawed and refrozen the toxin will survive in it even during prolonged periods of storage. It is therefore important to avoid repeated freezing and thawing as this damages the food resulting in a greater chance for microbial repair and growth.

At refrigeration temperatures (about 4°C), most microorganisms do not multiply as rapidly as they do at room temperature. In addition, chemical reactions proceed slowly. At ambient temperatures, microbial and enzymatic reactions proceed rapidly, accounting for the rapid degradation of food. Once the food product is exposed to temperatures of 60-70°C, microbial growth stops, and enzyme inactivation starts. Typical slow pasteurisation may occur in this range.

As the temperature is increased (80-90°C), the vegetative forms of microorganisms are destroyed and the rate of enzyme inactivation increases. Heat processing of acid products, such as fruits and fruit juices, is usually done at higher temperatures (100°C), for short times (10-15 seconds). In this way the microbes are destroyed, the enzymes are inactivated, and the physical characteristics of the food which are often adversely affected by elevated temperatures, are retained. Typically, canning of low acid foods take place at 121°C, and 15 psi, resulting in the destruction of all pathogenic and spoilage microorganisms.

Preservation by Fermentation

Food fermentation is usually carried out with the use of microorganisms, producing alcoholic, acetic or lactic end products as a result of their action on simple sugars present. These reactions take place in the absence of oxygen, that is anaerobically, and are responsible for the production of wine, vinegar, yoghurt and pickled vegetables among others.

Having pure cultures of the desirable microorganism in the food products being fermented is critical to obtaining "clean", characteristic flavours of end products.

Preservation using a Combination of Techniques

Food preservation limited solely to the application of one method may involve too severe a treatment for the product, and as a result may incur undesirable changes in the processed product.

Very often, the combination of two or more preservation techniques offer advantages to the product, ranging from an extended shelf life and improved storage quality to new product lines. A typical example involves concentration.

Concentration usually carried out by boiling will result in a reduction of the weight and volume of fresh foods, due to the removal of water. This produces a preservative effect, as the water activity is inevitably lowered below that necessary for the growth of

most microorganisms. Foods are also concentrated to provide a range of value-added products which are quite popular in the Caribbean and overseas, for example, jams and jellies, preserves, etc.

The processing of hams (utilizing heat and chemicals) also demonstrates how a combination of the technologies available may produce valuable products.