# SOME METHODS FOR THE DOMESTIC PRESERVATION OF FRUITS AND VEGETABLES

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# THE STORAGE OF SOME GRAINS, TUBERS AND FRUITS AND VEGETABLES in Ghana

by

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# P R E F A C E

The paper discusses, in some detail, few methods for the preservation and storage of some food crops, at the domestic and farm levels.

It is hoped that the methods presented would be found worthwhile.

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## INTRODUCTION

Ghana, like most developing countries, is in the process of industrialization. As a result people are leaving the food production areas and are moving into regions where industrial opportunities and the possiblities of a better life exist. This dislocation of populations means that improved methods of food production, storage, processing and distribution are required to feed not only the already located urban population, but also to feed those withdrawing from farming occupations.

Moreover, most of the relatively small quantities of food crops produced by those who are left behind on the farms, is lost through out poor and improper storage and processing. A suitable technology is therefore needed in the storage and preservation of these food crops in order to maintain these human populations in good health throughout the year.

## PRINCIPLES OF FOOD PRESERVATION

The Object of Preservation:- The object of preservation is to take food at its point of maximum palatability and nutritive value and keep it at this stage, instead of allowing it to undergo natural changes which make it unfit for consumption.

These changes are partly due to action of enzymes in the foods, and partly to the growth of micro-organisms contaminating them.

To understand the principles of preservation it is therefore necessary to know something of these factors and how they may be controlled.

Enzymes: These are complex chemical substances which control essential metabolic processes and they are present in all living organisms and tissues. Examples of these actions may be seen in the enzymes which bring about the digestion of foods in the alimentary tract of animals and man, as well as those which act within the cells of the body. Examples of enzymic action in plants are the browning of cut surfaces of fruits on exposure to air and the changing of pectin of pectic acid in over-ripe fruits. Enzymes are permanently inactivated by extreme heat but moderate warmth increases their activity. Extreme cold prevents their action temporarily but generally has no permanent effect once the temperature is allowed to rise again. Heat processes such as bottling and canning, which use various time-temperature relationships, are therefore effective in this aspect of preserving foods and the products can be stored at room temperature.

Deep freezing temperature are effective in inhibiting the majority of enzymic actions but temperatures above this are not effective. Hence changes may occur during the processes of freezing and thawing. This is particularly important in vegetables where off-flavours may result, and for this reason vegetables are generally blanched mostly in boiling water, before freezing to minimize undesired activity.

Micro-organisms: These are minute living organisms present in all normal surroundings which are capable of growth and multiplication under suitable conditions. The conditions are generally fulfilled by stored foods of all kinds, and it is therefore necessary to take precautions to prevent the growth of the organisms which would result in spoilage of foodstuffs and could endanger the health of the consumer.

Although some of these micro-organisms constitute a potential hazard, commercially, or medically others are of very definite value in producing such substances as venegar; and penicilin Micro-organisms which are important in food spoilage are divided into three main groups: bacteria, yeasts and moulds.

Bacteria are single-celled organisms, so small that they are visible only under the microscope but are capable of very rapid multiplication, and the colonies of cells thus formed may be seen with the naked eye on the surface of a suitable nutrient. Bacterial spoilage of food is sometimes difficult to detect. This is because not all bacteria produce gas, so that a preserving jar may remain sealed or a can ublown, although usually the contents have a sour smell and mushy appearance. Some bacteria are capable of producing highly resistant cells known as spores and in this form can survive adverse conditions which would destroy the normal bacterial cell.

The majority of bacteria grow best at temperatures between 70°F to 95°F (21°C to 35°C) but are destroyed at temperatures near the boiling point of water 212°F (100°C). Exceptions are spore-forming organisms which may survive boiling for several hours but are readily destroyed by temperatures in the region of 240°F (about 115°C) for which a pressure cooker is necessary.

Refrigeration slows down the rate of bacterial growth considerably, and deep-freezing inhibits it completely, but neither of these cold treatments has any permanent effect and organisms subjected to them begin to multiply again as soon as they are returned to a suitable temperature.

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Many other factors also influence the growth of bacteria and may be used to assist in the preservation of foods. Such growth is inhibited by the presence of high concentration of salt or sugar. In acid surroundings the majority of bacteria including the spore-forming organisms, are unable to grow and multiply and are more easily destroyed by heating; for this reason they rarely remain in active in bottled acid fruits, though they may cause spoilage of less acid fruits such as tomatoes and vegetables. Because of this all low-acid foods must be processed at higher temperatures and for longer times to ensure that the bacteria present will be destroyed.

Among the most important bacteria which can cause food poisoning are Salmonellae, Shigellae, Staphylococci and Clostridia, all of which may contaminate food from soil, other surrounding and from the hands of food handlers.

Many other bacteria may be present and capable of development in stored foods, but in general these are non-pathogenic and are important only in so far as they cause wastege of food.

The Salmonella-Shigella groups of organisms are the cause of typhoid fever, dysentery and similar diseases and it is the living organisms themselves multiplying within the body which ar responsible for the disease. These organisms are fairly easily destroyed by heat, so the normal processes of preservation are adequate provided they are carried out efficiently.

Staphylococci produce and liberate a toxic substance during their growth in foods, and it is the ingestion of this toxin, rather than the actual organisms, which causes food poisoning symptoms. The toxin is relatively stable at high temperatures and is not destroyed even by boiling, so emphasis must be placed on preventing growth of the organisms and production of toxin at any stage during food preservation. Among the Clostridia, Cl. botulinium is the mos most important as it produces an extremely dangerous and lethal toxin. Like Staphylococci it is very important to destroy the organism rapidly and prevent their growth at any stage, but the difficulties are increased in this case by the fact that Cl. botulinium is a spore-forming organism.

In view of this, numerous experiments have been carried out to ascertain safe processing times ensuring destruction of this organism during bottling or canning of various foods. In fact processing time-temperature relationships in canning and bottling are based on values suitable for the destruction of this organism.

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Yeasts: Although larger than bacteria yeasts are microscopic, uni-cellular organisms which are able to multiply in a number of foodstuffs. They grow well in acid conditions and are particularly active in fermenting sugars. Certain yeasts may grow in food containing 60 per cent sugar or even more, so they are important in the spoilage of jams, syrup etc., but the majority are non-pathogenic.

Most species of yeast are readily destroyed by heat, 140°F(60°C) for a few minutes generally being sufficient for this purpose. Some species are also inactivated or destroyed by deep freezing. There is therefore little difficulty in destroying yeasts and they are more important in re-contamination where a product is inadequately protected, may happen in jams.

Moulds: Like yeasts, the majority of moulds are sensitive to heat and are destroyed by 30 minutes at 140°F (60°F). One mould Byssochlamys fulva occasionally found on fruits, produces spores which withstand heating up to 30 minutes at 190°F (88°C) and may cause breakdon of bottled soft fruits.

Mould are inactivated at deep-freezing temperatures, but like bacteria the effect of cold are not permanent.

Very few mould produce disease in man, and like yeasts their importance in food preservation is due to spoilage of the food rather than danger to the consumer.

From this brief survey of the problems involved it can be seen that, to be effective, food preparation and preservation must be carried out as rapidly and hygienically as possible using good quality materials, and the heat processes used must be suited to the concentrations of acids and other substances present in the food. Where deep-freezing is used great care must be taken to minimize the length of time the foods are kep at room temperature, both before and after the freezing, as the process itself exerts practically no sterilizing effect.

METHODS OF PRESERVATION

When preserving fruits and vegetables it is essential not only to destroy these agents but, where no preservative is added, to prevent the entry of further micro-organisms during storage. This is done by using vacuum closures in jars and cans and by covering full-sugar jam surfaces with waxed discs.

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HEAT PROCESSING

Bacteria, yeasts, moulds can all be destroyed by heat. Heating to appropriate temperatures in suitable containers is therefore, one of most convenient methods of preserving. The correct regulation of temperature is of no use unless care is taken to see that cans or bottles are securely sealed so that unsterilized air cannot enter. If there is a leak, however, minute air will be drawn into the container. When this happens many air-borne micro-organisms are drawn into the container, and on developing, they render the contents unfit to eat.

Most bacteria, yeasts and moulds grow best between $70^0$C and $95^0$F ($21^0$C and $35^0$C) and they multiply rapidly if the preserving of picked fruits and vegetables is delayed without suitable conditions such as cold storage being taken. Ordinary refrigerator temperatures cannot be used for so doing for although they hinder the growth of micro-organisms, they do not destroy them. The methods of preservation, especially the time-temperature relationships, apply to normal fruits and vegetables not to those heavily infested with micro-organisms. If these time-temperature relationships are increased arbitrarily to preserve such normal produce it could result in mechanical breakdown and loss of flavour. The processing times and temperatures strength of preservatives normally used are the lowest found to give adequate destruction of micro-organism while producing the best flavour and appearance.

Bottling: In bottling prepared food is packed in containers - bottles which are heated to destroy spoilage organisms and sealed to keep out other organisms and air. The heat inactivates the micro-organisms and enzymes present in food.

Most of the air in the container and in the food itself is driven out during heating and is kept out thereafter by the tight seal that is formed. If air is left in, the top layers of the food may darken gradually because of oxidation. Such food is not dangerous, but it does not look good.

The temperatures required to sterilize different foods vary. For safety, the heat treatment must be right for a particularly food.

Fruit Bottling: Bottles:- Two types of bottles are in general use for home preservation of fruit - clip bottles and screw-band bottles. The clip bottles usually have lacquered tinplate or aluminium lids which are separated from the neck of the bottle by a rubber ring. During processing the lid is kept on by a metal spring-clip. As the contents of bottle become hot, the spring allows the lid to lift slightly so that air and steam may escape. When the bottle is cooling down the clip holds the lid firmly in position.

while a vacuum is forming.

There are various makes of covers in metal or glass with rubber bands and clips which can be used in the same way as clip bottles.

Screw-band bottles usually have glass lids and flat rubber rings or metal lids with a fitted plastic gasket replacing the rubber ring and are supplied with screw-bands made of lacquered tinplate or of aluminium to keep the lid in place. The metal band is screwed on to the bottle rather loosely during processing and air and steam can thus escape. Immediately after processing the band must be screwed down tightly as possible, so that the lid is held in position until the vacuum is formed by the cooling of the contents. The bands, particularly those of aluminium, are apt to scratch slightly with constant use, and unless care is taken to provide each bottle with a band that fits perfectly there is always a danger of a faulty seal.

Thin rubber rings are always inserted between the bottle and the lid if there is no fitted gasket, and it is essential to examine these rings very carefully before use. Perished rings, when stretched, will not return to their orginal size, and they should be discarded. It is not advisable to use the rings more than once, but if unused they can be kept from one season to another, provided they are not exposed to light or heat. The rings should be soaked in warm water for about ¼ hour than dipped in boiling water immediately before use.

Examination of Bottles or jars: Each bottle or jar must be examined carefully before use. The rim around the neck of the jar, on which the rubber ring fits, should be smooth. If it is chipped in any way the jar must be discarded. Sometimes a slight ridge occurs which can be filed down to give a flat surface.

The rim of the glass lid should also be examined. Lids are often chipped slightly when being removed from a sealed jar, and if these chipped lids are used again it will not be possible to obtain in airtight seal. As a further test, leaks can sometimes be detected by filling the jars with water, fitting on the rubber bands and lids with either screw-bands or clips and inverting the jars on draining board. These should not leak after a few minutes.

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Metal covers can be reused provided the lacquer inside is intact and the original shape is retained.

Washing the bottles: Before filling the bottles they must be washed thoroughly, with a bottle brush if necessary, to remove any dirt, and then rinsed and left to drain. If they are very dirty, after washing they should be put in a pan with a false bottom, covered with cold water which is brought to the boil and boiled for 5 minutes. The jars are then removed and left to drain. It is unnecessary to dry thebottles as the fruit slips into position more easily if the inside is wet.

Quality of Fruit: Only fruits of good quality should be used, because processing cannot make a good food out of a poor one. Fruits should be fresh firm, ripe and sound.

Slightly imperfect and less uniform but sound fruit and supluses of fully ripe fruit can be used to make jelly if pectin is added to them to help form the gel. Juices are another way to use large, small or mishapen produce. Sorting or cutting to provide pieces of similar size and maturity in each pack improves the quality because they process uniformly. Some fruits can be peeled to remove inedible parts. Peeling also helps to eliminate some of the micro-organisms which may be present on the raw material.

Preparing the Syrup: Fruit may be preserved in syrup or in water. Both are successful, but fruit which has been bottled in a solution of sugar and then stored in it for some months is of better flavour and colour than that preserved in water. The one drawback to the use of syrup is that it causes the fruit to rise in the bottles, which is rather detrimental to its appearance, but this is more than compensated by the greatly improved flavour.

The strength of the syrup can be varied according to individual taste: an average proportion is 8oz. sugar to 1 pint water which gives about 4oz per lb. of fruit bottled (normal pack). For tight packs a stronger syrup is recommended as a relatively smaller quantity will be used. Granulated or loaf sugar should be used and may be added to half the quantity of water; when dissolved, the syrup thus made should be brought to the boiling point, boiled for one minute and the remainder of the water then added. This method saves time in waiting for the syrup to cool down. If there is any doubt as to the wholesomeness of the water supply, all the water used should be boiled. If the syrup is to be kept hot for long, a lid should be placed on the pan to prevent evaporation, which would alter the strength of the pack. If the sugar is not very clean, it should be strained through muslin or cheese cloth.

Golden syrup or honey can be substituted for sugar in making the syrup, using equal weights.

Packing the Bottles: The fruit should generally be packed tightly without bruising, filling the bottle to the top before any liquid is added. When processing Method I (i.e. Slow Water Bath using a Thermometer) is used, however, if prepared the fruit and liquid can be added alternately until the bottle is quite full. By this means a better proportion of syrup to fruit is obtained. If a bottle is filled to the brim with soft fruit it is often difficult to add sufficient liquid or to get rid of trapped air bubbles. A long thin packing stick with a smooth, flat end can be used for placing the fruit in position. It is advisable to note the quantity of fruit and liquid packed into a jar.

The liquid may be added before or after processing. Cold bottles should be placed in a basin on a plate or a tray but hot bottles must be placed on wood. Just before the syrup is poured over the fruit the rubber ring, previously dipped in boiling water should be fitted on. If a flat ring is used care should be taken to see that it is lying quite flat. The bottle should be given a quick jerk by a movement of the wrist to remove as many air bubbles as possible. Having done this, the addition of a little more syrup may be necessary, after which the lid should be put on the bottle, followed by the clip or screw-band where necessary. It is essential that screw-bands, when placed on bottles before processing, should be loosened by about a quarter turn to allow air and steam to escape. Failure to do this may cause the bottle to burst.

Processing

Which bottling method is used will depend chiefly on the type of equipment available three methods described here. Method I and II are water bath methods, which strongly recommended for reliable results and economy of fuel. They require pans deep enough for the water to cover the jar. Method III using a pressure cooker is very quick and economical of fuel but soft fruits may look slightly overcooked.

Method I Slow Water Bath using a thermometer: A large saucepan or a similar vessel for heating water will suffice, provided it is deepe enough. Whatever type of vessel is used it should be provided with a false bottom, as bottles must not touch the hot base of the pan.

A wire frame with short legs, or strips of wood nailed together in trellis fashion, or even straw or a rough cloth will answer the purpose. The bottles should be entirely covered with water, so that all parts are subjected to a uniform heat. If, however, the bottles cannot be entirely submerged, the water should come at least to the shoulder and the sterilizer should have a very tight-fitting lid to prevent the escape of steam. A cloth placed under the lid may help to make it fit well.

For good results a thermometer reading up to $212^{\circ}$F ($100^{\circ}$C) is of great assistance. (For jam making thermometer should read up to $230^{\circ}$F ($110^{\circ}$C). The thermometer should be checked occasionally to see if it reads $212^{\circ}$F ($100^{\circ}$C) in boiling water. If this is not so, the difference between the higher reading and $212^{\circ}$F ($100^{\circ}$C) must be added to any required temperature, and the difference between $212^{\circ}$F ($100^{\circ}$C) and a lower reading must be substracted from it. During heating the bull of the thermometer should be immersed in the water surrounding the bottles and in small sterilizers it is convenient to have a hole in the lid through which the thermometer can be passed, so that reading may be taken without removing the lid of the vessel. The temperature of the water should be raised gradually to reach at least 130F ($55^{\circ}$C) in one hour and the required temperature in ½ hour

If the water is heated too quickly the fruit will probably rise in the bottles, and longer time must be given at the maximum temperature to allow the heat to penetrate the centre of the fruit. Longer times are needed when using larger jars.

When the bottles have been heated for the required times, they should be removed from the pan or boiler. In order to take out the bottles, the water in the pan should be baled out until the necks of the bottles are above the surface, when they can be taken out with the aid of a cloth. If screw-band bottles have been used the screws should be tightened immediately each bottle is removed from the sterilizer. The hot bottles should be placed on a wooden table, as they may crack if placed in a cold sink or on any other cold surface. They should be left undisturbed overnight.

Method II. Quick water Bath: This method may be used instead of Method I when there is no thermometer available. The temperatures given are therefore for the guidance of those who prefer a more accurate method. A pan should be used which is deep enough to immerse the bottles in water when standing on a false bottom, as in Method I.

The warm bottles are packed with fruit and filled with hot syrup (140°F or 60°C), covered and placed in the pan of warm water (100°F or 38°C). The water is then heated to simmering (190°F or 88°C) in 25 to 30 minutes and held at simmering point for the required processing time for that fruit. Additional time should be given for large jars of 2lb capacity. At the end of the process the bottles should be removed from the pan, screw-bands tightened and the bottles left to cool.

Method III Pressure Pan: A pressure pan may be used if it is of sufficient depth to take a preserving jar and has a guage or weight control to enable 5lb. steam preserve to be maintained steadily. The amount of water in the pan should measure at least one inch depth before the rack and bottles are put in.

The fruit is packed in warm bottles, boiling liquid added within 1 inch of the rim and the rubber rings, lids and clips fitted. When using screw-band type jars the hands should be loosened by a quarter turn. The jars are placed on the rack in the hot pan, the lid placed on with the vent open and the pan heated until steam appears. The vent is then closed and pressure brought up to 5lb. per sq. inch in not less than 5 minutes or more than 10 minutes. The pressure is maintained at 5lb for the required time after which the pan is removed from the heat and left for 10 minutes before opening and removing the bottles. This 10 minutes cooling is important as during this time the bottles are still processing.

Any screw-bands should be tightened when the bottles are removed and placed on a wooden surface to cool.

Testing Filled Bottles: When bottles covered with glass or metal covers with rubber rings are quite cool, preferably the day after processing, the clips or screw-bands should be removed and each bottle carefully tested by the lid. If the lid remains firm a vacuum has been formed. If the lid comes off, there is probably a flaw on the rim of the bottle or on the lid where the rubber ring fits, or the rubber ring itself may be faulty. The flaw should be found and remedied. If several bottles are unsealed they should be reprocessed. (Except for Method I the liquid must be poured off and heated separately.)

If reprocessing is not convenient or if only one bottle out of a batch is unsealed, the fruit should be used as soon as possible. For convenience, the screw-bands may be replaced on the bottles during storage but they should be rubbed on the inside with a little oil and should be quite loose. This will prevent rust and will obviate the difficulty sometimes experienced in their removal. The clips should be stored for use during another season and should not on any account be replaced on the bottles because if left on for too long they loose their resilience and become useless.

Storage: Bottles of fruit should be placed in a cool store, and if possible they should be protected from strong light which is harmful to the colour of the fruit. To open the bottles, insert the point of knife on the rubber ring and very gently lever up until a stream of air bubbles enter. To remove the lids allow the bottles to stand in hot water for a few minutes.

## Bottling Vegetables

Fresh vegetables are available more or less all the year round and in consequence their preservation is not generally so necessary as is that of fruits. Further, the bottling of vegetables is a more difficult process and more elaborate equipment is necessary. For these reasons the preservation of vegetables should not be carried out extensively in the home and the practice is not recommended except by persons who have the necessary equipment and are skilled and experienced in its use.

All vegetables may be heavily contaminated with soil organisms, which often include the most heat-resistant forms of bacteria, and unless these are killed during sterilization they may cause spoilage of the vegetables in the bottle. Among these organisms may be Clostridium botulinum, the spores of which, if not destroyed, are capable of developing and producing in the food a toxin causing botulism, a fatal food poisoning. The toxin may possibly be formed without obvious spoilage of the contents of the bottle.

Acid foods, such as tomatoes, inhibit the growth of this organism and prevent the formation of the toxin. Such foods can be processed at or near the temperature of boiling water.

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With non-acid foods, such as peas, beans and practically all other vegetables, the temperatures obtainable in steam pressure cookers, which are always used for sterilizing vegetables in commercial canneries, form a necessary part of the process for vegetable bottling and ensure that no subsequent bacterial growth will take place.

Quality of vegetables: Any vegetable for bottling must be freshly harvested - young, tender, firm and unwilted.
The vegetable should be sorted or cut to provide pieces of similar size or maturity. Where necessary, they should be peeled to remove inedible parts and to eliminate some of the organisms.

Bottles: As the bottles have to withstand high temperature, they should be of good quality and examined for flaws. They should also be thoroughly cleaned before use.

Washing: All vegetables should be thoroughly washed in clean water first of all. Root vegetables should be scrubbed to remove all traces of soil and then rinsed.

Scalding: After preliminary washing and trimming, vegetables are scalded or blanched in boiling water and dipped in cold water before being packed into the container.

Packing the bottles: When vegetables are filled it is a mistake to pack them too tightly. The bottles should be reasonably filled but not pressed down. Most vegetables are packed to $\frac{1}{2}$ inch of the top of the jars and then covered with brine.

Starch vegetables need more headspace because they swell during processing. It advisable to leave an inch at the top of the jars when packing corn, peas, beans, lima beans and sweet pototoes.

Brine: Salt water is generally used as a covering liquied for vegetables. Recommended quantities are $\frac{1}{2}$ - 1 oz to 1 quart of water according to taste. For peas, sugar added up to 1 oz per quart improves the flavour.

Sterilizing: The sterilizing of bottles in a pressure cooker fitted with an accurate pressure gauge must be carefully done otherwise there is the danger of cracking the jars or losing most of the liquid from the bottles. The following instructions should be observed.

1. If bottles with screw-bands are used, the screw-bands should be loosened by a quarter turn to allow the escape of air before placing them in the cooker.

2. Water should be poured into a depth of 2 inches over the bottom of the cooker. The bottles should stand on a wooden or metal rack. They should not touch one another or the sides of the cooker, as the bottles might crack.

3. After putting the bottles in the cooker with the necessary amount of water and screwing on the coger, the control valve or vent should remain open until steam escapes and then it should be allowed to steam for 7-10 minutes in order to expel the air; it should then be closed and the pressure allowed to rise to 10lb by adjusting the heat. This pressure should be maintained for the required sterilizing time. Fluctuations in pressure should be avoided.

4. At the end of the processing the cooker should be allowed to cool very gradually until the pressure registers zero (0lb or 212°F or 100°C). The control valve may then be opened to allow air enter after which the lid may be unfastened. If bottles with screw-bands are used, the bands should be screwed well down when the bottles are removed from the cooker.

Cooling the bottles: The jars will be very hot when taken from the sterilizer and care should be taken to put them on a wooden board and to stand them away from a draught while they are cooling. Under no circumstance should any adjustment of rubber rings or lids be attempted while the jars are cooling.

Testing the bottles: When the bottles are cold they will probably appear to have lost much of the brine, but, provided that the lids are securely fixed when tested that the sterilizing times and temperatures have been followed, the vegetables should keep perfectly. Any bottles found by testing to be imperfectly sealed must be either re-sterilized or the contents used at once. On no account should they be stored.

Using the vegetables: When required the vegetables should be re-heated in the brine covering them. Any liquid not used will be a good stock or base for soups.

Size of bottles: Jars used for bottling vegetables are mostly of 1 pint capacity and sterilizing times are based on this capacity. If larger jars are used, the times should be increased by 5 minutes to ensure that the heat in the centre is adequate. Jars larger than 1 quart size are not recommended for vegetables bottling.

DEHYDRATION/DRYING

Bacteria, yeasts, moulds and enzymes can grow and multiply only in the presence of moisture. By removing water, bacteria, yeast and moulds are unable to grow and decomposition is prevented. Removal of water from foods for purposes of preservation has been practised for hundreds of years. In the early days drying by means of the sun was the only method used. Although sun drying still remains the greatest food preservation action, yet because of the unpredictable nature of the sun, artificial means has to be found, especially for fruits and vegetables. The term dehydration has therefore taken the meaning of artificial drying. In Ghan, vegetables are the food crops which are mostly sun-dried or dehydrated.

Selection, Grading or Sorting

All vegetables intended for drying should be at the fully mature stage at the time of harvest. Vegetables which are defective in any way through insect attack or mold rot, should either be discarded or the defective part cut away. Grading as to the degree of maturity especially as to appearance or colour should be undertaken. In vegetables such as okro, garden eggs, grading should be based on variety, size and colour. Vegetables at different stages of maturity should never be mixed.

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Washing, Trimming, Cutting or Slicing

Washing of raw food materials is necessary before processing. Onions, however, need no washing. Vegetables need trimming before processing especially when they are defective due to bruises and damage sustained during harvesting. The removal of stalks and calyx of pepper and the cutting of the tops and bottoms of okro are some of the rimming operations needed. After trimming, they should be cut into slices by using sharp stainless steal knives. The slices shouldbe as uniform as possible in order that drying may be even. If this is not done some slices will dry faster than others and some may have higher moisture content and be of poor keeping quality. Some varieties of pepper are, however, small and therefore need no cutting or slicing.

Some vegetables when exposed to air after cutting start browning. This applies especially to garden eggs, bananas and plantain. To reduce browning the slices should be immersed in a solution of salt or sodium metabisulphite according to the individual product requirements.

Pre-treatment

After trimming or slicing, the vegetables are submitted to blanching i.e. to hot water or steam treatment. Blanching improves the keeping qualities, preserves the natural colours and shortens the soaking time and cooking time of the dried products. In sun-drying, water blanching is recommended due to the difficulties involved in steam blanching.

A suitable water blanching method is to put the sliced or prepared raw materials into an aluminium wire netting and then dip it into a pot or tank containing boiling water. By tying a string around the netting, the whole arrangement can be lower and raised. A cloth can be used instead of the aluminium netting.

The average time for blanching is 5 or 6 minutes. After blanching the whole arrangement can be dipped into cold water in order to prevent over-blanching.

Okro, green beans, red pepper, leafy vegetables should be blanched. The blanching of yams, sweet ptotato or cocoyam are optional. Onion, garlic, sweet pepper, garden eggs do not require blanching.

The Use of Preservatives

Vegetables are at times treated with certain chemicals in order to improve the colour and keeping quality of their final dried products Chemicals such as sulphur dioxide, salt or sugar, either as a single or compound components may be used as preservatives in this manner. Such a treatment to vegetables may take place after blanching, or where no blanching is required, it can be done after cutting.

The products, as previously described, are dipped for one minute in the proper solution, care being taken that they are not allowed to drain back into the tank, so as to avoid the weakening of the solution. It is advisable that after each dip the container is refilled with fresh solution Salt is used as a preservative for certain products only. The strength of the chemicals is expressed in parts per million (abbreviated "ppm"). For example, $1\frac{1}{2}$ grams of sodium metabisulphite dissolved in 1 litre of water will give 1,000 ppm. of sulphur dioxide ($SO_2$) and this is roughly the same as $\frac{1}{4}$oz. per gallon. No preservatives are required for onions, garlic and chillies.

Sun-drying

There are no definite methods nor special equipment used for sun-drying in Ghana. Products for sun-drying are spread on roof-tops on concrete constructions along roadsides and in courtyards and left to the dessicating action of the sun.

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In this manner, the food products are subjected to contamination from dust, flies, rodent and even human beings to mention a few.

Drying Yard and Shed

There should be a yard for drying. In the yard there should be a shed. The shed should be made of local construction materials with a non-leaking roof. Aluminium or galvanised roofing is recommended for such a shed. A cutting and trimming table with a hardwood top but without crevices into which juice can enter should be provided under the shed. A few benches should be provided for the working table. Provision should also be made for a small wooden cupboard for keeping knives and other pieces of equipment. The shed should have an ample supply of water for washing, blanching, and cleaning purposes. Where there is no tap the water should be supplied from a galvanished or concrete storage units. On no account should water be left for too long in the storage units. Regular cleaning of the tank and filling it with fresh water should be undertaken.

The shed should act as the centre for the grading, cutting, trimming and spreading of vegetables on drying trays.

Drying Units

The following drying units are recommended in order to facilitate the drying process and reduce contamination of materials during drying.

1. Bamboo trays: In areas where there are bamboos, trays for drying can be made from the bamboos. The size of each trays should be 6 feet long, 3feet wide and 1 inch deep, with a 6 inches handle at the long side. To be economical many of these trays should be needed for bulk drying. Loaded trays should be spread out in rows in areas free of dust with pathways between them to facilitate their handling. Where sawn timber, nails and aluminium wire netting are available they can be used to construct the trays.

2. Platform Drying Unit: A second type of drying unit can be made from 3, 1" x 12" x 12" boards, to make a platform of 12" x 3'. Sawn scantling 1" x 1" can be erected at the edges. The platform should have six legs made from 2" x 3" scantling. The legs should be made to stand in cigarette containers half-filled with turpentine or water to which kerosine has been added in 1:1 ratio. A .003 inch guage poly thene film should be spread on the platform.

3. The Sun-Drying Cabinet: A third sun-drying unit which can be used by processors consists of a rack with trays. Each tray measures 3 feet by two hings which allow them to be stretched out to form a 6 feet by 3 feet drying surface. Since the unit has four of such compound trays, each at a different horizontal plane plus a top tray of 12 square feet, the total drying surface is 84 square feet. Each tray should be at least 1 inch deep, to give approximately 90lbs of prepared wet material. The maximum load on each tray should not exceed 10lbs.

The prepared raw materials should be spread in even layers and should be turned or stirred during the first drying period, at least once every hour.

Stirring and turning speed up drying and improve the quality of the finished products. It is advisable that the drying be completed during the course of the day in order that ancillary oeprations connected with the drying such as inspection, packaging and storage, can be carried out before it is dark.

4. Oven Drying: Drying can be done in the oven, which should be only moderately warm. The spare heat in a solid fuel oven or stove may be utilized after cooking is over. Where oven heat can be regulated easily the process can be carried out continuously or intemittently according to the general use of the oven.

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The prepared raw material should be spread on the trays, without piling them on top of each other too thickly. The tray can then put on the shelf in the oven and the oven door can be kept slightly open so that steam from the food will escape easily and keep the food dry. The food should be turned to changing position constantly to give drying of the foodstuff. Dry for 6 hours at an oven temperature of about 160°F (71°C) or just warm enough for it to be comfortable for the hand.

Where the round clay or brick ovens are used, some ingenuity will have to be used.

Oven-drying and sun-drying can be combined profitably.

Inspection

On completion of the drying, the products should be inspected and sorted. The aim of sorting should be to remove poorly-dried pieces and any foreign matter. Lots of bad quality which show poor colour and appearance should be sorted out separately.

Dried vegetables must be "bone-dry" that is, so brittle that they will snap. Several pieces should therefore be tested for this characteristic before the dried food is removed from the drying trays or platforms.

Packaging and Storage

Packaging should follow immediately after cooling the dried products. For large quantities, the products should be packaged in either higher density polythene bags or in polythene-line bags. For consumer packs, the guage of the polythene pouches should be 0.003 inch.

Plastic bags as well as jute bags provide limited protection against insects and animals and therefore consideration should be given to packaging the products in tightly closed 4 gallon tins, especially for long storage periods.

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The packaged dehydrated products should be stored in a cool dry place to avoid deterioration which occurs when stored under hot conditions. Pungent vegetables such as onions and garlic should be kept in a separate storage place to avoid cross-contamination of other products.

FREEZING

When temperatures fall below 15°F (-9.4°C), the growth of micro-organisms is arrested and any bacteria, yeasts or moulds present on the fruit and vegetables remain dormant. The temperatures used in deep freezing are considerably lower, and therefore ice crystals formed within the food are small, enzyme activity and the loss of vitamins are also slowed down, and no spoilage by micro-organisms occur in the freezer. On thawing, these organisms start an active life again and may multiply more quickly than they do on fresh foods. Foods once frozen and thawed should not therefore be refrozen.

Temperature

In deep freezing under home conditions food is placed in a temperature between 0° and - 10°F. The food freezes within 6 to 7 hours but takes 15 to 24 hours to reach 0°F. Under these conditions most enzymes activity will be stopped, with consequent retention of colour and vitamins.
In any type of freezing the storage temperature of the frozen food should never be above - 5°F or enzyme activity will recommence, causing loss of colour, flavour and food value. Also, the ice crystals formed in the food on freezing will grow in size, rupturing the tissues and causing a greater amount of drip on thawing.

Containers; The food to be frozen may be put into boxes, bags or wrapped in suitable materials, such as polythene bag.

In these essential requirements are the same: the material must be moisture-proof and the seams good; the material must be vapour-proof so that the food does not loose moisture vapour and dry out, or pick up taints or odours from other foods; the material must withstand low temperatures and not become brittle. Rectangular containers are more economical in storage space than round tubs and odd shaped packets. As much air as possible should be excluded before sealing. Fruit in sugar and vegetables can be packed tightly, but when a liquid pack is to be frozen some room must be allowed for expansion otherwise the container will burst in the freezer.

There are two methods which can be used for the sealing of the polythene bags: either the open end can be twisted and tied with a soft string or wire, or a double fold can be made and sealed with a warm pressing iron (at the temperature used for artificial silk). When using the second method the material needs to be protected from the direct heat of the iron by placing a piece of paper either side of the seam during sealing.

Cellulose bags should be sealed with a double seam, but do not need protection from the heat of the sun.

Fruits: The choice of variety is important if the best results are to be obtained from the freezer. Soft fruits which do not need cooking before serving are usually preferred frozen with sugar or sugar syrup. Those which need cooking before serving are apt to break down when stewed and are better preserved by bottling. Fruits with stone or seeds freeze well in sugar syrup. It may be necessary to cut such fruits into suitable slices before freezing. Fruits which brown on slicing may be scalded or blanched in boiling water until just pliable, then cooled and packed either without sugar or in a weak syrup. Good cooking varieties are recommended to be treated in this way.

Vegetables: Most vegetables require scalding or blanching before freezing, otherwise off lavours may develop from enzyme action and the colour may not be retained so well. The vegetables should be prepared and scalded in not less than 3 quart of boiling water to each pound, so that the water returns to the boil in 1 minute after adding the vegetables. The scalding time varies for different kinds of vegetables and is about 3 to 5 minutes. After scalding the vegetables are lifted out and plunged into ice cold water to prevent overcooking and to cool as quickly as possible. The cooling time is usually the same as the scalding time, and the vegetables should not be warm after cooling.

After cooling the vegetables should be drained and put straight into the containers. Vegetables with air spaces between them, such as beans and carrots, may be filled to the top of the packet. Young tender vegetables should be chosen for freezing.

Labelling: Each container should be labelled with the kind, variety, amount of sugar if any, quantity and date when frozen. Stick-on labels are not satisfactory in the freezer; pencils or grease pencils are also preferable to ink. Coloured sealing tape or strings can help in quick identification. Separation trays or string bags are also useful.

Freezing: The packets of food should be placed in the coldest part of the freezer usually at one end. They should not be stacked tightly on top of each otherwise they will take a longer time to freeze. The maximum load of unfrozen food recommended by the makers of the freezer should not be exceeded. The packets may be removed from the freezing position the day after freezing and stacked for storage in baskets or bags in the main body of the freezer.

Thawing: Soft fruits should be thawed slowly in the unopened packets. Dessert fruits are best served when still chilled and only opened and turned into the dish just before serving. Thawing in a domestic refrigerator overnight gives very good results. At room temperature at least 4 hours is required and for more rapid thawing the packet may be put in a warm place or floated in warm water.

Stone fruit or fruit with seeds is liable to discolour and should be thawed rapidly in a draught from a fan, or in warm water before opening the package. Fruits for stewing may be placed in the pan in the frozen state and heated, gently at first, while the block is carefully broken with a fork. Fruit for pies should be thawed before being covered, otherwise the pastry becomes sodden.

All vegetables, except corn-on-the-cob, should be removed from the packet and the frozen block placed in a pan with ½pt boiling salted water for each 1lb. vegetables. The lid should be replaced while the water is brought back to the boil, and the block then broken up with a fork. Fronzen vegetables do not take as long as fresh vegetables to cook. Corn-on-the-cob requires thawing before cooking, otherwise the corn would cook while the cob was still frozen. Only sufficient food should be removed from the freezer for immediate requirements. Foods once thawed should not be refrozen.

Defrosting: The lid or doors of the freezer should be kept free from frost. This can be scraped off with a wooden spatula, care being taken not to scratch the metal. Provided that the doors are not opened more than necessary, and that moisture-proof containers are always used, the freezer should not require to be completely defrosted more than once a year.

STORAGE OF GRAINS

Cereals, especially rice, maize, millet and sorghum, are by far the most important food grains eaten in Ghana. However, the methods used in their storage and processing have still not gone beyond the predominantly traditional stage. Losses, both in quantity and in quality, are therefore of frequent occurrence in the application of these preservative methods.

In order to prevent losses in storage, the causes must be known. These storage losses can be attributed to:-

a. Harvesting procedures;

b. Pre-processing techniques;

c. Conditions of storage

Harvesting Procedures:

Proper food storage actually starts in the field. For, in order that food crops may store well, harvesting methods should be such as to prevent bruising, cracking and other damage of food grains, for these contribute to deterioration in storage. But this is exactly the case with our present simple harvesting methods. With increased mechanization of agriculutre such simple methods will have to be gradually replaced by mechanical harvesting which will be more economical in terms of harvesting, threshing and labour costs. However, consideration should be given to the initial investment involved in machine purchase and also the fact that machines are not adapted to harvesting any type of crop.

Pre-Processing Techniques:

Threshing and drying are the pre-processing techniques which food grains undergo before storage. The present methods of threshing are uneconomic, unhygienic and time-consuming. In addition broken grains are produced and extraneous matter such as stones and stalks are introduced in the process. The presence of the excessive thrash in the grains, accelerates deterioration, in storage by causing heat and creating conditions favourable for insect activity.

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Sun-drying, which is at the mercy of weather conditions, is still the method used for reducing the moisture of grains. This becomes a problem when the harvesting season is not followed by a sunny weather or falls within the rainy season. In such a case grains are delivered to storage with too much moisture and this leads to deterioration. The only way to avoid such losses is through the use of efficient machines for threshing and drying. There is a number of portable forced-air units on the market that are suitable for use on the farm. There is also a large range of modern artificial driers available which are, however, too big and too expensive for the individual farmer, but which could be installed by co-operative or government establishments. Unlike the locally-constructed ones, these driers can give the maximum drying temperatures and the moisture content for safe storage as shown in Table I and 2.

Table I: Maximum Drying Temperatures for Some Grains

| Grain | Maximum Drying Temp. of |
|---|---|
| Ear Corn | 130 |
| Shelled Corn | 140 - 180 |
| Rice | 110 - 120 |
| Grain Sorghum | 110 |

Table 2: Moisture Content for Safe Storage

| Crop | Moisture % |
|---|---|
| Shelled Corn | 13 |
| Sorghum | 13 |
| Rice | 12 - 13 |
| Millet | 16 |

Conditions of Storage:

The relationship between the moisture content of the stored grain and the relative humidity of the storage chamber is the key to sound storage. This relationship is influenced by temperature; an increase in temperature lowers the relative humidity and vice versa. Thus predominantly hot/damp conditions are least suitable for grain storage. Other enemies of sound storage are pests and rodents.

In controlling pests scrupulous warehouse hygiene, and disinfection by chemical treatment, are among the important measures to be taken. Special precautions are however, requred in the use of the insecticides to avoid danger to chemical handlers, the development of taint or damage to germination of certain produce, etc. Application of these chemicals is by machines which are available on the market in different sizes for different jobs.

Control of rodents is usually through poison baiting as trapping requires a high trap density and the fact that after sometime the rat population becomes trap-shy thus making it uneconomic and limiting its success.

Spoilage of grain can also occur notwithstanding the fact that only sufficiently dry grain has been stored. Such spoilage results from the existence of temperature gradients within the stored grain.

Levels of Storage: Three levels of storage of food grains may be distinguished: Storage at the farm level; Storate in sacks, mostly by trades; and storage in bulk.

Storage on the farm is done by different traditional methods. Modern methods, such as in-bag fumigation, storage in concrete blocks, etc. are being introduced in certain areas both to village groups and farmers' co-operatives.

Storage in sacks or bags, in a wide range of buildings, and at times in the openo protected from the weather by tarpaulins, is the most predominant form of storage by traders and at central storage depots. Storage in sacks is more flexible and requires lower capital cost than bulk storage. But on the other hand, running costs are higher, handling is slow and possible losses through spoilage and rodents are more promounced. Also, the conditions of storage are often unhygienic. The first step for avoiding losses here should be the introduction of orderliness and warehouse hygience in handling and storage. In many cases, there might not be immediate prospect of providing better premises, but whenever new buildings are planned sound modern warehouse construction should be adopted.

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With the increase in agricultural food production through mechanization the necessity to introduce more modern techniques and buildings to cater for bulk storage at large collecting or central depots arises.

a. to maintain food reserves for even annual distribution in order to maintain price equilibrium;

b. to control the processing of produce for local sale or export;

c. to control the quality and transportation for export.

The siting of bulk storage facilities should be based on production and consuming areas of a commodity and the availability of transport facilities.

STORAGE OF RUITS AND VEGETABLES:

Many tropical fruits and vegetables abound in Ghana. But the amount of these food crops and their processed products, in wholesome form, which is distributed and marketed successfully is so small because of poor methods of storage and improperly controlled processing techniques.

Proper storage of fruits and vegetables begins at the point of harvest or concentration. In Ghana, the manual harvesting of over-ripe fruits and vegetables, their packing in traditional basket containers, and their subsequent transportation to distributing centres are so inefficient that a high percentage of these products crack, are fractured, bruised or crushed.

For best storage, fruits and vegetables must be gathered at the proper stage of maturity in a way that would prevent injury and transported quickly and expeditiously in a reasonable container to the areasstorage.

There are no definite and proper storage centres at points of harvest of fruits and vegetables at the moment in Ghana, except open sheds and household kitchens. Most harvested fruits and vegetables are therefore quickly distributed to semi-rural and urban centres where markets exist but where suitable storage faciltjes are also absent. With the prevalence of high humidity and high temperatures coupled with poor handling, these foods start to deteriorate rapidly.

Fruits and vegetables are living organisms and therefore respire. Their rate of respiration varies with the commodity and increases with the storage temperature. Low temperatures near the freezing point of water are effective in reducing this rate of respiration. Hence low temperatures provided by ice or mechanical refrigeration systems are suitable for the sound storage of fruits and vegetables.

In areas where it is difficult to instal mechanical refrigeration, use can be made of ice chests or containers of suitable size which are well-insulated for short-term storage of harvested produce - the ice being replenished at regular intervals when cleaning of the chests is undertaken.

Where it is possible to instal mechanical refrigeration, it would be worthwhile to have the following information in order to establish the refrigeration load for the storage chamber; the initial temperature of the food; the optimum storage temperature of the food; the rate of respiration and heat evolution of the food; and amount of food to be stored. With this information it is possible to calculate the refrigeration requirement for storing a particular crop of fruits and vegetables.

Small refrigeration units can be established at certain points of harvested produce concentration but this should be utilized more as handling bays for produce in transit to major central storage depots.

The storage chamber; the most important funntion of the storage is to provide a suitable evironment for maintaining the quality, appearance and sale value of the fruits and vegetables. Variations from desired temperature and relative humidity conditions can be damaging. For fluctuations in temperature in rooms tend to cause moisture condensation on stored products and this favours the growth of fungi. In this respect large rooms are more easily controlled in temperature than small chambers as the large reservoir effect tends to resist temperature changes. However, because of the expensive nature of refrigeration systems full utilization of large storage areas is necessary.

Tables 3 and 4 show recommended storage temperatures and relative humidities for some local fruits and vegetables.

Most fruits are stored at 85 to 90 per cent relative humidity whilst leafy vegetables and root crops need between 90 and 95 relative humidity.

Table 3: Recommended Storage temperatures relative humidities and approximate storage life of some fruits

| COMMODITY | STORAGE TEMP. OF | RELATIVE HUMIDITY % | APPROXIMATE STORAGE LIFE |
|---|---|---|---|
| Bananas | 53 to 60 | 85 to 90 | 1 to 3 weeks |
| Mangoes | 50 | 85 to 90 | 15 to 20 days |
| Pineapples | | | |
| Mature | 50 to 60 | 85 to 90 | 3 to 4 weeks |
| Green Ripe | 40 to 50 | 85 to 90 | 2 to 4 weeks |

Table 4: Recommended storage temperatures, relative humidities and approximate storage life of some vegetables

| COMMODITY | STORAGE TEMP. OF | RELATIVE HUMIDITY % | APPROXIMATE STORAGE LIFE |
|---|---|---|---|
| Egg Plant | 45 to 50 | 90 to 95 | 10 days |
| Onions | 32 | 70 to 75 | 6 to 8 months |
| Tomatoes Ripe | 40 to 50 | 85 to 90 | 7 to 10 days |
| Mature Green | 55 to 70 | 80 to 85 | 3 to 5 weeks |
| Beans Lima-unshelled | 32 | 90 to 95 | 2 to 4 weeks |
| Shelled | 32 | 90 to 95 | 15 days |

Storage management: A good storage is important in maintaining high quality in stored fruits and vegetables. But a good storage does not in itself gurantee successful results. These depend to no less extent upon the skillful management of the storage by the operator. Storage management involves proper sanitation practices, orderly stocking of produce to permit air circulation for cooling and removal of respiration heat, the storage of only sound produce of proper maturity and free from injury and the operation and manipluation of cooling equipment in order to maintain optimum temperature/relative humidity conditions within the storage chamber.

STORAGE OF TUBERS

Yam storage: There are two types of yams in Ghana - an early maturing type and a late maturing type. The early maturing yam comprise the Puna, [illegible]e Labrekor etc. and the late maturing ones or the white yams as they are generally called, consists of varieties like Dentempruga etc.

The early maturing ones are normally on the market in June to November after which the late maturing yams predominate the market.

Generally, the early maturing yams do not store well and practically, there is no need to hold such yams for any considerable period of time, since there is always a great demand for them.

Factors responsible for storage losses: Five principle factors operate in the deterioration of yams. These are:-

a) Physical processes which include mechanical damage such as crushing and bruising during harvesting handling and transportation;

b) Autolytic processes which give rise to chemical or biochemical changes in the produce as a result of basic metabolic processes or the interaction between yam compounds, or between it and the atmoshpere or other elements of the inorganic enviroment;

c) Insect attach due to insect infestation of produce in storage causing destruction of part or all of the produce;

d) Microbial attach, particularly fungi and bacteria which cause rotting of the whole or part of the yam, and

e) Rodent attack and the attack of higher animals, inflicting wounds on the tubers and these serve as points of attach by other spoilage organisms.

Yam Storage Practices:

a) Yam in moulds: Normally the white yams which store well are left in the mounds until required. This type of storage exposes the tubers to unnecessary attach by pre-harvest pests such as yam beetles and termites. In addition, the harvesting becomes difficult when the ground becomes sun-baked.

b) Stacking in small heaps: For this storage practice, sites are selected where there is some protection from the sun or from flooding. Such sites as crevices in out-crops or between the "buttresses" of large trees such as silk cotton are usually used. Individual stacks normally contain a few dozen tubers. Yam stored in this way are susceptible to termite or rodent attack as well thieving from humans and monkeys.

(c) Storage in ordinary store rooms: Sheds or huts are either solely constructed for such a purpose or use is made of those which are not in use. In such store-rooms the tubers may either be stacked in heaps on the floor or be supported on shelves or dunnage. Free air circulation is assured with this type of storage.

d) Small thatched shelters: In such shelters the tubers are carefully stacked on top of each other to a height of about one meter. This type of storage is suitable for a firmer or hard fleshed white yams which do not bruise bruise easily.

e) Yam Silos: These are constructed by digging out a circular trench, piling and ramming the earth so dug into a low circular wall immediately within the trench, which presumably affords some protection against flooding or marauders.

These dug-out silos are used especially for early crop yams which are harvested before the end of the rainy season in the Northern parts of Ghana.

(f) Yam barn: Throughout Ghana, by far the commonest type of storage is the yam barn. This barn vary considerably in detail of design and construction in different parts of the yam growing areas, but all of them consists, in principle, of a vertical wooden frame-work about one to two metre high.

In some areas, the height may be as high as four metres, depending upon the amount of material to be stored. To this frame-work the yam tubers are fastened individually by means of a string or cordage material such as raffia. In many cases, the barns are covered with a thatched roof but others are shaded only with palm branches or by the branches sprouting from the live poles.

Treatment before Storage: It is a commom practice to treat all cut or bruised portions of the tuber with alkaline material, such as line-wash or wood-ash to reduce the probability of microbial infection, before storage. Bordeaux mixture may also be used with satisfactory results.

Nature of Storage: The criteria for successful storage of yams are the yams are the avoidance of excessive high temperature and the provision of maximum ventilation in the storage structures. All such should face the wind-ward side.

Cassava storage

Cassava ranks as the most important root crop in Ghana. Cassava tubers are, however, extremely perishable after harvest and cannot be kept for more than a few days without severe rotting. They then become unfit not only for edible purposes but also for processing into any useful product. Methods to control spoilage and prolong the storage life have been investigated only very spasmodically and there is still a paucity of reliable information.

Natural Storage techniques: Under subsistence farming conditions, the normal way of overcoming the storage difficulty is to leave the plants in the ground until needed, and, once harvested, to process the roots, immediately into some form of dried product, of inherently longer storage life. This system, however, has many disadvantages. The most important, perhaps, is that large areas of land are occupied by a crop which is already mature, and are thus unavailable for further cropping. Further, the susceptibility to loss is increased by allowing cassava to remain in the ground after it has matured. The tubers may increase in size, but they become more fibrous and woody and their starch content declines. Also harvested tubers cannot be utilized immediately, they are simply reburied underground to preserve them until required.

Surplus tubers are also sometimes heaped and watered daily to keep them fresh. Sometimes a thick coating of paste consisting of earth or mud can preserve the freshness for four to six days.

At times the harvested tubers are submerged in cold water. This method prevents the drying of the surface and helps to prolong the shelf life for 2 to 3 days.

Tubers are also sometimes buried in dug out holes, and covered with soil. Once or twice a day, cold or boiling water is poured on them. Such a storage method is able to keep the tubers for 7 to 8 days.

An improvement in this method of storage is to dig a trench in which layers of tubers can be stored. The layers can be arranged alternately with about 3 inches of soil on each layer, with the topmost being covered with 6 inches of well-beaten earth and build up to a ridge. When required, cassava can be withdrawn from an opening at the bottom end of the trench. If the trench is carefully designed and unbruised tubers are stored they are likely to stay fresh for some few months.

Blanching or hot water treatment: Blanching or scalding, a process involving the immersion in water at a temperature of 180° - 200°F (82° - 93°C) for one or two minutes, helps to prolong the shelf life of the tuber for a maximum of two weeks or more. This method causes a partial gelatinization of the outer surface of the edible portion of the tuber and thus inhibits surface infection. It also helps to decrease the bacterial load, remove any foreign matter and reduce enzymic activities.

Cold Storage: Post-harvest storage life can be extended by refrigeration. Tubers to be stored under refrigeration are to be blanched. Pieces of cut, peeled, fresh tubers can also be stored under deep freezing conditions.

Handling before Storage: Tubers intended for storage should be collected in dry warm weather, extreme care being taken to avoid damage. The tubers must be at the right age, neither immature nor over-mature. Depending upon the method of storage, the tubers must not be washed but they should be cleaned of any adhering extraneous material.

## CONCLUSION:

Foods spoil because of the action of enzymes, moulds, yeasts, bacteria, insect attack, rodent attack etc. Spoilage in foods leads to losses, in quantity and in quality.

There is therefore the need for suitable technogical methods for the preservation, storage and distribution of foods.

At the domestic and farm levels, such technological methods need to be simple but effective.

An intensive and a continual research and development programmes are therefore needed for the effective technology transfer and transformation to these levels.

Concomitant with such programmes is the need for the training of suitable personnel in the application of such technoligical innovation.

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