NUTRITIONAL VALUE OF CHILLED AND FROZEN FOODS

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ABSTRACT

Low temperature preservation is based on the fact that the biological/chemical changes that might occur in food at higher temperatures are retarded at lower temperatures. Low temperature preservation is divided into: (a) cooled/chilled products stored and distributed under cold conditions but not below 0 °C, and (b) frozen products stored and distributed under temperatures below 0 °C. As chilling and freezing are relatively harmless and effective methods of food preservation, these foods are becoming more and more common. It is therefore important to understand if significant nutritional changes result from these food preservation and storage procedures. Studies carried out elsewhere have shown that on the whole, the nutritional value of foods preserved by chilling and freezing are well retained. However, losses of nutrients could occur in one or more steps between the time of production and the ultimate use by the consumer. Vitamins are generally more unstable, whereas lower losses have been reported for protein, carbohydrate, fat and minerals. The significance of losses depends in part upon the proportion of the nutrient lost and in part upon the value of the food item as a source of the nutrient affected. Locally, studies on the effect of chilling and freezing on nutritional value of foods are grossly lacking. The importance of maintaining the cold chain to minimise nutrient losses should be emphasised to all those involved in the chain.

INTRODUCTION

Most foods of either plant or animal sources are extremely active biological systems. Chemical changes continue to occur in these foods, for example, in cereal grains and green vegetables after harvest, milk after milking, meat following the slaughter and fish caught from the sea. These foods contain a number of substrates and potentially active enzymes either inherent in the food itself or externally added. In addition, a number of chemical reactions in food are catalyzed by oxygen, light and metals. Under favourable conditions of temperature, pH and moisture, the biochemical activity continues at an increased rate, and the substrates are degraded, decomposed and also resynthesized to other substances (Nair, 1982).

Various methods of food processing, storage and transport have been devised to control or reduce such biological changes in food so that food lasts longer and is available far from its place of production (Nair, 1982). Food preservation procedures that have been used include (a) addition of chemical additives, (b) reduction of the moisture content of the food, (c) heat treatment to inactivate the enzymes present in the food, (d) the exclusion of catalyzing agents like oxygen and light, (e) the alteration of pH to a level suitable for the particular product and (f) through storage, transport and distribution at low temperatures (Gaman and Sherrington, 1981; Bender, 1982; Nair, 1982; Jones, 1988).

Freezing, canning and drying are the three most widely used methods for long term preservation of foods. Canned and dehydrated foods can be manufactured easily without massive capital investment and stored at relatively high temperatures for extended periods. Frozen foods, on the other hand, require practical refrigeration devices in processing plants, storage warehouses, in the transport and distribution system and user storage facilities. Because of the more expensive requirement for refrigeration, there are usually more canned and dried foods than frozen foods on the shelves of retail shops. However, as freezing is, in many respects the most harmless and effective method of food preservation, frozen foods are becoming more and more common (Gaman and Sherrington, 1981; Nair, 1982; Jones, 1988).

Low Temperature Preservation of Foods

Low temperature preservation is based on the fact that the biological/chemical changes that might occur in food at higher temperature are retarded at lower temperatures. The longer the storage time, the lower the temperature required for storage. Low temperature preservation is divided into (1) cooled products stored and distributed under cold conditions but not below 0°C (chilled storage), and (2) frozen products stored and distributed under temperature below 0°C (Gaman and Sherrington, 1981; Nair, 1982).

The cooling process is a mild operation and does not involve important changes. But changes can and do take place during the cold (chilled) storage period. Cooling prolongs the life of perishable vegetable products by arresting their biological activity. Onions, potatoes and carrots remain inert without sprouting for many months under cold storage conditions. Generally, food materials need some kind of antimicrobial (pasteurization of milk) or other treatment (heat treatment) to inactivate the enzymes before cooling and cold storage. Better effect of cold storage perservation is also achieved by controlled atmosphere (humidity, oxygen, CO_2, etc.) (Nair, 1982; Bognar *et al.*, 1990).

Freezing, on the other hand, is a more drastic procedure. During freezing of food ice crystallizes out, the remaining solution gradually becomes saturated and, consequently, the solutes also crystallize.

There is an increasing demand for chilled and frozen foods, one of the reasons being that consumers are aware that these foods are preserved primarily by low temperature and therefore often contain no preservatives. With increasing use of frozen foods in the local dietary pattern, there is therefore increased interest in the nutritional value of these foods. All kinds of food processing methods alter the nutrient content of foods. Low temperature preservation, though the best available alternative, is not by any means perfect. Thus freezing and frozen storage often have complex effects on nutrients.

Effect of Freezing on Nutrients in Foods

A variety of nutrients occur in foods, and these nutrients have varied properties and characteristics. As such, they are expected to be affected differently by the process of chilling and freezing.

Proteins

Proteins are not dissolved to an appreciable extent in water, and as a rule they are not affected by freezer storage. So the protein content of frozen foods when they reach the table is as good as that of fresh foods. There is one possible exception to this. If some fish or shellfish are held in freezer storage for long periods, the protein becomes somewhat less digestible than in the fresh frozen product (Simpson, 1962). The deterioration of fish during freezing and storage is partly due to denaturation of proteins. Repeated freezing increases the tendency of proteins to undergo denaturation (Tressler and Evers, 1965).

Fats

Under proper freezing conditions, changes of fat in foods are of little significance from a nutritional standpoint. However, if foods high in fat have not been properly packaged, or have been held in the freezer for too long or at too high temperature, the fat may become rancid. As fats turn rancid, they become oxidised and hydrolysed simultaneously. The fats of fish become rancid more quickly than those of other meat, although pork fat turns rancid rather quickly if the frozen product is stored at a high temperature. The oxidation of fat is usually accompanied by the simultaneous destruction of vitamin A content.

Carbohydrates

The starch in foods which have been frozen is the same, nutritionally, as the starch in fresh foods. During rather extensive freezer storage of fruits, sucrose changes gradually to simpler sugars, dextrose and levulose. Since this action ultimately occurs during the digestion of fruits, it is not detrimental to the nutritional value of the fruit.

Minerals

While minerals cannot be destroyed, occasionally one may occur in a food in a form in which the body cannot use it and it is then not "available" to the body. This may be a problem with iron or calcium. However, the iron in a number of vegetables has been shown to be at least as available (occasionally more so) in frozen foods than in similar fresh ones. The main problem with minerals is the possibility of their being lost by solution. If meats, fish or poultry are allowed to thaw excessively, they may "leak" or "drip", thereby losing some minerals through the solution.

The main route of loss of minerals is by solution during the blanching and subsequent chilling in preparing vegetables for freezing, and in cooking the frozen vegetables. Some work has shown the extent of losses in blanching, and subsequent chilling, but little has been reported to tell us how much is lost in cooking frozen vegetables. Losses during preparation for freezing are apt to be offset by fewer losses in cooking frozen vegetables than in cooking fresh ones. So servings from frozen vegetables should be as high in minerals as those from fresh ones. This will be further discussed when dealing with losses of ascorbic acid which is also soluble in water.

Vitamin A and Carotene

These are fat-soluble vitamins, and therefore occur with the fat fraction of the food. As discussed above, the oxidation of fat in a food is accompanied by the simultaneous destruction of vitamin A content. In fruits and vegetables, the vitamin A potency is due to several carotenes and cryptoxanthin which are precursors of vitamin A. Carotenes are rather readily oxidized, and losses from 0 to 20 percent have been reported during blanching in preparing vegetables for freezing. However, during a year in the freezer, little loss occurs in many blanched vegetables. Unblanched vegetables, on the other hand, may lose a substantial amount when stored frozen.

Thiamin and Riboflavin

These are members of the B-complex vitamins and various studies on the effect of freezing have been carried out. These and all other B vitamins are soluble in water. Riboflavin is not destroyed by heat, but under some conditions heat can destroy thiamin.

Since thiamin is soluble in water and may also be destroyed by heat, some loss of the vitamin in preparing vegetables for freezing can be expected. Studies have shown that about 25 per cent of the vitamin is lost during blanching and other processes carried out during preparation of the vegetables for freezing. No further loss was noted during freezing and subsequent storage. Unblanched vegetables, however, lose a large proportion of this vitamin when stored frozen.

Studies into loss of riboflavin in vegetables have shown that from 0 to 20 per cent may be lost during blanching and subsequent chilling in preparing them for freezing. Little is lost during freezer storage of blanched vegetables, but loss may be substantial from unblanched ones.

Meats, fish and poultry are important sources of thiamin and are also good sources of riboflavin. There is no indication of loss of either of these vitamins from these foods during freezing or freezer storage. This is to be expected, since preparation for freezing does not involve standing in water or heating. So the only way in which loss of these vitamins can occur, it seems is by dissolving small amounts of them (or of other B vitamins) into the juices which "drip" during excessive thawing. This should not happen at all, when the products are cooked from the frozen state or are correctly thawed. If drip occurs, the juice can be added to the meat during cooking.

Ascorbic Acid (Vitamin C)

By far the greatest amount of work carried out to determine the nutritive value of frozen foods has been in connection with the ascorbic acid in frozen fruits and vegetables. The reason for this is because fruits and vegetables are almost our only source of this nutrient, so their ascorbic acid content when frozen is important. Ascorbic acid dissolves in water more readily than any of the other vitamins, so may be lost this way. Also, it is readily destroyed by oxidation. Certain enzymes, if present and heavy metals can hasten its oxidation.

Thus, of all the vitamins, ascorbic acid is the most readily lost or destroyed. We may therefore be fairly confident that if the ascorbic acid retention of a fruit or vegetable is good, other nutrients will also have been retained. Furthermore, it has been noticed repeatedly that when the ascorbic acid retention of a fruit or vegetable is high, its flavour, texture and colour are also good. The amount of ascorbic acid lost in a fruit or vegetable is often taken as an indication of the extent of possible losses of other nutrients.

The freezing process itself has no effect on the vitamin, apart possibly from a small loss of less than 10% of the vitamin C, and they are stable in the frozen foods for periods of a year or more. However, in preparing the vegetables for freezing and cold storage, e.g. blanching, some of the vitamin is lost. Nevertheless, because there is less loss of this vitamin during cooking of frozen than there is during cooking of fresh vegetables, frozen vegetables when served are as rich in ascorbic acid as fresh vegetables.

Nutrient Losses Associated with Chilled and Frozen Foods

Various studies carried out have shown that there is no appreciable decrease in any nutrient due to freezing itself. That is, from the time the food is first put into the freezer until it is hard-frozen, the nutritional value is not changed significantly. Similarly, little nutrient loss occurs during the chilling process, if carried out rapidly.

However, nutrient losses do occur in association with chilled/frozen foods. These losses are the result of allowing the fresh product to stand at room temperature, or of steps in preparing the food for freezing, or they happen during cold storage or in preparing the foods for the table. Some of these losses will be considered in the following paragraphs.

Effect of blanching and chilling

Prior to the process of freezing, foods must be blanched to inactivate enzymes which would cause deterioration during storage, even at low temperatures. Blanching of bulky vegetables reduces their volume, expels gases, maintains colour and cleans them. Such procedures cause a loss of water-soluble nutrients although there are modifications designed to minimise such losses. Oxidation can occur as well as leaching out. The amount of losses depend on the state of subdivision of the food (surface-area to volume ratio), relative volumes of water to food, time and sometimes temperature (Bender, 1982).

The commonest blanching procedure is immersion in hot water but a variety of other methods have been developed. The time of treatment varies with the food, its size and the particular process. Methods of reducing blanching losses include the use of steam instead of hot water but a longer time may be needed, so that even if less vitamin is extracted there is some destruction from oxidation. Colour may also be adversely affected but the inclusion of ammonia with the steam maintains a higher pH and stabilises the chlorophyll. There are conflicting reports of the advantages of steam blanching, possibly because the effects vary with the type of food but, in general, losses are less in steam (Bender, 1982).

Microwave blanching has been reported to cause less damage than steam and a combination of microwave and hot water treatment has been claimed to yield a product superior both in nutritional quality and palatability.

Effect of thawing and cooking of frozen foods

There is considerable differences in opinion concerning the effect of thawing on the nutritive value of frozen foods. Some workers reported that thawing causes serious losses of vitamin C from frozen fruits and vegetables. Other workers feel that thawing is not in itself highly destructive of the nutritive value of foods. In general, however, frozen foods should be thawed under conditions which will keep drip to a minimum in order to prevent some loss of water-soluble vitamins (Tressler and Evers, 1965).

Serious losses of vitamins can occur during cooking and preparation for the table. This is especially true of vegetables, which show a wide range of losses. The loss of vitamin C in cooking frozen vegetables in different ways have been reported to range from 3 to 48%, whereas the loss of thiamine varied from 18 to 38%. Loss of carotene has been thought to be low. Vegetables should therefore either be steamed or cooked in a minimum of water for a period just long enough to tenderize them, since frozen vegetables can be cooked in a much shorter time than fresh ones (Tressler and Evers, 1965).

Losses during storage, distribution and retailing

The quality, and therefore the nutritional value of chilled and frozen foods is very dependent on the product's time-temperature history which is determined by each and every person concerned with handling the food through the frozen or cold chain. This chain extends from the factory all the way to the retail sale to the consumer. Successful maintenance of the cold chain inhibits the activity of food spoilage micro-organisms and slows down the biological and chemical reactions which cause loss of quality. It is therefore essential that the temperature of chilled and frozen foods be maintained as low as practicable or permitted during storage, distribution and retailing (Stone, 1983; Bogh-Sorensen and Olsson, 1990). It is imperative that proper educational programmes be given to those involved in handling chilled and frozen foods during the frozen food chain, including sales staff, distributors, food packers/manufacturers and retail store personnel.

CONCLUSIONS

Freezing of food, when conducted properly, is considered one of the best methods for preserving nutrients and retaining the desirable organoleptic properties of food during storage. The freezing process itself has no effect on the vitamins, apart possibly from a small loss, less than 10% of the vitamin C, and they are stable in the frozen foods for periods of a year or more. However, freezing must be preceded by blanching with the losses described earlier.

Frozen foods present an example of nutrient losses in processing being in place of, rather than in addition to, final cooking, since the processing reduces the final cooking time. As a result there is often little difference between the vitamin content of the final cooked food, whether originally frozen or fresh.

However, fruits and vegetables required for freezing are harvested and processed at the peak of condition which usually means at the maximum vitamin content, while so-called "fresh foods" are invariably past their peak when purchased. Consequently foods may have a higher vitamin content after freezing and cooking than if cooked fresh.

Freezing has no effect on B vitamins but the rate of freezing can influence the subsequent loss of exudate from meat during thawing and cooking. From the limited amount of information available, thiamin, riboflavin, niacin and pantothenate appear to be quite stable during frozen storage while there are losses of vitamin B6.

Similarly, cold storage of food is favourable for the preservation of nutritional quality. Special care is required in storing fruits and vegetables. The storage atmosphere should have a high relative humidity in order to minimise losses in water and nutrients. The changes in protein, fat and carbohydrate contents during chilling, chilled storage and reheating of cooked meals are generally small. Factors affecting vitamin retention in chilled meals and pasteurised-chilled meals are cooking methods, delays after cooking, chilling time, storage time and temperature, and reheating.

Locally, little research has been carried out on the nutritional value of chilled and frozen foods. If the dependence on these foods continue to rise, the contribution of these foods to the daily nutritional needs of the people would also increase. It is therefore important to pay more attention to the subject. Besides focusing on appropriate procedures in chilling and freezing to retain nutrients in foods, it would be of utmost importance to monitor the maintenance of cold chain. The nutritional value of chilled and frozen foods, as given by one or two indicators, could be monitored in the cold chain.

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REFERENCES

Bender, A.E. (1982). The effects of food processing on the vitamins. *In* Vitamins in Medicine, Volume 2. Barker, B.M. and Bender, D.A., eds. 4th edition. The Whitefrairs Press Ltd., London. pp. 291-318.

Bogh-Sorensen, L. and Olsson, P. (1990). The chill chain. *In* Chilled Foods - The State of the Art. Gormley, T.R. ed. Elsevier Applied Science, London. pp. 245-267.

Bognar, A., Bohling, H. and Fort, H. (1990). Nutrient retention in chilled foods. *In* Chilled Foods - The State of the Art. Gormley, T.R. ed. Elsevier Applied Science, London. pp. 305-336.

Gaman, P.M. and Sherrington, K.B. (1981). Food spoilage and food preservation. *In* The Science of Food. Pergamon Press, Singapore. pp. 219-228.

Jones, G.P. (1988). Food processing. *In* Food and Nutrition in Australia. Wahlqvist, M.L., ed. 3rd edition. Thomas Nelson, Melbourne. pp

88-97.

Nair, B.M. (1982). The effect of low temperature preservation on the nutritional value of chicken meat protein. *Food & Nutrition* 8(2): 41-44.

Simpson, J.I. (1962). The Frozen Food Cookbook and Guide to Home Freezing. 2nd edition. AVI Publishing Co., Connecticut. pp. 19-29.

Stone, P. (1983). The frozen food chain - goodness from us to you. *J Food Nutr* 40: 120-122.

Tressler, D.K. and Evers, C.F. (19[illegible]). The nutritive values of frozen foods. *In* The Freezing Preservation of Foods. Volume 1. Freezing of Fresh Foods. 3rd Edition. AVI Publishing Co, Inc., Connecticut. pp. 946-1001.

DISCUSSION

Q. On the subject of blanching, what is the controversy regarding steam blanching?

A. According to literature, some say steam blanching is better, while others report a loss of colour. Therefore work should be carried out to study the effect under local conditions.

Q. Therefore, it appears that the problem more concerned with the time of steam blanching rather than with the steam itself?

A. Yes. However, it has been reported that addition of ammonia to steam can improve the colour. We should also consider the effect on the nutrient content.

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