

## CHANGES IN NUTRIENTS DURING STORAGE AND PROCESSING OF FOODS - A REVIEW

Dandago, M.A.

Department of Food Science and Technology, Kano University of Science and Technology, Wudil, Kano State  
dandago223@yahoo.com

### ABSTRACT

*Various changes that occur in nutrients during processing and storage of various food products were reviewed. Preliminary unit operations such as cleaning, soaking, peeling and dehulling leads to significant losses of vitamins and mineral contents of food products. Applications of heat during processing also lead to losses quantitatively and qualitatively and it was noticed that water soluble vitamins were worst affected. Undesirable reactions in proteins which can lead to decrease in its biological value may also occur in some foods products. Sugars are affected by leaching and also take part in browning reactions. Irradiation is not suitable for fatty foods. Recommendations were made on adopting new/modern processing methods to decrease the losses. Proper storage conditions especially temperature and humidity controls should be adhered to strictly at the same time local producers/processors should be educated on consequences of over processing.*

**Key words:** Nutrients, vitamins, dehulling, peeling, leaching, oxidation.

### INTRODUCTION

Food is any substance assimilated into the body of living organism, which provides energy, material for growth, body repair, reproduction and assist in regulation of various processes in the body (Odeyemi and Duramola, 2000). Food is like fine China not only is it expensive, but it must be handled carefully because of its fragile nature. Food products are susceptible to spoilage, loss of nutrients, insects and rodents infestations, and changes in color, flavor and odor (Hurst, Reynolds, Scheler and Christian, 1993).

Storage is defined as holding goods until needed for further processing, marketing or consumption. The expression connotes the expectation that goods would not just be kept, but in the most appropriate conditions for maximum retention of both quality and quantity (Wajilda, 2008).

The term processing cover an enormous field of widely different treatments carried out to render food safe, edible and palatable. The major methods of preservation all cause some changes in the nutritional value of food but the loss is not significant. Nutrients are those substances in foods which when eaten provide nourishment to the body. The most sensitive nutrients to change are vitamin C and to a lesser extent vitamin B<sub>1</sub>. Other nutrients are much more stable and very little is lost in most processes. However, greater losses can occur due to improper storage of food under adverse environmental conditions (Hurst *et al.*, 1993).

Cooking improves the digestibility of foods, promotes palatability and improves the keeping quality as well as wholesomeness. The heat used during processing can be a dry heat (as in baking) or wet heat (as in steaming). Heat helps to sterilize the food by killing harmful bacteria, control undesirable enzymatic reactions and enhance nutrients availability (Okaka and

Okaka, 2001). Proteins are denatured by heat where they are made more easily digestible by proteolytic enzymes and cellulosic cell walls that can not be broken down by monogastric animals (e.g. man) are broken down during heating. Heat also helps to inactivate anti-nutritional factors such as trypsin inhibitors.

There is significant improvement in quality and digestibility of carbohydrates after malting process and anti-nutritional substances in the grains are leached out. Soaking of cowpea prior to milling helps to hydrolyze the indigestible oligosaccharides. Foods are made more stable for certain period of time after drying, cold storage, irradiation, addition of preservatives etc however; despite all the advantages of food processing and storage there are adverse effects or changes that occur in the nutrients during some operations. There is need to understand these undesirable changes in food nutrients and take possible measures to overcome them.

### Changes in Various Nutrients: Changes in Vitamins and Minerals during storage

There is every reason to believe that only insignificant level of vitamin B is lost during storage of frozen meats provided the temperature is low enough and does not fluctuate. The most susceptible vitamins are B<sub>1</sub> and B<sub>2</sub>. Milk may lose substantial amounts of vitamins B<sub>2</sub> and C within few hours if stored in a clear bottle in sunlight whereas vitamins A and D are not affected (Hurst *et al.*, 1993).

The vitamin content of cereals (rice and wheat) remains relatively stable provided the moisture content does not increase above 10%. The vitamin B content of stored bread and break fast cereals remains stable provided good storage conditions are used.

Vitamins A and C are regarded as the most important nutrients in fruits and vegetables but substantial quantities of both vitamins are lost if kept at room temperature. Vitamin E which is highly susceptible to oxidation is found in substantial amount in nuts. The vitamin can be preserved by vacuum packaging or freezing the product in oxygen impermeable film (Hurst *et al.*, 1993).

According to Hurst *et al.*, (1993) drying does not cause major losses in vitamins provided the finished food are adequately protected from oxygen either by proper packaging or use of anti-oxidants.

### **Changes in Vitamins and Minerals during Processing**

Because of their essential nature, the extent of destruction of vitamins during processing is often the main criterion by which workers judge the quality of processed foods (Ihekoronye and Ngoddy, 1985). But it is often realized that home cooking generally lead to much greater loss of vitamins than those encountered in industrial processing. Generally, the skin of fruits and vegetables is richer in vitamins than other areas and also the bran of cereals grains contains the B vitamins. In tuber crops the surface is usually higher in vitamins than the cortex and consequently trimming, peeling, washing etc. of fruits and vegetables; root and tubers prior processing result in loss of vitamins and minerals.

To understand the effect of trimming or peeling on the nutritional value of foods it is important to understand the distribution of vitamins on food materials. Vitamin C for example is higher in the peels of fruits and vegetables than in the cortex. Niacin and Riboflavin are also slightly higher in the peel of fruits. Fresh citrus fruits show much higher concentration of Ascorbic acid in the outer peel and inner white skin than in the fruit pulp or juice whereas in vegetables, vitamins are normally higher in leafy portions. In carrots for example, the peel is much higher in niacin and carotene than the remaining root. The same is true of palm fruit and potatoes which show vitamin higher content in the peel than in the flesh. There is no doubt that trimming and peeling of fruits and vegetables reduce the nutrients content, however boiling the food material with the intact skin helps to retain these nutrients (Leriei 1998).

In Nigeria, leafy vegetables and many fruits are hardly processed and only small quantities of harvested vegetables are sun dried locally. Losses may occur with vitamins labile to heat, light and air (Ihekoronye and Ngoddy, 1985). Blanching is the first step for effective preservation of some fruits and vegetables and in many instances, blanching treatment is often combined with the use of chemicals in order to

produce certain desirable qualities. Loss of vitamins and minerals during blanching can be significant and is a function of surface area per mass of product, degree of maturity of the product, blanching method, blanching time and method of cooling after blanching. Nutrients losses that occur during blanching are caused by leaching, oxidation of water soluble nutrients and thermal destruction (Walter, Truond and Espinel, 1998).

Both vitamin A and Carotene are unaffected by most cooking methods but small amounts may be lost during frying. Also about 25% of thiamin is lost when potatoes are boiled, meat loses about 40% of its thiamine content when roasted and also when bread is baked about 25% of the thiamine is destroyed. According to Ihekoronye and Ngoddy (1985), the overall loss of water soluble vitamins is greater than that of fat soluble vitamins during cooking. Preservation by freezing and storage of these frozen products is generally regarded as the best method for long term preservation when judged on vitamin retention. Losses that occur are generally not significant if proper packaging and freezing procedures are used. A loss in the ranges of 0-40% vitamins does occur in vegetables and animal tissues during frozen storage (Okaka and Okaka, 2001).

During flour milling, the outer coat where B complex vitamins and minerals are localized are removed in order to obtain flour of desirable texture (Asiedu, 1989). This necessitates flour enrichment with vitamins and minerals after milling.

### **Changes in Proteins during storage**

The biological value of proteins is usually little affected by proper storage of food products. High storage temperature will cause certain amino acids (e.g. lysine) to chemically bind with simple sugars to form brown pigments through maillard reaction. The reaction affects the nutritional value of the food because it causes the essential amino acid to become physiologically unavailable (for example improperly stored dried milk and egg white powder are particularly susceptible to this browning reaction) the reaction will also occur if poor packaging of dried foods allow as increase in moisture level (Hurst *et al.*, 1993).

### **Changes in Proteins during Processing**

A number of changes may occur during processing, some of which are desirable while others are undesirable. Some chemical changes may lead to compounds which are non hydrolysable by the intestinal enzymes; or to improvement of nutritional value by deactivating certain anti-nutritional factors such as trypsin inhibitors (Ikeme, 1990). The types of changes in protein during processing are recognized as follows:

1. Denaturation which requires mild heat is the unfolding of the protein complex structure, and according to Nielsen (2004) the effects of denaturation include:
  - (a) Peptide bonds of the protein are more readily available for hydrolysis by proteolytic enzymes.
  - (b) Enzymes activity if originally present is lost or decreased.
  - (c) Crystallization of protein is no longer possible.
  - (d) Intrinsic viscosity is increased.

After all boiling and roasting of food materials certainly denature the protein as indeed will the acid of the stomach, but there is no loss of nutritive value (Behnsillan, Regier and Stahl, 2003).
2. The second type of change is caused by mild heat in the presence of reducing substances which results in a linkage between the end epsilon amino group of lysine with reducing substances which can not be hydrolyzed by the digestive enzymes. The lysine is still present and is liberated by acid hydrolysis, but since it can not be liberated during digestion, it is biologically unavailable.
3. More severe heating reduces availability of other amino acids as well as lysine and can occur in absence of reducing substances. At temperature of 115°C, cystine is relatively sensitive and can be oxidized to disulphide or disulphene. Milk for instance is pasteurized at 72°C for 15 seconds (Ihekoronye and Ngoddy, 1985). Changes in temperature and time will lead to off flavor production because of unfolding of  $\beta$ -lacto globulin. Consequently, there is exposure of sulphadryl groups of cystine for hydrolysis and production of hydrogen sulphide. Also light induced oxidation of proteins is known to lead to off flavor and destruction of essential amino acids in milk. Sunlight attacks methionine and converts it into methionol which cause a typical sunlight off flavor at 0.1ppm (Behsnillan *et al.*, 2003). The source of light induced off flavor in milk resides in low density lipo protein fraction.
4. Excessive heat such as applied to the outside of foods of the puffing exploding type of processing used in the manufacture of some breakfast cereals and pop corn causes severe protein damage. It leads to the destruction of amino acids by complete decomposition or by forming of cross linkages forming poly amino acids. Temperatures of 180°C such as used in roasting meat, fish, coffee and biscuit baking have these effects (Ihekoronye and Ngoddy, 1985).
5. Alkali treatment in conjunction with heat treatment and oxidation damages protein quality. Alkali treatment is been used in preparation of protein concentrates and isolates. This treatment leads to the

formation of new amino acids such as Lysino - alanine, Lanthronine and ornithino-alanine. Cystine, lysine and serine are primarily involved in such reactions (Ihekoronye and Ngoddy, 1985).

6. Ionizing radiations is a modern method that is employed in food processing and preservation. These radiations can produce charged particles (ions) in the materials they strike and hence undesirable reactions may occur. In proteins, deaminations, oxidations, polymerization and decarboxylation have been observed during irradiation. Histidine, phenylalanine, Tyrosine and sulphur containing amino acids are reported to be the most sensitive to the effect of irradiation (Fellows, 2000).

#### Changes in Lipids during Storage

The nutritional value of fat lies in the energy it supplied to the body during digestion. Fats are fairly stable to processing (except frying) but may undergo quality deterioration during prolonged storage.

Oxidation and hydrolytic rancidity occurs in stored foods leading to off flavor development. These reactions can be caused by enzymes or by moisture and air. They occur more rapidly under adverse conditions but can also develop in properly stored fatty acids. Lipids oxidation produces off flavor components called hydro peroxides and peroxides which react chemically with fat soluble vitamins rendering them nutritionally useless. Loss of these nutrients can be minimized by wrapping foods in moisture proof and oxygen impermeable packaging materials (Hurst *et al.*, 1993).

#### Changes in Lipids during Processing

Excessive heating will cause reaction of carbonyl components resulting from the decomposition of unsaturated fatty acids which may lead to reactions similar to those involved in non-enzymatic browning. Lipases and phospholipases release fatty acids from meat and fish during frozen storage and free fatty acids are more susceptible to oxidative rancidity (Okaka and Okaka, 2001). This problem is especially important in products with high degree of unsaturated fatty acids (e.g. pork and sea foods).

Many irradiation promoted reactions occur in lipids and produce results similar to oxidative rancidity with loss in fat soluble vitamins. Several carbonyl compounds may be formed together with other potentially active intermediates that can be carcinogenic.

#### Changes in Carbohydrates during Storage

Carbohydrates can be said to be relatively stable to processing and storage compared to sensitive nutrients such as vitamins.

There is no significant loss in the nutritional value of carbohydrates in frozen, canned or dried foods.

In fact, some carbohydrates are made more digestible through processing and thus nutritionally available and complex carbohydrates are converted to simple sugars. Adverse brown pigments occur in frozen and dried foods when carbohydrates react with proteins (Hurst *et al.*, 1993).

#### Changes in Carbohydrates during Processing

During wet heat treatment as in blanching and boiling; there is considerable loss of low molecular weight carbohydrates as well as micro-nutrients into the processing water. The loss of glucose and fructose at boiling is higher than that of sucrose. The loss of low molecular weight carbohydrates also may vary between species and cultivars.

Non enzymatic browning reactions occur between reducing sugars and amino groups in foods during processing and storage. These reactions are temperature dependent and most extensive at intermediate water activities (Leriei, 1998). They are important nutritionally as they may diminish the bio availability of amino acids especially lysine and thus diminishing the protein nutritional value. The carbohydrate content and availability is influenced only marginally.

When starch is heated in the presence of water, the starch granules rupture and form gels. The gelatinization increases the availability of starch for digestion by amylolytic enzymes. Gelatinized starch is not in thermodynamic equilibrium and according to Leriei (1998) there is therefore a progressive re-association of the starch molecules upon ageing. This recrystallization is referred to as retrogradation and may reduce the digestibility of the starch.

#### Changes in Moisture during Processing

Changes in moisture content of dried and frozen food can affect the nutritional quality of food.

#### REFERENCES

- Asiedu, J.J. (1989). *Processing Tropical Crops*. Macmillan Educational Limited London.
- Behnilan, D., Regier, M. and Stahl, M. (2003). *New methods in food processing*. Federal Research Centre for Nutrition, Germany.
- Fellows, P. (2000). *Food Processing Technology: Principles and Practice*. Wood Head Publishing Limited Cambridge.
- Hurst, W.C. Reynolds, A.E., Schuler, G.A. and Christian, J.A (1993). *Maintaining Food Quantity in Storage*. University Of Georgia Cooperative Extension Service Bulletin 914.
- Ihekoronye, A.I. and Ngoddy, P.O (1985). *Integrated Food Science and Technology for the Tropics*. 1<sup>st</sup> Ed Macmillan Educational Limited London.
- Ikeme, A.I. (1990). *Meat Science and Technology*. Africana Fep Publishers Bermenda Cameroon.
- Leriei, C.R. (1998). *Influence of Modern Technologies Of Processing, Storage and Distribution Of Food Products*. International Seminar on Nuclear War and Planetary Emergencies 23<sup>rd</sup> Session.
- Nielsen, T. (2004). *Underlying Principles and Actual Problems for the Processing Of Organic Meat Products*. Organic e-prints. Denmark.
- Odeyemi, O.O. and Daramola, A.M. (2000). *Storage Practices in the Tropics*. Vol. 1 Dare Collins Publications Akure. Nigeria Pp. 2
- Okaka, J.C and Okaka, A.N.C. (2001). *Food composition, Spoilage and Shelf life Extension*. Ocjanco Academic Publishers, Enugu.
- Walter, W.M., Tround, V.D. and Espind, K.R. (1998). *Effects of Puree Processing Methods on the Textural Characteristics Of an Alginate Textured Sweet Potato Products*. Food Science Research Unit. United States Department of Agriculture.
- Wajilda, J.I. (2008). *A Review Of Traditional Grain Storage Practices In Adamawa State*. M. Tech. Non Thesis Seminar Department of Crop Production and Horticulture Federal University of Technology Yola (Unpublished).

Increase in the moisture level of dried food promotes microbial deterioration and accelerate rancidity. Improperly wrapped foods suffer from freezer burn which is a form of dehydration from the food surface. This loss of moisture causes oxidation of fats and browning leading to off flavor development and at the same time lowering the nutritional value of the food (Hurst *et al.*, 1993).

#### CONCLUSION AND RECOMMENDATIONS

Processing foods is necessary to achieve desirable sensory and healthy attributes in the food product. Storage of food materials is also necessary to extend the shelf life of the product and make it available for future use and for processing. Because storage and processing of foods are inevitable, there is need to devise methods to at least reduce the adverse effects due to these processes. These effects can be reduced by the following recommendations:

- i. Strictly following the storage conditions of temperature and relative humidity for the particular food product and also avoiding temperature fluctuations.
- ii. Adopting high energy transfer processing method such as (HTST) to reduce the treatment time.
- iii. Adopting new processing methods such as high hydrostatic pressure technology, ohmic heating, and ultrasound technologies where necessary.
- iv. Improving temperature, humidity control and packaging systems in food storage and distributions
- v. It is also recommended that the populace be educated on the effect of over processing on the nutrients and suggest possible ways to avoid it. This can be achieved through radio jingles and or use of extension workers.

