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Popular Article

Different Types of Changes in Seafood during Frozen Storage

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Abstract

Frozen storage is widely applied method for extending shelf life of eventually refrigerated food products, mainly meat, fish and seafood. Due to different types of changes during frozen storage such as physical, chemical, microbial, sensory etc., Post-mortem changes can be described as deterioration mechanisms that are produced during and after frozen storage causing quality losses in frozen sea foods. So, to prevent these types of changes uses by some techniques and improve the quality of the product.

KEY WORDS: Frozen storage, Physical, Chemical

INTRODUCTION

Fish is highly perishable commodity and generally contain 70-80% moisture content. It is also highly nutritious food and is rich in protein, fat, minerals and certain vitamins that are required for human growth. When seafood is freshly caught or harvested, the eating quality is usually very good, but over the time overcome spoilage, different preservation methods are used. In the process of freezing, heat is removed from the product and waters converted into ice. It is the best method of heat removal of fish (Gopakumar, 2002). The faster the freezing process, the lesser the spoilage. In India, 80% of seafood export constitutes frozen fishery products. At a temperature of -35^{0}C. The largest part of the water which is about 75-80% is frozen between -1^{0}C to -5^{0}C and referred as Critical range or Zone of maximum ice crystallization. Freezing and cold storing techniques are now more attractive, modern and easy to handle. Low temperature preservation is the best method to retain the quality and freshness of fish and fish products for a long time. If fish are properly frozen within a few hours of catching and stored properly, it can help to reduce spoilage and extend shelf life of the food products (Balachandran, 2001). The International Institute of Refrigeration recommends a storage temperature of -18^{0}C for lean fish, -24^{0}C for fatty fish *spp.* The major problems during the freeze processing of fish are oxidative deterioration, dehydration, toughening, loss of juiciness and excessive drip.

Effect of Frozen Storage on Food Quality

What Is a Frozen Storage?

Frozen storage is widely applied method for extending shelf life of eventually refrigerated food products, mainly meat, fish and seafood.

Frozen food may undergo the quality changes during frozen storage. Physical and chemical changes can be described as deterioration mechanisms that are produced during frozen storage causing quality losses in frozen foods.

1.1 Physical Changes

The main physical changes during storage of frozen food are moisture migration, freeze burn and ice recrystallization.

1.1.1 Types of Physical Changes

- Moisture migration
- Freeze burn
- Recrystallization of ice
- Driploss
- Dehydration
- Sensory changes
- Gaping of fillet

1.1.1.1. Moisture Migration

A slow freezing process can allow sufficient time to water for migration from extracellular region to intracellular region because of osmotic forces. This can result in cell desiccation, cellwall disruption, loss of turgor and crushing of dried cell by large intercellular ice mass.

These may be affecting texture of frozen product, can cause significant drip loss during thawing & cooking and leading to a loss of nutrients. During frozen storage, the existence of temperature gradients within a product creates water vapor pressure profiles and result in moisture migrate on and relocation of the water.

1.1.1.2 Freeze Burn

Freezer burn is a condition that occurs when frozen food has been damaged by dehydration and oxidation due to air reaching the food. It is generally caused by food not being securely wrapped in air-tight packaging. The critical limit of dehydration or rate of weight loss of frozen fish in cold storage is 50g/m2/24h. Freezer burn increases oxygen contact with the food surface area and raises

oxidative reactions, which irreversibly alter color, texture and flavor. It is caused by the sublimation of ice on the surface region of the tissue where the water pressure of the ice is higher than the vapor pressure of the environment. In cold storage rooms the temperature of the freezing coil (evaporator) is always lower than the surrounding air, there for ice forms and accumulation the coil. Glazing, dipping or spraying a thin layer of ice on the surface of an unwrapped frozen product helps to prevent drying. Freezer burn is prevented if a product is packed in tight-fitting, water- proof, vapor proof material, because evaporation cannot take place (Zaritzky, 2010).

1.1.1.3.Recrystallization Of Ice

Slow freezing results in a low rate of nucleation and the production of a small number of large ice crystals, whereas fast freezing causes high rate of nucleation leading to the formation of a large number of small ice crystals. However, during frozen storage ice crystals undergo metamorphic changes. Recrystallization reduces the advantages of fast freezing and includes any change in the number, size, shape, orientation, or perfection of crystals following completion of initial solidification. Recrystallization basically involves small crystals disappearing, large crystals growing and crystals fusing together, and affects the quality of the product because small ice crystals make the product quality better; large crystals often cause damage during freezing.

Different Types of Recrystallization Processes:

(a) Isomass Recrystallization

(b) Migratory Recrystallization

(c) Accretive Recrystallization

(d) Pressure-induced Recrystallization

(e) Irruptive Recrystallization

2.1 CHEMICAL CHANGE

Chemical changes in muscle foods during frozen storage led to the water holding capacity, decrease in tenderness, and rancid flavor development.

2.1.1 Types of chemical changes:

- Protein denaturation
- Lipid hydrolysis
- Lipid oxidation
- Loss of electrolytes

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- Change of pH
- Changes in eating quality

CHANGE IN PROTEIN

2.1.1.1. Protein Denaturation

Proteins may undergo changes during freezing and frozen storage, because of Denaturation. Denaturation can be defined as a major change in the native structure that does not involve the loss of biological activity and significant changes in some physical or functional properties such as solubility. Oxidative process during storage can also contribute to protein denaturation; oxidizing agents (e.g.enzymes, transition metals) can react with proteins via lipid and non-lipid radials. Fish protein is particularly sensitive to denaturation, where protein develops cross links between adjacent protein molecules that effectively stop the thawed fish protein to reabsorb water to recreate the pre frozen gel structure. This denatured protein has a much tougher and rubbery texture than the native protein. The textual change in fish proteins is due to the changes in the myofibrils. The rate at which fish muscle is frozen also influences the degree of protein denaturation. The rapid freezing results in less denaturation than slower freezing, intermediate freezing can be more detrimental than slow freezing, as judged by textual changes and the solubility of act myosin (Ninawe, 2008).

Freezing and frozen storage do not significantly affect the nutritional value of fish proteins. However, on thawing frozen fish substantial amounts of intra- and extracellular fluids and their water-soluble proteins and other nutrients may be lost, and the term called **Drip loss.** The volume of drip loss on thawing of fish is highly variable, usually 2-10%of net weight. It is observed for fish that if the product is stored for an appropriate short time and at a sufficiently low temperature, the subsequently thawed fish would rehydrate with the protein returning to its original gel condition. Enzymes have also linked to protein denaturation, that low temperature decreases activity of enzymes in tissue, but does not inactive them (Gopakumar, 2002).

2.1.1.2. CHANGES IN LIPIDS

Fish lipids undergo two main types of changes during storage of fish, which are hydrolytic changes and oxidative changes. Both these changes will reduce the organoleptic quality and shelf life. These changes result in rancidity. The unsaturated bonds present in all fats and oils represent active centers that may react with oxygen. This reaction leads to the formation of primary, secondary and tertiary oxidation products that make the fats or fat containing foods unsuitable for consumption (Zaritzky, 2010).

Lipid oxidation is one of the major causes of food spoilage; it is of great economic concern to the food industry because it leads to the development of various off-flavors and off-odors. In addition, oxidative reactions can decrease the nutritional quality of foods. Lipids in foods can be oxidized by both enzymatic and non-enzymatic mechanisms. If the enzyme is not inactivated before freezing by blanching, it can generate offensive flavors and loss of pigment color. In fatty fish, oxidation takes place primarily in the depot fats which are composed of triglycerides. Peroxides, hydro peroxides, aldehydes, ketones, etc. are the types of products produced by the oxidation of the fatty acids. Lipid hydrolysis or lipolysis results in the release of free fatty acids and resulting in hydrolytic rancidity. Triglyceride in the depot fats is cleaved by triglyceride lipase and cellular lipases. The fatty acids themselves may cause a“soapy”off-flavor (Zaritzky, 2010).

2.1.1.3. CHANGES IN NUCLEOTIDE

Changes in Adenosine Nucleotides during Frozen Storage. In order to investigate the effect of nucleotide composition of fish muscle on protein denaturation. The sum of the quantity of ATP, ADP, AMP and IMP decreased meat in samples killed and eviscerated immediately toof meat in samples stored. The sum of HxR and Hx increased from of meat after 6- and 12-hstorage at 25 "C, respectively. The contents of HxR and Hx were high in fresh samples. This might be due to the struggling during netting and transporting and might accelerate the degradation of adenosine nucleotides. The levels of ATP, ADP, AMP and IMP decreased gradually during storage. The ATP in sample I disappeared after 3 weeks of storage. The development of HxR and Hx in all samples was observed during 18 weeks of storage. According to these data it appears that the changes in levels of adenosine nucleotides are much faster in room-temperature than in frozen storage. As indicated in the increase in K value of samples stored at 25 "C for 6 h was almost the same as that of samples stored at -20"Cfor 18 weeks. It suggests the importance of temperature in handling, transportation, storage, and processing of fish muscle (Jiang et al., 1987).

2.1.1.4. Freeze Denaturation

Unfolding of molecules due to secondary reaction between the reactive groups of different proteins and other components of fish muscle, leading to cross linking and formation of aggregates.

- The proteins lose part of their solubility and reduced enzyme activity.
- As a result of these changes significant deterioration of the functional properties of the fish meat.
- It is manifested by a decrease in water retention, gel forming ability and lipid emulsifying capacity deteriorating of texture and the increased dryness of fish meat
- Fish that are stored for longer period becomes tough, chewy, rubber and fibrous.

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2.1.1.5. CHANGE pH

Physicochemical alterations in frozen food products may be related to the composition and concentration of soluble salt. Salts in solution can increase the solubility or dispersibility of macromolecules and cause precipitation of proteins. A change in salt concentration and composition during freezing of food bring about a pH change, which is contributed to alterations in reactivity of proteins and in enzyme activity. The pH of a frozen food can be changed by an increase in the concentration of solutes and by precipitation of a salt at the super saturation level (Ninawe, 2008). Changes in pH of fish occur due to the ice formation during freezing. Changes in pH of products during frozen storage dependent on the salt composition and buffering capacity. After death the residual glycogen is broken down to pyruvic acid and the actic acid and flesh becomes more acidic (pH-6.0). As in other hand, the microbial decomposition of fish tissue results in the production of nitrogenous substances (pH-7.1to 7.2).

FACTORS THAT A FFECT CHEMICALCHANGES

- Initial substrate concentration
- pH, Aw
- Handling and Processing
- Time and Temperature

PREVENTION OF CHEMICAL CHANGES

- Inactivation of enzymes
- Low temperature storage
- Alteration of pH
- Exclusion of oxygen

3.1 BACTERIALCHANGES

- During freezing, 80to90% of the Gram-negative bacteria die out and the residual bacteria cannot grow in the temperature of frozen storage.
  - As the temperature falls, bacterial growth rate is reduced.
  - Lactic acid bacteria, mold, and psychrophilic microbes were formed during the 6months of frozen storage

3.1.1. QUALITATIVE CHANGES IN BACTERIAL FLORA DURING FREEZING

Freezing imparts a selective action on the bacterial flora of fish and various bacterial species are affected at different levels, But Gram-positive bacteria are more resistant to freezing and frozen storage than Gram negatives, but among Gram positives, differing sensitivity to freezing is noticed. *Bacillus, Lactobacillus and Micrococcus* are more susceptible to freezing than Coryneform‟ bacteria. Among the gram negatives, sensitivity to freezing is almost comparable

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except the case of *Vibrio* species that are very much sensitive. Pseudomonas and *Aeromonas, Moraxella and Flavobacterium* species are more resistant to the lethal action of freezing (Balachandran, 2001).

4.1 SENSORYCHANGES

4.1.1. DISCOLORATION

Freezing may also affect the natural coloration of a product due to difference of ice then water, however this change in color is reversible when product is thawed. Color is important factor in seafood quality. Discoloration is caused by enzymatic or non-enzymatic action such as fat oxidation or by pigments. Proteins are part of pigment complexes and they get denatured by chemical reactions. These changes are permanent and irreversible. Seafood also have high levels of PPO (polyphenol oxidase) enzymes and if they are not frozen and stored at right temperature or subjected to temperature a buse, they undergo this process of Melanes is and render the product with black spots (Balachandran, 2001).

4.1.2. Texture Change–Texture Hardening

Protein denaturation–toughening texture Freezing induces protein denaturation and related functionally losses are commonly observed in frozen fish. Effects of protein denaturation may be seen in water holding capacity, viscosity, gelation, emulsification and whipping properties of product and also, the textural changes(toughness) (Shenouda, 1980).

4.1.3. Taste & Odour Change

Several frozen foods deteriorate mainly by slow chemical reactions, such as loss of nutritional value. For consumers, taste, Sodour and appearance are the most obvious criteria in academia and in the industry, shelf-life assessments usually involve sensory evaluation and instrumental measurements based on a given quality index.

4.1.4. Flavor Change

5.1 POSTMORTEM CHANGE ON SENSORY QUALITIES

1. Post mortem changes constitute the natural progression of the body's decomposition after death, beginning at the cellular level.
2. The first sensory changes off is during storage are concerned with appearance and texture. The most dramatic change is onset of rigor mortis.

CONCLUSION

Frozen storage is a widely applied method for extending shelf life of fish & shellfish product for long period of time and used to the human consumption with a good quality of product. Due to different types of changes found during frozen storage such as Physical and chemical changes can be described as deterioration mechanisms that are produced during frozen storage causing quality losses in frozen foods. So, we reduce or prevent these types of changes and improve the quality of the product.

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