COURSE TITLE: Nutritional Evaluation of Food Processing

COURSE CODE: FST 512

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LECTURE 1

FREEZING AS A PRESERVATIVE METHOD

Freezing is an effective preservation technology because of the role of temperature in biosystem stability and the reduction of moisture levels within foods after freezing and during frozen storage. Both factors combine to significantly slow down the chemical, physical and biological reactions that govern the deterioration of foods. The process of freezing involves the removal of heat from a food material accompanied by a phase change as liquid water becomes solid ice. However, this is not without a damaging effect on the food.

Damaging Effect of Freezing on Meat / Fish Quality

Freezing damage may be attributable to a variety of effects, although it should be recognised that thawing may play just as important a role.

Sources of damage can arise from:

- The formation of ice within cells or in extracellular space
- The physical expansion of water into ice
- Cell dehydration and shrinkage and the potential rupture of membranes
- Changes in solute concentrations, both within and surrounding cells
- Migration of water from cells to extracellular space and potential dehydration.

Effects of Period of Frozen Storage

The period of frozen storage, which can last for several months or years is important in understanding the effects of freezing on food quality and safety. It is not uncommon for food ingredients or minor items to be frozen and stored for up to 18–24 months before being reconstituted and used as a component in other chilled, frozen or heat-processed food products. Even foods intended to be marketed as frozen products have shelf lives that extend up to 24 months. Fluctuations in temperature that occur during storage causes recrystallization phenomena and may explain the deterioration in meat quality over frozen storage. Table 1 indicates some suggested practical storage lives for various food commodities at different frozen storage temperatures. This illustrates the role of temperature in dictating the stability of frozen foods.

Table 1: Practical frozen storage lives (months) for meat and fish

Product	Frozen storage temperature		
	−12°C	−18°C	−24°C
Meat and poultry			
Beef steaks	8	18	24
Beef, ground	6	10	15
Lamb steaks	12	18	24
Pork steaks	6	10	15
Chicken, whole	9	18	>24
Chicken, cuts	9	18	>24
Turkey, whole	8	15	>24
Ducks/geese, whole	6	12	18
Fish and seafoods			
Fatty fish	3	5	>9
Lean fish	4	9	>12
Lobster, crabs, shrimps (in shell, cooked)	4	6	>12
Clams and oysters	4	6	>9
Shrimps, peeled and cooked	2	5	>9

While the temperatures associated with frozen storage are not capable of supporting the growth of microorganisms, the presence of microorganisms or bacteria within the food prior to freezing will lead to potential food safety issues as the food is thawed or regenerated. Freezing is an excellent means of preserving foods – but it is also an excellent means of preserving microorganisms. Therefore, hygiene rules for frozen food production are just as necessary as for all other food production processes.

LECTURE 2

EFFECT OF FREEZING STORAGE ON MEAT AND POULTRY QUALITY

Freezing is a thermodynamic process and can be described as a series of thermal events that approach conditions of equilibrium within the food. It is these states of equilibrium, as well as the kinetic changes that occur in reaching equilibrium, that describe the physical and chemical changes that occur in the food during freezing.

Although freezing acts as a preservation method by inactivating the meat enzymes and inhibiting the growth of spoilage organisms, it initiates several physical and physicochemical changes in meat that lead to the deterioration in quality. The rate of ice crystallization and the size of the crystals formed during freezing depend upon the temperature.

Slow freezing causes the water to separate from the tissue into pools that form large crystals, which may result from greater structural damage associated with larger intercellular ice crystals. These stretch and rupture some of the surrounding tissue. Rapid freezing results in very little water separation; therefore, the crystals are small and less expansive. Because there is practically no pool crystallization in very low temperature freezing, the drip is considerably less than from meats frozen at higher temperatures.

Therefore, some of the quality changes are associated with ice crystal formation: it is believed that;

- at very low temperatures, recrystallization is very slow and equilibrium is approached while the crystals are small.
- at temperatures near the melting point, recrystallization is rapid.
- the lower the temperature, the greater the inhibitory action and the longer the period of satisfactory storage,
- the solubility of myofibrillar proteins is lower in slowly frozen meat compared to fast frozen ones, however;
- the functionality of meat is adversely affected by long-term frozen storage.

Problems Associated with Freezing of Meat and Fish

Possible problems that are associated with freezing include;

- drip or sap losses,
- nutritional losses, and
- protein denaturation.

Drip or sap losses: After prolonged chilled or frozen storage of meat/fish, the proteins are less able to retain all the water, and some of it, containing dissolved substances, is lost as drip. Frozen fish that are stored at too high a temperature, for example, will produce a large amount of drip and consequently have reduced quality.

Nutritional losses: Drip loss from thawing meat/fish include proteins, vitamins, and other nutrients, in addition to moisture, and results in decreased cooked yields and juiciness.

Denaturation: When solution of a protein is boiled, the protein frequently becomes insoluble i.e., it is denatured and remains insoluble even when the solution is cooled.

Protein denaturation at low temperatures is a mirror image of the denaturation of proteins at higher temperatures, which lead to loss of water.

The rate of crystallization and the size of the crystals formed during freezing depend upon the temperature

The solubility of myofibrillar proteins is lower in slowly frozen meat compared to fast frozen ones.

Irreversible and Reversible Denaturation of Protein

Denaturation does not involve identical changes in protein molecules. A common property of denatured proteins, however, is the loss of biological activity—e.g., the ability to act as enzymes or hormones.

Although many native proteins are resistant to the action of the enzyme trypsin, which breaks down proteins during digestion, they are hydrolyzed by the same enzyme after denaturation.

The formation of a permanent foam when egg white is vigorously stirred is an example of **irreversible** **denaturation** by spreading in a surface. Also, the denaturation of the proteins of egg white by heat—as when boiling an egg—is an example of **irreversible** denaturation. In some instances the original structure of the protein can be regenerated; the process is called **reversible/renaturation**.

Colloidal and Organoleptic Changes in Frozen Meat/Fish

Organoleptic Changes:

Discolouration, rancidity- detected by odour and taste, poor visual appearance, flat taste and there could be fish weight loss.

Colloidal Changes:

When a protein solution is vigorously shaken in air, it forms a foam **referred to as a colloid**, because the soluble proteins migrate into the air–water interface and persist there, preventing or slowing the reconversion of the foam into a homogeneous solution. Foam is formed when many gas particles are trapped in liquid or solid e. g. bread, cake, *akara*, ice-cream, etc. Some of the unstable, easily modified proteins are denatured when spread in the air–water interface.

Methods to Alleviate Quality Deterioration in Frozen Meat and Fish

Appropriate processing methods can be employed to avoid freezing problems which include the following:

- Cold storage should be augmented by high air humidity (90%) and stationary non-circulating air to minimise or prevent dehydration.
- The freezer storage period of meat can be lengthened by omitting the seasoning and then adding the seasoning after the thawing.
- Thawing conditions should aim to minimize drip losses, microbiological growth, evaporation losses, and deterioration reactions. The most critical temperature in thawing meat is between –10°C and –2°C; therefore, meat must rapidly pass this range.
- An antioxidant such as BHA, BHT, or probyl gallat may be added at the second grinding in comminuted meat to delay fat oxidation.

SECOND TEST ON NUTRITIONAL EVALUATION OF FOOD PROCESSING

1. How will you describe freezing as a preservative process? **5 marks**

2. As a consultant to a frozen food processor, what type of freezing method will you recommend and why? **5 marks**

3. Explain two appropriate processing methods you could adapt to alleviate quality deterioration in frozen meat and fish. **8 marks**

4. Describe the common property of denatured proteins; site example where applicable. **2 marks**