Food preservation by drying

Preservation of foods by drying involves reducing the activity of microorganisms and enzymes by reducing moisture content. Lowering of moisture content inhibits the activities of food spoilage and food poisoning microorganisms. It is a traditional method of preservation of food, simple and easy to perform. Drying is generally done by exposing the fresh/ semi processed foods to sunlight until desired moisture level in attained.

Fish drying

Small fishes are dried whole without any processing while, large fish are dried by cutting open or cutting to small pieces to ensure faster drying. Fish may be salted or not salted before drying. After drying, fish are packed and stored for later consumption as human food. The storage stability or shelflife of dried fish depends on factors such as quality of the raw material used, extent of drying and storage conditions to which fish is exposed after drying.

Categories of dried foods

Dried foods are generally divided in to 2 categories based on moisture content. They are, Low moisture foods: These foods do not contain moisture level more than 25%, and have a_w of 0.6 or less. These foods have better keeping quality and shelflife.

Intermediate moisture foods (IMF): These contain 15-50% moisture and aw between 0.60 and 0.85.Ex: Dried fruits, cakes etc.

Effects of drying on microorganisms

Drying reduces the microbial activity in foods to a large extent, and depends on the moisture level attained after drying. Thus the storage stability (spoilage) of dried foods depends mainly on the aw of food. Generally, bacteria require high aw for growth (> 0.90) compared to yeasts and molds.

- **At a_w of 8.0~0.85:** Spoilage of dried foods is caused by a variety of fungi and spoilage occurs in 1-2 weeks period.
- **At a_w of 0.75:** Delayed spoilage caused by few types of organisms (fungi).
- **At a_w of 0.70:** Spoilage greatly delayed, may not occur during prolonged storage.
- **At a_w of 0.65:** Very few organisms can grow, and spoilage is unlikely for 2 years.

Growth of most organisms is prevented at aw <0.65, but some molds (Ex: *Aspergillus echinulatus, Zygosaccharomyces rouxii*) are able to grow and cause spoilage. Some of the molds involved in the spoilage of dried foods are *Candida*, *Botrytis, Rhizopus, Mucor, Saccharomycopsis, Alternaria, Aspergillus, Zygosaccharomyces* etc.

Though drying destroys some microorganisms, endospores of bacteria, yeasts, molds and certain bacteria survive drying process. Microbial spoilage of dried foods can be prevented by storing at low Rh condition. Storage at high Rh condition enables absorption of moisture from the atmosphere by dried foods until equilibrium is reached leading to spoilage beginning from the product surface.

Microorganisms associated with dried fish

Spoilage of dried fish during storage can result from bacteria and fungi.

Bacterial spoilage

In salt dried fish (marine) bacteria are capable of growing at varying concentration of salt and can cause spoilage. These include;

- **Slightly halophilic bacteria:** These grow at 2~5 % salt. Ex: Many marine bacteria.
- **Moderately halophilic bacteria:** These grow at 5-20 % salt content. Ex: Many bacteria such as Pseudomonas, Vibrio, Moraxella, Micrococcus, Acinetobacter, Flavobacterium etc.
- **Exstermely halophilic bacteria:** These tolerate 20-32 % salt. Ex: Halobacterium, Micrococcus, Sarcina etc. Exstremely halophilic bacteria cause intense red/pink pigmentation in dried food.
- **Halophic bacteria** are capable of growing at low RH (75%) unlike other bacteria. The main source of these bacteria to fish is through the salt used for salting of fish. These grow on surface of salt dried fish resulting in red coloration / pigmentation.

Fungal spoilage

Fungi are the common cause of spoilage of salt dried fish. Being aerobic and requiring low aw these grow on surface. Several species such as A*spergillus, Penicillium, Fusarium, Paecilomyces* etc have been recorded from dried fish in India.

Food preservation by use of radiation

Radiations have potential application in food preservation because of their destructive effect on microorganisms. Radiation is defined as the emission and propagation of energy through space or material medium. However, in food preservation electromagnetic radiations (EM) are important and these are self propagating eclectic or magnetic waves or vibrations of different wavelength. Generally, radiations of shorter wavelength are more damaging to microorganisms than long wavelengths.

EM radiations of importance in food preservation

The EM radiations of importance in food preservation are;

- Ultra violet rays
- X – rays
- Gamma rays
- Microwaves

In food preservation ionizing radiations of wavelength of 2000 A^o or less are important. These include beta rays; Gamma rays and X – rays. Ionizing radiations ionize molecules on their path and thus destroy microorganisms without raising temperature. Killing of microorganisms in foods using electromagnetic radiations without raising temperature is termed as cold sterilization. Ionizing radiations have high energy level to cause ejection of an orbital electron from an atom or a molecule.

Radiations types and their characters

1.UV rays

Ultraviolet radiations are powerful bactericidal agents. These non-ionizing radiations of < 450 nm wavelength are absorbed by proteins and nucleic acids leading to photochemical changes and subsequent cell death. The death of microorganisms results from the production of lethal mutations in nucleic acid preventing transcription and DNA replication.

UV rays are bactericidal/virucidal in the wave length between 200-290 nm, but are most effective at 260 nm (2600 A^o). These have poor penetration capacity (penetrate only 0.1 mm thickness) hence their application in food industry is limited to disinfection of air, and application on food surface especially the packaging material. However, some foods are also treated with UV radiation before wrapping. UV radiation can cause rancidity in high fat products. Workers have to be protected from UV rays as it can cause burning of skin and eye disorders.

2.Beta rays (β- particles)

These ionizing radiation are a stream of high energy electrons emitted by radioactive substances or machine generated electrons using cathode ray tubes. Beta rays have poor penetrating power but better than UV radiations. These are known to induce radioactivity in some foods under high energy sterilization conditions (at upper limit of energy level). Hence, these are of have limited application in food preservation.

3.Gamma rays

These are uncharged electromagnetic radiations emitted from the exited nucleus of radioactive elements such as ^{60}Cobalt, ^{137}cesium etc. These ionizing radiations produced by the decay of radioactive isotopes are cheapest form of radiations for use in food preservation since source elements are available as byproducts of atomic waste.

Gamma rays have excellent penetration power and penetrate almost anything. These can penetrate food up to a depth of 20 cm and effective as bactericidal agents.

4.X – rays

These ionizing radiations are produced by bombarding suitable metal target with high velocity electrons. These are similar to Gamma rays in their behavior.

Radiation energy unit

The radiation dose or amount of radiation applied for food preservation purpose is expressive by REP unit, RAD unit or GY unit.

REP unit (Roentgen – Equivalent physical)
1 REP = absorption of 83 ergs /g of matter.
Ergs is unit of energy.

RAD unit
RAD is unit of measurement of radiation.
1 RAD = absorption of 100 ergs / g of matter
1 K rad = 1000 rads

GY unit (Gray unit)
A newer and recently used unit of radiation
1 Gray = 100 rads = 11 joules /kg
1 KGy = 105 rads

Radiation process

The radiation process given to food is of 3 types.

1. Radappertization
2. Radicidation
3. Radurization

1. Radappertization

This refers to radiation process bringing about total destruction of microorganisms. It is equivalent to commercial sterility of heat processed foods, also called radiation sterilization. This process uses radiation dose of 30~40 K gray and ensures sterile product of prolonged shelflife.

2. Radicidation

This is a radiation process used for the reduction of number of viable non – spore forming pathogens which are undetectable by any standard method. This process is equivalent to pasteurization. Radiation level of 2.5~10 KGy is used in this process.

3Radurization

It is a process of irradiation given to minimize the load of spoilage organisms thus extending the shelflife of food. This may be considered equivalent to pasteurization. This ensures enhancement of the keeping quality of a food by causing substantial reduction in the number of viable specific

spoilage microorganisms. It is suitable for extending shelflife of fresh meat, sea food, fruits, vegetable etc. Dose used is 0.75~2.5 KGy.

Effect of radiation on food quality

Irradiation helps to improve the shelflife of food, but often it can bring about undesirable changes in irradiated food caused directly by irradiation and indirectly by post irradiation reactions. The free radicals that are produced during radiation process in some foods can bring about oxidative changes which can result in product discoloration, tissue softening (in fruits) due to degradation of pectin and cellulose, and development of rancidity in high fat products due to the production of carbonyl and peroxide radicals during radiation and subsequent storage in presence of oxygen. Product discoloration and rancidity can be reduced by giving radiation process at low temperature in the absence of oxygen.

Foods permitted for irradiation

Irradiation is permitted in many countries for several foods. These include,

- Inhibition of sprouting of potatoes, onion, garlic , mushrooms etc.
- Decontamination of food ingredients (species), and insect disinfection in cereals and grains.
- Destruction of parasites in meat
- Inactivation of *Salmonella* in poultry, eggs, shrimps, frog legs.
- Delay in fruit maturation (strawberries, mango, papaya).
- Mould and yeast reduction in many foods

Radiation resistance of microorganisms

Microbicidal effect of irradiation is due to the direct interaction of radiation with key molecules within the microbial cell as well as inhibitory effect of free radicals (H^+, OH^- ions) produced by the radiolysis of water. Resistance to radiation varies with different microorganisms. Among microorganisms, Gram negative bacteria are more sensitive than Gram positive followed by spores. Many spoilage bacteria of seafoods are Gram negative, hence are least resistant to irradiation. *E. coli* being highly sensitive not useful as indicator of fecal contamination in irradiated foods. Gram positive bacteria like *S. aureus, Micrococcus, Bacillus and Clostridium* are more resistant. Viruses are extremely resistant to irradiation

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Radiation resistant bacteria

Among microorganisms, *Deinococcus radiophilus*, a Gram positive, non-spore former is most resistant to radiation and can survive radiation of 15 K Gy. However, *D. radiodurans* is most well studied and first radio-resistant organism isolated.

The actual mechanism is of resistance is not clearly known, but it is attributed to its unusual cell wall composition (absence of techoic acid), presence of outer membrane and pigmentation besides other mechanisms.