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Principles of Food Preservation-Non-thermal methods

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- ❑ **Application of extreme heat treatments used for food preservation affect nutritional and organoleptic properties of food.**
- ❑ **Non-thermal methods of food preservation for inactivation of microorganisms and enzymes: Alternative to thermal processes.**
- ❑ **High resistance of certain enzymes and bacterial spores to non-thermal processes limit their application.**





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Low Temperature Preservation

- Storage at low temperatures prolongs shelf life of many foods.
- Low temperatures reduce growth rates of microorganisms and slow down physical and chemical reactions in foods.
- Low temperatures are used to preserve food by lowering microbial activity through reduction of microbial enzyme activity.
- Psychrotrophic bacteria grow at 7°C (*Pseudomonas*, *Alcaligenes*, *Micrococcus* and *Flavobacterium*). Freezing reduces microorganisms in foods but does not kill.
- Cell proteins undergo denaturation due to increasing concentrations of solutes in unfrozen water in foods, and damage is caused by ice crystals.



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Refrigeration

- 1.Slows down biological, chemical and physical reactions that shorten shelf life of food.**
- 2.Microbes are not killed at refrigeration temperature for a considerable period of time.**
- 3.In 5°C, foods remain unspoiled but in freezer at -5°C the crystals formed tear and shred microorganisms.**
- 4.Below 12°C, reduces respiration rate of fruits and vegetables, which retards reactions that promote spoilage.**
- 5.Generally used to reduce spoilage during distribution of perishable foods, increase holding period between harvesting and processing and extend storage life of commercially processed foods.**
- 6.All foods are not benefited from cold temperatures. Eg., bananas turn black when refrigerated.**



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Freezing

- Freezing makes water unavailable to microorganisms.
- Chemical and physical reactions leading to deterioration are slowed by freezing.
- White or grayish patches on frozen food caused by water evaporating into packages air spaces called freezer burn occurs which causes deterioration of taste and appearance.
- Home freezers are held at -10°C , commercial freezers are under -18°C .
- Uncooked fruits and vegetables must be blanched before freezing to prevent deteriorative enzymatic reactions.





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Slow freezing

- **Slow freezing (e.g. home freezer) forms large ice crystals which puncture cell walls and cellular fluid is released and results in shrunken appearance of thawed food.**
- **Freezing is done for 3-72 h.**
- **This method is used in home freezer and temperature is lowered to -15 to -29°C.**





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Rapid freezing

- Small, numerous ice crystals are formed and cell structure is not changed.
- Temperature of food is lowered to about -20°C within 30 min.
- Shelf life of frozen foods is largely dependent on storage conditions.
- Under ideal conditions, frozen foods have shelf life of one year.
- If foods are continuously exposed to warmer temperatures, such as opening and closing of freezer doors, then heat shock occurs. Heat shock is when ice melts and re-forms into larger ice crystals.
- **Advantages of freezing: Good retention of nutrients and prevention of microbial growth by low temperature and unavailability of water.**
- Loss of some B-group vitamins and vitamin C due to blanching of vegetables prior to freezing and unintended thawing can reduce product quality.



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Preservation by freeze drying (lyophilization)

- Food is deep frozen, after which water is drawn off by a vacuum pump in a machine.
- Dry product is then sealed in foil and reconstituted with water.
- Useful for storing, transporting and preserving bacterial cultures.
- Drying or dehydration involves removal of water from food by controlled processes. May be done by evaporation due to heating of product, e.g., drying of fruits, brining of fish and sublimation, or freeze drying e.g. drying of coffee.
- First stage: Removal of surface water depends solely on state of air surrounding the food, such as its temperature, RH and speed.
- Second phase of drying: Moisture within food moves to surface. As air is heated, its relative humidity decreases, resulting in more absorption of water. Here, rate of drying is dependent on time the moisture takes to get to the surface. Heating of air around food product cause it to dry more quickly.



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Freeze Drying Process





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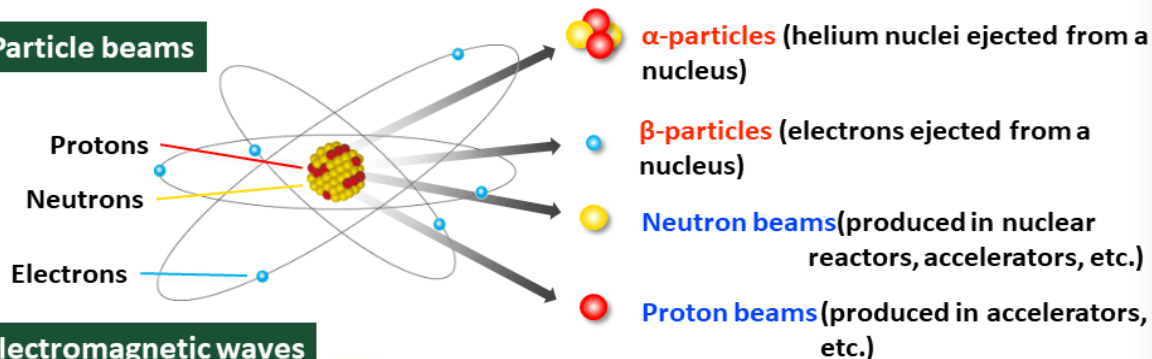
Irradiation

- Alpha, beta and gamma radiation particles are used for food preservation.
- Radiations are of high frequency with high energy content and have power to break molecules into oppositely charged ions (ionizing radiations).
- Sometimes called 'cold pasteurization' (product is not heated).
- Irradiation is useful only for foods of high initial quality.
- Not effective against viruses and prions and cannot eliminate toxins formed by microorganisms.

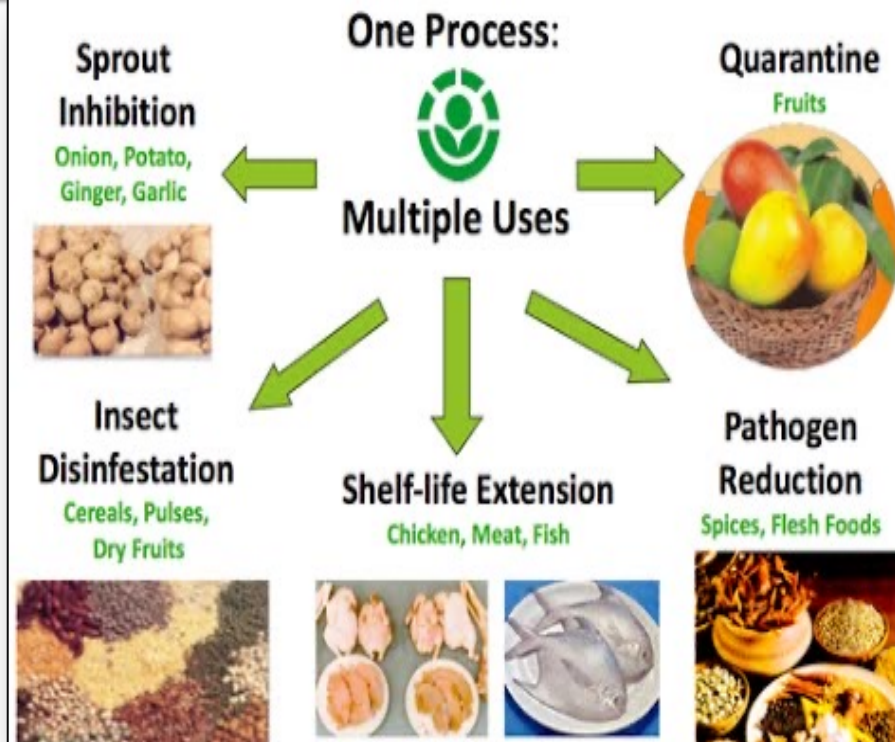
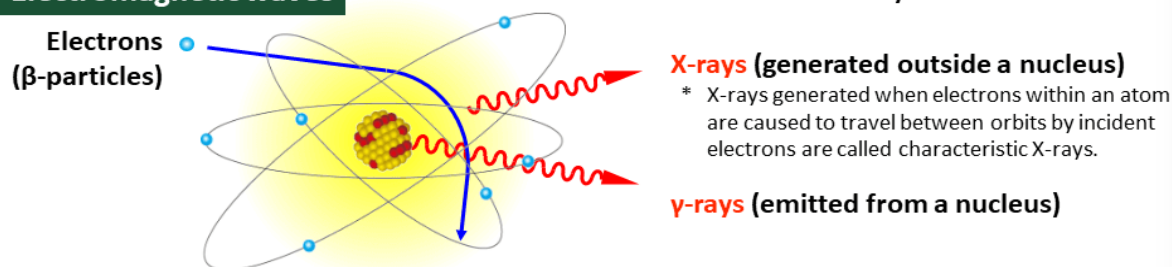
Ionizing radiation

Radiation that causes ionization

Particle beams



Electromagnetic waves

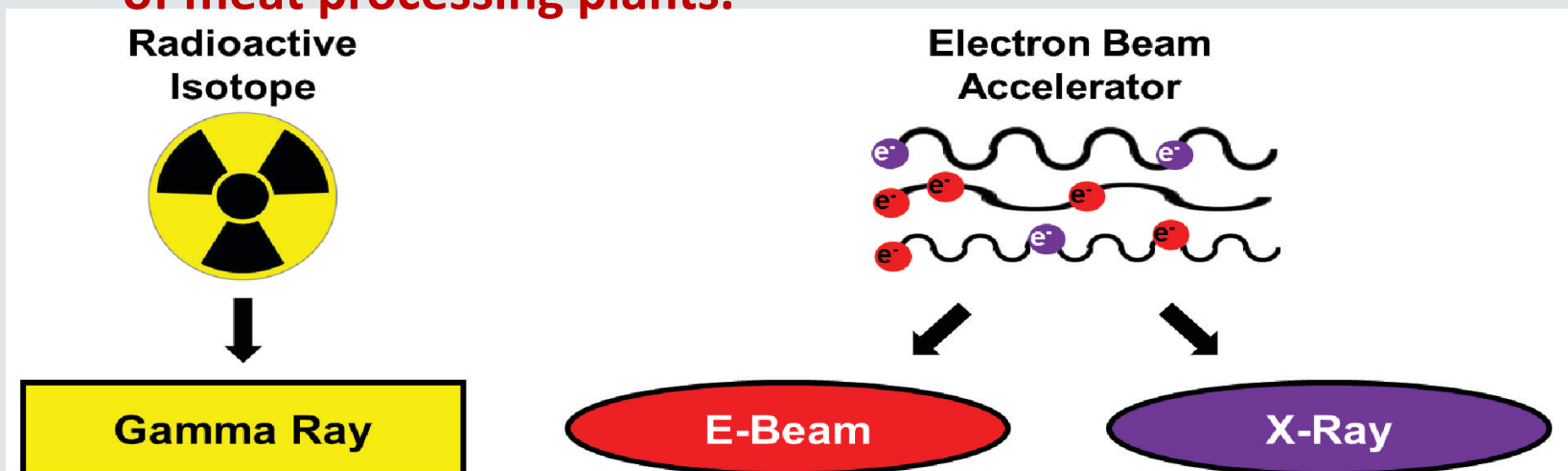




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- Irradiated food does not become radioactive.
- National and International expert bodies have declared food irradiation as 'wholesome'.
- Food exposed to controlled levels of ionizing radiation in form of gamma radiation, X-rays and electron beams kill harmful bacteria, pests, or parasites, or to preserve its freshness.
- Particle sources are readily available in form of radio-isotope Cobalt 60 (suitable gamma-particle emitter).
- Alpha particles are stopped by a sheet of paper, beta particles can penetrate through 1-2 cm thick sheet and gamma particles can penetrate through 30-120 cm thick sheet.
- UV-radiation penetration power is very low. Valuable for reducing surface contamination of foods and cold storage units of meat processing plants.

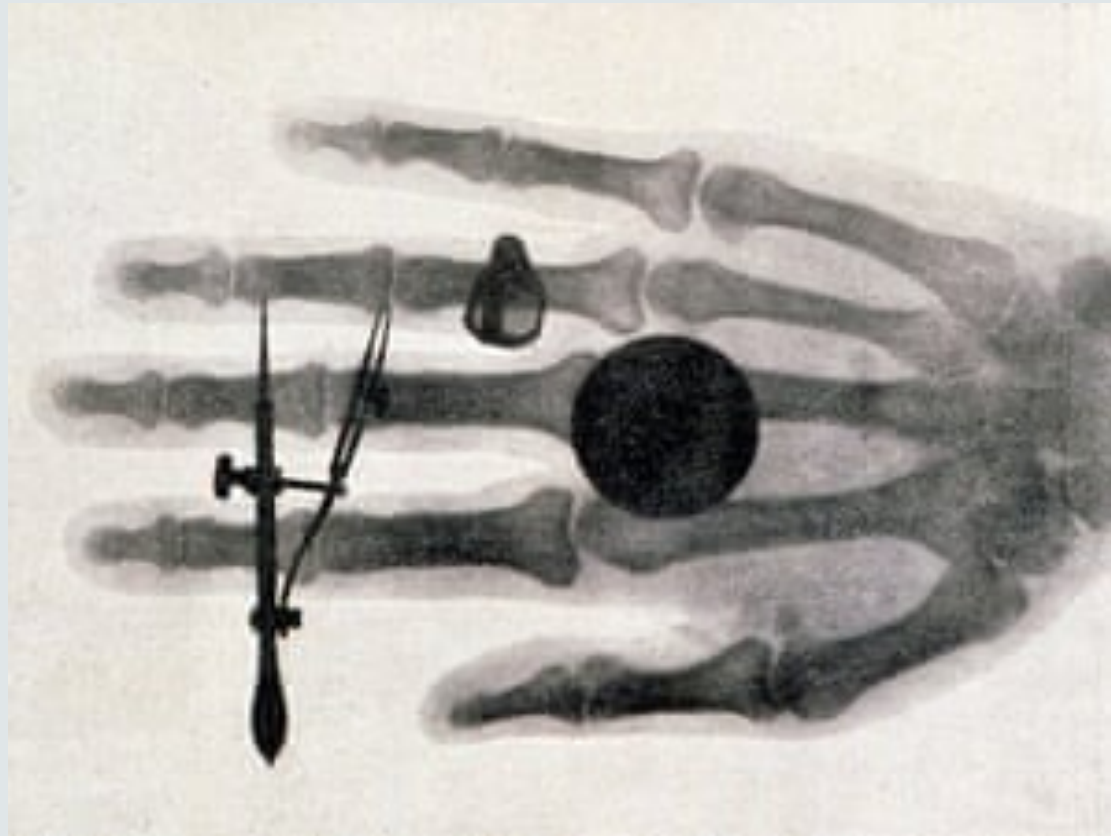




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- **A Roentgen (r) is the quantity of gamma or X-rays which produces one electrostatic unit of electric charge of either sign in a cubic centimeter of air under standard conditions.**
- **An electronvolt (eV) is the energy gained by an electron in moving through a potential difference of 1 volt. A meV is 1 million electronvolts.**



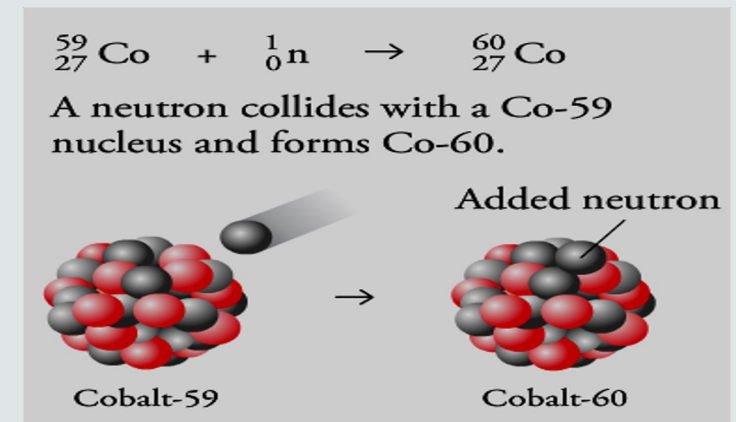
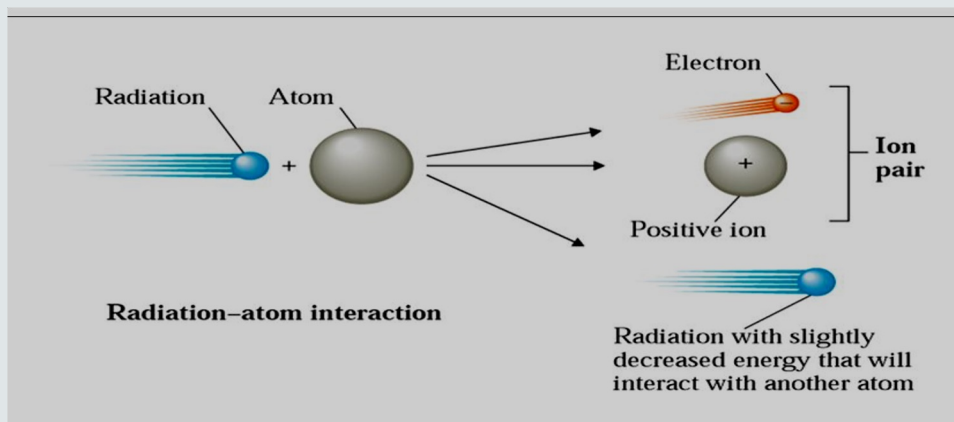


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Mechanism of microbial inactivation by radiation:

- Radiations causes disruption of internal metabolism of cells by destruction of chemical bonds, DNA cleavage results in loss of cells ability to reproduce.
- Free radicals are formed upon contact with water containing foods.
- Free radicals react with cellular DNA causing radiation damage.
- Shorter wavelengths have enough energy to knock off an electron to form free radical but not high enough to split an atom and become radioactive.
- Interaction between free radicals and DNA is responsible for killing effect of ionizing radiation.





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- **Ionizing radiations can cause chemical reaction and alterations of chemicals in tissues and can be toxic or fatal to humans in high dose.**
- **Much of the reactivity of ionizing radiations in organism is with water and produces superoxide radicals (O_2^-), hydroxyl radicals (HO^-), hydroperoxyl radicals (HOO^-) and hydrogen peroxide.**
- **Produced during high energy collisions of gamma rays and heavy elements (i.e. Tungsten)**



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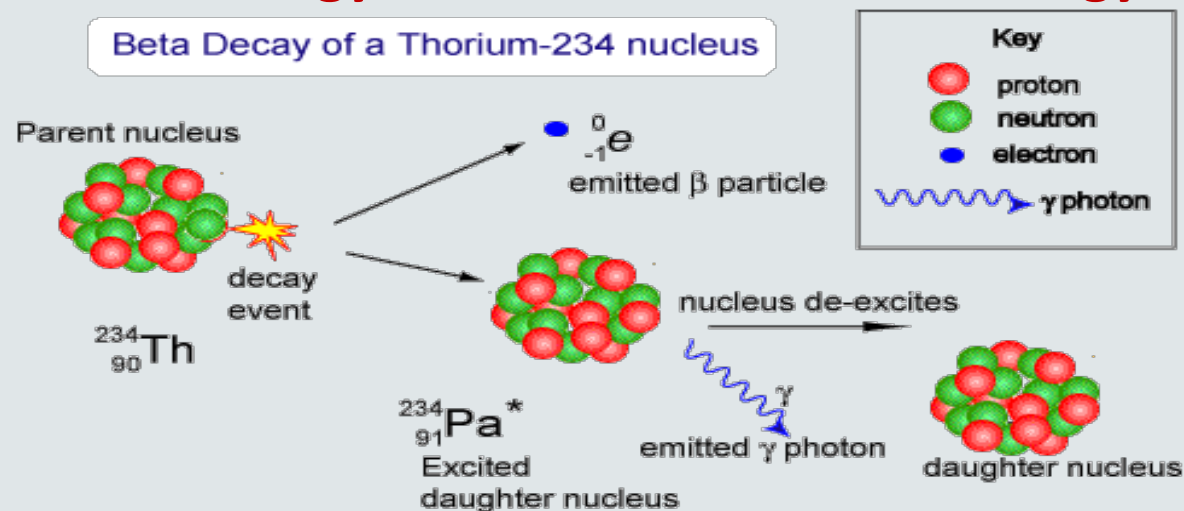
- ❖ **Alpha Particles are positively charged particle ejected spontaneously from nuclei of some radioactive elements and have low penetrating power and short range.**
- ❖ **This energetic particles will generally fail to penetrate dead layer of cell covering skin.**
- ❖ **Gamma Radiations are used type of ionizing radiation as they have good penetrating effect upto 20 cm in food.**
- ❖ **Produced by exposure of natural Cobalt-59 to neutrons in a reactor where reaction between two species produces Cobalt-60.**
- ❖ **Cobalt-60 is specifically manufactured for radiotherapy, medical device sterilization and food irradiation.**



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- ❖ Beta Particle is a charged particle emitted from a nucleus during radioactive decay.
- ❖ It has mass equal to $1/1837$ that of a proton.
- ❖ A negatively charged beta particle is identical to an electron and positively charged beta particle is called positron.
- ❖ Large amount of beta radiations may cause skin burns and beta emitters are harmful if they enter in body.
- ❖ Beta particle may be stopped by thin sheet of metal/plastics.
- ❖ Lethal dose for vegetative bacteria is 0.50-10 Kgy, bacterial spores is 10-50 Kgy, human beings and animals is 0.005-0.01 Kgy and for insects is 0.1-1.0 Kgy.





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- ❖ Eliminate harmful food borne pathogens e.g. *E. coli* O157:H7, *Campylobacter*, *Salmonella*, *Trichinella*, *Listeria*, delays ripening of fruits and vegetables, eliminates insects in fruits and vegetables, inhibits sprouting in onions, potatoes.
- ❖ Irradiation dose reduce microbial spoilage (1.5-3 kGy) and eliminated pathogenic microbes (3-7 kGy) to improve shelf-life of meat, poultry and sea foods under refrigeration.
- ❖ Reduce microorganisms in spices to improve hygienic quality (10 kGy)

Sprout inhibition in bulbs and tubers (0.03 - 0.15 kGy)





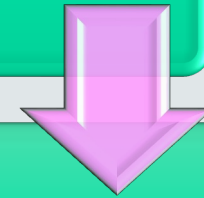
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Food Irradiation Processes

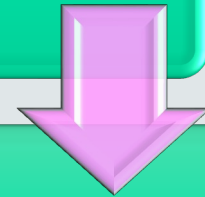
Radurization: (0.75-2.5 Kgy)

Mimics pasteurization. It inhibits sprouting and delays ripening, kills insects and it is used for shelf life extension.



Radicidation (2.5-10KGy)

Eliminate spoilage microorganisms and non spore forming pathogens. Food will not get spoiled.



Radappertization (10-50 kGy)

Also called radiation sterilization. Reduction of microorganisms occurs to point of sterility.



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Gram negative bacteria are generally more sensitive than Gram positive, bacterial spores are strongly resistant, yeasts tends to be rather more resistant than molds and viruses required doses of >200 kGy to achieve million-fold reduction in their numbers.

Organism	Approximate lethal dose (kGy)
Viruses	10 to 40
Yeasts (fermentative)	4 to 9
Yeasts (film)	3.7 to 18
Molds (with spores)	1.3 to 11
Bacteria	2-25
<i>Mycobacterium tuberculosis</i>	1.4
<i>Staphylococcus aureus</i>	1.4 to 7.0
<i>Bacillus stearothermophilus</i> (Spore)	10 to 17

Approximate Killing Doses of Ionizing Radiations in Kilorays (kGy)



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pH Control

Almost every food, with exception of egg whites and soda crackers, has a pH value of less than 7.

Most micro-organisms grow best in pH range of 6.5 to 7.5

**High acid (pH:
3.7) : apples,
lemons,
raspberries**

**Acid (pH: 3.7 to
4.6) : oranges,
olives, tomatoes
(some)**

**Medium acid
(pH: 4.6 to 5.3) :
bread, cheese,
carrots**

**Low acid (pH:
over 5.3) : meat,
fish and most
vegetables**

Osmotic Pressure

- Foods are preserved by adding salts and sugars.
- These chemicals remove water out of microbial cells causing them to shrink in hypertonic environment, thus stopping their metabolism.
- Jams, jellies, fruit syrups, honey etc. are preserved by high sugar concentration.
- Fish, meat beef and vegetable products are preserved with salt.

