**9.9. Radiofrequency (RF) Drying:**

RF can be used in drying, preheating, precooking, sterilizing and humidity control processes in the food industry. If a dielectric product enters the high frequency electric field and an alternating current is applied, the positively charged ions of the product move to the negative region of the electric field and the negative ones to the positive region. Meanwhile, the water in the product moves in gas form, not by capillary action, so solid migration is also prevented. The most positive aspect of this is the absence of curling, surface darkening and cracking seen in conventional drying. Although RF is a similar technique to MD, it has some differences in its effects. These include:

RF provides more homogeneous heating compared to MD.

RF costs less per kilowatt.

The capacity of RF generators can vary widely.

At frequencies below 100 MHz, RF penetration is better than MD.

**9.10. Infrared (IR) Drying:**

IR radiation is part of the electromagnetic spectrum. Although this was a known technique long ago, it is in constant development with new materials. In IR heating, heat is transferred from the hot surface of the heater to the material. The wavelength of IR radiation is 0.76-400 μm. This range in itself:

Near IR: 0.76-2 μm/ Medium IR: 2-4 μm/ Far IR: 4-100 μm and above.

IR is generated in two ways: from natural gas (40-46% efficiency) and electricity (78-85% efficiency).

The advantages of IR drying are: efficient energy use, short drying time and high product quality.

It is also suitable for small capacity applications. It can be combined with conventional techniques.

**9.11. Atmospheric Freeze Drying (AFD):**

Although freeze drying under vacuum yields excellent quality products, installation and operating costs are very high. In order to prevent this, the AFD technique has come to the fore. This technique combines the high quality of conventional FD and the economy of conventional drying. In this method, drying is done under a very light vacuum, while the air movement speed is very high. The differences are as follows:

Table: Comparison of atmospheric freeze drying with vacuum freeze drying

|  |  |  |
| --- | --- | --- |
| **Properties**  | **Atmospheric F.D.** | **Vacuum F.D.** |
| Process pressure | ca. atmospheric | Min 0.066 mbar (Up to 10-7 mbar) |
| Process temperature | -6 to -80C | -40 to -800C |
| Partial steam pressure | 4,56 to 0,1 mmHg | Vacuum |
| Freezing temperature | -30 to -400C | 50 to -800C |
| Air flow | 5 to 50 cm/s | No air flow |
| Energy requirement | ca. 5690 kJ/kg | ca. 7330 kJ/kg |

There are different equipment used for this purpose. These are fluidized bed FD, tunnel FD, atmospheric spray FD, heat pump technology.

**9.12. Osmotic Drying:**

In this method, the foodstuff (fruit, vegetables, fish, meat, cheese) is placed in a high concentration solution in whole or in pieces and the water in the structure is removed. There are 3 different mass transfers in the process. –

The solute transfer from the product to the solution (at 30-50 0C, it loses ~70% of its water content in the first 3 hours).

Solute transfer from solution to product, so that preservatives, nutrients or flavors can be transferred,

Transition of the solutes of the product (sugar, organic acid, mineral, etc.) into the solution.

The most important limitation of this technique is that the dry matter can only be raised up to a certain point. Sucrose is used as a solution in fruits and vegetables, salt in meat and cheese, salt and salt/sucrose solution in vegetables. This process is considered as a pre-drying. Then the drying level can be increased by other methods.

**9.13. Use of Beams:**

Some conditions require the use of rays (ionizing radiation). For example, the fact that the use of methyl bromide, which is a storage fumigant, banned all over the world in 2015 has led to new searches. Due to the loss of aroma in spices, sterility cannot be applied by thermal method. Sprouting is an important problem in vegetables such as potatoes, onions and garlic. One of the important alternatives in solving these problems is the use of beams. Rays used:

Gamma rays: Cobalt 60 and Cesium 137 or, x-rays (max 5 megaelectronvolts) and high-energy accelerated electrons (8-10 mega EVs) produced by special devices.

Generally, radiation dose is expressed in Gray (Gy) or Kilogray (kGy) units. (1kGy= 1000kJ). Another form of expression is Megarad (MR) (1 MR= 106 erg/g).

The doses used can be considered in 3 groups:

Low dose (< 1 kGy): Insectict inhibitor (spices, grains, dried fruit), ripening retarder (banana), anti-sprouting (potato, onion, garlic)

Medium dose (1-10 kGy): Microbial decontamination (spices, coffee beans, fruit, vegetables, seafood, chicken), shelf life extension.

High dose (10-60 kGy): Food for immunocompromised -or suppressed-people and astronauts

**9.14. UV-C Light:**

UV-C light lies in the 200-280 nm range of the electromagnetic spectrum. Mercury lamps, xenon pulsed lamps or excimer lasers are used in microorganism inactivation by UV system. Only mercury lamps are used in the food industry. 254 nm wavelength light is produced in low pressure lamps.

This light is called germicide effect light. In medium-pressure lamps, the wavelength can be 200-300 nm. Since UV light is not ionized, consumers look more favorably than radiation and it is a cheaper technique. This light is mostly used for disinfection of water, food surfaces or food preparation environments. The limiting feature of this technique is the lack of penetration depth and the mandatory contact of all surfaces with light. In addition, since mercury lamps cause the conversion of O2 to O3, adequate ventilation should be provided in environments where it is used heavily (photocopy shop smell).

**9.15. Pulsed Light:**

 It is very similar to UV-C light, except that the flow rate of electrons is higher. It is produced with xenon-flash lamps. Provides faster disinfection than UV-C. The disadvantage is that it is expensive and causes surface heating. Usage areas are the same as UV-C.

**9.16. Electrolyzed Oxidizing Water (EOW):**

EOW is based on the principle that NaCl is treated in an electrolysis unit and the disinfectant effect of the free chlorine formed there is utilized. The advantages of the technique over the use of normal chlorine are that it has very little impact on the environment and is supplied from ubiquitous materials. The main use of this water is the production of fresh-cut vegetables.

**9.17. Ozone (O3):**

Ozone is a molecule with very low stability and is obtained from oxygen (max. 6% purity) or air (max. 3% purity) by corona-discharge method in ozone generators. Ozone is a very strong oxidizer and its most important feature is that it transforms into oxygen in a very short time and therefore leaves no residue. However, it cannot be stored and must be produced where it will be used. In addition, care should be taken as it may affect the metals in the environment in which it is used. It is used in an aqueous environment or by giving it directly to the atmosphere where the food is present. Its stability in water is low, but dose adjustment is easy. Since it may also affect food components, the dosage should be adjusted carefully.

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