**9. New or Alternative Technologies**

**9.1. Fresh-cut Fruits and Vegetables**

Fruits and vegetables are the leading foods whose consumption is constantly increasing in the world. The fastest growing fruit and vegetable processing method is fresh-cut. The term fresh-cut means that the fruit or vegetable has undergone physical changes from its original form, but is still fresh. In other words, it means that the fruit and vegetables are sorted, peeled and made 100% consumable and packaged.

The most common product in fresh-cut technology is ready-made salads. While the average shelf life of fruits processed with this technique is 7-8 days, this period is 10-14 days for vegetables. Peeling, chopping etc. physical processes cause immediate physical and physiological changes, resulting in increased respiration and the amount of ethylene produced. This reduces the quality and shortens the shelf life. Respiratory rate is related to increased injury and temperature. The most critical factor in this technique is temperature and should be kept below 5 0C in all processes. The second factor is cleanliness. Normal water is sufficient for the first wash. The most commonly used chlorinated water for washing the peeled (chopped) raw material. However, hydrogen peroxide, surfactants (sulfones, ethoxy-alcohols, alkyl phenols, etc.), peroxyacetic acid, sodium phosphate and ozone can also be used. Covering the product with edible coatings (lipids, CMC, polysaccharides, etc.) also extends its shelf life. Fresh-cut technology can be combined with the MAP application.

One of the best ways to keep physical injury to a minimum is to use a sharp knife. Enzymatic peeling of citrus fruits is one of the alternatives. The water leaking from the tissue in cutting-chopping should be washed. The water temperature should be about zero degrees. Chlorinated water can also be used (50-100 ppm). The equipment (knife-cutting board) must be very clean. The water accumulated on the raw material is removed by giving compressed air to the raw material moving in the semi-fluid bed. The product packaged using the appropriate material. Storage temperature is very critical. For example, the shelf life of pineapples, which is 1-2 hours at 20 0C, is 5 weeks at 1 0C.

The cold chain should never be broken at the any stage until consumption and the temperature should not be allowed to rise above 5 0C. The ideal is 1 0C. The product must not be mechanically damaged. Excessive shaking caused increased leakage and browning, especially in watermelon cubes.

The main changes that can be seen during storage in fresh-cut products are: Surface darkening, softening in texture, loss of aroma. The flow of tissue fluid creates a favorable environment for the growth of microorganisms. The removal of the skin which is protecting the tissue causes water loss and thus surface drying, loss of gloss and tissue shrinkage. In order to reduce these negative effects, some pre-treatments are applied especially on fruits. For example, CaCl2, Na-erythorbate, ascorbic acid, Ca-lactate, hexylresorcinol, cysteine, or a combination thereof may be administered.

The most common products are:

Vegetables: Salads (lettuce), carrots, broccoli, cauliflower, tomatoes

Fruits: Melon, watermelon, apple, grape, pineapple and fruit mixes.

**9.2. Storage in Modified Atmosphere (MAP):**

In this technique, the shelf life of the product is extended by the following factors:

Decreased water loss

Decreased breathing

Decreased ethylene production

Decreased metabolic activity

Reduction of microbial spoilage

The basic principle in MAP storage is to change the composition of the atmosphere surrounding the food (in this case, the atmosphere inside the package), that is, to modify it.

The process is essentially based on reducing the O2 ratio and increasing the CO2. When the O2 ratio decreases, respiration decreases and this decrease goes to the point where anaerobic respiration starts. Decreased O2 means decreasing at the same time; means ethylene synthesis, chlorophyll degradation, cell wall destruction and phenolic substance oxidation. On the other hand, decreasing O2 level promotes fermentation and leads to accumulation of acetaldehyde, ethanol and lactate. The biosynthesis of aroma components is reduced. For a safe atmosphere, the tolerance of the product to low O2 and high CO2 levels should be well known.

The atmosphere can be modified in an active or passive way. In MAP storage in general:

O2 rate: 3-5% CO2 rate: 5-15%.

Suitable conditions and storage times for some fruits and vegetables are as follows:

Table: Storage conditions and storage life for several fruits and vegetables

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Fruit/****Vegetable** | **Temperature (0C)** | **Oxygen (%)** | **CO2** **(%)** | **Storage life in air (days)** | **Storage life in CA/MAP (days)** |
| Apple, Gala | 0-2 | 1,5-2,5 | 1-5 | 120 | 180 |
| Avocado | 5-13 | 2-5 | 3-10 | 42 | 84 |
| Banana | 13-16 | 2-5 | 2-5 | 28 | 49 |
| Bean, snap | 4-8 | 2-3 | 4-7 | 7 | 14 |
| Broccoli | 0-1 | 1-3 | 5-15 | 28 | 56 |
| Lettuce | 0-1 | 2-5 | <1 | 21 | 28 |
| Pear | -1 - 1 | 2-3 | 0-1 | 90 | 180 |
| Pepper, Bell | 7-12 | 2-5 | 2-5 | 21 | 28 |
| Strawberry | -0,5 - 0 | 5-10 | 15-20 | 14 | 21 |

**9.3. High Pressure Application (HPP):**

This technique has been applied for many years in the ceramic and steel industry. Its use in the food industry is new. Although it is an alternative to pasteurization and sterilization in general, it is also used in gelatinization of starch, activation of osmotic drying, and enzyme inactivation. The applied high pressure is mainly effective on vegetative bacteria. However, the combination of higher pressures (700-1000MPa=7,000-10,000 Atm) and high temperatures such as 70-90 0C was sufficient for sterilization in low acid foods. This technique has been used in the production of jam in fruit and vegetable technology. With HPP boiling, the transfer of substances (especially vitamins and minerals) to the water has decreased. Drying rate increased in HPP-treated vegetables. The texture was better preserved in the freezing of cabbages under pressure of 100-700 MPa. The PME enzyme was inactivated by applying a pressure of 900 MPa at 45 0C for 2 minutes.

**9.4. Microwave Heating:**

Microwave heating is very common in the household today and its use in industry is increasing rapidly. Especially in the fruit and vegetable industry, it finds use in thawing, drying, boiling and pasteurization of frozen foods. It has been used in sterilization for the last few years in industry. The frequency of the wave is 2450 or 900 MHz (12 or 34 cm). Every time the direction of the electric current changes, the water molecules line up and the food gets hot as a result of the friction that occurs during this time. At 2450 MHz, the processing depth of the wave is 1-2 cm. Further processing to the depths is by convection. The most important problem in this technique is to ensure the uniformity of the temperature. The use of microwave shows the future especially in pumpable products. Microwave applies directly to the liquid flowing through pipeline.

**9.5. Active Packaging:**

By adding some features to the packaging in which the food is placed, it is ensured that the quality is preserved at a higher level and the shelf life is extended in the production-consumption process. Major applications are:

(a) Oxygen Scavenger: Although there are many patented materials, it is the most widely used iron powder. Iron powder is packed in a bag. 1 gram of iron reacts with about 300 cm3 of oxygen. Finds use in MAP storage in the fruit/vegetable industry.

(b) CO2 Scavenger: CaO+silica mixture is most commonly used. Ca(OH)2 and CaCl2 are also used. It finds use in the meat industry.

(c) Moisture Retainer: It is also used in biscuit, milk powder and fruit-vegetable industry. The most widely used is silica gel. Others are modified starch and CaCl2.

(d) Ethylene Scavenger: Ethylene (C2H4) increases postharvest respiration rate. It is increasingly used in the fresh-cut and MAP industry. The most commonly used is silica + potassium permanganate. Silica retains ethylene, and K-permanganate raises ethylene to ethylene glycol. The other technique is zeolite+K-permanganate.

(e) Ethanol Spreaders: Reduces microbial growth. It can be used in bakery. Ethanol is placed in 0.6-6.0 gram plastic bags (ETHICAP, NEGAMOLD) and ethanol is spread into the package depending on the permeability of the plastic material.

(f) Flavor Retainer-Release Systems: The substances added to the plastic material in which the orange juices are placed retain the limonine, which increases after pasteurization and yields bitterness. For this purpose, a layer of cellulose acetate butyrate was added to the packaging material.

(g) Antimicrobial Films: Antimicrobial substance has been added into the film forming the packaging material. These are organic acids, spice extracts, enzymes, chelators, antibiotics, isothiocyanates, etc. it could be. These are incorporated into vegetable packaging, especially LDPE. Molds are important in citrus packaging, fungicides can be used for them. Discs that emit SO2 can be placed in the grape packaging. Papers containing chitosan can be spread inside the strawberry crates. Hexamethylene can be put in orange juice packaging and agzirconium can be added to lettuce-cucumber packaging.

(h) Packages containing antioxidants: BHA, BHT etc. antioxidants can be incorporated into the packaging material.

(i) Other: Pigmented films, light and microwave blockers, selective gas permeable films.

**9.6. Thin profile processing (TPP):**

It creates an alternative to the sterilization technique. It can be used in products with heat treatment in cans or jars. Packaging suitable for heat treatment can be used. The film is usually 3 layers. 0.012mmPE/0.0089 or 0.018 Al/0.076PP

Since the thermal conductivity is high, the time is short. Therefore, the food is less affected by heat. It is a useful technique in fruit/vegetable technology for products such as sauces, soups, potato salads. The process time is 30-40% less, the cost is low, the product can be heated in the microwave.

**9.7. Vibratory Heat Treatment:**

Vibration is applied continuously during pasteurization and sterilization. Heat conduction is accelerated and the cold point is provided to reach the desired temperature quickly.

**9.8. Microwave (MD) Drying:**

Electromagnetic radiation with a frequency of 300-3000 MHz is called microwave. Electromagnetic energy is absorbed in the product and creates heat in the product. (friction of water molecules). If the water content of the product is high, heating becomes easier. This technique is still widely used for home scale heating purposes and can also be used for drying food on an industrial scale.

Its advantages over other drying methods are:

Short drying time

Enhanced heat and mass transfer

High drying rate

Moisture removal without increasing the surface temperature

Enhanced product quality

Continuous or intermittent working possibility

Low operating cost.

The disadvantages are:

Product temperature is difficult to control

Irregular heating and possible texture problems

Not ecologically friendly due to the problems microwave can cause to humans

The process should be used by knowledgeable people and MD radiation should be under constant control.