Frequently Asked Questions

1. **Define Browning of foods and mention the types of browning reaction with examples.**

Ans: Browning of foods is defined as the process in which there is a change in the color of the food due to a chemical process. There are two types of browning reactions that occurs in foods i.e., enzymatic browning and non-enzymatic browning. Examples for enzymatic browning are browning of fruits such as apricots, apples, pears, peaches, bananas and grapes; vegetables such as potatoes, mushrooms, brinjal and lettuce and seafood such as shrimp, lobsters and crabs. Examples of non-enzymatic browning are caramelization or pyrolysis of carbohydrates, reaction of carbonyl groups with amino compounds and lipid browning.

2. **How do you differentiate enzymatic browning and non-enzymatic browning?**

Ans: Enzymatic browning of foods occurs mostly in fruits and vegetables wherein enzymes such as phenoloxidase, cresolase, dopa oxidase, catecholase, polyphenoloxidase etc oxidize substrates such as phenols, catechols, caffeic acid, chlorogenic acid, catechins etc to form black or brown pigments such as melanins whereas non-enzymatic browning does not involve enzymes and is observed when sugars individually when heated undergo caramelization or reducing sugars along with a mixture of amino acids when heated result in Maillard reaction.

3. **What is the mechanism involved in enzymatic browning reaction**

Ans: The mechanism of action proposed for an enzyme such as PPO is based on its capacity to oxidize phenolic compounds. Physical or mechanical damage to the tissue leads to the rupture of plastids, the cellular compartment where PPO is located. This facilitates the enzyme to come in contact with the phenolic compounds released by rupture of the vacuole which is the main storage organelle of these substrates. The active site of PPO consists of two copper atoms and the enzyme catalyzes two different reactions in the presence of molecular oxygen firstly, the hydroxylation of monophenols by monophenolase and then the oxidation of *o*-diphenols to *o*-quinones by diphenolase. This reaction is followed by non-enzymatic polymerization of the quinones giving rise to melanins, pigments of high molecular mass and dark color.

4: What are the physical factors which influence browning reactions?

Ans: Physical factors which influence browning are processing, permeability of packaging materials, post-harvest handling and the cultivar. Processes such as cutting, peeling causes destruction of cell membrane and exposes the cell components to air to initiate enzymatic browning. Delayed processing of minimally processed fruits and vegetables also influences enzymatic browning since the exposure of food to components that cause browning is higher. It is also a fact that the concentration of enzymes and substrates vary widely between cultivars.

5. What are the chemical factors which influence browning reactions?

Ans: Chemical factors which influence browning reactions are concentration of substrates and enzymes, presence of catalyst such as copper, presence of oxygen, pH and the temperature of processing or storage of the fruit or vegetable which in turn influence the enzyme activity.

6. What are the traditional or conventional methods to prevent browning reactions in fruits and vegetables?

Ans: Traditionally browning of fruits and vegetables were prevented by addition of sugar or honey through the process of dehydration. Natural acids such as citric acid and ascorbic acid from lemon and pineapple also prevent browning reactions by reducing the pH.

7. Name the physical methods involved to prevent enzymatic browning reactions.

Ans: Physical methods to prevent enzymatic browning are broadly classified into two categories, Thermal and non-thermal processes.

Thermal processes include blanching, steaming, boiling, ohmic heating and microwave heating whereas the non-thermal processes include refrigeration, freezing, high hydrostatic pressure, irradiation, modified atmosphere and coating.

8. Name the chemical methods used to prevent browning reactions with examples

Ans: The chemical methods to prevent browning reactions are mainly using antioxidant agents by breaking the chain reaction such as ascorbic acid, glutathione and erythrobic acid; oxidizing agents such as sodium chloride; chelating agents such as sulphites and citirc acid; firming agents

such as calcium lactate and calcium chloride; acidifying agents such as citirc acid, ascorbic acid; enzyme inhibitors such as cinnamic acids; and complexing agents such as β-cyclodextrins.

9. How is steaming, blanching and boiling different from each other? How do these processes prevent browning reaction?

Ans: Boiling is by direct contact of fruits and vegetables with hot boiling water. Steaming works by boiling water continuously, causing it to vaporize into steam; the steam then carries heat to the nearby food, thus cooking the food. The food is kept separate from the boiling water but has direct contact with the steam. Both the techniques i.e., boiling and steaming reach the temperature of 100°C. Blanching is of two types, hot water blanching and steam blanching. Blanching of fruits and vegetables is done using boiling or steaming techniques for a short period of time to preserve the texture. The temperature in blanching range between 70-100°C. The basic principle behind all the three methods is inactivation of enzymes using high temperature and moist heat.

10. Differentiate between ohmic heating and microwave heating

Ans: Ohmic heating is a heat preservation method in which the temperature of food is increased by passing an electric alternating current of low frequency. Around 50-60 Hz is passed through a conducting solution such as salt brine with special electrodes to heat the food followed by cooling whereas heating with microwave makes use of microwave energy. Microwaves are electromagnetic in nature with a wavelength of 0.025-0.75m. In the food system frequency of 2450 MHz and 915 MHz are used. Higher the degree of penetration of microwaves into an absorbing material, greater is the heat produced.

11. Write the action of irradiation against browning reaction with an example.

Ans: Ionizing radiations penetrate food materials to varying degrees depending on the nature of the food. Gamma rays have better penetrating power than beta rays. Exposing food to radiation causes changes in texture, colour, protein molecule due to direct contact to high energy rays. Along with methods such as blanching or pH control, irradiation increases the shelf life of vegetables such as potatoes, onions, garlic; inactivates enzymes, prevents insect infestation,

delays maturation, eliminates specific pathogens and sterilizes the food. An example for usage of irradiation in foods is in preventing sprouting of potatoes.

12. What is PEF? How does this process help in preventing browning reaction?

Ans: PEF stands for Pulsed electric field which is a non-thermal method of food preservation that uses short pulses of electricity for microbial and enzyme inactivation. It causes minimal detrimental effect on food quality attributes. PEF technology involves the application of pulses of high voltage to liquid or semi-solid foods placed between two electrodes with duration of microseconds to milliseconds and intensity in the order of 10-80 kV/cm. Food product is placed in the treatment chamber, either in a static or continuous design, where two electrodes are connected together with a nonconductive material to avoid electrical flow from one to the other. Generated high voltage electrical pulses are applied to the electrodes, which then conduct the high intensity electrical pulse to the product placed between the two electrodes. The food product experiences a force per unit charge, the so-called electric field, which is responsible for the irreversible cell membrane breakdown in microorganisms. This action has also reported to induce changes in secondary structure of PPO and peroxidase thus preventing browning reactions in fruit and vegetable juices.

13. What is the difference in principles of ohmic heating and pulsed electric field?

Ans: Ohmic heating is one of the earliest forms of electricity applied to food pasteurization. This method relies on the heat generated in food products when an electric current is passed through them. A 220V, 15kW alternating current supply is applied to liquid foods through carbon electrodes in an electrical heating chamber. The food is heated and held at a particular time and temperature. Ohmic heating is suitable for viscous products and foods containing particles, and this method is considered to be a promising technique for the aseptic processing of foods. In pulsed electric field, a high voltage is applied to liquid or semi-solid foods placed between two electrodes for duration of microseconds to milliseconds and intensity in the order of 10-80 kV/cm. An increase in the electric field intensity and number of pulses leads to an increase in the inactivation of microorganisms. Other factors that influence microbial inactivation by PEFs are the treatment temperature, pH, ionic strength, and conductivity of the medium containing the microorganisms. The reversible or irreversible rupture through electroporation of a cell

membrane or change in the structure of enzymes depend on factors such as intensity of the electric field, number of pulses, and duration of the pulses.

14. What are the primary goals to be kept in mind to prevent browning reaction?

Ans: The primary goal of preventing browning reaction is inactivation of enzymes or to slow down the enzyme activity. Preventing physical damage and cutting fruits & vegetables with larger surface area during pre-processing will cause minimum exposure of enzymes to the substrate. Immediate processing using different methods to prevent browning in fruits and vegetables after the pre-processing steps such as sorting, washing and cutting plays a vital role.

15. How do you handle post harvested apples to prevent browning?

Ans: Apples are subjected to browning reactions mainly due to physical damage and during processing. Post harvested apples should be immediately kept in temporary cold storage while shifting from the field to the processing unit. Blanching of apples after sorting and washing at high temperature short time can remove the surface micro-organisms which could cause spoilage. Whole apples can be coated with coating agents such as starch, glycerol, pectin, alginate, trehalose and chitosan after blanching. Apple slices or juice can be treated with solution of SO_2 with 2-3% NaCl under vacuum to prevent browning. Various chemical preservatives are used at different concentrations and combinations to prevent browning of apples. One such example is combination of sodium chloride (300 mg /L), acidified sodium chlorite (300 mg /L), citric acid (20 g/ L) and calcium chloride (20 g/L) at room temperature for 1 minute before packaging. The best known compound that has inhibited PPO activity by 99.2% in apple at 0.08% concentration is phytic acid.