Food browning: enzymatic and non-enzymatic

Andriana Kaliora

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Food browning

- A very important process to discuss in the food industry.
- Browning is a common colour change seen in food during pre-preparation, processing, or storage of food.
- It occurs in varying degrees in some food material.
- The colour produced range from cream or pale yellow to dark brown or black, depending on the food item and the extent of the reaction.

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Browning: desirable or undesirable?

- In some foods, the brown colour and flavour developed during **browning is highly desirable** and associated with a delicious, highly acceptable, and quality product.
- Browning reactions contribute to the aroma, flavour and colour of the product such as the browning crust of bread, and all baked goods, potato chips, roasted nuts, roasted coffee beans and many other processed foods.
- The **undesirable effects of browning reactions** are seen in dehydrated foods such as milk, eggs, dry fruits, in cut fruits and citrus fruit juice concentrates, or in canned milk.
- The colour varies from light cream to black while coconut develops a saffron colour.
- The off-colour and off-odour developed in foods depends on the extent to which the browning reaction has progressed.
- Off-flavours may vary from mild flavour changes to stale and very bitter.
- Controlled browning is necessary even in foods where browning is desired because excessive browning can produce an undesirable product.

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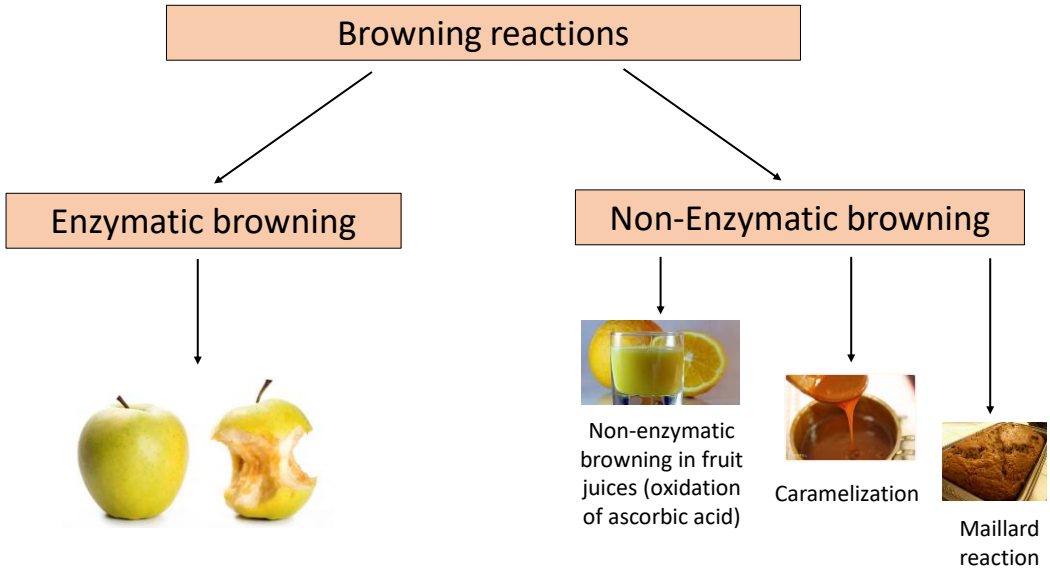

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Enzymatic Browning

- The colour change that takes place in fruits & vegetables, etc. due to the presence of enzymes is called as enzymatic browning.
- Light colour fruits and vegetables darken when exposed to air as a result of the presence of oxidative enzymes.
- Enzymatic browning occurs in those fruits and vegetables when the cell structure is disrupted by cutting or hurting the tissues.
- This is due to the action of oxidative enzymes on the presence of phenolic substances present in the fruit and vegetable tissues.
- Apples, Banana, Pears, Eggplants and potatoes undergo enzymatic browning.
- Enzymatic browning takes place only in fruits and vegetables which contain phenolic compounds. These phenolic compounds act as the substrate, and in the presence of oxygen and by the action of enzymes, the following oxidative reaction is observed

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Non-Enzymatic Browning

- **Maillard Reaction-** It is a protein-sugar interaction. It leads to the development of brown colour in a mixture containing amino acids and reducing sugars. It is also called carbonyl-amine reaction. The brown colour formed contributes to the aroma, flavor, and colour of many ready to eat cereals, baked food, malted barley etc. various factors which affect this reaction are-type of sugar- the more percentage of reducing sugar, the darker the crust in the bakery products, type of amino acid, temperature, moisture.
  Maillard reaction also leads to undesirable changes like unfavourable brown colour eg. in dried milk. Detrimental flavour changes eg. Burnt flavour.
- **Caramelization-** when sugar is heated at high temperature(160 deg C) in the absence of water and amino acids, it turns brown and this sugar-sugar interaction is known as caramelization. Development of caramel flavour and colour in caramel custard is a desirable change, whereas uncontrolled heating of sugar can lead to objectionable burnt colour and flavour.
- **Ascorbic acid browning-** Ascorbic acid present in fruits undergo oxidation with the formation of a compound which produces a brown pigment and causes discolouration. This type of browning is seen in preserves. Low storage temp can help in retarding the reaction.

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Effect on the nutritional value of food

- The binding of amino acids to various complexes results in products not hydrolyzed in the digestive system, hence many essential amino acids are lost
- Vitamins B1, B6, B12 and pantothenic acid can react with products of the Maillard reactions, the value of these vitamins is diminished

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Enzymatic vs non-enzymatic browning

	Enzymatic browning	Non-enzymatic browning
Definition	The process of food turning brown due to an enzyme catalyzed chemical reaction that takes place in food	The process of food turning brown due to a chemical reaction that is not catalyzed by an enzyme
Contribution	Involves enzymes such as polyphenol oxidase	Does not involve any enzymatic activity
Reaction mechanism	Oxidation of phenols by phenoloxidase into quinones which are then polymerized to produce brown colored pigments	It involves a chemical reaction between the amine group of free amino acid and the carbonyl group of reducing sugar

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Control of enzymatic browning

- Wrapping up your apple slices, or equivalent fruit, can help prevent the oxygen in the surrounding air from coming in contact with the newly exposed surface. By keeping oxygen away from the enzymes responsible for the oxidation of polyphenols, the mechanism of browning can be slowed.
- Lemon juice and other acids lower the pH and remove the copper cofactor necessary for the responsible enzymes to function
- Blanching or roasting of foods, to denature the enzymes, and destroy to responsible reactants.
- Low temperatures can also prevent enzymatic browning by reducing rate of reaction.
- Use of ascorbic acid to control browning of apples under certain conditions.
- Use of sodium chlorite to inhibit key reaction pathways in enzymatic browning.
- Arctic Apples have been genetically modified to avoid expressing polyphenol oxidase and thus do not brown

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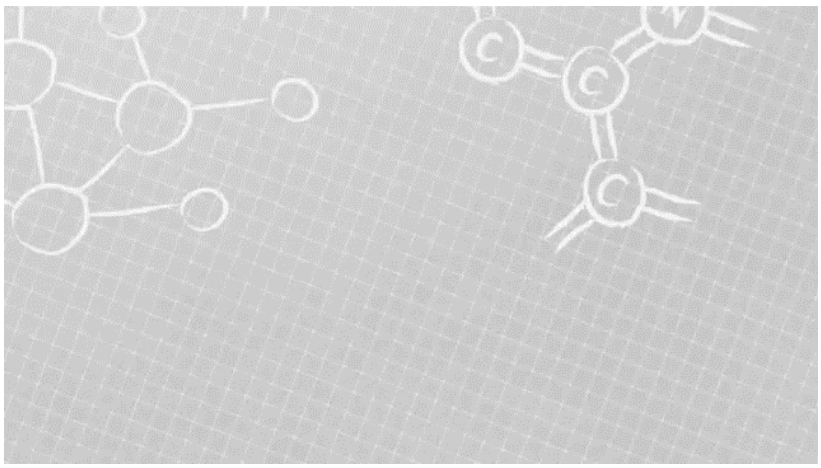
Control of enzymatic browning



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Control of non-enzymatic browning

- Decrease in temperature causes inhibition
- Control the percentage of water / moisture in liquid food as the higher water content (dilution) reduces the reaction rate
- In solid foods, if water is lacking, then there is no contact of the molecules of the reacting bodies and initiation of the reaction is inhibited
- The reaction is inhibited at water activity other than 0.6-0.8
- Reduction of PH, ie addition of citric acid, inactivates the free amino groups, which would normally participate in the reaction
- Control the availability of reactants, the reaction can be inhibited by
  - enzymes → destruction of sugar
  - chemical → binding of sugar carbonyl group with sulfites

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Lab exercises

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1. Inhibition of Enzymatic Browning in bananas

- Purpose
  - to monitor the browning of a banana and the potential inhibition of different solutions
- Implementation
  - Banana pieces are placed in one of the glasses as shown below.
  - EVALUATE the browning or control after 30 min exposure.

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Banana Browning

Solution	Colour	Mechanism
d.w.		
Thiourea		
Ascorbic acid		
Sodium sulfite		
Copper sulfate		

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2. Non-Enzymatic Browning

- Purpose
  - The detection and evaluation of odor and color resulting from Maillard reaction of various solutions of amino acids and sugars
- Implementation
  - Mixtures of amino acids and sugars are placed in test tubes as shown in table ii.
  - The mixtures are mixed well with 1mL d.w. and are covered with foil before placed in a boiling water bath
  - After 45min in the boiling water bath, the odor and color are evaluated

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Results

	Baseline odor	Baseline colour	Follow up odor	Follow up colour
Gluc + Asp	-			
Gluc + Pro	-			
Gluc + Phe	-			
Gluc + Val	-			
Gluc + Met	-			
Gluc + Leu	-			
Gluc + Arg	-			
Gluc + Ala	-			
Gluc + Lys	-			
Fruc + Lys	-			
Sucr + Lys	-			

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Some tips for your evaluation

Smells are marked as
- Smell of chocolate
- Potato smell
- Smell of popcorn etc

The colors are marked as
- They are colorless
- Slightly yellow
- Deep yellow
- Brown

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