Extent of nonenzymatic browning measurement

Processing, storage and preparation of foods and food ingredient are the source or factors that cause development of brown colour-browning reaction. There is two type of browning reaction, one is the enzyme-catalyzed and another one is nonenzymatic browning. Enzyme-catalyzed browning involves oxidation of food component, example changing the structure of reducing sugar by amino group. For nonenzymatic browning normally included Caramelization of sugar and maillard reaction.

Sugar solution is normally thermally stable within the pH range of 3-7. However, with the present of acidic or base catalysts in the heating sugar solution or melting dry sugar will cause some caramelization. Caramelization resulting brown colour and pleasing aroma toward the sugar solution. Caramelization is widely used in food industry e. g. development of brown cola beverage and other food. Caramels are complex mixture with various molecular weights and can be classified into 3 groups: caramelan, caramelen and caramelin, all are large molecular weight complex.

Oppositely, maillard reaction is a reaction between reducing sugars and amine resulting in browning and flavor development. Two criteria for this type reaction to occur, low temperature and at higher dilution comparatively to the caramelization. The brown colour formed is due to the molecule formed known as melanoidins, which are complex of large molecular weight molecule. The reaction occur initially at the free aldehyde or ketone group on a sugar molecule and free amino group on a protein or amino acid molecule, hence the often used term called sugar amine reaction.

The reaction produces glucosyl amine and also amadori rearrangement to form an amino-deoxy-ketose. Instability of amadori product undergoes a complex series of reactions that ultimately produce flavor and aroma compounds and brown pigments called melanoidins.

Apparatus:

pH meter, pipettes (10mL), beakers (1L), test tubes, hot plate, graduated cylinders, stirring rods, permanent marker, UV/Vis spectrometer, water bath, boiling chips.

Materials:

- Glucose, 0. 25M + glycine, 0. 25, in phosphate buffer, 0. 067, pH 5 and 8
- Sucrose, 0. 25M + glycine, 0. 25, in phosphate buffer, 0. 067, pH 5 and 8
- sorbitol, 0. 25M + glycine, 0. 25, in phosphate buffer, 0. 067, pH 5 and 8
- glucose, 0. 25M, in phosphate buffer, 0. 0067M, pH 5 and 8
- sucrose, 0. 25M, in phosphate buffer, 0. 0067M, pH 5 and 8
- glycine , 0. 25M, in phosphate buffer, 0. 0067M, pH 5 and 8

Discussion:

Glucose-glycine, pH 8 (non enzymatic browning)

pH medium more than 5 is comparatively more reactive due to quick polymerization to a dark-colored, insoluble material containing nitrogen.

There are series of properties given by the heating of aldoses or ketoses in solution with the amines e. g. give rise to flavoring, aromas smell and

darkening. However both the reactant reacts slowly to give brown colour instead of quick darkening. Browning is thus controllable due to the slow reacting of the reactant.

Reducing sugar (glucose) having an open chain with an aldehyde group is able to be oxidized via redox reaction. Glucose reacts reversibly with the amine to produce a glycosylamine. However, glycosylamine can undergoes a reaction called the amadori rearrangement to tive, in the case of glucose, a derivative of 1-amino-1-deoy-D-fructose. Reaction continues to give an intermediate that dehydrates. Eventually furan derivative is formed; that from a hexose is 5-hydrpxylmethyl-2-furaldehyde (HMF). Under less acidic condition (higher han pH 5) the reactive cyclic compounds (HMF and others) polymerize quickly to a dark-colored, insoluble material containing nitrogen

Starting reactions

a) Sugar-amino condensation

b) Amadori or Heyns rearrangement

Degradative reactions causing the formation of colorless or yellow products with strong ultraviolet absorbance and the release of carbon dioxide

Sugar dehydration

Ring splitting (Strecker degradation).

Polymerizing or condensing reactions forming strongly colored components of relatively high molecular weight

Aldol condensations

Aldehyde/amino polymerization and formation of heterocyclic nitrogen compounds.

Glucose, pH 8 (Caramelization)

Caramelization is a reaction of forming a complex group by the reducing sugar or sucrose without nitrogen containing compounds. Thermolysis causes dehydration of the sugar molecule with introduction of double bonds or formation of anhydro rings.

During a Caramelization reaction, the sugars initially undergo dehydration and then condensation or polymerization into complex molecules of varying molecular weights. Lightly colored, pleasant-tasting caramel flavors reproduced during the initial stages, but as the reaction continues more high molecular weight color bodies are produced.

Caramelized sucrose contains three main products: a dehydration product, caramelan $C_{12}H_{18}O_9$ and two polymers, caramelen $C_{36}H_{50}O_{25}$ and caramelin $C_{96}H_{102}O_{51}$.