Paper No. 01

Paper Title: Food Chemistry

Module -5: Food Polysaccharides-1: Starch

Polysaccharides are linear or branched polymer of monosaccharide units linked by glycosidic bonds. Polysaccharides are insoluble, unsweet and are important as storage molecules (starch, glycogen, inulin) and as reinforcing materials (cellulose, chitin).

Starch

Starch is the most important homopolysaccharide, acting as a reserve food material of the higher plants (in plastids, separated from the cytoplasm).Starch and its hydrolysis products constitute most of the digestible carbohydrate in the human diet.Commercial starches are obtained from cereal grain seeds, particularly from corn, waxy corn (waxy maize), high-amylose corn, wheat and various rices, and from tubers and roots, particularly potato, sweet potato and tapioca.Starch occurs naturally as discrete particle (granules). Starch granules are relatively dense and insoluble and hydrate only slightly in cold water. They can be dispersed in water, producing low-viscosity slurries that can be easily mixed and pumped, even at concentrations of greater than 35%.Starch and modified starches have an enormous number of food uses, including adhesive, binding, clouding, dusting, film forming, foam strengthening, antistaling, gelling, glazing, moisture retaining, stabilizing, texturizing and thickening applications.

Starch granules are composed of a mixture of two polymers:-

1. Amylose – linear polysaccharide
2. Amylopectin- a highly branched polysaccharide

1. Amylose

Amylose is a linear chain of (1-4) linked α- D- glucopyranosyl units (like maltose).Chain lengths vary from 250-350 glucose units, and the long molecules appear to be coiled in an α-helix.

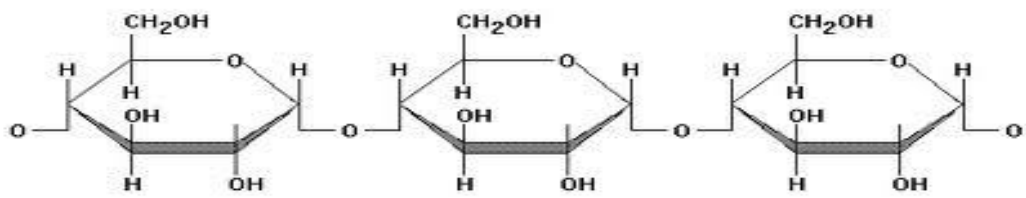

Figure 1.structure of α-amylose.

Amyloses form gels more rapidly because the linear shape allows the formation of a 3-D network with ease. However, these molecules associate and crystallize readily and the starch dispersion undergoes retro-gradation. Amylopectin molecules, with their bushy structure, do not crystallize readily.

2. Amylopectin (Isoamylose; β-amylose)

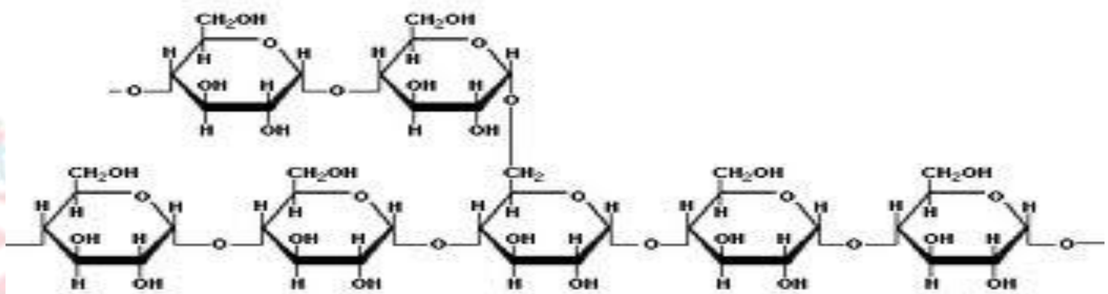

Figure 2.structure of amylopectin

This possesses the same basic unit of α-1, 4- glucoside linkage like that of amylose but has, in addition, may side chains attached to the basic chain by α-1,6-glucoside linkages.Amylopectin is a component of starch and it also consists entirely of repeating chains of glucose. It is different from amylose because it has two different types of linkages between the glucose subunits: the 1C-4C and the 1C-6C. The 1:6 linkage makes a branched structure instead of a linear structure. The branches occur every 24 to 30 glucose units. The molecules of amylopectin are composed of between 2000 and 200,000 units of glucose.

Amylopectin consists of a chain containing the only reducing end group, called C-chain.

Amylopectin is present in all starches, consisting about 75% of most common starches.

Starch exhibits the following properties-

- They are not sweet,
- Specific rotation of starch is $+196^{o}$.
- They form pastes and gel in hot water,
- They are nonreducing carbohydrates since carbonyl groups of all units (except one of the two terminal ones) participate in the glycosidic linkages,
- They provide a reserve energy source in plants and supply energy in nutrition.

Partial breakdown of starches yields dextrins, which are intermediate in chain length between starch and sugars and exhibit other properties intermediate between these two classes of compounds.

Granules Gelatinization and Pasting

Gelatinization process is characterized by the gelatinization temperature, above which the gelatinization of the starch suspension starts due to heat and moisture transfer phenomena.When moist heat is applied to starch, the granules gelatinize, forming a mixture of thick, soft and creamy consistency.This behavior makes starch useful for many purposes in food as an adhesive and thickening agent and industrial applications such as making paper paint and cosmetics.There are three stages of gelatinization of starch 1) Heating the starch; 2) Absorbing the liquid; 3) Thickening the liquid

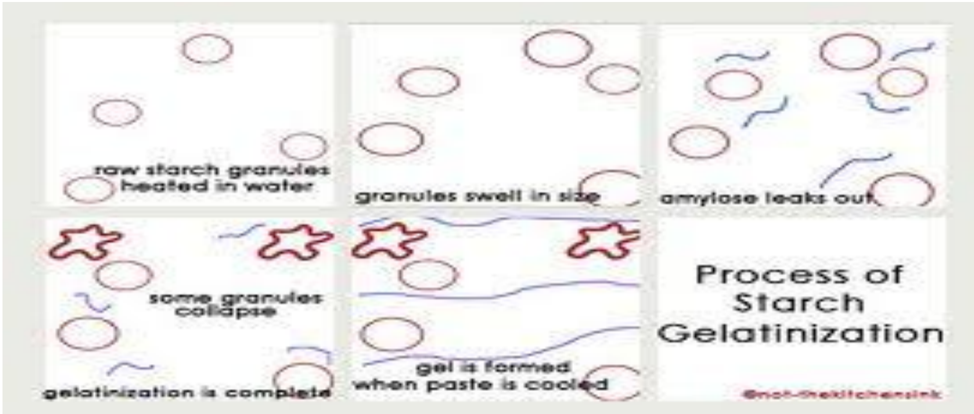

Figure 3 Process of Starch Gelatinization

Undamaged starch granules are insoluble in cold water, but can imbibe water reversibly; that is, they can swell slightly and then return to their original size on drying. When heated in water, starch granules undergo a process called gelatinization.

Gelatinization depends on a number of factors:-

i. The temperature at which gelatinization starts and the exact changes during the course of gelatinization
ii. The pH at which gelatinization is measured.
iii. The temperature at which observations are made and the length of heating are important.
iv. Size of the granule.

Retrogradation

Retrogradation is a reaction that takes place in gelatinized starch when the amylose and amylopectin chains realign themselves, causing the liquid to gel.When native (natural) starch is heated and dissolves in water, the crystalline structure of amylose and amylopectin molecules are lost and they hydrate to form a viscous solution.If the viscous solution is cooled or left at lower temperature for long enough period, the linear molecules, amylose, and linear parts of amylopectin molecules (produces a viscoelastic, firm, rigid gel) retrograde and rearrange themselves again to a more crystalline structure. The linear chains place themselves parallel and form H- bridges.In dilute solution, starch molecules will aggregate and forms microcrystals that precipitate, with the insoluble material being difficult to redissolve by heating. The collective processes of dissolved starch becoming less soluble are called retrogradation.

The rate of retrogradation depends on several variables

i. Molecular ratio of amylose to amylopectin
ii. Structures of the amylose and amylopectin
iii. Presence of concentration of other ingredients, such as surfactants and salts.

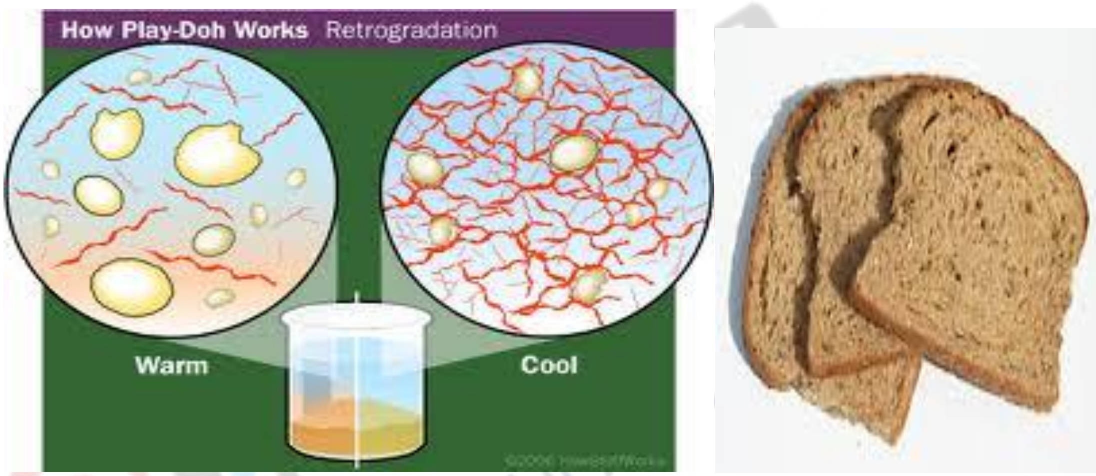

Figure 4 Retrogradation and staling (of bread).

Staling

Staling (aging of bread) is a chemical and physical process in bread and other foods that reduces their palatability. This undesirable reaction decreases the water retention in bread and this results in the bread becoming hard (dry) and leathery.Some of the changes which occur in bread as a result of staling are 1) Increase of crumb firmness; 2) Increase in crumbliness of the crumb; 3) Deterioration in flavour and aroma; 4) Loss of crust crispiness. Although changes occur both in the crust and in the crumb of the bread, the majority of the studies involving bread staling have been concerned with changes in the crumb.

Modified Food Starch

Modified Food Starch is made by physically, enzymatically or chemically altering starch to change its inherent properties. Modified starches are typically used in foods for the same reasons as conventional starches like thickening, stabilizing or emulsifying agents.

Some of the properties gained by changing the original starch can include the ability to stand different temperatures (excessive heat, freezing, etc), increase the shelf life of the desired property (for example, it will keep thickening the sauce for a longer time than its conventional counterpart), alter their thickening ability and shorten the thickening time (for example a modified starch may thicken a sauce much faster than its conventional counterpart). Corn, potato, rice and wheat are the commonly used starches.

These are some methods of producing a modified starch:

- Treatment with acid
- Roasting
- Treatment with sodium hydroxide, potassium hydroxide
- Addition of positive electrical charge
- Treatment with emulsifiers
- Treatment with starch ether

In general, modified food starches are used for three reasons.First, they providefunctional attributes in food applications that native starches normally cannot provide (native starches produce weak-bodied, cohesive, rubbery pastes when cooked and un-desirable gels when the paste are cooled).Inthe pudding mix, the starch provides thickening power, a creamy short texture, andconvenience if it is an instant system. In other applications, modified starch can provide awide range of functions, from binding to disintegrating; imbibing or inhibiting moisture;producing a short, stringy, or cuttable texture; creating a smooth or pulpy texture;developing a soft or crisp coating; or stabilizing an emulsion.Modified starch has many uses in food products:

- Making a product easier to dissolve in cold water or milk for instant gelatinized recipes
- Helping powdered foods to achieve desirable consistancy
- Fat replacer

- Act as emulsifier and thickener
- Formation of hard shell on some candies like jelly beans
- Ability to withstand high temperatures
- Anti-caking agents
- Act as humectant

References

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