# LECTURE 3: PROPERTIES AND UTILIZATION OF COMMON POLYSACCHARIDES

## Starch

Starch is a natural polymer of the sugar D-glucose. Starch occurs widely in the vegetables kingdom. The important of starch in food processing is based on the fact that it provides a very high proportion of the world's food energy intake; over 80 % of all food crops are composed of cereals and starchy – food crops.

Starch occurs in nature in the form of microscopically small, spherical particles or granules whose size and shape are characteristic for each species. The granules can be shown by ordinary and polarized light microscopy and by X-ray diffraction to have a highly order crystalline structure.

It is formed in plants by the condensation of a large number of glucose molecules (few hundred to several thousand units) into two types of polymers. One of these is a linear polymer, amylose, that is made up of more than 2000 glucose units. The individual glucose units are connected to each other by α-1,4-glycosidic linkage. A second starch component, called, amylopectin, has a highly branched structure, with each branch consisting of 20 to 30 glucose units, and each molecule containing several hundreds of these branches. The glucose units in each linear branch are connected by α-1,4 linkage. The branch points, are connected through α-1,6-glycosidic linkages. Both amylose and amylopectin molecules are deposited in starch granules in an orderly radial pattern.

The important sources of starch are

(i) Cereals and millets (65 to 85 %) e.g. maize, wheat, rice
(ii) Roots and tubes (19 to 35 %) e.g. potato, tapioca

Cereal starches differ from root and tuber starches in their physical properties. A cereal starch paste (5%) sets to a thick jelly on cooling whereas a turber starch paste (5%) remains as a fluid and does not set to a thick jelly.

In cereals moisture content is low and the starch granules are embedded in a hard, proteinaceous matrix, which requires preliminary softening before starch extraction. Potato contains high moisture and no preliminary softening is required.

## Amylose

This is a long unbranched chain of D-glucose molecules linked together by α-1,4 linkage, similar to that present in maltose. Molecular weight of amylose range from 105 to 106 daltons and one molecule of amylose may contain 500 to 5000 glucose molecules. The solution on keeping turns turbid due to the precipitations of amylose by a process known as retrogradation. Amylose is mainly responsible for the stiffening of cooked rice on standing. Amylose gives a blue colour with iodine. Amylose content of a starch can vary considerably depending on the botanical species. Cereal starches such as wheat starch contains 25 – 30%

amylose, corn starch (amylomaize) contains 40 – 80% amylose. Waxy maize contain 0% amylose starch.

### Gelatinization of starch

Amylopectin is branched chain polysaccharide component of starch. In this polysaccharide short chains (20 to 30 molecules) of D- glucose linked by α-1,4 linkages. These chains are linked to each other by α-linkages.

Molecular weight of amylopectin range from 107 to 108 daltons, and one molecule of amylopectin may contain 50000 to 500000 molecules of D-glucose.

Amylopectin gives a purple colour with iodine.Starch gelatinization is a process that breaks down the intermolecular bonds of starch molecules in the presence of water and heat, allowing the hydrogen bonding sites (the hydroxyl hydrogen and oxygen) to engage more water. This irreversibly dissolves the starch granule. Penetration of water increases randomness in the general granule structure and decreases the number and size of crystalline regions. Crystalline regions do not allow water entry. Heat causes such regions to become diffuse, so that the chains begin to separate into an amorphous form. Under the microscope in polarized light starch loses its birefringence. Gelatinization is influenced by a number of factors. The gelatinization temperature and the length of heating, plant type (wheat and corn starch show different behaviour patterns) and the amount of water present, pH, size of starch granule. Some type of unmodified native starches start swelling at 55 °C, other types at 85 °C.

### Retrogradation of starch

In dilute solutions, starch molecules will precipitate, with the insoluble material being difficult to redissolve by heating. The process of dissolved starch becoming less soluble is called retrogradation. Retrogradation of cooked starch involves amylose and amylopectin, with amylose undergoing retrogradation at a much more rapid rate than does amylopectin. The rate of retrogradation depends on several variables, including molecular ratio of amylose to amylopectin; botanical source of starch; temperature; starch concentration; salts; surfactants. Bread staling is due to starch retrogradation. Staling is due to the gradual transition of amorphous starch to a partially crystalline, retrograded state.

## Modified starches

The behaviour of pastes of the common native starches when subjected to the effects of heat and shear used in modern food technology is often unsatisfactory. Consequently modified starches and starch derivatives with more sophisticated stability characteristics have been developed. In this section, the characteristic properties and uses of some of these starches are out-lined.

Modified starches include

(i) Acid modified starches
(ii) Pre-gelatinized starches
(iii) Cross-linked starches
(iv) Esters & ethers of starch

(v) Starch phosphates
(vi) Hydroxyalkyl substituted starch

***Acid modified starch***

Acid modified or thin boiling starches are prepared by heating starch granules with diluted hydrochloric acid at temperature below that of gelatinization. The resultant superficially uncharged granules fragment appear to swell less during gelatinization, with a consequent reduced volume and lower maximum hot paste viscosity. The solubility in hot water is increased, the extent depending on the degree of acid treatment.

Acid-degraded starch, particularly the non-waxy cereal type, is widely used in the manufacture of fruit gums on account of the strength and clarity of the resultant gel which is much improved in comparison to an unmodified, thick-boiling starch. The viscosity of the gel prepared from acid-modified starch is much lower than that prepared from the corresponding concentration of the unmodified starch. As a result hot gel can be easily poured into moulds. The acid treatment causes an increase in the resultant gel strength, probably because of the preferential degradation of amylopectin. The gel clarity is also improved.

***Pre-gelatinized starches***

For many food uses, a water holding or thickening agent is required to function without the application of heat. For this purpose a pre-gelatinized starch is often used. Pre-gelatinized starch is prepared by destroying the granular structure on cooking, which simultaneously causes a considerable reduction in paste viscosity. The cooked paste is then dried on rollers or with a spray-drier. The powdered product will easily rehydrate in cold water but, the resultant dispersions are not equivalent to freshly prepared paste. This is due to the starch degradation which has taken place.

The largest use of pre-gelatinized starch is in the instant puddings – a packaged powder which only needs to be mixed with cold milk and allowed to stand for a few minutes, producing a simple pudding. The powders are mixture of pre-gelatinized starch with sugar and flavourings, together with salts which produce sufficient viscosity increase in the milk to keep the starch suspended until hydration can take place. Another widespread use is in frozen fruit-pie fillings where a pre-gelatinized starch keeps the fruit suspended and helps retain the flavour without the need for heating.