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Gıda Tarım
San. Ve Tic. A.ş.

Aksoy Mh. 1768 Sk.
No:22/2 Karşıyaka
İzmir/Turkey

Tel: +90 232 381 68 57

info@agrobynature.com

Starch Dictionary

H.J. Meijer, MSc.

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Starch Dictionary

Introduction

In this brochure an overview with definitions and descriptions of important terms of the starch chemistry, starch technology and industrial applications is listed in alphabetical order. The subject index below links you directly to the terms, synonyms and related terms which are arranged alphabetically. Press <**Strg + click**> to go directly to the subject. You may also use the <search> function in Acrobat Reader or Word to find the required subject.

Subject Index

1 A

1.1. Acetylated distarch adipate

Acetylated distarch adipate is a crosslinked starch ester in which certain starch hydroxyl groups have been crosslinked by adipate bridges (generally by means of adipic anhydride) and certain other starch hydroxyl groups have been esterified by acetyl groups (generally by means of acetic anhydride or vinyl acetate).

1.2. Acetylated distarch phosphate

Acetylated distarch phosphate is a crosslinked starch ester in which certain starch hydroxyl groups have been crosslinked by phosphate bridges (generally by means of phosphorus oxychloride or sodium trimetaphosphate) and certain other starch hydroxyl groups have been esterified by acetyl groups (generally by means of acetic anhydride or vinyl acetate).
Acetylated distarch phosphates are produced in the form of cold-water-insoluble granular
(cook-up) products, or produced in the form of cold-water-soluble, drum-dried (pregelatinized) products.

1.3. Acetyl value

Acetyl value is the % of acetyl groups on a modified starch based on a dry weight basis. It is measured by hydrolysis of the acetyl groups and subsequent titration.

1.4. Acetylated starch

Starch in which some of the hydroxyl groups have been esterified with acetyl groups by treatment with acetic anhydride.

1.5. Acid hydrolysis of starch

Acid hydrolysis of starch is the reduction in size (degradation, depolymerization), to a greater or lesser extent, of starch molecules by the action of an acid (as catalyst).

1.6. Acidity

Synonym: titratable acidity.
The acidity is expressed as the amount of alkali (e.g. in millilitres of 0.1 N sodium hydroxide) required for the neutralization of the titratable acids in 10 g of a starch product under defined conditions.

1.7. Acid-modified starch

Synonyms: acid-treated starch, acid-thinned starch. Related term: thin-boiling starch.
Acid-modified starches are prepared by mild treatment of starch, suspended in water and agitated, with dilute acid below the gelatinization temperature. At the proper degree of conversion, the acid is neutralized and the starch is filtered, washed and dried. The pastes of acid-modified starches have reduced viscosities when warm and have a strong tendency to gel when cooled.

1.8. Agglomerated starch

Cook up or instant starch which has been specially processed to give granular agglomerates to improve dispersibility in liquids or to modify flow properties or density. A second material such as maltodextrin may be present to serve as binder or inter-particle adhesive.

1.9. Alkali number

When starch is digested in hot alkali, the aldehydic terminals of the starch molecules are subject to an enediol rearrangement, and the starch chains then undergo a slow progressive destruction. The principal products are simple organic acids, for example, acetic and lactic acids. If this alkaline decomposition is conducted under carefully standardized conditions, the amount of acid so produced will provide a relative measure of the number of terminal aldehyde groups in the starch, and hence of its molecular weight. The alkali number is the amount of alkali (expressed in millilitres of 0.1 N sodium hydroxide) consumed by a given mass of starch product when it is treated under defined conditions. The method is applicable to unmodified starches, dextrins, acid-modified starches and enzyme-modified starches. The alkali number rises progressively with increasing degree of hydrolysis. The alkali number is believed to be a measure of the average chain length (average degree of polymerization; average molecular weight) of the starch molecules in a starch product. A higher alkali number indicates a lower average molecular weight. The alkali number of native potato starch is about 6 and of native maize starch about 11. This is an indication of the higher average molecular weight of potato starch as compared with the average molecular weight of maize starch. The alkali number of acid-modified starches ranges from 11 to 42 and of white dextrins from 55 to 65.

1.10. Alpha-amylase

The alpha-amylases attack the starch molecules in a starch paste and bring about a random fragmentation of the starch chains by hydrolysing the 1,4-alpha-glucosidic bonds (see figure 5). Bacterial alpha-amylases are used tor starch liquefaction (thinning) to a low DE prior to glucoamylase treatment in the production of dextrose and isoglucose. Alpha-amylase is also employed for the preparation of low-viscosity starches in the paper mill.

1.11. Amorphous

An amorphous material is non-crystalline. Within the starch granule there are both amorphous and crystalline regions. The amorphous areas are characterized by a high degree of molecular disorder with the chains having a random configuration. In the crystalline regions the linear sections of molecules, of amylose and amylopectin, are arranged in parallel crystalline bundles.

1.12. Amylopectin

Amylopectin is a polysaccharide component of starch, the macromolecules of which have a branched structure. Amylopectin molecules consist of repeating anhydroglucose units Connected by alpha-1,4-bonds but having an alpha-1,6-linkage at selected sites, generating a branch point (see figure 1). The common starches contain between 70 and 85 percent by weight of amylopectin. The average degree of polymerization (DP) of amylopectin molecules is about 2,000,000.

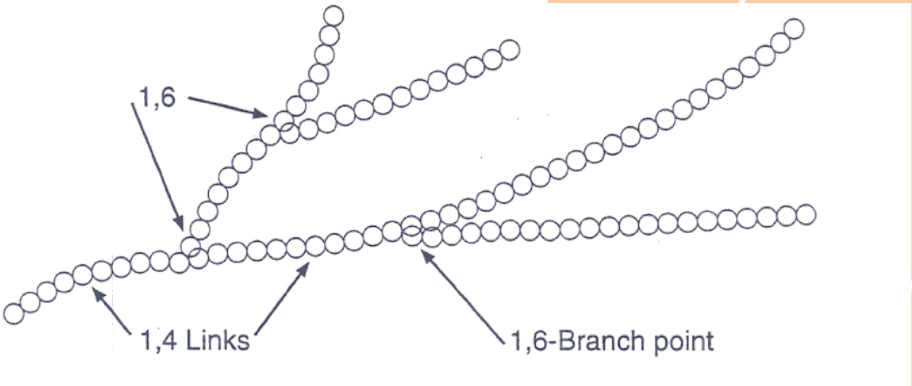

Figure 1 - Segment of the branched amylopectin molecule (**O** represents 1 anhydroglucose unit)

1.13. Amylose

Amylose is a polysaccharide component of starch, the macromolecules of which have a predominantly linear structure. Amylose molecules consist of repeating anhydroglucose units connected by alpha-1,4-linkages (see figure 2). The common starches contain between 15 and 30 percent by weight of amylose. Potato starch contains 21 percent of amylose and maize starch contains 28 percent of amylose. Potato starch amylose is a much larger molecule than maize starch amylose. Potato starch amylose molecules have a number average degree of polymerization (DP) of about 4900. The number-average DP of maize starch amylose molecules is about 930.

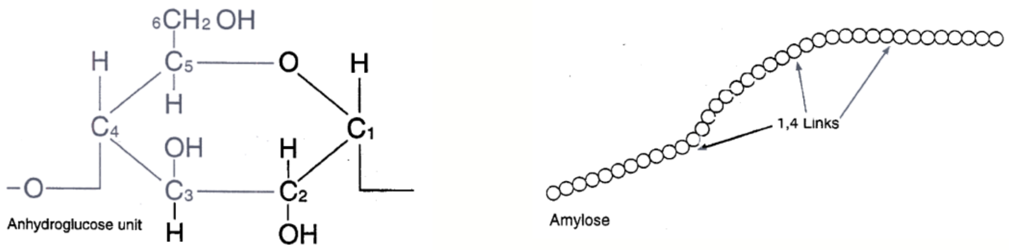

Figure 2 - Segment of the linear amylose molecule (O represents 1 anhydroglucose unit)

1.14. Angle of repose

A widely used test for assessing the cohesiveness of relatively free flowing powders and granules has been to measure their angle of repose. This can be done in several different ways: the funnel method, the cylinder method, the revolving drum, the tilting box and the platform method. The angles vary depending on the method of measurement. It is found that there is an increase in the angle of repose as the moisture content of the material is increased.

1.15. Anionic starch

Anionic starches contain groups capable of conferring on the starch molecules a negative charge in aqueous dispersions under appropriate pH-conditions. Examples of anionic starches are monostarch phosphates, oxidized starches and carboxymethyl starches.

1.16. Arrowroot starch

Starch isolated by wet milling of the tuberous roots of the genus Maranta linnaeus and Maranta arundinacea Linnaeus.

1.17. Ash

Ash is the residue of a starch product that remains after complete combustion (ignition) at a specified temperature. The ash of potato starch consists mainly of phosphate salts remaining from the phosphate ester groups in the amylopectin molecules.

2 <u>B</u>

2.1. Baumé (abbreviated as Bé)

Baumé is a hydrometer scale commonly used for designating the solids content of suspensions and solutions. It is an arbitrary scale of specific gravity invented in 1768 by

the Frenchman Antoine Baumé. The observed Baumé is a measure of the dry substance content, the specific gravity, the density and the concentration of solids. One degree of Baumé represents about 2 grams of dry substance per 100 millilitre solution or suspension.
In other words, the number of degrees Baumé is about one half of the concentration of solids. For suspensions of native potato starch in water (room temperature) the following table may be used.

Gram dry (waterfree) potato starch per 100 ml suspension	Degrees Baumé (° Bé)
20,7	10,4
28,7	14,0
35,8	17,2
41,8	19,8

Baumé determination of solutions of starch hydrolysates has been largely superseded by the direct determination of solids by refractive index.

2.2. Beta-amylase

Beta-amylase acts on the 1, 4-glucosidic linkages of starch molecules in such a manner, that maltose units are successively released from the non-reducing ends of the starch chains (see figure 5). Beta-amylase converts starch to maltose and residual dextrin (limitdextrin) containing the original branching linkages. Malt extract and certain bacteria are the usual sources of this amylase. Beta-amylase is used in the production of maltose syrups.

2.3. Biodegradable

The gradual degradation of molecular structure of materials induced by environmental conditions such as for instance sunlight, rain and earth-borne bacteria. Biodegradability is an inherent characteristic of starch and most starch derivatives and has been exploited in the development of biodegradable ingredients and starch-based foams.

2.4. Birefringence

When starch granules are viewed under the microscope using polarized light, they exhibit a phenomenon known as birefringence. The refraction of polarized light by the intact crystalline regions in starch gives characteristic "Maltese cross" patterns on each granule. The disappearance of these crosses on heating a starch suspension can be used to determine gelatinization temperature.

2.5. Bleached starch

Bleached starches are manufactured from native starches by treating them with small amounts of certain oxidizing agents. The conditions of application are designed to whiten the native starches. The reaction is carried out in an aqueous starch suspension. The bleached starch is recovered on continuous filters or centrifuges, washed with water and dried. The mild bleaching treatment also lowers the bacterial count of the starch product.

2.6. Bound phosphate

This term refers to covalently-bound phosphate groups on an anhydroglucose unit in the starch polymer chain. This may be either naturally-occurring as in the case of potato starch with or as the result of chemical modification (phosphorylation).

2.7. Brabender viscogram

The Brabender Amylograph is a rotational instrument which permits continuous determination of viscosity while cooking and cooling a starch paste. The instrument is started and the temperature of an aqueous starch suspension is heated automatically at a rate of 1.5 °C per minute. Heating is continued until the sample temperature reaches 90 °C (in the case of potato starch products). The sample is maintained at this temperature for 20 minutes, while stirring and recording the viscosity continuously. The paste is then cooled to 20 °C at a rate of 1 .5 °C per minute. Then the paste may be held at 20 °C for 20 minutes.

Figure 3 shows the Brabender viscosity curves of native potato starch, crosslinked potato starch and oxidized potato starch. These curves are characteristic for each kind of starch product. The Brabender viscosity curves contain the following significant points:

a) The pasting temperature is the temperature at which the viscosity begins to rise. This temperature varies with starch type and modification. The pasting temperature of potato starch is about 60 °C and of maize starch about 75 °C.
b) The peak viscosity indicates the highest viscosity which can be reached in the preparation of a starch paste (first maximum of the curve). The peak viscositiy is a measure of the thickening power of a starch product. Potato starch shows a very high peak viscosity of about 3,000 Brabender Units (BU) at a starch concentration of 5 % (m/m). Maize starch has a peak viscosity of about 800 BU (same conditions).
c) The viscosity after 20 minutes at 90 °C indicates the viscosity stability of a starch paste during cooking under relative low shear.
d) The viscosity of the cooked starch paste after cooling to 20 °C is a measure of the retrogradation (set-back) produced by cooling. Starches that exhibit strong set-back increase sharply in viscosity upon cooling.

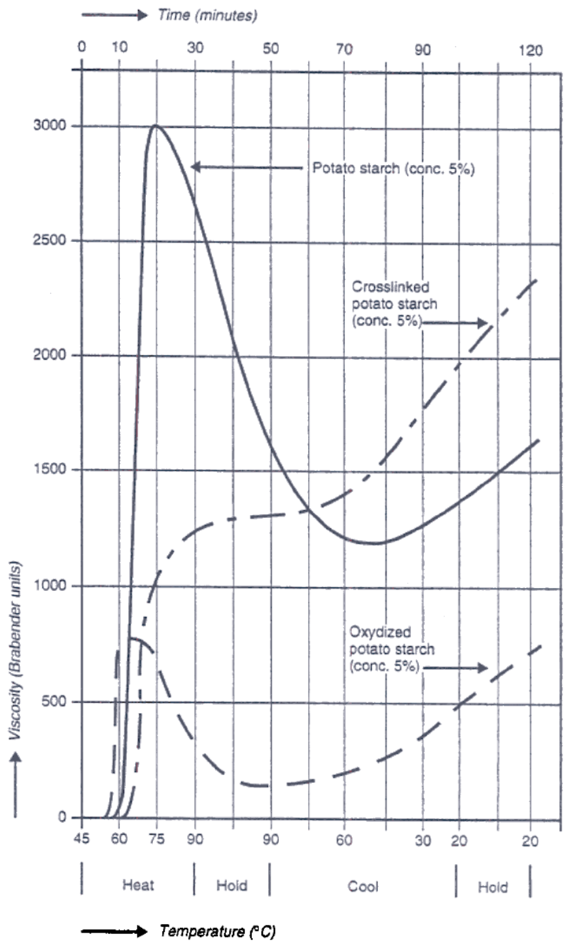

Figure 3 – Brabender viscosity curves

2.8. British gum

British gum is a dextrin type, which has a dark yellow or brown colour. The product is darker in color than standard yellow dextrin and is prepared by the dry roasting of neutral pH starch at high temperatures.

2.9. Brix

The Brix scale is widely accepted and used in the sucrose industry. This scale refers to the percentage by weight of sucrose in a pure solution of this sugar (in g/100 g). Measurement of Brix degrees is made by a hydrometer calibrated in Brix degrees or by means of a refractometer calibrated in percent sugar. Brix refers only to pure sucrose solutions, but it measures an "apparent" content of dry substance (in g/100 g) in aqueous solutions of other carbohydrates which is not too far from the actual truth. Although for most other sugars the discrepancy between Brix refractometer reading and actual solids content is not great, for glucose syrup the percentages indicated according to the sucrose scale are about 2 to 2.6 % too high. In practice, therefore, one must resort to tables, differentiated to DE value of the syrup.

2.10. Brookfield viscometer

Ease of cleaning, operational simplicity and instrument portabitity favour the use of Brookfield Synchro-Lectric viscosimeters. The instrument employs a rotating cylinder or disk (referred to as spindle) driven by a constant speed synchronous motor. The drive shaft is connected to the spindle shaft through a torsion spring, which provides the restoring force to balance the viscous resistance to rotation of the spindle. Application of the restoring force is accompanied by an angular deflection of the spindle

shaft retative to the drive shaft. This deflection is proportional to sample viscosity and spindle size and speed, and is indicated on a viscosimeter scale.
The viscosity of the cooked paste may be determined immediately after preparation with the Brookfield viscosimeter, or after cooling at a prescribed rate to a lower temperature while stirring. The Brookfield Viscosimeter is equipped with several spindies of different size, and the instrument contains a gear transmission permitting spindle operation at several speeds.
These features permit determination of viscosities over a broad range. The same spindle and speed should be employed in all sample comparisons involving a single observation. The spindle number and speed should be reported with all calculated viscosities.

2.11. Bulk density

The bulk density of a powder is the weight of a unit volume of it including the pores and the voids between the particles. The data can be expressed as grams per millilitre (g/ml), g/cm^3, kg/l or kg/m^3. Potato starch has a bulk density of about 0.7...0.85 g/cm^3 (= 700 ... 850 kg/m^3).
Drum-dried pregelatinized potato starch may have a bulk density of about 0.4 g/cm^3 (about
400 kg/m^3).

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info@agrobynature.com

3 C

3.1. Canary dextrin

See Yellow dextrin

3.2. Carbohydrate

A carbohydrate is a chemical compound composed of carbon, hydrogen and oxygen. Cellulose, starch, saccharose, lactose, glucose, fructose, maltose and the oligosaccharides are examples of the most common types.

3.3. Carboxymethyl starch

Carboxymethyl starch is starch ether in which some or all of the available hydroxyl groups of the starch molecules have been etherified by carboxymethyl groups, generally by means of monochloroacetic acid (c.q. sodium chloroacetate).

3.4. Cassava starch

See Tapioca starch.

3.5. Catalyst

A catalyst is a substance that causes or accelerates a chemical reaction but which remains unchanged during the reaction. Acids (catalyze starch hydrolysis), alkalies (catalyze crosslinking, esterification and etherification) and amylases (catalyze starch hydrolysis) are used as catalyst in the starch industry.

3.6. Cationic starch

Cationic starches contain groups capable of conferring on the macromolecule as positive charge in aqueous solution under suitable conditions of pH. Cationic starches are usually obtained by reaction of starch with tertiary or quaternary amines yielding amino alkyl or quaternary ammonium starches. Dispersed cationic starches are strongly absorbed by negatively charged cellulose fibres in the manufacture of paper.

3.7. Cereal starch

Cereal starches are contained in the grains of various species of plant belonging to the cereal family e.g. maize (= corn), wheat, waxy maize, rice, sorghum and barley. The industrial cereal starches are extracted from the cereal grains by wet milling. The properties of the common cereal starches are radically different from those of the root and tuber starches.

3.8. CFR

CFR is the abbreviation for Code Federal Regulations.

3.9. Chemical gelatinization

Starch may be gelatinized in aqueous medium either by heating to a suitable temperature or by treatment with certain chemicals. The most common type of chemical gelatinization is the treatment of starch with alkali such as caustic soda. This is used widely in the corrugating industry.

3.10. Chemically-modified starch

A starch based product that was treated with chemicals, in such a way that some hydroxyl groups were replaced by either ester or ether groups. Crosslinking, in which two hydroxyl groups on neighboring starch molecules are chemically linked is also a form of chemical modification. Very low levels of chemical modification can significantly change the rheological, physical, and chemical properties of starch. Chemically modified starch for use in foodstuffs is restricted in range and level of modification by various legislative bodies.

3.11. Clarity of starch pastes

The clarity of starch pastes is visually judged by light reflectance. Pastes of the root and tuber starches are much clearer than those of the ordinary cereal starches. Potato starch undoubtedly gives the clearest paste. Maize starch pastes are relatively opaque.

3.12. Cohesive

Cohesive is a description of starch texture where the solution exhibits a long, stringy, and undesirable nature. This texture is normally found in traditional native or overcooked starches.

3.13. Cold-water soluble starch

Synonyms: cold-water swellable starch, cold-water dispersible starch.
Cold-water soluble starches have the property of swelling in cold water and giving a colloidal solution (dispersion). Cold-water soluble starches may be in granular form (e.g. carboxymethyl starch with a higher DS) or may be in pregelatinized form (e.g. drum-dried starches).

3.14. Cold-water solubility

The cold-water solubility is the proportion of a starch product passing into solution in cold water under defined conditions.

3.15. Cold water swelling (CWS)

A term used to describe granular instant starches that swell in cold systems to develop viscosity.

3.16. Colour

Several methods are in use for the determination of colour in starch products ranging from visual inspection to the use of a photometer. The whiteness is measured by determination of the light reflectance of a starch surface compared with that of a standard white surface under defined conditions. The determination of the colour intensity of a starch hydrolysis product is carried out by comparison with reference standards or by measurement of the absorbance using a spectrophotometer under defined conditions.

3.17. Colloid or colloidal suspension

A system comprising particles dispersed in a liquid that do not settle out of solution due to their extremely small size.

3.18. Combinations of treatments

Synonym: multiple treatments

Very often starches are modified by combining two or more physical and/or chemical treatments. Multiple treatments are employed to become the desired combination of properties (see figure 9, F). A stabilized starch (ester or ether) made from undegraded starch may subsequently be subjected to enzyme conversion or oxidation treatment to obtain the desired range of viscosity. Oxidized starch may be used for further esterification or etherification modification. Crosslinking is often used in combination with esterification or etherification treatment to maintain paste viscosity upon exposure to high temperature cooking, high shear or acid. Stabilized and crosslinked starches may be pregelatinized (drumdried or extruded) in order to make them cold-water swellable.

3.19. Concentration

The concentration of a substance is the amount of the substance in mass (weight), moles or equivalents contained in unit volume. The dry substance concentration is the total amount of solids in unit volume. The concentration may be expressed as gram per litre (g/l), gram per 100 millilitre (g/100 ml), kilogram per cubic metre (kg/m^3), mol per litre (mol/l) etc. Calculation of the concentration of starch products in any system must be done on the basis of dry substance since air-dry starch products contain from 5 to 20 % (m/m) moisture.

3.20. Cook-up starch

A term used to describe starches that must be heated (gelatinized) to function.

3.21. Corn (maize) gluten feed

This is a commercial by-product from the wet milling of corn containing fiber, **gluten, starch, and a small amount of oil.**

3.22. Corn (maize) gluten meal

A commercial by-product from the wet milling of corn containing fiber, gluten, starch, and oil like gluten feed (see above) but with a higher level of gluten.

3.23. Corn oil

Corn oil is a high-value by-product of the corn wet milling process.

3.24. Corn steep liquor

Corn steep liquor is the product resulting from steeping of corn, which is concentrated before being supplied as a fermentation feedstock. Corn steep liquor contains lactic acid, amino acids, peptides, proteins, carbohydrates, vitamins, trace metals, and minerals.

3.25. Crossbonded starch

See Crosslinked Starch (below)

3.26. Crosslinked starch

Synonyms: crossbonded starch, inhibited starch

Crosslinked starches are modified starches in which crosslinks (bridges) in and between starch molecules have been formed by means of bifunctional or polyfunctional chemical reagents (see figure 4). Crosslinked starches are made by treating starch in the granule state with di- or polyfunctional reagents, capable of reacting with hydroxyl groups in and between starch molecules within the granule. Reagents such as phosphorus oxychloride, sodium trimetaphosphate, adipic acid and epichlorohydrin may be used as crosslinking agents. Only a small amount of crosslinking reagent is required because, generally, only one crosslink is required for every 100 to 2,000 anhydroglucose units. The degree of crosslinking controls the rate and extent to which starch swells on cooking. The toughening of the granule leads to restriction in swelling during gelatinization.

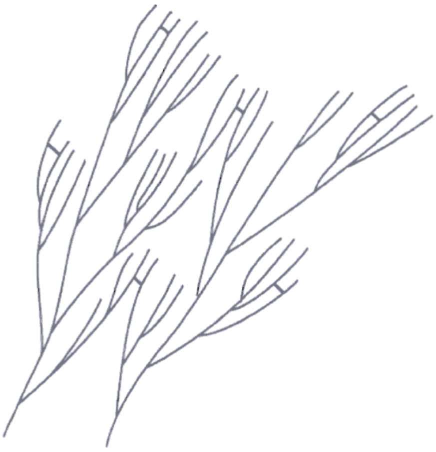


Figure 4 - Chemical bridges (**-**) in and between starch (mainly amylopectin) molecules decrease the degree of swelling of crosslinked starch granules (schematic)

3.27. Crude fiber

Crude fiber is insoluble cellulosic material which may be present at very low level in products of the starch industry.

3.28. Crystallinity

Crystalline materials are characterized by a highly ordered molecular structure.

3.29. Cyclodextrin

A non-reducing cyclic oligosaccharide with at least 6 anhydroglucose units linked in a ring by a-1,4 bonds. The most common cyclodextrins are alpha-, beta-, and gamma cyclodextrins having six- (alpha), seven (beta), or eight (gamma) anhydroglucose units in the ring structure.

3.30. Cyanoethyl starch

Cyanoethyl starches are obtained by etherification of starch with acrylonitril.

4 D

4.1. Degradation

Related terms: depolymerization, conversion.

Degradation of starch is the reduction of the size (degree of polymerization) of starch molecules with the aid of chemical and/ or enzymic reagents.

4.2. Degree of polymerization (DP)

The degree of polymerization (DP) of a starch molecule is the number of anhydroglucose units in the molecule. Anhydroglucose unit is commonly abbreviated as AGU. Potato starch has an average DP of about 14,000 and maize starch has an average DP of about 3,000.

4.3. Degree of substitution (DS)

The degree of substitution (DS) of starch esters and ethers is a measure of the average number of hydroxyl groups on each anhydroglucose unit which are derivatized by substituent groups. DS is expressed as moles of substituent per anhydroglucose unit. Since the anhydroglucose units in starch have 3 hydroxyl groups available for substitution, the maximum possible DS is 3. A stabilized starch (ester or ether) with a DS of 0.05 contains an average of 5 substituent groups for every 100 anhydroglucose units. Most commercially produced starch esters and ethers have a DS of less than 0.2 (less than an average of 20 substituent groups for every 100 anhydroglucose units).

4.4. Density

Synonyms: volumic mass, specific mass, particle density. Related term: specific gravity
Density is the concentration of matter, measured by the mass per unit volume. Thus d = m/v, where d is the density, m the mass and v the volume. The density of air-dry granular starches containing 10 ... 20 % (m/m) moisture is about 1.5 g/cm^3 (1.5 g/ml = 1,5 kg/l = 1500 kg/m^3).

4.5. Dextrin

Synonyms: pyrodextrin, rossted starch. Related term: British gum
Dextrins are prepared from native starch by heat treatment in the dry state (roasting) with the addition of hydrochloric acid or other acid. The white dextrins have a white colour, a limited cold-water solublility and a limited viscosity stability of solution. After cooling, a cooked solution of white dextrin soon sets to a gel. The yellow dextrins (canary dextrins) have a yellowish to brown-yellow colour and a high cold-water solubility. Cooked solutions of yellow dextrins give considerably less set-back than those of white dextrins. British gum is prepared from native starch by dry-roasting either alone or in the presence of added traces of alkali.

4.6. Dextrose

Dextrose is crystallized D-glucose. Dextrose is obtained by the nearly complete hydrolysis of starch, followed by purification and crystallization. Dextrose can be obtained in either anhydrous or monohydrate form. The anhydrous form is called anhydrous dextrose. The hydrated form is called dextrose monohydrate and contains one molecule of water of crystallization per molecule of D-glucose.

4.7. Dextrose-Equivalent (DE)

The Dextrose-Equivalent (DE) is the reducing power of a starch product expressed as D-glucose on the dry-weight basis. The DE is a measure of the number of reducing ends in a starch hydrolysate. Unhydrolyzed starch has a DE of virtually zero, whereas the DE of dextrose (pure glucose) is defined as 100. The DE value of a starch hydrolysate is inversely related to the average degree of polymerization (DP) of the starch hydrolysate. The product
DE x DP (average) is about 120.

4.8. Dilatant

Dilatant is a term from rheology. At low shear rates the initial flow of a dilatant substance is high but further increases in shear decrease the rate of flow.

4.9. Distarch glycerol

Distarch glycerol is a crosslinked starch in which certain starch hydroxyl groups have been etherified by glycerol bridges by means of reaction with epichlorohydrin.

4.10. Distarch phosphate

Distarch phosphate is a crosslinked starch in which certain starch hydroxyl groups have been esterified by phosphate bridges by means of reaction with phosphorus oxychloride or sodium trimetaphosphate.

4.11. Drum-dried starch

Synonym: roll-dried starch

Drum-dried starches are pregelatinized starches obtained by cooking and drying suspensions or solutions of starch products on steam-heated roller drums. In drum-drying, a starch slurry or paste is spread on hot rotating drums as a thin film and cooked and dried before being scraped from the drums. The dried product is then ground to the desired particle size.

4.12. Dry substance content

Synonyms: dry solids content, solids content, dry matter content (DMC).

The dry substance content of a product is the matter remaining after all moisture has been evaporated. The dry substance content may be expressed as percent by weight, % (w/w), % (m/m) or as g/100 g. The relation between % (m/m) dry substance and % (m/m) moisture of a product is expressed by the formula:

% (m/m) dry substance = 100 - % (m/m) moisture

4.13. Dual modified starch

This term is used to signify a starch which has undergone two chemical modification reactions so that the starch molecule bears two different chemical substituents.

4.14. Dusting starch

Starch powder which is applied to a surface to reduce or eliminate adhesion to other substrates. A specific case is starch used for dusting surgical rubber latex gloves. Starch used in this application is usually highly crosslinked to provide resistance to the sterilization process.

5 E

5.1. Emulsifying starch

Emulsifying starch is a modified starch having both hydrophilic and hydrophobic groups to give emulsion-stabilizing properties. An example is octenyl succinate starches having the hydrophilic carboxyl group and the lipophilic carbon chain. It is used for the stabilization of concentrated beverage emulsions as well as an encapsulation agent in the food industry.

5.2. Emulsion

An emulsion is an intimate mixture of oil in water with a dispersed and continuous phase.

5.3. Endosperm

Endosperm is one of the three main components of the corn kernel (endosperm, bran, and germ) which contains most of the starch and protein.

5.4. End viscosity

The term "end viscosity" refers to the final viscosity value in the curve produced by the Brabender viscograph. It usually denotes the viscosity of a fully gelatinized starch dispersion after cooling the resultant paste to a specific temperature.

5.5. Enzyme

An enzyme is one of a group of chemical substances produced by living organisms (e.g. bacteria, fungi) which promote and catalyze highly specific chemical reactions. The cleavage of glucosidic chemical bonds in starch by amylase enzymes is an example.

5.6. Enzyme-converted starch

This term refers to the enzyme-catalyzed thinning of starch pastes practiced in the food and paper industries to reduce viscosity to a specific range.

5.7. Enzymatic hydrolysis of starch

Enzymatic hydrolysis is the degradation (depolymerization conversion) to a lesser or greater extent of starch molecules by the action of amylases. Each type of amylase has its own pattern of hydrolysis (see figure 5).

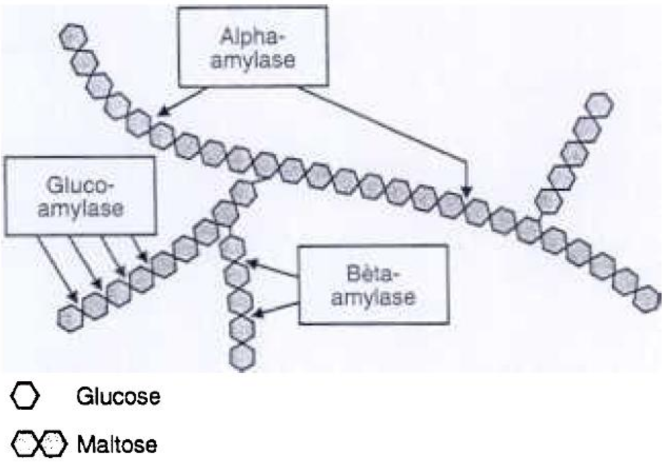


Figure 5 - Enzymatic hydrolysis of starch molecules with amylases

5.8. Excipient

A term used in the pharmaceutical industry to describe the inactive matrix material used to guarantee good tablet formation, integrity, and strength. A variety of products are used as tabletting excipients ranging from corn starch, pre-gelatinized starch and starch hydrolysates.

5.9. Extruded starch

Extruded starches are pregelatinized (cold-water swellable) starches obtained by extrusion of starch products. In the extrusion process, moistened granular starch is forced through a superheated chamber under very high shear, then expanded and simultaneously dried by venting to atmospheric pressure. Extruded starches have a lower viscosity than drum-dried starches owing to molecular degradation produced by the shear action of the rotating extruder screw(s).

6 F

6.1. Farina

Farina is another name for potato starch.

6.2. Fat

See Lipids

6.3. Fiber

Term used in the starch industry to describe the predominantly cellulosic material present in corn husks.

6.4. Film properties

Solutions of starch and its derivatives that form films when spread on a plane surface and dried. Starch film properties depend on the type of starch used and the presence of any chemical substituents. Hydrolyzed starch is particularly suitable for film applications as its low viscosity permits cooking at higher concentrations than unmodified starch. There is less water to evaporate in drying so the development of tack and adhesion occur more quickly than with unmodified starches.

6.5. Flash dryer

A flash dryer is a circular dryer with very fast drying action where the wet material is conveyed by the flow of hot drying air.

6.6. Flavour of starch products

Related terms: taste, odour.
The pregelatinized common cereal starches (maize, wheat) have a relatively raw cereal flavour. These starches impart cereal-type flavours to the foods in which they are incorporated. The root-type starches contain only a low amount of flavour substances and this may be due to their low lipid and protein content.

6.7. Flowability

The flowability is the tendency of a powder to flow freely from a container or funnel. Some compounds are used as additives to improve powder flowability e.g. calcium triphosphate.

6.8. Fluidity

Related term: alkali-fluidity.
Fluidity is the reciprocal of viscosity. The fluidity is the volume of a cooked starch paste at a standardized concentration that will flow through an orifice of known dimensions in a fixed time. Oxidized and acid-modified starches are manufactured to various fluidity values and sold under this specification. The alkali-fluidity (fluidity in cold alkali) is the fluidity of alkaline
solutions of starch products.The higher the number, the more hydrolyzed the starch. Water has a value of 100. Thin-boiling starches used in candy are in the range of 60 to 75.

6.9. Food starch

This term denotes any starch, native or modified, which is used or permitted for use in food applications. All native starches are allowed for use in food, but the range of chemically-modified starch for food use is restricted. European legislation applies in European countries and the FDA has developed legislation for the USA.

6.10. Food Starch-Modified

The term used to declare modified starches on food labels in the U.S.A.

6.11. Freeze-thaw stability

The ability of a starch paste or food composition containing starch or modified starch to maintain its integrity without syneresis when subjected to repeated thermal cycling between ambient and freezing temperatures. Freeze-thaw stability is imparted to starches by substitution with monofunctional reagents. Starch ethers, e.g. hydroxypropyl starches, are particularly suitable for food applications requiring freeze-thaw stability. Acetylated starches are also used for this purpose.

7 G

Gel - The rigid structure which is formed when cooked starch paste is cooled and stored at room temperature. It is usually associated with native starches (containing amylose) and acid-thinned starches.

7.1. Gelatinization

Synonym: Cooking
Gelatinization is the process involving the transformation of an aqueous starch suspension into a starch paste or starch solution (see figure 6). Generally, starch is gelatinized by cooking starch granules in an aqueous suspension forming a starch paste or solution. Starch molecules are polyhydroxy compounds and, when heated in water, combine with individual water molecules (hydration). As the starch molecules hydrate they increase in size, immobilize much of the water present, thicken the aqueous system and form a paste.
Essentially completed is aggregation (molecular solution) of native starch granules can be achieved by heating under pressure at 100. ..160 °C (see figure 6).

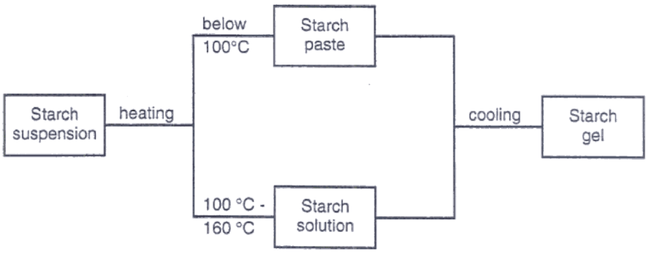


Figure 6 – Gelatinization and gelling of native starch

7.2. Gelatinization temperature (range)

Related term: pasting temperature.
The gelatinization temperature is the temperature range at which aqueous suspensions of starch granules pass into the paste form, under specified conditions, When heated in water to progressively higher temperatures, the starch granules first lose their polarization crosses, and thereafter undergo continued swelling. The Kofler gelatinization temperature is the temperature at which the starch granules lose their polarization crosses. While each individual granule gelatinizes quite sharply, not all the granules in a starch sample gelatinize at the same temperature, but rather over a range of some 10 °C. The Kofler gelatinization temperature range for potato starch is 56..66 °C and for maize starch 62..72 °C.
The temperature at which the viscosity in the Brabender-viscogram begins to rise is termed pasting termperatue. Appreciable granule swelling must occur, before the viscosity is sufficient to be recorded by the Brabender instrument. Usually, starch granules are completely gelatinized (as judged by loss of polarization cross) before this point is reached,
The Brabender pasting temperature of potato starch is 60..65 °C and of maize starch 75 ... 80 °C. Under alkaline conditions, starch gelatinizes at lower temperatures. An

aqueous solution of sodium hydroxide at a molarity of 0.1 or more gelatinizes native starch at room temperature (chemical gelatinization). Salts, such as sodium chloride and sodium sulfate, are used to raise the gelatinization temperature of starches.

7.3. Gelling

Synonyms: gel forming, gelation.

When cooked starch pastes or solutions are allowed to cool they can thicken and congeal into a semi-solid gel (see figure 6). Gelling occurs as the hydrated and dissolved linear amylose molecules in a starch paste or solution associate to form a three-dimensional network. Maize starch pastes gel faster and further than potato starch pastes.

7.4. Gel strength

The gel strength is measured by determination of the resistance to deformation of a starch gel, under defined conditions. The gel strength may be measured by several techniques.

These include measuring the force to move a disc into the gel and the opposite prodecure of withdrawing an imbedded disc from the gel. The gel strength may be determined with a Boucher Electronic Jelly Tester or with a Bloom Gelometer. Gel strength may be expressed in Boucher Units (B.U.). Gel strength is often confused with gel rigidity (lack of elasticity) but the two properties are not identical.

7.5. Germ

Term used in the starch industry to denote the embryo from which oil is expelled then refined to give the commercial product.

7.6. Glass transition temperature (Tg)

The properties of a polymer are determined by the extent to which the molecular motion of its constituent polymer chains are restricted or hindered. As temperature falls, molecular motion is reduced. When cooled further, a transition occurs where a glassy frozen state is formed and there is no motion of the atoms in the molecule. At this point, the material is typically glassy and brittle. Above the glass transition it is flexible. This boundary is known as the glass transition temperature.

7.7. Gloss

Gloss refers to the tendency of a surface to reflect light. A glossy surface is shiny and sparkling.

7.8. Glucoamylase

Synonym: amyloglucosidase

Glucoamylase converts starch almost completely to D-glucose by the successive removal of D-glucose units from the non-reducing ends of 1,4-linked starch chains and by hydrolysing the 1,6-branching linkages (see figure 5). Glucoamylase is used in the production of dextrose and isoglucose.

7.9. Glucose

Glucose is a monosaccharide found in fruits (e.g. as grape-sugar) and in blood. Glucose is produced commercially by hydrolysing starch.

7.10. Glucose syrup

Synonym: corn syrup.

Glucose syrup is the purified, concentrated aqueous solution of nutritive saccharides (mono di- and oligosaccharides) with a DE of 20 or more obtained from starch. In the USA this product is known as corn syrup.

7.11. Glucosidic bonds

These are the covalent chemical bonds which link anhydroglucose units in starch chains. They may be linked in the a-1,4 configuration to form a linear chain or in the a-1,6 configuration which gives a branch point. The glucosidic bonds may be ruptured by enzymes at specific sites in the amylose and amylopectin polymers.

7.12. Gluten

The water-insoluble protein complex extracted from cereal grains. Maize or corn gluten is used in animal feed but wheat gluten, also known as vital gluten, has more functionality. When wheat gluten is hydrated, it develops a cohesive and elastic character and is widely used in the bakery sector, particularly in bread.

7.13. GMO

Genetically Modified Organism, an organism that has been genetically altered. This is associated with regular corn starch where around 40 % of the 1999 US corn crop is BT corn.

7.14. Good Cook

A starch paste which has been optimally cooked giving intact, fully swollen granules. This yields high viscosity, good clarity, taste and stability.

7.15. Governmental regulations

The use of modified starches and other starch derivatives in foods and as a component of articles intended for use in manufacturing, packing, processing, preparing, treating, packaging, transporting or holding food is restricted by legislation. The governments have issued regulations specifying the reagents, the amount of these reagents and the amounts of residual reagents and residual by-products that are cleared in treating starch to make modified starches suitable of direct addition to foods and/or suitable of coming in contact with food (for example as components in paper products and adhesives). There are also regulations relating to the migration limits of starch products (including residual reagents and residual by-products) as components in articles, packaging materials and adhesives that can come in contact with food. Examples of residual by-products in chemically modified starches are chlorohydrins (resulting from the use of reagents such as ethyleneoxide, propyleneoxide, epichlorohydrin and/or cationic reagents) and acetaldehyde(resulting from the use of vinyl acetate as reagent). The quality and purity of chemically modified starches and other starch products must meet performance standards and comply with manufacturing practices specified in national and international regulations. Each country has its own regulations and these vary considerably. The full regulations should be consulted before using starch derivatives.

7.16. Granular Starch

This term is used to describe both cook-up starches and also instant starches that have been pre-cooked but have maintained a granular structure. When the second type of starch is dispersed in cold or warm water, swelling occurs followed by viscosity development.

7.17. Granule

Starch exists in certain plant species in the form of small bundles known as granules. These granules have a characteristic size and shape depending on the particular source involved. Microscopic examination may be used to identify starch type by reference to standard images of different starch granule types.

7.18. Granule size

Starch granule size is generally expressed as a range depending on the particular starch type e.g. corn starch granules are in the range 5-25 microns.

7.19. GRAS "Generally Recognized as Safe"

The GRAS status is a classification for food and food ingredients co-ordinated by the Food and Drug Administration in the USA.

8 H

8.1. Heat stability

The stability of a particular product property when the product is exposed to storage under hot conditions, such as the viscosity of starch paste.

8.2. High amylose starch

Genetic varieties of starch containing over 50% amylose. Current commercial varieties contain 55% and 70% amylose. High amylose starch is highly crystalline and requires high cooking temperatures and/or pressures to achieve full gelatinization. They are used in cereals, batters, and confectionery for their strong film forming and gelling capabilities.

8.3. High fructose corn syrup (HFCS)

A special type of glucose syrup containing high levels of fructose. HFCS is produced by enzymatic conversion of starch to glucose followed by conversion of some of the dextrose to fructose using the enzyme isomerase.

8.4. Hydrocolloid

A term used to encompass a range of starches and gums used in industry all having an affinity for water.

8.5. Hydrogen bond

A relatively weak, localized bond between the polar hydroxyl groups of water and the hydroxyl groups on starch. Hydrogen bonds are of fundamental importance in the behavior of starch and its derivatives as they play a role in granule structure, gelatinization, and retrogradation.

8.6. Hydrolysates

Formed from hydrolysis (See below).

8.7. Hydrolysis

The chemical reaction of a molecule with water to produce two or more smaller molecules. Specific hydrolysis processes may be catalyzed by acids, alkalis, or enzymes according to type of reaction. Hydrolysis is the underlying reaction in the enzyme- or acid-catalyzed conversion of starch into maltodextrins and glucose syrups. The degree of hydrolysis determines the final molecular weight and properties of the product.

8.8. Hydrophilic

The product property which describes affinity for water, water compatibility and water absorption. Carbohydrates as a class are naturally hydrophilic due to their abundant hydroxyl groups.

8.9. Hydrophobic starch

Starch which has been chemically modified to give a hydrophobic character. An example is the ester starch Octenyl Succinate made by treating starch with Octenyl Succinic anhydride (OSA). This is used as a food starch, e.g. for emulsion stabilization, and as an encapsulation agent.

8.10. Hydroxyethyl starch

Synonym: ethylated starch.

Hydroxyethyl starch is obtained by etherification of starch with ethyleneoxide. The Preparation of low-substituted ungelatinized hydroxyethyl starches is generally carried out in alkaline aqueous starch suspensions. Most hydroxyethyl starches are also "acid-modified or oxidized to reduce their viscosity. The cooked pastes of hydroxyethyl starches are noncongealing and stable.

8.11. Hydroxyl group

A chemical group consisting of one atom of oxygen and one of hydrogen. Each anhydroglucose unit in starch has three hydroxyl groups. The hydroxyl groups in starch and its derivatives account for their hydrophilic nature.

8.12. Hydroxypropyl starch

Hydroxypropyl starches are obtained by etherification of starch with propyleneoxide. Most hydroxypropyl starches are also degraded or crosslinked. The crosslinked hydroxypropyl starches may also be drum-dried. The introduction of hydroxypropyl groups into the starch molecules stabilizes the viscosity of the cooked products

Hydroxypropyl distarch phosphate – Starch in which both monofunctional hydroxypropyl groups have been added in combination with phosphate crosslinking. These products are used widely in the food industry.

Hygroscopicity - The property of absorbing moisture, particularly from the atmosphere. Starch dried to below its equilibrium moisture content will slowly absorb atmospheric moisture until the equilibrium moisture level is reached.

9 I

9.1. Inhibited starch

Another name for a crossbonded starch produced by treatment with a bi- or polyfunctional reagents. (See crosslinking).

9.2. Instant starch

A starch that is functional in cold water. (See cold water swelling and pregelatinized starch.)

9.3. Iodine affinity

Measure of the amount of iodine bound by the starch. It is a reflection of the amount of linear material [amylose] in the starch.

9.4. Iodine test

Starches containing amylose will develop a blue color in the presence of iodine due to its formation of an inclusion complex with amylose. This is the basis of the simplest test available to check for the presence of starch. The blue coloration is also obtained with starch degradation products down to quite low DP (<100). Amylopectin gives a red/brown coloration which can be used to distinguish waxy starches.

9.5. Isoglucose

Synonyms: isoglucose syrup, High-Fructose-Glucose-Syrup (HFGS), High-Fructose-Corn-Syrup (HFCS).
Isoglucose syrups are prepared by enzymatically converting glucose in high-DE substrates to fructose (= levulose) with glucose isomerase. The isomerization results in a syrup containing about 42 % (percent by weight on dry substance) fructose, 51 % glucose and about 7 % oligosaccharides. Enriched isoglucose syrups (Enriched Fructose Glucose Syrup = EFGS) contain about 55 % fructose and about 42 % glucose.

9.6. Isomer

An isomer of a chemical compound has the same molecular formula but the atoms comprising the compound are arranged in a different way.

10 J

10.1. Jet-cooker

Synonyms: steam jet-heater, continuous cooker.
The continuous preparation of starch solutions is widely used. Dry starch is slurried in water and passed through a jet-cooker where the slurry is instantaneously gelatinized with steam. Starch slurry can be continuously passed through a jet-cooker and heated to a temperature of 100 to 160 °C. The heat gelatinizes the starch, and the mechanical shearing action of the expanding steam disrupt the swollen granules

11 K

12 L

12.1. Legislation

The use of some products of the starch industry, particularly in foods, are governed by both country and regional food legislation. Modified starch for food use is restricted in terms of the chemical reagents which may be used for modification, their amount, the extent of the resultant modification and the permitted levels of undesirable by-products or residues.

12.2. Long

A term used to describe the stretch or cohesiveness of a starch paste.

12.3. Low-viscosity starches

Related terms: thin-boiling starches, converted starches.
Cooked native starches have such a great thickening power, that pastes containing more than 2 to 5 % solids are too thick (too viscous) to handle. For many uses higher-solids-containing pastes are required. Viscosity of native starch is often reduced for effective use. Low-viscosity starches may be prepared by controlled degradation of native starch or stabilized starch. Examples of low-viscosity starches are dextrins, acid-modified starches, oxidized starches and enzymatically modified starches.

12.4. Lipids

Synonyms: fatty substances, fats, fat-like materials.

The common cereal starches (maize, wheat, sorghum) differ from those from tubers (potato) or roots (tapioca) in a range of properties. One of the most important differences is the high lipid content of the common cereal starches which is about 0.8. ..1.0 % (m/m). The lipids may form a complex (helix) with the amylose molecules. Maize starch contains 0.8 % lipids, namely 0.5 % free fatty acids (mainly palmitic and linoleic acid) and 0.3 % lysophospholipids. About 60 % (m/m) of the lipids of maize starch are unsaturated lipids.
The presence of a relative high amount of lipids in the common cereal starches (e.g. maize starch) has the following effects:

a) The lipids repress the swelling and solubilization of the starch granules. Lipids increase the pasting temperature, reduce the water-binding capacity, reduce the swelling power and reduce the solubility of starches.
b) The presence or formation of insoluble amylose-lipid complexes causes turbidity and precipitation in starch pastes and starch solutions.
c) The oxidation of unsaturated lipids may cause the formation of undesirable flavours in pregelatinized maize and wheat starch products.

Potato starch products contain only a low amount of lipids (about 0.1 %) and do not show the effects mentioned before. Although lipids are mostly removed from corn as oil during the wet milling process there is a low level (up to 1%) of residual lipid (fat) present in starch. Potato and tapioca starch contain lower lipid levels than corn starch.

12.5. Lipophilic

Starches can be chemically modified to have an affinity for oils. This attraction makes them ideal for stabilizing emulsions and these starches are described as lipophilic.

12.6. Liquefaction

Synonym: thinning.
The objective of the liquefaction process is to convert a concentrated suspension of starch granules into a solution of degraded starch molecules. Typically, a starch suspension which contains bacterial alpha-amylase is pumped into a steam jet-cooker where the temperature is raised instantaneously to 80 ... 115 °C. The starch is immediately gelatinized and is depolymerized rapidly to a fluid mass that is easily handled.

13 M

13.1. Maize germ cake

Residue left after the removal of oil from maize germ.

13.2. Maize gluten feed

A by-product of the corn wet milling process consisting of fiber, gluten, starch, and a small amount of oil.

13.3. Maize gluten meal

A by-product of the corn wet milling process consisting of the same ingredients as maize gluten feed (fiber, gluten, starch, and a small amount of oil) but with a higher level of gluten.

13.4. Maize starch

Synonyms: corn starch, dent corn starch

Maize starch is the industrial starch product obtained by wet milling of certain varieties of the species Zea mays Linnaeus. In the USA and in some other countries, the term corn starch is used as a synonym.

13.5. Maltodextrin

Starch hydrolysis product generally having a Dextrose Equivalent (DE) between 5 and 20 usually produced by the action of an amylase enzyme on gelatinized starch. Maltodextrin contains a range of non-sweet polysaccharides with a distribution of molecular weights where the anhydroglucose units are linked predominantly by 1,4 bonds.

13.6. Maltose

Maltose is a disaccharide composed of two molecules of D-glucose joined by 1,4 -links. Maltose is an important component of glucose syrups. Maltose is less sweet than glucose and is a major component of high and very high maltose syrups used in confectionery and other food applications.

13.7. Maltose syrup

Maltose syrups are glucose syrups with a maltose content of 45 to 85 percent by weight on dry substance. Maltose syrups have a DE of 35 to 60 and are produced by converting thinned (liquefied) starch with beta-amylase.

13.8. Manioc starch

See Tapioca starch.

13.9. Mill conversion of starch

Related terms: in-mill starch conversion, on-site conversion.

Native starches are too high in viscosity for many applications. Low-viscosity starches may be prepared by the starch manufacurer (e.g. oxidized starch) or starches may be thinned on-site e.g. in the paper mill. Today, thinning at the paper mill is widely practised. Several low-cost methods may be used. Most important are batch or continuous enzyme conversion and continuous thermochemical conversion. On-site conversion is accomplished by adding alpha-amylase or oxidizing agents to the starch slurry and then cooking the starch through a jetcooker system with a holding chamber.

13.10. Modified starches

Modified starch is a native starch treated in such a way as to modify one or more of its original physical or chemical properties. Modified starches have remained their starch character. The native starches are modified to produce starch products with desirable properties. The modified starches include the low-viscosity starches, crosslinked starches, starch esters, starch ethers and the pregelatinized starches.

13.11. Moisture content of starch products

All methods for the determination of the moisture content of natural organic substances are empirical and the moisture content must be related to the method of determination. For starch products there are standardized procedures for the determination of their moisture content (ISO-methods). The moisture content may be calculated from the formula:

% (m/m) Moisture = 100 - % (m/m) Dry Substance.

The moisture content of a starch product may be expressed in percent by weight, % (w/w), %
(m/m), gram moisture per 100 g starch product, g/100 g or in mg/g. Native potato starch and granular modified potato starches (starch acetates, starch ethers, crosslinked starches,
oxidized starches) generally have a moisture content varying from 17 % (m/m) to 20 % (m/m), corresponding with 170 to 200 mg/g. Pregelatinized potato starches (drum-dried) have a moisture content of 4 to 10% (m/m), corresponding with 40 to 100 mg/g. Potato starch dextrins and monostarch phosphates have a moisture content of about 12-13 % (m/m). Glucose syrups contain about 20 % (m/m) moisture.

13.12. Molding starch

Starch with low levels of added oil which is applied by spraying. This starch has poor flow properties and therefore retains a distinct impression. It is used as depositing medium for molded candies and gum confectionery.

13.13. Molecular weight

This is the average molecular weight used to characterize natural and synthetic polymers. It reflects the average number of units in the starch polymer chains.

13.14. Monostarch phosphate

Related terms: starch phosphate, starch monoester of phosphoric acid.
Monostarch phosphate is formed by heating a dry, intimate mixture of granular starch and orthophosphoric acid, sodium or potassium orthophosphate or sodium tripolyphosphate.
Monostarch phosphate is a starch ester, essentially without crosslink-bridge. Potato starch already contains a low level of naturally-occurring monophosphate groups giving it a slightly anionic character.

13.15. Morphology

The morphology of a material is concerned with the different molecular configurations occurring in the various crystalline and amorphous forms of the material.

14 N

14.1. Native starch

Related terms: unmodified starch, raw starch
Native starch is obtained in granular form by a wet milling process from starch-containing raw materials such as cereals, tubers and roots. Often used to distinguish unmodified starch from starch which has undergone physical or chemical modification. More recently, new types of native starches have been developed with many of the properties of modified food starches.

14.2. Newtonian

A rheological term; as a Newtonian material undergoes deformation (flow) the ratio of shear stress (applied force) to shear rate (flow or deformation) remains constant.

14.3. Non-Newtonian

Non-Newtonian is a rheological term used to describe materials whose rheological behavior deviates from Newtonian response as defined above.

15 O

15.1. Oligosaccharides

Related terms: malto-oligosaccharides, starch oligosaccharides, higher sugars.
Starch oligosaccharides represent fragments of the original starch polysaccharide molecules.
They are composed of anhydroglucose units linked bij 1,4 and 1, 6-bonds. The oligosaccharides contain from 3 up to about 10 anhydroglucose units (DP 3 to DP 10). Examples of oligosaccharides are maltotriose (DP 3), maltotetraose(DP 4), maltopentaose
(DP 5), maltohexaose (DP 6) etc..

15.2. Organoleptic properties

Those properties of a foodstuff or food ingredient which are perceived in the mouth during eating. The properties include taste, mouthfeel, consistency, texture, stickiness etc. Crosslinking has a positive effect on starch paste texture; crosslinked starches generally have a short stringless consistency.

15.3. Overcook

A starch paste where the granules have been ruptured and a long cohesive texture develops.

15.4. Oxidized starch

Related terms: chlorinated starch, thermochemical conversion.
Oxidized starch is a low-viscosity starch obtained by the oxidation of starch. The oxidation causes a whiter color than native starch and depolymerization which results in a lower viscosity. Further, the oxidation may introduce carbonyl and carboxyl groups, which minimize retrogradation of amylose molecules thus giving viscosity stability.
The starch industry produces granular oxidized starches. In this method, aqueous starch suspensions under continuous agitation are treated with dilute sodium hypochlorite containing a small excess of NaOH. When the desired degree of oxidation is reached, the starch suspension is adjusted to the desired pH, filtered, washed and dried. This oxidized starch retains its original granule structure and is still insoluble in cold water. After gelatinization, these oxidized starches may give high-solids pastes with resistance to viscosity increases and gelling. Papermills use thermochemical conversion of native starch to produce solutions of oxidized starch. In this method, oxidizing agents (e.g. ammonium persulfate or hydrogen peroxide) are added to a starch suspension and this suspension is then cooked in a continuous jet-cooker system. During and after cooking the starch is converted to the desired degree of oxidation.

16 P

16.1. Particle size

Usually expressed as a particle size distribution giving the full range particle sizes found in the sample.

16.2. Pasting temperature

The temperature at which the viscosity curve produced in the Brabender viscograph leaves the baseline as the temperature rises during the initial heating process.

16.3. Peak viscosity

Related term: top viscosity.
The peak viscosity indicates the highest viscosity in the preparation of a starch paste. The peak viscosity can be demonstrated with a Brabender viscogram (see figure 3). The peak viscosity is obtained when the starch granules have swollen to such an extent that

they occupy a high proportion of the total volume and are in contact with their immediate neighbours. Potato starch shows the highest peak viscosity as compared with the other commercial starches. The peak viscosity is a measure of the thickening power of a starch product.

16.4. Pearl starch

A term referring to the physical form of starches dried in the old kiln type dryers which preceded the flash dryer in common use today.

16.5. Percentage substitution

This refers to the level of chemical substitution in a chemically modified starch expressed as weight of the substituent as a percent of total starch weight (anhydrous).

16.6. pH

pH is defined as the logarithm of the reciprocal of the molar hydrogen ion concentration in a solution. The pH is a measure of the acidity or alkalinity of a solution or suspension. pH 7 is neutral, lower values are acid and higher values are alkaline. The range is from 0 to 14.

16.7. Phosphorylated starches

Another term for monostarch phosphate where a starch has been substituted with anionic phosphate groups.

16.8. Physically-modified starch

Starch which has been physically treated by the manufacturer without the introduction of new chemical groupings. Examples of physical modification include drum-drying, extrusion, spray drying, heat/moisture treatment etc. Physically modified starches have a 'cleaner' image than chemically-modified starch particularly in the food industry.

16.9. Plate heat exchanger

A piece of equipment used to heat low-viscosity fluids in the food industry. It consists of a series of plates that allow a heated fluid (steam) to indirectly heat the food product continuously.

16.10. Polyols

Polyols are sugar alcohols: this means that they are sugars to which one or more molecular groups containing an oxygen and a hydrogen atom have been added. They are produced by the catalytic hydrogenation of carbohydrates such as glucose syrups or dextrose.

16.11. Polysaccharide

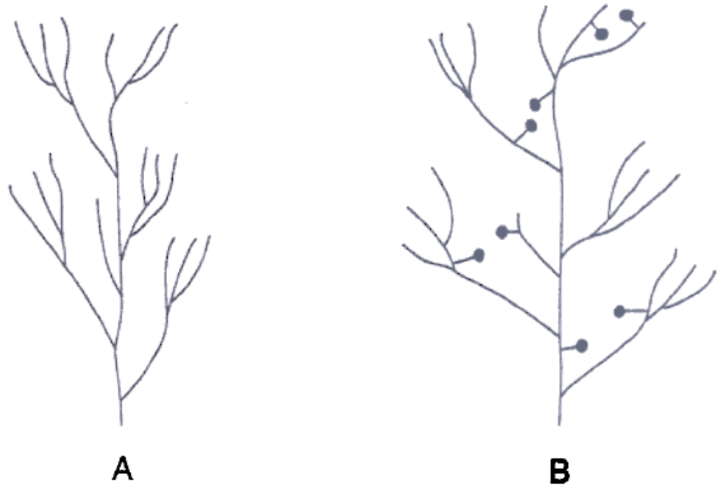
A general term used to describe a polymer built from the anhydroglucose building block. Examples include amylose, amylopectin and other hydrocolloids.

16.12. Potato starch

Synonym: farina.

Potato starch is obtained by wet milling of tubers of the species Solanum tuberosum Linnaeus. The amylopectin molecules of potato starch contain one phosphoric ester group for every 200 to 400 anhydroglucose units. The negatively charged phosphate groups are chemically bound to the C6-position of a small portion of the anhydroglucose units. In aqueous pastes, the repulsion of like charges helps to untangle the individual potato amylopectin molecules and extends their sphere of influence. This extension or uncoiling of the branches of the anionic potato starch amylopectin molecules is shown in figure 7.

The high viscosity of potatos tarch pastes, and certain other characteristics are related to the presence of these esterified phosphate groups.



A - Dissolved amylopectin molecule (segment) of cereal and root starches

B - Expanded dissolved amylopectin molecule (segment) of potato starch.

(-• represents a dissociated anionic phosphate group)

Figure 7 - Dissolved amylopectin molecules (schematic)

16.13. Powdered starch

Starch which has been milled and screened so that it passes through a sieve of specified size.

16.14. Pregelatinized starch

Synonyms: precooked starch, pregels.

Related terms: instant starch, cold-water soluble starch, drum-dried starch, extruded starch.

Pregelatinized starches are obtained by gelatinizing and drying of starch suspensions (drumdrying) or by extrusion cooking of semi-dry starches. Pregelatinized starches have the property of marked swelling in contact with cold water and giving a colloidal solution. During pregelatinization the granular structure of the starch is destroyed.

16.15. Propylene Oxide

The cyclic compound with formula C_3H_6O which is used to treat starch to give hydroxypropyl starch ethers. Propylene oxide is a volatile liquid with a low boiling point. It forms explosive mixtures with oxygen and air. Hydroxypropyl starches are sometimes referred to as propylene oxide starches.

16.16. Pseudoplastic

A rheological term used to describe material which has a yield stress above which flow occurs and where the flow rate increases sharply with further increases in stress.

16.17. Pyroconversion

The physical or chemical modification of starch by heating to elevated temperatures with or without chemicals is known as pyroconversion. The process is used to produce dextrins using a variety of different pieces of equipment.

Agro Anatolia
Gıda Tarım
San. Ve Tic. A.Ş.

Aksoy Mh. 1768 Sk.
No:22/2 Karşıyaka
İzmir/Turkey

Tel: +90 232 381 68 57

info@agrobynature.com

17 Q

18 R

18.1. Reducing power

Glucose, maltose and the oligosaccharides contain one reducing end group (carbonyl function) per molecule. These reducing sugars are capable of chemically reducing copper in alkaline solution. If measurements are carried out under determined conditions the results can be expressed in dextrose equivalent value.

18.2. Refractive index

The index of refraction of a substance is the ratio of the velocity of light in a vacuum to its velocity in the substance. This last velocity is dependent on composition, concentration and temperature of the substance. When solids composition and temperature are known, index of refraction is a measure of dry substance content or Baumé. The refractive index method is used for the determination of the amount of dissolved substances (refractometric solids) in solutions containing mainly sucrose. The method is also applicable to glucose syrups and dextrose solutions. The determination of soluble solids by refractive index measurement has the great advantage of being a rapid and easy procedure. The refractive indexes of all starch hydrolysates deviate from the values from sucrose of equal percentage dry substance. It is for this reason that tables have been prepared, in which the percent solids are correlated with the refractive index for several of these starch hydrolysates. The refractive index of a glucose syrup is dependent on its DE-value, percentage of ash and of course temperature and solids concentration.

18.3. Repolymerization

Glucose and other oligosaccharides are capable of repolymerization at high temperatures in the presence of catalytic amounts of acid. Repolymerization occurs at the high temperatures encountered in dextrin production processes. This generates dextrins with a higher degree of solution stability.

18.4. Resistant starch

A food starch or starch derivative which is not digestible by the human body. The official definition is "the sum of starch and products of starch degradation not absorbed in the small intestine of healthy individuals." There are four main groups of resistant starches: RS1, RS2, RS3 and RS4. RS1 is physically inaccessible starch, e.g. trapped in seeds. RS2 starch is granular starch. Examples include banana, high amylose starches. RS3 starch is a highly retrograded starch, e.g. extruded cereals. RS4 is chemically modified and still under development. They all have different properties but in general have both positive effects on food texture, processing, colonic health, and they analyze as total dietary fiber using the AOAC method.

18.5. Retrogradation

Related term: set-back.

The term retrogradation means a return of dissolved starch molecules to a more orderly state but one quite different from the original state in the starch granule. Retrogradation is mainly due to the presence of amylose molecules in starch pastes and starch solutions. Usually, retrogradation is a very undesirable phenomenon. There are two forms of retrogradation namely "normal retrogradation and - "high-temperature retrogradation".

Normal retrogradation is a process of gradual and irreversible insolubilization of dissolved amylose molecules in starch pastes and solutions. It arises from the inherent tendency of dissolved linear amylose molecules to line up parallel to each other. The hydroxyl groups on parallel amylose molecules exert attractive forces (hydrogen bonding) and the molecules are pulled together. The tendency of amylose molecules to retrogradate is enhanced if the amylose molecules are degraded to an average chain length of about 100 to 200 glucose units. Amylopectin, having branched molecules, shows little tendency to retrogradate.
During the process of normal retrogradation the following effects may be observed in starch pastes:

a. The starch pastes become more and more opalescent with a gradual increase in turbidity.
b. Spontaneous thickening of the starch paste with a gradual increase in viscosity.
c. In many cases the starch paste sets to a rigid irreversible gel.
d. Subsequent to gel formation separation of water (sometimes called syneresis or weeping) may occur.
e. Formation of insoluble skins on hot starch pastes.
f. Precipitation (deposition) of insoluble particles consisting of aggregated amylose micelles.

Pastes of maize starch have a higher tendency towards normal retrogradation than pastes of potato starch. This is mainly attributed to the relatively small size of the maize amylose molecules and the high amylose content of maize starch.

The high-temperature retrogradation is another form of retrogradation. It is observed when native maize starch or degraded maize starch is cooked at temperatures of 120 to 160 °C (e.g. jet-cooked) and the resultant solution is stored at 75...95 °C. The maize starch solution becomes turbid and precipitation of particles takes place. The precipitated particles are formed from insoluble inclusion complexes of maize starch amylose molecules with free fatty acids, which are naturally present in maize starch. High-temperature retrogradation is not observed when potato starch is jet-cooked and cooled because free fatty acids (or other complexing lipids) are virtually absent in potato starch

18.6. Rheology

The study of the flow of materials and the response of flow properties such as apparent viscosity under different conditions of applied shear. Rheology is often described in terms of a stress/strain relationship.

18.7. Rheopectic

A rheological term used to denote an increase of apparent viscosity with time at a constant rate of agitation or shear.

18.8. Rice starch

Starch from various species of the genus Oryza Linnaeus.

19 S

19.1. Saccharification

The objective of saccharification is to convert starch to D-glucose in yields as high as possible. Generally, native starch is liquefied with alpha-amylase and the liquefied starch

(DE of 5 to 20) is then saccharified with glucoamylase. It is possible to obtain a saccharified solution that contains 93 to 97 percent by weight of glucose on dry substance (corresponding with a DE of about 95 to 98). The saccharified solution is used in the production of dextrose and isoglucose.

19.2. Sago starch

Starch from the genera Metroxylon sagu Rottboel and Metroxylon rumphii Martins. It is typically found in Southeast Asia and sourced from the pith of the sago palm tree.

19.3. Scraped surface heat exchanger

Process equipment used to heat higher viscosity fluids in the food industry. The food product passes through a central circular chamber with scrapers as heat is applied from an outer jacket.

19.4. Sensorial properties

The sensorial properties of a starch are extremely important in determining its suitability for specific food applications. These include taste, mouthfeel, touch, odor, visual appearance etc. Sensorial properties are normally assessed by a trained panel operating in a controlled environment.

19.5. Set back

Used as a synonym for retrogradation to describe the rise in paste viscosity as a starch paste cools.

19.6. Shear stability

The shear stability is defined as the resistance to viscosity breakdown of a starch paste as shear is applied. Highly crosslinked starches are used for their good shear stability.

19.7. Shelf stability

Shelf stability is defined as the maintenance of the original properties of a product as it is stored for appropriate periods of time in varying conditions of temperature, relative humidity, incident sunlight etc. The properties to be maintained may include color, viscosity, taste, texture, acidity, freedom from syneresis etc. .

19.8. Short texture

The texture of a liquid composition is referred to as being "short" when it is not cohesive and is free from stringing. Starch gels prepared from highly crosslinked starches typically exhibit a short texture. Short, cuttable, rigid textures are associated with increased amylose levels in starch. Some high amylose starch hybrids are used for quick setting confectionery applications which exploit the rapid setting and short texture required in these products.

19.9. Solubility

When starch is pasted in hot water, the individual granules swell and a portion of the starch molecules dissolves (diffuses) in the surrounding aqueous medium. The amount of solubles will depend on the starch species, on the type and extent of modification and on the temperature of pasting. The solubility of various starches can be determined by suspending a weighed dry starch sampie in water, heating the mixture for 30 minutes in a thermostated bath and centrifuging the supernatant solution from the swollen sediment. The supernatant solution of molecularly dissolved starch molecules is then evaporated to dryness. The solubility is expressed as the percentage (by weight) of the starch sample that is dissolved after heating in water during 30 minutes at a certain temperature of pasting. Potato starch shows a much higher solubility as compared with maize starch. At 95 °C, the solubility of potato starch is 82 % compared to 25 % for maize starch. The lipids in maize starch reduce the solubility.

19.10. Solubilized starch

Starch which has been either intentionally or unintentionally rendered water-soluble as a result of processing. The term is often used to refer to the small amount of starch which is solubilized unintentionally, e.g. by drying at excessive temperatures. High levels of chemical modification, particularly thinning and etherification, can lead to significant yield losses due to the formation of solubles.

19.11. Solution stable dextrins

A new type of dextrin characterized by very high levels of solution stability.

19.12. Sorbitol

Is produced industrially by the catalytic hydrogenation of D-glucose which has been obtained by enzymatic hydrolysis of starch. Unlike reducing sugars, sorbitol does not undergo browning reactions with amines and amino acids. Its relative sweetness compared to sucrose is between 50 and 60. It is stable to mild alkaline and acidic conditions and will not react with other ingredients in the usual food, pharmaceutical and cosmetic formulations.

19.13. Sorghum starch

Starch from various species of the genus Sorghum Persoon

19.14. Specific gravity

Related term: density.

The specific gravity of a substance is the ratio between the mass (or weight) of a given volume of the substance to the mass (or weight) of an equal volume of water at the standard temperature. Air-dry granular starches (10...20 % moisture) have a specific gravity of about

1.5. According to the SI-system of units density should be used instead of specific gravity.

19.15. Stabilization

This term is sometimes used to indicate the presence of a monofunctional chemical substituent which has the effect of stabilizing paste viscosity. These stabilized modified starches may be, for example, hydroxypropyl or carboxymethyl starch ethers or the monofunctional substituents can be phosphate or acetyl ester groups. Generally the D.S. [degree of substitution] of these starches is between 0.01 and 0.2. The substituent groups have the effect of providing steric hindrance to chain association which stabilizes viscosity by preventing possible retrogradation.

19.16. Stabilized starches

Related terms: starch esters, starch ethers, viscosity stability.

Stable starch pastes do not change appreciably in viscosity, clarity or texture with age (low rate of retrogradation). Starch may be stabilized against retrogradation by using monofunctional reagents, which react with hydroxyl groups on the starch molecules to introduce substituent groups. These substituent groups interfere with intermolecular association between dissolved amylose molecules in starch pastes and solutions (see figure 8).

Examples of stabilized starches are monostarch phosphate, starch acetate, hydroxyethyl starch, hydroxypropyl starch, cyanoethyl starch, carboxymethyl starch and cationic starch.

Generally, the degree of substitution (DS) of these starches is between 0.01 and 0.2 (an average of 1 to 20 substituent groups per 100 anhydroglucose units).

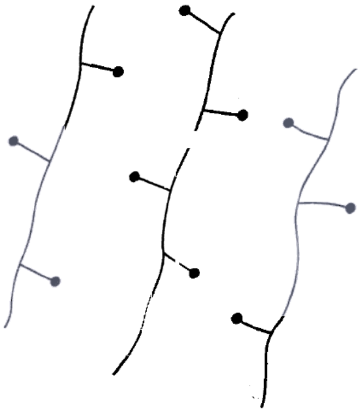


Figure 8 - Substituent groups (-•) prevent linear association of amylose molecules in pastes and films of stabilized starches (schematic).

19.17. Starch

Starch is a carbohydrate occurring in granular form in the organs of certain plants. Starch molecules are polysaccharides composed almost exclusively of anhydroglucose units.

Starches and modified starches are hydrophilic colloids. The number-average degree of polymerization (DP) of potato starch molecules is about 14,000 and of maize starch molecules about 3,000.

19.18. Starch acetate

Synonym: acetylated starch

Starch acetate is a stabilized starch in which some or all of the available hydroxyl groups of the starch molecules have been esterified by acetyl groups. The addition of acetyl groups improves filming properties and reduces gelling tendencies of the starch pastes. The preparation of starch acetates is generally done with aqueous suspensions of starch using acetic anhydride or vinyl acetate as reactants under alkaline conditions. After reaction the starch acetate is isolated by filtration, washed and dried. Commercial starch acetates are generally granular and have a DS less than 0.2.

19.19. Starch alkenyl succinate

A chemically modified starch produced by treating starch with alkenyl succinic anhydride under controlled pH conditions. Commercial alkenyl succinic anhydride is available for use in food in the octenyl form. These starches have lipophilic ("oil-loving") properties and are used in emulsions and encapsulation. Example of a commercially available product is OSA-starch, OSA is an abbreviation of octenyl succinic acid.

19.20. Starch derivatives

Starch derivatives are obtained from native starch and include the modified starches (which retained a starch character) and the starch hydrolysates (which have little resemblance to starch). Starch derivatives are obtained by physical, chemical and/or enzymatical treatment of native starch. The wide range of products offered by the starch industry comprises almost 600 different finished products. The important starch derivatives are shown in figure 9.

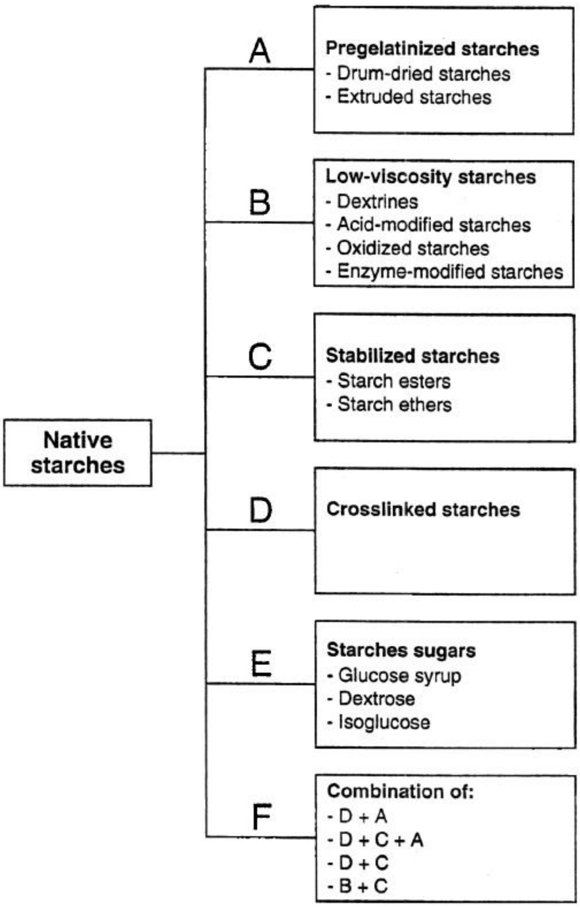


Figure 9 - Various starch derivatives from native starches

19.21. Starch ester

Synonym: esterified starch.
A starch ester is a modified starch in which some or all of the available hydroxyl groups of the starch molecules have been esterified. Examples of starch esters are monostarch phosphates and starch acetates.

19.22. Starch ether

Synonym: etherified starch
Starch ether is a modified starch in which some or all of the available hydroxyl groups of the starch molecules have been etherified. Examples of starch ethers are hydroxyethyl starch, hydroxypropyl starch, cyanoethyl starch, carboxymethyl starch and cationic starch.

19.23. Starch film

Starch films are obtained when starch pastes are spread on solid surfaces followed by drying. Most of the industrial uses of starch products involve the use of dried starch films. Starch films are employed in the manufacture of gummed papers, gummed tape, sized yarns, sized paper and adhesive bonds (to cause two surfaces to stick together). Starch films obtained from potato starch products have a higher clarity, a greater flexibility, a higher tensile strength and a higher solubility as compared to starch films obtained from maize starch products.

19.24. Starch gel

An elastic deformable mass formed from an aqueous dispersion of gelatinized starch which has gone through some degree of retrogradation.

19.25. Starch granule

Starch occurs in the form of granules in the plant cell. Starch granules have a shape that varies with the source of the starch. The granules of potato starch are oval and relatively large (diameter range 5 to 100 micrometer; number average diameter 23 micrometer). The granules of maize starch are round or polygonal and relatively small (diameter range 2...30 micrometer; number average diameter 10 micrometer).

19.26. Starch hydrolysates

Synonym: Starch hydrolysis products
Starch hydrolysates are obtained by hydrolysis of starch with acids and/or enzymes. Starch hydrolysates consist of polysaccharides, oligosaccharides, maltose, glucose and/or fructose.
Examples of starch hydrolysates are glucose syrups, isoglucose and dextrose.

19.27. Starch hydrolysis product

Generic term to describe products such as maltodextrins, glucose syrup and dextrose.

19.28. Starch octenyl succinate

Common name given to Starch n-Octenyl succinate which is made by treating starch with n-Octenyl succinic anhydride at pH 8-8.5. This starch derivative is anionic due to a carboxyl group and hydrophobic due to the C8 unsaturated alkene chain. Food uses include encapsulation of flavors and emulsion stabilization.

19.29. Starch paste

Related terms: cooked starch (paste), gelatinized starch.
Starch paste refers to the viscous mass resulting from the swelling and the colloidal dispersion of starch granules in an aqueous medium. Generally, starch pastes are mixtures of water, swollen starch granules, swollen starch granule fragments and molecularly dissolved starch molecules leached from the granules.

19.30. Starch phosphate

Starch ester in which some of the available hydroxyl groups have been esterified by monophosphate groups. Distarch phosphate is very different and refers to the crosslinked product e.g. using phosphorous oxychloride or sodium trimetaphosphate (STMP) as reagents.

19.31. Starch slurry

Aqueous suspension of unswollen starch granules also known as starch suspension and starch milk.

19.32. Starch solution

Starch solutions contain only molecularly dissolved starch molecules and have a low viscosity. Starch solutions are obtained by cooking starch suspensions at temperatures of 100 to 160 °C (dependent upon the type of starch). The cooking can be carried out in a steam jet-cooker or in an autoclave. Potato starch can be cooked to a complete dissolved state at about 100 °C. Maize starch requires a temperature of about 125 °C.**Starch succinate**
Starch ester in which some of the available hydroxyl groups have been esterified by succinate groups with or without crosslinking.

19.33. Starch suspension

Synonyms: starch slurry, starch milk.
A starch suspension is a suspension of unswollen starch granules in an aqueous liquid.

19.34. Steepwater

Liquid which has been used for soaking and softening (i.e. steeping) corn before wet milling the grain to remove the starch. At the end of the steeping cycle steepwater contains dissolved proteins, minerals, and other substances leached from the corn. Steepwater is used in the production of the wet milling by-product gluten feed which is used in animal feed.

19.35. Sterilizable starch

This refers to the very highly crosslinked starch which is used to dust latex surgical gloves to prevent adhesion. This starch must resist the high temperatures encountered when the gloves are subjected to a sterilization process.

19.36. Sweetness

The sweetness of simple sugars generally decreases with increasing molecular weight. Thus DP3 is less sweet than maltose (DP2) which in turn is less sweet than dextrose (DP1). Relative sweetness is the level of perceived sweetness compared to that of pure sucrose assessed under the same conditions.

19.37. Sweet potato starch

Starch obtained by wet milling the tuberous roots of the species Ipomoea batatas Poiret.

19.38. Swelling power

If an aqueous suspension of starch is heated above the gelatinization temperature, the starch granules undergo a progressive swelling. The pattern of this swelling will depend on the type of starch. The extent of swelling can be determined by suspending a weighed starch sample in water, heating for 30 minutes in a thermostated bath, then centrifuging the aqueous supernate and weighing the precipitate of swollen granules. The swelling power is defined as the swollen sediment weight (in gram) per gram of dry starch (corrected for solubles). The swelling power is a measure of hydration capacity. Potato starch swells enormously and give pastes which appear uniformly clear throughout. The relative low swelling power of maize starch is partly due to the presence of amylose-lipid complexes in the maize starch granules. At 90 °C, the swelling power of potato starch is 350 compared to 16 for maize starch.

19.39. Syneresis

The seepage or release of water from starch pastes or gels, particularly on storage is known as syneresis. Syneresis in food applications may be avoided by choosing a suitable chemically stabilized starch.

20 T

20.1. Tabletting starch

Corn starch has been used for years as a tabletting binder. The granules partially fuse together under the influence of the high compression forces of the tabletting machine to provide a strong tablet which is resistant to breakage but has well-defined disintegration properties after ingestion.

20.2. Tapioca starch

Synonyms: cassava starch, manioc starch

Tapioca starch is obtained by wet milling of tuberous roots of the species Manihot utilissima
Pohl (syn. Manihot esculenta Cranz).

20.3. Taste

In general, the taste of starch or modified starch for food use must be as close to neutral as possible; this is particularly critical for dairy products, e.g. yogurt. Off flavors can arise in modified starches and may be related to insufficient washing or the saponification of the naturally-occurring fatty acids in the starch granule during chemical modification.

20.4. Texture of starch pastes

Related terms: consistency, rheology, mouthfeel
Paste texture is a complex property comprising several interrelated physical parameters such as viscosity, elasticity, tackiness, smoothness, plasticity and density. The behaviour of starch pastes can be expressed according to defined rheological measurements. The gelatinized particles in a potato starch paste are far more swollen than those in a maize starch paste of comparable viscosity. Consequently, potato starch pastes are long, cohesive, tacky and fluid whereas maize starch pastes are short, heavy-bodied, pasty and salve-like. A short paste is one that breaks abruptly when allowed to flow from a stirring rod, as opposed to a long paste which forms long strings under the same conditions

20.5. Thin-boiling starch

A modified starch which gives a lower viscosity paste than unmodified starch at the same concentration in water. Also known as acid-thinned starch.

20.6. Thixotropic

A rheological term used to describe the behavior of some viscous liquids where the rate of flow increases with increasing duration of agitation or shear and with increasing shear rate. The effect is sometimes reversible, i.e., there is a gradual thickening of the material when the source of stress (shear) is removed.

20.7. Transglucosidation

This term refers to a two step process in which rupture of the a-D-1,4 glucosidic bond is immediately followed by combination of the resultant fragments with neighboring hydroxyl groups to produce new branched structures. Transglucosidation can occur in the dextrinization processes, producing dextrins with good solution stability.

20.8. Tubular heat exchanger

A continuous heat exchanger used to heat (or cool) liquid food systems where the food flows through a number of parallel tubes indirectly heated by a separate medium.

21 <u>U</u>

21.1. Undercook

A starch that has not been sufficiently heated and has underswollen granules. This can be a problem in the food industry and leads to low viscosity, a starchy taste and poor stability.

22 <u>V</u>

22.1. Viscometer

Apparatus or instrument designed for the measurement of the viscosity of fluids. Viscometers cover a very wide range of design from simple portable low shear instruments (Brookfield), sophisticated oscillatory rheometers, and high shear instruments (Haake) and the Brabender Viscoamylograph which gives a complete pasting curve of the starch.

22.2. Viscosity

Related terms: rheology, consistency.
Viscosity is a term used to indicate the resistance of liquids (fluids) to shear, agitation or flow.
Viscosity is defined as the tangential force which a fluid flowing in one plane exerts on an adjacent plane. The unit of dynamic viscosity is the Pascal second (Pa.s).
When heated in water starch produces a viscous paste. Viscosity is one of the most important properties of starch pastes and is of the highest interest to starch processing industries and to users of their products. The viscosity indicates the utility of a starch product in specific applications. Although the term viscosity finds general usage, starch pastes are non-Newtonian and a more apt description is that the pastes develop resistance to deformation. The determination of viscosity of starch pastes is problematic since the measured viscosity varies according to the rate of shear. Furthermore, measured viscosity decreases with time due to breakdown of the structure of the starch paste. In practice, starch viscosity-can only be determined in arbitrary units and viscosity data for starch pastes can only be compared by using the same set of standard conditions. The method of preparation of the starch paste, the stirring speed, the hardness of the water used, the pH, the starch concentration and the course of temperature change all affect the measured viscosity.

The rheological characterization of starch pastes is possible by means of continuous automatic recording viscosimeters, using a constant stirring speed. Several commercial types of rotating viscosimeters, such as the Brabender-viscograph, the Brookfield-viscosimeter and the Haake-Rotovisco are routinely used for viscosity measurements on starch pastes. Each starch type produces a typical viscosity curve which can be used to forecast its applicability as a thickening agent.

Units of dynamic viscosity are the following:

SI-units
1 Pascal second = 1 Pa.s = 1 kg/(m.s) = 1 N.s/m^2
1 Millipascal second= 1 mPa.s = 10^{-3}P a.s = 1 cP

Other units
1 Poise = 1 P = 0.1 Pa.s
1 Centipoise = 1 cP = 1 mPa.s = 0.01 P
1 Poiseuille = 1 Pl = 1 Pa.s

1 Brabender Unit = 1 BU = about 2 mPa.s = about 2 cP.

22.3. Vital (wheat) gluten

The water-insoluble protein extracted from wheat which, in the hydrated state, has elastic cohesive properties. The main application of vital gluten is in the bakery industry where it is used to strengthen flour so that it can be used in bread baking.

23 W

23.1. Waxy (maize) starch

Synonyms: waxy corn starch, glutinous maize starch, amioca
Waxy maize starch is obtained from a botanical variety of maize (corn). It consists nearly solely of branched amylopectin molecules. According to the starch source, the terms waxy maize starch, waxy rice starch may be used. Waxy starches are inherently more solution stable and can be chemically modified to further improve stability along with heat, acid and shear resistance.

23.2. Wheat starch

Wheat starch is obtained by wet milling of certain species of the genus Triticum Linnaeus

23.3. Water activity

The ratio of the water vapor pressure of a product to the saturation pressure of water at the same temperature. It depends on the composition, percent moisture, and the temperature. Water activity of foodstuffs is important in determining their physical structure, handling characteristics, digestibility, and shelf life.

23.4. Water binding capacity

The amount of water which an insoluble starch is able to hold in relation to its own weight.

23.5. Wet milling

The commercial multi-step process for separating corn into its component parts is known as wet milling. Starch is the main product of the wet milling process with protein (gluten), fiber, and oil as by-products.

23.6. White corn starch

Starch extracted from white corn, a special corn hybrid grown in South Africa, is remarkably white in color and is preferred for applications demanding a 'natural' whiteness, i.e. whiteness achieved without bleaching.

23.7. White dextrin

These products are produced by roasting starch at relatively low temperatures depending on high acidity (low pH) to achieve the required degree of conversion without increasing color formation.

23.8. Whiteness

The apparent whiteness of the surface of starch powder, determined by reflectance in comparison to a known standard surface. There are various methods in current use in determining whiteness.

24 X

25 Y

25.1. Yellow corn

The usual corn type used as a raw material in the corn wet milling industry.

25.2. Yellow dextrin

A type of dextrin produced by dry roasting in the presence of acid. Also know as canary dextrin. Yellow dextrins are highly converted products made at high temperature and low pH.

26 Z

26.1. Zea Mays Linnaeus

The correct term for the corn genus used as raw material for the corn wet milling industry.

26.2. Zein

A specific fraction of corn protein which is extracted, purified, and dried to a free-flowing powder.

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Agro Anatolia
Gıda Tarım
San. Ve Tic. A.ş.

Aksoy Mh. 1768 Sk.
No:22/2 Karşıyaka
İzmir/Turkey

Tel: +90 232 381 68 57

info@agrobynature.com