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Xanthan Gum - A Boon to Food Industry

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Introduction

Naturally occurring polysaccharides from seaweeds have been in use from many decades in immense quantities. Dextran, discovered in early 1940s, was the first microbial polysaccharide to be commercialized. The second microbial polysaccharide commercialized was xanthan. It was discovered in the 1950s by the US Department of the Agriculture during research work on the industrial applications of microbial biopolymers.

Xanthan is one of the most extensively investigated polysaccharides. It is high in molecular weight (1-2 million) and is produced by a pure culture fermentation of a carbohydrate by naturally occurring bacterium *Xanthomonas compestris*. It is then purified by recovery with alcohol, dried and milled. Xanthan is completely soluble in hot or cold water, hydrates quickly once dispersed and provides water binding resulting in very high viscosity solutions at low concentration. Its rheological behavior enables xanthan to contribute to good sensory qualities, including mouth-feel and flavor release in food.

Moreover, its solutions provide uniform viscosities over the temperature range freezing to near boiling with excellent thermal stability. Xanthan's excellent solubility and stability under both acidic and alkaline conditions, its stability with salts and its resistance to common enzymes, it has become one of the top industrial and food polymers.

Chemistry and Structure of Xanthan Gum

The primary structure of xanthan consists of repeating pentasaccharide units consisting of two D-glucopyranosyl units, two D-mannopyranosyl units and one D-glucopyranosyluronic

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acid (Fig. 1). The polymer backbone is made up of (1→4)-linked β-D-glucopyranosyl units, is identical to that of cellulose. To alternate D-glucosyl units at the *O*-3 position, a trisaccharide side chain containing a D-glucuronosyl unit between two D-mannosyl units is attached. The terminal β-D-mannopyranosyl unit is glycosidically linked to the *O*-4 position of the β-D-glucopyranosyluronic acid unit, which in turn is glycosidically linked to the *O*-2 position of a α-D-mannopyranosyl unit. Approximately one-half of the terminal D-mannosyl units contain a pyruvic acid moiety as a 4, 6-cyclic acetal. Finally, the nonterminal D-mannosyl unit is stoichiometrically substituted at *O*-6 with an acetyl group.

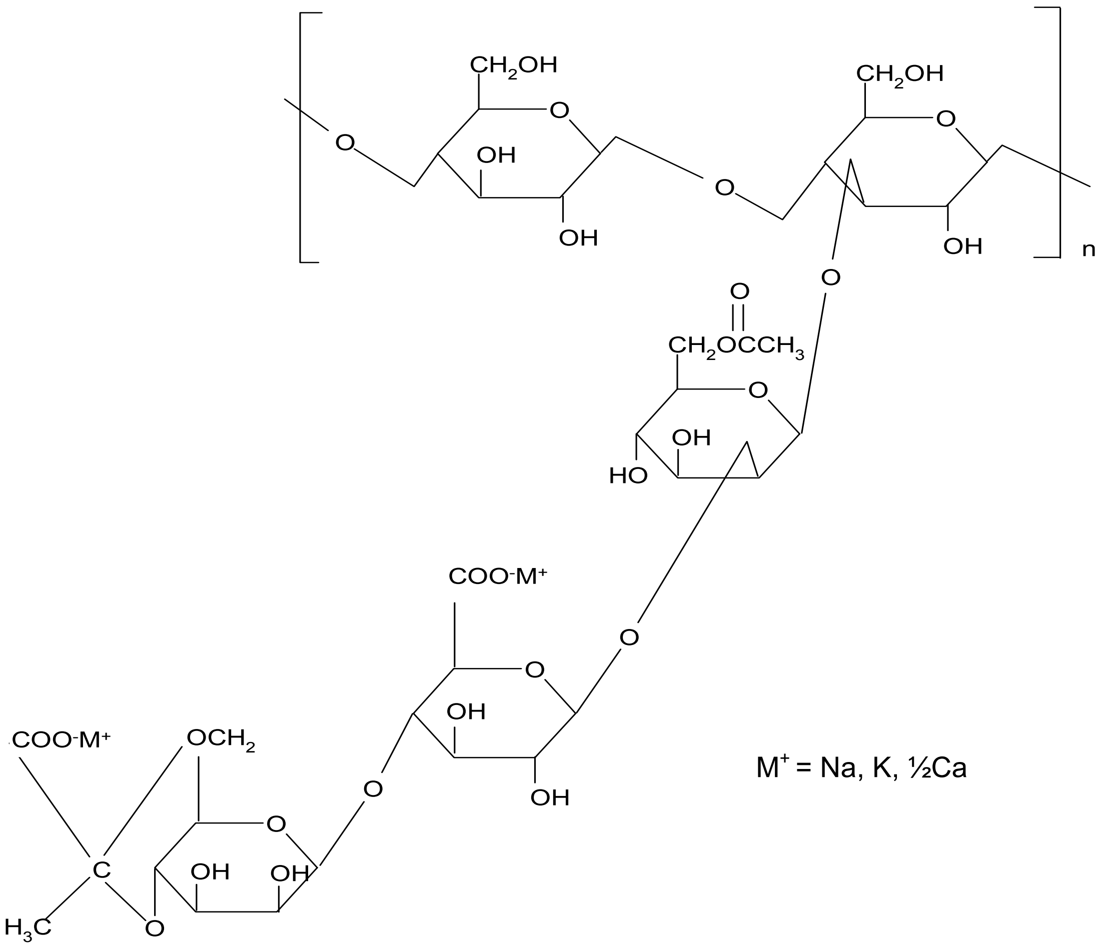

Figure 1. Structure of Xanthan Gum

Toxicology, Safety and Regulatory Status

Lots of investigations have been done on rats and dogs with respect to the safety of xanthan. On the basis of these studies xanthan was cleared by the US Food and Drug Administration (FDA) in 1969, permitting use of xanthan in food products without any specific quantity limitations. FDA regulations permit addition of xanthan to many standardized foods such as cheese, cheese products, milk and cream products, dressings, table syrups etc. The USDA regulations permit its use in sauces, gravies and breadings used with meat and poultry products.

The Canadian Governor-in-Council has also approved general use of xanthan in food. Xanthan is on Annex-I of the European Economic Community emulsifier/stabilizer list as item E-415. The Joint Expert Committee of the Food and Agriculture Organization/World Health Organization of the United Nations (FAO/WHO) have issued an acceptable daily intake (ADI) for xanthan. In addition, many other countries have approved xanthan for various food uses.

Properties of Xanthan Gum

Xanthan is a white to cream colored free flowing powder soluble in both hot and cold water to give viscous solutions at low concentrations. Its industrial importance is based upon its ability to control the rheology of water based systems. Even at low concentrations xanthan gum solutions show a high viscosity in comparison with other polysaccharide solutions. This property makes it a very effective thickener and stabilizer.

Xanthan gum solutions are highly Pseudoplastic i.e. even after high shear rates the initial viscosity is rebuilt immediately. No hysteresis is evident, i.e., shear thinning and recovery are instantaneous. This pseudoplasticity enhances sensory qualities (mouth feel, flavor release etc.) in final products and guarantees high degree mix-, pump- and pourability.

Xanthan gum solutions are very resistant to pH variations, i.e. they are stable in both alkaline and acidic conditions. Between pH 1 to 13, the viscosity of xanthan solution is practically constant. At pH 9 or above, xanthan is gradually deacetylated, but this has little effect on its solution properties.

The viscosity of aqueous solution of xanthan is nearly independent of temperature over a wide range. The viscosity of a xanthan solution is virtually unaffected by temperatures from freezing point to boiling point of pure water. Thus the rheological properties of the final products remain stable irrespective of being kept in a refrigerator, stored at room temperature of heated.

The effects of electrolytes on xanthan solutions are dependent upon gum concentration. Below a gum concentration of 0.15%, the addition of an electrolyte (NaCl) reduces viscosity slightly, whereas at higher gum concentrations, the electrolyte has the opposite effect. Peak viscosity is achieved at a concentration of 0.02-0.07% NaCl, beyond this level, additional salt has negligible effect on viscosity. Magnesium and calcium salts have a similar influence on viscosity. Only at high pH levels (pH>10) xanthan gum tends to form gels in the presence of divalent cations. Trivalent cations like aluminium or iron form gels at acid or neutral pH levels. Gelling may be prevented by high levels of monovalent metal salts.

Xanthan gum is compatible with various materials; it may be dissolves directly in many highly acidic, alkaline, alcoholic systems and various systems containing different components (Table 1). Xanthan is also compatible with most commercially available thickeners such as sodium alginate, carboxymethyl cellulose and starch.

Table 1. Compatibilities of xanthan gum

Material	Material (%)	Xanthan* (%)	Viscosity (cps)**	
			Initial	After 90 days
Acetic acid	10.0 / 20.0	2.0 / 2.0	4200 / 4300	4050 / 4400
Citric acid	10.0 / 20.0	1.0 / 1.0	1200 / 1400	900 / 1030
Hydrochloric acid	5.0 / 10.0	2.0 / 2.0	3400 / 3500	2750/ 1250
Phosphoric acid	30.0 / 40.0	2.0 / 2.0	4850 / 5600	5250 / 7000
Sulfuric acid	5.0 / 10.0	2.0 / 2.0	3610 / 3800	3150 / 3100
Tartaric acid	10.0 / 20.0	1.0 / 1.0	1210 / 1400	900 / 1010
Diammonium phosphate	5.0 / 10.0	1.0 / 1.0	1100 / 1190	1100 / 1230
Calcium chloride	10.0/ 20.0	1.0 / 1.0	1260 / 1580	1300 / 1600
Ferrous sulfate	5.0 / 15.0	1.0 / 1.0	1410 / 1600	300 / gel
Potassium chloride	5.0 / 15.0	1.0 / 1.0	1240 / 1200	1200 / 1115
Sodium chloride	5.0 / 15.0	1.0 / 1.0	1110 / 1330	1090 / 1200
Sodium citrate	5.0 / 15.0	1.0 / 1.0	1240 / 1390	1170 / 1240
Sodium hydroxide	5.0 / 10.0	1.0 / 1.0	1360 / 1390	810 / 115
Sodium sulfate	5.0 / 15.0	1.0 / 1.0	1070 / 1460	1100 / 1550

**Xanthan gum preserved with 0.1% formaldehyde; 1.0% viscosity (initial= 860 cps, after 90 days= 990 cps); 2.0% viscosity (initial= 2350 cps, after 90 days= 2500 cps).*

***Brookefield model LVF viscometer at 60 rpm, appropriate spindle.*

Xanthan interacts with galactomannans such as guar and locust bean gums (LBG) giving a synergistic increase in solution viscosity i.e. the observed viscosity is higher than the sum of viscosities of either gum alone. In the case of LBG, a large synergistic viscosity increase is observed at low gum concentrations and as the concentration of gum is increased, a heat reversible gel is formed. This synergistic property facilitates the use of xanthan gum in many applications such as ice creams, pasteurized process cheese dips & spreads as well as a variety of frozen desserts.

Xanthan gum is resistant to enzymatic degradation by different enzymes such as protease, cellulose, hemicellulase, pectinase and amylase. However, xanthan is completely biodegradable i.e. it is subject to depolymerization by enzymes formed by certain microorganisms under certain environmental conditions. Also in common with other gums, xanthan is degraded by strong oxidizing agents like peroxides and persulfates.

Due to the extraordinary properties xanthan gum is used in the food, cosmetic and pharmaceutical industry. In all these areas xanthan gum is accepted as an excellent stabilizer, thickener and a useful processing aid.

Xanthan Gum in Food Applications

The major food applications of xanthan gum stem from the fact that when it is dispersed either in hot or cold water, the resultant aqueous dispersions are thixotropic. The weak gel like structure formed results in an unusually high "low shear rate viscosity" at low polymer concentrations, which can be used to thicken aqueous samples and permits stabilization of emulsions, foams and particulate suspensions. Finally, the reversible shear thinning behavior allows manipulation and control of processes such as spreading, pumping, pouring and spraying.

Bakery Products- In the bakery industry xanthan gum is used to increase water binding during baking and storage and extends the shelf life of baked goods and refrigerated doughs. In soft baked goods xanthan gum can also be used as an egg replacer, in particular the egg-white content can be reduced without affecting appearance and taste. Xanthan inhibits syneresis and prevents the filling from being absorbed by the pastry. In baking goods and refrigerated dough, it increases moisture retention and inhibits retrogradation thus extending shelf life.

Beverages- Xanthan is used as bodying agent in beverages and squashes. When these drinks contain particles of fruit pulp, inclusion of xanthan helps in maintaining the suspension, resulting in good product appearance. Xanthan contributes to pleasing mouth-feel, rapid and complete solubility at low pH with excellent suspension of insolubles and compatibility with most components.

Dairy- Xanthan blends with guar, LBG or both which can be effective stabilizer for ice cream, ice milk, sherbet, milk shakes and water ices. Xanthan with methyl-carboxymethyl cellulose works for frozen dairy and with carboxymethyl cellulose for directly acidified yogurts. Similar blends are used for dessert puddings, acidified milk gels, and others. The Xanthan, guar and LBG blend is vital to sliceability, firm body and flavor release of cream cheese. Also, xanthan works with wheat flour and soy flour as a matrix for spices and flavoring. Xanthan thickens cottage cheese dressings by providing good drainage control. Xanthan improves consistency, body and syneresis in sour cream.

Dressings- Sauces and salad dressings accompany almost every meal and grant it that "personal touch". Xanthan provides stability to the emulsion for periods up to 1 year. Because of the imparted rheological properties, the dressings can be easily pumped during the filling operation, helps in easy flow from the bottle during use and they cling well to a salad. Xanthan is widely used in pourable salad dressings, (alone or in combination with propylene glycol alginate or pectin) imparting the clean mouth-feel due to its high pseudoplasticity that also helps keep the dressing on top of the salad.

Pet Food- Xanthan, along with LBG or guar produces a homogeneous gelled product (for blood chunks or semi-moist pet foods. In liquid milk replacers for calves and piglets xanthan gum is used to stabilize the suspension of insoluble substances. Xanthan is often used in combination with LBG and guar gum as stabilizer and binder in the formulation of canned gravy based pet food.

Syrups, Toppings, Relishes and Sauces- The outstanding solution properties of xanthan are utilized in syrups, toppings, relishes and sauces. Buttered syrups and chocolate toppings containing xanthan have excellent consistency and flow properties and because of their high at-rest viscosities, appear thick and appetizing on products such as pancakes, ice cream and cooked meats. Xanthan is an ideal thickener for these products because of its high acid stability and the pseudoplastic flow properties it imparts. High at-rest viscosity ensures that the tendency for the relish and sauce to soak into the buns is minimized, providing the consumer with a more attractive food item.

Table 2. Maximum usages level of xanthan gum in various food products

Food Category	**Maximum Level**
Buttermilk (plain)	3000 mg/kg
Fermented milks (plain), heat-treated after fermentation	5000 mg/kg
Pasteurized cream	GMP
Sterilized, UHT, whipping or whipped, and reduced fat creams	5000 mg/kg
Butter and concentrated butter	5000 mg/kg
Pre-cooked or dried pastas and noodles and like products	4000 mg/kg
Frozen fish, fish fillets, and fish products, including mollusks, crustaceans, and echinoderms	5000 mg/kg
Frozen battered fish, fish fillets, and fish products, including mollusks, crustaceans, and echinoderms	GMP
Liquid egg products	GMP
Frozen egg products	GMP
Other sugars and syrups (e.g., brown sugar, maple syrup)	5000 mg/kg
Weaning foods for infants and growing children	20000 mg/kg
Canned or bottled (pasteurized) fruit juice	5000 mg/kg
Canned or bottled (pasteurized) fruit nectar	3000 mg/kg

Source: www.fao.org

Suggested Readings

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