Research Paper

Volume : 4 | Issue : 8 | Aug 2015 • ISSN No 2277 - 8179

Sustainable Production of Microbial Polysaccharide Xanthan Gum From Supplemental Subststrate.

Engineering

KEYWORDS : Xanthan gum; white biotechnology; substrate; starch; glucose

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ABSTRACT

There are several pathways to produce bio-based chemicals and polymers. The pathways that are most important in terms of production volumes today and in the medium-term future are white biotechnology (industrial biotechnology) and the use of natural polymer (in particular xanthan gum, cellulose and starch).Increasing market price and demand suggest that glucose may no longer economics for the raw material, while using batch process may also limit the capacity. It is therefore the purpose of this review to investigate alternative to economically produce xanthan gum. The various researches studied that most supplemental substrate are best sole of carbon source. The scenario review shows properties of xanthan, various aspects of xanthan production including the various strains used for the production and various supplemental substrates used as alternate source of glucose. Substrate used for the production of xanthan were agro-industry or by products including spent malt grains, apple pomace, grape pomace citrus peels, which can be obtained at a very low cost. Also cheese whey hydrolyzed rice, barely, corn flour, and sugarcane molasses, Sugar beet molasses, olive mill wastewater etc.which causes several drawbacks on environment, when it is directly disposed in the environment. Utilization of these streams for the xanthan production increases economy of the process.With most substrate, xanthan yields were comparable to those obtained from conventional submerged cultivation. The basic characteristics of the process were studied on various supplemental substrate prepared with a solution of nutrients.

1.0 Introduction:

Xanthan gum is complex exopolysaccharides produced by the yellow pigmented gram –ve bacterium xanthomonas campestis [1-2]. Xanthan is composed of pentasaccharide repeated units containing d-glucose, d-mannose, D-glucoronic acid [at a ratio 2:2:1] acetal linked pyruvic acid and d-acetyl groups [1]. Operational conditions include an adequate medium containing different nutrients, a temperature of 28^0 C pH 7 and adequate aeration [3]. Xanthan is a biopolymer with a high molecular weight between $2x10^6$ and 20 X 10^6 da.the polysaccharide has a relatively high solubility in water ,and the size of the molecules has a relatively high solubility in water ,and the size of the molecules and their interactions provide a very high viscosity to aqueous solution.[3].xanthan gum was discovered in 1950's at the northern regional research laboratories (NRRL) of the united states department of agriculture [4].extensive research was carried out in several industrial laboratories during 1960's culminating in semi commercial production as kalzen by Kelco. Substantial commercial production began in early 1964s [4].garcia-ochoa F. in 2000 reported that the major producers of xanthan are Merck and Pfizer the united states, hone Poulenc and sanofi- EIF in france,and jungbunzlauer in Austria. Currently the worldwide consumption of xanthan gum is approximately 23 million kg/y approximately 5 million kg/y are used as a drillings fluid viscosity in the oil industry. Xanthan gum consumption in the United States has an estimated annual growth rate between 5 and 10%. the petrochemical industry uses other plant derived polysaccharide and synthetic polymers. Instead of xanthan gum based on the relative costs of xanthan gum to the other polymers. In the United States, the only commercially available xanthan gum is food grade [5].Commercially available of xanthan gum is relatively expensive due to glucose or sucrose being used as sole carbon source and very stringent purity standards of the food and drug Administration for foods. For food grade xanthan gum,upto 50% of the production costs are related to downstream purification steps, may of which would not be necessary for non-food application. Several researches have investigated using less expensive carbon sources to produce xanthan gum [2,5-9].For the efficient production of xanthan gum, xanthomonas campestis needs several nutrients, including micronutrients (eg.potassium iron and calcium salts)and macronutrients such as carbon and nitrogen. glucose and sucrose are the most frequently used carbon sources[9].Psomas,s.k.,et.al.,in 2007 reported that production and properties of of xanthan gum are influenced by bacterial strain, culture medium ,substrate composition, temperature ,pH time of fermentation, agitation rate, impeller type,oxygenation.xanthan gum is major commercial biopolymer having worldwide production 30,000tons of market price costs $408million.Due to its unique structure xanthan displays special pseudoplastic properties high viscosity and solubility, enhanced stability[8].The viscosity of the solutions is stable over wide range of salt concentrations (up to 150 g/l NaCl),temperature (up to 90^0 C), pH(2-11).These solutions characteristics of xanthan gives rise to functional properties such as thickening and stabilizing ability, which are used in diverse range of applications[11]. xanthan having high viscosity yield at lower shear rates, shear thinning ability are particularly important during and after many industrial application[12].Sharp increase in viscosity (about hundred fold) when the pyruvate content increased above 3.0% by wt.[13].The use of carbon to nitrogen ratios in the defined medium resulted in a major increase in the broth consistency index. Maximum production was achieved in nitrogen limitations, at a carbon to nitrogen ratios of 23.Mineral sources such as $CaCO_3$and KH_2PO_4 proved to be important factors influencing polysaccharide production and quality. A maximum concentrations of 11.15 g/l of xanthan gum was obtained during the optimization of defined medium , an increase of xanthan gum production was accompanied by a decrease of exocellular protein[14].The pentasaccharide repeating units is assembled on an iosprenoid lipid carrier by sequential addition of individual sugar residue that are denoted by sugar nucleotide diphosphate precursors. Each sugar addition is catalyzed by a specific glycosyltransferase enzyme. The mannose residue of the repeating units are specifically acetylated and pyruylates.the repeating unit is polymerized, and the polymer is subsequently secreted [15].xanthan gum mixture shows a synergistic behavior, increasing the viscosity and forming gels. Xanthan molecular structure affects to xanthan/galactomannose mixture solution viscosity. Stronger interaction between galactomannose and xanthan gum was observed in mixtures containing deacetlated or native xanthan than in those containing depyruvated xanthan. Xanthan fermentations by xanthomonas campestis is well studied with respect to aeration effects on growth and production as well as,

the rheological characteristics of the fermentations broths[17].

2.0 Growth Rate of Xanthan Gum.

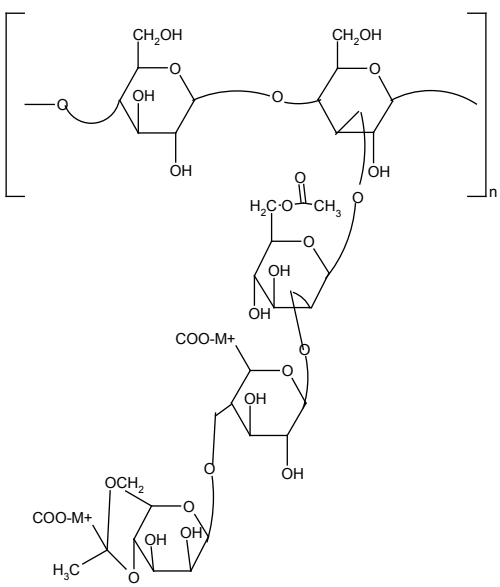
Annual Average Growth Rate			
Polysaccharide	Food	Petroleum Industry	Cosmetics
Starches	2.5	1.5	~
CMC	3.5	0.5	3
MC	3.5	~	3.7
HEC	~	0.5	~
HPG	~	1.5	~
Xanthan	8.3	2	5.9
Pectin	5.2	~	~

CMC: Carboxymethyl Cellulose MC: Methyl Cellulose

HEC: Hydroxyethyl Cellulose
HPG: Hydroxypropyl Guar

3.0 Chemical Structure

Xanthan gum is natural biopolymer is repeated unit of five sugars and varying amount of acetate and pyruvate i.e. two-D-Glucose, Two-D-Mannose, One-D-Glucornate.Molecular formula- $C_{32.34}H_{48.58}0_{27.36}Na_{1.38}$ [12].



M+= Na, K, 1/2Ca

Fig: 1: Chemical structure of Xanthan Gum

4.0 Growth Medium

All the Media Used for Xanthomonas Campestris growth are complex media. The most commonly used are the YM Medium[4].Cultivations on agar medium surface will be performed using 100 mm Petri dishes filled with 25 ml of 2% agar medium incubated in a water saturated atmosphere at 30 0 c for either 4 or 8 hours.[6].

4.1 Growth Temperature

Xanthomonas Campestris has been cultured at different temperatures ranging from 25 to 30° c [12-14]. Several authors studied the influence of temperature on growth in the temperature range of 22-35°c; 28°c is the optimal growth temperature in the media used[10-11].

5.0 Analytical methods

4.2 Xanthan production by xanthomonas Campestris by different supplemental substrate

Author	Substrate	Substrate Composition (g)	Xanthan gum yield (g/l)
Stredansky M.,et.al.,[6]	Apple pomace	1000	281
Stredansky M.,et.al.,[6]	Grape pomace	--	10
Garcia-ocha et.al.,[4]	glucose	--	75
Yoo S.D., et.al.,[5]	waste sugar beet pulp	2.29	0.88
Lopez M.J., et.al.,[7]	olive mill wastewater	20	07
Kalogiannis s., et.al., [24]	sugar beet molasses	175	53
Kalogiannis s., et.al., [24]	sugar cane molasses	25 %	70.5
Kurbanoglu E.B., et.al.,[25]	Ram horn hydrolysate	03 %	25
Ashraf S., et.al., [2]	whey	--	10
Silva M.F., et.al., [9]	cheese whey	--	25

6.0 Chemistry of xanthan gum

Xanthan gum is a complex microbial exo-polysaccharide industrially produced from glucose via fermentation by the plant–pathogenic bacterium,Xanthmonas pv. campestris. The molecular weight of xanthan gum is approximately 2 million but it can go as high as 13–50 million. As shown in**"FIG.1"** xanthan gum consists of d-glucosyl, d-mannosyl, and d-glucuronyl acid residues in a molar ratio of 2:2:1 and variable proportions of *O*-acetyl and pyruvyl residues. Xanthan gum is an acidic polymer made up of pentasaccharide subunits, forming a cellulose backbone with trisaccharide side-chains composed of mannose (β1,4) glucuronic acid (β1,2) mannose attached to alternate glucose residues in the backbone by α-1,3 linkages. On approximately half of the terminal mannose residues is a ketal linkage joined by a pyruvic acid moiety. Acetyl groups are often present as 6-*O* substituents on the internal mannose residues. Some external mannoses contain a second 6-*O*-acetyl substituent . [18].

7.0 Conclusion

Many attempts have been reported for optimizing variables of the xanthan gum fermentation i.e. nutrient composition and feeding technique, temperature, pH, agitation, adding antifoam, use of immobilized-cell cultures, recombinant DNA for the production of xanthan gum. All shows some improvement in the area studied. Other substrates were also tested and but glucose is still the best in term of the product yield, supply, and the product quality. Most of the previous works are not attempted to give a huse impact on the price of xanthan gum but more on the fine tunings on the particular areas studied, conclusion is that it initiate a new strategy on the xanthan gum processing technology that could improve the quality, increase the productivity and also reduce the cost. Most of the works are carried out to recover xanthan from highly viscous broth on which 50% of the total cost of production is utilized. But up to 80 % of the cost of recovery and energy is reduced.

8.0 Future scope

Study hydrodynamic and mass transfer in fermentation with rheologically complex culture medium. The determination of media nutrient in order to reach high product yields at low cost. Attainment of optimal conditions for production is a time- consuming task with many variable. it is possible to undertake a rational study by using adequate experimental statistical designs which avoids a great amount of tedious work by reducing the number of experiments and broadening the range of informa-

Volume : 4 | Issue : 8 | Aug 2015 • ISSN No 2277 - 8179

tion about the system. Xanthan gum currently dominates the microbial gum market, which is growing at between 6 and 7 % per year. It has been suggested that global production exceeds 50000 tons per year. The world wide xanthan market is valued between $600 and $800 millions per year. Development and improvement of xanthan production, membrane processes have been increasingly used for concentrating of high viscous broth .the axial-flow hollow fibre cell culture bioreactors, fibrous- bed bioreactors for continuous production ,ceramic membrane reactor possibly help in development of the continuous xanthan gum production.

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