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UTILIZATION OF SOME INDUSTRIAL WASTES AND RAW MATERIALS FOR HIGHLY XANTHAN GUM PRODUCTION BY *Xanthomonas campestris*

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ABSTRACT

Xanthan gum is a biopolymer heteropolysaccharide used in wide variety of foods / feed and other applications such as pharmaceuticals, cosmetic, petroleum production and other industries. Therefore, this study was aimed to produce highest amount of xanthan by *Xanthomonas campestris* grown on some industrial wastes and the results are summarized as follow: xanthan gum was maximized on the fourth day of fermentation with Garcia – Ochoa's medium supplemented with 3% sucrose + 5% corn steep liquor, which they stimulated the production of xanthan by tested organism. The addition of molasses such as sugar cane or beet as well as sugar cane juice and whey to the fermentation medium reduced greatly the production of xanthan, but the addition of whey plus whey hydrolyzed enzyme and sucrose to Garcia – Ochoa's medium enhanced the production of xanthan. Potato starchy waste reduced the production of xanthan with much more amount, but xanthan production was enhanced greatly with the addition of glucose syrup to the production media. Also, glucose syrup at 0.6% plus potato starchy waste (3%) gave over production of xanthan by *Xanthomonas campestris*. This means that, some available low price industrial wastes and raw materials may be used for highest production of an important product from microbes such as xanthan gum.

Keywords: Xanthan gum, Production, Viscosity, *Xanthomonas campestris*, industrial wastes, raw materials

INTRODUCTION

Xanthan gum is a natural polysaccharide and an important industrial biopolymer. Due to its excellent rheological properties, xanthan gum has wide application in food (as a thickening, suspending and stabilizing agent), pharmaceutical and oil recovery industrials (an emulsifier, lubricant and thickening or mobility – control agent) (Hashimoto *et al.,* 1998; Abdelhady *et al*., 2000; Garcia – Ochoa *et al*., 2000). Xanthan gum is a heteropolysaccharide produced by the plant pathogenic bacterium *Xanthomonas campestris* which is a primary structure consisting of repeated pentasaccahride units formed by two glucose units, two mannose units and one glucuronic acid unit, in the molar ratio 2.8 : 2.0 : 2.0. Its main chain consists of â – D glucose units linked at the 1 and 4 positions. The chemical structure of the main chain is identical to that of cellulose. Trisaccharide side chains contain a D – glucuronic acid unit between two D – mannose units linked at the O – 3 position of every other glucose residue in the main chain, which interacts with other polymer molecules to form a complex of xanthan. The molecular weigh of xanthan gum ranges from 2×10^6 to 20×10^6 Da. (Andrew, 1997; Hashimoto *et al.,* 1998; Liakopoulou – Kyriakides *et al*., 1999 and Garcia – Ochoa *et al*., 2000).

Xanthan gum is a microbial polysaccharide commercially produced by fermentation with *Xanthomonas campestris,* which, they are Gram – negative and obligate aerobes bacterium that produces xanthan gum, a water – soluble extracellular polysaccharide. Many investigators studied the effect of nutritional requirements and environmental factors on the production of xanthan by *X. campestris* (Garcia – Ochoa *et al*., 1992; Molina *et al*., 1993; Lee *et al*., 1996; Garcia – Ochoa *et al*., 2000 and Ramadan *et al*., 2000).

From the above excellent rheological properties of xanthan gum, the present work was carried out for highly production of xanthan gum by *Xanthomonas campestris* using some available low price industrial wastes and raw materials as a trial to reduce the production costs of xanthan gum.

MATERIALS AND METHODS

Bacterial strain:

Xanthomonas campestris was kindly obtained from Dept. of plant pathology, Fac. Agric., Mansoura Univ., Mansoura, Egypt. The organism was subcultured on YM agar slants (Roseiro *et al*., 1992), maintained at 4ïC after incubation at 28°C for 48 hrs and transferred every week to keep cells young for inoculation and highly xanthan gum production.

Media used:

YM medium (Roseiro *et al*., 1992) was used for propagation and culture maintenance of *Xanthomonas campestris*. It consists of yeast extract, 3.0; malt extract, 3.0, peptone, 5.0, glucose, 10.0, and agar 20 g L^{-1} tap water.

Garcia – Ochoa's medium (Garcia – Ochoa *et al*., 1992) was used as basal medium for xanthan gum production by *Xanthomonas campestris* after replacement of its carbon or nitrogen source with suitable raw material. It consists of (g): sucrose, 20; citric acid, 2.1; NH_4NO_3, 1.144; KH_2PO_4, 2.866; $MgCl_2$, 0.507; Na_2SO_4, 0.089; H_3PO_4, 0.006; ZnO, 0.006; $FeCl_2.H_2O_2$, 0.0024; $CaCO_3$, 0.02; distilled water, 1000 ml with pH adjusted to 7.0.

Inocula preparation:

Standard inoculum was prepared by inoculation of 250 ml conical flasks containing 50 ml of YM medium with a loop of the tested culture. The inoculated flasks were incubated on a rotary shaker (200 rpm) for 24 hours at 28ïC. The content of this flask was used for preparation of standard inocula (1 ml contained approximately 4.0 – 5.0 × 10^5 viable cells) for shake flasks experiments (Abdelhady *et al.,* 2000).

Raw materials:

Some local materials were used for xanthan production by *Xanthomonas campestris*. These materials were obtained from different sources as follows: 1- corn steep liquor (CSL) and glucose syrup were supplied as concentrated liquor (48%) from Egyptian Co. for production of starch and glucose, Torra, Cairo, Egypt. 2- Sugar – cane molasses and Sugar – cane juice were obtained from local market, Mansoura, Egypt. 3- Sweet whey was obtained from Dairy Dept., Fac. Agric. Mansoura Univ.

Mansoura, Egypt. 4- Potato starchy waste was obtained from Farm frites factory at 10th Ramadan city, Egypt.

Sweet whey was hydrolyzed by â – galactosidase (20 units) according to the method of Stauffer and Leeder (1978). â – galactosidase enzyme was produced according to the method reported by Shady *et al*. (1997).

For acidic hydrolyzation of whey, concentrated H_2SO_4 was added to one liter of the sweet dairy whey to make a 0.1N and then autoclaved at 121°C for 20 min and centrifuged for 10 min at 2000 rpm to clarify (Abdelhady *et al*., 2000).

Xanthan production:

In this experiments corn steep liquor (CSL) was used as nitrogen source whereas other materials were used as carbon source at 2% total sugar. Different concentrations of effective raw materials (as CSL, potato starchy waste and glucose syrup) on xanthan production were also studied. The combination of some raw materials such as potato starchy waste and glucose syrup was carried out to enhance the production of xanthan.

Fermentation was carried out in 250 ml Erlenmeyer flasks, each containing 100 ml of Garcia – Ochoa's medium which inoculated with 1 ml inoculum. The flasks were then incubated at 28ïC for 6 days as reported by Ramadan *et al*. (2000) using rotary shaker (200 rpm). Samples (10 ml) were taken from the growing culture periodically every 24 hr. and till the end of incubation period under aseptic conditions to determine the optical density (at 420 nm) of growth, culture viscosity and pH value. Viscosity of cultures was determined by Ostwald viscometer. The relative viscosity (to water) of the sample solution was calculated from the following equation:

$ç/ç_o = ð t / ð_o t_o$

Where: ç = coefficient of viscosity of the sample solution.

$ç_o$ = coefficient of viscosity of water.

ð = Density of sample solution.

$ð_o$ = Density of water.

t = time of flow in seconds of the sample solution.

t_o = time of flow in seconds of water.

The specific viscosity can be derived from the relative viscosity according to the following: $ç_{sp} = ç - ç_o/ç_o$ (saber, 1999).

Chemical determinations:

Total sugar and total nitrogen were determined in different raw materials according to the method of Flood & Preistly, (1973); and Jackson (1973), respectively.

Xanthan in culture fluid was precipitated, purified and determined as dry weight according to method of Cadmus *et al*. (1978).

Protein determination:

Protein was determined according to the method of Lowry *et al*. (1951), using bovine serum albumin as a standard.

RESULTS AND DISCUSSION

I. Effect of some nutritional and environmental factors on xanthan production

I. 1- Effect of fermentation period on xanthan production:

Xanthomonas campestris has been cultured for different time (1- to 6 day). The results in Table (1) shows that, the culture fluid turned be viscous after two days of fermentation. Thus, these results gave good evidence that the tested organism produces slime material, and xanthan gum started to accumulate by approximately 48 h and reached its maximum amount after 4 days which, thereafter decreased gradually. At the same time, the increasing of incubation period led to gradual increase in net biomass dry weight for the tested organism. The highest net biomass being 4.30 mg/ml was recorded after 4 days.

Table (1): Effect of fermentation period on xanthan production by *Xanthomonas campestris.*

Fermentation period (day)	Final pH	Protein (mg/ml)	Cell dry mass (mg/ml)	Viscosity	Xanthan dry mass (mg/ml)
1	7.02	0.50	0.29	0.06	0.00
2	7.25	0.55	2.31	90.08	8.90
3	7.10	0.75	3.39	120.15	17.50
4	7.05	0.92	4.30	135.28	25.90
5	6.90	0.85	2.59	117.16	24.00
6	6.75	0.45	2.35	100.15	21.30

Slight increase in pH values was noticed during the first and second day of fermentation, and then gradually decreased to reach the minimum value at the end of incubation period. The results also show that cell protein increased from 0.5 mg/ml in the first day to 0.92 mg/ml in the fourth day, thereafter, it decreased gradually to 0.45 mg/ml at the end of fermentation period. These results and observations are similar to those reported by Lin & Tseng (1979), Saber (1999), and Ramadan *et al*. (2000).

I. 2- Effect of carbon sources:

Various sugars were added separately to the fermentation medium (Garcia – Ochoa's medium) to study their effect on xanthan production. The results in Table (2) showed that, the production of xanthan by *Xanthomonas campestris* is greatly influenced by the type of carbon source.

Sucrose and glucose were enhanced and stimulated the highest production of xanthan, but, sucrose is the highest inducer one. Other sugars reduced xanthan production especially lactose. This is due to the low level of â – galactosidase present in *Xanthomonas*. Consequently, the bacterium grows poorly and produces little amount of xanthan in a medium containing lactose as the sole carbon source (Fu and Tseng, 1990). This means that sucrose was the best carbon source, which supported xanthan production. This is may be due to its dissimilate via glycolysis and form sugar nucleotides

readily and naturally support good growth as well as high yield of xanthan or any other polysaccharides (Lin and Tseng, 1979).

Table (2): Effect of various carbon sources on xanthan production.

Carbon source	Final pH	Protein (mg/ml)	Cell dry mass (mg/ml)	Viscosity	Xanthan dry mass (mg/ml)
Sucrose	7.05	0.92	4.30	135.50	26.0
Glucose	6.90	0.65	3.10	127.90	24.6
Mannose	7.05	0.55	2.60	0.95	3.80
Galactose	6.95	0.63	3.05	1.15	5.90
Fructose	6.65	0.52	2.45	82.90	16.50
Xylose	6.05	0.85	4.02	0.44	3.30
Lactose	6.50	0.45	2.20	0.20	1.20
Glycerol	7.40	0.21	0.95	0.98	3.50

I. 3- Effect of different sucrose concentrations on xanthan production:

The results (Table 3) showed that different concentrations of sucrose influenced greatly the growth and exopolysaccharide (EPS) synthesis (xanthan production). Increasing sucrose concentration up to 3 % caused an increment of both bacterial growth and xanthan production, which, the maximal production of xanthan was noticed at 3 % sucrose concentration. Above this concentration, reduction of xanthan synthesis was recorded. These results are in line with those reported by Rajeshwari *et al.,* (1995), who reported that lower concentration of sugar gave better overall results of xanthan production, compared to that with high sugar concentration.

Table (3): Effect of different concentrations of sucrose on xanthan production.

Sucrose (%)	Final pH	Protein (mg/ml)	Cell dry mass (mg/ml)	Viscosity	Xanthan dry mass (mg/ml)
1	7.10	0.70	3.85	61.20	16.55
2	7.05	0.92	4.32	135.60	26.05
3	6.95	0.97	4.95	163.40	30.35
4	6.94	0.95	4.35	149.50	29.45
5	6.94	0.95	4.35	115.60	27.92
6	6.99	0.96	4.30	107.30	25.90
7	6.99	0.98	4.25	93.50	22.91
8	6.99	0.93	4.25	87.80	20.70
9	6.99	0.91	4.20	69.06	17.13
10	6.99	0.85	4.15	53.81	15.50

I. 4- Effect of corn steep Liquor:

Corn steep Liquor (CSL) is a by product produced during the manufacture of starch and other corn products. It is a good nitrogen source for xanthan formation. But, at higher concentration inhibited the production of xanthan, because carbon and nitrogen sources were consumed for growth, resulting in lower xanthan production (Rajeshwari *et al*., 1995). It was added

to Garcia – Ochoa's medium or some of its ingredients in order to select the best treatment for xanthan production by *X. campestris*.

The results (Table, 4) showed that the addition of CSL (2%) to the production media (Garcia – Ochoa's medium) gave lower culture viscosities than that obtained with other CSL treatments. But, the addition of CSL to Garcia – Ochoa's medium supplemented with sucrose (3%) gave higher culture viscosity than other CSL treatments. Also the results showed that the addition of NH_4 NO_3 or mineral salts of Garcia – Ochoa's medium in CSL treatment had bad effect on xanthan production; this is may be due to their higher concentration after the addition of CSL. At the same time, culture conditions contained 2% CSL + 3% sucrose gave highest xanthan production than other treatment contained CSL.

Table (4): Effect of different treatments of corn steep liquor on xanthan production.

Treatments	Final pH	Protein (mg/ml)	Cell dry mass (mg/ml)	Viscosity	Xanthan dry mass (mg/ml)
Garcia – Ochoa's medium (complete medium)	6.95	0.98	5.00	163.8	30.35
CSL (2%) + Garcia – Ochoa's medium contained 2% sucrose	6.75	0.85	4.51	135.8	19.76
CSL (2%) + Garcia – Ochoa's medium contained 2% sucrose + NH_4NO_3	6.70	0.90	4.55	145.9	20.64
CSL (2%) + mineral salts of Garcia–Ochoa's medium contained 2% sucrose	6.80	0.95	4.60	159.0	22.50
CSL (2%) + Garcia – Ochoa's medium with 3% sucrose	7.10	1.05	5.05	205.6	34.61

Generally, it could be concluded that the treatment contained Garcia – Ochoa's medium supplemented with 2% CSL as sole nitrogen source and sucrose (3%) DS sole carbon source is the best treatment for *Xanthomonas* growth and its xanthan production.

I. 5- Effect of different concentrations of CSL on xanthan production

With studying the effect of CSL concentrations on the growth of *Xanthomonas* and its xanthan production with sucrose (3%) as carbon source. The results (Table 5) showed that the increasing of CSL up to 5% concentration increased culture viscosity and xanthan level gradually. Higher concentrations of CSL, rapidly decreased xanthan level, but, at high concentration of CSL (15%), sharp reduction in xanthan synthesis was observed. Molina *et al.* (1993); De Vuyst & Vermeire (1994); Rajeshwari *et al.* (1995); Saber (1999) and Abdelhady *et al*. (2000) reported similar observations. They found that xanthan levels were maximal at lower concentrations of CSL and the higher concentrations of CSL had an inhibitory effect on xanthan production.

Table (5): Effect of different concentrations of corn steep liquor on xanthan production.

CLS conc. (%)	Final pH	Protein (mg/ml)	Cell dry mass (mg/ml)	Viscosity	Xanthan dry mass (mg/ml)
Control	7.10	1.05	5.05	205.6	34.61
1	6.98	1.02	5.15	195.7	33.60
2.5	7.05	1.45	5.49	213.9	38.90
5.0	7.10	1.49	5.52	217.2	41.91
7.5	6.92	1.00	5.07	187.5	29.72
10.0	6.85	0.95	5.05	160.6	26.53
12.5	7.15	0.88	4.09	147.8	23.05
15.0	7.20	0.77	4.60	124.4	21.70

Control = the production media containing CSL (2%) + sucrose (3%).

II. Effect of some raw materials and by–products on xanthan production

II. 1- Effect of molasses and cane juice on xanthan production:

Sugar – cane molasses, sugar – beet molasses and cane – juice were added to the production media instead of sucrose (3%) to study their effect on xanthan production by *X. campestris*. The results (Table, 6) showed that the use of sugar – cane molasses as a sole carbon source with different concentrations resulted in little xanthan production than sucrose – containing medium. Moreover, the used strain failed to synthesis xanthan at high concentrations of molasses. This means that, sugar – cane molasses seemed to be not good substrate or carbon source for xanthan production. De Vuyst and Vermeire (1994) found that higher concentrations of molasses have stimulated effect on xanthan production.

At the same time, the results indicated that the culture viscosity and xanthan production on sugar – beet molasses and sugar – cane juice treatments were very low as compared with that produced by fermentation medium containing 3% sucrose. The failure of molasses and sugar – cane juice to support xanthan production by *X. campestris* may be due to the presence of some inhibitory substances (Abdelhady *et al*., 2000).

II. 2- Effect of different sweet whey treatments on xanthan production:

Whey is a nutrient – rich dairy by product, which contains 4 – 5% lactose, 0.8% to 1% proteins, minerals and some small organic molecules. It is produced by the dairy industry in such quantities annually that its propel disposal has long been a major problem. The most desirable way of handling this waste is to utilize it as a substrate for production of useful products such xanthan (Fu & Tseng, 1990 and Abdelhady *et al*., 2000). Therefore, the results presented in Table (7) showed the effect of different whey treatments on xanthan production. The addition of whey alone to xanthan production media gave lowest concentration of xanthan as well as culture viscosity. But, the addition of â – galactosidase to hydrolysis whey lactose enhancing the production of xanthan and gives highest culture viscosity, especially with the supplementation of the production media with sucrose and CSL. While, with acid hydrolyzed whey, sharp reduction in culture viscosity and xanthan production were observed. These treatments gave very lowest amount of

xanthan as well as culture viscosity. In other words, these treatments inhibited greatly xanthan production.

Also, noticed from the results that final pH values of the best treatment for xanthan production medium containing hydrolyzed whey were higher. These results are in agreement with those obtained by Fu & Tseng (1990 & 1992) and Abdelhady *et al*., (2000).

Table (6): Effect of different concentrations of molasses and sugar – cane juice on xanthan production.

Treatment (% v/v)		Final pH	Protein (mg/ml)	Cell dry mass (mg/ml)	Viscosity	Xanthan dry mass (mg/ml)
Control		7.10	1.49	5.52	217.2	41.91
Sugar – cane molasses	1.0	6.89	0.75	3.37	57.5	15.75
	2.5	6.79	0.81	3.98	125.6	27.64
	5.0	6.40	0.74	3.15	93.9	19.81
	7.5	5.95	0.61	2.65	43.3	10.55
	10.0	5.55	0.50	1.87	0.95	3.22
Sugar – beet molasses	1.0	6.82	0.78	3.95	132.85	22.57
	2.5	6.51	0.58	3.53	95.93	18.65
	5.0	6.05	0.49	2.68	31.70	9.71
	7.5	5.78	0.44	1.97	11.06	5.05
	10.0	5.50	0.22	0.85	0.56	0.00
Sugar – cane juice	1.0	7.00	0.55	2.55	1.06	11.50
	2.5	6.95	0.44	2.02	0.75	5.75
	5.0	6.70	0.33	1.51	0.43	0.33
	7.5	6.30	0.21	0.68	0.22	0.19
	10.0	5.95	0.15	0.38	0.06	0.06

Control = the production media containing 5% CSL + 3% sucrose.

Table (7): Effect of different whey treatments on xanthan production.

Whey treatment	Final pH	Protein (mg/ml)	Cell dry mass (mg/ml)	Viscosity	Xanthan dry mass (mg/ml)
Control	7.10	1.49	5.52	218.0	41.91
Whey 2% + Garcia – Ochoa's medium	6.40	0.19	0.65	8.93	2.41
Whey 2% + 20 units of â – galactosidase	6.60	0.78	2.11	82.70	14.92
Whey 2% + 5% CSL + 20 units of â – galactosidase	6.80	1.21	4.81	187.50	27.60
Whey 2% + 5% CSL + 3% sucrose + 20 units of â – galactosidase	6.90	1.48	5.65	229.50	43.70
Acid hydrolyzed whey (2% sugar)	5.20	0.09	0.27	3.61	0.65
Acid hydrolyzed whey + control without CSL and sucrose	6.20	0.55	1.15	15.80	1.50

Control = the production media containing 5% CSL + 3% sucrose.

II. 3- Effect of potato starchy waste on xanthan production:

Potato starchy waste is an industrial waste product of the semi – fried potatoes factories. It contained 40% total carbon and 0.83 % total nitrogen on dry basis. Disposal of potato starchy waste is a problem due to the high biological oxygen demand when it is placed in the local sewage system

(Abdelhady *et al*., 2000). Thus, in this experiment it used as a carbon source to convert it to useful product such as xanthan. Different concentrations of potato starchy waste were added to the production media instead of sucrose. The results in Table (8) showed that up to 2% of starchy waste resulted completely inhibition of xanthan production as well as it decreased greatly the culture viscosity. This may be due to the deficiency of nitrogen or mineral content of potato starchy waste. But when this waste was added as a sole carbon source to the production media with higher concentrations up to 2%, a remarkable increase in culture viscosity and xanthan production was detected. Also the results showed that the culture viscosity increased with the increasing of potato starchy waste concentrations, which reached its maximum at 3% concentration, thereafter decreased gradually. Among the treatments contained potato starchy waste, the highest culture viscosity and xanthan production were observed with the production media supplemented with 1.5% starchy waste plus 0.5% sucrose. But, in general, fermentation media gave higher xanthan production than other treatments containing potato starchy waste. Therefore, the last treatment should be taken into consideration as a mean of using industrial waste in fermentation. The same observations were detected by Abdelhady *et al*., (2000).

Table (8): Effect of different concentrations of potato starchy waste on xanthan production.

Potato starchy waste conc. (%)	Final pH	Protein (mg/ml)	Cell dry mass (mg/ml)	Viscosity	Xanthan dry mass (mg/ml)
1.0	7.00	1.00	3.45	8.50	0.00
1.5	6.80	1.30	3.58	9.50	0.00
2.0	6.75	1.45	4.65	9.50	0.00
2.5	6.60	1.50	5.60	19.50	5.40
3.0	6.50	1.55	6.20	88.60	14.60
3.5	6.70	1.52	5.90	56.90	12.51
4.0	6.70	1.50	5.70	31.53	10.73
4.5	6.80	1.45	4.90	25.78	8.43
5.0	6.80	1.40	4.70	20.66	5.65
3% potato starch waste + Garcia – Ochoa's medium + 0.5% sucrose	6.50	1.65	6.45	190.55	16.6
1.5% potato starch waste + Garcia – Ochoa's medium + 0.5% sucrose	7.01	1.30	6.55	165.0	29.8
Control	7.10	1.49	5.52	218.5	41.91

Control = the production media containing 5% CSL + 3% sucrose.

II. 4- Effect of different concentrations of glucose syrup on xanthan production:

Glucose syrup is a concentrated aqueous solution of D (+) – glucose, maltose and other polymers of D – glucose, obtained by the hydrolysis of starch (Jackson, 1995 and Abdelhady *et al.,* 2000). Total sugars content of glucose syrup 42% determined as reducing sugars. Using of glucose syrup (2 % sugars) as a sole carbon source in the production media led to increasing the growth intensity, culture viscosity and xanthan production (Table, 9).

Table (9): Effect of different concentrations of glucose syrup on xanthan production.

Glucose syrup conc. (%)	Final pH	Protein (mg/ml)	Cell dry mass (mg/ml)	Viscosity	Xanthan dry mass (mg/ml)
Control	7.10	1.49	5.52	218.50	41.91
1.0	7.00	1.50	6.20	278.90	44.80
2.0	6.83	1.55	6.75	319.30	47.60
3.0	6.71	1.50	6.40	305.70	45.40
4.0	6.61	1.50	6.30	287.30	41.90
5.0	6.40	1.45	6.00	268.40	37.60

Control = the production media containing 5% CSL + 3% sucrose.

Also, the final pH values during the fermentation of this treatment were higher than observed in control. The results also showed that glucose syrup (2% sugars) was stimulated xanthan production, but, the increasing of glucose syrup than 2%, decreased the bacterium growth and its culture viscosity. These results are similar to those reported on the effect of carbon sources on the production of xanthan. Similar results and findings were reported by De Vuyst and Vermeire (1994) and Abdelhady *et al*., (2000).

II. 5- Effect of mixture of glucose syrup and potato starchy waste on xanthan production:

From the above results, glucose syrup stimulated xanthan production, but starchy waste reduced it. Therefore, in this experiment, the combination between 3% potato starchy waste and different glucose syrup concentrations up to 2 % was used as a carbon source in Garcia – Ochoa's medium in order to select the best concentration that gives the highest xanthan production.

Results presented in Table (10) showed that the combination of raw materials (potato starchy waste (3%) with glucose syrup (up to 0.6%) increased both culture viscosity and xanthan production. This means that 3% potato starchy waste + glucose syrup (0.6%) are the best raw materials and by-products used as carbon source for xanthan production. At the same time, both xanthan production and culture viscosity decreased gradually with the increasing of glucose syrup than 0.6% sugars presented in the fermentation media supplemented with 3% potato starchy waste. Abdelhady *et al*., (2000) reported similar observations.

Table (10): Effect of mixture of glucose syrup and potato starchy waste on xanthan production.

3% potato starchy waste + different conc. of glucose syrup	Final pH	Protein (mg/ml)	Cell dry mass (mg/ml)	Viscosity	Xanthan dry mass (mg/ml)
0.0	6.50	1.55	6.20	88.60	14.60
0.2	6.90	1.55	6.65	118.9	15.60
0.4	6.95	1.50	6.70	227.6	25.80
0.6	7.00	1.60	6.75	323.9	49.90
0.8	7.05	1.40	6.70	315.8	42.00
1.0	7.00	1.35	6.40	301.6	37.50
1.5	6.90	1.30	5.70	281.6	31.50
2.0	6.80	1.15	4.75	219.5	27.60

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استخدام بعض المخلفات الصناعية والمواد الخام للإنتاج العالي من صمغ الزانثان باستخدام بكتيريا الزانثومونس كامبستريز.

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اتجهت كبرى الشركات العالمية الآن مثل فايزر وميرك في الولايات المتحدة الأميركية لإنتاج صمغ الزانثان الميكروبي نظراً لأهميته الكبيرة كمادة مثبتة ومستحلبة ومدعمة للقوام في الصناعات الغذائية المختلفة وكذلك الصناعات الدوائية وصناعة المنسوجات ومواد التجميل لما له من خواص ريولوجية وثباته العالي تجاه درجات الحرارة ودرجات الـ pH المختلفة ونظراً لهذه الاستخدامات المتعددة فقد اتجهت الدراسة في هذا البحث لاستخدام مخلفات ومواد رخيصة الثمن للإنتاج العالي من صمغ الزانثان لتقليل تكاليف إنتاج هذا المنتج الميكروبي الهام وقد أوضحت الدراسة النتائج التالية:-

١- تم الحصول على أعلى كمية من صمغ الزنثان في اليوم الرابع من التخمير.

٢- كان لاستخدام السكروز ومنقوع الذرة بمعدل ٣ % و٥% على الترتيب تأثير حثي عالي على إنتاج الزنثان في حين كان لإضافة المولاس سواء من بنجر السكر أو قصب السكر أو عصير القصب إلى بيئة الإنتاج تأثير مثبط لإنتاج الزانثان.

٣- استخدام الشرش في بيئة الإنتاج أدى إلى تقليل إنتاج الزانثان في حين كانت إضافة الشرش إلى بيئة التخمير مدعما بالسكروز ٣% ومنقوع الذرة ٥% تأثير حثى عالي على إنتاج الزانثان.

٤- إضافة مخلف نشا البطاطس إلى بيئة التخمير أدت إلى تقليل إنتاج الزانثان في حين كان لإضافة شراب الجلوكوز بمعدل ٢%تأثير حثي كبير لإنتاج الزنثان والأفضل منه استخدام شراب الجلوكوز بمعدل ٠,٦ % مع ٣% من مخلف نشا البطاطس.

ونتائج هذا البحث تشير إلى إمكانية إنتاج كمية عالية من صمغ الزانثان باستخدام هذه المخلفات الرخيصة الثمن والتي تؤدى إلى خفض تكاليف إنتاج الزانثان وهذا مهم من الناحية التطبيقية والبيئية والاقتصادية.