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Influence of Xanthan Gum and Inulin as Thickening Agents for Jam Production

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REPLACING pectin with natural biopolymer substances has importance in food industry to ensure functional properties. The aim of the study was to evaluate a xanthan gum and inulin as pectin substitute and biopolymers thickening agents for jam production. Physio-chemical properties for three tested types of fruits differ in pectin percentage (strawberry, apricot and apple) and their jams were evaluated. Effect of replacement different concentrations of pectin with xanthan gum, inulin and their blend on total soluble solids, pH,titratable acidity, viscosity, colour, microstructural and sensory characteristics was performed on the final products and after eight month of storage period. The results indicated that the viscosity decreased as pectin replacement level increased.Type of jam and level of pectin replacement affected the values of lightness (L^*), redness (a^*) and yellowness (b^*). No differences were shown in total soluble solids between all treatments comparing to the control samples of the three types of jams. Up to 50% pectin substitution with xanthan gum,there was no significant difference in texture and spreadability of the jam samples. Increasing the replacement level of pectin more than 50% reduced the texture quality. The lowest score for texture and spreadability were produced for jam containing 50% xanthan gum and 50% inulin followed by 50% inulin. Xanthan-inulin-pectin blend (1:1:2) was the best formulation than other jams formulated containing blend .The results after eight month of storage indicated that xanthan gum could successfully replace 25 % pectin in producing high quality jam having good overall sensory acceptability and great textural property .

Keywords: Xanthan gum,Inulin,Food industry, Functional properties.

Introduction

The development of food products with health promoting properties has become a key target for the industry. Xanthan gum, a thickening agent or a stabilizer in the food industry, is a polysaccharide derived from *Xanthomonas campestris* (Bemiller and Whistler, 1996). Xanthan gum gives excellent suspension and coating properties to colloidal suspensions and provide optimal viscosity, long-term stability, heat shock protection of dairy products, potential antioxidant activity for long shelf life for baked goods and improve stability and oxidative properties of meat emulsions (Gavilighi et al., 2006, Thacker et al., 2010, Demirciet al., 2014 and Sajadet al., 2016).

Long-chain inulin was reported to improve and develop a gel structure formed by a network of crystalline particles in soft candies and food products (Hébette et al., 1998 and Chiavaro et al., 2007). Also, it increased the hardness and viscosity and decreased freezing point for several dairy products (Schaller-Povolny & Smith 2001 and Abd El-Razek et al., 2013).

Pectin has a variety of uses in food, pharmaceuticals and industrial fields. It is used as a gelling agent in jam which is one of the largest known applications, and as a functional food in beverages. High methoxyl pectins are used in a wide range of jam products, depending on the type and quantity of fruits. Some fruits provide enough pectin for jam making, whilst others need to have pectin added from another source (Srivastava and Malviya, 2011). Strawberry contains little pectin compared to apple fruit which has a high pectin content while apricot contains a moderate level of pectin and these fruits are widely used in Egypt .

There is a great demand for gelling polysaccharides in the industry to meet the demand for low-calorie healthier foods containing dietary fiber. Recently, xanthan gum is used to enhance gelation (Khouryieh et al., 2015) because of its unique synergistic interaction and functional properties. Therefore, this study was undertaken to compare and evaluate xanthan and inulin and their mixture as thickening agents on viscosity, colour, some physico-chemical properties, microstructural and sensory characteristics of fruit jam (apple, apricot and strawberry).

Materials and Methods

Materials

Three different fruits; namely strawberry, apricot and apple were obtained from Edfina Company for Preserved Foods, Alexandria, Egypt. Inulin (Frutafit® TEX), of long average chain length ≥ 23 monomers (Sensus, Brenntag Química, Spain), high methoxyl pectin (type B rapid set-USA-150 sag) and xanthan gum (Qingdao Fraken International Trading Co., China) were mainly imported by Edfina Company for Preserved Foods. Sucrose and citric acid were purchased from El Nasr Pharmaceutical Chemical Co. Cairo, Egypt.

Methods

Technological process

The jam processing of different fruits was prepared in laboratory of Edfina Company for preserved Foods according to the procedure described by Rababah et al.(2011). Xanthan gum and inulin (Frutafit® TEX) were tested for gelling thickening agents needed to produce acceptable jam. For each fruit, jams were prepared by replacing pectin as follows: Control, 100% pectin, T_1: replacing 25% of pectin by xanthan, T_2: replacing 50% of pectin by xanthan ,$T_{3:}$ replacing 50% of pectin by inulin ,T_4: replacing 50% of pectin by a mix (25% xanthan and 25% inulin) , T_5: replacing 75% of pectin by a mix (25% xanthan and 50% inulin) ,$T_{6:}$ replacing 75% of pectin by a mix(50% xanthan and 25 % inulin), and T_7: replacing 100 % of pectin by 50% xanthan and 50% inulin .

Jam formulation included 450 g of fruits (strawberry, apricot, orapple),550 g sucrose, 5 g high methoxyl pectin and 4g citric acid. Fruits were ground using a mixer then sucrose was added and heated with stirring in a double-walled stainless steel vessel at 80 °C for 15 min. After that, pectin was separately added under continuous stirring and the mixture was heated to full boiling (101-103°C) for 2–3 min to allow proper pectin hydration. Acidity was adjusted at 3.0 to 3.2 by adding citric acid . When the final TSS of the mixture reached 65%, the jam was packed in 100 g glass jars, allowed to cool at room temperature and kept at 20 °C until analysis. The jam samples were analyzed at after 15 day and 8 months of storage.

Physico-chemical measurements

The total soluble solids (%) were determined by direct reading in a Pocket referactometer (Atagoa.PDL-3, Japan) at room temperature (25°C). The pH value was measured using a pH meter (pH MVx 100 Beckman. USA), and titratable acidity content was expressed as % citric acid according to AOAC (2012). Viscosity was measured with a rotary viscometer (Brookfield Model DV-II+Pro , USA) at 30 rpm (Suwonsichon and Peleg 1999). Total sugars were analyzed by the phenol-sulphuric acid method (Dubois et al., 1956). Sucrose and pectin were determined according to AOAC (2012).

Colour analysis

Colour of all jam samples were evaluated by a Hunter Lab (Ultra Scan VIS model, colorimeter, USA). The lightness (L^*), redness (a^*) and yellowness (b^*) were calculated from the colour primaries (Santipanichwong and Suphantharika, 2007). Total colour difference (Δ E) and chroma (C^*) were calculated as follows: $\Delta E = [(\Delta L^*)^2 + (\Delta a^*)2 + (\Delta b^*)2]^{1/2}$,$C^* = \sqrt{(a^*2 + b^*2)}$

Scanning electron

Microscopy

Jam microstructure samples were examined by Scanning Electron Microscopy (SEM) using a JEOL, model JSM-6360-LA. Samples were dehydrated by lyophyilization (Telstar, cryodos-50,Spain), then coated with gold by Fine Coating (Ion SputierIEC-1100, Japan) at mA = 10 and KV = 1 and examined by SEM. Photomicrographs were taken with a digital system Scan vision 1.2 of RONTEC (800 × 1.200 pixel) (Alvarez et al., 2010).

Microbiological quality

Microbiological analysis (mould and yeast count and coliform group) were carried out following American Public Health Association

(APHA 1992). Jam samples were analyzed at 0 time and at the end of the storage period.

Sensory evaluation

Each jam sample was coded and served in a clean plate with white bread to 16 untrained and trained panelists .The samples were assessed for flavour, colour, taste, texture, spreadability and acceptability using a hedonic scale ranging from extremely dislike (1) to extremely like (9) (Basu et al. (2011). The panelist assessed spreading behaviour of the jam by applying the jam on a slice of bread and allowing the panelists to write their comments on the assessment form.

Statistical analysis

Data were analyzed using Co-Stat Software (2004) computer program for statistics. The level of significant difference was determined at $p \leq 0.05$.

Results and Discussion

Physico-chemical properties of fruits and their jams

Physico-chemical properties including, total soluble solids, total sugars, sucrose, pectin, titratable acidity, and pH of the three tested fruits (strawberry, apricot and apple) and their jams are shown in Table 1. It can be noted that there were significant differences among some characteristics for the three tested fruits.The strawberry fruit had the lowest total soluble solids (TSS) (9.42 %), total sugars (7.02%), sucrose (0.46 %) and pectin (0.55%),while apple fruit had the highest TSS (14.4 %), total sugars (10.49%) , sucrose (2.11 %) and pectin (1.09%) content. TSS and total sugars of strawberry pulp were 8.33%, and 6.51%, respectively as reported by Sonawane et al. (2007). Acidity values of all fruits ranged from 0.35 to 0.80% and pH ranged from 3.24 to 4.15. The value of total sugars, titratable acidity and pH agree with the results of Sharma (2002).The changes of physic-chemical properties for fresh fruit pulps depend on fruit type and degree of ripeness (stages of maturity).

Also, physico-chemical properties of the jam prepared with these fruits were recorded at the beginning on 15 days of storage (Table 1). Jams presented had TSS values of 64.5, 65.8 and 67.2% for strawberry, apricot and apple, respectively. The mean values of total sugars for apricot and strawberry jams are similar to the results obtained by Lago et al. (2006) and Touati et al. (2014) . The sucrose which helps in promoting pectin

TABLE 1:Physico-chemical properties of fruits and their jams.

Product		Physico-chemical properties					
		Total soluble solids (TSS)%	Total sugars %	Sucrose %	Pectin %	Titratableacidity (%)	pH
Fruit	Strawberry	9.42±0.08^{b}	7.02± 0.39^{c}	0.46 ±0.15^{c}	0.55±0.10^{c}	0.80±0.03^{a}	3.24±0.02^{b}
	Apricot	13.25 ± 0.37^{a}	9.26 ± 0.33^{b}	0.86 ±0.01^{b}	0.93±0.05^{b}	0.60±0.01^{a}	4.15±0.05^{a}
	Apple	14.4 ± 1.01^{a}	10.49±0.35^{a}	2.11 ± 0.35^{a}	1.09±0.06^{a}	0.35±0.05^{b}	4.13±0.02^{a}
Jam	Strawberry	64.50 ± 1.03^{b}	59.86± 1.60^{b}	19.08 ±1.60^{b}	0.74 ± 0.13^{b*}	0.50±0.09^{a}	3.19±0.04^{a}
	Apricot	65.8± 0.25^{b}	61.21±1.94^{ab}	22.49 ±4.72^{a}	0.91 ± 0.06^{a*}	0.46±0.05^{a}	3.53±0.05^{a}
	Apple	67.20 ±0.08^{a}	63.98 ±0.77^{a}	21.64±0.20^{ab}	0.99 ±0.09^{a*}	0.52±0.06^{a}	3.37±0.07^{a}

* Pectin content in jam products was theoretically calculated.

gelation during jam-making process,varied from 19.08% to 22.49% of the jam formulations (Table 1).The mean values of total acidity and the pH of jam formulations were 0.50, 0.46 and 0.52% and 3.19, 3.53 and 3.37 for strawberry, apricot and apple, respectively. The variation may be caused by different varieties of fruit used for the jams. In earlier studies, it was reported that the TSS should be 65% with a pH of 3.0 to 3.5 and 0.5% pectin level (Ndabikunze et al., 2011).These results conform with the Egyptian Standards No 296 (Anonymous, 2006) Lago et al. (2006) reported that pH, titratable acidity and TSS are important factors for the strength of gel and would affect the stability and sensory quality of the formulated jams (Ferreira et al., 2004).

Jam viscosity

The results in Fig. 1 revealed differences in viscosity among the jam samples. It was obvious that replacing a portion of pectin by xanthan, inulin or their blends caused decrease in the viscosity of the three types of jams. There were slight decreases in viscosity of jam samples containing 25% xanthan gum. The viscosity decreased as pectin replacement level increased. The lowest viscosity was obtained for samples containing 50% inulin (T3). It decreased from 7240, 6800 , 6220 c P in the control to 3860,5640 and 4540cP of strawberry , apricot and apple jam, respectively (Fig.1). Viscosity of polysaccharide depends upon the mechanical treatment , the temperature applied, the degree of methylation and concentration used (Panda, 2011). Dhiaa (2012) reported that viscosity of xanthan gum solution increases with higher polymer concentrations and lower speeds and temperatures at 80º C.While, inulin gels formed under heating are stronger, smoother and more uniform but able to release reducing sugars at pH values around 3.5 (Kim et al., 2001).

Colour characteristics

The effect of xanthan, inulin or their blends on colour values in terms of L*, a* and b* values of strawberry, apricot and apple jam are given in Table 2. Colour lightness (L*) in jams containing pectin ranged from 22.83 to 25.13. The redness (a*) ranged between 2.24 - 3.89, while the yellowness (b*) showed a wide range which varied between 1.13 –8.2. Colour can be attributed to the individual ingredients present in the product and their interactions (Walker et al., 2014). The L* value was not affected by increasing the level of pectin replacement in strawberry jams, whereas, it increased in apricot and apple samples. As seen in Table 2, the value of redness (a*) in the tested samples was affected by treatments. It was noted that high a* value was observed in jam containing inulin when compared to pectin samples. However, b* values in strawberry and apple jam samples show significant ($P \leq 0.05$) differences. On the other hand, yellowness increased as pectin replacement level increased in apricot samples but it showed insignificant effect (Table 2). Type of pectin and water activity of the jams affected the colour of strawberry jams when cooked under reduced pressure (Holzwarth et al., 2013).

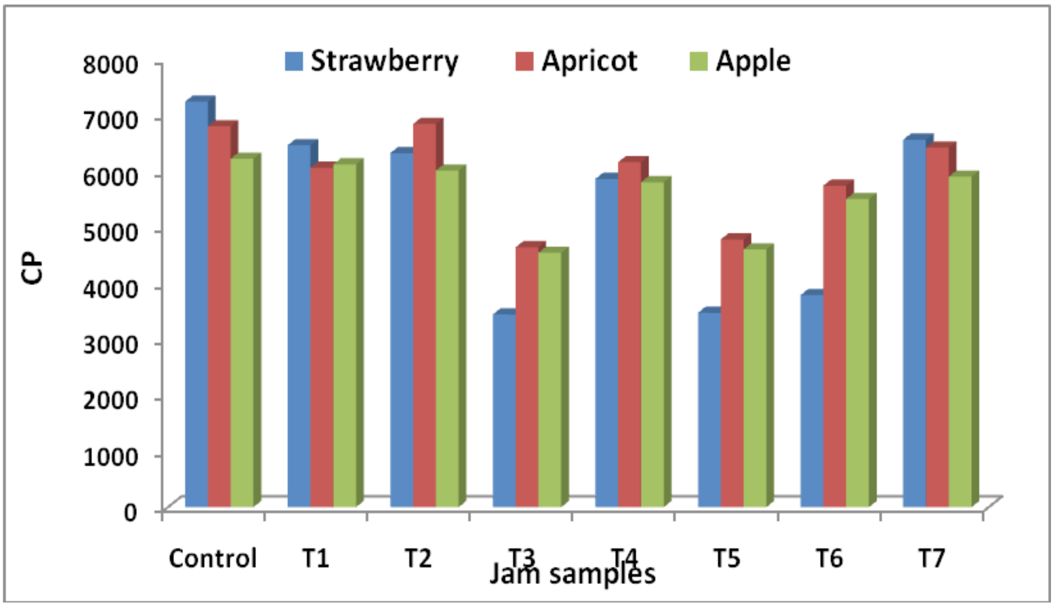

Fig. 1. Effect of xanthan and inulin as a pectin replacer on viscosity of jam samples.

TABLE 2. Effect of xanthan and inulin as a pectin replacer on colour parameters of jam samples.

Jam	Strawberry			Apricot			Apple		
	L*	a*	b*	L*	a*	b*	L*	a*	b*
control	24.29[a]	3.89[a]	1.13[a]	25.13[a]	3.41[a]	8.2[a]	22.83[a]	2.24[a]	5.31[a]
T_1	24.28[a]	3.52[a]	1.21[a]	25.45[a]	3.47[a]	8.27[a]	23.06[a]	2.32[a]	5.39[a]
T_2	24.32[a]	3.58[a]	1.22[a]	29.64[b]	3.8[a]	8.21[a]	24.00[a]	2.33[a]	5.37[a]
T_3	23.97[a]	5.51[b]	1.65[ab]	29.5[b]	4.14[b]	8.29[a]	27.14[b]	3.51[b]	5.32[a]
T_4	24.54[a]	3.57[a]	1.21[a]	28.06[b]	3.54[a]	8.65[a]	27.17[b]	2.27[a]	5.53[ab]
T_5	24.53[a]	5.05[b]	1.52[ab]	27.82[b]	3.95[b]	8.52[a]	27.55[b]	3.39[b]	5.5[ab]
T_6	24.54[a]	4.04[ab]	1.64[ab]	29.13[b]	3.78[a]	8.72[a]	28.19[b]	2.21[a]	5.72[b]
T_7	23.63[a]	3.92[a]	1.81[b]	30.16[c]	3.75[a]	8.8[a]	28.00[b]	2.35[a]	5.52[ab]

Means in a column not sharing the same letter are significantly differentat P≤0.05.
L*, lightness ; a*, redness; b*, yellowness.

Total soluble solids, pH and titratable acidity

The averages of physico-chemical properties namely TSS, pH and titratable acidity of jam samples prepared with xanthan , inulin and their mixture are shown in Table 3. No differences were shown in TSS between all treatments comparing with the control sample of the three types of jams. A slight decrease in pH value was noted when the level of xanthan or inulin increased in comparison with the control jam samples.No difference in titratable acidity values was observed in processed jams.The pH of the jamis inaccordance with the required limit of Food and Agriculture Organization of the United Nations(1990)

Scanning electron microscopy

Jam variety has its characteristic structural features, which reflect the texture changes in the jam. The morphology of micrographs of the apple jam samples are illustrated in Fig. 2. The xanthan are partially gelatinized and immersed in a continuous matrix formed. As the pectin replacement level increased, xanthan granules were not fully embedded and they were observed as detached structures on the matrix surface. Also, the microstructure of jams containing inulin T_3,T_4,T_5 and T_6 show a less developed structure dispersion in comparison with xanthan alone (Fig. 2). It has been reported that as the level of xanthan increases, peak stress of gels increased resulting in the formation of tough gels (Nagaprabha and Bhattacharya, 2016). In the case of the existence of a favourable interaction between the chains of starch and hydrocolloid connected together by intermolecular binding or two different polymers, they interact by mutual entanglements leading to an increase in the structural integrity (Sikora et al., 2008).

Sensory evaluation

In fact, texture and spreadability are an important organoleptic attributes of jam products. The results of sensory evaluation of jams are shown in Table 4. Among the three control fruit jams, apple jam had the higher score of overall acceptability, followed by strawberry and apricot. The scores of colour and flavour of all samples were very close to the control except for jam containing 50% xanthan and 50% inulin which had a relatively lower score. Up to 50 % pectin substitution, there is no noticeable difference in texture and spreadability of the jam samples. The lowest score for texture and spreadability were produced for jam containing 50% xanthan and 50% inulin (T_7) followed by 50% inulin (T_3andT_5). Increasing the replacment of pectin more than 50%, the texture quality decreased. Xanthan-inulin-pectin blend (1:1:2) was the best formulation than the other jams formulated containing blend (T_5andT_6). In general, the data in Table 4 revealed that xanthan can be used in jam manufacture as a pectin substitute for up to 50%. It was observed that the best formula in jam production was obtained using a 25% followed by 50 % xanthan, then a combination of 25% xanthan with 25% inulin. Xanthan gum as a bonding agent, improves texture, increases TSS content and promotes stability by avoiding syneresis of products without added sugar (Fiszman and Durán, 1989). Xanthan gum shown an improvement in firmness and weight of cooked pasta products (Manthey and Sandhu, 2009) and noodles products (Mitra et al., 2012) .

TABLE 3. Total soluble solids, pH andtitratable acidity of processed jam containing xanthan and inulin as a pectin replacer.

Pectin replacement%	0	25%	50%			75%		100%
Properties	**Control**	**Xanthan T_1**	**Xanthan T_2**	**Inulin T_3**	**25% xanthan & 25% inulin T_4**	**25% xanthan &50% inulin T_5**	**50% xanthan & 25% inulin T_6**	**50% xanthan & 50% inulin T_7**
				Strawberry jam				
Total soluble solids %	64.50	64.9	64.6	65.7	64.8	64.2	64.1	64.5
pH	3.19	3.07	3.05	2.97	3.03	3.13	2.96	3.09
Titratable acidity%	0.50	0.51	0.52	0.46	0.49	0.50	0.49	0.46
				Apricot jam				
Total soluble solids%	65.8	66.2	65.6	65.2	64.4	64.4	62.4	64.9
pH	3.53	3.52	3.49	3.48	3.42	3.22	3.39	3.31
Titratable acidity%	0.46	0.51	0.50	0.45	0.46	0.45	0.42	0.49
				Apple jam				
Total soluble solids %	67.20	68.2	68.9	65.1	65.4	66.3	67.4	66
pH	3.37	3.36	3.36	3.35	3.36	3.37	3.35	3.35
Titratable acidity%	0.52	0.46	0.44	0.49	0.49	0.46	0.52	0.54

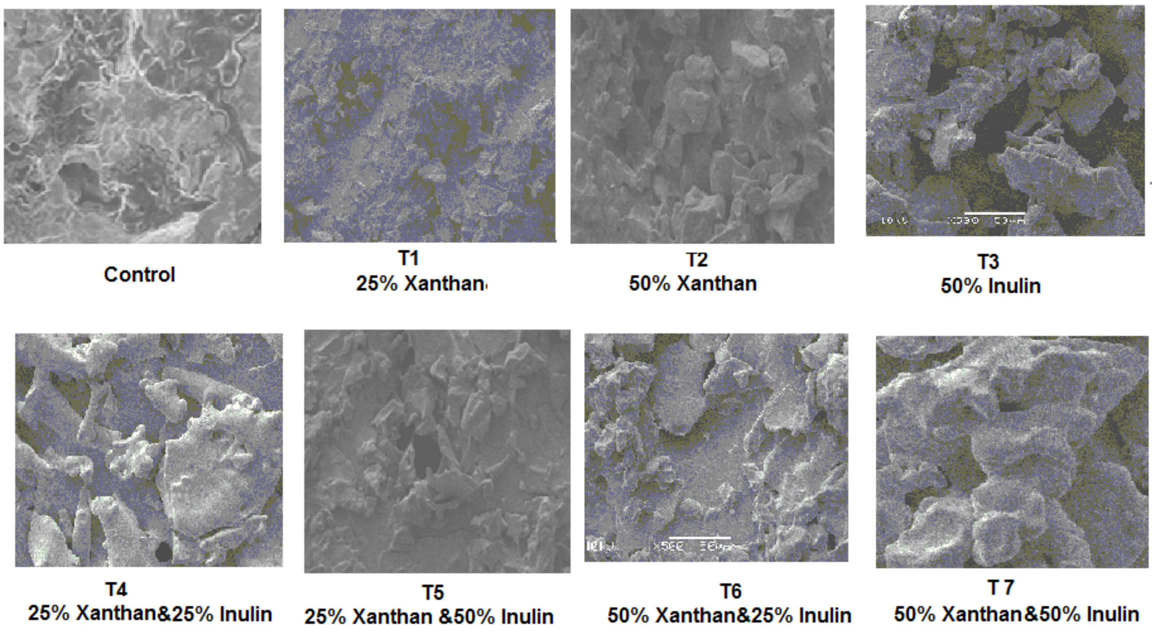

Fig. 2. Scanning electron microscopy photographs of apple jam using different concentrations of xanthan and texturized inulin.

From the previous discussion of the organoleptic properties, it could be arranged the overall acceptability of fruit jam , in a descending order as follows: T1 > T2 > T4 and these formulations were selected to study changes in physico-chemical attributes after eight months of storage .

TABLE 4. Average scores for the sensory attributes of jams.

Character / Treatment	Colour	Flavour	Texture	Spreadability	Taste	Overall acceptability
			Strawberry jam			
Control	8.51[a]	8.78[a]	8. 30[a]	8.10[a]	8.67[a]	8.50[a]
T_1	8.42[a]	8.5[a]	8.16[a]	8.16[a]	8.55[a]	8.60[a]
T_2	8.48[a]	8.67[a]	8.08[a]	8.08[a]	8.50[a]	8.50[a]
T_3	8.50[a]	8.58[a]	7.5[bc]	6.5[c]	8.55[a]	8.09[a]
T_4	8.47[a]	8.55[a]	7.92[ab]	7.52[ab]	8.14[ab]	8.55[a]
T_5	8.35[a]	8.54[a]	7.18[c]	6.88[bc]	7.89[b]	7.08[b]
T_6	8.18[a]	8.45[a]	7.59[bc]	7.09[b]	8.00[b]	7.29[b]
T_7	8.15[a]	8.38[a]	6.64[d]	6.40[c]	7.71[b]	6.05[c]
			Apricot jam			
Control	8.48[a]	8.55[a]	8.50[a]	8.66[a]	8.50[a]	8.39[a]
T_1	8.43[a]	8.60[a]	8.33[a]	8.53[a]	8.56[a]	8.4[a]
T_2	8.46[a]	8.40[a]	8.37[a]	8.44[a]	8.54[a]	8.25[a]
T_3	8.33[a]	8.13[a]	7.55[b]	6.55[b]	8.73[a]	8.00[a]
T_4	8.38[a]	8.30[a]	8.22[a]	8.22[a]	8.11[ab]	8.18[a]
T_5	8.08[a]	8.20[a]	6.89[cd]	6.70[b]	8.13[ab]	6.85[b]
T_6	8.24[a]	8.20[a]	7.11[c]	6.39[b]	7.63[b]	7.36[b]
T_7	8.23[a]	8.10[a]	6.67[d]	5.97[c]	7.38[b]	6.92[b]
			Apple jam			
Control	8.36[a]	8.7[a]	8.20[a]	8.20[a]	8.63[a]	8.78[a]
T_1	8.27[a]	8.9[a]	7.9[ab]	8.19[a]	8.85[a]	8.80[a]
T_2	8.27[a]	8.9[a]	7.8[ab]	8.08[ab]	8.38[a]	8.66[a]
T_3	8.2[a]	8.9[a]	7.70[ab]	7.70[c]	8.62[a]	8.00[b]
T_4	8.18[a]	8.9[a]	7.73[ab]	8.03[ab]	8.88[a]	8.6[a]
T_5	8.63[a]	8.8[a]	7.6[b]	7.87[bc]	8.86[a]	7.38[bc]
T_6	8.45[a]	8.6[a]	7.55[b]	6.55[d]	8.57[a]	6.89[cd]
T_7	8.09[a]	8.44[a]	7.5[b]	5.66[e]	8.43[a]	6.55[d]

Means in the same row followed by the same letter(s) are not significantly different at≤ 5% probability level

Effect of storage on physico-chemical and colour of selected jams

The storage period for 8 months shows a slight increment and insignificant (p >0.05) on the TSS in all fruit jams formulations (Table 5). The increment in TSS may be due to the conversion of polysaccharides to simple sugars. The pH of all treatments including the control sample showed a slight decrease after 8 month of storage. Coinciding, with the decrement in pH, an increase in titratable acidity was found. Substitution with xanthan or inulin did not affect the titratable acidity of jam; even if a slight but not significant rise in the titratable acidity of all jams was observed during the storage period (Sindumathi and Amutha, 2014). Viscosity value showed a gradual decrease for all treatments after 8 months of storage (Table 5).

The effect of storage on colour parameters for the selected jams is summarized in Table 5. It was noted that L* values increased and a values decreased in the formulations . The lightness value (L*) of apricot and apple jam decreased of all formulations, while it increased in strawberry jam.All jam samples showed a reduction in the redness (a*value) during storage period .On the other hand, it is clear that Δ E parameters were lower than 3 in all samples which is not obvious for the human eye in comparison to the control.

TABLE 5. Physico-chemical and colour of jam containing xanthan , inulin and their mixture after storage for 8 months (5°C).

Type of jam	Properties	Control	T_1 25% Xanthan	T_2 50% Xanthan	T_4 25% xanthan & 25% inulin
	Total soluble solids	64.8	65.1	64.9	66.7
Strawberry	pH	2.86	2.73	2.82	2.7
	Titratable acidity	0.53	0.54	0.53	0.51
	Viscosity	6990	6210	6310	5600
	Colour L^*	25.12	24.37	24.81	24.73
	a^*	2.16	2.05	1.8	1.95
	b^*	1.63	1.31	1.3	1.44
	C^*	2.71	2.43	2.22	2.42
	ΔE	-	0.82	0.58	0.48
Apricot	Total soluble solids	66.7	67.4	65.5	67.1
	pH	3.36	3.4	3.34	3.32
	Titratable acidity	0.49	0.52	0.52	0.49
	Viscosity	6430	6010	6830	6000
	Colour L^*	28.29	29	28.66	28.91
	a^*	3.32	3.31	3.16	3.41
	b^*	7.17	7.75	6.8	7.66
	C^*	8.07	8.51	7.5	8.47
	ΔE	-	0.94	0.77	0.79
Apple	Total soluble solids	68.7	69.4	69.6	66.7
	pH	2.66	2.78	2.74	2.76
	Titratable acidity	0.54	0.53	0.52	0.52
	Viscosity	6100	6110	6000	5620
	Colour L^*	26.75	27.34	27.32	27.7
	a^*	1.82	2.19	2.15	2.15
	b^*	3.52	5.22	4.03	3.99
	C^*	3.96	5.87	4.57	4.53
	ΔE	-	1.99	0.83	1.11

Means in a column not sharing the same letter are significantly differentat P≤0.05.

L*, lightness ; a*, redness; b*, yellowness. $\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$,Chroma $(C^*) = [(a)^2 + (b)^2]^{1/2}$

These results are in accordance with those reported by Wicklund et al. (2005) and Patraset al.(2011) when studying changes in colour values of strawberry jams stored at 4 °C and 20 °C. They observed a significant decrease of lightness during storage (28 days) of strawberry jam. Shahnawaz and Sheikh (2008) reported that anthocyanins and lutein pigments are sensitive to heat during jam processing and lost their original colour during storage at room temperature.

Sensory attributes of selected jams after storage for 8 months (5°C).

The apple jam had the highest mean scores for all parameters compared to strawberry or apricot jam (Fig. 3). The sensory scores of all jam samples decreased after eight months of storage period as compared to those evaluated after 15 day of storage (a fresh jam) . However, samples containing 25% xanthan + 25% inulin (T4) had the lowest scores of spreadability and overall acceptability compared to the other samples. Samples containing 25% xanthan (T2) were found to be the most acceptable from the organoleptic point of view .

Microbial growth of the selected jams

After 15 days of storage period, no growth of mould and yeast was detected in all jam samples. This is due to the good hygienic conditions during manufacture and storage, as well as the high sugar concentration in all jam (Nicol, 1980). At the end of 8 month storage period .mould and yeast count was within the limits required under standards (<12 × 10^3cfu.g^{-1}sample) and no coliform growth has observed in all formulated jams. The fruit jams that had low pectin content that lead to their poor gel formation and its consequent separation would increase the water activity of the product, and could influence the growth of microorganism in 8 month of storage.

Conclusion

From the aforementioned results, it can be concluded that xanthan could successfully replace pectin at 25% replacement level in producing jam without significant change in organoleptic properties (taste or texture).

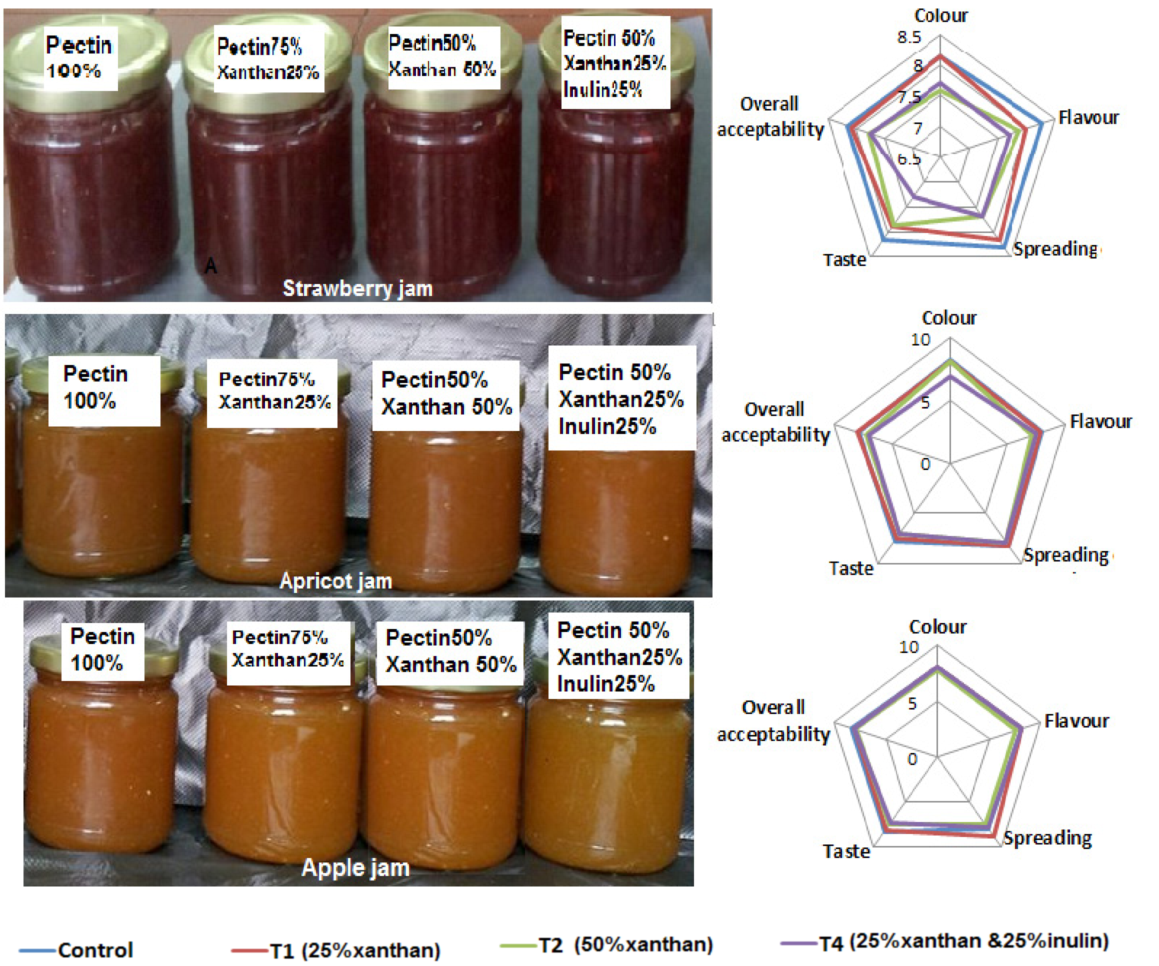

Fig. 3. Effect of storage for 8 months (5°C) on sensory attributes of jam containing xanthan, inulin and their mixture.

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References

Alvarez,M.D.,Cristina, F., Olivares M. and Canet ,W. (2010) Rheological behaviour and functionality of inulin-extra virgin olive oil-based mashed potatoes. *International Journal of Food Science and Technology*, **45,** 2108–2118.

Anonymous (2006) Egyptian Standards ,Cod of hyginic practice for low and acidified low acid canned foods: 5119/ 2006 CAC/RCP 23/1979, Rev.2 14.

Abd El-Razek, Amal, M., Alnemr, T. M. and Massoud, Mona, I. (2013) Potential Utilization of Texturized Inulin as a Fat Replacer in Some Food Products . *Alex. J. of Food Sci. & Technol.,* **10,** pp. 13-22.

AOAC (2012) *Official Methods of Analysis of AOAC International,* 19th edition, volume II. Association of Official Analytical Chemists. Gaithersburg, Maryland 20877-2417, USA.

APHA (1992) *Compendium of methods for the microbiological examination of foods.* In: Speck ML (Ed), 16th ed. American Public Health Association, Washington

Basu, S., Shivhare, U. S. Singh, T. V. and Beniwal, V. S. (2011) Rheological, textural and spectral characteristics of sorbitol substituted mango jam. *Journal of Food Engineering,* **105,** 503–512.

Bemiller,J.N.and Whistler, R.L. (1996) Carbohydrates. In: *Food Chemistry.* Fennema OR (Ed.) Marcel Dekker, Inc. New York, p 157–223.

Chiavaro, E, Vittadini,E. and Corradin, C. (2007) Physicochemical characterization and stability of inulin gels. *Eur Food Res Technol.* **225,** 85–94

Co-Stat Software. (2004) User's Manual Version. CohortTusson, Arizona USA. htti//www.Cohort.com.info@cohort.com

Dhiaa, A.H. (2012) The temperature effect on the vioscosty and density of xanthan gum solution Kufa *Journal of Engineering,* **3**, No.2, **20123** (2) 17-30

Demirci, Z.O., Yılmaz, I. and Demirci, A.S.(2014) Effects of xanthan, guar, carrageenan and locust bean gum addition on physical, chemical and sensory properties of meatballs. *J. Food Sci. & Technol.* **51** (5), 936–942. doi: 10.1007/s13197-011-0588-5

Dubois, M., Gilles, K.A., Hamilton, J.K., Rebers, P.A. and Smith, F. (1956) Colorimetric method for determination of sugars and related substances. *Analytical Chemistry,* **28,** 350–356.

Ferreira, I. M. P. L. V. O., Pestana, N., Alves, M. R., Mota, F. J. M., Reu, C. and Cunha, S. and M. Beatriz P.P. Oliveiraa (2004) Quince jam quality: Microbiological, physicochemical and sensory evaluation. *Food Control,* **15,** 291–295.

Fiszman, S. M. and Durán, L. (1989) Mechanical properties of kappa carrageenan-locust bean gum mixed gels with added sucrose. *Food Hydrocolloids,* **35,** 12, pp. 209-216, 1989.

Food and Agriculture Organization of the United Nations.(1990).http://www.fao.org/fileadmin/templates/inpho/documents/JAM.pdf.

Gavilighi, H.A., Azizi, M.H., Barzegar, M. and Ameri, M.A.(2006) Effect of selected hydrocolloids on bread staling as evaluated by DSC and XRD. *Journal of Food Technology,* **4,** 185-188.

Hébette, C.L.M., Delcour, J.A. and Koch, M.J.H. (1998) Complex melting of semi crystalline chicory (*Cichorium intybus* L.) root inulin. *Carbohydrate Research,* **310,** 65–75.

Holzwarth, M., Korhummel, S., Siekmann, T., Carle, R. and Kammerer, D.R. (2013) Influence of different pectins, process and storage conditions on anthocyanin and colour retention in strawberry jams and spreads. *LWT Food Sci. Technol.* **52,**131–138.

Khouryieh, H., Puli, G., Williams, K. and Aramouni, F. (2015) Effects of xanthan–locust bean gum mixtures on the physicochemical properties and oxidative stability of whey protein stabilised oil-in-water emulsions. *Food Chem.* **167,** 340–348.

Kim, Y., Faqih, M.N., & Wang, S.S. (2001) Factors affecting gel formation of inulin. *Carbohydrate Polymers*, **46,** 135–145.

Lago, E. S., Gomes, E. and Silva, R. (2006) Produção de geleiadejambolão (*Syzygiumcumini Lamarck*): process amento, parâmetrosfísico-químicos e avaliação sensorial, Ciência e Tecnologia de Alimentos, *Campinas,* **26,** 4, pp.847-856.

Manthey, F. A. and Sandhu, G. K. (2009) Effect of additives on the processing and cooking properties of pasta containing flaxseed flour. pp. 143-149 In: *Proceedings of Flax Institute of United States,* 62nd ed, J. F. Carter Ed., North Dakota State University: Fargo, ND.

Mitra, S., Cato, L., James, A. P. and Solah, V. A. (2012) Evaluation of white noodles enriched with oat flour. *Cereal Chem.* **89,**117-125.

Nagaprabha, P. and Bhattacharya, S. (2016)Textural characterization of foxtail millet gels: effect of cations and hydrocolloids *J. Food Sci.Technol.* (January 2016) **53** (1), 257–268.

Ndabikunze, B., Masambu, B., Tiisekwa,B. and Issa-Zacharia, A. (2011) The production of jam from indigenous fruits using baobab (*Adansonia digitata* L.) powder as a substitute for commercial pectin. *African Journal of Food Science,* 2011; **5** (3), 168-175.

Nicol , W.M. (1980) Sucrose in food systems. In *Carbohydrate Sweeteners in Foods and Nutrition,* (P. Koivistoinen and L. Hyvonen, Ed.) p. 151, Academic Press, London.

Panda, H. (2011) Pectins. In: *The complete book on gums and stabilizers for food industry.* Delhi: Asia Pacific Business Press: 2011.

Patras, A., Brunton, N. P., Tiwari, B. K. and Butler, F. (2011) Stability and degradation kinetics of bioactive compounds and colour in strawberry jam during storage. *Food Bioprocess Technology,* **4,** 1245–1252.

Rababah, T. M., Al-Mahasneh, M. A., Kilani, I., Yang, W., Alhamad, M. N., Ereifej, K. and AL-u'datt, M. (2011) Effect of jam processing and storage on total phenolics, antioxidant activity, and anthocyanins of different fruits. *J. Sci. Food Agric*. **91,**1096-1102.

Sajad, A. R, F. A. Masoodi,R A, Jahangir A. R, Adil G, Wani,S. M. and Malik,A. H. (2016) Application of guar–xanthan gum mixture as a partial fat replacer in meat emulsions. *J Food Sci Technol*. **53** (6), 2876–2886**.**

Santipanichwong, R. and Suphantharika, M. (2007) Carotenoids as colorants in reduced-fat mayonnaise containing spent brewer's yeast b glucan as a fat replacer. *Food Hydrocolloids,* **21,** 565–574.

Schaller-Povolny, L.A. and Smith, D.E. (2001) Viscosity and freezing point of a reduced fat icecream mix as related to inulin content. *Milchwissenschaft,* **56,** 25-9.

Shahnawaz, M. and Sheikh, S.A. (2008) Study on off-colouring of jamun fruit products during storage. *J. Agric. Res.* **46** (1),37-88

Sharma, R.R. (2002) Growing Strawberries, International Book Distributing Company, 1st ed, Lucknow, India, 1-3.

Sikora, M., Kowalski, S. and Tomasik P. (2008) Binary hydrocolloids from starches and xanthan gum. *Food Hydrocoll*. **22,** 943–952.

Sindumathi, G. and Amutha, S. (2014) Processing and quality evaluation of coconut based jam. IOSRJ. *Environ. Sci., Toxicol. Food Technol,* **8** (1), 10-14.

Sonawane, V.M., Chavan, K.D. and Pawar, B.K. (2007) Effect of levels of strawberry pulp and sugar on chemical composition during storage of shrikhand. *J. Dairying, Foods & H.S.* **26** (3/4),153-158.

Srivastava,P . and Malviya, R. (2011) Sources of pectin extraction and its applications in pharmaceutical industry –An overview. *Indian J. of Natural Products and Resources,* **2,**10-18.

Suwonsichon, T. and Peleg, M. (1999) Rheological characterisation of almost intact and stirred yogurt by imperfect squeezing flow viscometry. *Journal of the Science of Food and Agriculture*, **79**, 911-921.

Thacker, A., Fu, S., Boni, R.L. and Block, L.H. (2010) Inter- and intra manufacturer variability in pharmaceutical grades and lots of xanthan gum. *AAPS Pharm Sci.Tech.* **11,** 4, pp. 1619-1626.

Touati, N., Tarazona, MP and Hayette, L.O. (2014) Effect of storage time and temperature on the physicochemical and sensory characteristics of commercial apricot jam. *Food Chemistry,* 145 23–27.

Walker, R., Tseng, A., Cavender, G., Ross, A.and Zhao, Y. (2014 **)** Physicochemical, nutritional, and sensory qualities of wine grape pomace fortified baked goods. *J. Food Sci.* **79,** S1811–S1822

Wicklund, T., Rosenfeld, H. J., Martinsen, B. K., Sundfor, M. W., Lea, P.,and Bruun, T (2005) Antioxidant capacity and colour of strawberry jam as influenced by cultivar and storage conditions. *Food Science and Technology,* **38,** 387–391.

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تأثير صمغ الزانثان و الإنيولين كمثخنات للقوام فى إنتاج المربى

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استبدال البكتين بالبوليمرات الحيوية الطبيعية ذو الخواص الوظيفية له تاثير إيجابى فى التصنيع الغذائى. لذا تهدف هذه الدراسة إلي تقييم استخدام صمغ الزانثان والإنيولين المعدل كبوليمرات طبيعية كبدائل البكتين ومثخنة للقوام فى انتاج المربى. وقد تم تقييم الصفات الفيزيوكيماوية لثلاثة أنواع من الفواكه المختلفة فى نسبة البكتين (الفراولة , المشمش و التفاح) وتاثير استبدال تركيزات مختلفة من البكتين بصمغ الزانثان والإنيولين أو خليط منهما فى إنتاج المربى المنتجة منهم من خلال تقديرالمواد الصلبة الذائبة الكلية ، رقم الحموضة ، الحموضة الكلية، اللزوجة ، اللون ، الشبكه البكتينة والتقييم الحسى لتلك المنتجات بعد التصنيع و بعد فترة ٨ شهور من التخزين. أوضحت النتائج انخفاض قيم اللزوجة بزيادة نسبة الاستبدال للبكتين كما اثر كل من نوع المربى ونسبة استبدال البكتين على قيم اللون الفاتح (L*) , اللون الأحمر (a*)واللون الأصفر(b*). كما أوضحت النتائج عدم وجود اختلافات فى نسبة المواد الصلبة الذائبة الكلية بين كل العينات مقارنة بالعينات المرجعية لأنواع المربى الثلاثة كما أوضحت نتائج الخواص الحسية عدم وجود أى فروق معنوية فى مقاييس خاصية القوام والفرد على الخبزفى المربى المصنعة باحلال ٥٠٪ من البكتين بصمغ الزانثان، وبزيادة نسبة الاستبدال للبكتين عن ٥٠٪ زاد انخفاض جودة قوام المربى.كماأوضح التقييم الحسى أن المربى المصنعة من ٥٠٪ صمغ الزانثان و٥٠٪ إنيولين حازت على أقل درجة فى خاصيةالقوام والفرد على الخبز ويليها المربى المحتوية ٥٠٪ إنيولين. وكما حازاستخدام خليط الزانثان مع الانيولين وبكتين بنسب١:١:٢ فى إنتاج المربى على أعلى درجة فى الخواص الحسية مقارنة بالمخاليط الأخرى.ويستنتج من نتائج التخزين لمدة ٨ شهورانه يمكن استخدام ٢٥٪ من صمغ الزانثان بديلاً طبيعيا للبكتين فى إنتاج المربى التى حازت على أعلى درجة تقبل من قبل المحكمين مع الاحتفاظ بخواص وصفات القوام التى تضاهى نظيراتها للمنتجات الكاملة البكتين .