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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Fortification of Yoghurt with Xanthan Gum Biosynthesized from Grape Juice Pomace: Physicochemical, Textural and Sensory Characterization

Üzüm Suyu Posasından Biyosentezlenen Ksantan Gam ile Yoğurdun Zenginleştirilmesi: Fizikokimyasal, Tekstürel ve Duyusal Karakterizasyon

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Abstract

The impact of adding xanthan gum (0.05, 0.1 and 0.2%) biosynthesized from grape juice pomace on the physicochemical characteristics (pH, titratable acidity, total solid, water holding capacity and syneresis) of set-type yoghurt was examined during 21 days of storage period at 4 ºC in this study. Textural, color (L*, a* and b*) and sensory attributes (appearance, color, texture, taste and odor) were also assessed in samples with and without biosynthesized xanthan gum. The textural properties and water-holding capacity of the yoghurt were significantly ($p<0.05$) improved with the increase of the xanthan gum concentration. Accordingly, 0.2% of xanthan supplementation resulted in the best texture of yoghurt and obtained an average firmness of 411.52 g. The pH decrease trend was more pronounced in samples containing more than 0.1% xanthan on the first day of storage. The susceptibility to syneresis of yoghurt samples increased with the addition of xanthan gum however, there was no significant difference ($p>0.05$) between the samples at the end of storage, except for the sample with 0.2% xanthan gum. The addition of the highest concentration of xanthan gum increased the a* and b* values while decreasing the L* value ($p<0.05$). There was no significant difference ($p> 0.05$) between $BX_{0.1\%}$ and $BX_{0.2\%}$, the samples with the lowest L* value. The addition of biosynthesized xanthan had no significant effect ($p> 0.05$) on the total solid, protein and ash content of yoğurt. Besides, the biosynthesized xanthan gum had no negative impacts on the sensory characteristics of yoghurt, except for the appearance. The findings indicated that biosynthesized xanthan may be a desirable additive since it enhances the physical characteristics of yoghurt without affecting its nutritional value or sensory properties.

Key words: Yoghurt, Biosynthesized xanthan, Gum, Grape pomace, Hydrocolloid.

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Öz

Bu çalışmada, üzüm suyu posasından biyosentezlenen ksantan gam (%0.05, 0.1 ve 0.2) ilavesinin set tipi yoğurdun 4°C'de 21 günlük depolama süresi boyunca fizikokimyasal özellikleri (pH, titre edilebilir asitlik, toplam katı, su tutma kapasitesi ve sineresiz) üzerindeki etkisi incelenmiştir. Biyosentezlenmiş ksantan gam içeren ve içermeyen numunelerde tekstürel, renk (L *, a * ve b *) ve duyusal özellikler (görünüş, renk, tekstür, tat ve koku) de değerlendirilmeye tabi tutulmuştur. Yoğurdun tekstürel özellikleri ve su tutma kapasitesi, ksantan gam konsantrasyonunun artması ile beraber önemli ölçüde ($p<0.05$) iyileşmiştir. Buna göre, yoğurtta en iyi tekstür ortalama 411.52 g sertlik değeri olarak %0.2 oranında ksantan ilavesi ile elde edilmiştir. Depolamanın ilk gününde %0.1'den fazla ksantan içeren numunelerde pH düşüş eğilimi daha belirgin olmuştur. Yoğurt örneklerinin sineresiz duyarlılığı ksantan gam ilavesiyle artmış ancak depolama sonunda %0.2 ksantan gam içeren örnek dışında örnekler arasında önemli bir fark görülmemiştir ($p>0.05$). Ksantan gamın en yüksek konsantrasyonda eklenmesi yoğurdun L * değerini düşürürken a * ve b * değerlerinin yükselmesine neden olmuştur ($p<0.05$). En düşük L * değerine sahip örnekler olan $BX_{0.1\%}$ ve $BX_{0.2\%}$ arasında önemli farklılık olmadığı belirlenmiştir ($p>0.05$). Biyosentezlenmiş ksantan ilavesinin yoğurdun toplam katı madde, protein ve kül içeriği üzerinde önemli bir etkisi olmamıştır ($p>0.05$). Ayrıca biyosentezlenmiş ksantan gamın yoğurdun duyusal özellikleri üzerinde görünüm dışında herhangi bir olumsuz etkisi olmadığı belirlenmiştir. Elde edilen bulgular, biyosentezlenmiş ksantan ilavesinin yoğurdun besin değerini veya duyusal özelliklerini etkilemeden fiziksel özelliklerini geliştirdiği için arzu edilen bir katkı maddesi olabileceğini göstermiştir.

Anahtar Kelimeler: Yoğurt, Biyosentezlenmiş ksantan, Gam, Üzüm posası, Hidrokolloid.

1. Introduction

Yoghurt is a frequently consumed fermented dairy food that is recognized for its nutritional content, digestibility, and health advantages (Nguyen et al., 2017). Since it aids in lactose digestion, yoghurt made using typical yoghurt cultures (*Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus salivarius* subsp. *thermophilus*) is currently regarded as a probiotic product (Hill et al., 2014). The taste and texture of probiotic products are significant factors that affect customer preference in addition to their health advantages. Various factors, like the starter type, fermentation period, total solid and water content have an impact on the texture, which is a crucial characteristic of yoghurt quality (Vareltzis et al., 2016). However, a number of quality issues such as poor firm and texture, low viscosity and syneresis are also encountered in non-fat or low-fat yoghurts, which have recently been in high demand by consumers. Reducing fat in yoghurt also leads to sensory problems such as reduced smoothness and creamy mouthfeel, which are considered important consumer expectations (Lee and Lucey, 2010). Therefore, the desired physicochemical characteristics and sensory qualities of yoghurt are produced by adding dietary fiber, pectin, protein, and hydrocolloids in order to meet consumer expectations.

Researchers have investigated the benefits of adding various hydrocolloid stabilizers to the milk base to preserve or improve yoghurt characteristics like texture, mouthfeel, appearance, viscosity, and consistency as well as to prevent whey separation (Nguyen et al., 2017; Mohsin et al., 2019; Ghasempour et al., 2020). Apart from that, hydrocolloids have also been reported to may have prebiotic potential and antioxidant properties (Tiwari et al., 2021). The hydrocolloids must be effective at the typical pH range of 4.0–4.6 and must not change the product's natural flavor for the consumer. However, the most issue with the use of hydrocolloids is its high production cost, which is still a major problem. Therefore, the choice of hydrocolloid to be used to improve the quality of yoghurt is important.

Xanthan gum is a microbial extracellular hydrocolloid produced by aerobic fermentation by *Xanthomonas* spp and widely used in many industries as a stabilizer and thickening due to its unique properties (Şen et al., 2022). It has been found to be effective in improving the viscosity, firmness, and texture of yoghurt without altering pH and acidity values (Soukoulis et al., 2007). Hence, xanthan is also regarded as an excellent stabilizer that may be able to create curd with a larger total solid content and less syneresis without altering any sensory properties.

The production cost of xanthan gum is high due to the expensive substrates such as glucose and sucrose used as carbon sources. The main factor that raises the cost of producing xanthan gum is substrate cost, which accounts for around 30% of the overall price (Demirci et al., 2019; Bhat et al., 2022). Since more economical carbon sources are needed to reduce the raw material costs in xanthan gum production, many researchers have used alternative substrates such as waste bread (Demirci et al., 2019; Apaydın et al., 2019) or kitchen waste (Li et al., 2016), etc. for xanthan biosynthesis. However, studies on the use of biosynthesized xanthan (BX) from waste material to produce food products are very limited. Therefore, research focusing on the use of BX from waste materials to produce some food products will be of significant value as an economic step forward.

In this study, yoghurt was prepared using xanthan gum, which is biosynthesized by using pomace with high soluble carbohydrate content, which is formed as a waste in high amounts as a result of the processing of grape juice. Our earlier laboratory study reported the whole fermentation and characterisation of xanthan gum synthesized from grape juice pomace (GJP) (Şen et al., 2022). In current study, it was aimed to investigate the effect of xanthan addition produced from GJP on the physicochemical, textural and sensory properties of yoghurt.

2. Materials and Methods

2.1. Materials

Pasteurized cow milk (3.1% protein, 3.2% fat, 3.54% lactose, pH:6.97) purchased from AK Gıda (Adapazarı, Turkey). Commercial freeze-dried yoghurt starters containing *Lactobacillus delbrueckii* ssp. *bulgaricus* and *Streptococcus thermophilus* was obtained from Maysa Gıda (İstanbul, Turkey). All of the chemicals used in the study were obtained by Merck (Darmstadt, Germany).

2.2. Xanthan gum fermentation and recovery

Xanthomonas axonopodis pv. *vesicotoria* strain of xanthan gums, which in our previous study shown the best production efficiency and rheological characteristics from GJP, was used in the production of yoghurt. In our previous study, the whole preparation of inoculum and the content of the medium used in xanthan production were reported (Şen et al., 2022). GJP was used as a sole carbon source (40 g L^{-1}). The fermentation experiments were conducted at 220 rpm agitation rate, 28ºC, 7.2 pH on an orbital shaker for 72 h (Infors HT Ecotron). The fermented broth was centrifuged for 30 minutes at 4ºC and 11,000 g-force to remove the cells. For the purpose of precipitating the biopolymer, isopropanol (Merck) was added 1:3 (v/v) into the supernatant. To recover the precipitated gum, the mixture was centrifuged once more at 11,000 g for 30 minutes at 4°C after being kept at 4°C for 24 h. The precipitate was dried in an oven at 50°C until stable weight to determine the xanthan gum concentration. After that, a disk mill was used to grind the dried polymer until the granule size was 0.5 µm.

2.3. Production of yoghurts

Branded and pasteurised milk was used to make yoghurt that resembled homemade yoghurt, without using any additional milk powder. Pasteurized milk was conducted to heat treatment at 85°C 10 min in a water bath. Biosynthesized xanthan was added in accordance with the experimental plan, at concentrations of 0, 0.05, 0.1, and 0.2% respectively, and the mixture was once again heated at 55°C for 20 min and then quickly cooled in chilled 43°C. Yoghurt culture was propagated in one liter sterilized skim milk at 30°C for 30 min. The propagated culture (2.5 mL kg^{-1} milk) was inoculated into xanthan supplemented milk. The inoculated milk was later transferred to 100 g plastic containers and incubated at 42°C until the pH dropped 4.6. For subsequent testing, all of the samples were maintained at 4 ±1°C.

The total solid, pH, titratable acidity, water holding capacity (WHC) and syneresis of samples were evaluated on days 1, 7, 14, and 21 of the cold storage period. Protein, mineral (ash), texture, color and sensory properties were assessed one day after production.

2.4. Physicochemical analysis

The pH value of samples was measured with a pH meter (Interlab, Turkey) after calibration it (Eser and İnanç, 2022). The titratable acidity and total solids of yoghurt samples was assessed using the techniques described in AOAC (2000). The ash and protein content of samples were measured by the dry-ash and Kjeldahl methods, respectively (Aziznia et al., 2008). Syneresis index and WHC were analyzed according to the methods described by García-Pérez et al. (2005). The colour of the yoghurt samples was measured by a Chroma meter CR 400 (Konica Minolta Sensing, Inc., Japan), and the data were reported as L*, a*, and b*. The L* parameters indicate the degree of brightness (0–100), the a* red to green and the b* yellow to blue (García-Pérez et al., 2005).

2.5. Texture profile analysis

The texture analyzer (TA. HD. PLUS, Stable Micro Systems, Godalming, Surrey) was used to evaluate firmness, adhesiveness, cohesiveness, and gumminess index. The probe was a 25 mm acrylic cylinder moved speed of 1 mm/s and test speed of 1 mm s^{-1} through 10 mm within the sample. The data were presented as the average of three measurements.

2.6. Sensory analysis

The fifteen expert panelists conducted sensory profiling (appearance, color, texture, odor and taste) of the yoghurt samples using a 5-point hedonic scale in accordance with the procedure described by Mousavi et al. (2019). These 15 expert judges were chosen from among the lecturers and students of the Department of Food Engineering, Tekirdag Namık Kemal University, Tekirdag, Turkey.

2.7. Statistical analysis

ANOVA was used to analyze the data in JMP 5.0.1 (SAS Institute) in order to determine significant differences between means of samples and storage days. The Tukey test was used to compare various groups at $p< 0.05$, and significant differences were shown by different letters.

3. Results and Discussion

3.1. Effect of biosynthesized xanthan on total solid, pH, acidity, syneresis and WHC of yoghurt during the 21 day storage

Table 1 displays the results of total solid, post-acidification (pH), titratable acidity, WHC and syneresis during the storage period of yoghurts. As can be seen from the results of the first day of storage BX had no effect on the total solid content of yoghurt samples ($p > 0.05$). In addition, there was no significant change in the total solids of the yoghurt samples during storage.

The pH and acidity of yoghurt are crucial indicators of its quality. The texture, syneresis, and taste of the yoghurt are significantly influenced by the pH. On the other hand, post-acidification during storage could be viewed as a negative aspect by yoghurt customers. The addition of biosynthesized xanthan caused a decrease in the pH of yoghurt ($p < 0.05$). While the pH of all samples decreased up until the 14th day of storage, there was a significant increase following that day. The control group showed the lowest pH ($p < 0.05$) at the end of storage time. The addition of xanthan gum slightly increased the acidity value, but this increase was statistically insignificant ($p > 0.05$). During the storage period, the samples with added BX showed an increase in acidity values, except for the control sample. This can be interpreted as increased bacterial activity in the presence of the xanthan content. In other words, yoghurt bacteria may have shown more acid-forming activity in the presence of xanthan gum during storage. Xanthan can act as an additional carbon source, causing slightly higher acidity than the non-xanthan yoghurt sample. This result was similar to those reported by Mohsin et al. (2019), who mentioned that the acidity of yoghurt samples with xanthan increased during storage.

WHC assesses the yoghurt's ability to hold water and its resistance to whey expulsion. As shown in Table 1, the WHC values of the yoghurts ranged from 42.26 to 50.75% on the initial of storage. WHC was significantly increased by BX addition, with the highest WHC value found in a yoghurt sample containing 0.2% BX. Stabilisers strengthen the structure of yoghurt and increase its capacity to bind water, enhancing the overall texture of yoghurt. (Bulca et al., 2019). It was determined that exopolysaccharides interact with protein micelles to increase the yoghurt's ability to hold water (Yang et al., 2014). The WHC of the $BX_{0.1\%}$ and $BX_{0.2\%}$ samples significantly increased during the storage period, whereas the WHC of the control and the $BX_{0.05\%}$ samples remained constant.

Table 1. Total solid, post-acidification (pH), titratable acidity, WHC and syneresis during cold (4±1°C) storage of yoghurt samples

Parameter	Samples	1.day	7.day	14.day	21.day
Total solid (%)	C	$12.41 \pm 0.14^{A.a}$	$12.93 \pm 0.24^{A.b}$	$13.30 \pm 0.33^{A.a}$	$12.93 \pm 0.24^{A.b}$
	$BX_{0.05\%}$	$12.16 \pm 0.16^{B.a}$	$13.93 \pm 0.08^{A.a}$	$12.28 \pm 0.32^{B.ab}$	$13.93 \pm 0.08^{A.a}$
	$BX_{0.1\%}$	$11.45 \pm 0.23^{A.a}$	$11.91 \pm 0.16^{A.c}$	$11.61 \pm 0.12^{A.b}$	$11.91 \pm 0.16^{A.c}$
	$BX_{0.2\%}$	$12.40 \pm 0.09^{A.a}$	$12.53 \pm 0.08^{A.bc}$	$12.09 \pm 0.30^{A.b}$	$12.53 \pm 0.08^{A.bc}$
pH	C	$4.56 \pm 0.01^{A.a}$	$4.33 \pm 0.02^{A.a}$	$4.27 \pm 0.01^{B.a}$	$4.45 \pm 0.01^{A.d}$
	$BX_{0.05\%}$	$4.53 \pm 0.02^{A.ab}$	$4.28 \pm 0.01^{B.b}$	$3.96 \pm 0.04^{C.c}$	$4.48 \pm 0.01^{A.c}$
	$BX_{0.1\%}$	$4.48 \pm 0.00^{B.b}$	$4.29 \pm 0.01^{C.ab}$	$4.16 \pm 0.02^{D.b}$	$4.57 \pm 0.01^{A.a}$
	$BX_{0.2\%}$	$4.48 \pm 0.01^{A.b}$	$4.27 \pm 0.00^{B.b}$	$4.22 \pm 0.01^{C.ab}$	$4.51 \pm 0.01^{A.b}$
Titratable acidity (% lactic acid)	C	$2.99 \pm 0.02^{A.a}$	$3.24 \pm 0.03^{A.a}$	$3.34 \pm 0.01^{A.c}$	$3.31 \pm 0.02^{A.b}$
	$BX_{0.05\%}$	$3.12 \pm 0.02^{B.a}$	$3.47 \pm 0.02^{A.a}$	$3.69 \pm 0.02^{A.b}$	$3.59 \pm 0.02^{A.a}$
	$BX_{0.1\%}$	$3.06 \pm 0.03^{B.a}$	$3.31 \pm 0.01^{A.a}$	$3.57 \pm 0.01^{A.bc}$	$3.46 \pm 0.01^{A.b}$
	$BX_{0.2\%}$	$3.09 \pm 0.03^{C.a}$	$3.59 \pm 0.01^{B.a}$	$3.89 \pm 0.01^{A.a}$	$3.81 \pm 0.01^{AB.a}$
WHC (%)	C	$42.26 \pm 0.23^{A.c}$	$42.42 \pm 0.72^{A.c}$	$42.34 \pm 0.36^{A.c}$	$42.38 \pm 0.15^{A.b}$
	$BX_{0.05\%}$	$43.07 \pm 0.77^{A.b}$	$45.91 \pm 0.79^{A.b}$	$44.49 \pm 1.23^{A.b}$	$45.20 \pm 2.15^{A.b}$
	$BX_{0.1\%}$	$49.26 \pm 0.12^{B.b}$	$56.55 \pm 0.70^{A.a}$	$52.90 \pm 1.27^{B.a}$	$54.72 \pm 0.17^{A.a}$
	$BX_{0.2\%}$	$50.75 \pm 0.38^{C.a}$	$57.79 \pm 0.89^{A.a}$	$54.27 \pm 0.21^{B.a}$	$56.03 \pm 0.14^{A.a}$
Syneresis (%)	C	$40.29 \pm 1.38^{A.c}$	$39.29 \pm 0.55^{A.a}$	$41.01 \pm 0.10^{A.b}$	$41.66 \pm 0.23^{A.b}$
	$BX_{0.05\%}$	$47.96 \pm 0.33^{A.b}$	$40.33 \pm 0.25^{B.a}$	$42.42 \pm 0.32^{B.ab}$	$43.93 \pm 0.21^{AB.b}$
	$BX_{0.1\%}$	$48.95 \pm 0.19^{A.a}$	$41.51 \pm 0.60^{B.a}$	$44.78 \pm 0.03^{AB.ab}$	$43.87 \pm 0.29^{AB.b}$
	$BX_{0.2\%}$	$48.52 \pm 0.26^{A.a}$	$44.97 \pm 0.18^{B.a}$	$47.22 \pm 0.52^{A.a}$	$49.47 \pm 0.01^{A.a}$

C: Control. [a,b,c,d]Different lowercase superscripts in the same column depict the significant difference between the samples for the same period of storage ($p < 0.05$).
[A,B,C]Different uppercase superscripts in the same row depict the significant difference between means for same type of yoghurt sample at 1st, 7th, 14th, and 21th day of refrigerated storage ($p < 0.05$).

Xanthan addition significantly increased the yoghurt syneresis and this effect increases with the concentration of xanthan (*Table 1*). The findings are consistent with the earlier results; an increase in syneresis was noted as the concentration of xanthan was increased (Nguyen et al., 2017; Andiç et al., 2013). According to the literature, by adding different hydrocolloids, the syneresis percentage of yoghurt changed differently. For instance, whereas gelatin dramatically reduced the syneresis, other hydrocolloids (xanthan, carrageenan etc.) had the opposite effect (Nguyen et al., 2017). The interconnected protein network is strengthened by the addition of xanthan gum, but on the other hand, depleted flocculation causes more syneresis (Hemar et al., 2001). The syneresis of yoghurt samples did not differ significantly during storage time from 1 to 21 days.

3.2. Effect of biosynthesized xanthan on the protein, ash contents and colour values of yoghurt

The protein and ash content and color analysis of yoghurt formulations were measured in 1 day and the results were given in *Table 2*. The protein and ash contents of the yoghurts ranged from 3.73 to 3.81%, and 3.86–4.62%, respectively and did not significantly ($p > 0.05$) differ. The protein and ash content of the yoghurt samples fluctuated irregularly as BX levels increased, but these variations were not statistically significant ($p > 0.05$). These findings are in accordance with those of Mohsin et al. (2019), who found that the addition of the biosynthesized xanthan from orange waste and storage time had no significant effects on the protein content of the yoghurt.

Color is one of the important criteria affecting the acceptance of consumers. L*, a* and b* values of yoghurts supplemented with or without BX stored at 4°C are presented in *Table 2*. After 1 day of storage, plain control yoghurt had considerably higher L* value than BX-supplemented yoghurts ($p < 0.05$). As the added BX concentration increased (up to 0.1%), the brightness of the samples decreased, however, there was no significant difference between samples $BX_{0.1\%}$ and $BX_{0.1\%}$. All yoghurt formulations had negative a* (greenness) levels and also the addition of BX significantly increased a* value when we compared to control and BX- added samples (Table 2). The highest a* value (-1.59) was observed in the sample with 0.1% BX ($p<0.05$). Increasing BX concentration caused irregular changes on the b* value of the yoghurt samples. The addition of 0.1% BX decreased the value of b* but raised it by an additional 0.2% when compared to the control sample ($p<0.05$), whereas a 0.05% concentration had no noticeable impact ($p>0.05$). Other studies found similar trends for color values of different hydrocolloid-added yoghurts (Nguyen et al., 2017; Mohsin et al., 2019).

Table 2. Physicochemical characteristics of yoghurt samples*

Parameter	**Yoghurt samples**			
	Control	**$BX_{0.05\%}$**	**$BX_{0.1\%}$**	**$BX_{0.2\%}$**
Protein (%)	3.81 ± 0.13^{A}	3.80 ± 0.14^{A}	3.73 ± 0.04^{A}	3.80 ± 0.28^{A}
Ash (%)	3.86 ± 1.48^{A}	4.24 ± 1.14^{A}	4.62 ± 0.48^{A}	4.16 ± 0.66^{A}
*L**	91.36 ± 0.43^{A}	89.86 ± 0.40^{B}	87.96 ± 0.22^{C}	87.64 ± 0.06^{C}
*a**	-3.45 ± 0.02^{B}	-2.84 ± 0.05^{AB}	-2.58 ± 0.02^{AB}	-1.59 ± 0.08^{A}
*b**	5.83 ± 0.55^{B}	6.06 ± 0.48^{B}	4.80 ± 0.20^{C}	7.22 ± 0.12^{A}

^{A,B,C}Different superscript letters in the same row indicate significant difference ($p < 0.05$). * The results were given for 1 days.

3.3. Effect of biosynthesized xanthan on the textural characteristics of yoghurt

Texture is another crucial factor for evaluating yoghurt qualities as it directly affects sensory perception by consumers. The TPA results in *Table 3* summarize the yoghurts' textural attributes (firmness, adhesiveness, cohesiveness and gumminess). The firmness of the yoghurt increased with the addition of BX in direct proportion to the xanthan concentration ($p<0.05$) and 0.2% of xanthan supplementation resulted in the best texture of yoghurt and obtained an average firmness of 411.52 g. Similarly, the addition of xanthan in yoghurt caused an increase ($p<0.05$) in adhesiveness and the highest adhesiveness was the yoghurt sample with a concentration of 0.2%. In low pH conditions, the positively charged surface of casein micelles interacts with xanthan gum, a negatively charged hydrocolloid, to create highly structured and accessible protein networks (Sanchez et al., 2000). The improvement in texture caused by the addition of xanthan gum is in accordance with previous research (Nguyen et al., 2017; El-Sayed et al., 2002). On the contrary, the addition of xanthan reduced the gumminess of the yoghurts and this decrease was also concentration dependent ($p<0.05$). In addition, BX did not significantly affect ($p>0.05$) the cohesiveness of the yoghurt at lower concentrations (0.05 and 0.1%) while a higher level (0.2%) of BX was required to increase cohesiveness ($p<0.05$).

Table 3. Texture analyis of yoghurt samples*

Parameter	Yoghurt samples			
	Control	**$BX_{0.05\%}$**	**$BX_{0.1\%}$**	**$BX_{0.2\%}$**
Firmness (g)	$320.95±29.70^{D}$	$360.19±15.69^{C}$	$396.84±14.85^{B}$	$411.52±33.94^{A}$
Adhesiveness (g. sec)	$-1205.61±26.87^{D}$	$-1038.02±15.56^{C}$	$-494.96±43.84^{B}$	$-124.60±26.16^{A}$
Cohesiveness (g)	$0.38±0.06^{B}$	$0.34±0.01^{B}$	$0.49±0.00^{AB}$	$0.68±0.11^{A}$
Gumminess (g)	$126.12±1.41^{A}$	$119.18±0.03^{B}$	$85.88±0.01^{C}$	$56.48±0.01^{D}$

^{A,B,C}Different superscript letters in the same row indicate significant difference ($p<0.05$). * The results were given for 1 days.

3.4. Effect of biosynthesized xanthan on the sensory properties of yoghurt

Table 4 presents the sensory evaluations of all yoghurt treatments on the first day of storage at 4°C. As seen in *Table 4*, the addition of biosynthesized xanthan (BX) had no significant effects on the color, texture, odor, and taste sensory attributes of yoghurt samples ($p>0.05$). Whereas, the appearance of the yoghurt samples was significantly reduced by the addition of 0.1% and 0.2% BX ($p<0.05$). Control and $BX_{0.05\%}$ yoghurt samples scored the highest preference rating based on appearance sensory parameter, with a rating of 4.60 and 4.40, respectively ($p> 0.05$). Mohsin et al. (2019) reported that the sensorial attributes for yoghurt samples in terms of texture and appearance were significantly higher for yoghurt prepared using xanthan ($p<0.05$) while non-significant difference was found in aroma, taste and flavor of the yoghurt samples.

Table 4. Sensorial attributes of yoghurt samples*

Characteristic	Yoghurt samples			
	Control	**$BX_{0.05\%}$**	**$BX_{0.1\%}$**	**$BX_{0.2\%}$**
Appearance	$4.60±0.55^{A}$	$4.40±0.55^{A}$	$3.40±1.34^{AB}$	$2.40±1.14^{B}$
Color	$4.80±0.45^{A}$	$4.60±0.55^{A}$	$4.40±0.55^{A}$	$4.60±0.55^{A}$
Texture	$3.80±1.30^{A}$	$3.60±1.34^{A}$	$3.65±1.34^{A}$	$3.70±1.30^{A}$
Odor	$4.20±1.30^{A}$	$4.40±0.89^{A}$	$4.80±0.45^{A}$	$4.80±0.45^{A}$
Taste	$3.60±1.14^{A}$	$3.10±1.41^{A}$	$3.20±0.84^{A}$	$3.00±0.71^{A}$

^{A,B,C}Different superscript letters in the same row indicate significant difference ($p < 0.05$). * The results were given for 1 days.

4. Conclusions

In this study, the utilization strategy of using biosynthesized xanthan from grape juice pulp, which is a waste material, was adapted for the preparation of yoghurt. The incorporation of xanthan gum (0.05–0.2%), a novel stabilizing agent biosynthesized from grape juice pomace, in yoghurt caused some changes in physicochemical properties. These changes in physicochemical properties were more pronounced, especially when high concentrations of BX (0.1 and 0.2%) were added. The addition of BX had no significant effect on the total solid, protein and ash content of yoğurt ($p>0.05$). Yoghurt's physical characteristics were improved by BX, which increased firmness and WHC while reducing gumminess. Although the addition of xanthan increased the syneresis on the first day of storage, only the $BX_{0.2\%}$ sample had a significantly higher syneresis value than the other samples

after 21 days of storage. Our findings show that, except for appearance, the BX had no adverse effects on the sensory qualities of yoghurt. In conclusion, BX can be a promising alternative to use as a low-cost hydrocolloid by improving the physical properties of yoghurt without changing its nutritional and sensory properties.

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