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Studying of Physicochemical and Sensory Properties of Reduced Fat Yogurt Manufactured by Adding Beta-Glucan of Barley

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Abstract

The current study was conducted and aimed to determine the effect of using beta-glucan extracted from flour of barley as a replacer for fat on the physiochemical and sensory properties of fat free low energy yogurt by adding beta-glucan to bovine skimmed milk in different ratio of 0.1, 0.2, 0.3 and 0.4% represented by the treatments T1, T2, T3 and T4 respectively, in addition to positive control treatment C^+ which made from whole milk and negative control C^- treatment in which the yogurt was made from the skimmed milk without beta-glucan. The chemical properties included estimating the percentage of moisture, protein, fat, carbohydrates, ash and non-protein nitrogen, while the physical properties included total acidity, pH, viscosity, spontaneous whey separation and water holding capacity, in addition to sensory evaluation it was estimated immediately after manufacturing and during storage at (5±1) Cº for 21 days. The results showed that the non-fat yogurt treatments were distinguished by their high moisture content compared to the positive control treatment and during storage a slight decrease in the moisture values was observed for all treatments. Protein percentage , non-protein nitrogen and pH values were non-significant differences for all treatments. The addition of beta-glucan improved the rheological characteristics of yogurt, such as viscosity, spontaneous whey separation and water holding capacity, and also improved the sensory evaluation properties of free fat yogurt, especially the treatment with an addition rate of 0.4% of beta-glucan.

Keywords: Beta-glucan, Skimmed milk, Yogurt, Water holding capacity.

Part of M.Sc. thesis of the 1st author.

Introduction

The idea that said foods that have health-promoting benefits that raise their nutritional value has been increasingly accepted in recent years, as certain nutrients have shown a major role in preventing many diseases until the discovery of functional foods (Butnariu and Sarac, 2019). Increasing people's awareness of physical fitness and a healthy lifestyle has led to an increased demand for low-energy or low-calorie foods, especially free fat or low-fat (Nikoofar *et al.*, 2013). It is believed that animal saturated fat is the main factor responsible for increasing

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cholesterol levels in the blood, and that high cholesterol and LDL (low density lipoprotein) in the blood is one of the risk factors that contribute to the development of cardiovascular and other metabolic diseases. Fats or the use of fat mimetic in the diet is an effective strategy to reduce the risk of developing cardiovascular disease (Chen *et al.*, 2020). Fats play an essential role in food, as they are the main contributor to highlighting flavor, texture, and quality of consistency, studies have indicated that removing fat from dairy products negatively affects the texture, and in such cases the problem of deterioration of texture emerges (Hakim *et al.*, 2016). Therefore, researchers tended to add some materials as fat replacers called fat mimetic, which improve the rheological characteristics of products, fat replacers have a chemical composition differs from the chemical composition of fats, but they have similar physical characteristics to fats. The fat mimetic is either from a carbohydrate source such as beta-glucan, inulin and microcrystalline cellulose, or from a protein source such as sodium caseinate, whey protein concentrates or isolates, or from a fat source such as oleistra (Food Safety Network, 2014).

Materials and methods

Source of milk and beta-glucan

Raw bulk milk which used in the manufacture of positive control treatment supplied by the dairy plant - College of Agricultural Engineering Sciences - University of Baghdad, as well as the 0.0% fat-free skimmed dry milk available in the local markets of Baghdad. Brand Regalia, French origin it was used in manufacturing of yogurt treatments. beta-glucan, was obtained from barley flour (Local class) by aqueous extraction method, the starter which used in yogurt manufacturing Danisco ,French origin.

yogurt Manufacturing

Manufacturing of yogurt was done according to the method used by Tamime and Robinson (1999) and as following: Bulk milk was received from the Dairy Factory - College of Agricultural Engineering Sciences – University of Baghdad and was used in the manufacture of positive control treatment C^+ after adjusting the percentage of total solids to 14% using skimmed milk type Regalia and homogenized, while skimmed milk brand Regalia was a recovery as 1:9 and divided into two parts, the first leaving without any treatment and used in manufacturing negative control treatment C^-, while the second was divided into four parts, to which the beta-fat replacer was added in proportions 0.1, 0.2, 0.3 and 0.4% represented by the treatments T1, T2, T3 and T4 respectively. Then all yogurt treatments was heated at 90Cº for 10 minutes, after that it wa cooling to 42Cº and inoculated with the starter consisting of *Streptococcus Salivarius* Subsp thermophilus and *Lactobacillus delbrueckii* Subsp *bulgaricus* in direct addition and in the quantity indicated by the producing company and packed in plastic containers of 100 ml and incubated at 42 ± 2 Cº until coagulation is complete, within 4.5 hours until the pH reached to 4.6, then it is removed from the incubator and transferred to the refrigerator for cooling and

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preservation at 5 ± 1 Cº until the necessary tests are carried out after 1, 3, 7, 14 and 21 days of storage.

Chemical and physical tests of yogurt

The moisture content was estimated according to A.O.A.C (2005). ash, was estimated by the direct burning method described in A.O.A.C (2008) and the non-protein nitrogen (NPN) according to the method mentioned by Ling (2008).total nitrogen content was measured by kjeldahls method AOAC(1980)protein content in samples determined by multiplying nitrogen with constant factor 6.38 .Fat percentage was estimated by Kerber's method (2008), while carbohydrates were calculated by difference method according to what was mentioned by Ihekoronye and Ngoddy (1985), and the total titrable acidity and pH were estimated according to A.O.A.C (2008).

Viscosity estimation:

The apparent viscosity of the yogurt samples were estimated at 10 Cº after 1, 3, 7, 14 and 21 days of refrigerated storage using Mry-VR3000 viscometer supplied by the company (Mry-VR3000 Engineering Lab Inc, Stoughton, Mass), using the axial spindle No. 4, with a number of 10 recycle / minute (Donkor et al., 2007).

Water holding capacity (WHC)

The water holding capacity was estimated by exposing 10 gm of the yogurt sample to a centrifugal force at a speed of 3000 xg for 60 minutes at a temperature 10 Cº, after h the filtrate was removed and the weight of the remaining sediment was calculated WHC calculated according to Parnell-Clunies,. *et al*.(1986) as a fallow-

WHC%= (The weight of the precipitate / The weight of original sample) *100

Spontaneous Whey Separation

Spontaneous whey separation was determined by using method described by (Amatayakul et al., 2006). 50 ml of yogurt was placed in a bowl diagonally at an angle of 45º for two hours at 5 Cº, then the supernatant was removed from the surface using a syringe and then the bowl re-weighing and the operation was performed within a period of 10 seconds to avoid excessive perfusion .

Sensory evaluation of yogurt

Sensory tests of yogurt samples were conducted in the Department of Food Sciences - College of Agricultural Engineering Sciences by a number of professors with specialization in accordance with the sensory evaluation form developed by Nelson and Trout (1964).

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Statistical analysis

The software Statistical Analysis Method- SAS (2012) was used .

Results and discussion

Chemical composition and physical properties of low-energy functional yogurt with beta-glucan fat substitute

Table 1 shows the chemical composition of the yogurt made from whole milk, the positive control yogurt C^+, the yogurt made from fat free milk without any addition, the negative control C^- yogurt, and the treatments made from fat free milk, beta-glucan, were added by following proportions: 0.1 and 2.0, 0.3 and 0.4% represented by the treatments T1, T2, T3 and T4, respectively, immediately after manufacture and during storage at a temperature (5±1) Cº for a period of 21 days.

The percentage of Moisture

Table 1 shows the percentage of moisture for positive and negative control C^+ and C^- treatment and the different yogurt treatments with beta-glucan T1, T2, T3 and T4. The value of moisture immediately after manufacturing for treatment C^+ is 87.01%, and this result is consistent with what Sadiq (2019) for yogurt made from whole milk, amounting to 87.02%,but the result differed with Sheikh (2018) which was 86.01%.while for C^- was higher compared to C^+ , reaching 89.20%. This result is similar to what Al-Badrani (2016) found for fat-free yogurt of 89.00%, the reason for this increase was belonged to the lack of total solids due to the reduction of fat, and this is consistent with what was found by Madadlou *et al.* (2005). The moisture content of fat-free yogurt treatments with beta-glucan was 88.97, 88.90, 88.72 and 88.63%, respectively. A slight decrease in the percentage of moisture occurred with the advancement of the storage period for all yogurt treatments, the values after 21 days of storage at (5±1) Cº for the C^+ and C^- are 86.57 and 88.47%, respectively. And for treatments with beta-glucan were 88.33, 88.90, 88.28, and 88.13%, respectively. This result is agreed with what Qureshi *et al.*, (2011) found, which indicated a decrease in the moisture content of the yogurt from 84.78 to 84.65% during cold storage. The results of the statistical analysis indicate that there was no significant differences ($P \leq 0.05$) in the percentage of moisture between the different treatments at the end of the 21 day cold storage period.

Percentage of protein

Table 1 shows the percentages of protein in yogurt for C^+ and C^- and the fat free yogurt treatments with beta-glucan T1, T2, T3 and T4, as immediately after manufacturing for treatment C^+ was 4.28% this result is agreed with what Sadiq (2019) found for yogurt made from 4.21% whole milk. While for C^- was 4.62%, which is close to what Al-Badrani (2016) found for fat free yogurt it was 4.56%, while for the treatments with beta-glucan were 4.51, 4.51, 4.38 and 4.32%,

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respectively. from the results of the statistical analysis there was no significant differences ($P \leq 0.05$) in the percentage of protein immediately after manufacturing between all treatments. While during storage the percentage of protein was increased for all treatments, so the values after 21 days of manufacturing the values for C^+ and C^- were 4.40 and 4.83%, respectively. And for the treatments with beta-glucan, were 4.66, 4.66, 4.45 and 4.43%, respectively, this result is agreed with Qureshi et al., (2011) he indicated an increase in the protein content in yogurt treatments from 4.76 immediately after manufacturing to 4.80. At the end of the 15 days storage period, the results also agreed with what Al-Badrani (2016) found, which indicated an increase in the protein content in yogurt treatments from 4.34% immediately after manufacturing to 4.44% at the end of the 14 days storage period, the reason for the high protein content may belonged to the decrease in the moisture content, which led to the high percentage of total solids, including protein. The results of the statistical analysis indicate that there are no significant differences ($P \leq 0.05$) in protein percentage between different yogurt treatments immediately after processing and during the storage period of 21 days.

Table 1: Chemical analysis of the treatment of positive and negative control yogurt and fat free yogurt to which different percentages of beta-glucan have been added during storage at a temperature of (5±1) Cº for a period of 21 days.

Treatment	Storage period (days)	Humidity %	Protein %	Fat %	Carbohydrates %	Ash %	NPN
C^+	1	87.01	4.28	3.73	4.43	0.55	0.0221
	3	86.93	4.31	3.76	4.42	0.58	0.0227
	7	86.81	4.33	3.82	4.37	0.62	0.0243
	14	86.64	4.36	3.87	4.33	0.73	0.0273
	21	86.57	4.40	3.90	4.30	0.81	0.0296
C^-	1	89.20	4.62	0.183	5.73	0.59	0.0312
	3	88.94	4.65	0.191	5.71	0.64	0.0317
	7	88.87	4.70	0.221	5.67	0.72	0.0354
	14	88.61	4.79	0.243	5.63	0.83	0.0371
	21	88.47	4.83	0.256	5.60	0.95	0.0383
T1	1	88.97	4.51	0.157	5.65	0.58	0.0333
	3	88.90	4.54	0.158	5.83	0.64	0.0363
	7	88.79	4.59	0.159	5.81	0.72	0.0348
	14	88.56	4.62	0.160	5.79	0.90	0.0362
	21	88.33	4.66	0.161	5.70	0.92	0.0367
T2	1	88.90	4.51	0.156	5.90	0.60	0.0313
	3	88.87	4.51	0.156	5.95	0.62	0.0318
	7	8874	4.54	0.157	5.93	0.65	0.0348
	14	88.45	4.61	0.161	5.90	0.90	0.0367
	21	88.90	4.66	0.163	5.88	0.94	0.0318
T3	1	88.72	4.38	0.157	6.45	0.64	0.0261
	3	88.63	4.35	0.157	6.42	0.65	0.0263
	7	88.50	4.41	0.158	6.31	0.81	0.0271
	14	88.31	4.43	0.160	6.26	0.92	0.0284
	21	88.28	4.45	0.161	6.24	0.97	0.0295

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T4	**1**	**88.63**	**4.32**	**0.157**	**6.51**	**0.65**	**0.0250**
	3	**88.56**	**4.33**	**0.157**	**6.48**	**0.60**	**0.0258**
	7	**88.34**	**4.39**	**0.158**	**6.27**	**0.85**	**0.0273**
	14	**88.27**	**4.41**	**0.159**	**6.19**	**0.90**	**0.0289**
	21	**88.13**	**4.43**	**0.160**	**6.11**	**0.99**	**0.0299**
LSD Value	—	**4.78 NS**	**0.702 NS**	**1.018 ***	**1.85 ***	**0.492 NS**	**0.0108 NS**

Each number in the table represents a mean of two replicates. *(P≤0.05) significant difference. NS (no significant difference).

Fat percentage

Table 1 shows the percentage of fat in yogurt from the various treatments mentioned previously, the percentage of fat immediately after manufacturing for C^+ was 3.73%, and this result is agreed with what Sheikh (2018) found, who indicated that the percentage of fat in yogurt made from whole milk was 3.70%. while for C^-, it was significantly low 0.183% compared to C^+ . The percentage of fat in yogurt treatments with beta-glucan were 0.157, 0.156, 0.157 and 0.157%, respectively. The results showed a significant differences (P≤0.05) in the fat percentage immediately after manufacturing between C^+ and all yogurt treatments. also the results showed differences in fat percentage between treatments with beta-glucan and C^- this may be due to increased in the total solid when fat replacers beta-glucan was added to the free fat yogurt. While during storage, there has been an increase in the percentage of fat in yogurt for all treatments, so the values after 21 days of manufacturing for treatment C^+ and C^- are 3.90% and 0.256% respectively. And for treatments with beta glucan, 0.161, 0.163, 0.161 and 0.160%, respectively. The reason for the increase in fat percentage is due to the decrease in the moisture content, which led to an increase in the percentage of total solids including fat.

The percentage of carbohydrates

Table 1 shows carbohydrate percentage of the different treatments mentioned above, the carbohydrates value immediately after manufacturing for C^+ was 4.43%, this agreed with what Sengupta (2014) which found that the percentage of carbohydrates in full fat yogurt is 4.47%. However, this result differs from what Sheikh (2018) found, who indicated that the percentage of carbohydrates to full fat yogurt was 5.60%. while the value for C was 5.73%. and for treatments with beta-glucan were 5.65, 5.90, 6.45 and 6.51% respectively. from the results of statistical analysis showed that there was a significant differences (P≤0.05) in the percentage of carbohydrates between treatment C^+ and all other treatments immediately after manufacturing. It is also noticed that there is an increase in the percentage of carbohydrates with an increase in the amount of percentage of beta-glucan which added , this results was agreed with the results of Al-Badrani (2016), which indicated an increase in the percentage of carbohydrates with the increase in the added percentages of fat replacers. It is also noticed that the percentage of carbohydrates decreased with the advancement of the storage period for all treatments, so the values after 21 days it was for C^+ and C^- were 4.30 and 5.60%, respectively. and for the treatments of yogurt with beta-glucan, were 5.70, 5.88, 6.24 and 6.11%, respectively. The reason for this decrease is

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due to the activity of the starter bacteria, which convert the sugar lactose into lactic acid, and this is agreed with what Yilmaz-Ersan et al, (2014) found, which indicated a decrease in the proportion of carbohydrates in therapeutic yogurt from 4.42% to 4.07% during the storage period. 25 days, and also agreed with what was reached by Sadiq (2019) regarding a decrease in the percentage of carbohydrates in yogurt fortified with iron coated when refrigerated storage for 21 days. The results of the statistical analysis ($P \leq 0.05$) also indicate that there are a significant differences in the percentage of carbohydrates at the end of the storage period of 21 days between the positive control treatment C^+ and all other treatments.

The percentage of ash

The results shown in Table 1 show the ash percentage in the different yogurt treatments mentioned above, the ash percentage immediately after manufacturing for the C^+ was 0.55%, and this result is not agreed with what Stijepic et al. (2013) found, who indicated that the ash percentage in the treatment of yogurt made from whole milk was 0.70 while for C^- was 0.59%, and it is noted that the percentage of ashes of this treatment is higher compared to the treatment C^+. The reason for this is due to the composition of milk used in the manufacture of yogurt, by removing the fat, the moisture and protein ratios are raised, and the high moisture content may cause an increase in the amount of dissolved mineral salts, which leads to an increase in the proportion of ash compared to the treatment of full fat yogurt (Madadlou et al., 2005). the ash percentage of the treatments with beta-glucan was 0.58, 0.60, 0.64, and 0.65%, respectively, no significant differences ($P \leq 0.05$) in the percentage of ash between all yogurt treatments immediately after manufacturing. Also, an increase in the percentage of ash occurred with an increase in the percentage of beta-glucan fat substitute, and this is agreed with what Al-Badrani (2016) found, which indicated an increase in the percentage of free fat yogurt ashes by increasing the added percentages of fat replacers. from the same table ash contents was increased during storage at (5±1) C° for all treatments. The values after 21 days for C^+ and C^- were 0.81 and 0.95%, respectively. And for treatments with beta-glucan were 0.92, 0.94, 0.97 and 0.99%, respectively. there are significant differences in ash percentage within treatment during storage.

Change in the yogurt content of non-protein nitrogen (NPN)

Table 1 shows the percentage of non-protein nitrogen for all yogurt treatments immediately after manufacturing, percentage of C^+ and C^- were 0.0221 and 0.0312% respectively, and for the yogurt treatments with fat replacers were 0.0333, 0.0313, 0.0261, and 0.0250% respectively. no significant differences ($P \leq 0.05$) in these percentages between all treatments, these percentages increase during storage, so the values after 21 days for treatment C^+ and C^- were 0.0296 and 0.0383% respectively, and for treatments with beta-glucan were 0.0367, 0.0318, 0.0295, and 0.0299% respectively, The reason for the high values of non-protein nitrogen during storage due to the action of the protease enzymes produced by the starter bacteria. Although pasteurization treatment killed psychrotrophic bacteria but cant destroyed enzymes produced by it this enzymes resistant high temperature up to sterilization (McSweeney and Patrick, 2013).

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Physical properties of functional, low-energy yogurt with beta-glucan fat replacer

pH

The results in table 2 indicate the pH values of the different yogurt treatments immediately after manufacturing for the C^+ was 4.60, this results was agreed with Ibrahim (2015) it was 4.59, while for the C^- treatment it was 4.50. It is noticeable that the pH values for treatment decreased compared to the treatment C^+, this is agreed with what Al-Badrani (2016) found, who indicated a decrease in the pH value of the treatment of free fat yogurt compared to the treatment of full fat yogurt. As for the yogurt treatments with added beta-glucan, they were 4.57, 4.56, 4.56 and 4.55 respectively. It is noticed from the results of the statistical analysis that there were no significant differences ($P \leq 0.05$) in the pH values immediately after manufacturing between the different treatments. While during storage, the pH values decreased for all treatments, so the values after 21 days for treatment C^+ and C^- were 4.30 and 4.27 respectively, and for the treatments with beta-glucan 4.31, 4.31, 4.30 and 4.28 respectively, and this corresponds to what Pappa et al , (2018) which indicated a decrease in the pH value of yogurt treatments with beta-glucan from 4.29 to 4.26 during the storage period of 21 days. This remarkable decrease in the pH value is due to the continuous fermentation of lactose into lactic acid. The results of the statistical analysis indicate that there are no significant differences ($P \leq 0.05$) in pH values between different yogurt treatments during Storage period of 21 days.

Total acidity

The results shown in table 2 show the titrable acidity values (calculated as lactic acid) for different treatments, immediately after manufacturing for treatment C^+ were 0.88%, this is agreed with Al-Badrani (2016) found 0.90%. and for C^- was 0.96%. The results show an increase in the titrable acidity values of all treatments during storage, the values after 21 days for the C^+ and C^- was1.09 and 1.23% respectively, as well as for yogurt treatments with beta-glucan 1.10, 1.11, 1.12 and 1.15%.this results was in agreement with what was found by (Kaur and Riar, 2020), whom indicated an increase in the acidity rate in the yogurt treatments from 1.22% for the control treatment to 1.41% for the yogurt treatment containing 2% beta-glucan and there were no significant differences ($P \leq 0.05$). Acidity within yogurt samples containing different concentrations of beta-glucan within the storage period of 14 days, the increase in acidity in yogurt models containing beta-glucan may be due to the effect of beta-glucan in increasing the production of acetic acid and propionic acid (Nikoofar et al., 2013). The results of the statistical analysis indicate that there was no significant difference ($P \leq 0.05$) in the acidity percentage between all treatments immediately after manufacturing and during storage period of 21 days.

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Table 2: Physical and rheological properties of the positive and negative control treatments, and the fat-free treatments with beta-glucan addition in different proportions during the period of 21 days at a temperature of (5±1) C°.

Treatment	Properties			
	Storage period (days)	**pH**	**Acidity%**	**Spontaneous whey separation (50gm/ml)**
C⁺	1	4.60	0.88	1.22
	3	4.52	0.94	1.11
	7	4.48	0.99	5.20
	14	4.35	1.06	4.85
	21	4.30	1.09	4.70
C⁻	1	4.50	0.96	8.50
	3	4.47	0.99	7.90
	7	4.36	1.07	7.25
	14	4.31	1.19	7.20
	21	4.27	1.23	7.00
T1	1	4.57	0.91	1.50
	3	4.52	0.93	1.30
	7	4.46	0.99	4.65
	14	4.35	1.09	4.62
	21	4.31	1.10	4.53
T2	1	4.56	0.91	1.45
	3	4.50	0.95	1.25
	7	4.42	1.01	3.25
	14	4.35	1.06	3.10
	21	4.31	1.11	3.00
T3	1	4.56	0.90	1.27
	3	4.50	0.95	1.13
	7	4.41	1.01	1.44
	14	4.33	1.07	1.37
	21	4.30	1.12	1.32
T4	1	4.55	0.91	1.20
	3	4.51	0.95	1.10
	7	4.38	1.00	1.33
	14	4.33	1.05	1.30
	21	4.28	1.15	1.27
LSD Value	—	0.448 NS	0.318 NS	2.603 *

Each number in the table represents a mean of two replicates. *(P≤0.05) significant difference. NS (no significant difference).

The rheological characteristics of low-energy functional yogurt with added beta-glucan lipid substitute

Viscosity

viscosity is an important factor in determining the quality of yogurt, which is closely related to both the stability of the fermented milk product (Lewis, 1996). According to Rawson and

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Marshal (1997), *Streptococcus Salivarius Subspp. Thermophilus* play a major role in the production of texture which are from the outer cell products called exopolysaccharides and interfere with the protein content of milk and increase its viscosity and improve its quality properties, the results in fig. 1 show that the values of viscosity immediately after manufacturing for C^+ was 1565 cP, and for C^- was 1315 cP, these results indicating a significant differences between the two treatments. The reason belonged to removing the fat leads to a decrease the viscosity as a result of increased in moisture content in C^- , the viscosity values for yogurt with beta-glucan, it increased with the increase in percentage of adding, 1610, 1625, 1630 and 1660 cP respectively, this results consist with Al-Badrani (2016) while during storage the viscosity was increased for all treatments after 21 days for the C^+ and C^- treatments, was 2025 and 1790 cP respectively, and this is agreed with what Al-Badrani (2016) found, which indicated an increase in the viscosity values of the positive and negative control treatments after storage for 14 days. The reason for this may be due to the decrease in the pH of the yogurt, which leads to an increase in its hardness and consequently an increase in its viscosity (Walstra et al., 2005). while for the treatments of yogurt with beta-glucan was 2030, 2020, 2015 and 2015 cP respectively, and this is agreed with what Pappa et al., (2018) .

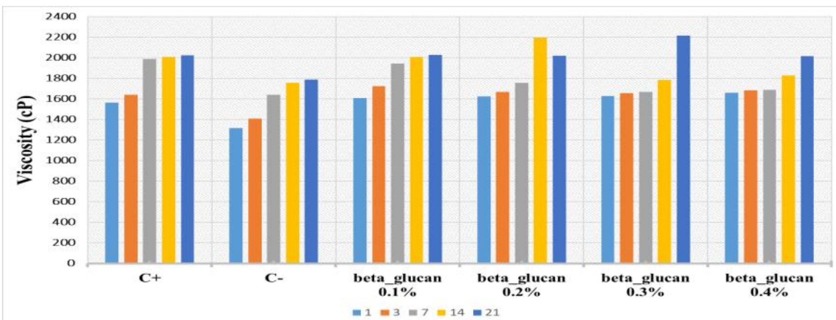

Figure 1: Viscosity values of treated yogurt samples

Spontaneous whey separation

Spontaneous whey separation is defined as the appearance of whey on the jelly surface of the yogurt, which occurs automatically without the influence of any external force and is considered an important defect of the yogurt (Kaur and Riar, 2020). The spontaneous whey separation in yogurt is an undesirable characteristic due to the lack of holding of the water by the protein network, either due to the lack of solids or due to insufficient heating or a lower pH than 4.4 (Konhorst, 2007). The results shown in table 2 show the quantities of fresh whey for the different yogurt treatments mentioned previously, as the treatment C^+ and C^- immediately after manufacturing were 1.22 and 8.50 ml / 50 ml respectively, and the yogurt treatments with beta-glucan were 1.50, 1.45, 1.27 and 1. 20 ml / 50 ml respectively, the quantities of exuded whey from the treatments with beta-glucan was less than it is in C^-, because the removal of fat, this caused the increase in the moisture content and the decrease of total solids for this treatment, and the amount of whey exuded increased. It is also noted that the rate of whey separation decreases

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with an increase in the added percentage of the beta-glucan, and this is agreed with what Kaur and Riar (2020). This may be due to the high molecular weight of beta-glucan, which improved the water holding capacity of the yogurt and prevented the excretion of the whey to the surface (Zhao et al., 2015). A decrease in the quantities of whey exuded with storage is observed, and this is agreed with what Çelik (2007), who indicated a decrease in the percentage of whey separation of yogurt from 55.8% on the first day to 51.3% on the 21th day of storage due to the metabolic activity of the starter bacteria and to the decrease in net pressure. Within the protein matrix, which reduces perfusion (Guler-Akin and Akınm, 2007). The values after 21 days for treatment C^+ and C^- were 4.70 and 7.00 ml / 50 ml respectively, and for yogurt with beta-glucan were 4.53, 3.00, 1.32 and 1.27 ml / 50 ml respectively, the results of the statistical analysis indicated that there was a significant difference ($P \leq 0.05$) between the negative control treatment and the treatments with beta glucan immediately and during the storage period of 21 days.

Water holding capacity (WHC)

Syneresis is an important characteristic for determining the quality of yogurt and fermented milk. It leads to the separation of whey during storage due to the contraction of the casein gel network, thus it becomes in the form of a crack layer visible on the surface of the yogurt and negatively affects consumer perception (Vanegas-Azuero and Gutiérrez, 2018). Figure 2 shows the values of water retention percentages for the different yogurt treatments mentioned in it, and it is clear from them that the water holding capacity for treatment C^+ immediately after manufacturing was 29.27%. Directly, it is 31.1% for the treatment C^-, and it reached 19.00%, and this is agreed with what Al-Badrani (2016) who found that the water holding for the manufactured yogurt from skimmed milk reached 18.90%, while WHC for yogurt with beta-glucan immediately after manufacturing were 25.27 and 27. 31, 32.50 and 33.41% respectively, it was increased with increased in percentage of beta-glucan addition , we also find that the ability to hold water is affected by the storage periods , it increased with in all treatments with increased in storage periods, the values after 21 days for treatment C^+ and C^- were 38.38 and 19.93% respectively, and for yogurt treatments with beta-glucan 26.23, 34.83, 35.21 and 35.39%. the results of the statistical analysis show a significant differences ($P \leq 0.05$) between the positive control treatment and all treatments containing beta-glucan.

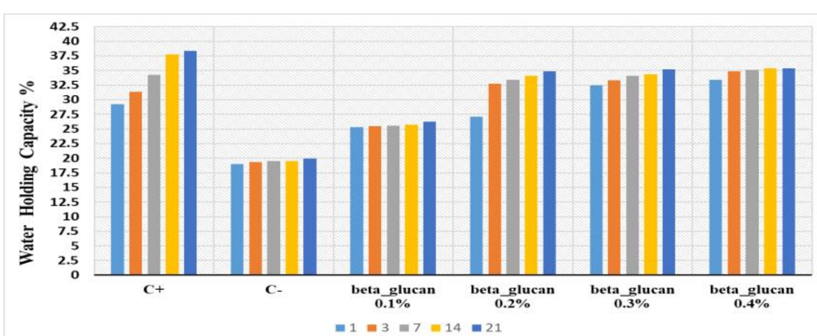

Figure 2: Water Holding Capacity (WHC) of yogurt samples.

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Sensory evaluation

The sensory evaluation for all yogurt treatments was summarized in Table 3 the parameters that mentioned, flavor, consistency, color, whey separation and appearance positive control C^+ treatment get the greater scores at the first day of manufacture 97.2 compared to C^- 69.5 this due to the role of the fat in imparting good and desired characteristics such color, taste, flavor and texture , the treatments with beta-glucan get a total of scores for T1, T2, T3 and T4 as 82.4, 89.7, 94.7 and 96.6 respectively, It is evident from the results that beta-glucan has a clear role in preserving the sensory characteristics of the yogurt. In direct proportion to the increase in the percentage of beta-glucan added, treatment T4 with 0.4% beta- glucan, are very close to the characteristics of the positive control this agreed with what Kaur and Riar (2020), they indicate that average general acceptance increases with the ratio of beta-glucan which added to yogurt . while at the end of the storage period 21 days, the degrees of sensory evaluation for C^+ and C^- were 68.9 and 50.6 respectively, and for the yogurt parameters with added beta-glucan were 55.4, 67.8, 72.7 and 75.9 respectively. the results showed that treatment C^- get the lowest scores of evaluation compared to all yogurt treatments, and T4 get the highest score over all the parameters immediately after the first day of manufacture and through the storage period of 21 days. The results of the statistical analysis indicate that there was a significant difference ($P \leq 0.05$) between the negative control treatment and the other yogurt treatments also there are significant differences in the sensory evaluation scores between the different time periods within the same treatment.

Table 3: The results of the sensory evaluation of the positive and negative control treatment, and the fat-free treatments with different percentages of beta-glucan added during storage at a temperature of (5±1) C° for 21 days.

Treatment	Storage period (days)	Flavor 45°	Texture and consistency 25°	color 10°	Whey separation 10°	Appearance 10°	Total 100°
C^+	1	43.5	23.8	9.5	9.4	10	97.2
	3	38.7	20.5	7.6	9.5	9.1	85.4
	7	36.5	17.3	7.3	7.8	8.4	77.3
	14	34.4	16.5	7.0	7.4	7.9	73.2
	21	32.6	15.9	6.5	6.7	7.2	68.9
C^-	1	32.25	16.25	8.0	6.0	7.0	69.5
	3	30.0	15.75	7.5	6.7	6.7	66.7
	7	28.5	13.87	6.9	6.7	6.0	61.9
	14	26.8	11.3	6.3	5.6	5.7	55.5
	21	24.5	9.8	6.0	5.1	5.2	50.6
T1	1	36.3	19.5	8.1	9.3	9.2	82.4
	3	33.5	18.2	8.0	9.2	7.6	76.5
	7	30.0	15.7	6.3	8.3	6.4	66.7
	14	27.3	13.7	5.1	8.0	6.2	60.3
	21	25.1	12.5	4.9	7.1	5.8	55.4
T2	1	39.6	22.0	9.0	9.4	9.7	89.7
	3	38.0	19.1	8.6	9.2	8.0	82.9
	7	33.0	17.5	8.0	7.1	8.6	74.2
	14	31.8	17.1	7.8	5.9	8.4	71.0
	21	30.7	16.7	7.2	5.4	7.8	67.8

T3	**1**	**41.3**	**24.0**	**9.6**	**9.8**	**10**	**94.7**
	3	**39.5**	**21.8**	**8.6**	**9.6**	**9.0**	**88.5**
	7	**37.3**	**19.3**	**7.6**	**8.6**	**9.1**	**81.9**
	14	**35.8**	**18.5**	**7.4**	**7.3**	**8.6**	**77.6**
	21	**33.9**	**17.1**	**7.1**	**6.8**	**7.8**	**72.7**
T4	**1**	**42.5**	**24.5**	**9.6**	**10**	**10**	**96.6**
	3	**40.9**	**22.6**	**9.2**	**9.9**	**9.3**	**91.9**
	7	**38.5**	**19.1**	**8.4**	**7.6**	**9.5**	**83.1**
	14	**37.3**	**18.5**	**7.9**	**7.5**	**9.0**	**80.2**
	21	**35.9**	**17.8**	**7.4**	**6.9**	**7.9**	**75.9**
LSD Value	**—**	**5.29 ***	**3.88 ***	**1.82 ***	**2.65 ***	**2.04 ***	**8.19 ***

Each number in the table represents a rate of two duplicates. *(P≤0.05) significant difference.

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