USING CELLULOSE GUM TO IMPROVE THE PHYSICOCHEMICAL, RHEOLOGICAL, AND SENSORY PROPERTIES OF LOW-FAT MOZZARELLA CHEESE

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ABSTRACT

This study was aimed to investigate the potential of cellulose gum as a substitute for fat in Mozzarella cheese production and evaluate its impact on the cheese's physicochemical, rheological, and sensory properties. Cellulose gum was added in different ratios of 0.1, 0.2, 0.3, 0.4, and 0.5%, revealing treatments A_1, A_2, A_3, A_4, and A_5 to skimmed milk, respectively. As well as the positive control treatment C+ manufactured from whole milk, there is a negative control treatment C- made from skimmed milk without cellulose gum. After processing, several tests were conducted to determine the quality of the product. Chemical tests were carried out to measure moisture, protein, fat, lactose, and ash and total acidity percentage. Physical tests were also conducted, including, pH, compression, and elasticity measurements. In addition, sensory evaluations were conducted immediately and after 120 days of storage at (5 ± 1) º C. The results revealed that the cellulose gum treatments contained a higher moisture content than C+ and C- recorded at 48.13 and 50.40 %, respectively. In comparison, it varied from 56.85 to 55.00 % for cellulose gum treatments A2 (the best treatment in sensory properties). During 120 days of storage at (5±1)ºC, all treatment values significantly reduced moisture content. Fat content increased significantly in all cellulose gum-treated skimmed milk, while lactose percentage remained constant across all treatments. Adding cellulose gum to cheese production improved its rheological test results for compression and elasticity compared to the control group. Also, adding cellulose gum enhanced cheese yield and improved the sensory properties of low-fat Mozzarella cheese.

Keywords: flexibility , cheese yield, melting test ,total acidity.

استخدام صمغ السليلوز في تحسين الخواص الفيزيوكيميائية والريولوجية والحسية لجبن الموزاريلا قليل الدسم

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المستخلص

هدفت هذه الدراسة إلى التحري عن إمكانية استخدام صمغ السليلوز بديلا عن الدهون في إنتاج جبن الموزريلا ودراسة تأثيره في الخواص الفيزيائية والكيميائية والريولوجية والحسية للجبن. تمت إضافة صمغ السليلوز بنسب مختلفة 0.1، 0.2، 0.3، 0.4، و 0.5٪، متمثل بالمعاملات A1، A2، A3، A4، و A5 للحليب منزوع الدسم، على التوالي. بالإضافة إلى معاملة السيطرة الموجبة +C المصنعة من الحليب كامل الدسم، وكذلك معاملة السيطرة السالبة –C المصنوعة من الحليب منزوع الدسم بدون صمغ السليلوز. بعد المعاملة بصمغ السليلوز، تم إجراء العديد من الفحوص لتحديد جودة المنتج. أجريت الفحوص الكيميائية لقياس نسبة الرطوبة والبروتين والدهون واللاكتوز والرماد والحموضة الكلية . كما تم إجراء الفحوص الفيزيائية، المتمثلة بقياس الحموضة الكلية والأس الهايدروجيني والأنضغاط والمرونة. كما أجريت الفحوص الحسية مباشرة وبعد 120 يوماً من التخزين عند درجة حرارة (5 ± 1) م^{O} . وأظهرت النتائج أن المعاملات المضاف لها صمغ السليلوز تحتوي على نسبة رطوبة أعلى من +C و-C أذ كانت 48.13 و50.40% على التوالي، بالمقارنة مع المعاملات المصنعه بأضافة صمغ السليلوز فقد تراوحت من 56.85 إلى 55.00% وقد تبين أن معاملة صمغ السليلوز A2 (أفضل معاملة في الخواص الحسية). خلال 120 يوما من التخزين عند (5±1) م^{O} ، تبين أنخفاض محتوى الرطوبة بشكل ملحوظ لجميع العينات خلال الخزن. ارتفعت نسبة الدهن بشكل ملحوظ في جميع أنواع المعاملات منزوعة الدسم المعاملة بصمغ السليلوز، في حين ظلت نسبة اللاكتوز ثابتة في جميع المعاملات. أدت إضافة صمغ السليلوز في إنتاج الجبن إلى تحسين نتائج الفحوص الريولوجية مثل الأنضغاط والمرونة مقارنة بمجموعة السيطرة. كما أن إضافة صمغ السليلوز أدى إلى تحسين تصافي الجبن وتحسين الصفات الحسية لجبن الموزاريلا قليل الدسم.

الكلمات الأفتتاحية : المرونة، تصافي الجبن ، نقطة الذوبان ، الحموضة الكلية.

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INTRODUCTION

Today's global markets tend to meet consumer desires to provide functional foods with health benefits (18,26). The consumer has become more aware of the link between diet and healthy food, so the demand has increased for the manufacture of functional foods that use natural alternatives to provide a specific health benefit (33,34). The positive impact of functional foods encourages food manufacturers to develop new products that possess healthy properties, which made them face the challenge of determining the type of these alternatives, as well as the nutritional value they possess and their efficiency in providing products that possess good functional qualities (13,35,41). Fat plays a significant role in food and highlights flavor, texture quality, and cohesion. Reducing or removing the fat percentage while maintaining sensory quality and texture is food producers' biggest challenge (18,19). Research papers have shown that removing fat from dairy products can has a negative impact on their texture (16,21,22). Thus, modern studies have inclined to add specific substances as substitutes for fats, named Fat mimetics, that work to develop the product's rheological properties. Fat substitutes have a different chemical composition than fats, but share similar physical characteristics. These substitutes are added to food products to give them a creamy taste, a soft texture in the mouth, and a viscosity that matches the quality of the manufactured product. (27). Grains are composed of both soluble and insoluble fiber varieties. Oats, barley contain a high percentage of insoluble fiber, such as cellulose gum, which are Hydrophilic colloids with high viscosity that ferment in the intestine by intestinal flora. Therefore, they are used as sound sources for producing functional foods that are free of fat (12,22). Dietary fiber and the cellulose it contains, which is characterized by its great ability to act as prebiotic, increase bodily immunity, reduce cholesterol and blood sugar(28), in addition to its effects in reducing weight and reducing the incidence of cancer, pointed to the use of fats in some food products. Furthermore, (19) used Gum Arabic to improve the texture of yogurt, and enzymes were used as fat substitutes, such as the transglutaminase enzyme, to improve the taste, flavor, and texture of the drinking yogurt to which it was added. Given modern trends in the use of fat substitutes in the dairy manufacturing and the good functional properties they possess in addition to their nutritional properties, as some of them contain high percentages of biologically active compounds, furthermore to their effective role in reducing energy, enhancing the immune system, reducing cholesterol (26), and improving texture of many dairy products that are free or low-fat. Therefore, many recent studies have been performed on manufacturing different low-fat cheeses, such as mozzarella, cheddar, kashkaval, and edamame (19). Because dairy products made from whole milk affect the health of the consumer while removing fat affects the texture and consistency of these products. Accordingly, the current study aimed to use fat substitutes represented by cellulose gum, demonstrate the effect of using them as fat substitutes when manufacturing fat-free mozzarella cheese and then examine their effect on processed cheese's physicochemical and rheological properties.

MATERIALS AND METHODS

The positive control treatment C+ for manufacturing mozzarella cheese involves using raw cow's milk, a full-fat mixture. While the skimmed cow's milk used in the cheese manufacture refers to negative control treatment C-. In comparison, Cellulose gum was added in different ratios of 0.1, 0.2, 0.3, 0.4, and 0.5%, revealing treatments A_1, A_2, A_3, A_4, and A_5 to skimmed milk, respectively, were prepared from the dairy factory - College of Agricultural Engineering Sciences - University of Baghdad. As for the microbial rennet used in Cheese manufacturing was produced by the Danish Chris Hansen Company. The cellulose gum has a molecular weight 700000 Daltons and it was produced by the Fooding Company.

Manufacture of mozzarella cheese

Mozzarella cheese was made according to (26), where bulk quantities of raw cow's milk were obtained from the dairy factory - the College of Agricultural Engineering Sciences - University of Baghdad. Then, the milk was divided into two parts; the first part was untreated to cheese manufacturing (the positive control treatment C+). The other part was subjected to a skim process and divided into two parts; The first part was left without any treatment to manufacture (the negative control cheese treatment C-). As for the second part, the fat substitute, represented by cellulose gum powder, was added to it in proportions of 0.1, 0.2, 0.3, 0.4, and 0.5%, represented by treatments A_1, A_2, A_3, A_4, and A_5, respectively. The homogenization process was carried out for the milk of the treatments, and it was pasteurized at a temperature of 63°C for 30 minutes, then refrigerated to 25°C. Citric acid was added until a pH of 5.3 was reached. The temperature was slowly increased, and the Danish Chris Hansen company's microbial rennet (chymosin) was added. It was first dissolved with distilled water, following the production company's instructions. The mixture was left to settle for half an hour until coagulation occurred. The curd was cut both lengthwise and crosswise, then left undisturbed for 5 minutes. After that, temperature was raised gradually with slow stirring until a temperature of 48-49°C was reached. The curd was collected, formed into a ball, and then placed in water at 9-11°C. Then, the cheese was salted with a 15% brine solution for ten hours, and stored in the refrigerator at a temperature of 5±1°C in air-tight bags, Finally, a portion of it was taken to conduct the necessary tests after 1, 30, 60, 90, and 120 days of storage.

Chemical tests for mozzarella cheese

The moisture percentage, ash, total acidity, and pH in the cheese were estimated according to the method mentioned in (32), and the fat percentage according to what was mentioned in (10, 31).

The concentration of lactose in mozzarella cheese samples was estimated according to (1,20,33).

Physical tests for mozzarella

Compression test

The study estimated the compressive force cheese models can withstand using a Uniaxial compression device, which measures in small parts of Newton units according to the method mentioned by (5,39) with some modifications. It was the device features a cylinder that has a diameter of 49 mm, The cheese sample was cut into a cylinder shape measuring 2.4cm in diameter and 1.6cm in height at a temperature of 6°C. It was placed in a tightly closed container to prevent moisture loss from the sample, then it was stored at room temperature for four hours. It was placed in the device, and pressure was applied by lowering the non-axial compressor on it at a speed of 50 mm/min until the sample was destroyed, the reading was recorded in Newton Units.

Flexibility test

The flexibility of the cheese models was estimated using the method of weights of known weight by placing the cheese sample on the support of the measurement corresponding to the scale, placing weights with fixed weights on it, and calculating the compression distance at which the descent stops and the time required for that. Then, the weights are removed, and the time required for the test sample to restore its initial state is calculated before the pressure (26).

Elongation test:

The elongation ability of cheese samples was measured after they were cut into 10 x 10 mm to suit the work of the device. As for measuring the ability of cheese samples to elongate, a sample was taken, and the samples were cut with a sharp, hollow tool to obtain samples in the shape of a cylinder and measuring 30 x 10. mm, the sample was fixed to the device and the metal base so that the elasticity was measured with the device, and pressure was applied to it to measure the extent of the sample's resistance to elongation (6,26).

Melting test

This test was conducted according to (24). A cheese sample with a diameter of 10 mm and a thickness of 10 mm was placed in the oven at a temperature of 90.6°C for 3 minutes, and the diameter rate was measured.

Cheese yield:

The yield percentage was calculated by dividing the mass of produced cheese by the milk weight used (24), as in the following equation:

$$(\%)\textbf{Yield} = \frac{\textbf{Cheese weight}}{\textbf{Weight of milk used}} \times \mathbf{100}$$

Sensory evaluation of cheese:

Sensory tests of mozzarella cheese samples were accomplished in the Food Sciences Department - College of Agricultural Engineering Sciences - University of Baghdad by 10 specialized professors about according to what was stated in the sensory evaluation form used by (30).

Statistical Analysis

The Statistical Analysis System- SAS (37), program was used to detect the effect of difference factors in study parameters. Least significant difference –LSD test (Analysis of Variation-ANOVA) was used to significant compare between means in this study.

RESULTS AND DISCUSSION

The overall composition of cheese

Moisture: Table (1) shows the moisture percentage results for the mozzarella cheese treatments of the treatment C+ and the cheese of the negative control treatment C-. However, the cheese of the treatments made from skimmed milk and cellulose gum was added to it in proportions of 0.1, 0.2, 0.3, 0.4, and 0.5%, represented by treatments A_1, A_2, A_3, A_4, and A_5, respectively. The treatment that was sensory superior to the rest of the treatments was chosen, represented by treatment A_2 and all tests for this treatment were followed up throughout the storage period. The moisture values directly after manufacturing for treatments C+ and C^- were 48.13 and 50.40%, respectively, while their values for the treatment A_2 was added were 56.85%. Furthermore, it is observed from the table that there are differences between the moisture percentage of the C+ treatment cheese and the cheese of the treatment containing cellulose gum, as it is noted that the moisture percentages are higher in the latter and a decrease in the moisture percentage for all treatments with storage, as after 120 days for the C+ and C- treatments it was 46.40 and 48.10 %, respectively, for the treatment with 55.00% cellulose gum added. This supports the results of (4,6) that the moisture content of soft cheese decreases over time during storage

Protein: Table (1) shows the protein percentage results for the previously mentioned mozzarella cheese treatments, where it was 26.4 and 29.70%, respectively, immediately after manufacturing for treatment C+ and C-. The statistical analysis shows significant differences (P<0.05) between the C+ treatment and treatments with cellulose gum If protein percentage for the treatment containing cellulose gum immediately after manufacturing reached 20.2%. An increase in the protein percentage is observed through storage for all treatments. After 120 days, it was, 27.4% and 32% for treatments C+ and C- As for the treatment containing cellulose gum, it was 21.9 %, respectively. The protein percentage increases during production company's in structionsoisture percentage, which increases the total solid's percentage, including protein. The results are consistent with what was found by (7,38), which indicated an increase in the protein percentage in the cheese of the C-, as protein becomes dominant and, formed into a ball, because of acidity and percentage of total solids in the absence of fat.

Fat: The fat percentage results in the different mozzarella cheese treatments are listed in Table 1. The fat percentage for treatments C+ and C- was 19.60 and 2.9%. The table also shows a significant difference (P < 0.05) in the fat percentage between the C+ , C- treatments and the A2 treatment; the percentage instantly after manufacturing reached 2.8%. It can be noted that the fat percentage increased in all treatments and for all storage periods. After 120 days for the treatments C+ and C-, it was 20.40 and 3.95%, respectively. For cheese of treatment with added cellulose gum, it was 3.40%, respectively. This is reliable with what was found by (3), who pointed an increase in the fat percentage during storage and attributed it to the whey separation and the decrease in moisture, thus to the increase in total solids.

Lactose: Lactose percentage results for the different mozzarella cheese treatments are listed in Table 1, as it reached 3.97 and 15.38% directly after manufacturing for the C+ and C- treatments, respectively, The reason for the increase in lactose in the C- and the A_2 treatment compared to the C+ is due to the separation of fat and the increase in moisture in the previous two treatments, and thus the proportions of the remaining components increase., and for the cheese treatment containing cellulose gum,it was 17.9%, respectively. Statistical analysis shows significant differences in the percentage of lactose between the C+ and C- treatments and the A_2. Likewise, a decrease in the lactose percentage with storage and for all treatments can be noted. After 120 days, it was 3.40, 14.40%, respectively, for the C+ and C- treatments, and for the cheese of the treatment A_2, it was 16.26%, respectively. The decrease in the percentage of lactose sugar during storage is attributed to the conversion of some of it into lactic acid by the action of lactic acid bacteria, or it may be attributed to the loss of it occurring during whey separation(26).

Ash*:* the ash percentages in the different mozzarella cheese treatments are listed in table 1, which reached 1.90 and 1.62% instantly after manufacturing the C+ and C- treatments, As for the ash percentages in the cheese of the treatment A_2 were 2.25%, respectively. It is noted that adding cellulose gum to cheese increases its ash percentage compared to C+ and C- treatments. This is due to the cellulose gum effect as a fat substitute, which increases the ash content of the cheese (14). It is worth noting that the ash percentage increases for all treatments during storage, as shown in the table. After 120 days, it was 2.40 and 2.00% for the C+ and C- treatments, respectively, and for the cheese of the treatment with cellulose gum added, it was 3.44%.

pH: Table (1) shows the results of the pH values for the different mozzarella cheese treatments, where the pH value immediately after manufacturing for the C+ and C^- treatments was 5.58 and 5.42, respectively. As for the pH value for the cheese treatment A_2, it was 5.54. According to statistical analysis results, there were no significant differences in pH values between the cheese treatments. During storage, the pH values decreased, reaching 5.10 and 4.92 after 120 days for treatments C+ and C-, respectively, and for the cheese of the treatment with cellulose gum added, they were 5.33, respectively. The statistical analysis results indicate no significant differences within a single treatment between the start and the end of the storage time for all treatments(15,26).

Total acidity: Table (1) shows the total acidity values (calculated based on lactic acid), %, for the different mozzarella cheese treatments, reaching 0.53 and 0.63% immediately after manufacturing for treatment C+ and C-, respectively. As for the cheese of the treatment containing cellulose gum, it was 0.60%. It is also observed that the percentage values of restorative acidity increased during storage, which after 120 days for the C+ and C- treatments were 0.71 and 0.76%, respectively, and for the cheese of the treatment to which cellulose gum was added, it was 0.68%. The reason for this increase at the end of the storage stage is due to the conversion of part of the lactose sugar into lactic acid (20). The statistical analysis results shows that there are no significant differences in the total acidity values between the first day and the last day of storage for C- and A_2 treatments, especially Psychrophilic bacteria and different cheese treatments at the end of the storage stage. There are also significant differences within a single treatment between the beginning and the end of the storage period for the C+(19,26).

Table 1. Chemical analysis, pH values, and restorative acidity for mozzarella cheese treatments during storage at 5±1°C

Treatment		Age of cheese (days)	% Components Moisture	Protein	Fat	Ash	Lactose	pH	Total acidity
C+		**1**	**48.13**	**26.40**	**19.6**	**1.90**	**3.97**	**5.58**	**0.53**
		30	**47.6**	**26.90**	**19.7**	**2.00**	**3.80**	**5.49**	**0.62**
		60	**47.3**	**27.03**	**19.81**	**2.12**	**3.74**	**5.34**	**0.66**
		90	**46.70**	**27.60**	**19.9**	**2.17**	**3.63**	**5.30**	**0.69**
		120	**46.40**	**27.40**	**20.4**	**2.40**	**3.40**	**5.10**	**0.71**
C^-		**1**	**50.40**	**29.7**	**2.9**	**1.62**	**15.38**	**5.42**	**0.63**
		30	**50.10**	**30.10**	**2.95**	**1.67**	**15.18**	**5.40**	**0.70**
		60	**49.70**	**30.4**	**3.1**	**1.70**	**15.10**	**5.35**	**0.73**
		90	**49.50**	**30.6**	**3.2**	**1.78**	**14.92**	**5.00**	**0.75**
		120	**48.10**	**32**	**3.5**	**2.00**	**14.40**	**4.92**	**0.76**
Mozzarella cheese with added cellulose gum	**A_2 0.2 %**	**1**	**56.85**	**20.2**	**2.80**	**2.25**	**17.90**	**5.54**	**0.60**
		30	**56.6**	**20.36**	**2.90**	**3.00**	**17.14**	**5.47**	**0.63**
		60	**56.3**	**20.63**	**3.00**	**3.12**	**16.95**	**5.43**	**0.65**
		90	**55.9**	**21.3**	**3.2**	**3.22**	**16.38**	**5.40**	**0.67**
		120	**55**	**21.9**	**3.4**	**3.44**	**16.26**	**5.33**	**0.68**
LSD value			**5.617 ***	**4.702 ***	**4.147 ***	**1.088 ***	**4.935 ***	**0.673 NS**	**0.144 ***

*** (P≤0.015).**

***Each number in the table represents an average of three replicates, the positive control treatment C+ manufactured from whole milk, negative control treatment C- made from skimmed milk without cellulose gum**

Sensory evaluation: Table (2) shows the sensory evaluation results of cheese samples of the different treatments during storage at a temperature of (1±5) °C for 120 days. The results showed that the scores given to the A_2 treatments with added cellulose gum were higher than those of the cheese of
the C-treatment. An improvement is also noted in the sensory properties increased by increasing the added percentage of gum to reach the best in the treatment with the additional percentage 0.2%. This is consistent with what was found by (9) regarding the deterioration of the sensory properties of low-fat cheese free of fat substitutes. Furthermore, the results are consistent with the findings of (4), who observed the superiority of the C+ treatment made from whole milk over the C- treatment manufactured from skimmed milk. The results are also consistent with (38), that adding cellulose gum to best results compared to the rest of the treatments. It is also noted from the results that the scores given to most of the studied traits decreased as storage progressed. This is consistent with what was found by (17) who found that soft cheese's sensory properties gradually decrease as storage progresses. The statistical analysis results indicate that there are no significant differences in the scores given to all traits and all treatments on the first day. However, as the storage periods progressed, the cheese treatments to which cellulose gum was added, especially the 0.2% treatment, exceeded all treatments in all the studied sensory properties

Table 2. Sensory evaluation of mozzarella cheese, made from whole milk C+ and skim milk C⁻ treatments, and low-fat cheese treatments containing different percentages of cellulose gum during storage at a temperature (5±1) °C for 120 days.

Treatment		Age of cheese (days)	Taste and flavor 45	Texture 35	Color 10	Bitterness 10	Total score out of 100
C+		1	41	33	9	9	92
		30	40	32	9	9	90
		60	39	32	9	9	89
		90	39	31	9	9	88
		120	38	31	8	8	83
C⁻		1	36	23	7	9	75
		30	34	21	7	7	69
		60	33	20	7	7	67
		90	31	20	7	7	65
		120	29	19	7	7	62
Mozzarella cheese with added cellulose gum	A_1 0.1%	1	38	25	9	9	81
		30	37	24	9	9	79
		60	36	23	8	9	76
		90	36	22	8	9	75
		120	35	21	8	8	72
	A_2 0.2%	1	43	32	9	9	93
		30	42	31	9	9	91
		60	41	31	9	9	89
		90	40	30	9	9	88
		120	39	29	9	9	86
	A_3 0.3%	1	41	29	8	9	87
		30	40	27	8	8	83
		60	39	26	8	8	81
		90	37	25	8	8	78
		120	36	24	8	8	76
	A_4 0.4%	1	39	27	8	9	83
		30	37	25	8	8	78
		60	36	25	8	8	77
		90	35	25	7	8	75
		120	33	24	7	7	71
	A_5 0.5%	1	37	27	7	9	80
		30	36	25	7	8	76
		60	35	24	7	8	74
		90	34	23	7	7	71
		120	33	23	6	7	69
LSD value			4.219 *	4.077 *	1.834 *	1.659 *	8.952 *

* (P≤0.015).

Each number in the table represents an average of three replicates

Compensability

Figures (1, 2, 3) show the hardness test results for cheese of the C+ treatment made from whole milk, cheese of the C- treatment made from skimmed milk, and cheese in treatment A_2 with 0.2% cellulose gum added throughout the storage period of 120 days. The figure showed apparent differences in the amount of force applied to the cheese samples of the different treatments, indicating their hardness depending on their chemical composition, the type of milk used in their manufacture, and the fat substitute material. It is noted that the cheese hardness of the C- treatment was higher than the cheese hardness of the C+ and A_2 treatment. The results are consistent with what was found by (41) for mozzarella cheese made from skimmed milk, whose hardness was greater than that of treatments to which fat substitutes were added, represented by extra polysaccharides. The results are also consistent with (8), who found that Al-Dhafair cheese made from skimmed milk had a greater hardness than treatments cheese to which plant-based fat substitutes were added, represented by CMC and guar gum, added at a rate of 0.25%. In addition to the fact that fat particles in low-fat cheese are few in number and small in size compared to the fat particles in full-fat cheese (40).

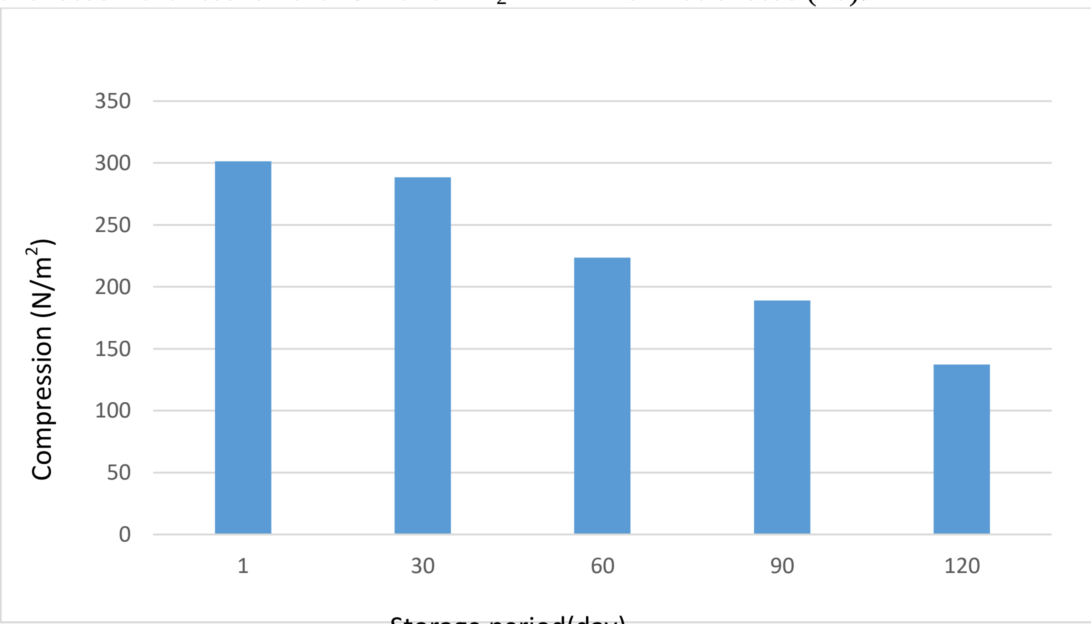

Figure 1. The force required to compress samples of cheese produced from whole milk C+ during storage at a temperature of (5±1 °C) for a period of 120 days.

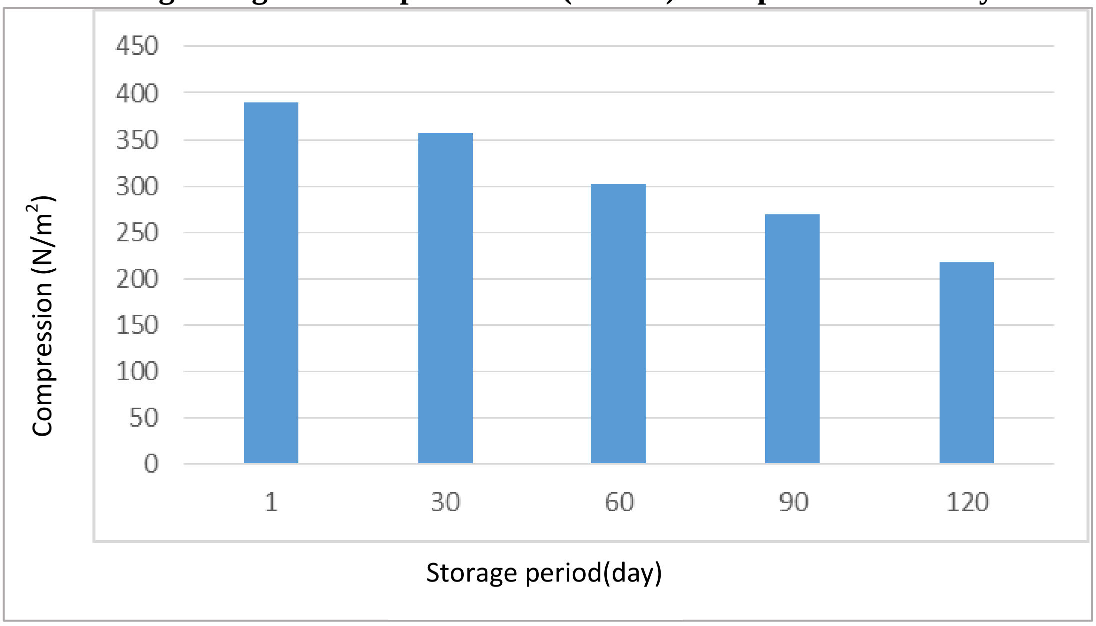

Figure 2. The force required to compress samples of cheese produced from skimmed milk C⁻ during storage at a temperature of (5±1 °C) for a period of 120 days

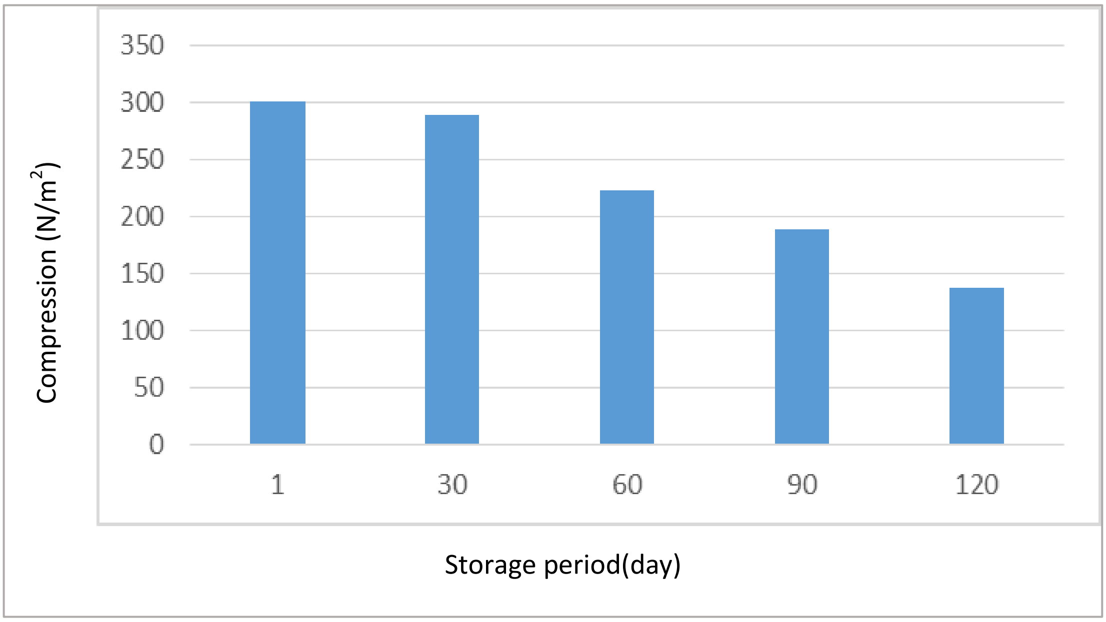

Figure 3. The force required to compress cheese samples produced from skimmed milk with added cellulose gum A_2 treatment during storage at a temperature of (5±1°C) for a period of 120 days.

Flexibility: Figures (4,5,6) show the test results of the cheese's ability to resist the weights placed on it for a fixed period and return to its original state that it was in before the weights were placed on it directly after manufacturing for the cheese treatments C+ and C- and the cellulose gum treatment. It is clear from the figure that there is a clear difference in the time it takes for the different cheese samples to return to their original state, and thus their difference in the degree of elasticity they possess, which is naturally affected by their chemical composition and the type and quantity of the fat substitutes. It is noted that the C- treatment took longer to return to its normal 3.8 min. condition than the C+ treatment, which took a shorter time to return to its original state 8 min. This is consistent with what (23,31) found of higher elasticity in the fresh, full-fat Kashar cheese treatment compared to the low-fat treatment made from skimmed milk. The reason for this is the high protein content of this treatment because it is made from skimmed milk, which gives it a compact and rough protein matrix and reduces the spongy nature imparted by the presence of fat permeating the protein matrix, as is the case in the C+ treatment cheese, which makes it easy for the cheese matrix to return to its original state. As is evident from the figure, the flexibility of the cheese treatment with added cellulose gum A_2 was increased, and thus, the period of time it took to return to its original state compared to the negative control treatment is short.

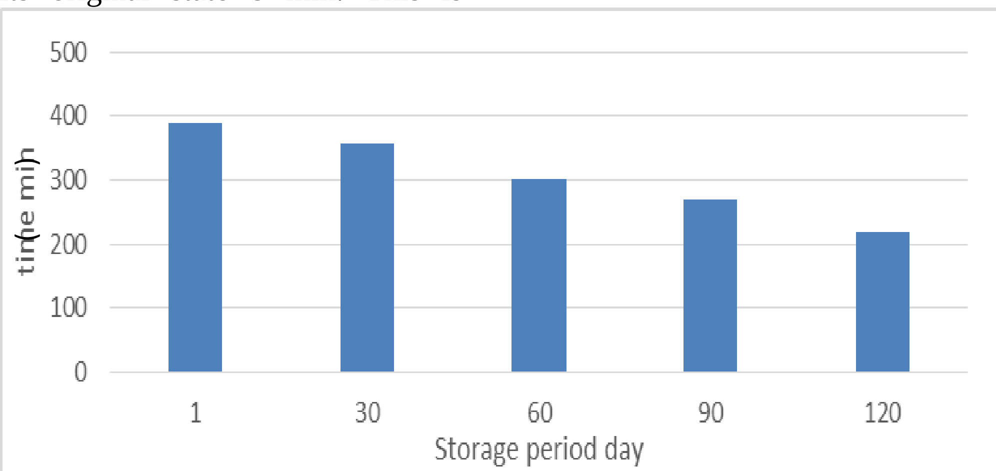

Figure 4. The time taken (minutes) to measure the elasticity of cheese samples produced from skimmed milk only C^- during storage at (5±1 °C) for 120 days .

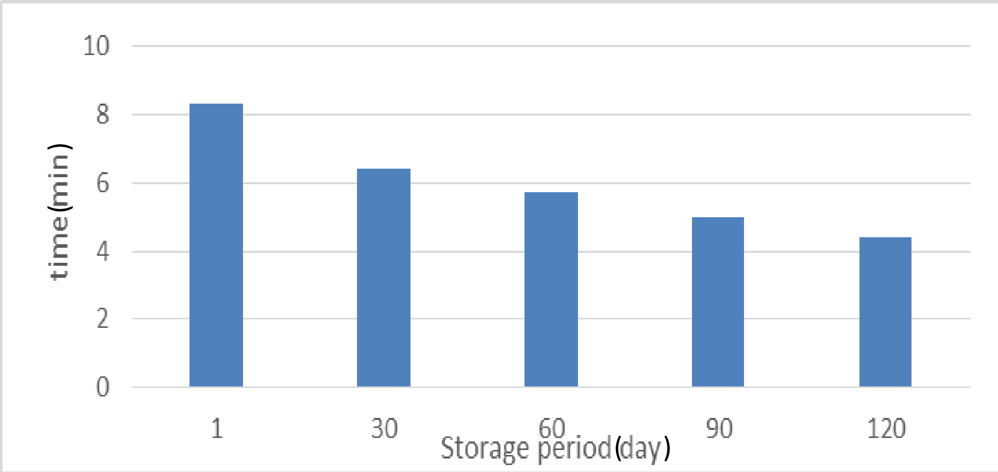

Figure 5. The time taken (minutes) to measure the elasticity of cheese samples produced from skimmed milk only C⁻ during storage at (5±1 °C) for 120 days .

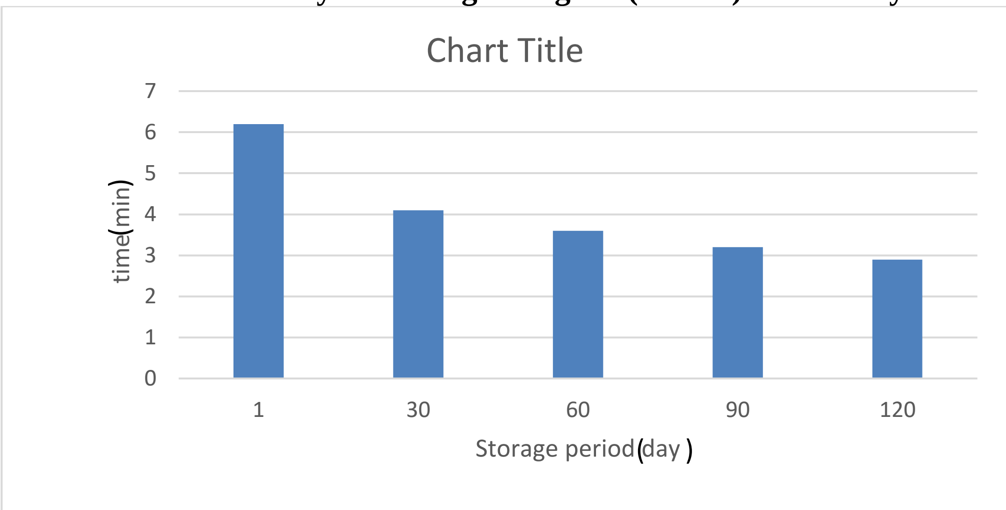

Figure 6. The time taken (minutes) to measure the elasticity of cheese samples produced from skimmed milk to which 0.2% cellulose gum was added during storage at (1±5 °C) for 120 days

This is consistent alongside (4), which observed that soft cheese made using fat substitutes represented by CMC and inulin, added at a rate of 0.2 and 2%, respectively, took less time to return to its normal state compared to the negative control treatment, which took a longer time to return to its original state.

Ability to elongate or stretch:

The results in Figures (7, 8, and 9) show that the fat substitutes that were added to develop the cheese production properties improved the texture and softness of the curd. Besides, its ability to elongate in varying proportions, compared to the C- treatment, which was characterized by a weak ability to elongate. It required a higher elongation weight than treatment A_2, which added cellulose gum. (2) indicated that the mozzarella cheese quality can be determined by the extent of its ability to elongate, which is affected by cetain factors such as pH , temperature and shelf life. The results are regular with (8) results, who realized that the addition of CMC, guar gum, and C. sebestena, it improved the texture and softness of the curd and its ability to elongate compared to the C⁻ treatment.

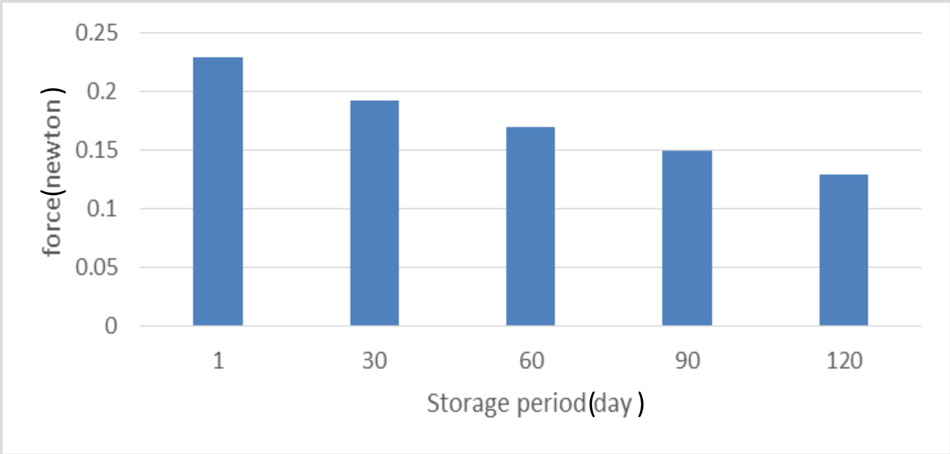

Figure 7. The force required for elongation for the C+ treatment of cheese produced from whole milk during storage at (5±1 °C) for 120 days .

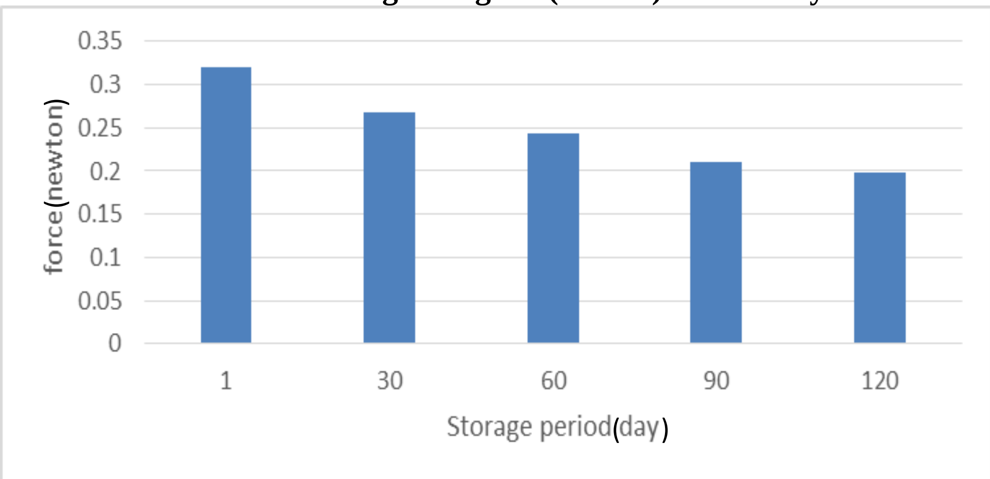

Figure 8. The force required for elongation for C- treatment of cheese produced from skim milk only during storage at (5±1 °C) for 120 days .

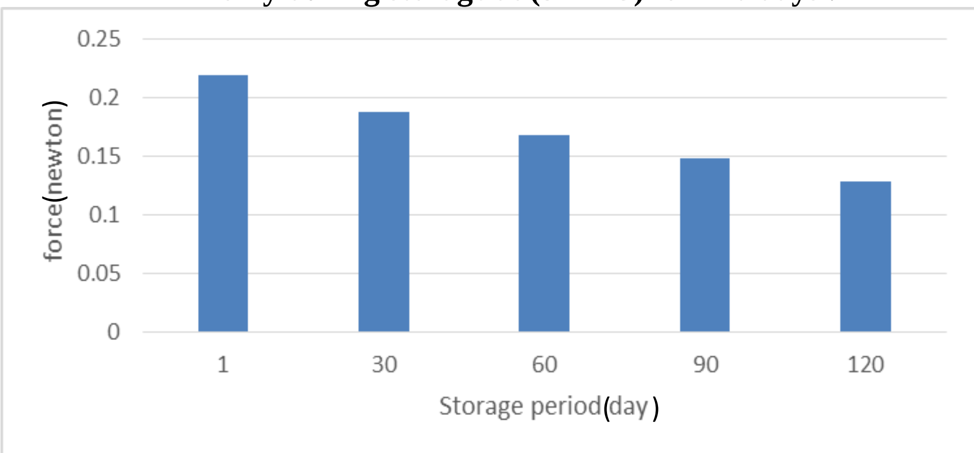

Figure 9. The force required for elongation for treatment A_2 to which cellulose gum was added during storage at (1±5 °C) for 120 days .

Melting test: Melting is one of the distinctive characteristics of this type of cheese, which the consumer prefers in the production of pies, pastries, and pizza. One of the factors that aid in melting cheese is the low pH; with the heat, the cheese turns from solid to melted. Figures (10, 11, 12) show that mozzarella cheese, produced from skimmed cow's milk, has 0.2% cellulose gum added, which is represented by treatment A_2, as this addition worked to raise the moisture levels for the above treatments compared to C- treatment. However, treatment A_2 obtained the highest melting values compared with the C- treatment due to its influential role in holding moisture. Since the additives improved the solubility of the cheese produced. (29) indicated that adding polysaccharides in the low-fat mozzarella cheese production improved its solubility properties, as raising the moisture content in the cheese has a direct role in improving solubility. This variation in solubility values may be attributed to the material's ability to hold moisture. It can be concluded that moisture has an effective role in improving the solubility of fat-free mozzarella cheese. The results are reliable to what was noticed by (8), who concluded that adding fat substitutes of plant origin improved the solubility of Al-Dhafair cheese compared to the C- treatment. This is because the cheese used in this treatment is made from skimmed milk. as well as the ability of the substances added to the milk in this treatment to retain water, increase the level of moisture in the cheese., as well as reduce the total solids values.

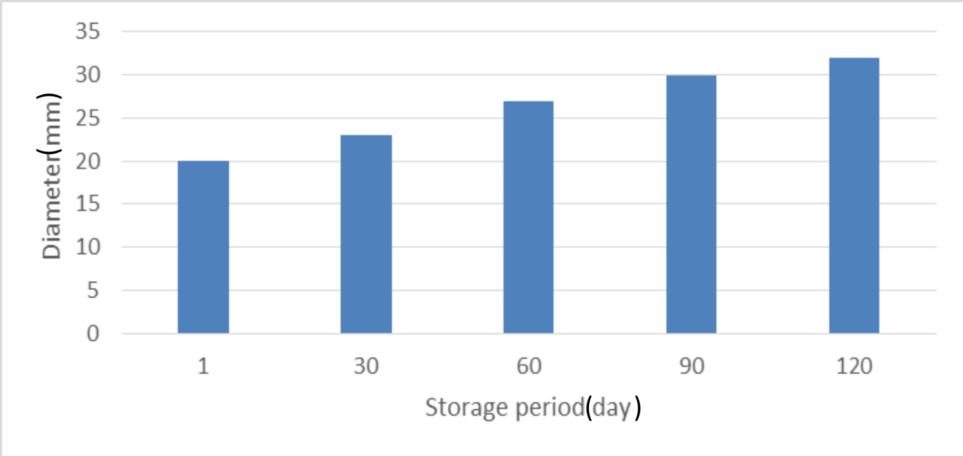

Figure 10. Melting test for the C+ treatment of cheese produced from whole milk C+ after the manufacturing process and while being stored at a specific temperature of (5±1)°C for 120 days

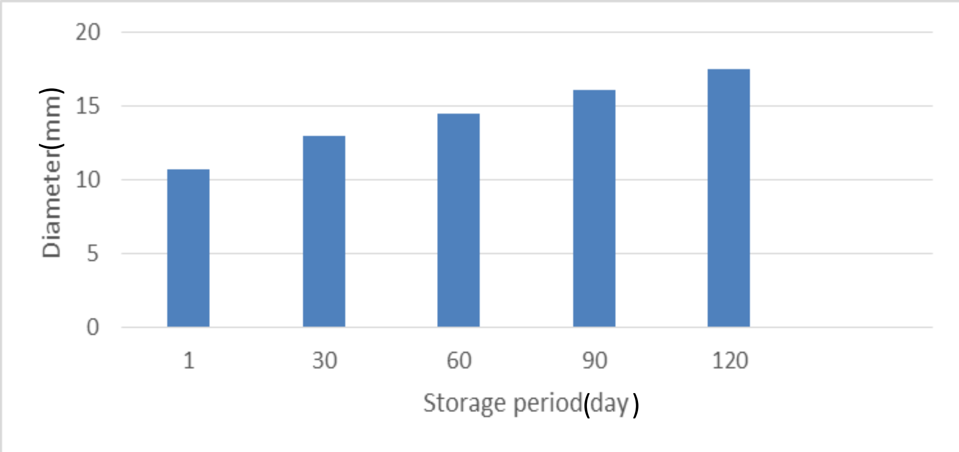

Figure 11. Melting test for the C⁻ treatment of cheese produced from skim milk only after the manufacturing process and while being stored at a specific temperature of (5±1)°C for 120 days

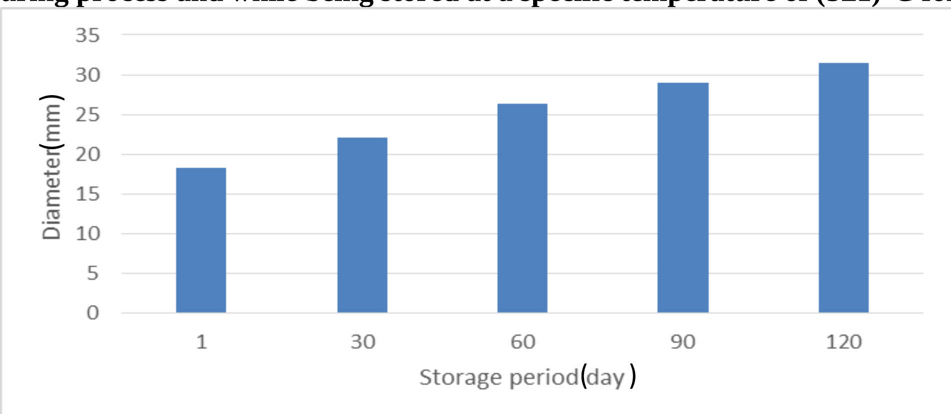

Figure 12. Melting test for treatment A_2 manufactured from skimmed milk with added cellulose gum after the manufacturing process and while being stored at a specific temperature of (5±1)°C for 120 days

Cheese yield: Table (5) shows the yield percentage results of the cheese for the C+ and C- treatments and the low-fat cheese treatments containing cellulose gum A_2 at a rate of 2.0%, where the yield percentage was 9% after manufacturing for the C+ treatment. This is disagreed with (11) findings, which indicated that the yield percentage of soft cheese made from full-fat cow's milk was 12.78%. The statistical analysis results also showed significant differences ($P < 0.05$) between the yield percentage of C+ and C- treatments, which amounted to 8.00%. This difference in treatment yield is due to the cheese from the C-treatment being made from skimmed milk, which has a lower yield percentage. This is consistent with (37,38) that a low percentage of yield characterizes cheeses made from skimmed milk due to their low total solids content. Substances added to milk prepared for cheese making also increase its yield percentage, depending on their quantities (38). It is also noted from the statistical analysis results that there are significant differences between the yield percentage of cheese made from skimmed milk with 0.2% cellulose gum added to treatment A_2, which reached 12.5% immediately after manufacturing, and the C+ and C⁻ treatments. The results are agreed with (8) who noted that the use of carbohydrate fat substitutes represented by CMC, guar gum, and *C. sebestena* when manufacturing low-fat Al-Dhafair cheese contributed to raising manufactured cheese of the yield percentage in comparison to the cheese of the control treatment. The yield percentage of Al-Dhafair cheese made from skimmed milk with the above fat substitutes added was 13.13, 12.84, and 10.33%, respectively, compared to the C-C-treatment, where the yield percentage reached 9.73%. The findings align with (4) study findings, who used fat substitutes represented by CMC and inulin in the manufacture of soft, low-fat cheese, which contributed to raising the yield percentage of the manufactured cheese compared to the C+ and C- treatments. However, the yield percentage for the C+ treatment was 12.5%, while the C⁻ treatment was 8.75%, and the treatment to which inulin was added was %. 18.25, and the treatment with added CMC reached 15.13%. From the above results, the cheese treatment with added cellulose gum was superior in the yield percentage.

REFERENCES

1.Abdulkarem, K., A.,and S., K. Hasan,. 2022. Effect of addition raw bacteriocin produced by *Lactobacillus delbrueckii Sub-Sp. bulgaricus* on soft cheese. Iraqi Journal of Market Research and Consumer Protection. 14(2), 90–102. http://dx.doi.org/10.28936/jmracpc14.2.2022.(1)

2.Ak, M. M. and S. Gunasekaran, 1995. Measuring elongational properties of Mozzarella cheese. J. Texture Stud. 26: 147–160. DOI:10.1111/j.1745-4603.1995.tb00790.x

3.Al- Jasser, M. S. and A. A. Al- Dogan.2009. Properties of white soft cheese produced using rennet substitute extracted from Solanum dubium seeds. Egyptian J. Dairy Sci. 37: 237-243. DOI:10.3844/ajas.2009.551.554.

4.Al-Badrani, D. I. and J. H. 2017 Manufacturing Low-energy Dairy Products Using Mimetics and Studying Their Physicochemical and Nutritional properties. Ph.D. Dissertation - College of Agricultural Engineering Science - University of Baghdad.

5.Al-Barazinji,Y.M.S. and, F.K. Zainal. Genetic evalution of milk traits in local goat . Iraqi Journal of Agricultural Sciences –2023:54(6):1548-1556. https://doi.org/10.36103/ijas.v54i6.1855

6.AL-Darwash, A. K.; A. J. Al-Mosawey, and A. M. AL-Sultan, 2014. study of chemical, microbiological and organoliptic properties of high protein iraqi soft cheese.J. Biol. Chem. 9: 365-376. DOI:10.33762/bagrs.2013.111631

7.Al-Eydam, J. M. M. 1998. A Study on Accelerating The Ripening of Ushari-like Cheese. Ph.D. Dissertation. faculty of Agriculture. Baghdad University. Iraq.

8.Al-Hadithi, F. N. I. 2015. Improving The Rheological and Sensory Characteristics of low-fat Iraqi Mazfar Cheese. Ph.D. Dissertation - College of Agriculture - University of Baghdad

9.Alnemr, T. M.; A. M. Abd El- Razek; H. M. A. Hasan, and M. I. Massoud. 2013. Improving of karish cheese by using enhanced technological texturizing inulin. Alex. J. Agric. Res.58(2):173- 181.

DOI 10.1088/1755-1315/910/1/012040
10. A.O.A.C. 2010. Official Methods of Analysis of AOAC International. 18th edition., revision 3. Gaithersburg, Maryland, AOAC International. Ch. 17. USA.
11.Apolinario,A.C.Delima,B.P.Demacedo,B.N .Pessoa,A.Convert,A.and Dasilva,J. 2014. Inulin -type Fructans :Areview on different aspects of biochemical and pharmaceutical technology .Carbohydrate Polymers.101:368-378. https://doi.org/10.1002/mnfr.201600518.
12.El-Baz;.M. Azza 2013. The use of inulin as a dietary fiber in the production of synbiotic UF-soft cheese.J. Food and Dairy Sci. 4 (12): 663 - 677. https://jfds.journals.ekb.eg/article_72121_a30819bedb4ac4fe3fe2590f61a6f7f9.pdf
13.Food Safety Network. 2014. Providing reliable information to help keep food safe and healthful. University of Guelph.Retrieved from https:// www.uoguelph.ca/foodsafetynetwork/fat-substitutes
14.Hakim, L., I. T, H. Evanuarini, and A. Manab, 2016. Physical and chemical properties of mozzarella cheese analogue microwavable. International Journal of Chem Tech Research, 9(7), 171-181. https://www.sphinxsai.com/2016/ch_vol9_no7/1/(171-181)V9N7CT.pdf
15.Hamad, M. N. and M. M. Ismail, 2013. Improvement of white cheese spread properties.2.Adding of some flavoring agents. J. Food and Dairy Sci.4(5): 235-245. file:///C:/Users/HP/Downloads/spreadcheeseflouvrings.pdf
16.Khairi,S.R., Sh. S. Lafta.., and M., E,Fathil .2020. Effect of adding guar gum to yogurt free fat and studying some of its properties. Food Chem. Ann Trop Med & Public Health; 23(S13B): SP231385. DOI: http://doi.org/10.36295/ASRO.2020.231385
17.Khairy, L., H, Sh. S. Lafta.. and F. A.Saadoon 2020. Utilizing of the guar gum for improving the physiochemical, rheological, and sensory properties of low-energy mozzarella cheese. Ann. of Trop. Med., & Public Health; 23(16)163-174: http://doi.org/10.36295/ASRO.2020.231622.
18.Khalil. A. H. 2023. Studying The Physiochemical ,Microbiological and Rheological Properties Of Yoghurt Which are Fortified By Encapsulated Folic Acid. A Thesis. Dissertation. Collage of Agricultural Engineering Science, University of Baghdad, Iraq https://doi.org/10.59807/jlsar.v2i1.20.
19.Khalil, A. H., Sh. S. Lafta,. 2023. Study The Chemical Properties of Lactic Fermenter Which is Fortified Encapsulated Folic Acid by Sodium Alginate and It's Antioxidant Effectiveeness. Iraqi Journal of Market Research and Consumer Protection,15(1): 268-277. DOI:http://dx.doi.org/10.28936/jmracpc15.1.2023.(25)
20.Khalil, A. H., Sh. S. Lafta. 2023. Studying the Physiochemical, Sensory and Microbiological Properties of Yoghurt Which are Fortified by Encapsulated Folic Acid. IOP Conference Series: Earth and Environmental Science, 1259 (2023) 012067. DOI:10.1088/1755-1315/1259/1/012067
21.Koca, N. and M. Metin, 2004. Textural, melting and sensory properties of low-fat fresh kashar cheeses produced by using fat replacers. Int. Dairy J., 14: 365-373. DOI:10.1016/j.idairyj.2003.08.006
22.Kosikowski, F. V. and V. V. Mistry, 1999. Cheese and fermented milk foods. vol I: origins and principles. great falls, virginia,-USA: F.V. Kosikowski: L.C.C. Publishers. pp 56 & 147- 161. https://www.scirp.org/reference/referencespapers?referenceid=1456216
23.Lafta, S. S. 2014. Effect of Transglut-aminase enzyme on drinking yogurt properties. Iraqi Academic Scientific Journals, 6(1)163-174 https://www.researchgate.net/publication/329514808_Effect_of_Transeglutaminase_enzyme_on_drinking_yogurt_properties.
24.Lafta, S. S. 2018. Utilization of β-Glucan and Inulin to Improve the physiochemical, Rheological and Nutritional Properties of Low –Fat Mozzarella Cheese. Ph.D. Dissertation. Collage of Agricultural Engineering Science, University of Baghdad, Iraq.
25.Lafta, S., S., L., H. Khairy, and I. M. Hakim, 2019. Effect of fortified low fat-soft cheese with arabic gum on physicochemical and rheological properties. Plant Archives. 19(2): 616 -621.

26.Mahdi, L.S., A., L.S. Ibrahim, and ,G.H., Radha 2023. Efficiency of Different Levels of L-carnitine Supplementation on Growth Performance and Blood Parameters in Three Lines of Kurdish Quails (coturnix). Iraqi Journal of Agricultural Sciences , 54(6):1509-1519. https://doi.org/10.36103/ijas.v54i6.1850

27.McMahon, D. J.; M. C. Alleyne;R. L. Fife, and C. J. Oberg. 1996. Use of fat replacers in low fat LF mozzarella cheese. J. Dairy Science. 79:1911-1921. DOI:10.1016/j.idairyj.2003.08.006

28.Mensink, M. A., H. W., Frijlink, van der K., Voort Maarschalk, and W. L. Hinrichs, 2015. Inulin, a flexible oligosaccharide I: Review of its physicochemical characteristics. Carbohydrate Polymers, 130, 405-419. https://doi.org/10.1016/j.carbpol.2015.05.026

29.Min, D. B. and W. C. Ellefson, 2010. Fat Analysis. In: Food Analysis. Nielsen, S.S. Fourth Edition. Springer Science & Business Media. (Chapter 8). 118-132. https://fcen.uncuyo.edu.ar/upload/food-analysis.pdf

30.Mousa, E. F., Sh. S. lafta, and A. S. Ahmaed, 2019. antimicrobial, physicoch-emical and sensory characteristics of honey treated cream. Plant Archives Vol. 19, Supplement 1, 2019 pp. 764-772. http://www.plantarchives.org/PDF%20SUPPLEMENT%202019/123__764-772_.pdf

31.Rasheed, S. A. . and S. M. A. Al Nuaimmi, 2022. "Effect of adding dry yeast and folic acid on improving the physiological and productive performance of quail., Iraqi Journal of Agricultural Sciences, 53(4): 789–797. https://doi.org/10.36103/ijas.v53i4.1590

32.Rinaldoni, A. N., D. R., Palatnik, N. Zaritzky, and M. E. Campderros, 2014. Soft cheese-like product development enriched with soy protein concentrates. LWT-Food science and Technology, 55(1), 139-147. DOI:10.1016/j.lwt.2013.09.003.

33. Saeed, K. A, Doosh, SH. S. Lafta, M. R. Mohammed and A, Sharaf.2023. Studying some of health indicators in the laboratory mice feeding on white cheese fortified with selenium. Full Text Book of Minar Congress:153-174.
DOI: 10.47832/MinarCongress7-12

34.Saeed, K. A, D. 2022. Study the effect of purified cow milk glutathione on cancer cell growth (HePG2) in vitro. International Journal of Health Sciences. 11583—11592.. http://dx.doi.org/10.53730/ijhs.v6nS4.11238

35.SAS. (2018). Statistical Analysis System, User's Guide. Statistical. Version 9.6th ed. SAS. Inst. Inc. Cary. N.C. USA.

36.Scattar, M.U.; S.; Aysha, H. Nuzhat, and Sh. Muhammad, 2015. Exploit Fat Mimetic Potential of Different Hydrocolloids in Low Fat Mozzarella Cheese. J Food and Nut. Res.. 3(8): 518-525. doi: 10.12691/jfnr-3-8-7

37.Shendi, A. 2012. Structure and rheological properties of water soluble cellulose gum from oat cultivars of *Avena sativa* and *Avena bysantina*.J.of Cereal Sci.38:31-43. DOI:10.1016/S0733-5210(02)00137-6

38.Sipahioglu, O.; V. B. Alvarez, and L. C. Solano, 1999. Structure, physicochemical and sensory properties of Feta cheese made with tapioca starch and lecithin as fat mimetic. Inter. Dairy J., 9: 783-789..

39.Stephen, A. M., M. M. Champ, S. J., Cloran, M. Fleith, L. Van Lieshout, H., Mejborn, and V. J. Burley, 2017. Dietary fibre in Europe: current state of knowledge on definitions, sources, recommendations, intakes and relationships to health. Nutrition Research Reviews, 30(2), 149-190. https://doi.org/10.1017/S095442241700004X

40.Zisu, B. and N. P. Shah, 2005. Textural and functional changes in low-fat mozzarella cheese in relation to proteolysis and microstructure as influenced by the use of fat replacers, pre-acidificataion and EPS Starter. Inter. Dairy J., 15: 957-972. DOI:10.1016/j.idairyj.2004.09.014