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Research Article

Physicochemical Properties of Yogurt Manufactured from Soft Cheese Waste

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Abstract

Given the need to produce low-energy yogurt with superior sensory and rheological properties comparable to commercial yogurt, this study was conducted to investigate the use of dried whey proteins as an alternative and their role in improving the physical and chemical properties of yogurt produced, thus producing and utilizing high-nutrition yogurt. The study demonstrated the use of whey, a by-product of soft cheese production, in yogurt production by mixing it with dried skim milk at different concentrations (6%, 7%, 8%, and 9%), in addition to thickeners such as gelatin, starch, and guar gum in varying proportions. The physical and chemical changes in the product were observed over different storage periods. Chemical analysis was conducted on the skim milk used in the production process. Significant differences were observed between treatments, especially in the pH levels of the treatment in which starch was added at a concentration of 0.5 g on the first day of storage, reaching values of (4.40, 4.36, 4.27, 4.25), respectively. Acidity increased in the treatment in which gelatin was added at a concentration of 0.25 g for all studied treatments on the first day of storage, reaching values of (0.93, 0.94, 0.95, 0.97). As for water retention, the highest values were recorded in the treatments in which gelatin was added at a concentration of (0.25 and 0.5) g on the first day of storage, reaching values of (6.18, 6.22, 6.12, 6.16, 6.06, 6.10, 6.00, 6.04). All physical and chemical properties showed a decrease in guar gum treatments by the 14th day of storage.

Keywords

Whey Protein Cheese, Yogurts, pH, Acidity, Water Retention, Yogurt Thickeners Guar, Gelatin

1. Introduction

Yogurt is a major fermented milk product that provides probiotics, lactic acid bacteria, vitamins, calcium, and proteins. However, health-promoting phenols, flavonoids, anthocyanins, and iron are absent in regular yogurt. These compounds may provide antidiabetic, anti-obesity, anti-microbial, and anti-cancer properties [1] Yogurt is a dairy product that is made by fermenting fresh milk using lactic acid bacteria as a starter. The origin of yogurt dates back to ancient times (Ilya Ilyich Metchnikov) confirmed that lactic acid bacteria bacilli are responsible for fermenting yogurt

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such as Lactobacillus and Streptococcus These are homogeneous fermenting bacteria that produce about (90%) of lactic acid, which is a major product in fermented milk, with an estimated acidity value (pH) of 3.8-4.6 [2].

Whey is a by-product of cheese production and is the clear liquid portion of milk that contains whey proteins, lactose, and minerals. Whey proteins are isolated using various techniques, and efforts have been made to prevent the disposal of untreated whey while exploring its nutritional and functional properties. Therefore, whey is utilized in many food industries and as a source of proteins and dietary (nutritional) supplements [3]. Over the past years, numerous studies have been conducted on the nutritional value and properties of whey, which is predominantly composed of proteins. Whey proteins have antimicrobial, antiviral, and antioxidant properties. Given the significant challenges in processing whey as biological waste and its high potential as a valuable raw material, global whey production is estimated at around 165 million tons annually [4]. About 75% of whey production in Europe is used for various applications, while only 50% is utilized in other parts of the world, leading to the disposal of a large amount of valuable material [5].

Yogurt was prepared from camel milk supplemented with 0, 3, and 5% whey proteins and compared with cow's milk yogurt. The results showed that the water-holding capacity was affected by the addition of whey proteins, with values of 31.3%, 56.8%, 64.7%, and 45.1% for camel milk yogurt containing 0, 3, or 5% whey proteins, and cow's milk yogurt, respectively, after 15 days, the addition of whey proteins increased yogurt firmness and stickiness while reducing its elasticity. The camel milk yogurt without whey proteins showed a noticeable decrease in viscosity, storage modulus, and loss factor compared to the other samples. Adding camel milk with whey proteins improved the rheological properties of the resulting yogurt [6].

The addition of 1-1.25 gelatin to yogurt enhances its sensory qualities and increases its texture [7]. Furthermore, the addition of 1% starch to yogurt reduced whey separation, increased solids, improved texture, and enhanced sensory characteristics. The pH remained stable during storage, which increased shelf life [8]. The aim of this study is to utilize the whey produced from soft cheese-making and add skim milk in certain proportions, along with other thickening agents, to produce high-nutritional-value yogurt and benefit from it.

2. Materials and Methods

2.1. Sodium Hydroxide Solution

A 1 N solution of sodium hydroxide (NaOH) was prepared by dissolving 40 grams of NaOH in 1 liter of distilled water. A 0.1 N solution was prepared by dissolving 4 grams of sodium hydroxide in 1 liter of distilled water.

Phenolphthalein Reagent (1%):

This was prepared by weighing 1 gram of phenolphthalein and dissolving it in 95% ethyl alcohol. It was used for total acidity determination.

Laboratory Cheese Production:

Materials Used in Cheese Production:

Full-fat cow milk samples were used, sourced from Al-Alam district in Salah al-Din Governorate. The samples were stored in airtight, sterilized containers under low temperatures (4 ℃) and were kept for no more than 3-5 hours before experimentation.

2.2. Rennet

The rennet was supplied by Mayas an Turkish company.

Calcium Chloride:

A calcium chloride package prepared by the Chinese company Inovance was used.

Milk Composition Estimation:

The milk's components were estimated using a (Milko-tester device) to analyze its chemical properties, including fat percentage, protein percentage, lactose content, and non-fat solids. The ash content percentage of the milk was determined using a Muffle Furnace, as per the AOAC method. The acidity was measured according to the method outlined by [9], and the pH was measured using a pH-meter device.

Soft Cheese Production:

After determining the milk composition, the milk was pasteurized at 63 ℃ for 30 minutes, following the procedure described by [10]. The milk was then cooled to a temperature between (42-45) ℃. Calcium chloride (0.2%) was added after dissolving it in warm water. Microbial rennet (enzymatic) was then added after being dissolved in distilled water, as instructed by the manufacturer (producing company). After half an hour, the coagulation state was reached and then it was cut. The clot was shaped into cubes and left for five minutes without stirring. Then the clot was placed in containers with holes after wrapping it with a piece of gauze and pressed (by placing a weight on it equivalent to approximately 4-5 kg) to obtain the largest amount of whey protein.

Yogurt Production:

The method used by [11] was followed, which included filtering fresh cow's milk with a clean piece of cloth, then and raising the temperature to 90 ℃ for 30 minutes. The milk was then cooled to 42-45 ℃ and inoculated with a local starter culture consisting of Lactobacillus thermophilus and Lactobacillus bulgaricus at a rate of 3% inoculum. The mixture was stirred for 2 minutes, then poured into special containers, and the containers were covered, and transferred to be placed in an incubator at 42-45 ℃ until coagulation was completed, which usually takes around 4 hours. The yogurt was then cooled to 2-5 ℃ before conducting the analyses.

Yogurt Production from Reconstituted Skim Milk with Whey:

For each treatment, 100 grams of reconstituted skim milk powder (6%, 7%, 8%, 9%) from Millac brand was dissolved in the sweet whey obtained from soft cheese production,

following the method outlined by [12]. by gradually dissolving the milk powder in the whey was done, with the addition of gelatin, starch, and guar gum at concentrations a rate of (0.25, 0.5) g. The mixture was heated to temperatures between 30-50 ℃ for two hours to increase the hydration properties of the skimmed milk powder. Skim milk was used and the local starter was used to manufacture the yogurt. The milk was homogenized at 65 C and a pressure of 150 kilo pascals to obtain the optimal physical properties in the yogurt. Then the temperature of the milk was raised to (90-95) ℃ for five minutes to ensure denaturation of (70%-80%) of proteins. The whey was then cooled to (45) C and incubated at a temperature of (42-44) ℃ after adding 2% of the curd starter to the milk. The curd samples were taken out after the completion of complete fermentation after about 3 hours. Plastic containers with a capacity of 150 ml were used and stored at a temperature of (2-5) ℃ to conduct sensory, physicochemical and microbiological tests.

2.3. Chemical Analysis of the Produced Yogurt for Different Storage Periods

Determination of Total Acidity Percentage

The acidity was estimated according to the method mentioned in [10]. Nine milliliters of the sample were taken and placed in a glass beaker, then a few drops of phenolphthalein reagent were added. The sample was then titrated with a 0.1 N sodium hydroxide (NaOH) solution. The percentage was calculated based on lactic acid content using the following equation:

Acidity% = volume of base consumed (ml) × base standard × Gram equivalent weight of lactic acid (0.009) × 100 / (sample weight).

2.4. PH Estimation

The pH was measured using a (PH-meter) device after calibrating the device with Buffer4 and Buffer7 solutions.

2.5. Determination of Water Holding Capacity (WHC) in Yogurt

Water retention in curd Empty sterile plastic bottles were weighed, and 200 ml of curd containing 0.003% Na+ formate were added. The samples were incubated at 40 ℃ until the pH was reached 4.55. Afterward, the samples were cooled in an ice bath for 30 minutes and stored overnight at 4 ℃. The samples were then centrifuged at 2325 rpm for 3 minutes, and the whey protein was carefully drained from the plastic bottles. The samples were weighed before and after whey removal. The Water Holding Capacity (WHC) was expressed as curd yield. Three replicates were prepared for each sample.

Statistical Analysis:

The data were analyzed statistically using the SAS software (program) and according to one-way analysis of variance (ANOVA). The arithmetic means of the coefficients were tested using the Duncan multiple range test at a significance level of 0.05 to determine the significant differences between the groups.

Results and Discussion:

Table 1 indicates the percentages of the chemical composition of the milk used in the experiment, as analyzed by a Milkotester device. It is noted from the table that the percentage of fat was 3.70%, the protein percentage was 3.40%, and the lactose percentage was 4.25%. These results represent the components of the milk used in the experiment. The rates of the percentages of the main components of the milk used in this work were within the specifications mentioned [13]. and what was indicated [14] that cow's milk should contain at least 8.25% and 3.25% of non-fat solids and fats, respectively. The results also matched those reported [15] regarding the fat, protein, and lactose percentages, which were 3.9%, 3.25%, and 4.60%, respectively.

Table 1. *Chemical composition of skimmed milk used.*

Ingredients	Proportions
Fat	70%
Protein	3.40%
Lactose	4.25%
Solids Non-Fat SNF	7.35%
pH	6.61
Acidity	0.16%
Moisture	86.90%
Ash	0.78%

Table 2 illustrates the results of estimating the pH, acidity, and water retention in the yogurt produced by adding 6% skimmed dry milk and 94% whey protein. It was found that there were significant differences among the treatments with varying additions of gelatin, starch, and guar gum.

It was noted that the highest pH value was for the treatment to which 0.5 g of starch was added, which was 4.40 for the first day of manufacturing. On the other hand, the lowest pH values were for the two treatments to which guar was added at a rate of (0.25, 0.5) g, as it was 4.09 for both of them for the fourteenth day of storage.

When measuring the acidity manually for the studied treatments, it showed a significant difference between the treatments, as the acidity value for the treatment containing 0.25 g gelatin was recorded at 0.936 for the first day of storage, but the acidity value decreased significantly for the treatment to which 0.25 g guar was added to be 0.906, which is considered the lowest value among the treatments after storage

for 14 days. [15] stated that the use of guar in the production of yogurt from skimmed milk in different proportions helps in reducing acidity and helps in retaining water, which makes the product more acceptable to the consumer with an increase in the storage period.

Regarding the water holding capacity (WHC) of the treatments, the results showed that there were significant differences between the treatments. The highest WHC values were recorded for the treatments containing gelatin (0.25, 0.5) g, with values of 6.18 and 6.22 on the first day of storage, respectively. On the other hand, the values significantly decreased for the treatments containing guar gum (0.25 and 0.5 g), recording values of 3.60 and 3.66, respectively [14] clarified that when starch was used at different concentrations up to 1%, the physicochemical properties were notably affected, with these properties improving as the storage period increased at 5 ℃. This supports the use of starch at various concentrations to improve the properties of yogurt produced from different sources.

Table 2. *Analysis of yogurt produced by adding 6% skimmed dry milk + 94 whey.*

Storage period	Transactions		PH	Diarrheal acidity	Water retention
First day	1	Gelatin 0.25	4.30000 c	0.93667 a	6.18333 a
	2	Gelatin 0.5	4.28000 c	0.91000 b c	6.22333 a
	3	Starch 0.25	4.35333 b	0.93000 a b c	5.24000 b
	4	Starch 0.5	4.40000 a	0.92667 a b c	5.26333 b
	5	Ghawar 0.25	4.37000 b a	0.91000 b c	5.10667 c
	6	Ghawar 0.5	4.37333 b a	0.93333 a b	5.13000 c
the seventh day	7	Gelatin 0.25	4.21000 d	0.92667 a b c	5.08333 c
	8	Gelatin 0.5	4.20000 e d	0.91000 b c	5.22333 b
	9	Starch 0.25	4.17000 e f	0.91667 a b c	4.24000 f
	10	Starch 0.5	4.15000 g f	0.91333 a b c	4.26333 f
	11	Ghawar 0.25	4.17333 e f	0.92667 a b c	4.10667 g
	12	Ghawar 0.5	4.17333 e f	0.91333 a b c	4.13000 g
Day fourteen	13	Gelatin 0.25	4.13333 g h	0.91000 b c	4.58333 e
	14	Gelatin 0.5	4.13667 g h	0.91667 a b c	4.72333 d
	15	Starch 0.25	4.13000 g h	0.92667 a b c	3.74000 h
	16	Starch 0.5	4.11333 i h	0.92000 a b c	3.76333 h
	17	Ghawar 0.25	4.09667 i	0.90667 c	3.60667 i
	18	Ghawar 0.5	4.09333 i	0.92333 a b c	3.63000 i

Similar letters mean no semantic differences.

Table 3, shows significant differences among the treatments at a 0.05 level of significance. The highest pH was recorded for the treatment containing 0.5 g of starch, which reached 4.36 on the first day of storage. On the other hand, the pH value decreased for the treatment containing 0.5 g of guar gum on the fourteenth day of storage.

As for the acidity, it was high for the treatment to which 0.25 gelatin on the first day of storage, as it recorded 0.94, However, it significantly decreased for the treatment containing 0.25 g of guar gum, reaching 0.91 on the fourteenth day of storage.

Regarding the water holding capacity (WHC), the highest values were recorded for the two treatments containing gelatin, as it reached (6.12, 6.16) respectively for the first day of storage; while it decreased in the two treatments to which guar was added to record (3.49, 3.52) for the fourteenth day of the storage period.

Starch helps improve the physical and chemical properties of the produced yogurt. This was shown [16] When added to yogurt, Starch has been shown to improve the physicochemical properties of yogurt, as [16] demonstrated that starch addition helps increase water retention and improves other yogurt properties, especially with prolonged storage. Furthermore, the addition of guar gum at different concentrations helps extend the shelf life of yogurt and enhances the properties of the final product, as [17] have pointed out.

Table 3. *Analysis of Yogurt Produced by Adding 7% skimmed dry milk + 93 whey.*

Storage period	Transactions		PH	Diarrheal acidity	Water retention
First day	1	Gelatin 0.25	4.26000 abc	0.94667 a	6.12333 a
	2	Gelatin 0.5	4.24000 c	0.92000 bc	6.16333 a
	3	Starch 0.25	4.31333 ab	0.94000 abc	5.14000 b
	4	Starch 0.5	4.36000 a	0.93667 abc	b 5.15333
	5	Ghawar 0.25	4.33000 ab	0.92000 bc	c 4.95667
	6	Ghawar 0.5	4.33333 ab	0.94333 ab	c 4.98000
the seventh day	7	Gelatin 0.25	4.17000 cde	0.93667 abc	c 5.03333
	8	Gelatin 0.5	4.16000 cde	0.92000 bc	b 5.17333
	9	Starch 0.25	4.13000 def	0.92667 abc	f 4.16000
	10	Starch 0.5	4.11000 def	0.92333 abc	f 4.17333
	11	Ghawar 0.25	4.13333 def	0.93667 abc	g 3.98667
	12	Ghawar 0.5	4.13333 def	0.92333 abc	g 4.01000
Day fourteen	13	Gelatin 0.25	4.09333 ef	0.92000 bc	e 4.53667
	14	Gelatin 0.5	4.09667 ef	0.92667 abc	d 4.67333
	15	Starch 0.25	4.09000 ef	0.93667 abc	h 3.67000
	16	Starch 0.5	4.07333 ef	0.93000 abc	h 3.68333
	17	Ghawar 0.25	4.20333 cd	0.91667 c	i 3.4967
	18	Ghawar 0.5	4.05333 f	0.93333 abc	i 3.52

Table 4 shows the analysis of yogurt produced by adding 8% sorted skim milk. It was observed that there were clear differences among the treatments during their storage periods. The highest pH value was recorded for the treatment containing 0.5 g of starch on the first day of storage, reaching 4.27. In contrast, the pH value decreased for the treatment containing 0.5 g of guar gum on the fourteenth day of storage, reaching 4.01.

When measuring the acidity of the studied treatments, it was found that its highest value was 0.95 in the treatment to which 0.25 g gelatin was added for the first day of storage, but it decreased to 0.92 in the treatment containing 0.25 g guar for the fourteenth day of storage.

As for the water holding capacity (WHC), the treatments containing gelatin (0.25 and 0.5 g) showed a significant increase in water retention, with values of 6.06 and 6.10 on the first day of storage, respectively. On the other hand, the lowest water retention values were recorded for the treatments containing guar gum (0.25 and 0.5 g), with values of 3.39 and 3.40 on the fourteenth day of storage, respectively. The first day of storage represents freshly manufactured products, so changes in the additives are not immediately noticeable. However, as the storage period progresses, the shelf life of the yogurt increases.

Table 4. *Analysis of Yogurt Produced by Adding 8% skimmed dry milk + 92% whey protein.*

Storage period	Transactions		PH	Diarrheal acidity	Water retention
First day	1	Gelatin 0.25	C 4.17	A 0.957	A 6.06
	2	Gelatin 0.5	C 4.157	B C 0.93	A 6.10
	3	Starch 0.25	B 4.22	B A C 0.95	C B 5.04
	4	Starch 0.5	A 4.27	B A C 0.95	C B 5.05
	5	Ghawar 0.25	B A 4.24	B C 0.93	D 4.807
	6	Ghawar 0.5	B A 4.24	B A 0.95	D 4.83
the seventh day	7	Gelatin 0.25	D 4.09	B A C 0.95	C 4.98
	8	Gelatin 0.5	E D 4.08	B C 0.93	B 5.12
	9	Starch 0.25	E F G 4.05	B A C 0.937	G 4.08
	10	Starch 0.5	H F G 4.03	B A C 0.93	G 4.09
	11	Ghawar 0.25	E F 4.05	B A C 0.947	H 3.87
	12	Ghawar 0.5	E F 4.05	B A C 0.93	H 3.89
Day fourteen	13	Gelatin 0.25	H 4.01	B C 0.93	F 4.49
	14	Gelatin 0.5	H G 4.017	B A C 0.937	E 4.62
	15	Starch 0.25	H F G 4.02	B A C 0.947	I 3.60
	16	Starch 0.5	H F G 4.03	B A C 0.94	I 3.61
	17	Ghawar 0.25	H F G 4.04	C 0.927	J 3.397
	18	Ghawar 0.5	H 4.01	B A C 0.94	J 3.41

Table 5 presents the results of the studied treatments produced from whey and 9% skim milk. Significant differences were observed among the treatments during the different storage periods. The highest pH value was recorded for the treatment containing 0.5 g of starch on the first day of storage. In contrast, the pH value decreased for the treatment containing 0.25 g of guar gum on the fourteenth day of storage, recording 3.96, the lowest value among all treatments.

Regarding acidity, the highest value was 0.97 for the treatment containing 0.25 g of gelatin on the first day of storage. However, the lowest value was recorded for the treatment containing 0.25 g of guar gum on the fourteenth day of storage, with a value of 0.94.

As for water retention, the highest value was found in the treatments containing gelatin (0.25 and 0.5 g), with values of 6.00 and 6.04 on the first day of storage, respectively. In contrast, the water retention values continued to decrease in the other treatments with increasing storage periods, recording the lowest levels of 3.29 and 3.31 in the treatments containing guar gum.

3. Conclusion

In conclusion, this study showed that the use of whey, a by-product of soft cheese production, in yogurt production is a promising option to improve the properties of dairy products when mixed with skimmed milk and different proportions of thickeners such as gelatin, starch, and whey. The results showed significant differences in the chemical and physical changes of the products over different storage periods, as some treatments recorded higher values in pH and water retention compared to other treatments. In contrast, some treatments to which whey was added showed a decrease in the physical and chemical properties on the 14th day of storage. These results demonstrate that adjusting the proportions of additional components can significantly affect the quality of the final products and provide opportunities to improve the sensory and nutritional properties of dairy products.

Table 5. Analysis of Yogurt Produced by Adding 9% skimmed dry milk + 91% whey protein.

Storage period	Transactions		PH	Diarrheal acidity	Water retention
First day	1	Gelatin 0.25	C 4.15333	A 0.97667	A 6.00333
	2	Gelatin 0.5	C 4.13667	B C 0.95000	A 6.04333
	3	Starch 0.25	B 4.20333	B A C 0.97000	C 4.94000
	4	Starch 0.5	A 4.25000	B A C 0.96667	C 4.95333
	5	Ghawar 0.25	B A 4.22000	B C 0.95000	D 4.66667
	6	Ghawar 0.5	B A 4.22333	B A 0.97333	D 4.68667
the seventh day	7	Gelatin 0.25	D 4.07000	B A C 0.96667	C 4.93333
	8	Gelatin 0.5	D 4.06000	B C 0.95000	B 5.07333
	9	Starch 0.25	E D 4.03000	B A C 0.95667	G 4.00000
	10	Starch 0.5	E 4.01000	B A C 0.95333	G 4.01333
	11	Ghawar 0.25	E D 4.03333	B A C 0.96667	H 3.74667
	12	Ghawar 0.5	E D 4.03333	B A C 0.95333	H 3.77000
Day fourteen	13	Gelatin 0.25	E F 3.99333	B C 0.95000	F 4.44333
	14	Gelatin 0.5	E F 3.99667	B A C 0.95667	E 4.57333
	15	Starch 0.25	E F 4.00333	B A C 0.96667	I 3.53000
	16	Starch 0.5	E 4.01333	B A C 0.96000	I 3.54333
	17	Ghawar 0.25	F 3.96333	C 0.94667	J 3.29667
	18	Ghawar 0.5	E F 3.99333	B A C 0.96333	J 3.31000

Abbreviations

WHC	Water Holding Capacity
AOAC	Association of Official Analytical Chemists

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Conflicts of Interest

The authors declare no conflicts of interest.

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