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Research Article

Effect of adding sodium caseinate, whey protein concentrateand milk protein concentrate on the physical, rheological and sensory properties of yogurt produced from goat milk

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Abstract
Yogurt is a widespread fermented dairy product widely consumed worldwide. The present study aimed to examine the impact on the yogurt's made from goat milk's physicochemical, rheological, and sensory aspects by incorporating varying percentages of Sodium Caseinate (SC), whey protein concentrate (WPC), and cow milk protein concentrate (MPC) during production to produce good quality yogurt. Four different treatments weremade and assigned as control treatment C, treatment C1 (SC was added at a percentage of 1% and 2%), treatment C2 (WPC added at a percentage of 1% and 2%), and treatment C3 (MPC added at a percentage of 1% and 2%). Estimates of pH and total acidity were among the physiochemical tests performed. Rheological evaluations includedviscosity, the ability to separate whey spontaneously, and moisture retention. Texture tests included hardness, springiness, and cohesiveness. A sensory evaluation of the produced yogurt was also done. The results showed an approximation in the additional treatments' total acidity and pH values immediately after manufacturing. Compared to the control treatment, the additional treatments decreased the values of spontaneous whey separation and increased the water holding capacity and viscosity. However, the product's texture was enhanced due to the addition of the three protein components, which contributed to its hardness, springiness, and cohesion. There was an improvement in the sensory properties of the addition treatments compared to the control treatment and directly related to the increment in the addition percentage.The yogurt resulting from the addition of (SC, WPC, and MPC) led to the production of good-quality yogurt.

Keywords: Goat's milk,Sensory Properties, Sodium Caseinate, Yogurt

INTRODUCTION

There has been considerable academic interest in producing dairy products to which other foodstuffs have been added, whether or not these ingredients are produced from milk. such as dried fruits and natural sweeteners, are included in ice cteam industry (Hasan *et al*., 2020; Saadi *et al*., 2022; Mulakhudaire*t al*., 2023). Yogurt manufacturers may add dry mushroom powder, stabilizers, or various kinds of milk to the mix (ALKaisy*et al*., 2023; Saadi *et al*., 2022; Al-Bedrani*et al*., 2023). Vegetable oils, cardamom, the enzyme trypsin used in buffalo milk cheese production, and sheep and camel milk blends are just a few examples of what is added throughout the cheesemaking process (Saadi *et al*., 2019; Saadi, 2018; Salih *et al*., 2021; Ali and Saady, 2019).
Yogurt is among the most accepted fermented foods

among other dairy products due to its high nutritional value and multiple health benefits. Milk from cows, buffalo, sheep, or goats can be used to manufacture yogurt alone or in a mixture. Goat milk has weak structural properties; its gelatinous network is easy to break in comparison to that of a cow (Bintsis and Papademas, 2022; Genis *et al*., 2019; ALKaisy*et al*., 2023; Wang *et al*., 2022).

Despite its negative qualities, goat milk is considered an indispensable raw material thanks to its high nutritional value. That is beneficial regardless of the consumers' age group as it has positive physiological effects, especially on people suffering from malnutrition and indigestion (Filipczak-Fiutak*et al*., 2021; Gupta and Mishra, 2021).Goat milk also has special nutritional properties that make it important to consumers (Paskaš*et al*., 2020). Furthermore, goat milk is easier to digest and has a longer shelf life than cow milk, but despite the mentioned good characteristics of their milk, goats are mostly raised for their meat instead of their milk in most countries (Nayik*et al*., 2022). Goat milk has been used in feeding infants since ancient times; a tradition passed on to modern societies. Currently, markets specialize in providing goat milk for feeding children in many developed countries, such as the United States and South Africa. The more common problem of cow milk intolerance in infants seems rare in goat milk. Indigestion symptoms such as colic, diarrhea, vomiting, constipation, and many respiratory problems in infants can be eliminated by feeding them goat milk. Its ability to relieve many respiratory problems in infants is due to the structure of its casein particles (Gregoricka and Ullinger, 2022).

Pasteurized goat milk is also easier to eat for children with digestive and respiratory problems. Fermented dairy products based on goat milk are ideal for people who are intolerant to cow milk. Additionally, regular consumption of this milk significantly improves body weight and mineral salts deposition in bones and improves the different vitamin indexes in blood serum within the normal ranges. These previously mentioned advantages are positive compared to those of cow milk. The high concentration of medium-chain fatty acids is one of the many health advantages of goat milk, as it plays a great role in treating malabsorption and elevated lipoproteins in the blood. It is considered a good alternative for regular fat in people with gallstones and helps decrease steatorrhea in patients with cystic fibrosis. Medium-chain fatty acids in goat milk reduce the accumulation of cholesterol in the arteries (Nayik*et al*., 2021; Bhatia and Tandon, 2021; Bu *et al*., 2021; Panta *et al*., 2021).

The physical, structural, and sensory properties are very important as they give the yogurt its quality properties, thus directly influencing consumer preference and product acceptance (Gyawali *et al*., 2022). Solids and total protein (TP) are quality determinants, so adding some thickeners, such as milk protein concentrate and whey protein concentrate, will improve the desired structural properties of the produced yogurt (Atallah *et al*., 2020). Adding these substances increases the total solids and the total protein (Abd-Alla*et al*., 2023).Due to the increasing demand for processing functional and nutritionally beneficial foods and because proteins provide a great opportunity in this field, the use of WPC has increased in processed food products due to its important role in nutrition as a rich and balanced source of amino acids (Wen*et al.,*2023). Whey proteins also possess important functional properties as they can be used as emulsifying and stabilizing agents and thickeners, improving appearance, taste, texture, and the ability to bind fats and water. Whey proteins comprise β-lactoglobulin (β-LG) (Wang *et al*., 2019; Kusio *et al*., 2020).

Sodium caseinate is a milk-derived protein known for its exceptional emulsifying properties, high springiness, and wide use as a stabilizer in food emulsifiers (Asaithambi *et al.*, 2022). However, this protein is very sensitive to low pH conditions (Xi *et al*.,2020).

The study aimed to determine the effect of adding sodium caseinate, whey protein concentrate, and milk protein concentrate at an addition ratio of 1.0 and 2.0% to goat milk prepared for the manufacture of yogurt on the quality properties of the produced yogurt.

MATERIALS AND METHODS

Materials

Whole raw goat milk was used to manufacture goat yogurt collected from the fields adjacent to the College of Food Sciences - Al-Qasim Green University, Babylon/Iraq. The yogurt starter used in the manufacture was from the French company (Danisco). In contrast, the dried Sodium Caseinate (SC), whey protein concentrate (WPC), and cow milk protein concentrate (MPC) were bought from an Iranian company (Golshad).

Methods

Yogurt manufacture

The yogurt was made using the procedure outlined by Tamime and Robinson (1999):

The whole raw goat milk was taken and divided into four treatments: control treatment (C), the C1 treatment (SC was added at two different rates of 1.0 and 2.0%) C2 treatment(WPC was added at two different rates of 1.0 and 2.0%) and the treatment C3 (MPC was added at two different rates of 1.0 and 2.0%). The milk was heated to 90 degrees Celsius for 10 minutes, cooled to 42 degrees Celsius, and then inoculated with a starter culture containing *streptococcus thermophilus* var salivarius and *Lactobacillus bulgaricus* var delbrueckiiaccording to the manufacturer's specifications (Danisco, France, 0.00209%). The mixture was kept in 200 cc containers and heated to 42°C to coagulate. After removal, it was placed in a refrigerator and kept at 5 °C until the required tests could be run on days 1, 7, and 14.

Physicochemical analysis

Standards were used to determine the total acidity. Yogurt samples diluted with distilled water were placed into a pH meter (Model: 211, type: HANNA Instruments Microprocessor) to approximate the pH value AOAC (2000).

Viscosity

According to the procedure described by Donkor *et al*. (2007), the apparent viscosity was measured using a (Brookfield DVII+ viscometer manufactured by Brookfield Engineering Lab Inc., Stoughton Mass), with the axial spindle set to number 4 and rotated at a speed of 10 rpm for 60 seconds. The results were recorded in the centipoise unit.

Water Holding capacity

It was calculated by centrifuging 10 grams of sample at 3000 revolutions per minute for 60 minutes at 10 degrees Celsius. The filtrate was discarded, and the remaining wet precipitate was weighed to determine WHC using the following formula (Parnell-Clunies*et al*.,1986).

$$WHC\% = [1-(w2\,/\,w1)]\;x\,100 \qquad \text{Eq. 1}$$

Whereas: W_1: is the weight of the used yogurt, W_2: is the weight of the whey after the centrifugation.

Spontaneous whey separation

Using the technique described by (Amatayakul, 2006), Aa chilled yogurt cup was positioned at an angle of 45° for two hours in the refrigerator at 5°C, drained the secreted whey at the surface using a syringe, and weighed the yogurt sample once again to determine its fat content.

Texture analysis

The mechanical tests used to estimate hardness, springiness, and cohesiveness were performed using a texture analyzer type (CT3,4500 Brookfield engineering lab) equipped with a load cell of 5 kg following the method mentioned by Joon *et al*. (2017).

Sensory evaluation

This was conducted by several specialized professors at the College of Food Sciences - Al-Qasim Green University to judge the yogurt samples' characteristics of flavor, texture, sour taste, and appearance that are listed in a form developed by Almosawi (2015) for sensory assessment.

Statistical analysis

Using a completely randomized design (CRD), we analyzed the data with SAS (2012) to determine the impact of the treatments on the characteristics we measured, and we compared the means using the Least Significant Difference (LSD) test to determine whether or not there were statistically significant differences.

RESULTS AND DISCUSSION

Physical properties

pH is a major factor affecting the degree to which the casein network develops, which is responsible for forming yogurt gel (Asaduzzaman*et al*., 2021). The results in Table1 show the pH values immediately after manufacture, being 4.60 for the control treatment C, 4.50 and 4.55 for the 1.0% and 2.0% SC addition ratios of the C1 treatment, respectively, 4.56 and 4.56 for the 1.0% and 2.0% WPC addition ratios of the C2 treatment, 4.57 and 4.57 for the 1.0% and 2.0% MPC addition ratios of the C3 treatment. It was seen that the addition treatments had lower pH values when compared to the control treatment indicating the effect of the added proteins on the pH of the treatments This was consistent with Tupamahu *et al.* (2017), who indicated that yogurt treatments fortified with mushrooms of high protein content were distinguished with a decrease in pH concurrent with the increment in the percentage of the added mushrooms. This was attributed to the high protein content of the mushrooms which may provide many nutrients like the peptides and amino acids required to revive the starter and increase its activity. The results also agree with what Al-Bedrani*et al*. (2019c) discovered, who reported a decrease in the pH values of the processed cheese treatments that included WPC. As of storage day 14, pH readings had dropped across all treatments; the values became 4.45 for treatment C1, (4.4, 4.4), (4.45, 4.45), (4.4, 4.3) for the two addition percentages in each of the C2, C3, and C4 treatments respectively. This result agrees with what was found by Adriana Dabija *et al.* (2018) and Habibi *et al*. (2019), who pointed out the decrease in pH values of yogurt with storage. It was also reported by Macit and Bakirci (2017)that the total acidity of natural yogurt was increased when stored for three weeks. Norouzbeigi*et al*.(2021) studied the effect of adding cysteine on the activity of the starter and the physicochemical properties of goat milk bio yogurt stored for four weeks; he confirmed an increase in total acidity in all treatments and a decrease in pH values. There was no statistically significant difference (P≤0.05) between any of the treatments regarding pH levels either just after production or throughout storage.

Total acidity

Table 1 displays the total acidity of the yogurts immediately after production, with 0.80% for the control treatment C, 0.9% for the 1.0% SC addition ratio of the C1 treatment, 0.9% for the 2.0% WPC addition ratio of the C2 treatment, and 0.8% and 0.9% for the 1.0% MPC and 2.0% MPC ratios, respectively. After 14 days in storage, the acidity was 1.2% for the C1 treatment, 1.1% for the C2 treatment, 1.3% for the C3 treatment, and 1.1% and 1.2% for the two addition percentages in the C1, C2, and C3 treatments,

Table 1. Physical properties and total acidity of all yogurt treatments; control treatment, treatments with 1.0% and 2.0% addition of SC, WPC, and MPC during storage.

Temperature		Storage (dsy)	pH	%Total acidity	Viscosity (Centipoise)	Spontaneous whey Separation (ml)	%Water holding capacity
Control C	0	1	4.60	0.8	1500	7.5	71.0
		7	5.51	1.0	1550	6.5	72.7
		14	4.45	1.2	1566	5.4	74.22
SC C1	1.0%	1	4.50	0.9	1500	6.6	72.5
		7	4.45	1.0	1560	6.0	73.66
		14	4.40	1.1	1655	5.4	74.0
	2.0%	1	4.55	1.0	1590	6.0	73.0
		7	4.50	1.1	1620	5.4	73.8
		14	4.40	1.2	1700	5.0	74.2
WPC C2	1.0%	1	4.56	0.9	1550	7.0	72.7
		7	4.52	1.1	1600	6.5	73.6
		14	4.45	1.3	1655	5.9	74.9
	2.0%	1	4.56	1.0	1570	6.9	72.99
		7	4.52	1.2	1666	6.1	74.0
		14	4.45	1.35	1700	5.9	75.2
MPC C3	1.0%	1	4.57	0.8	1600	6.0	73.0
		7	4.55	1.0	1710	5.5	74.1
		14	4.40	1.1	1800	5.0	75.0
	2.0%	1	4.57	0.9	1650	5.0	74.0
		7	4.45	1.1	1776	4.6	74.9
		14	4.30	1.2	1810	4.0	75.4
LSD value			0.993 *	0.451 *	192.07 *	1.084 *	4.021 *

** (P≤0.05).

respectively. These findings are consistent with those of Kaur and Riar (2020), who reported that the acidity of the yogurt treatments increased from 1.22% at zero time to 1.41% after being stored in the refrigerator. Al-Bedrani*et al*.'s (2019b) findings, indicated an increase in acidity of all yogurt treatments supplemented with orange marmalade throughout a storage duration of 14 days, which is consistent with this idea. Neither the acidity nor the pH seem to have changed significantly (P≤0.05) between treatments either immediately after production or throughout storage.

Rheological properties

One of the most important physical properties of yogurt is stability; it is affected by several factors,including;the acidity of yogurt, percentage of total solids, protein content, heat treatment, storage temperature, and the activity of the Bacterial starter(Arab *et al*., 2023).

Spontaneous whey separation

The results in Table 1 show the amount of whey exuded from the yogurt treatments immediately after manufacture, being 7.5 ml/100 ml from the control treatment C, 6.6 and 6.0 ml/100 ml from the 1.0% and 2.0% SC addition parts of the C1 treatment respectively, 7.0 and, 6.9 ml/100 ml from the 1.0% and 2.0% WPC addition parts of the C2 treatment respectively, 6.0 and, 5.0 ml/100 ml from the 1.0% and 2.0% MPC addition parts of the C1 treatment respectively. All of the additional treatments produced less whey than the control treatment, which is in line with the findings of Barkallah*et al*. (2017), who observed that the quantity of whey produced by yogurt decreased with increasing amounts of added solids. Increasing the protein content of yogurt increases its gel strength, reducing the casein-to-whey protein ratio, resulting in less whey separation (Wilbanks*et al.* (2023). It is also noted from the results that the amounts of the exuded whey decrease during storage, so after 14 days, these amounts become 5.4 ml/100 ml for treatment C, (5.4, 5.0 ml/100ml), (5.9, 5.9 ml/100 ml), and (5.0, 4.0 ml/100ml) for the two addition percentages in each of the treatments C1, C2, and C3 respectively. This agrees with what was reported by Al-Bedrani*et al.* (2019c), who reported a whey separation in all yogurt fortified with date syrup (dibis),and also agrees with what was reported by Kaur and Riar (2020) that may be the cause for this is due to the higher molecular weight of the added solid material, leading to an improved water holding capacity in milk thus prevented the whey from exuding at the surface.

Water holding capacity

The water-holding capacity (WHC) of yogurt indicates its ability to retain whey in its jelly structure (Li*et al*., 2022). Although negatively perceived by consumers, as they generally associate it with negative changes in quality and perceive it as a sign of deterioration, the separation of whey from yogurt is a normal phenomenon (Vanegas-Azuero, Gutiérrez (2018). For this reason, consumers prefer to consume yogurt with a low degree of separation. Additives can be used to achieve this purpose.

The results in Table 1 show the percentage of water holding capacity of the yogurt treatments immediately after manufacturing, being 71% for the control treatment C, (72.5 and 72.99%) for the 1.0% and 2.0% SC addition ratios of the C1 treatment respectively, (72.7 and 74.9%) for the 1.0% and 2.0% WPC addition ratios of the C2 treatment, (73 and 74%) for the 1.0% and 2.0% MPC addition ratios of the C3 treatment. It is also noted that the additional treatments have a higher water-holding capacity. This is consistent with the findings of Xie *et al*. (2022), who hypothesized that the greater cross-linking of the gel in protein-fortified products may be due to their higher water-holding ability compared to milk without protein preparations.Gilbert *et al*. (2021) also reported that total solid content and the ratio of casein to whey protein are important factors influencing the water-holding capacity of yogurt. The results also noted that the water holding capacity is higher in both 1.0 and 2.0% WPC addition percentages of treatment C2 compared to other treatments. This may be due to the ability of WPC to bind water, especially after being denatured by heat treatment. This is consistent with the findings of Kadian*et al*. (2023),who indicated that whey proteins' ability to bind water increases as their solubility decreases due to denaturation, thus encouraging the use of this ability to improve the texture of fermented dairy products, as the solubility of whey proteins decreases due to increases its ability to bind water. There are statistically significant changes in water-holding capacity between the control treatment C and all other treatments just after production and throughout storage, as determined by analysis of variance (P≤0.05).

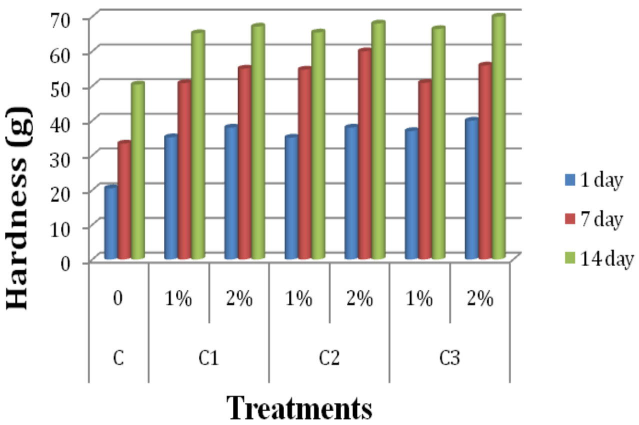

Fig. 1. *Hardness values for different yogurt treatment;* L.S.D = 6.58

The data also show that the storage length affects the capacity to retain water, as it tends to rise in all the treatments to reach its maximum after 14 days of storage to 74.22% for the control treatment C and (74.0, 74.2), (74.9, 75.2), (75.0, 74.4%) for the two addition percentages in each of the C1, C2, and C3 treatments respectively. This is consistent with the results of Atallah*et al.* (2020) observed that the addition of protein concentrates to the yogurt'sbasic ingredientswill enhance the water-holding capacity more than the caseinates can do; this rise in the WHC may be caused by the increment in the amount of the added concentrates as they are considered stabilizers that intertwine with the casein network.

Viscosity

In Table 1, the yogurt treatments ranged in initial viscosity from 1500 to 1590 centipoise, with the control treatment C having a value of 1500 centipoise and the C1 treatment having values of 1.0% and 2.0% SC addition ratios, respectively (1600 and 1680) centipoise for the 1.0% and 2.0% WPC addition ratios of the C2 treatment, (1590 and 1650) centipoise for the 1.0% and 2.0% MPC addition ratios of the C3 treatment. Viscosity was noted to be higher in the C2 and C3 treatments when compared with the control treatment C and the C1 treatment; this may be due to the higher protein content in these two treatments as C2 has a WPC addition and C3 has MPC addition that is partially composed of whey proteins. This is consistent with the findings ofKadian*et al*. (2023), who indicated that subjecting whey proteins to heat treatment could cause an increase in both viscosity and water-holding capacity because heat opens the structure of the protein to show the sites for binding water that were hidden before the heat treatment thus increasing the volume occupied by the protein. It is also noted that the viscosity in the protein addition treatments is generally higher than that of the control treatment. This may be due to the increase in the added protein percentage that will increase the percentage of total solids in the product, leading to an increment in viscosity (Ranaweera *et al*., 2022). After 14 days of storage, the control treatment C reached 1566 centipoise, the two additional percentages in each of the C1, C2, and C3 treatments reached 1655, 1700 centipoise, and the two additional percentages in each of the C2, C3, and C4 treatments reached 1800, 1810 centipoise. This result agrees with what was found by Al-Bedrani*et al.* (2022), who indicated an increase in viscosity values in yogurt treatments which enrichment with sodium pyrophosphate after being stored for 14 days. This may be caused by the decrease in the yogurt's pH index, causing an increase in hardness that will lead to an increased viscosity (Zang*et al*., 2023; ALKaisy and Rahi, 2022).

Table 2. Sensory evaluation of yogurt treatments, control treatment, and additional treatments to yogurt added to it SC, WPC, and MPC at 1.0% and 2.0% during storage

Treatments		Storage period (day)	Flavor 45°	Texture and consistency 35°	Acidity 10°	Appearance 10°	Total 100°
Control C	0	1	44	32	10	10	96
		7	43	32	10	10	95
		14	40	30	10	10	90
SC C1	1.0%	1	43	33	10	10	96
		7	40	30	10	10	90
		14	40	30	10	10	90
	2.0%	1	44	34	10	10	98
		7	43	31	10	10	94
		14	40	30	10	10	90
WPC C2	1.0%	1	44	34	10	10	98
		7	42	33	10	10	95
		14	40	30	10	10	90
	2.0%	1	45	35	10	10	100
		7	44	32	10	10	96
		14	43	30	10	10	93
MPC C3	1.0%	1	45	34	10	10	99
		7	43	34	10	10	97
		14	42	33	10	10	95
	2.0%	1	45	35	10	10	100
		7	44	35	10	10	99
		14	43	33	10	10	96
LSD value			4.237*	3.961*	0.772 NS	0.772 NS	6.724*

** (P≤0.05).

Texture properties

Hardness

Fig. 1 illustrates the hardness test results of the different yogurt treatments immediately after manufacture, being 20.5 g for the control treatment C, 35.2 and 38 gm for the 1.0% and 2.0% SC addition ratios of the C1 treatment, respectively, 35.1 and 35.2 gm for the 1.0% and 2.0% WPC addition ratios of the C2 treatment, 37 and 40 gm for the 1.0% and 2.0% MPC addition ratios of the C3 treatment. It is clear from the results that the hardness in the yogurt treatments produced of goat milk with protein addition is higher in comparison to that of the control treatment, for it was the treatment with the lowest hardness because the casein particles in goat milk are very small (Wang *et al*., 2022). Also, goat milk is characterized by having small-sized fat granules and a high percentage of short and medium-chain saturated fatty acids such as butyric, caproic, caprylic, and capric acid (Massouras*et al*., 2023), making the produced yogurt weak in terms of texture and rheological properties, mainly viscosity and whey separation, that is why adding proteins will improve these properties. Also, Bruzantin *et al.* (2016) indicated that adding some materials, whether of milky or non-milky origin, especially protein materials, can improve fermented dairy products' rheological and texture properties. Looking at the results, it was noticed that the portion with 2.0% MPC addition of treatment C3 has a higher hardness when compared to that of the other treatments. The high total solids content may be to blame for this.

Hardness increased during storage in all treatments, with the C treatment reaching 50.4 g after 14 days and the other treatments reaching (69 g, 68.3 g), (65.4 g, 70.55 g), and (70 g, 70 g) for the two addition percentages in each of the C1, C2, and C3 treatments, respectively.Mustafa and Albadawi (2019) discovered that the yogurt's hardness grew from 71 gm immediately after manufacture to 110 g after the 21-day storage period. Therefore,the present result is in line with them. It is also consistent with Ibrahim and Al-Saadi (2018), who found that the hardness of the yogurt made from whole milk increased from 71 gm immediately after processing to 85 gm at the end of the 28-day storage period.

Cohesiveness

Cohesiveness is an important property regarding texture in yogurt;it is defined as the forces of internal bonds that maintain the product intact for the consumer and is expressed as the extent to which the material is deformed when subjected to a deforming force before it ruptures, this depends on the nature of the protein ma-

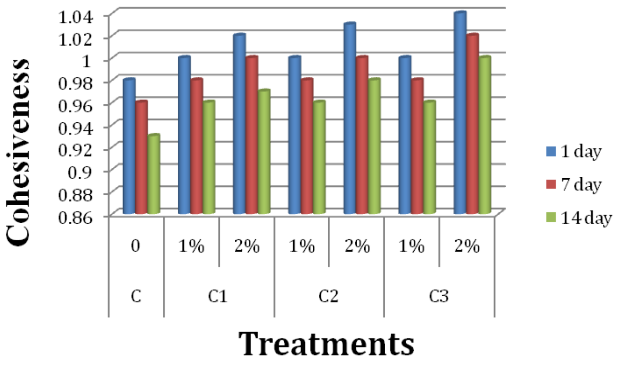

Fig. 2. *Cohesiveness values for different yogurt treatments; L.S.D = 0.091*

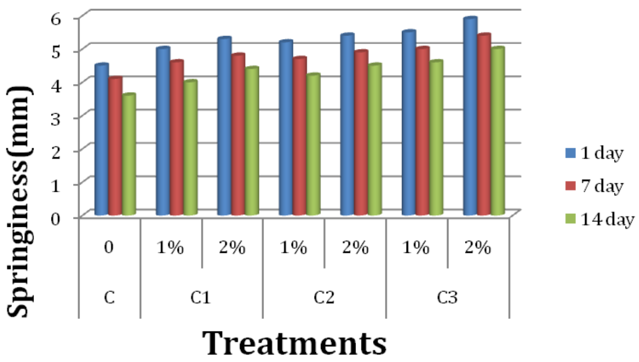

Fig. 3. *Springiness values for different yogurt treatments; L.S.D = 1.17, NS = (P≤0.05)*

terial in it, Mousavi *et al.* (2019). Fig. 2 displays the cohesiveness in the yogurt treatments right after production; for the control treatment C, it was 0.98; for the C1 treatment, it was 1.0, 1.2; for the C2 treatment, it was 1.0, 1.03; for the C3 treatment, it was 1.2, 1.45; and for the C4 treatment, it was 1.0, 2.0%. It was noted in the results that the cohesiveness of the two addition percentages in each of the addition treatments was higher than that of the control treatment. On the one hand, this may be caused by the increased total solids in the addition treatments, particularly the proteins and on the other hand, it was due to the weak properties of goat milk casein in the control treatment compared to other proteins. It was that the cohesiveness of the MPC addition yogurt treatment (C3) was higher when compared to that of the treatments C1 and C2; the reason for this may be due to the synergistic effect of both casein and whey proteins on binding water leading to a higher cohesiveness, this is consistent with the findings of Mousavi *et al. (*2019) who reported that casein and whey proteins could increase synergy leading to increased cohesiveness of yogurt.

After 14 days of storage, the cohesiveness of the control treatment C was 0.93, whereas the cohesiveness of the two addition percentages in each of the C1, C2, and C3 treatments was (0.94, 0.97), (0.96, 0.98), and (0.96, 1.0). Yilmaz-Ersan *et al.* (2014) indicated that the lower the cohesiveness of milk products, the smoother the texture will be (i.e., fineness to the touch). Previous studies showed that the most effective component in increasing the consistency of yogurt is protein and that the effect of fat is of secondary importance (Santiago-García *et al*., 2021). The results also indicate a statistically significant difference in cohesiveness between the control treatment C and all other treatments at the end of the 14-day storage period.

Springiness

The results in Fig. 3 show the springiness of the yogurt treatments immediately after manufacture, being 5.7 mm for the control treatment C and; (5.0 mm and 5.1 mm) for the 1.0% and 2.0% SC addition ratios of the C1 treatment respectively, (5.1 mm, 5.2 mm) for the 1.0% and 2.0% WPC addition ratios of the C2 treatment respectively, (5.3 mm, 5.5 mm) for the 1.0% and 2.0% MPC addition ratios of the C3 treatment respectively. The results also noted that the springiness of both MPC addition ratios of the C3 treatment was higher immediately after manufacture when compared to that of the C2 and C3 treatments. This may be due to the type of added protein that consists of both casein and whey proteins.

Furthermore, the results show that the springiness decreased in all of the yogurt treatments during storage, with the C treatment reaching a value of 3.6 mm after 14 days and the other treatments ranging from 4.0, 4.0 mm to 4.6, 4.4 mm for the two addition percentages in each of the C1, C2, and C3 treatments. This result was consistent with the findings of Mustafa and, Albadawi (2019), who indicated that the springiness of the control yogurt treatment, which amounted to 17.6 mm immediately after manufacture, was increased to 21.5 mm on the seventh day, then decreased at the end of the 21-day storage period.

Sensory evaluation

The sensory assessment scores for each yogurt treatment are shown in Table 2, both immediately after production and after cold storage. Flavor, texture, appearance, and an acid test were some of the criteria used in the analysis.

The WPC and MPC addition treatments were superior to the control treatment, as the type of added protein played a positive role in imparting good and desirable qualities such as color, taste, and flavor. In this evaluation, after manufacture, WPC addition treatment C2 got 98 and 100 degrees for the two addition percentages, and MPC addition treatment C3 got 99 and 100 degrees for the two addition percentages, respectively. The added proteins had a clear role in maintaining the sensory properties of yogurt; this is consistent with what was mentioned by Kaur and Riar (2020) that the general acceptance increases with the increment in the percentage of the added proteins. The weak properties of goat milk, such as the small-sized casein particles, small-sized lipid granules, and its short and medium-chain saturated fatty acid content, give goat milk products poor texture and less fluidity. Therefore, it is challenging to gain the acceptance of consumers who are not accustomed to fermented goat milk products, such as yogurt, not just regarding flavor but also regardingbody and texture (Costa *et al.*, 2014; Mosquera Ramos, 2022).

It was also noted from the results that there was a decline in sensory evaluation marks given to each one of the treatments during storage. Nonetheless, the decline was less in the addition treatments in comparison to that in the control treatment, evidenced by the fact that the 96 degrees given to the 2% MPC addition part of the C3 treatment was the highest total evaluation degree given to any of the treatments at the end of the 14-day storage period.

Khalifa and Gomaa, (2021) indicated that storage negatively affectsthe color and exterior appearance of yogurt, from which a decline in general acceptance and a deterioration in color characteristics will result. Adding to that, when Ziarno and Zaręba (2020)studied the addition of dried protein powder in high percentages to the milk prepared for low-fat yogurt processing and its effect on the quality properties of the product, they found a deterioration in the organoleptic characteristics of the produced yogurt during storage.

Conclusion

The addition of different percentages of each sodium caseinate, whey protein concentrate, and cow milk protein concentrate affected the physiochemical, rheological, and sensory characteristics of yogurt produced from full-fat goat milk. Adding these proteins showed increased hardness and viscosity of the yogurt manufactured. The treatments obtained high degrees of sensory evaluation and led to good quality yogurt.

Conflict of interest

The authors declare that they have no conflict of interest.

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