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Chemical, rheological, microbial and sensorial properties of bio-Greek yogurt made from cow, buffalo, goat, sheep or camel milk using transglutaminase

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Chemical, rheological, microbial and sensorial properties of bio-Greek yogurt made from cow, buffalo, goat, sheep or camel milk using transglutaminase

Abstract

Greek yogurt is one of the most important fermented dairy products which receives great popularity among consumers. The production of Greek yogurt from cow, buffalo, camel, goat, or sheep milk using transglutaminase and probiotic culture was evaluated. The highest values of total solids, fat, total protein, acetaldehyde and diacetyl were detected in sheep and buffalo milk yogurt followed by goat, cow and camel milk yogurt. Camel yogurt had the greatest levels of antioxidant activity and total phenolic content. Sheep and buffalo milk yogurts showed higher water holding capacity, hardness, gumminess and chewiness and lower syneresis values whereas camel milk yogurt exhibited the weakest levels. Using transglutaminase improved the textural profile in all treatments. Sheep and camel yogurt contained the highest *L. acidophilus* populations. Additionally, camel milk yogurt provided the most suitable environment for *Bifidobacterium bifidum*. Because of a white color, a creamy and smooth body and high spreadability, sheep and buffalo yogurt gained the highest sensory attributes scores. Bio-Greek yogurt with favorable chemical, rheological and sensory characteristics can be produced from sheep, buffalo and cow milk using transglutaminase. Further studies are needed to improve the flavor attributes of goat Greek yogurt, and the rheological properties of camel Greek yogurt, potentially through the additions of natural ingredients such as honey or fruit.

Keywords Greek yogurt . Camel milk . Sheep milk . Probiotics . Transglutaminase

Introduction

Traditionally fermented milk products have been made using milk of various mill animals such as cow, sheep, goat and buffalo according to the availability. However, different types of milk

are used for yoghurt preparation in different regions of the world; cow's milk is the most common type and is mostly used in the industrial production of yogurt (Yildiz, 2010). The chemical composition of milk varies according to different factors like species, breed, and season. This may affect the fermentation process and the yogurt properties. For instance, the amount of protein and fat in yoghurt, which varies significantly depending on the species, affects its sensory qualities including texture and flavor. Milk from sheep and buffalo has an extremely high fat content—more than 7%. The highest protein content is seen in sheep milk (4.6%). Because of its high fat content, yoghurt prepared from sheep or buffalo milk has a creamy texture and buttery flavor. The yogurt's flavor is also influenced by the concentration of minor ingredients. The high concentration of free fatty acids in goat's milk has been related to the yogurt's special "goaty" flavor (Chandan & Kilara, 2013).

On the other hand, yogurts contained high-protein levels were first commercially introduced in 2007 under the name Greek yogurt. Now, Greek yogurt is one of the fastest-growing segments in the dairy food category. It can be made by straining the whey or not; the latter is known as "Greek style yoghurt" and can be made from cow, sheep, goat, or buffalo milk without homogenization, which results in the formation of a characteristic crust layer on the yogurt's surface made of fat and milk's serum proteins (Serafeimidou et al., 2012).

Additionally, the therapeutic and nutritional benefits of Greek yogurt may be similar to or slightly better than those of regular yogurt. Adding probiotic cultures to Greek yogurt can further enhance its health-beneficial aspects by combining the potential health effects of probiotic bacteria. The discovered health benefits associated with yogurt and probiotics include growth promotion, enhancement of mineral absorption, lactose digestion, antimicrobial function, anticholesterol impact, anticarcinogenic factor, stimulation of the host immunological system,

restoration of normal balance of gastrointestinal microflora, and positive contribution to longevity (Chandan et al., 2012). The live microorganisms in Greek yoghurt can help to enhance digestive system, by increasing the beneficial bacteria in gut. This also helps in relieving digestive conditions such as constipation, inflammatory bowel disease, lactose intolerance, and diarrhea. Greek yoghurt/Greek-style yoghurt is an important source of calcium, magnesium and potassium which reduces high blood pressure.

Greek-style yoghurt is frequently supplemented with milk proteins to achieve the necessary levels of protein content and gel firmness. Several milk protein components are used, such as skimmed milk powder, whey powder, whey protein concentrate, whey protein isolates, caseins, and newer components such as milk protein concentrates (MPC), milk casein concentrates, and milk soluble protein concentrates (Rameshchandra, 2017). MPC is a high-protein powder that has the same amount of casein to milk's whey protein. It is highly soluble, has no unpleasant aftertaste, and is stable at normal pasteurization temperatures. According to reports, adding MPC to yoghurt milk enhances the end product's protein and total solids content, making the yoghurt firmer and smoother (Jørgensen et al., 2019). Therefore, in industrial production of Greek yogurt, cow's milk is usually supplemented with MPC to achieve the desired impact of increasing total solids and protein.

Conversely, the low α-S1-casein content in some other milk types, such goat's milk, results in reduced heat stability and lower quality gel formation during yoghurt manufacture (Munekata et al., 2021). Also, the manufacturing of yoghurt from camel milk brings some problems during fermentation (Bulca et al., 2019). Coagulation may not occur, or it may occur producing a weak gel. The cultured milk becomes a watery consistency with fragile and poor structure (Abdel Rahman et al., 2009). Because of the ability of microbial transglutaminase (TG) to form

crosslinking reactions with milk proteins, it has been used to improve the physicochemical and rheological characteristics of dairy products such as yogurt, ice cream and cheese at the same time, it has no negative effects on their sensory properties (Gharibzahedi & Chronakis, 2018). Vasić et al. (2023) stated that in an acidic environment, TG enhances yoghurt resilience, gel strength, and heat stability. Additionally, TG crosslinking improves overall product quality by reducing whey separation and increasing water retention (Akbari et al., 2021). While there are numerous research about using cow, goat, or sheep milk to make Greek yoghurt, the majority of them did not concentrate on the usage of transglutaminase or probiotics. Also, there is no any studies are available on Greek yoghurt made from camel milk. Hence the present work is aimed to develop probiotic Greek yoghurt made from cow, buffalo, goat, sheep and camel milk using probiotic cultures and TG.

Materials and Methods

Materials

Fresh cow, buffalo, goat, sheep and camel milk was obtained from Animal Production Research Institute, Agricultural Research center, Egypt. *S. thermophiles*, *Lactobacillus acidophilus*, and *Bifidobacterium bifidum* (Chr. Hansen's Lab A/S Copenhagen, Denmark) were included in the ABT-5 culture. Starter cultures were in freeze-dried direct-to-vat set form and stored at –18°C until used. Transglutaminase (Tgase, Activa TG-1, with activity of 100 units /g powder) was bought from Ajinomoto Europe Sales GmbH, Hamburg, Germany. We obtained milk protein concentrate (MPC, 70% protein) from the Fonterra Company in New Zealand.

Methods

Greek yogurt Preparation

Five treatments of Greek yogurt were made as follows:

A: Greek yogurt made from cow milk + 8% MPC + 0.04% Tgase

B: Greek yogurt made from buffalo milk + 8% MPC + 0.04% Tgase

C: Greek yogurt made from camel milk + 8% MPC + 0.04% Tgase

D: Greek yogurt made from goat milk + 8% MPC + 0.04% Tgase

E: Greek yogurt made from sheep milk + 8% MPC + 0.04% Tgase

After pasteurization, milk of various treatments were cooled to 40°C, mixed with MPC, stirred well and left for 30 minutes then Tgase was added, followed by inoculation with the starter culture (0.1 g/L of milk mix), incubated at 40°C for fully coagulation, and stored at 4°C for 14 days. Greek yogurt samples were analyzed when fresh and after 7 and 14 days of refrigerated storage.

Chemical analyses

Total solids, titratable acidity, total nitrogen, fat, and ash contents of milk and Greek yogurt samples were determined according to AOAC (2019). A digital laboratory pH meter (Jenway 3510, UK) was used to measure the pH values following calibration with standard buffers (pH 4.0 and 7.0). Carbohydrate content of milk was calculated by difference using the following equation:

Carbohydrates (%) = 100 − [Protein (%) + Fat (%) + Ash (%) + Moisture (%)]

Greek yogurt's diacetyl and acetaldehyde ratios were estimated in accordance with Lees and Jago (1970). According to Politeo et al. (2006) Greek yogurt's antioxidant activity was measured in terms of its hydrogen-donating or radical-scavenging activity using the stable radical DPPH. The modified Folin-Ciocalteu colorimetric method, as reported by Singleton et al. (1999) and Shiri et al. (2011), was used to spectrophotometrically analyze the total phenolic content. After extracting each sample (1g) with 10 mL of acidic methanol, 250 µL of the methanolic extract

was combined with 250 µL of distilled water in a test tube. Next, 2.5 mL of 10% Folin-Ciocalteu reagent was added, and the mixture was left for six minutes. Next, two millilitres of a 7.5% sodium carbonate solution were added. An UV/Vis spectrophotometer (model PG Instrument +80, Leicester, United Kingdom) was used to measure the absorbance at 760 nm after each sample was left to stand for 90 minutes at room temperature in the dark. Gallic acid is used as the standard, and the results are given as mg gallic acid/100 g of material.

Rheological analyses

Syneresis

50 g of yoghurt sample was put in a funnel with Whatman No. 1 filter paper (Whatman Ltd., Maidstone, UK) and allowed to sit at 4°C for five hours in order to determine syneresis. The volume of whey extracted from the yoghurt mass was multiplied by two to determine the ratio of syneresis (Dimitrellou et al., 2019a).

Water holding capacity

A 10g yoghurt sample was centrifuged at 4500 rpm for 30 minutes at 10°C to obtain the water holding capacity (WHC), which was then, determined using the following formula:

$$\mathrm{WHC}(\%) = \left(1 - \frac{\mathrm{W1}}{\mathrm{W2}}\right) \times 100,$$

Where W1 is the weight of whey after centrifugation and W2 is the weight of the yoghurt sample (Dimitrellou et al., 2019a).

Analysis of texture profile

A texture analyzer (TA-XT2 Texture Analyzer, Texture Technologies Crop, Scarsdale, NY) equipped with load cell of 5 kg and a cylindrical probe (25.4 mm in diameters) supplied with texture exponent programs (Exponent, Version 6.0.6.0., Texture Technologies Corp.) was

used to perform texture profile analysis (TPA) of the Greek yoghurt samples. Before measurement of TPA, the samples were left at 25 ºC (Kose et al., 2018). TPA was performed by compressed twice utilizing probe to form 10-mm penetration with the speed of 5 mm/s. The hardness, cohesiveness, springiness, gumminess and chewiness were computed from the obtained TPA by using software. For all samples, different determinations were made in triplicate.

Microbial analysis

Greek yogurt samples were analyzed for *Streptococcus thermophiles* and *Lactobacillus acidophilus* counts according to the methods described by Tharmaraj and Shah (2003). The counting of *Bifidobacteria* was determined according to Dinakar and Mistry (1994). Total viable bacterial count (TVBC), coliform bacteria, molds, and yeast counts were measured in yoghurt samples using the procedures outlined by the American Public Health Association (1992).

Sensory properties judging

The sensory evaluation was carried out using the quantitative descriptive profile method (QDP) in accordance with EN ISO 13299 (2016). Ten trained panelists—five men and five women—from our dairy science department were invited to take part in the sensory evaluation sessions, along with five additional laypeople from outside the organization who were regular customers between the ages of 25 and 55. During the sensory evaluation period, the same arbitrators were required to perform the sensory evaluation at fresh, 7, and 14 days. A testing-appropriate room with a temperature of 22–24°C and a humidity of roughly 45% was used for the sensory evaluation test. They were given the possibility to test the quantity of sample needed to express an opinion. Panelists are shown the samples one at a time, with water used to thoroughly clean their palates in between. Four factors were used to evaluate the samples: general look (10

points), body and texture (45 points), flavor (30 points), and odor (15 points). Conversely, all sensory parameters had total acceptability scores ranging from 60 to 100, with scores below 60 representing unacceptability and scores over 60 representing acceptability.

Statistical analysis

The SPSS 17.0 software was used to do analysis of variance (ANOVA). Duncan's multiple range test was used to identify significant differences between samples ($p<0.05$).

Results and Discussion

Physiochemical properties of milk from cows, buffalo, camels, goats, and sheep

Table 1 displays the titratable acidity, pH, total solids, fat, total protein, ash, and carbohydrates of cow, buffalo, camel, goat, and sheep milk used to produce yoghurt. Generally, the physicochemical characterizations of all milk type ranged within normal levels which reported in different literatures (Karami, 2018; Boukria et al., 2020). The acidity and ash values were slightly high in camel milk whereas sheep and buffalo milk recorded the greatest total solids and fat contents and camel milk had the lowest. Total protein concentration was high in sheep milk followed by goat milk and buffalo milk. Cow and camel milk had the highest carbohydrate contents. Similar results were detected by Miocinovic et al., (2007) who cleared that the total solids value of ewe milk is one fold and half of that of cow milk solids, while fat and protein levels are two folds. According to Ahmad et al. (2008), buffalo milk had higher levels of lactose, fat, protein, inorganic phosphate, vitamins, and minerals (such as calcium and magnesium) than cow's milk. Arain et al. (2024) reported that the average moisture level of camel milk is approximately 87%–89% which was quite similar to cow milk. The protein value in camel milk is similar to cow milk.

Chemical composition of bio-Greek yogurt made from different types of milk

Because the chemical composition of yogurt is closely linked to the chemical composition of the milk used in its production, therefore, they both followed a parallel path in the results obtained and this is quite apparent from the outcomes shown in Table 2. The highest values for total solids, fat, and protein were recorded in sheep milk and buffalo milk Greek yogurt, while the lowest values for these components were found in camel milk yogurt. The concentrations of total solids and fat were higher in goat milk yogurt compared to that made from cow milk, while the total protein content was similar between the two. This result is in line with the findings of Pappa et al. (2024), who discovered that the kind of milk significantly affected the fat content. Greek yoghurts made from sheep milk had the highest fat content when compared to yoghurts prepared from cow or goat milk. In this sense, Atamian et al. (2014) reported the physicochemical and sensory properties of cow, goat, and ewe milk Greek yogurt with various fat contents. They concluded that the types of milk fat significantly affected the chemical composition (total solids, fat, protein, ash, acidity, and magnesium) and sensory attributes of yogurt.

It is demonstrated when comparing the total solids and total protein data in Tables 1 and 2 that adding 8% milk protein concentrate (MPC) to yoghurt milk significantly increased the total solids and total protein contents of the various Greek yoghurt treatments. Fresh ewe and buffalo yogurt had 23.12, 22.46, 9.21 and 8.89% total solids and total protein respectively. As the most characteristic that distinguishes Greek yogurt from regular yogurt is its high protein level. Thus, the objective of adding MPC was to achieve this property, and it was successfully accomplished. The final product's firmness and texture are greatly influenced by the yoghurt's total solids content. Most consumers like yoghurts with a high total solids percentage because they have a thicker, creamier mouthfeel (Tarrega et al., 2016). In general, Greek yoghurt contains 7– 10 % fat and 10– 12 % solids not fat. It also has a higher protein (2.5 x) and minerals (1.5 x) levels, a

greater number of viable lactic acid bacteria, and a very low content of lactose compared to regular yogurt, making this type of strained yogurt more suitable for people with lactose intolerance (Rameshchandra, 2017).

On the other hand, acidity levels were similar between buffalo, sheep, and goat milk yogurts during the storage period, but were slightly lower in cow milk yogurt and even lower in camel milk yogurt. The pH values showed a trend opposite to acidity. In similar report to our work, According to Yüksel-Önür (2015), yoghurts made from buffalo, sheep, and goat milk are by nature more acidic than cow milk. Additionally, Dimitrellou et al. (2019b) found that using goat milk in production of probiotic fermented milk caused higher acidification comparing with cow milk. Utilization different types of milk can affect the acidification level of various types of lactic acid bacteria; thus, some may be more active in cow's milk while others are more active in goat's milk. This variation is attributed to goat's milk's lower buffering capacity compared to cow's milk. On the whole, the pH values of Greek yogurt made from cow milk, buffalo milk, camel milk, goat milk, and sheep milk at the beginning and end of the storage period ranged between 5.07-4.71, 4.89-4.56, 5.41-4.82, 5.02-4.62 and 5.01-4.60 respectively (Table 2). These values are higher than those for Greek yogurt in other previous studies, for example, Greek yoghurt samples from sheep had pH values between 3.69 and 4.64, samples from goats had pH values between 3.82 and 4.57, and samples from cows had pH values between 3.58 and 4.59, according to Pappa et al. (2024). This is probably due to the fact that probiotic cultures have lower acidification levels than lactic acid bacteria starters. Similar observations were reported by Soni et al. (2020) and Ayaz et al. (2024). According to Demirhan et al. (2026), yoghurt treatments using *B. animalis* subsp. *lactis* BB-12 had the greatest pH values when compared to

other samples. As a result, compared with standard yoghurt formulations, probiotic yoghurts that contain bifidobacteria typically exhibit lower overall acidity levels.

Throughout the duration of the storage period, the general spiking, total solids, fat, and total protein concentrations of the Greek yoghurt samples little changed. In contrast, as the storage duration grew, acidity values in all yoghurt treatments consistently increased. This could be because starter bacteria were breaking down the lactose. Studies using sheep, goats, and cow yoghurt have demonstrated similar results (Tarchi et al., 2025).

Aroma components analysis

Acetaldehyde, a carbonyl compound, is responsible for yogurt's distinctive aroma. Another carbonyl compound is diacetyl which formed by yogurt starter in the citrate cycle. Diacetyl plays a significant role in imparting the characteristic flavor and aroma of yogurt when acetaldehyde is found at low levels (Terzioğlu & Bakirci, 2024). Figure 1 shows the acetaldehyde and diacetyl levels of Greek yogurt samples. During storage period, sheep and buffalo milk Greek yogurt exhibited the highest concentrations of acetaldehyde. This is may be attributed to the high total solids and total protein contents in sheep and buffalo milk which had stimulation effect on the starter culture during fermentation period. According to Saint-Eve et al. (2006), yogurt's protein content has an impact on the synthesis of carbonyl compounds. Through both reversible and irreversible binding, proteins interact with a variety of flavor substances. On the other side, bio-Greek yogurt made from cow milk possessed higher levels of acetaldehyde than those of yogurt prepared from goat milk. Lastly, the lowest acetaldehyde values were detected in camel milk yogurt. The results were in agreement with the observation of Erkaya and Suengul (2011) who reported that the acetaldehyde content was lower in goats' yoghurt than that in yoghurts made from cow's, buffalo's and ewe's milk. The highest acetaldehyde amount was noticed in

253 buffaloes' yoghurt. The low content of acetaldehyde in goats' yoghurt, which is richer in glycine,
254 may be attributed to the inhibition of threonine aldolase by glycine. In the same trend, Terzioğlu
255 and Bakırcı (2023) cleared that goat yogurt had the lowest acetaldehyde amount as compared
256 with yogurts made from buffalo's and sheep's milk.

257 Just as acetaldehyde production increased in sheep and buffalo milk yogurt, diacetyl values
258 also followed the same behavior. The diacetyl levels were in the following order: sheep milk
259 yogurt> buffalo milk yogurt > cow milk yogurt > goat milk yogurt > camel milk yogurt.
260 According to De Leonardis et al. (2013), the activity of the starter cultures, the components of
261 milk (lactose and protein), and the fermentation conditions (temperature, pH, oxygen, etc.) all
262 impact the diacetyl concentrations of dairy products. On a general note, in all yogurt samples the
263 acetaldehyde values gradually reduced within storage period whereas, diacetyl levels increased
264 up to the seventh day of storage then lowered at the end storage period. While the diacetyl value
265 may decrease during storage for a variety of reasons, including the activity of the starter cultures,
266 the hydrolysis reaction of microbial enzymes to form other substances, and the evaporation of
267 precursors from yoghurt (Karami, 2018), the acetaldehyde amount may decrease during the
268 yoghurt storage period due to the oxidation of aldehydes to form carboxylic acid or their
269 reduction by enzymatic reactions for alcohol production (Papaioannou et al., 2021).

270 **Antioxidant activity and total phenolic content (TPC)**

271 The values of antioxidant activity (DPPH%) and TPC (mg GAE/100 g) of fresh Greek yogurt
272 and at the end of storage period were cleared in Figure 2. Greek yogurt made from camel milk
273 was highly richer in the level of antioxidant activity whereas the least value was detected in goat
274 milk yogurt sample. Sheep and buffalo milk yogurts contained higher DPPH ratios than those of
275 cow and goat milk yogurts. These findings are consistent with those of Stobiecka et al. (2022),

who found that the antioxidant component value in milk is significantly influenced by the animal species. Compared to cow milk, sheep, camel, and buffalo milks have higher ratios of antioxidant activity, primarily vitamins A and E, β-LG, LF, and PUFA acids. In the same contest, Yilmaz-Ersan et al. (2018) described that kefir manufactured from sheep milk had higher DPPH% than kefir prepared using cow milk. Additionally, Khan et al. (2017) referred to high levels of antioxidant activity in buffalo milk comparing with cow milk.

TPC values had similar trend to antioxidant activity where camel yogurt had the greatest TPC levels followed by sheep and buffalo yogurt and cow and goat yogurt possessed the lowest. In all Greek yogurt treatments, the antioxidant activity and TPC levels reduced during storage period. The lowering values of antioxidant activity were 24.59, 19.08, 16.57, 28.01 and 18.49% and for TPC were 32.30, 28.59, 27.92, 33.17 and 29.02% for samples A, B, C, D and E respectively. Many explanations were introduced to explain the reducing in antioxidant activity and TPC during the storage period of yogurt. For instance, lowering antioxidant activity of yogurt samples through storage may be attributed to milk-polyphenol interactions, which caused reducing in antioxidant capacity values (Arts et al., 2002). Other authors (Lamothe et al., 2014) cleared that the degradation of in antioxidant capacity and TPC in yogurt after one week of storage may be due to the production of a complex between polyphenols and milk proteins, which decreased phenols extractability. Pascariu et al. (2025) showed that the reducing in TPC in yogurt treatments during storage may be attributed to a slight decomposition of polyphenolic compounds.

Rheological properties

Syneresis and water holding capacity (WHC)

The effect of using different types of milk on syneresis and WHC of Greek yogurt are explained in Figure 3. Because of the high total solids and protein levels, the lowest syneresis ratios were detected in ovine and buffalo milk yogurts while the highest were in camel milk yogurts. Bovine and caprine milk yogurt samples demonstrated comparable syneresis values. These results are in accordance with those of Khalifa and Zakaria (2019) who reported that the syneresis values were higher in camel milk yogurt than those of goat milk yogurt whereas buffalo milk yogurt had the lowest. Conforming to these findings, Li et al. (2022) stated that the syneresis and water holding capacity values of yogurt are associated with the protein content.

In a trend completely opposite to syneresis, the highest WHC values were observed in sheep yogurt followed by buffalo one. Camel yogurt possessed the lowest WHC ratio. These results are somewhat consistent with Demirhan et al. (2026), who showed that buffalo milk yoghurt had the highest WHC values when compared to yoghurts made from cow, goat, or camel milk. This is because buffalo milk has higher concentrations of total solids and protein, particularly casein and colloidal calcium, which improve the formation of a dense, continuous protein network that can hold water more effectively. Additionally, by filling the protein matrix and supporting structural stability, the increased fat content of buffalo milk aids in improving gel structure and reducing whey separation (Barakat et al. 2021). As shown in Figure 3, cow yogurt had higher WHC ratios than those of goat yogurt. Goat milk has a weaker yoghurt structure than cow, buffalo, and sheep milk because it contains less casein and more serum proteins and non-protein nitrogen (Miocinovic et al., 2016).

In different Greek yogurt samples, syneresis values slightly decreased during storage period, which aligns with outcomes from the research of Nelios et al. (2023) who cleared that syneresis ratio of the traditional-type Greek yoghurt lowered during the storage period. On the contrary,

Akbulut-Çakır and Teker (2021) showed that WHC lowered whereas syneresis increased during storage of sheep, goat, and cow milk yogurts. Concerning the effect of storage time on WHC values of yogurt, data of Figure 3 illustrated that WHC levels increased until the seventh day and then decreased towards the end of the storage period. Comparing the syneresis and WHC results obtained in the current study with those in other literatures, it is observed that the syneresis values of yogurt were lower and WHC ratios higher. For example, the syneresis values of cow milk yogurt in our work ranged between 30.12- 31.24 and the WHC values ranged between 55.85- 58.11, while Nelios et al. (2023) reported that the syneresis and WHC ratios of Friesian cow milk Greek yogurt ranged between 34.3- 38.2 and 52.7- 55.0 respectively. This may be attributed to the utilization of Transglutaminase (Tgase) in yogurt preparation which improved its texture and body. Similar results were found by Yuksel and Erdem (2010) who cleared that water holding capacity values of yoghurt treatments contained Tgase-active or Tgase-inactive were significantly higher ($P < 0.01$)than that of control samples free from Tgase.

Texture Profile Analysis (TPA)

The textural characteristics of fermented milk foods, such as yogurt, are one of the key criteria that determine their acceptance by consumers (Delikanlı & Ozcan, 2017). As is evident from Table 3, the type of milk and storage time had a significant effect on the texture profile parameters of Greek yogurt during the storage period. Similar findings were reported by Costa et al. (2015), who demonstrated that the production of the gel structure—which plays an important role for the textural profile of yogurt—is influenced by variables such the kind of milk, fermentation conditions, starter culture used, and storage time. It is well known that yoghurt with a high protein and total solids content has a stronger protein network and more water binding, which increases the hardness value (Basiri et al., 2022). Hence, sheep milk Greek yogurt

exhibited the greatest hardness values followed by yogurt made from buffalo milk while camel milk yogurt showed the lowest. These outcomes agree with prior study of Demirhan et al. (2026) who reported that the casein and colloidal calcium levels are higher in sheep milk comparing with other milks, whereas proteins of buffalo milk have higher thermal resistance. As a result, sheep milk yoghurt had the greatest hardness values, followed by yoghurts made from buffalo, cows, and goats. Data of Table 3 demonstrated that cow yogurt's hardness values were marginally greater than goat yogurt's. Goat milk produced the softest yoghurt due to its greater micelle size and lower casein content (Roy et al., 2020). According to Joon et al. (2017), goat milk yoghurt has lower hardness values than cow milk yoghurt. Gel hardness was influenced by fat globule size and lipid content, which were associated with the small fat globule size in goat milk and the low hardness value in goat yoghurt. In the same context, Nguyen et al. (2018) demonstrated that goat yoghurt had softer gel and lower textural characteristics than cow yoghurt. This was related to the protein properties (casein and whey protein) of goat milk, which have very low concentrations of αs1-casein, lower amounts of casein, and higher contents of non-protein nitrogenous compounds.

Goat and sheep milk yogurts possessed the highest cohesiveness and springiness values (Table 3). Buffalo and cow milk yogurts had similar levels. Also, the camel milk yogurt had the lowest value of these parameters. A study using sheep, cow, and goat milk yoghurts demonstrated similar results (Tarchi et al., 2025). Gumminess and chewiness values had the same trend of hardness where the sheep milk yogurt had the highest value followed by buffalo, cow, goat and camel milk yogurt. These findings are consistent with earlier studies that found cow milk yoghurt to be gummier than goat milk yoghurt (Joon et al., 2017; Terzioğlu & Bakirci, 2024) and buffalo milk yoghurt to be gummier than cow milk yoghurt (Jooyandeh et al., 2022).

In all Greek yogurt samples the values of hardness, gumminess and chewiness increased over storage period. Inversely, cohesiveness and springiness values declined. Mohammadzadeh et al. (2026) found that hardness, gumminess and chewiness of Greek-style yoghurt increased during storage. Cohesiveness and springiness values did not show pronounced changes during storage time. As previously mentioned, using Tgase promotes the rheological properties of yogurt. Ilicic et al. (2014) showed that the yoghurt treatments containing 0.12% (w/w) not inactivated Tgase had the highest values of textural properties (firmness, consistency, cohesiveness, index of viscosity), whereas the values of control sample without Tgase were the lowest. These results explain why the textural properties values were higher in our study compared to other works which Tgase was not used.

Microbiological analysis

The effects of utilization of cow, buffalo, camel, goat and sheep milk in Greek yogurt preparation on total viable bacterial counts (TVBC), *Str. thermophillus*, *L. acidophilus*, *B. bifidum*, moulds and yeasts and coliform bacteria populations were illustrated in Table 4. Coliform bacteria were not detected in all fresh yogurt samples and remained nil during storage period which indicates that the necessary hygienic conditions were maintained during processing and storage. Moulds and yeasts were only detected at the end of storage where the cow and sheep milk yogurt contained the highest numbers and camel milk yogurt had the lowest. Regarding the total viable bacterial count, the buffalo milk yogurt had the greatest TVBC followed by sheep, goat, cow and camel milk yogurt. In various yogurt treatments, TVBC gradually increased over storage time.

No significant differences in *Str. thermophiles* counts were detected between yogurt samples made from cow, buffalo, goat and sheep milk whereas camel milk yogurt had slightly lower

numbers. In similar results to our present study, Dimitrellou et al. (2019b) stated that fermented milk treatments manufactured from cow and goat milk had similar *Str. thermophiles* numbers. The same trend has been found in the study of Varga et al. (2014) who used cow, goat and camel milk in preparing of probiotic fermented milk. On the other side, the numbers of *Str. thermophiles* in various Greek yogurt treatments gradually increased up to 7 days before declining at the end of the storage period. The increase in viability values of *Str. thermophillus* during storage from day one to day seven were higher in cow and sheep milk yogurt. These values were 19.64, 16.98, 10.64, 15.79 and 18.18% for samples A, B, C, D and E respectively. In the opposite trend, the loss of survival values of *Str. thermophillus* through storage from day seven till day fourteen were lower in buffalo milk yogurt treatment compared to other samples. Loss of survival levels for samples A, B, C, D and E were 8.95, 6.45, 7.68, 7.57 and 7.69% respectively. Yoghurts made from cow, sheep, and goat milk and stored for 28 days showed similar results (Vianna et al., 2019).

In fresh samples and during storage period, sheep and camel milk yogurts had the highest *L. acidophilus* counts followed by goat, cow and buffalo milk yogurts. During storage period, the *L. acidophilus* numbers had the same trend of *Str. thermophillus*. The increase in vitality values within storage from day one to day seven were 21.87, 18.75, 18.92, 16.67 and 20.51% for samples A, B, C, D and E respectively. Lose of viability from day 7 to day 14 were 9.76, 7.69, 9.09, 9.52 and 6.38% for A, B, C, D and E treatments respectively. Similar research demonstrated that whereas *L. acidophilus* populations increased in sheep milk yoghurts; they decreased over storage in cow and buffalo milk yoghurts and fell below the 7-log limit (Barakat et al., 2021).

412 Concerning *B. bifidum*, Greek yogurt made from camel milk had the highest numbers
413 followed by yogurts prepared using sheep and buffalo milk. The counts of *B. bifidum* in cow and
414 goat milk yogurts were similar. Camel milk is an effective probiotic carrier because of its
415 suitable physicochemical properties, such as acceptable pH, titratable acidity (Table 2), and
416 acidification capacity (Galina et al., 2007), which may account for the high activity and numbers
417 of *B. bifidum* in camel milk yoghurt. As cleared in Table 4, the *B. bifidum* counts increased until
418 day 7 and then decreased at the end of the storage time. The increase in vitality levels over
419 storage from day one to day seven were 40.91, 36.36, 42.86, 30.43 and 38.46% for samples A, B,
420 C, D and E respectively. Lose of viability from day 7 to day 14 were 11.11, 8.57, 7.50, 13.33 and
421 8.33% for A, B, C, D and E treatments respectively.

422 However the probiotic bacteria counts decreased in all Greek yogurt samples at the end of
423 storage period, but they remained above 10^6 cfu.g^{-1}, which indicates that the viability of these
424 bacteria at the end of storage was sufficient to form beneficial organisms populations that were
425 higher than the accepted threshold (10^6 cfu.g^{-1}) for a probiotic impact. Hence, all Greek yogurt
426 samples in our study can be considered as probiotic products. Bedani et al. (2013) showed that to
427 classify a product as probiotic, a viable number of at least 10^6–10^7 CFU/g is required.

428 **Sensory properties analysis**

429 The panelists' scores of color and appearance, body and texture, flavor, odor and overall
430 acceptability of Greek yogurt made from different types of milk are given in Table 5. Due to the
431 yellow color of cow milk, the color of cow yogurt treatment differed from the color of other
432 samples and exhibited lowest color and appearance score**.** Conversely, because of the bright
433 white color of buffalo, goat, and sheep milk, the yogurt made from these milks achieved the
434 highest color and appearance score. Camel yogurt showed slightly lower color and appearance

evaluation and compared to buffalo and sheep yogurt. These findings are consistent with earlier research that found fermented cow milk had lower color scores than fermented goat milk, which was described as a whiter product (Dimitrellou et al., 2019b).

One important point to note is that an increased stickiness was recorded by panelists in yogurts manufactured from sheep and buffalo milk which of course is attributed to the high total solids, fat and total protein contents. The sheep and buffalo milk yogurt gained the highest body and texture scores followed by the goat and cow milk yogurt meanwhile, camel yogurt came in last order. These findings are consistent with research by Karami (2018), which found that using sheep milk to produce yoghurt is more appropriate due to its high total solids (fat and proteins) content, which results in a final product with a richer, creamier texture and a more acceptable flavor when compared to yoghurt produced using cow's milk. The flavor scores of yogurt had the same trend of body and texture, where the sheep and buffalo milk yogurt received the highest flavor scores followed by cow milk yogurt. The goat and camel milk yogurt gained the lowest flavor scores. Similar results with some changes were observed in the odor values. The highest odor values were found in buffalo and sheep milk yogurt followed by cow and camel milk yogurt. Goat milk yogurt recoded the lowest odor scores. This finding is consistent with those reported by Erkaya and Suengul (2011) who cleared that high fat and proteins contents in ewes' milk produce yogurt with pleasant creamy-sour flavor as compared with cows' yoghurt. Also, according to Ahmed et al. (2014), buffalo yoghurts scored higher on sensory evaluation than goat and cow yoghurts. Contrariwise, goat milk contains high levels of medium-chain fatty acids such as caproic, caprylic, and capric acid that negatively affect the flavor and hinder its use in many dairy products processing (Demirhan et al., 20226).

Lastly, the results of overall acceptability took the following order; buffalo yogurt > sheep yogurt > cow yogurt > goat yogurt > camel yogurt. Overall, fresh Greek yogurt samples ranked the greatest scores of body and texture, flavor, odor and overall acceptability. With storage time progressive, the sensory properties values of different samples reduced. Nevertheless, all types of yogurts were still accepted by the panelists.

Conclusions

In this study, the effect of using various types of milk and Tgase on the chemical, rheological, microbial and sensorial properties of bio-Greek yogurt was investigated. Sheep and buffalo milk yogurts had the best chemical and rheological characteristics comparing with cow, goat or camel milk yogurts. Because of a white color, a creamy and smooth body and high spreadability, sheep and buffalo milk yogurts recorded the highest sensory properties values. Tgase promoted the textural properties of different yogurt treatments. The probiotic bacteria counts remained above 10^6 cfu.g^{-1} in different Greek yogurt samples throughout storage. Camel milk yogurt had the highest results of antioxidant activity, total phenolic, *L. acidophilus* and *B. bifidum*, confirming its health effects. Further research is required to improve the taste and flavor characteristics of goat milk Greek yoghurt as well as the body and texture characteristics of camel milk Greek yoghurt. This could be done by combining it with other milk types like sheep, buffalo, and cow milk or by adding natural ingredients like honey or fruit.

Data availability

All data generated or analyzed during this study are included in the published article.

Declarations

Competing interests

The authors declare no competing interests.

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Table 1 Chemical composition of cow, buffalo, camel, goat and sheep milk

Treatments	Acidity (%)	pH values	Total solids (%)	Fat (%)	Total protein (%)	Ash (%)	Carbohydrate (%)
A	$0.17^{AB}\pm0.01$	$6.66^{B}\pm0.10$	$12.08^{C}\pm1.2$	$3.3^{D}\pm0.50$	$3.6^{D}\pm1.02$	$0.83^{C}\pm0.02$	$4.18^{A}\pm0.50$
B	$0.16^{BC}\pm0.01$	$6.68^{A}\pm0.08$	$15.57^{B}\pm2.0$	$6.4^{B}\pm0.60$	$4.3^{BC}\pm0.90$	$0.91^{AB}\pm0.11$	$3.80^{C}\pm0.88$
C	$0.18^{A}\pm0.02$	$6.61^{D}\pm0.02$	$11.64^{D}\pm1.8$	$3.1^{DE}\pm0.20$	$3.4^{DE}\pm1.00$	$0.93^{A}\pm0.05$	$4.03^{B}\pm0.53$
D	$0.17^{AB}\pm1.01$	$6.64^{C}\pm0.20$	$12.94^{C}\pm1.1$	$4.3^{C}\pm.010$	$4.4^{B}\pm.0.50$	$0.81^{CD}\pm0.20$	$3.26^{D}\pm0.22$
E	$0.15^{CD}\pm1.04$	$6.69^{A}\pm0.40$	$16.12^{A}\pm0.5$	$7.1^{A}\pm0.10$	$4.9^{A}\pm1.10$	$0.90^{AB}\pm0.03$	$3.07^{E}\pm0.90$

A: Cow milk, B: Buffalo milk, C: Camel milk, D: Goat milk, E: Sheep milk

Table 2 Chemical composition of bio-Greek yogurt made from different types of milk

Properties	Treatments	Storage period (days)			Means
		Fresh	7	14	
Acidity %	A	$0.97^{a}\pm0.02$	$1.05^{d}\pm0.2$	$1.14^{b}\pm0.3$	$1.53^{A}\pm0.17$
	B	$0.99^{a}\pm0.01$	$1.12^{a}\pm0.5$	$1.20^{a}\pm0.1$	$1.11^{B}\pm0.2$
	C	$0.90^{b}\pm0.01$	$0.99^{e}\pm0.01$	$1.08^{c}\pm0.5$	$0.99^{D}\pm0.17$
	D	$0.98^{a}\pm0.03$	$1.08^{bc}\pm0.01$	$1.18^{ab}\pm0.1$	$1.08^{C}\pm0.47$
	E	$0.98^{a}\pm0.01$	$1.09^{b}\pm0.04$	$1.19^{ab}\pm0.2$	$1.09^{C}\pm0.08$
	Means	$0.96^{B}\pm0.02$	$1.07^{A}\pm0.15$	$1.16^{A}\pm0.24$	
pH values	A	5.07b±0.50	$4.86^{b}\pm0.09$	$4.71^{ab}\pm0.03$	$4.88^{B}\pm0.21$
	B	4.89d±0.80	$4.72^{bc}\pm0.4$	$4.56^{b}\pm0.08$	$4.72^{BC}\pm0.43$
	C	5.41a±0.10	$5.17^{a}\pm0.33$	$4.82^{a}\pm0.08$	$5.13^{A}\pm0.17$
	D	5.02c±0.10	$4.74^{bc}\pm0.12$	$4.62^{ab}\pm0.10$	$4.79^{BC}\pm0.11$
	E	5.01c±0.40	$4.71^{bc}\pm0.8$	$4.60^{ab}\pm0.40$	$4.77^{C}\pm0.53$
	Means	$5.08^{A}\pm0.38$	$4.84^{B}\pm0.35$	$4.66^{C}\pm0.14$	
TS %	A	$18.11^{cd}\pm1.1$	$18.37^{d}\pm2.0$	$18.82^{d}\pm1.4$	$18.43^{D}\pm1.5$
	B	$22.46^{b}\pm1.0$	$22.57^{b}\pm1.8$	$22.91^{b}\pm2.1$	$22.65^{B}\pm1.63$
	C	$17.78^{de}\pm0.9$	$17.91^{de}\pm1.1$	$18.12^{d}\pm1.1$	$17.94^{E}\pm1.03$
	D	$19.57^{c}\pm0.5$	$19.73^{c}\pm1.5$	$19.94^{c}\pm1.4$	$19.75^{C}\pm1.13$
	E	$23.12^{a}\pm1.5$	$23.31^{a}\pm1.8$	$23.54^{a}\pm3.2$	$23.32^{A}\pm2.17$
	Means	$20.21^{A}\pm1.0$	$20.38^{A}\pm1.64$	$20.67^{A}\pm1.84$	
Fat %	A	$3.6^{d}\pm0.5$	$3.7^{d}\pm0.5$	$3.7^{d}\pm0.5$	$3.7^{D}\pm0.5$
	B	$6.8^{b}\pm0.3$	$6.8^{b}\pm0.2$	$6.9^{b}\pm0.5$	$6.8^{B}\pm0.33$
	C	$3.4^{d}\pm0.1$	$3.5^{d}\pm0.2$	$3.6^{d}\pm0.3$	$3.5^{D}\pm0.20$
	D	$4.5^{c}\pm0.1$	$4.7^{c}\pm0.1$	$4.7^{c}\pm0.1$	$4.6^{C}\pm0.1$
	E	$7.5^{a}\pm0.6$	$7.5^{a}\pm0.4$	$7.6^{a}\pm0.1$	$7.5^{A}\pm0.37$
	Means	$5.6^{A}\pm0.32$	$5.24^{B}\pm0.28$	$5.3^{B}\pm0.30$	
Total Protein %	A	$7.91^{c}\pm1.0$	$7.95^{c}\pm1.1$	$8.02^{bc}\pm0.8$	$7.96^{C}\pm0.97$
	B	$8.89^{b}\pm1.1$	$8.93^{b}\pm1.3$	$8.98^{b}\pm0.3$	$8.93^{B}\pm0.90$
	C	$7.79^{c}\pm0.8$	$7.86^{c}\pm0.8$	$7.90^{c}\pm1.0$	$7.85^{C}\pm0.57$
	D	$8.86^{b}\pm1.2$	$8.94^{b}\pm0.9$	$8.97^{b}\pm0.5$	$8.92^{B}\pm0.87$
	E	$9.21^{a}\pm1.1$	$9.26^{a}\pm1.4$	$9.33^{a}\pm0.3$	$9.27^{A}\pm0.93$
	Means	$8.53^{BC}\pm1.04$	$8.59^{A}\pm1.1$	$8.64^{B}\pm0.58$	

A: Greek yogurt made from cow milk + 8% MPC + 0.04% Tgase; B: Greek yogurt made from buffalo milk + 8% MPC + 0.04% Tgase; C: Greek yogurt made from camel milk + 8% MPC + 0.04% Tgase; D: Greek yogurt made from goat milk + 8% MPC + 0.04% Tgase; E: Greek yogurt made from sheep milk + 8% MPC + 0.04% Tgase

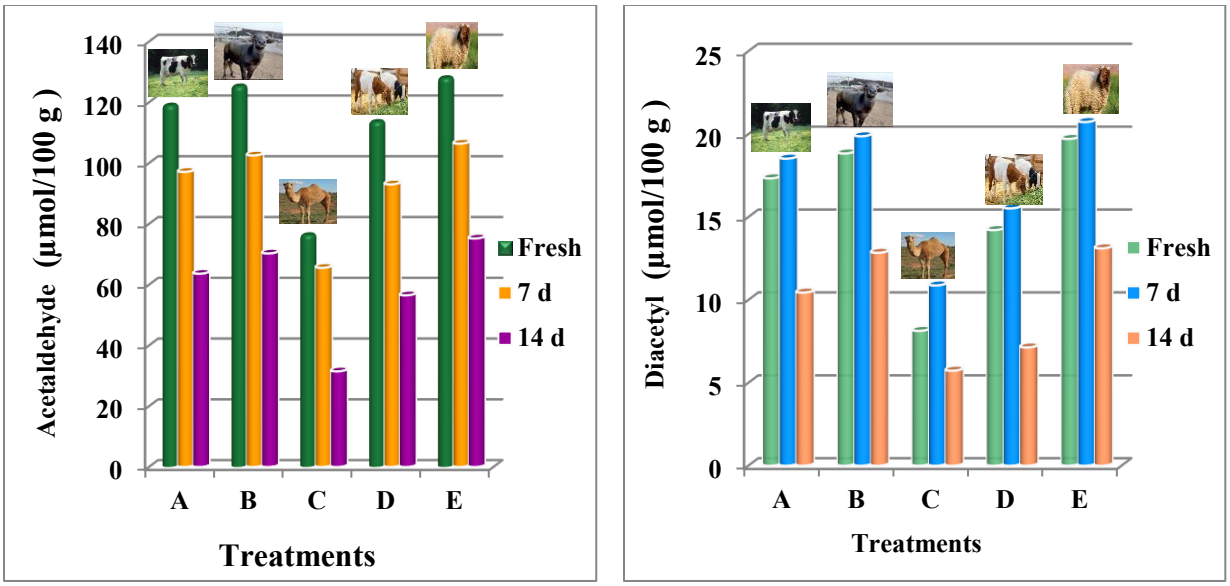


Fig. 1 Acetaldehyde and diacetyl contents of bio-Greek yogurt made from different types of milk

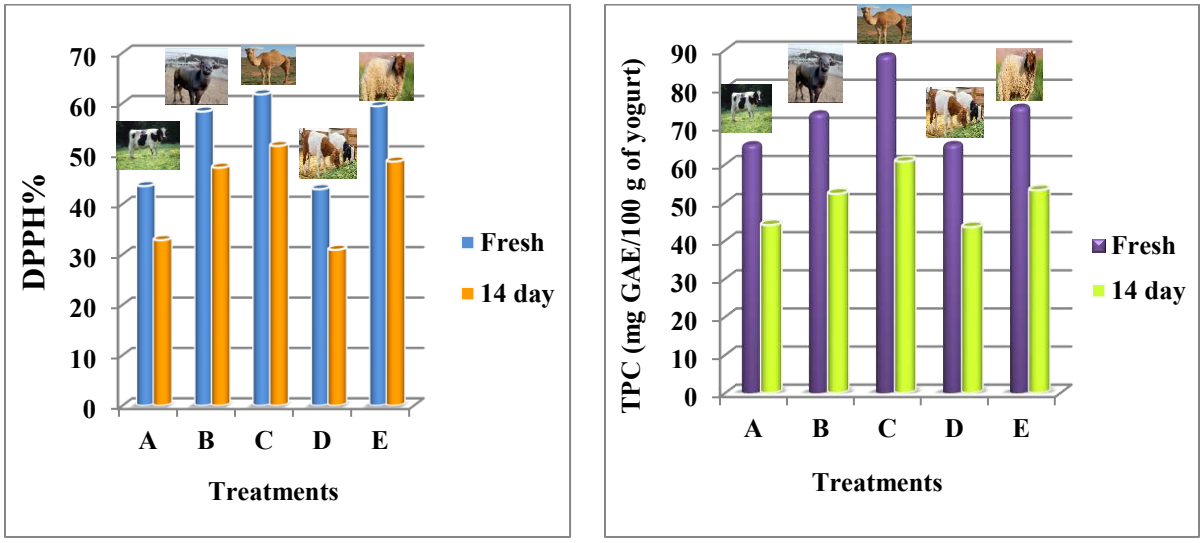


Fig. 2 Antioxidant activity in DPPH (%) and total phenolic content (mg GAE/100 g of yogurt) values of bio-Greek yogurt made from different types of milk

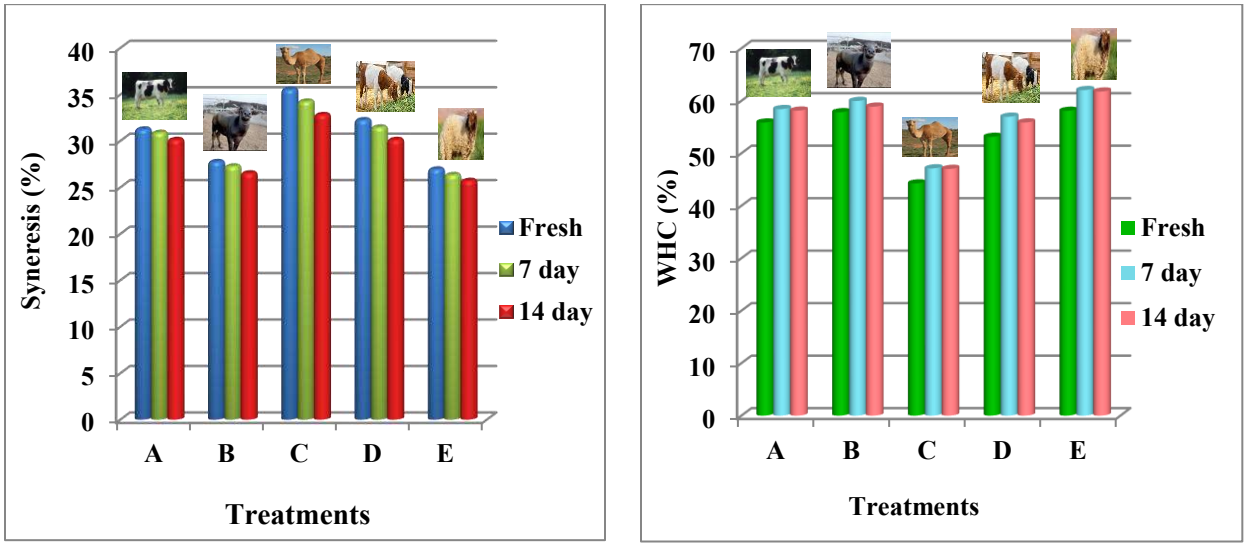


Fig. 3 Syneresis (%) and water holding capacity (%) values of bio-Greek yogurt made from different types of milk

Table 3 Changes in the textural properties of the Greek yoghurt samples on the first and fourteen days of storage

Properties	Treatments	Storage period (days)		Means
		Fresh	14	
Hardness (N)	A	$4.50^{b}\pm0.90$	$5.05^{b}\pm0.90$	$4.78^{B}\pm0.90$
	B	$5.80^{a}\pm1.10$	$6.40^{a}\pm1.08$	$6.10^{A}\pm1.09$
	C	$3.49^{c}\pm0.33$	$3.78^{d}\pm0.03$	$3.64^{D}\pm0.18$
	D	$4.12^{b}\pm0.50$	$5.04^{b}\pm0.90$	$4.13^{BC}\pm0.50$
	E	$5.95^{a}\pm0.18$	$6.62^{a}\pm1.20$	$6.29^{A}\pm0.15$
	Means	$4.77^{B}\pm0.60$	$5.26^{A}\pm0.74$	
Cohesiveness	A	$0.59^{ab}\pm0.05$	$0.56^{ab}\pm0.05$	$0.58^{B}\pm0.05$
	B	$0.58^{ab}\pm0.01$	$0.55^{ab}\pm0.01$	$0.57^{B}\pm0.01$
	C	$0.40^{c}\pm0.10$	$0.38^{c}\pm0.10$	$0.39^{C}\pm0.10$
	D	$0.64^{a}\pm0.02$	$0.59^{a}\pm0.10$	$0.62^{A}\pm0.06$
	E	$0.63^{a}\pm0.10$	$0.59^{a}\pm0.3$	$0.61^{A}\pm0.20$
		$0.57^{A}\pm0.06$	$0.53A^{B}\pm0.11$	
Springiness	A	$0.89^{ab}\pm0.10$	$0.84^{b}\pm0.11$	$0.87^{B}\pm0.11$
	B	$0.90^{ab}\pm0.05$	$0.83^{b}\pm0.05$	$0.86^{B}\pm0.05$
	C	$0.77^{c}\pm0.02$	$0.70^{c}\pm0.08$	$0.74^{C}\pm0.05$
	D	$0.97^{a}\pm0.31$	$0.97^{a}\pm$-.0.07	$0.97^{A}\pm0.19$
	E	$0.95^{a}\pm0.04$	$0.90^{ab}\pm0.01$	$0.93^{A}\pm0.03$
		$0.90^{A}\pm0.10$	$0.85^{B}\pm0.06$	
Gumminess (N)	A	$2.84^{b}\pm0.01$	$2.89^{b}\pm0.20$	$2.86^{B}\pm0.11$
	B	$3.01^{a}\pm0.01$	$3.04^{ab}\pm0.50$	$3.03^{A}\pm0.26$
	C	$1.25^{c}\pm0.02$	$1.29^{c}\pm0.06$	$1.27^{C}\pm0.04$
	D	$2.83^{b}\pm0.02$	$2.88^{b}\pm0.20$	$2.86^{B}\pm0.11$
	E	$3.08^{a}\pm0.01$	$3.12^{a}\pm0.50$	$3.10^{A}\pm0.26$
		$2.60^{AB}\pm0.01$	$2.64^{A}\pm0.20$	
Chewiness (N/mm)	A	$1.46^{b}\pm0.22$	$1.57^{b}\pm0.50$	$1.50^{B}\pm0.36$
	B	$1.88^{a}\pm0.60$	$1.98^{a}\pm0.20$	$1.93^{A}\pm0.40$
	C	$0.85^{c}\pm0.05$	$0.89^{c}\pm0.02$	$0.87^{C}\pm0.04$
	D	$1.45^{b}\pm0.09$	$1.56^{b}\pm0.30$	$1.51^{B}\pm0.20$
	E	$1.90^{a}\pm0.20$	$2.01^{a}\pm0.01$	$1.96^{A}\pm0.11$
		$1.52^{AB}\pm0.23$	$1.59^{A}\pm0.21$	

Table 4 Effect of using different types of milk on some microbial groups of bio-Greek yoghurt

Properties	Treatments	Storage period (day)			
		1	7	14	Means ± SD
TVBC (x 10^7)	A	146^{b}±2.10	162^{b}±9.50	188^{c}±10.0	165^{C}±7.20
	B	155^{a}±7.20	171^{a}±6.60	197^{a}±9.50	174.3^{A}±7.78
	C	142^{c}±1.55	157^{c}±11.2	179^{d}±12.2	159.33^{D}±8.32
	D	147^{b}±8.40	164^{b}±15.5	190^{b}±8.90	167^{B}±10.93
	E	150^{b}±3.80	165^{b}±13.7	192^{b}±7.45	169^{B}±8.32
	Means ± SD	148^{C}±4.61	163.8^{B}±11.3	189^{A}±9.61	
Streptococcus thermophiles (CFU x10^6/ml)	A	56^{a}±5.50	67^{a}±5.50	60^{a}±10.0	61.00^{A}±7.00
	B	53^{a}±6.30	64^{a}±4.90	59^{a}±8.10	58.67^{AB}±6.43
	C	47^{b}±5.00	52^{c}±3.50	50^{b}±10.0	49.67^{BC}±6.17
	D	57^{a}±7.50	66^{a}±6.66	61^{a}±6.60	61.33^{A}±6.92
	E	55^{a}±1.50	63^{b}±3.00	58^{a}±5.30	58.67^{AB}±3.27
	Means ± SD	53.6^{C}±5.16	62.4^{A}±4.71	57.6^{B}±8.00	
Lactobacillus acidophilus (CFU×10^6/ml)	A	35^{ab}±2.40	41^{b}±5.80	37^{b}±3.90	37.67^{C}±4.03
	B	32^{ab}±5.70	38^{c}±3.85	35^{b}±1.90	35.00^{C}±3.82
	C	37^{a}±6.60	44^{b}±3.22	40^{a}±5.50	40.33^{AB}±5.10
	D	36^{a}±3.80	42^{b}±5.80	38^{ab}±2.80	38.67^{BC}±4.13
	E	39^{a}±3.33	47^{a}±1.70	42^{a}±7.50	42.67^{A}±4.18
	Means ± SD	35.8^{C}±4.37	42.4^{A}±4.07	38.4^{B}±4.32	
Bifidobacterium bifidum (CFU×10^6/ml)	A	22^{c}±1.80	31^{bc}±4.20	27^{c}±4.10	26.67^{C}±3.37
	B	25^{ab}±2.10	35^{b}±3.50	32^{ab}±2.20	30.67^{B}±2.60
	C	28^{a}±1.50	40^{a}±1.60	35^{a}±1.50	43.33^{A}±1.53
	D	21^{c}±1.40	32^{b}±2.22	26^{c}±6.00	26.33^{C}±3.21
	E	26^{a}±4.30	34^{b}±5.20	31^{ab}±3.33	30.33^{B}±4.28
	Means ± SD	24.4^{C}±2.22	34.4^{A}±3.34	30.2^{B}±3.43	
Molds & Yeast (x 10^3)	A	0	0	7^{a}±1.00	7^{A}±1.00
	B	0	0	3^{d}±1.50	3^{D}±1.50
	C	0	0	2^{e}±0.50	2^{E}±0.50
	D	0	0	4^{c}±1.02	4^{C}±1.02
	E	0	0	5^{b}±1.10	5^{B}±1.10
	Means ± SD			4.2^{A}±1.024	
Coliform bacteria (x 10^2)	A	0	0	0	0
	B	0	0	0	0
	C	0	0	0	0
	D	0	0	0	0
	E	0	0	0	0
	Means ± SD				

905 **Table 5 |** Effect of using different types of milk on sensory properties of bio-Greek yoghurt

Properties	Treatments	Storage period (day)			
		1	7	14	Means ± SD
Color & Appearance (10)	A	8^{c}±1.1	8^{c}±0.9	8^{c}±0.5	8^{C}±0.83
	B	10^{a}±0.9	10^{a}±0.5	10^{a}±1.1	10^{A}±0.82
	C	9^{b}±0.5	9^{b}±1.1	9^{b}±1.05	9^{B}±0.88
	D	10^{a}±1.3	10^{a}±0.3	10^{a}±0.70	10^{A}±0.77
	E	10^{a}±1.6	10^{a}±1.5	10^{a}±0.9	10^{A}±1.33
	Means ± SD	9.4^{A}±1.08	9.4^{A}±0.86	9.4^{A}±0.85	
Body & Texture (30)	A	27^{c}±2.7	27^{c}±2.1	25^{b}±2.1	26.3^{A}±2.30
	B	29^{a}±2.2	29^{a}±4.0	28^{a}±2.5	28.7^{A}±2.90
	C	25^{d}±1.6	25^{d}±3.3	22^{c}±1.3	24.0^{B}±2.07
	D	28^{b}±1.0	28^{b}±1.8	25^{b}±1.1	27.0^{A}±1.30
	E	29^{a}±1.1	29^{a}±1.0	28^{a}±1.0	28.7^{A}±1.03
	Means ± SD	27.6^{A}±1.72	27.6^{A}±2.44	25.6^{B}±1.6	
Flavor (45)	A	43^{b}±3.3	43^{b}±3.3	40^{c}±2.8	42.0^{A}±3.13
	B	44^{a}±2.5	44^{a}±3.8	42^{a}±2.4	43.3^{A}±2.90
	C	40^{c}±1.0	39^{d}±5.8	37^{d}±4.1	38.7^{A}±3.63
	D	41^{c}±1.5	41^{c}±8.8	37^{d}±3.3	39.7^{A}±4.53
	E	44^{a}±1.1	44^{a}±2.6	41^{b}±2.0	43.0^{A}±1.90
	Means ± SD	42.4^{A}±1.88	$41.2A^{B}$±4.86	39.4^{B}±2.92	
Odor (15)	A	13^{c}±1.0	13^{c}±1.0	13^{b}±1.2	13.0^{A}±1.06
	B	15^{a}±1.0	15^{a}±1.0	14^{a}±1.9	12.5^{A}±1.30
	C	13^{c}±2.1	12^{d}±1.5	11^{d}±0.9	12^{AB}±1.50
	D	12^{d}±2.5	11^{e}±1.7	10^{e}±1.0	11.0^{B}±1.73
	E	14^{b}±1.5	14^{b}±0.9	12^{c}±1.0	13.3^{A}±1.13
	Means ± SD	13.4^{A}±1.62	13^{A}±1.22	12^{B}±1.20	
Overall acceptability (100)	A	91^{b}±3.8	91^{b}±5.5	86^{c}±4.4	89.3^{B}±4.57
	B	98^{a}±2.5	98^{a}±7.8	94^{a}±2.7	96.7^{A}±4.33
	C	87^{c}±4.1	85^{c}±4.7	79^{e}±3.5	83.7^{C}±4.10
	D	91^{b}±1.6	90^{b}±8.8	82^{d}±3.33	87.7^{B}±4.58
	E	97^{a}±1.91	97^{a}±3.7	91^{b}±2.9	95.0^{A}±2.84
	Means ± SD	92.8^{A}±2.78	92.2^{A}±6.10	86.4^{B}±3.37	

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