ANSF APPLIED AND NATURAL SCIENCE FOUNDATION

Journal of Applied and Natural Science
15(1), 128 - 136 (2023)
ISSN : 0974-9411 (Print), 2231-5209 (Online)
journals.ansfoundation.org

Research Article

Evaluation of milk source on physicochemical, texture, rheological and sensory properties of yogurts

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Article Info
https://doi.org/10.31018/jans.v15i1.4269
Received: December 11, 2022
Revised: February 1, 2023
Accepted: February 5, 2023

How to Cite
Al-Bedrani, D. I. J. *et al.* (2023). Evaluation of milk source on physicochemical, texture, rheological and sensory properties of yogurts. *Journal of Applied and Natural Science*, 15(1), 128 - 136. https://doi.org/10.31018/jans.v15i1.4269

Abstract
Yogurt is one of the world's most widely consumed dairy products and can be produced from different types of milk. The present research aimed to compare the effects of utilizing whole raw milk from cattle viz. cows, buffaloes, sheep, and goats in four different milk-type yogurts, T_1- cow's milk (CM), T_2- buffalo's milk (BM), T_3- sheep's milk (SM), and T_4- goat's milk (GM) on their physicochemical, texture, rheological, and sensory qualities. The physiochemical testing included estimating pH, the percentages of moisture, fat, protein, ash, and total acidity, and the sensory assessment of the yogurt. The rheological tests also included the viscosity test, spontaneous whey separation, water-holding capacity, firmness, cohesiveness, and springiness. The results showed that T_2- BM yogurt and T_3- SM yogurt excelled in the percentage of fat, protein, lactose, and ash, where the ratio (4.35, 8.4, 4.70, 0.8) (5.55, 7.45, 4.80, 1.1) was for each of T_2- BM yogurt and T_3- SM yogurt respectively. The rheological properties were the spontaneous whey separation for each of T1-CM, T_2-BM, T_3-SM, T_4-GM yogurt were 4.1, 2.2, 2.1 and 5.3, respectively, while the water holding capacity was 55, 60, 71 and 53 and the viscosity was 7000, 8900, 6700 and 1510 respectively. The results of the texture properties were 126.2, 199.5, 176.3, and 38.9 for firmness, while the cohesiveness values were 0.41, 0.63, 0.65, and 0.4, respectively. Finally, T_2-BM and T_3-SM yogurt excelled in the value obtained for sensory evaluation. The importance of the present study lies in the fact that milk with a high percentage of total solids gives good-quality yogurt.

Keywords: Milk source, Yogurt, Physicochemical properties, Sensory evaluation, Rheological analysis

INTRODUCTION

Yogurt is one of the fermented dairy products that are widely traded in the world, where transportation and circulation lead to a decrease in the quality of the final product, including texture, viscosity and the amount of separated whey, so many researchers aim to improve the quality of these products(Saadi *et al*., 2022). It has many health benefits by promoting bone health, improving the quality of the diet, and reducing the incidence of chronic diseases such as obesity and cardiovascular diseases, enters into its manufacture a combination of the starter culture of *Streptococcus thermophilus* and *Lactobacillus bulgaricus*.(Pelegrine and Souza, 2014; Bilgin and Kaptan, 2016; Kaur *et al*., 2017). It can be produced from many types of milk, including full-fat, low-fat, or skimmed milk (Baba *et al*., 2018). Cow's milk is consumed in the human diet as it contributes to maintaining a healthy nutritional status, providing good sources of energy, calcium, protein, vitamins and fats (Verduci *et al*., 2019). Cow's milk is consumed in the human diet as it contributes to maintaining a healthy nutritional status, providing good sources of energy, calcium, protein, vitamins and fats (Verduci *et al*., 2019;

Jaiswal and Worku, 2021). Cow's milk is also characterized by containing vitamin A, C, D and E with all the important mineral elements (Shiny, 2020). Sheep's milk, has a high nutritional value because it contains high concentrations of proteins, fats, minerals and vitamins, compared to the milk of other local types (Balthazar *et al*., 2017). It is one of the functionally active dairy foods with high nutritional value due to its content of fatty acids, immunoglobulins and non-immune protein contents (Mohapatra *et al*., 2019).

Sheep's milk is also nutritionally and biologically important due to its fatty acid content, fat cell size, sphingomyelin and fat-soluble vitamin contents, making it more nutritiously beneficial than cow's milk in addition to its high protein content (Moatsou and Sakkas, 2019). Sheep milk is distinguished by having higher calcium levels than cow and goat milk and being an excellent source of medium-chain triglycerides that may help lower cholesterol levels. It is also high in key mineral salts like zinc, magnesium, and phosphorus, as well as vitamins A, D, and E. It serves as an excellent source of folic acid and vitamin B. Additionally, it has somewhat more protein than other varieties of milk. (Hardy, 2000). Interest in goat milk and dairy products has increased recently in developed countries due to the increased demand for healthy foods. People who suffer from allergies due to the use of cow's milk have a lower percentage of casein and, at the same time, a higher percentage of non-protein nitrogen than cow's milk. (Park, 2017). As goat milk has different effects on human health due to its content of total solids in addition to its positive effects on the sensory and structural properties of dairy products, where the goat milk fat is easily digested with containing small fat pellets and the content of short and medium chain fatty acids in addition to containing a high percentage of conjugated linoleic acid, which plays an important role in promoting growth, preventing diseases and increasing immunity (Turkmen, 2017).

Buffalo milk comes second in the world in terms of the amount of production (Pantoja *et al*., 2022). Dairy products resulting from buffalo milk provide many health benefits for humans because buffalo milk is a rich source of fat, protein, lactose and minerals (calcium, phosphorus and iron) in addition to containing vitamin A and natural antioxidants (Abesinghe *et al*., 2020). The importance of the present study lies in the use of different types of milk in the yogurt industry and the study of the effect of different milk sources on the chemical-physical, biological and organoleptic properties of the resulting yogurt. The main objective of this study was to evaluate the type of milk used (cows, buffaloes, sheep, and goats) in yogurt production on the physical, chemical, biological and organoleptic properties of yogurt.

MATERIALS AND METHODS

Materials

Whole cow, buffalo, sheep, and goats' raw milk from the pastures next to Al Qasim Green University's College of Food Sciences was taken to make yogurt treatments. Sasco's yogurt starter was also used (Italy).

Methods

Yogurt manufacture

Following Tamime and Robinson's (2007) instructions, yogurt was inoculated as follows: Milk was divided into four treatments: (T_1-cow milk CM, T_2-buffalo milk BM, T_3-sheep milk SM and T_4-goat milk GM). According to the manufacturing company's instructions, for treatments T_1, T_2, T_3, and T_4, the milk was heated at 90 °C for 10 minutes, cooled to 42 °C, and then inoculated with the starter of *Streptococcus salivarius subsp. thermophilus* and *Lactobacillus delbrueckii subsp. bulgaricus* in a direct addition (Sasco). Sheep milk was incubated at 42 2 ° C for 3 hours until the pH reached 4.6, whereas cow, buffalo, and goat milk were incubated for 3.5 hours at the same temperature until the coagulation was complete. After the coagulation process was complete, the sample was put into 200 ml plastic bags and put in the refrigerator to chill and store at a temperature of 51 °C until the required tests were conducted as per the method of Tamime and Robinson (2007).

Yogurt's physicochemical tests

The yogurt's moisture (%) content was evaluated according to AOAC (2016). The total nitrogen was calculated using the approach indicated in (Ling, 2008), Protein was estimated using the Kjeldahl method, and the ash had a direct burning method provided in AOAC (2016). According to AOAC (2016), the Gerber technique was used to compute fat percentage. According to Ihekoronye and Ngoddy (1985), the percentage of carbohydrates was estimated as:

$$\% \text{ Carbohydrates} = 100 \quad \% - (\text{ash} + \text{protein} + \text{fat} + \text{moisture}) \qquad \text{Eq.1}$$

AOAC (2016) was used to gauge the general acidity. The pH level of yougurt was measured by a pH meter (Model 211 HANNA (Instruments Microprocessor, Romania)).

Rheological analysis

Viscosity

Using a Brookfield DVII + viscometer made by Brookfield Engineering Lab Inc., Stoughton, Massachusetts, and using a modified version of the technique described by Donkor *et al*. (2007), At 10 °C, the apparent viscosity was determined. When using axial spindle No. 4 and a sample volume of 150 ml, the sample was completely mixed by spinning the spindle ten times in a clockwise direction and ten times in a counterclockwise direction. Centipoise units were used to measure the outcomes.

Water holding capacity

It was calculated using the technique described by (Parnell-Clunies *et al*., 1986) by centrifuging a 10 g sample of yogurt for 60 minutes at 3000 rpm and 10 °C to determine its composition.

Following removing the leachate and the remaining wet precipitate, the water holding capacity was determined by dividing the weight of the remaining precipitate by the weight of the original sample.

Water holding capacity = Weight of precipitate/ The original weight of the sample x 100 ….Eq. 2

Spontaneous whey separation

It was calculated using the technique described by Amatayakul *et al*. (2006) by removing the yogurt cup from the refrigerator and placing it at a 45-degree angle for two hours at a temperature of 5 °C.

To prevent excessive perfusion, the procedure included using the syringe to remove the whey off the surface and then weighing the cup again.

Texture profile analysis of yogurt

Measurements of texture characteristics, including hardness (firmness) and cohesiveness, were made using a texture analyzer of type (CT3,4500, Brookfield engineering lab).

According to the technique described by (Bonczar, *et al*. 2002), the firmness was assessed at 5 °C with a load strength of 5 kg. The yogurt sample was squeezed with a cylindrical probe with a diameter of 20 mm and a depth of 10 mm at a constant speed of 1 mm/s.

Sensory evaluation

According to the sensory assessment form (Almosawi et al., 2015), sensory testing of yogurt samples was carried out at the College of Food Sciences, Al-Qasim Green University by several qualified Academics.

RESULTS AND DISCUSSION

Chemical composition

The findings of the chemical analysis of the yogurt samples are shown in Table 2, and it is evident from them that the proportions of the majority of the yogurt components varied between the treatments. It is clear from the Table that the per cent of moisture reached 86.50, 82.75, 81.3 and 86.6% for the treatments (T_1-CM, T_2-BM, T_3-SM and T_4-GM), respectively. It was found from the outcomes that, when comparing the moisture percentages of the CM and GM treatments, these outcomes concur with Desouky and EL-Gendy (2017) found for GM, amounting to 86.9%. Guven *et al.* (2005) found that yogurt made from the whole CM amounted to 86.63%. It is also noticed the converging of this per cent for BM and SM yogurt treatments and a low per cent of their moisture content compared to cow and sheep yogurt. This is because each milk type has a high percentage of total solids, which is consistent with (Monteiro *et al*., 2019), who reported that yogurt prepared from SM had less moisture than yogurt manufactured from other milk types GM.

The per cent of protein reached 4.31, 4.35, 5.55, and 3.80% for the above treatments, respectively. The composition of the yogurt corresponded to the composition of the milk that was produced from it despite some of the differences resulting from the action of the initiating bacteria by converting lactose sugar into lactic acid as well as adding powdered milk powder that will increase the proportion of total solids, including protein (Deeth and Tamine, 1981). The present findings showed that the protein percentage of yogurt made from cow's and buffalo's milk was converging, and that the protein percentage of GM yogurt was lower than that of other varieties, particularly yogurt made from SM. This is consistent with Park (2017,(Wendorff and Haenleinm (2017), who noted that the protein content of goat milk GM is low compared to sheep, cow and buffalo milk.

As for the per cent of fat, it amounted to 3.84, 8.4, 7.45 and 4.80% for the above treatments, respectively. It

Table 1. Chemical analysis and pH value for different yogurts

Type of yogurt	%						pH
	Moisture	Protein	Fat	Lactose	Ash	Total acidity	
T_1- CM yogurt	86.51.23±0[a]	4.31±0.06[b]	3.840.09±[d]	4.640.09±[ab]	0.710.05±[b]	0.90±0.01[b]	4.61±0.01[ab]
T_2- BM yogurt	82.751.06±[b]	4.35±0.05[b]	8.4±0.11[a]	4.700.09±[a]	0.80.05±[ab]	0.88±0.01[b]	4.68±0.01[a]
T_3- SM yogurt	81.30.98±[c]	5.550.06±[a]	7.450.10±[b]	4.800.09±[a]	1.10.05±[a]	0.93±0.01[ab]	4.51±0.01[b]
T_4- GM yogurt	86.61.11±[a]	3.800.07±[b]	4.800.09±[c]	3.920.08±[b]	0.70.05±[b]	0.980.01±[a]	4.200.01±[c]

Different letters indicate significant differences within the column at ($P < 0.05$).

wass noted that CM yogurt was the lowest in the per cent of fat, followed by GM, while noting the clear increase in the fat per cent for each buffalo and CM, respectively. The low per cent of fat is related to many factors, including animal nutrition, climate, environment, and animal strain, in addition to the milking stage. The per cent of lactose was 4.64, 4.70, 4.80 and 3.92% for the above treatments. It is noted that the per cent of lactose decreased in GM compared to yogurt milk, which excelled in all the treatments followed by the BM yogurt treatment and, then, the CM yogurt treatment. This is consistent with what was found by (Kapadiya *et al*., 2016), who indicated a low lactose level in GM yogurt compared to the same product as buffalo and CM. The ash content was 0.71, 0.88, 1.10, and 0.70%, respectively. It is noted that the highest ash content was in the SM yogurt treatment, followed by the buffalo and CM treatments, and the GM yogurt treatment was the lowest in ash per cent. This is in line with Nahar *et al.* (2007)'s findings that the values of the dahi (yogurt) made from buffalo, cow, and GM separately followed the same pattern. Additionally, the higher percentage of total solids in BM yogurt compared to cow and GM yogurt accounts for the higher ash content of the latter GM.

Total acidity

The total acidity per cent results in Table 2 of (T_1-cow milk, T_2-buffalo milk, T_3-sheep milk and T_4-goat milk) treatments reached 0.90, 0.88, 0.93 and 0.98,% respectively. It was noted that the high acidity value of SM yogurt compared to CM and BM yoghurt was due to the high buffer capacity of SM, which is related to its high content of mineral salts, protein and dissolved carbon dioxide compared to CM and BM (Salaün *et al*., 2005). This leads to taking more NaOH solution during the titration. This is consistent with Domagała (2009) and Erkaya and Şengül (2012), who reported that the SM and its based yogurt had higher acidity than cow and GM.

The findings are shown in Table 2, and the pH values for treatments T_1-cow milk, T_2-buffalo milk, T_3-sheep milk and T_4-goat milk. Because of this, the corresponding numbers were 4.61, 4.68, 4.51, and 4.20. It is noted that there were significant differences in the pH values between the different yogurt treatments, especially between the SM and GM yogurt, compared to the yogurt produced from the milk of other types under study, where this pH was characterized by depression. This may be due to the high nitrogen content of SM, where the high protein content of SM can play a big role as a high buffer capacity component, increasing the starter activity and increasing acidity. This high buffer capacity and acidity can be obtained when the growth environment remains without significant changes (Urbach, 1995). It can also be said that the increase in the bacteria starter count and activity depends on the growth environment protein content, especially the amino acids (Güler-Akın and Akin, 2007). The GM yogurt pH value decrease goes back to the fact that the electrical point of GM casein is at pH 4.2 (where it starts to aggregate) (Espírito-Santo *et al.*, 2013)

Rheological properties

Spontaneous whey separation

Fig. 1 shows spontaneous whey separation values (ml / 100 g yogurt) results. A large variation in these values is noted due to the difference in the milk chemical composition, especially the per cent of the protein responsible for increasing the cross-linking in the protein network. When high milk protein levels, the cross-linking in the protein network and the water bonding increases, decreasing the whey separation, which is consistent with what (Vital *et al*., 2015) found. It is noted that whey separation is higher for both CM and GM yogurt milk than BM and SM yogurt. From the results, we note that the amount of separate whey was lower for each of the yogurt samples (SM, BM) compared to the yogurt samples (GM, CM) due to their higher content of total solids for both sheep and buffalo milk (Ibrahim and Doosh, 2017). Reducing whey separation is a good and important advantage of yogurt (Gilbert et al., 2020).

Water holding capacity

Fig. 2 shows the per cent of water holding capacity (WHC) of yogurt treatments. This susceptibility varies from one yogurt treatment to another, contrasting with the whey separation. Sheep or BM yogurt treatments displayed a higher WHC than CM and GM yogurt. The high percentage of total solids in the milk boosted the curd's hardness because the protein content of yogurt jelly plays a key role in the strength of the protein network's construction. As opposed to CM and BM, SM and BM have higher levels of protein, which increases

Table 2. Sensory evaluation for different yogurts

Type of yogurt	Flavor 45 ˚	Texture and Consistency 35 ˚	Acidity 10 ˚	Appearance 10 ˚	Total 100 ˚
T_1- CM yogurt	44	32	10	10	97
T_2- BM yogurt	45	35	10	8	98
T_3- SM yogurt	44	35	10	10	99
T_4- GM yogurt	42	31	10	8	91

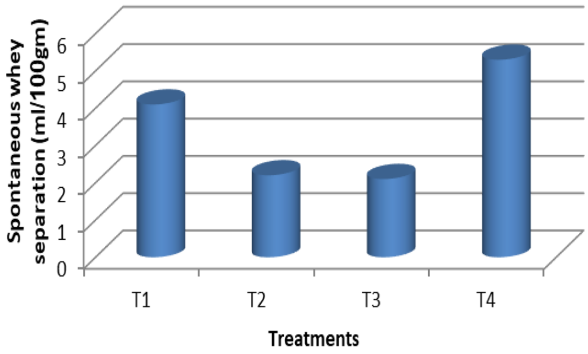

Fig. 1. *Natural whey separation in the various yogurt preparations T_1: Cow's milk yogurt , T_2: Buffalo's milk yogurt , T_3: Sheep's milk yogurt , T_4: Goat's milk yogurt*

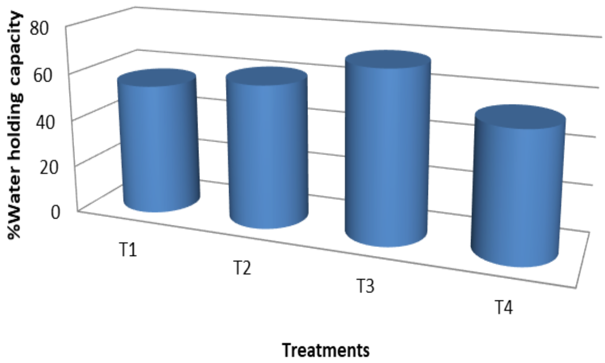

Fig. 2. *Water holding capacity for various yogurt procedures T_1: Cow's milk yogurt , T_2: Buffalo's milk yogurt , T_3: Sheep's milk yogurt , T_4: Goat's milk yogurt*

WHC and inhibits its leaking from inside the folds of the protein matrix GM. The (WHC) of the yogurt made from milk may also be impacted by its fat level, which is compatible with what was described by Al-Bedrani *et al*. (2019). When comparing, types of yogurt with similar quantities of total dry solids with high fat per cent indicated an improvement in their (WHC) due to the high per cent of total solids in them. Hanif *et al*. (2012) indicated that all the sensory and rheological properties of yogurt made from BM excelled that of CM. The results also suggest that although yogurt produced from CM and GM contains the same percentage of total solids, CM yogurt is lower in whey separation and higher in WHC compared to GM yogurtm, this is consistent with Kim *et al*. (2020), who stated that the higher the WHC value, the less whey separation in yogurt.

Viscosity

In Fig. 3, the corresponding viscosity values for the T_1-cow milk, T_2-buffalo milk, T_3-sheep milk and T_4-goat milk treatments were 7000, 8900, 6700, and 1510 centipoise. According to Jumah *et al*. (2001) and Martín-Diana *et al*. (2003), different milk varieties have diverse chemical compositions, particularly in terms of total solids, which results in distinct changes in the viscosity of the various yogurt types. Additionally, it should be highlighted that SM and BM yoghurts had higher viscosities than other yoghurts, particularly GM, which had the lowest viscosity. These obvious variances result from the various major milk components used in these therapies (Park, 2017). The two factors that impact milk viscosity most are protein and fat (Li *et al*., 2018; Sobti *et al*., 2019). Consequently, SM and BM yoghurt viscosity increased in comparison to other varieties. Additionally, increasing the percentage of milk's total solids utilized will make the yogurt thicker (Saadi *et al*., 2022). According to (Jumah *et al*., 2001), SM has a high viscosity that influences the hardness of the dairy product created from it and may result in its capacity to bind water via its protein content. In general, adjustments must be made to milk with low total solids content CM and GM in order to raise its total solids content and, therefore, its viscosity (Remeuf *et al*., 2003; Herrero and Requena, 2006).

Texture properties

One of the main characteristics on which yogurt acceptance depends is texture, which must be monitored to ensure a quality product (Batista *et al*., 2021). Interest has increased by many researchers on the rheological and structural properties of yogurt and the main factors that affect it, milk preparation and type, fermentation processes, incubation conditions and beyond are the most important factors affecting the texture of yogurt (Prajapati *et al*., 2016).

Firmness

The results of the firmness of the various yogurt samples are shown in Fig. 4. It was evident that the two yogurt treatments made from BM and SM had a high firmness compared to other types of yogurt studied, with GM yogurt having a significant decrease in firmness. This is congruent with what Park (2017) reported, which showed that the varying milk content of various species of animals influences the hardness of the

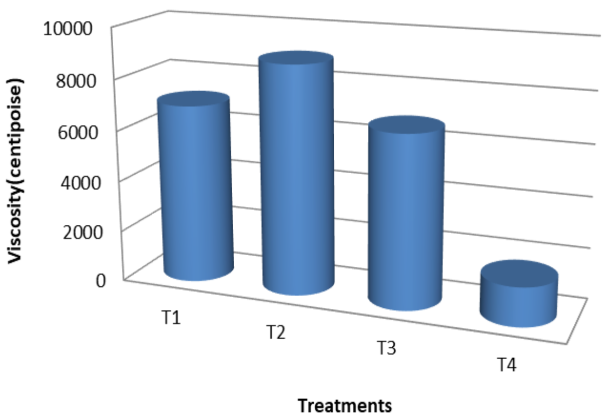

Fig. 3. *Values of viscosity for various yogurts T_1: Cow's milk yogurt , T_2: Buffalo's milk yogurt , T_3: Sheep's milk yogurt , T_4: Goat's milk yogurt*

curd generated from them. This may be caused by the increase in total solids in BM and SM, particularly protein and fat. Along with affecting the curd's hardness, the fat content variation between different kinds of milk also influences the size of the fatty globules, which distinguishes BM and SM from GM fat globules. The large -sized fatty globules of the other milk types can rise to the surface and make the protein more compact, which gives high yogurt firmness. The small size of the GM fat globules causes It to spread between the casein folds when the protein network forms, giving the yogurt a loose texture and less firmness. Further, the research revealed that the use of GM had an impact on the rheological and texture properties of fermented milk products or yogurt, including lower consistency, firmness, viscosity, and cohesiveness (Miocinovic *et al*., 2016). Due to the high protein content and total solids, yogurts prepared with BM and SM had higher firmness than yogurts made with CM and GM. This was consistent with the study of Prajapati *et al*. (2016) and Lesme *et al*. (2020), who stated that increasing the concentration of protein and total solids leads to increased firmness.

Cohesiveness

This characteristic is indicated by the force that may distort the substance before it breaks down, pertains to the strength of the internal bonds of a yogurt structure that preserves a single mass. Adhesion is a significant factor in the yogurt's quality and demonstrates customer acceptability since low values indicate the composition's softest consistency.

It is clear from the results in Fig. 5 that there is a strong relationship between the total solids content of the specific type of milk and the adhesion value of the yogurt produced from it. The high levels of yogurt texture parameters produced from the SM and BM relate to the high levels of protein and total solids, so they were the most solid, and consistency, viscosity, and adhesion were the best in texture characteristics, quality (Prajapati et al., 2016; Lesme et al., 2020). Therefore, it was observed that BM and SM yogurt cohesiveness was high compared to the CW and GM yogurt.

Sensory evaluation

Using different milk sources prepared to manufacture yogurt results in different flavours and fixed and synthetic qualities. The results are given in Table 2 of high scores given to sensory traits under study for BM and SM. This may be due to the improvement of the taste of the yogurt produced from this milk and characterized by creamy texture due to high-fat content was consistent with Junaid *et al*., (2022) who mentioned that yogurt prepared from high-fat milk (buffalo milk) had a stronger flavor and organoleptic properties than yogurt made from low-fat milk (cow's milk). It can be said that the higher content of BM from total solids with higher levels of both fat and protein made it more suitable for making yogurt with a distinguished creamy texture and flavor rich in fat. The present study on SM yogurt sensory evaluation results agrees with Bernacka *et al*. (2017), who reported that SM yogurt had the best taste and smell compared to CM and GM yogurt.

As for CM yogurt came in the second degree of evaluation due to its low flavour and texture properties compared to the yogurt produced from BM and SM. It was also noted from the results of the decrease in the awarded degrees to evaluate the sensory properties of GM compared to the awarded degrees to other types. This may be due to the distinctive and repulsive GM flavour because GM contains a high per cent of volatile short-chain fatty acids (SCFAs) such as capric, caproic and caprylic. This was consistent with what Stelios and Emmanuel (2004) found, who pointed out that making yogurt from GM only made it less stable because of its low total solids content, which made the resulting yogurt less solid and weaker in terms of sensory properties.

In recent years, it has become apparent that many researchers have concentrated more on the potential to enhance the sensory qualities of yogurt made from

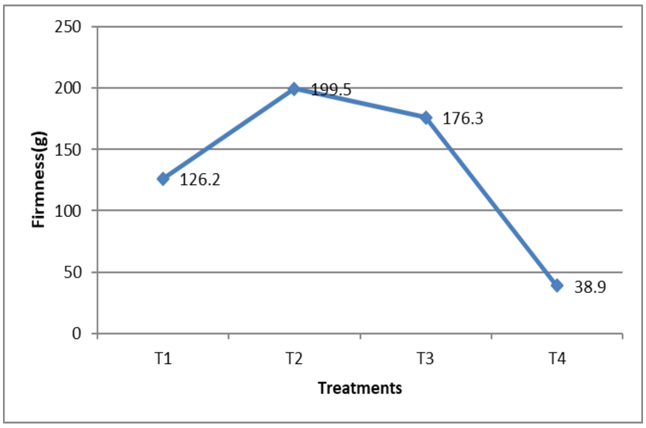

Fig. 4. *Firmness values for different yogurts T_1: Cow's milk yogurt , T_2: Buffalo's milk yogurt , T_3: Sheep's milk yogurt , T_4: Goat's milk yogurt*

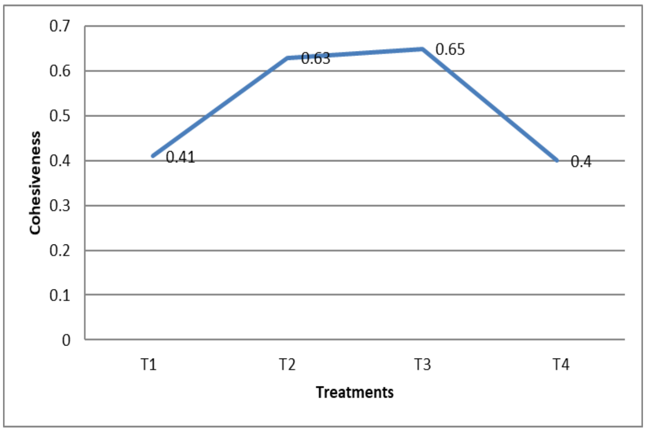

Fig. 5. *Cohesiveness values for different yogurts T_1: Cow's milk yogurt , T_2: Buffalo's milk yogurt , T_3: Sheep's milk yogurt , T_4: Goat's milk yogurt*

goat's milk, particularly its taste, by fortifying it with fruit juices, fruit pulps, or other naturally occurring sweetening materials (Machado *et al*., 2017; Ranadheera *et al*., 2012; Silva *et al*., 2017). According to Gomes et al., 2013), the most important issue with GM in processing dairy products is its stronger taste than CM. The sweet taste was found to reduce GM's flavour, making these products somewhat unacceptable to the consumer (De Santis and others, 2019). It was indicated that by growth in positive sensual features such as sweetness and creamy taste boosted from the acceptance of GM yogurt until less sensory characteristics are less wanted by the customer, such as sour, salty taste and sense of unique GM flavour. Megalemou et al. (2017) compared yogurt treatments made from various kinds of milk. They discovered that the GM yogurt sample separated itself substantially from other varieties of yogurt in terms of sour taste, flavour clarity, smoothness, and more fluid texture.

Conclusion

It can be said, from the results of the current study, that the source of milk had a significant impact on the chemical composition, especially with regard to the percentage of moisture, protein, fat, and ash for yogurt produced from the milk of all buffaloes and sheep compared to yogurt made from the milk of both cows and goats, in addition, some significant impact in rheological properties, and texture characteristics of the produced yogurt. Thus, it can be said that the percentage of total solids for the source of milk has the greatest impact on all these properties.

Conflict of interest

The authors declare that they have no conflict of interest.

REFERENCES

1. Abesinghe, A. M. N. L., Priyashantha, H., Prasanna, P. H. P., Kurukulasuriya, M. S., Ranadheera, C. S. & Vidanarachchi, J. K. (2020). Inclusion of probiotics into fermented buffalo (Bubalus bubalis) milk: an overview of challenges and opportunities. Fermentation, 6(4), 121. https://doi.org/10.3390/fermentation6040121
2. Al-Bedrani, D. I., ALKaisy, Q. H. & Mohammed, Z. M. (2019, November). Physicochemical, rheological and sensory properties of yogurt flavored with sweet orange (citrus sinensis) marmalade. In *IOP Conference Series: Earth and Environmental Science* (Vol. 388, No. 1, p. 012052). DOI 10.1088/1755-1315/388/1/012052
3. Almosawi, B. N., Al-Hamdani, H. M. & Dubaish, A. N. (2015). Study of qualification and Sensation properties by using date extraction and date syrup in yoghurt processing. *Adv. Life Sci. Technol*, *32*, 49-58.
4. Amatayakul, T., Sherkat, F. & Shah, N. P. (2006). Syneresis in set yogurt as affected by EPS starter cultures and levels of solids. *International Journal of dairy technology*, *59*(3), 216-221. https://doi.org/10.1111/j.1471-0307.2006.00264.x
5. Association of Official Agricultural Chemists (AOAC) (2016). Official Methods of Analysis Guidelines for Standard Method Performance Requirements.
6. Baba, W. N., Jan, K., Punoo, H. A., Wani, T. A., Dar, M. M. & Masoodi, F. A. (2018). Techno-functional properties of yoghurts fortified with walnut and flaxseed oil emulsions in guar gum. *LWT-Food Science and Technology*, *92*, 242-249. https://doi.org/10.1016/j.lwt.2018.02.007
7. Balthazar, C. F., Pimentel, T. C., Ferrão, L. L., Almada, C. N., Santillo, A., Albenzio, M. & Cruz, A. G. (2017). Sheep milk: physicochemical characteristics and relevance for functional food development. Comprehensive reviews in food science and food safety, 16(2), 247-262. https://doi.org/10.1111/1541-4337.12250
8. Batista, L. F., Marques, C. S., dos Santos Pires, A. C., Minim, L. A., Soares, N. D. F. F. & Vidigal, M. C. T. R. (2021). Artificial neural networks modeling of non-fat yogurt texture properties: effect of process conditions and food composition. Food and Bioproducts Processing, 126, 164-174. https://doi.org/10.1016/j.fbp.2021.01.002
9. Bernacka, H., Chwalna, A., Jarzynowska, A. & Mistrzak, M. (2017). Consumer assessment of yogurts made from sheep's, goat's, cow's and mixed milk. *Acta Scientiarum Polonorum Zootechnica*, *13*(1), 19-28.
10. Bilgin, B. & Kaptan, B. (2016). A study on microbiological and physicochemical properties of homemade and small scale dairy plant buffalo milk yoghurts. *International Journal of Pharmaceutical Research & Allied Sciences*, *5*(3).
11. Bonczar, G., Wszołek, M. & Siuta, A. (2002). The effects of certain factors on the properties of yoghurt made from ewe's milk. *Food chemistry*, *79*(1), 85-91. https://doi.org/10.1016/S0308-8146(02)00182-6
12. De Santis, D., Giacinti, G., Chemello, G., & Frangipane, M. T. (2019). Improvement of the sensory characteristics of goat milk yogurt. *Journal of food science*, *84*(8), 2289-2296. https://doi.org/10.1111/1750-3841.14692
13. Deeth, H. C. & Tamime, A. Y. (1981). Yogurt: Nutritive and therapeutic aspects. *Journal of food protection*, *44*(1), 78-86. DOI: 10.4315/0362-028x-44.1.78
14. Desouky, M. M. & EL-Gendy, M. H. (2017). Physicochemical Characteristics of Functional Goats' Milk Yogurt as Affected by some Milk Heat Treatments. *International Journal of Dairy Science*, *12*(1), 12-27.
15. Domagała, J. (2009). Instrumental texture, syneresis and microstructure of yoghurts prepared from goat, cow and sheep milk. *International Journal of Food Properties*, *12*(3), 605-615. https://doi.org/10.1080/10942910801992934
16. Donkor, O. N., Nilmini, S. L. I., Stolic, P., Vasiljevic, T. & Shah, N. P. (2007). Survival and activity of selected probiotic organisms in set-type yoghurt during cold storage. *International dairy journal*, *17*(6), 657-665. https://doi.org/10.1016/j.idairyj.2006.08.006
17. Erkaya, T. & Şengül, M. (2012). A Comparative Study on Some Quality Properties and Mineral Contents of Yoghurts Produced From Different Type of Milks. *Kafkas Universitesi Veteriner Fakultesi Dergisi*, *18*(2).
18. Espírito-Santo, A. P., Lagazzo, A., Sousa, A. L. O. P., Perego, P., Converti, A. & Oliveira, M. N. (2013). Rheology, spontaneous whey separation, microstructure and

sensorial characteristics of probiotic yoghurts enriched with passion fruit fiber. *Food Research International*, *50* (1), 224-231. https://doi.org/10.1016/j.foodres.2012.09.012
19. Gilbert, A., Rioux, L. E., St-Gelais, D. & Turgeon, S. L. (2020). Characterization of syneresis phenomena in stirred acid milk gel using low frequency nuclear magnetic resonance on hydrogen and image analyses. Food Hydrocolloids, 106, 105907. https://doi.org/10.1016/j.foodhyd.2020.105907
20. Gomes, J. J. L., Duarte, A. M., Batista, A. S. M., de Figueiredo, R. M. F., de Sousa, E. P., de Souza, E. L. & do Egypto, R. D. C. R. (2013). Physicochemical and sensory properties of fermented dairy beverages made with goat's milk, cow's milk and a mixture of the two milks. *LWT-Food Science and Technology*, *54*(1), 18-24. https://doi.org/10.1016/j.lwt.2013.04.022
21. Guven, M., Yasar, K., Karaca, O. B. & Hayaloglu, A. A. (2005). The effect of inulin as a fat replacer on the quality of set□type low□fat yogurt manufacture. *International journal of dairy Technology*, *58*(3), 180-184. https://doi.org/10.1111/j.1471-0307.2005.00210.x
22. Güler-Akın, M. B. & Akın, M. S. (2007). Effects of cysteine and different incubation temperatures on the microflora, chemical composition and sensory characteristics of bio-yogurt made from goat's milk. *Food Chemistry*, *100*(2), 788-793. https://doi.org/10.1016/j.foodchem.2005.10.038
23. Hanif, M. S., Zahoor, T., Iqbal, Z. & Ihsan-ul-Haq, A. A. (2012). Effect of storage on rheological and sensory characteristics of cow and buffalo milk yogurt. *Pakistan Journal of Food Sciences*, *22*(2), 61-70.
24. Hardy, G. (2000). The nutritional value of SM: anatural supplement for clinical nutrition. In:Proceedings, International Symposium, Development Strategy for the Sheep and Goat Dairy Sector, Nicosia,Cyprus, Brit. Sheep Dairy News. 17, 23-24.
25. Herrero, A. M. & Requena, T. (2006). The effect of supplementing goats milk with whey protein concentrate on textural properties of set□type yoghurt. *International Journal of Food Science & Technology*, *41*(1), 87-92. https://doi.org/10.1111/j.1365-2621.2005.01045.x
26. Ibrahim, D., & Doosh, K. S. (2017). Physicochemical and sensorial properties of low energy yogurt produced by adding whey protein concentrate. iraq journal of agricultural research, 22(5).
27. Ihekoronye, A. I. & Ngoddy, P. O. (1985). *Integrated food science and technology for the tropics*. Macmillan.
28. Jaiswal, L., & Worku, M. (2021). Recent perspective on cow's milk allergy and dairy nutrition. *Critical Reviews in Food Science and Nutrition*, 1-16.
29. Jandal, J. M. (1996). Comparative aspects of goat and sheep milk. *Small ruminant research*, *22*(2), 177-185. https://doi.org/10.1080/10408398.2021.1915241
30. Jumah, R. Y., Shaker, R. R. & Abu□Jdayil, B. (2001). Effect of milk source on the rheological properties of yogurt during the gelation process. *International Journal of Dairy Technology*, *54*(3), 89-93. https://doi.org/10.1046/j.1364-727x.2001.00012.x
31. Junaid, M., Inayat, S., Gulzar, N., Khalique, A., Shahzad, F., Irshad, I. & Imran, M. (2022). Physical, chemical, microbial, and sensory evaluation and fatty acid profiling of value-added drinking yogurt (laban) under various storage conditions. *Journal of Dairy Science*, S0022-0302. https://doi.org/10.3168/jds.2022-22358
32. Kapadiya, D. B., Prajapati, D. B., Jain, A. K., Mehta, B. M., Darji, V. B. & Aparnathi, K. D. (2016). Comparison of Surti goat milk with cow and buffalo milk for gross composition, nitrogen distribution, and selected minerals content. *Veterinary World*, *9*(7), 710. doi: 10.14202/vetworld.2016.710-716
33. Kaur R., Kaur G., Mishra S. K., Panwar H., Mishra K. K. & Brar G. S. (2017). Yogurt: A nature's wonder for mankind. International Journal of Fermented Foods, 6, (1), pp. 57-69. DOI: 10.5958/2321-712X.2017.00006.0
34. Kim, S. Y., Hyeonbin, O., Lee, P. & Kim, Y. S. (2020). The quality characteristics, antioxidant activity, and sensory evaluation of reduced-fat yogurt and nonfat yogurt supplemented with basil seed gum as a fat substitute. *Journal of Dairy Science,* 103(2), 1324-1336. https://doi.org/10.3168/jds.2019-17117
35. Lesme, H., Rannou, C., Famelart, M. H., Bouhallab, S. & Prost, C. (2020). Yogurts enriched with milk proteins: Texture properties, aroma release and sensory perception. *Trends in Food Science & Technology*, *98*, 140-149. https://doi.org/10.1016/j.tifs.2020.02.006
36. Li, Y., Joyner, H. S., Carter, B. G. & Drake, M. A. (2018). Effects of fat content, pasteurization method, homogenization pressure, and storage time on the mechanical and sensory properties of bovine milk. *Journal of Dairy Science,* 101(4), 2941-2955. https://doi.org/10.3168/jds.2017-13568
37. Ling, E.R. (2008). "A textbook of dairy chemistry " . Vol. II practical, Chapman and Hall. LTD, (London).
38. Machado, T. A. D. G., de Oliveira, M. E. G., Campos, M. I. F., de Assis, P. O. A., de Souza, E. L., Madruga, M. S., ... & do Egypto, R. D. C. R. (2017). Impact of honey on quality characteristics of goat yogurt containing probiotic Lactobacillus acidophilus. *Lwt*, *80*, 221-229. https://doi.org/10.1016/j.lwt.2017.02.013
39. Martín-Diana, A. B., Janer, C., Peláez, C. & Requena, T. (2003). Development of a fermented goat's milk containing probiotic bacteria. *International Dairy Journal*, *13*(10), 827-833. https://doi.org/10.1016/S0958-6946(03)00117-1
40. Megalemou, K., Sioriki, E., Lordan, R., Dermiki, M., Nasopoulou, C. & Zabetakis, I. (2017). Evaluation of sensory and in vitro anti-thrombotic properties of traditional Greek yogurts derived from different types of milk. *Heliyon*, *3*(1), e00227. https://doi.org/10.1016/j.heliyon.2016.e00227
41. Miocinovic, J., Miloradovic, Z., Josipovic, M., Nedeljkovic, A., Radovanovic, M. & Pudja, P. (2016). Rheological and textural properties of goat and cow milk set type yoghurts. *International Dairy Journal*, *58*, 43-45. https://doi.org/10.1016/j.idairyj.2015.11.006
42. Moatsou, G. & Sakkas, L. (2019). Sheep milk components: Focus on nutritional advantages and biofunctional potential. Small Ruminant Research, 180, 86-99. https://doi.org/10.1016/j.smallrumres.2019.07.009
43. Mohapatra, A., Shinde, A. K. & Singh, R. (2019). Sheep milk: A pertinent functional food. Small ruminant research, 181, 6-11. https://doi.org/10.1016/j.smallrumres.2019.10.002
44. Monteiro, A., Loureiro, S., Matos, S. & Correia, P. (2019). Goat and sheep milk as raw material for yoghurt. *Milk Production, Processing and Marketing*, 13.

45. Nahar, A., Al-Amin, M., Alam, S. M. K., Wadud, A., & Islam, M. N. (2007). A comparative study on the quality of Dahi (yoghurt) prepared from cow, goat and buffalo milk. *International Journal of Dairy Science*, *2*(3), 260-267.
46. Pantoja, L. S. G., Amante, E. R., da Cruz Rodrigues, A. M. & da Silva, L. H. M. (2022). World scenario for the valorization of byproducts of buffalo milk production chain. *Journal of Cleaner Production*, 132605. https://doi.org/10.1016/j.jclepro.2022.132605
47. Park, Y. W. (2017). Goat milk–chemistry and nutrition. Handbook of milk of non□bovine mammals, 42-83. https://doi.org/10.1002/9781119110316.ch2.2
48. Parnell-Clunies, E. M., Kakuda, Y., Mullen, K., Arnott, D. R. & Deman, J. M. (1986). Physical properties of yogurt: a comparison of vat versus continuous heating systems of milk. *Journal of Dairy Science*, *69*(10), 2593-2603. https://doi.org/10.3168/jds.S0022-0302(86)80706-8
49. Pelegrine, D. H. G. & Souza, F. R. S. (2014). Dairy products production with buffalo milk. *International, Journal of Applied Science and Technology*, *4*(3), 14-19.
50. Prajapati, D. M., Shrigod, N. M., Prajapati, R. J. & Pandit, P. D. (2016). Textural and rheological properties of yoghurt: a review. Adv Life Sci, 5(13), 5238-5254.
51. Ranadheera, C. S., Evans, C. A., Adams, M. C. & Baines, S. K. (2012). Probiotic viability and physico-chemical and sensory properties of plain and stirred fruit yogurts made from goat's milk. *Food Chemistry*, *135*(3), 1411-1418. https://doi.org/10.1016/j.foodchem.2012.06.025
52. Remeuf, F., Mohammed, S., Sodini, I. & Tissier, J. P. (2003). Preliminary observations on the effects of milk fortification and heating on microstructure and physical properties of stirred yogurt. *International Dairy Journal*, *13* (9), 773-782. https://doi.org/10.1016/S0958-6946(03)00092-X
53. Salaün, F., Mietton, B. & Gaucheron, F. (2005). Buffering capacity of dairy products. *International Dairy Journal*, *15* (2), 95-109. https://doi.org/10.1016/j.idairyj.2004.06.007
54. Saadi, A. M., Jafar, N. B., & Jassim, M. A. (2022). Effect of some types of stabilizers on the quality of yogurt during storage. *Journal of Hygienic Engineering and Design*, *38*, 125-130.
55. Shiny, A. (2020). In invitro analysis of nutritional compositions of milk from umbalacheri and jersey cow. *International Journal Of Advanced Research In Medical & Pharmaceutical Sciences*, 5(11), 1-4.
56. Silva, F. A., de Oliveira, M. E. G., de Figueirêdo, R. M. F., Sampaio, K. B., de Souza, E. L., de Oliveira, C. E. V., ... & do Egypto, R. D. C. R. (2017). The effect of Isabel grape addition on the physicochemical, microbiological and sensory characteristics of probiotic goat milk yogurt. *Food & Function*, *8*(6), 2121-2132. https://doi.org/10.1039/C6FO01795A
57. Sobti, B., Al Teneiji, H. A. & Kamal-Eldin, A. (2019). Effect of added bovine casein and whey protein on the quality of camel and bovine milk yoghurts. Emirates Journal of Food and Agriculture, 31(10), 804-811. DOI https://doi.org/10.9755/ejfa.2019.v31.i10.2022
58. Stelios, K. & Emmanuel, A. (2004). Characteristics of set type yoghurt made from caprine or ovine milk and mixtures of the two. *International Journal of Food Science & technology*, *39*(3), 319-324. https://doi.org/10.1111/j.1365-2621.2004.00788.x
59. Tamime, A. Y. & Robinson, R. K. (2007). Tamime and Robinson's yoghurt: science and technology. *Tamime and Robinson's yoghurt: science and technology*., (Ed. 3).
60. Turkmen N (2017). The nutritional value and health benefits of goat milk components. In: Nutrients in dairy and their implications on health and disease, Academic Press, pp 441–449. https://doi.org/10.1016/B978-0-12-809762-5.00035-8
61. Urbach, G. (1995). Contribution of lactic acid bacteria to flavour compound formation in dairy products. *International Dairy Journal*, *5*(8), 877-903. https://doi.org/10.1016/0958-6946(95)00037-2
62. Verduci, E., D'Elios, S., Cerrato, L., Comberiati, P., Calvani, M., Palazzo, S., ... & Peroni, D. G. (2019). Cow's milk substitutes for children: Nutritional aspects of milk from different mammalian species, special formula and plant-based beverages. *Nutrients,* 11(8), 1739. https://doi.org/10.3390/nu11081739
63. Vital, A. C. P., Goto, P. A., Hanai, L. N., Gomes-da-Costa, S. M., de Abreu Filho, B. A., Nakamura, C. V. & Matumoto -Pintro, P. T. (2015). Microbiological, functional and rheological properties of low fat yogurt supplemented with Pleurotus ostreatus aqueous extract. LWT-*Food Science and Technology,* 64(2), 1028-1035. https://doi.org/10.1016/j.lwt.2015.07.003
64. Wendorff, W. L. & Haenlein, G. F. (2017). Sheep milk–composition and nutrition. *Handbook of Milk of Non-bovine Mammals*, 210-221. https://doi.org/10.1002/9781119110316.ch3.2