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ORIGINAL PAPER

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PHYSICO-CHEMICAL AND SENSORY CHARACTERIZATION OF CAMEL MILK YOGURT ENRICHED WITH PERSIMMON (*DIOSPYROS KAKI*) FRUIT

Omar Ait El Alia[1], Yassine Zine-Eddine[1], Salah Chaji[2,3,4], Said Souhassou[5], Fouzia Kzaiber[1], Abdelkhalek Oussama[1], Khalid Boutoial[1]✉

[1]Laboratory of the Engineering and Applied Technologies, Higher School of Technology, Sultan Moulay Slimane University Pb 591 M'Ghila, Béni Mellal, **Morocco**
[2]Department of Drug Science and Technology, University of Turin Via P. Giuria 9, 10125 Turin, **Italy**
[3]Laboratory of Food and Food By-Products Chemistry and Processing Technology, National School of Agriculture in Meknès Haj Kaddour Road, B.P. S/40, Meknès, **Morocco**
[4]Laboratory of Bioprocess and Bio-interfaces, Faculty of Sciences and Techniques, University Sultan Moulay Slimane B.P. 523 M'Ghila, Beni Mellal, **Morocco**
[5]Laboratory of Spectroscopy and Chemometrics, Faculty of Sciences and Techniques, University Sultan Moulay Slimane B.P. 523 M'Ghila, Beni Mellal, **Morocco**

ABSTRACT

Background. Although camel milk is widely recognized for its nutritional value and pharmaceutical benefits, processing technology and consumer acceptability of its yogurt still need to be improved due to poor curd formation, taste, and flavor. Persimmon is a fruit known for its sweet and tangy flavor and is popular in many parts of the world.

Materials and methods. In this study, gelatin was used to manufacture camel milk yogurt to obtain an adequate level of firmness. Afterward, to enhance sensory characteristics and consumer acceptance of camel milk yogurt, persimmon pulp was added as a natural additive at different levels (3%, 5%, and 10%). Subsequently, the camel milk yogurt enriched with *Diospyros kaki* L. fruit was chemically analyzed and assessed for viscosity and sensory perception.

Results. 1% gelatin and 1.2% starter culture containing *Lactobacillus delbrueckii* subsp. *Bulgaricus* and *Streptococcus thermophilus* demonstrated the ability to form a good gel, reduce fermentation time to 6 hours, and improve consistency. Furthermore, adding persimmon pulp significantly enhanced the sensory characteristics of camel milk yogurt. Finally, the 5% level of persimmon pulp was the most preferred by consumers.

Conclusion. These findings open up promising opportunities for enhancing camel milk yogurt's quality and market appeal, making it a more desirable and nutritious choice for consumers.

Keywords: camel milk, yogurt, enrichment, persimmon pulp, consumer's acceptance

INTRODUCTION

Since earliest times, camel milk has been consumed in arid and desert regions where other milk sources are scarce. It is widely considered to be a healthier alternative to cow's milk (Swelum et al., 2021). Camels are

✉khalid.boutoial@usms.ma

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known to adapt to extreme weather conditions and can thrive in regions with limited water and food resources (Al-Juboori et al., 2013). Camel milk consumption is steadily increasing, as people have become recently more aware of its health benefits and particular taste (Ait El Alia et al., 2023a).

The composition of camel milk is unique compared to other ruminants, as it contains more concentrations of certain minerals and vitamins (Hammam, 2019). In particular, it is a rich source of calcium, iron, magnesium, vitamin C, and B vitamins, making it an ideal choice for people who seek a healthier alternative to traditional dairy products (Benmeziane--Derradji, 2021). Camel milk also contains higher concentrations of healthy fats, including unsaturated fatty acids, which are known to be beneficial for preventing cardiovascular diseases. These fatty acids help reduce cholesterol levels and prevent plaque formation in the arteries (Swelum et al., 2021). In addition to its nutritional benefits, camel milk has also been shown to positively affect various health conditions, such as allergies and others (Hammam, 2019). For example, it has already been used to treat diabetes and has been shown to enhance insulin sensitivity in diabetic patients (Shori, 2015). Camel milk has also induced an effective activity against digestive issues, such as lactose intolerance, as it contains a lower amount of lactose than cow's milk (Ho et al., 2022a). Other studies have indicated that camel milk may boost the immune system and help prevent infections and illnesses because it contains antibodies and immunoglobulins, which are known to fight against harmful bacteria and viruses (Khan et al., 2021).

The production of camel milk yogurt and other fermented products is challenging due to the lackluster coagulation capacity of camel milk (Ait El Alia et al., 2023b; Berhe et al., 2017). This results in a yogurt with an unappealing texture, separating whey, and a thin consistency that negatively impacts the overall appeal and acceptability to consumers (El Zubeir et al., 2012; Khalifa and Zakaria, 2019). In particular, the texture of the yogurt is of pivotal importance in determining its appearance, the sensation in the mouth, and overall appeal to the consumer (Al-Zoreky and Al-Otaibi, 2015).

Many studies have been conducted to improve the texture of camel milk yogurt and prevent syneresis. For instance, camel milk was combined with milks from other mammals, including sheep (Ibrahem and El Zubeir, 2016), buffalo (Khalifa and Zakaria, 2019), and cows (Kamal-Eldin et al., 2020). However, camel milk's inherent usefulness, qualities, and features are diminished when combined with other milk kinds. Employing a single stabilizer and hydrocolloid or their mixtures such as gelatin, carboxymethyl cellulose, gum, pectin, alginate, biosynthesized xanthan from orange peels, or banana fiber and banana peel fiber to enhance the consistency of camel milk yogurt have therefore all been investigated (Al-Zoreky and Al-Otaibi, 2015; Ho et al., 2022b; Mohsin et al., 2019; Mudgil et al., 2018; Safdari et al., 2021).

In a relevant study conducted by Mudgil et al. (2018), the effects of adding gelatin on the quality characteristics of camel milk yogurt were determined. The researchers found that adding proportions of gelatin ranging between 0.75% and 1.25% to the yogurt improved the microstructure and syneresis. Additionally, the texture and rheology of the camel milk yogurt became more similar to that of commercial and bovine milk yogurt. Nevertheless, camel milk yogurt's sensory properties were rated lower than bovine milk yogurt. Galeboea and colleagues also published a different formulation to develop a camel milk yogurt with acceptable quality that contained 4.0% maple strawberry syrup, 4.0% maple syrup, 1.2% gelatin, 5.0% bovine skim milk powder, 0.15% $CaCl_2$, and 6% yogurt culture (YF-L811) (Galeboea et al., 2018). The milk was then incubated at 42°C for 18 hours.

Food flavors play a critical role in determining the acceptability of dairy products among consumers. Numerous studies have revealed a strong preference for fruity yogurt (Fazilah et al., 2018). This may explain the continuously growing trend towards incorporating various fruits into yogurt production. The addition of such ingredients enhances the taste of the yogurt, and provides the added benefits of the fruit (Ahmad et al., 2022). Furthermore, the combination of pectin and sugars from the fruit with the yogurt increases its consistency and viscosity, resulting in an improved mouthfeel (Chandan, 2017). Pectins are also used in acidified dairy products to prevent syneresis (Tromp et al., 2004). They adsorb onto the casein protein, increasing steric repulsion and reducing aggregation (Nongonierma et al., 2007).

The persimmon fruit has garnered unique interest as a valuable functional ingredient due to its sensory appeal, excellent nutritional profile, and potential industrial use (Kaur et al., 2022). Persimmon is a valuable tropical fruit, owing to its richness in macro- and micro-nutrients and low-fat content (Barea-Álvarez et al., 2016). Furthermore, it contains different phenolic compounds that have been shown to help prevent various health issues, such as diabetes, cardiovascular diseases, and cancer, among others (Direito et al., 2021; Esteban-Muñoz et al., 2021; Izuchi et al., 2011). As the interest in functional ingredients continues to grow, researchers have been exploring the potential applications of persimmon in the development of dairy products like milk drinks (Jokar and Azizi, 2022), ice cream (Karaman et al., 2014), and fermented milk (Arslan and Bayrakçi, 2016).

With a vision to innovate the camel dairy industry, this study aims to formulate a new type of camel milk yogurt enriched with persimmon pulp and subsequently evaluate its quality characteristics.

MATERIALS AND METHODS

Ethical statement

All data were acquired anonymously following national ethical standards, including Article 24 of the Moroccan Constitution, Dahir n 1-09-15 of 22 Safar 1430. (February 18, 2009) Promulgated Regulation No. 09-08 on personal data protection concerning the processing of personal data. Decree No. 2-09-165 on May 21, 2009, relates to Law No. 09-08 on protecting people regarding personal data processing. Therefore, all the procedures involving human beings were reviewed and approved by the University of Sultan Moulay Slimane Research Ethics Committee.

Materials

Camel milk was procured from a cooperative named ‘The Camels’ located in Beni Mellal, Morocco, while fresh persimmons (*Diospyros kaki*) were obtained from a local market in Beni Mellal. A commercial lyophilized yogurt starter culture of *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus* was obtained from Chr-Hansen in Istanbul, Turkey. The suitability of these starter cultures for the industrial production of yogurt with enhanced intrinsic sweetness and low residual levels of lactose has already been demonstrated (Sørensen et al., 2016). It was inoculated until the pH reached 4.5 in pasteurized camel milk at 45°C. Food-grade bovine gelatin from VAHINE in Khraicia, Algeria, was used in this study.

Physicochemical analysis of raw camel milk

100 ml of fresh camel milk at 16°C was used to determine the studied physico-chemical parameters. Milko-Scan (Foss 5000 combi, Foss Electric, Hillerod, Denmark) was used for the milk composition analysis. The milk acidity was determined by a method described by Guiraud (1998), which involves acid-base titration using sodium hydroxide (NaOH) and phenolphthalein as a color indicator. The milk acidity results are reported in lactic acid %. Additionally, the pH of the milk was measured with a HI 2211 pH/ORP pH meter.

Persimmon pulp production

Fresh persimmon (*Diospyros kaki* L.) was purchased from a local market in Beni Mellal. The fresh fruit was washed with cold tap water to eliminate dust or residue. The peel of the persimmon was carefully removed using a sharp knife, and the pulp was subsequently extracted. To prevent the risk of harmful microorganisms, the fruit pulp underwent the process of homogenization and blanching, conducted at a temperature of 70°C for a duration of 5 minutes. Subsequently, the fruit pulp was stored at a refrigeration temperature of 4°C for future utilization. The pH, dry matter using a drying oven, and proteins using Kjeldahl method of the extracted fruit pulp were analyzed (AOAC, 2003), and the obtained results revealed that it contains 2.1% protein, 30% dry matter, and a pH of 5.3.

Preparation of yogurt

The camel milk underwent heat treatment at 60°C for 30 minutes in a water bath. Afterward, the milk was cooled to 45°C and subjected to an inoculation process. It was inoculated with a 1.2% starter culture containing *Lactobacillus delbrueckii* subsp. *bulgaricus and Streptococcus thermophilus*, and 1% gelatin was added and dissolved. The inoculated milk was then placed in an incubator at 45°C until the pH dropped below 4.5, indicating completion of the fermentation process. Following fermentation, all samples were

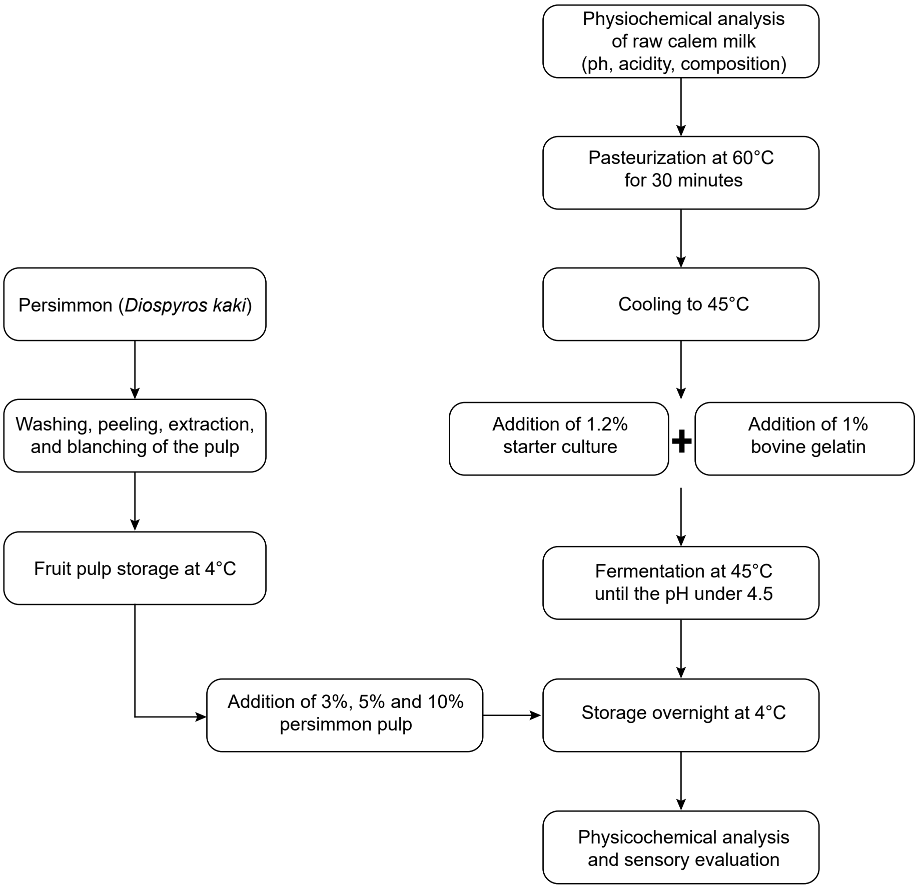

Fig. 1. Experimental procedure for the production of yogurt from camel milk enriched with persimmon pulp

stored at 4°C. To prepare the yogurt products, different concentrations of kaki pulp (by weight) were added: 0% (pure yogurt without kaki), 3%, 5%, and 10% kaki. The resulting yogurts were transferred to 50 mL transparent plastic cups with lids, labeled according to the fruit pulp concentration, and stored at 4°C for further analysis. Physicochemical analysis and sensory assessments were conducted on the produced yogurts. Figure 1 shows an overview of the experimental setup and the steps involved in making yogurt.

Physicochemical properties of yogurts

Hourly monitoring was conducted to track changes in pH and titratable acidity (% of lactic acid) throughout the fermentation of camel milk, until the pH level dropped below 4.5. The pH was measured using a HI 2211 pH/ORP pH meter, while the titratable acidity was determined through titration with 0.1 N of NaOH in the presence of a phenolphthalein indicator (AOAC, 2003). Additionally, dry matter content was assessed using the forced draft oven method, fat content was measured by the Gerber method, and protein content was determined using the Kjeldahl method (AOAC, 2003). The viscosity of yogurt samples was assessed at a temperature of 25°C and a shear rate range of 0 to 85 S^{-1}, utilizing a rotation viscometer (Brookfield DVIII Ultra, model RV, USA) (Gustaw et al., 2011).

Sensory evaluation of a camel milk yogurt enriched with persimmon pulp

In a blind test, a group of seven trained panelists, aged between 22 and 45 with a median age of 30 years old, and who were familiar with yogurt consumption, participated in the sensory evaluation of one-day-old yogurt samples. Panelists training for sensory evaluation of yogurt fortified with fruit is a crucial step in ensuring the product's quality and consumer satisfaction. These trained individuals undergo a rigorous process to develop their sensory acumen, honing their ability to discern and describe various attributes such as taste, texture, aroma, and appearance. By exposing them to different yogurt and fruit combinations, they become adept at identifying subtle nuances and differences in flavor profiles, sweetness levels, fruit distribution, and overall mouthfeel. Panelist training is considered effective when the ratings closely resemble each other (Rogers, 2018). The panelists comprised laboratory technicians, PhD students, professors, and administrative personnel. To evaluate the organoleptic quality of the yogurt samples, the panelists employed various sensory criteria such as homogeneity of color, presence of whey, fermented gel, viscosity, creaminess, fruit smell, acid smell, cream smell, fruit taste, cream taste, acid taste, sweet taste, milk taste (which is a characteristic taste of camel milk), bitter aftertaste, and characteristic aftertaste of fruit on a scale of 0-9. The results were expressed as an average score for each characteristic. The panelists were given water to neutralize the taste after each sample evaluation to avoid taste contamination. The yogurt samples were assigned three-digit codes before the sensory evaluation, and each criterion was scaled independently (Lawless and Heymamn, 2010; Zine-eddine et al., 2021).

To conduct the acceptance test, the evaluation was carried out by 56 individuals consisting of civil servants, researchers, and students from Béni Mellal's Higher School of Technology, Sultan Moulay Slimane University, Morocco. The participants were asked to rate the yogurt samples on a scale from 0, representing "Dislike Extremely", to 9, representing "Like Extremely". A total of 224 samples were tested in this study (Lawless and Heymamn, 2010).

Statistical analysis

The data analysis involved conducting a one-way multivariate ANOVA and a Tukey test at a significance level of 0.05, using Minitab's statistical package, version 18 (Minitab, Inc.).

RESULTS AND DISCUSSION

Chemical composition of fresh camel milk

The physicochemical properties of the fresh camel milk used to prepare the yogurts in this study (Table 1) is in accordance with previously reported results (Al Haj and Al Kanhal, 2010; Benmeziane-Derradji, 2021). However, multiple studies have demonstrated that pure camel milk cannot be used to produce yogurt. Gels can only be formed in yogurts containing a minimum of 40% milk from other ruminants, such as bovine, sheep, or buffalo milk (Ibrahem and El Zubeir, 2016; Kamal-Eldin et al., 2020; Khalifa and Zakaria, 2019). This results in an inferior texture and weak structural integrity of the final product, along with prolonged coagulation duration (Ho et al., 2022). Consequently, the inclusion of a stabilizing agent and hydrocolloid or other additives has become imperative for enhancing the quality of camel milk yogurts.

Physicochemical characteristics

Table 2 presents a summary of the pH and acidity measurements taken during the fermentation process. The results obtained indicate that coagulation occurred in batches that contained commercial yogurt culture and 1% gelatin. These batches coagulated within 6 hours of fermentation, reaching a pH of 4.34, resulting in a curd with sufficient firmness to be classified as set yogurt. Additionally, it was observed that samples supplemented with chymosin and gelatin coagulated at similar pH values to those previously observed in camel milk acid gels, which are typically below the

Table 1. Physiochemical composition of raw camel milk

Variable	pH	Acidity lactic acid	Fat	Dry matter	Density	Protein content	Lactose	Salts
Units		%	%	%		%	%	%
Camel milk	6.54 ±0.02	0.18 ±0.01	2.66 ±0.01	10.85 ±0.04	1.03 ±0.001	3.01 ±0.01	4.51 ±0.01	0.67 ±0.01

Table 2. pH and titratable acidity (lactic acid %) during the production of camel milk yogurt enhanced with 1% gelatin

Fermentation hours	pH	Titratable acidity lactic acid %
2	5.77 ±0.02	0.31 ±0.01
4	4.82 ±0.03	0.68 ±0.01
6	4.34 ±0.01	0.78 ±0.01

isoelectric point of casein (pH 4.6) (Benkerroum et al., 2022). The titratable acidity of coagulated batches after 6 hours of fermentation was 0.78% lactic acid, consistent with previous reports on camel milk coagulation (0.78–0.91%) (Abou-Soliman et al., 2017; Al-Zoreky and Al-Otaibi, 2015). Table 2 demonstrates a statistically significant effect ($p < 0.05$) of gelatin incorporation and starter cultures on the pH and titratable acidity evolution during camel milk yogurt fermentation. The addition of these substances resulted in a remarkable reduction in fermentation time to 6 hours, which is considerably shorter than the 16 ±1 hours required for plain camel milk yogurt (Ibrahem and El Zubeir, 2016; Khalifa and Zakaria, 2019).

The effect of gelatin on camel milk acidification during the fermentation process has been a topic of debate in the scientific community. Previous investigations have demonstrated that the adding of gelatin to cow or camel milk, at concentrations ranging from 0.4–2%, did not affect the pH or titratable acidity of yogurt (Al-Zoreky and Al-Otaibi, 2015; Hashim et al., 2009). However, in agreement with our findings, Ibarhim and Khalifa reported that adding gelatin to camel milk at concentrations between 0.5–1.5% increased yogurt acidity, compared to samples without gelatin (Ibarhim and Khalifa, 2015). On the other hand, Mudgil et al. (2018) observed that the effect of gelatin on camel milk pH during gelation varied depending on the used concentration. In more detail, their study showed that the addition of gelatin at concentrations of 1% and 1.25% did not impact pH or titratable acidity. In contrast, at lower concentrations of 0.5% and 0.75%, the coagulation occurred at higher pH values than in control samples (Mudgil et al., 2018). These results are quite different to our findings, as we observed a significant effect at a concentration of 1%.

Table 3 shows the variations in pH and acidity (% lactic acid) of camel milk yoghurt enriched with different ratios of persimmon pulp in the fresh state and during storage at 4°C. The pH values decreased during storage, while the lactic acid percentage values of all samples increased. The addition of persimmon caused a significant increase in the developed acidity of the yoghurt during refrigerated storage. The addition of 10% persimmon gave the highest development in acidity.

Table 3. pH and acidity (% of lactic acid) content value of camel's milk yogurt fortified with different ratios of persimmon pulp when fresh and during storage at 4°C

Parameters	Storage period (days)	Yogurt preparation*			
		0%	3%	5%	10%
pH	1	4.30^{a} ±0.02	4.24^{b} ±0.01	4.23^{b} ±0.02	4.19^{c} ±0.01
	7	4.27^{a} ±0.01	4.22^{b} ±0.01	4.20^{b} ±0.02	4.15^{c} ±0.02
	14	4.24^{a} ±0.01	4.19^{b} ±0.01	4.16^{c} ±0.01	4.11^{d} ±0.02
Titratable acidity (lactic acid, %)	1	0.80^{a} ±0.02	0.80^{a} ±0.01	0.82^{a} ±0.01	0.82^{a} ±0.02
	7	0.82^{a} ±0.02	0.83^{a} ±0.01	0.86^{b} ±0.01	0.87^{b} ±0.02
	14	0.85^{a} ±0.02	0.87^{ab} ±0.01	0.89^{bc} ±0.01	0.91^{c} ±0.02

*0% – control yogurt; 3% – yogurt produced by adding 3% persimmon pulp; 5% – yogurt produced by adding 5% persimmon pulp; 10% – yogurt produced by adding 10% persimmon pulp.
Means that do not share the same letter in the same row are significantly different.

The observed decrease in pH may be explained by the prebiotic effects of fiber in persimmon fruit, which have been reported to improve the growth and activity of probiotic bacteria (Gustaw et al., 2011). The enhanced activity of probiotic bacteria induces an increase in the production of acidic metabolites, leading to a decrease in the final pH of the product. Another factor contributing to the pH decrease and the growth of lactic acid bacteria in yogurt is the sugars and organic acids in persimmon fruit. Birollo et al. (2000) demonstrated that high sugar concentrations in yogurt negatively affect the viability of lactic acid bacteria, leading to an increased acidity and a decreased pH (Birollo et al., 2000). Similarly, another study by Aly et al. (2004) reported that the presence of organic acids and sugars from carrot extract lowers the pH of yogurt (Aly et al., 2004). These findings are in agreement with the literature (Arslan and Bayrakçi, 2016; Safdari et al., 2021).

Table 4 presents the results of evaluating dry matter, protein, fat, and viscosity of yogurt samples after being stored at 4°C for 24 hours. Fat and protein contents decreased by the fortification of camel milk yogurt with persimmon pulp, ranging from 3.00% to 2.94% and 3.35% to 2.86%, respectively. Previous studies have shown that when the concentration of fruit pulp or juice increases in yogurt, a significant decrease in both protein content and fat percentage can be noticed; this decrease can be explained by the fact that fruit has a lower protein content compared to milk (Elsayed et al., 2020; Mbaeyi-Nwaoha et al., 2017).

According to Table 4, the total solid content of yogurt is influenced by the concentration of the added persimmon pulp. The mean value of the total solid content in the control sample was 15.67%, which was lower than other yogurt samples supplemented with persimmon pulp. Moreover, the study suggests that an increase in the amount of added persimmon pulp to yogurt (at concentrations of 3%, 5%, and 10%) leads to an increase in the total solid content. A previous investigation reported that supplementing yogurt with apple pulp at concentrations ranging from 10 to 30% led to a rise in the overall solid content of yogurt. Precisely, the increase in total solid content was measured as 17.48%, 22.57%, 25.96%, and 27.31%, respectively, for each of the four levels of apple pulp addition (Chakraborty et al., 2019).

The quality of fermented camel's milk largely depends on its viscosity, as consumers prefer yogurt with higher viscosity over thin, stirred ones due to better mouthfeel (Soliman and Shehata, 2019). Adding persimmon pulp to yogurt significantly increases its viscosity, which may be attributed to the fruit's high fiber content acting as a thickening agent. Increasing the concentration of the added persimmon pulp from 3% to 10% further enhances the apparent viscosity, with the highest viscosity observed at a 10% ratio. Similar findings were reported by Soliman and Shehata (2019) for fermented camel's milk that was fortified with kiwi or avocado fruits (Soliman and Shehata, 2019).

Sensory evaluation

Table 5 presents the results of a one-way ANOVA analysis conducted on the sensory evaluation responses for camel milk yogurt that was fortified with various

Table 4. Chemical composition and viscosity characteristics of camel milk yogurts enriched with persimmon pulp

Parameters	Yogurt preparation*			
	0%	3%	5%	10%
Dry matter, %	15.67^{b} ±0.42	16.45^{ab} ±0.67	16.78^{ab} ±0.65	17.86^{a} ±0.68
Protein, %	3.35^{a} ±0.21	3.04^{a} ±0.43	2.98^{a} ±0.45	2.86^{a} ±0.32
Fat, %	3.00^{a} ±0.12	2.97^{a} ±0.15	2.97^{a} ±0.21	2.94^{a} ±0.17
Viscosity, cP	17 600^{b} ±1964	20 300^{b} ±2340	22 080^{ab} ±2560	27 040^{a} ±2320

*0% – control yogurt; 3% – yogurt produced by adding 3% persimmon pulp; 5% – yogurt produced by adding 5% persimmon pulp; 10% – yogurt produced by adding 10% persimmon pulp; cP – centipoise.
Means that do not share the same letter in the same row are significantly different.

Table 5. One-way ANOVA analysis of sensory attributes response as a function of persimmon pulp concentration in camel milk yogurt using Tukey test for clustering information and 95% confidence level

Yogurt type	Color consistency	Gel firmness	Viscosity	Fruit odor	Acidic smell	Fruit taste	Acidic flavour	Milk aroma (characteristic taste of camel milk)	Bitter aftertaste	Characteristic fruity aftertaste
0%	9.000[a] ±0.000	6.286[a] ±0.469	2.571[c] ±0.514	0.000[d] ±0.000	1.000[a] ±0.000	0.000[d] ±0.000	1.857[a] ±0.363	8.000[a] ±0.555	2.286[a] ±0.469	0.000[c] ±0.000
3%	6.429[b] ±0.514	3.714[d] ±0.469	2.714[c] ±0.469	2.429[c] ±0.514	0.143[b] ±0.363	2.429[c] ±0.514	1.000[b] ±0.000	1.000[b] ±0.000	2.000[b] ±0.000	0.286[c] ±0.469
5%	4.571[c] ±0.514	5.000[c] ±0.000	4.857[b] ±0.363	4.429[b] ±0.514	0.143[b] ±0.363	5.000[b] ±0.000	0.000[c] ±0.000	0.000[c] ±0.000	1.000[c] ±0.000	2.000[b] ±0.000
10%	1.000[d] ±0.000	5.714[b] ±0.469	5.571[a] ±0.514	5.857[a] ±0.363	0.000[b] ±0.000	8.857[a] ±0.363	0.000[c] ±0.000	0.000[c] ±0.000	0.000[d] ±0.000	3.714[a] ±0.469

Means that do not share the same letter in the same column are considered as significantly different.

amounts of persimmon pulp (0%, 3%, 5%, and 10%). The Tukey test was employed to provide grouping information with a 95% confidence level. In this study, the sensory evaluation of camel milk yogurt enriched with persimmon pulp was conducted on day 0 using a 9-point hedonic scale. A panel of seven trained evaluators, consisting of six male and one female judges, assessed the sensory properties of the camel milk yogurt samples. Negligible scores ranging from 0 to 1 were obtained for some parameters of sensory evaluation for all types of yogurts, including the smell and taste of cream, creaminess, and presence of whey. The smell and taste of cream were found to be masked by the characteristic taste of camel milk and the presence of fruit. Additionally, whey was absent in all types of yogurts, confirming that gelatin effectively resolved one of the main textural defects of camel milk yogurts. Our results are in accordance with previous studies, which have shown that gelatin is the best thickening agent and its optimal use improves the texture and viscosity of camel milk yogurt (Ho et al., 2022; Mudgil et al., 2018). The color consistency of the four types was significantly different ($p < 0.05$). The yogurt with 0% persimmon pulp had the most homogeneous color, which decreased with the addition of persimmon pulp. Hence, the 10% fortified yogurt had the lowest color homogeneity. Yogurt gel firmness depends on several factors, such as milk composition (especially protein and fat content), yogurt processing parameters, and added ingredients like stabilizers. In our study, the control yogurt (0%) had the highest gel firmness, followed by 10%, and the lowest score was obtained by the 3% sample. By adding persimmon pulp to the yogurt, its viscosity improved. Similarly, the viscosity of camel milk yogurt increased with the amount of persimmon pulp added. The concentration of persimmon pulp also affected the yogurt's smell, taste, and characteristic aftertaste of persimmon fruit in yogurts. The score obtained for these three characteristics increased linearly with the increase of concentration. Furthermore, enriching the yogurt with persimmon pulp masked the acidic taste and odor, bitter aftertaste, and milk aroma (characteristic taste of camel milk). These sensory characteristics decreased as the amount of added persimmon pulp increased. The addition of persimmon pulp masked the salty taste that characterizes camel milk, as well as the bad smell of gelatin, thereby enhancing the sensory quality of our camel milk yogurts.

The results presented in Figure 2 indicate the acceptance levels of participants towards camel milk yogurt fortified with varying concentrations of persimmon pulp, with the mean values represented by a 95% confidence interval. Statistical analysis revealed a significant difference ($p < 0.05$) in the participants' responses. Among the different types of fortified yogurt, the one containing 5% persimmon pulp was found to be the most favored by the participants, followed by

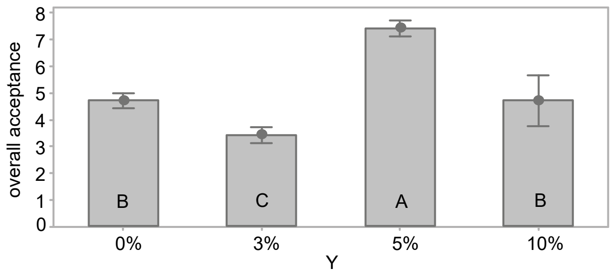

Fig. 2. Interval plot of participants' acceptance of camel milk yogurt fortified with persimmon pulp (95% CI of the mean). Y: yogurt, A, B: grouping information using the Tukey method and 95% confidence for the one-way ANOVA analysis of acceptance. Means that do not share a letter are significantly different

the control yogurt with 0% pulp and then the 10% pulp fortified yogurt. On the other hand, the yogurt fortified with 3% persimmon pulp was found to be the least preferred. Therefore, using a low proportion of fruit in the yogurt formulation decreases consumers' acceptability. Previous studies have suggested that adding fruit pulps to fermented camel milk can enhance its quality. For instance, sidr fruit pulp is effective, with fortified fermented camel milk containing 15% sidr fruit pulp yielding the highest sensory acceptance (Atwaa et al., 2022). In addition, studies have shown that adding 4% avocado paste or 6% kiwi paste, closer to the optimal concentration, can increase the acceptability of stirred camel milk yogurt (Soliman and Shehata, 2019). Another research study has demonstrated the effectiveness of using biosynthesized xanthan, produced from waste material, as a thickening and stabilizing agent in camel milk yogurt production. The study found that incorporating 0.75% xanthan resulted in the best curd formation from camel milk, and fortification with date paste significantly improved the sensory parameters (Mohsin et al., 2019).

CONCLUSION

In this study, we have developed a new formula for producing camel milk yogurt. The process involves the use of gelatin as a stabilizing agent, followed by fortification with persimmon pulp. This process had a positive impact on several important quality parameters, including fermentation time, viscosity, syneresis, and sensory acceptance. Specifically, the addition of 1% bovine gelatin improved the properties of the camel milk gel. Simultaneously, fortification with 5% persimmon pulp significantly enhanced sensory characteristics. Furthermore, this fortification effectively masked the unpleasant odor of gelatin and the characteristic taste of camel milk. Hence, it can be concluded that our results suggest that the combination of gelatin and persimmon pulp can improve the physicochemical, rheological, and sensory properties of camel milk yogurt. This developed process would, from our point of view, unlock new opportunities for the production of camel milk yogurt fortified with other popular fruits, potentially promoting its consumption worldwide. The development of such yoghurts would also participate in extending the production and commercialization of camel milk yoghurts around the world.

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