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Quality Characteristics of Goat Milk Yogurt Jelly Drink

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ABSTRACT

Background: The research aimed to create a new probiotic jelly drink using goat milk yogurt and hydrocolloids. It assessed the drink's quality, physicochemical properties, sensory attributes and microbial stability during refrigerated storage.

Methods: The goat milk yogurt jelly drink consisted of 50% goat milk yogurt and various hydrocolloids. Evaluation of samples was carried out during storage to determine the syneresis, pH, total acidity, total soluble solids, color, rheology, microbiological assessments and sensory evaluations.

Result: During refrigerated storage of the drink, both syneresis and total acidity increased, while pH and total soluble solids decreased. The drink had high positive L* values, low negative a* values and low b* values, exhibiting pseudoplastic behavior characterized by an increased consistency index and a decreased flow behavior index. Texture profile parameters declined throughout storage. Total bacterial counts exceeded 10^4 cfu/g by day 21; no significant changes were observed in sensory attributes up to day 14 of storage. Extending the shelf life of the drink product would increase the potential for its successful commercial launch.

Key words: Goat milk yogurt, Physicochemical properties, Quality characteristics, Yogurt jelly drink.

INTRODUCTION

Yogurt is a fermented dairy product high in probiotics, which contribute to its unique flavor by synthesizing aromatic compounds (Zahir *et al.*, 2023). Goat milk yogurt, known for its nutritious and therapeutic benefits, is gaining attention. Compared to cow milk yogurt, it offers higher vitamin B6 and A levels, increased calcium, smaller fat globules and lower lactose (Getaneh *et al.*, 2016). It is particularly beneficial for conditions such as lactose intolerance, inflammatory bowel disease and cardiovascular issues (Hammam *et al.*, 2022). However, in Thailand, goat milk and its products are primarily consumed by a niche market.

Hydrocolloids are essential in food processing, enhancing texture and sensory qualities. They function in gel formation, thickening and stabilization and can serve as fat substitutes in low-fat yogurt while also providing dietary fiber, like guar gum and psyllium (Zang *et al.*, 2024). Various natural hydrocolloids include: pectin, used for gels in acidified beverages and yogurt; carrageenan, which stabilizes dairy products; xanthan gum, known for its high viscosity and use in reversible gels and konjac glucomannan, a thickener stable in heat and acidic conditions (Pirsa and Hafezi, 2023; Zang *et al.*, 2024).

Jelly drink is a gel-like beverage made from hydrocolloids and water, creating a semisolid texture. It can be prepared with or without food ingredients and is consumed to satisfy hunger and aid digestion (Agusthi and Romadhan, 2024). Most published research has focused on jelly drinks that incorporate various compounds, such as plant extracts (Kusumajati and Budhiyanti, 2023; Agusthi and Romadhan, 2024; Saloko *et al.*, 2024) or fruit juices (Handayani, 2021). However, there has been no research conducted on probiotic jelly drinks. Therefore, the objective of the current research was to develop a novel goat milk yogurt jelly drink, utilizing goat milk yogurt along with various hydrocolloids, as a novel food product, highligh-ting its unique sensory characteristics, nutritional benefits and therapeutic values, while also increasing the market share of goat milk products in Thailand. Results were recorded of quality characteristics (physicochemical properties, sensory attributes and microbial tests) over 28 days of storage.

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MATERIALS AND METHODS

The experiment was conducted at the Dairy and Dairy Product Laboratory, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom, Thailand, from June 2022 to August 2024.

Materials

Raw goat milk (3.62% protein, 4.97% fat, 3.75% lactose) was sourced from TT Garden and Goat Farm, Ratchaburi,

Thailand. The yogurt was made using Duchie Original Yogurt (Dutch Mill Co., Ltd., Bang Phlat, Bangkok, Thailand) and Meiji Bulgaria Yogurt (CP-Meiji Co., Ltd., Din Daeng, Bangkok, Thailand) as starter cultures, containing *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. The whole-milk powder came from EUROSERUM (Port-sur-Saône, France), while corn flour, gelatin, pectin and carrageenan were sourced from various suppliers in Thailand and xanthan gum, konjac glucomannan, malic acid and citric acid were obtained from Bangkok Chemical Industrial Co., Ltd. (Mueng, Samut Prakan, Thailand).

Goat milk yogurt production

The raw goat milk sample was heated and then mixed with whole milk, sugar, gelatin and corn flour in the following proportions: 3.2%, 6%, 0.27% and 0.8% (w/w), respectively. The mixture was stirred to 60°C and then filtered and pasteurized at 80°C for 5 minutes before rapidly cooling to 42°C. A 12% (w/v) starter culture was added and the mixture was incubated at 42°C until the pH reached 4.5, forming yogurt, which was then stored at 4°C for further use.

Production of goat milk yogurt jelly drink

Hydrocolloids were mixed with goat milk yogurt to create a goat milk yogurt jelly drink. Initially, various ratios based on the literature were pretested, focusing on two commonly used commercial hydrocolloids: carrageenan and konjac glucomannan. After optimizing these ratios, the final mixture was refined further by incorporating goat milk yogurt along with pectin and xanthan gum to achieve a stable jelly texture for the product. The complete production of goat milk yogurt jelly drink involved heating to 40°C to dissolve hydrocolloids in a mixture of 48% distilled water, 1.5% granulated sugar and 0.033% each of lactic, malic and citric acids, along with 0.16% carrageenan, 0.24% konjac glucomannan, 0.15% xanthan gum and 0.15% pectin. The mixture was stirred at 90°C for 5 minutes, then cooled to 42°C before adding 50% goat milk yogurt to create a yogurt jelly drink. The drink was portioned into 50 ml polyethylene pouches (40 g each) and stored at 4±2°C, with samples taken on days 1, 7, 14, 21 and 28.

Physicochemical measurements

The syneresis of the goat milk yogurt jelly drink was determined using a modified drainage method based on the approach by García-Pérez *et al.* (2005). A 30 g sample was stored at 4±2°C for 2 hours, after which the separated liquid was collected and weighed to calculate the percentage of syneresis.

The pH value was measured using a Consort pH meter (Turnhout, Belgium). Total acidity (TA) of the yogurt jelly drink samples was assessed using the titratable acidity method from AOAC (1990), titrating a mixture of 9 g of sample and 17.6 ml distilled water with 0.1 N NaOH, using 0.5 ml of 1% phenolphthalein as an indicator. The NaOH volumes were converted to total lactic acid. Total soluble solids (TSS) were measured using a digital refractometer (Woonsocket, USA).

The L*, a* and b* values of the yogurt jelly samples were determined using a spectrophotometer (Miniscan EZ 4500L; Hunter Lab; Reston, USA) with aD65 illuminant and a 2° standard observer.

The rheological properties of yogurt jelly drinks were analyzed using texture profile analysis (TPA), shear flow and viscoelastic assessments. TPA was performed using a Lloyd LR10K testing machine (Bognor Regis, UK) and involved compressing 80 g of the sample at 1 mm/s to 40% of its height to measure hardness, adhesiveness, cohesiveness and gumminess. The shear flow and viscoelastic behaviors were assessed using a HAAKE RheoStress 1 rheometer (Karlsruhe, Germany) at shear rates of 1-50 s^{-} with an amplitude sweep at 1 Hz to determine the linear range, followed by a frequency sweep from 0.1 to 10 Hz.

Microbiological analysis

The total plate count, coliform count and the yeast and mold count were determined according to ISO 4833-1 (2013), Bacteriological Analytical Manual (2013) and AOAC (2003), respectively.

Sensory evaluation

A sensory panel was composed of 10 individuals, ranging in age from 25 to 55, recruited from Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom, Thailand. These panelists had prior experience with goat milk yogurt and jelly products. They underwent a familiarization training session regarding the characteristics relevant to jelly drink evaluation, which took place 1 hour before the experimental assessments. During the sensory evaluation, the panelists assessed the yogurt jelly drink samples using a line rating scale from 0 to 10 for various attributes, consisting of appearance, odor, taste, texture and overall satisfaction.

Statistical analysis

The experiment trials were carried out using five replicates. Statistical analysis was performed using the R software package version 4.2.1 (R Core Team, 2022). ANOVA was conducted to assess significant differences in means across various storage durations. Following this, post-hoc analysis was executed using Duncan's new multiple range test at a significance level of $p<0.05$, with results reported as mean±standard deviation values.

RESULTS AND DISCUSSION

Physicochemical properties during storage

Syneresis in goat milk yogurt jelly drink

As shown in Table 1, the goat milk yogurt jelly drink, like traditional yogurt, experienced syneresis due to the shrinkage of its gel structure and the separation of the whey protein from the casein and fat network (Bahrami *et al.*, 2013; Arab *et al.*, 2023, Zahir *et al.*, 2023). Reduced syneresis occurred due to the addition of hydrocolloids that improved the gel network (Arab *et al.*, 2023). Notably,

syneresis increased over time, particularly between days 14 and 28, due to the high proteolytic activity leading to gel disintegration (Amani *et al.*, 2016).

pH, total acidity and total soluble solids of goat milk yogurt jelly drink

Table 1 shows that the yogurt jelly drink met the standards to be classified as yogurt, with pH values below 4.6 (Maisano *et al.*, 2023). During storage, the pH decreased while total acidity increased, reflecting typical post-acidification in yogurt as the lactic acid cultures converted lactose into lactic acid, lowering the pH and raising the acidity (Garczewska-Murzyn *et al.*, 2021).

Table 1 shows a decline in the TSS in the goat milk yogurt jelly drink during storage, aligning with studies by Aluko *et al.* (2016); Wijesinghe *et al.* (2016) and Keyore *et al.* (2024). In addition, Mataragas *et al.* (2011) reported decreased concentrations of fructose, lactose and glucose in fruit-flavored yogurt over time. The TSS was correlated with the pH and total acidity, which typically decrease during fermentation as yogurt cultures metabolize lactose, resulting in a gel-like structure and increased acidity (Sinamo *et al.*, 2020; Zahir *et al.*, 2023; Kim *et al.*, 2025).

Color value of goat milk yogurt jelly drink

From Table 1, the goat milk yogurt jelly drink had high L* values and low a* and b* values during storage, typical of plain yogurt products (Noh *et al.*, 2013; Jakubowska and Karamucki, 2019). A high L* value indicates whiteness due to light dispersion in the casein-calcium complex; overall, the product had a grayish-greenish-yellow hue, influenced by yogurt culture activity (Jakubowska and Karamucki, 2019). The gradual decline in L* values along with rising a* and b* values suggested product deterioration during storage.

Rheological properties of goat milk yogurt jelly drink

An investigation into the flow behavior of the goat milk yogurt jelly drink showed pseudoplastic or shear-thinning behavior throughout storage (Fig 1 and 2). This characteristic is observed in yogurt products regardless of hydrocolloid addition (Koksoy and Kilic, 2004; Prajapati *et al.*, 2016; Altay, 2017). The shear stress increased with the shear rate, while longer storage times increased both the shear stress and apparent viscosity, likely due to the reduced water content from syneresis (Kusumajati and Budhiyanti, 2023). The flow behavior was described by a power law model eq. (1), with the model parameters in Table 2.

$$\sigma = K\dot{\gamma}^{n} \quad \text{... (1)}$$

Where

σ = Shear stress.

$\dot{\gamma}$ = Shear rate.

K = Consistency index.

n = Flow behavior index.

The flow behavior index decreased over time, indicating greater pseudoplasticity (Koksoy and Kilic, 2004; Altay, 2017). The consistency index increased along with viscosity, suggesting links to taste perception. These parameters are related to food ingestion; the consistency index affects flow velocity, while the flow behavior index influences sliminess. A high flow behavior index leads to a slower flow velocity and increased sliminess (Yoon and Yoo, 2017).

Viscoelastic properties are crucial in the swallowing of food boluses (Yoon and Yoo, 2017). Based on the current results, as shown in Fig 3, the storage modulus (G′) exceeded the loss modulus (G″), indicating a gel-like texture with minimal changes over time. The phase angle (G′/G″) values remained below 1 (Fig 4), confirming the product had greater elasticity than viscosity, which was stable during storage. Therefore, the swallowing characteristics of the goat milk yogurt jelly drink remained largely unchanged.

TPA was used to assess the morphology of the food bolus during chewing and to predict its transportability to the pharynx. Hardness indicates food toughness, while cohesiveness correlates with residue in the pharynx and adhesiveness relates to ease of passage. Gumminess, linked to hardness and adhesiveness, may affect aspiration risk (Momosaki *et al.*, 2013). Table 3 shows that the hardness, cohesiveness and adhesiveness of the goat milk yogurt jelly drink were similar to those of whipped cream (Park *et al.*, 2020), suggesting it is a soft semi-solid that is easy to swallow. Low gumminess values indicate minimal aspirational risk (Momosaki *et al.*, 2013). However, the texture values slightly decreased over storage time,

Table 1: Physicochemical parameters of goat milk yogurt jelly drink during storage.

Physicochemical parameter	Storage time (days)				
	1	7	14	21	28
Syneresis (%)	0.63±0.07^{b}	0.76±0.03^{b}	1.05±0.00^{a}	1.07±0.01^{a}	1.23±0.24^{a}
pH	4.05±0.02^{a}	3.88±0.01^{b}	3.79±0.01^{c}	3.78±0.00^{c}	3.77±0.01^{c}
TA (%)	0.65±0.00^{b}	0.66±0.00^{b}	0.67±0.02^{b}	0.69±0.01^{b}	0.95±0.07^{a}
TSS (^{o}Brix)	10.83±0.06^{a}	9.43±0.06^{b}	9.43±0.31^{b}	9.33±0.06^{b}	9.00±0.10^{c}
Color values					
L*	99.83±0.26^{a}	99.25±0.91^{a}	85.93±0.98^{c}	89.27±0.23^{b}	89.24±0.11^{b}
a*	-3.19±0.02^{c}	-3.10±0.16^{c}	-2.21±0.24^{a}	-2.93±0.04^{b}	-2.79±0.01^{b}
b*	-2.72±0.83^{d}	1.27±0.27^{c}	4.86±0.78^{b}	8.51±0.37^{a}	8.01±0.08^{a}

$^{a–d}$ Mean ± standard deviation values in same row with different lowercase superscripts are significantly different ($p<0.05$).

likely due to syneresis and acid buildup, which compromised the structural integrity of the product.

Microbiological analysis

According to Table 4, coliform bacteria and yeast and mold were consistently present at low levels throughout the entire 28 days of storage. In contrast, the total bacteria count remained low for the first 14 days but increased sharply at 21 days, reaching 5.8×10^7 cfu/g by day 28. From a food safety perspective, referencing the Thai Community Product Standards for liquid jelly (Office of Community Product Standards, 2004), the microbiological limits set are less than 1×10^4 colonies/g for total bacteria, fewer than 3 colonies/g for coliforms and under 100 colonies/g for yeast and mold.

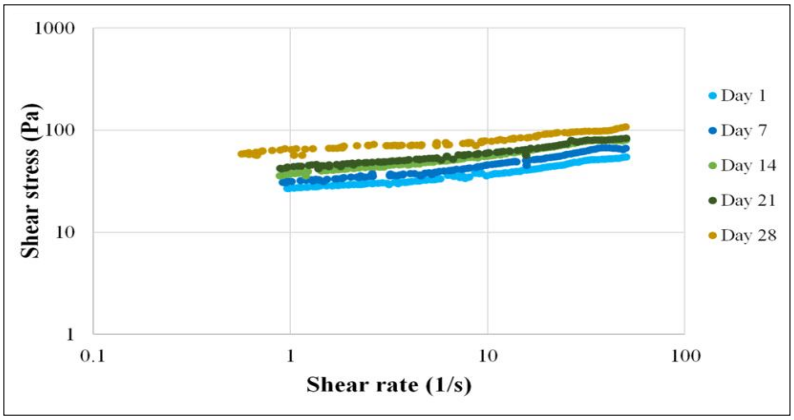


Fig 1: Shear stress and shear rate of goat milk yogurt jelly drink during storage.

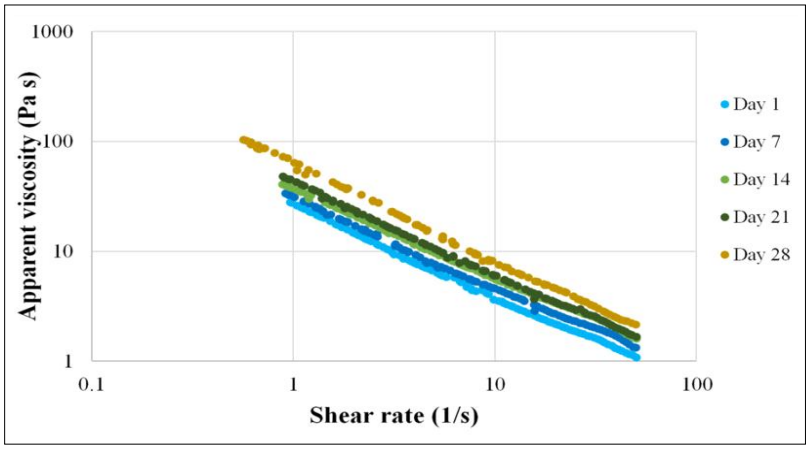


Fig 2: Apparent viscosity of goat milk yogurt jelly drink during storage.

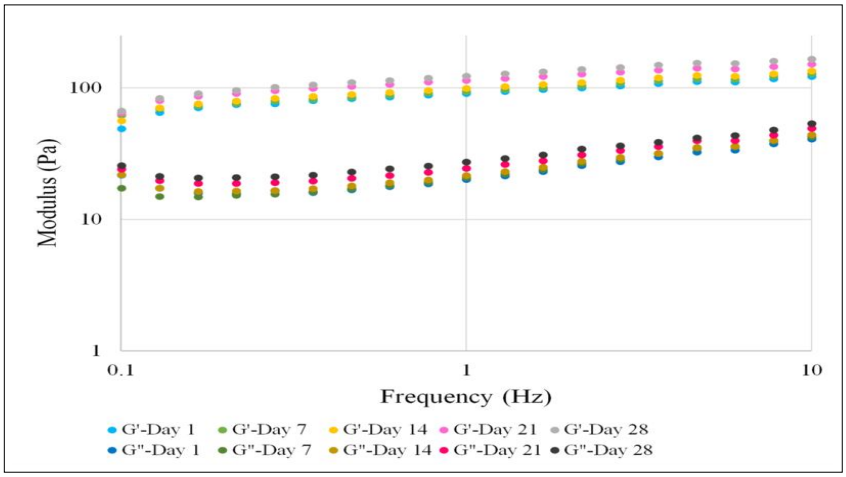


Fig 3: Storage and loss moduli of goat milk yogurt jelly drink during storage.

Consequently, given that the total bacteria count exceeded the maximum acceptable level after 14 days, it could be concluded that the goat milk yogurt jelly drink was acceptable for consumption for up to 14 days of storage.

Table 2: Power law model parameters of goat milk yogurt jelly drink during storage.

Storage time (days)	K (Pa s^n)	n	R^2
1	25.674±0.689^{d}	0.178±0.002^{abc}	0.944
7	30.095±0.520^{d}	0.203±0.003^{a}	0.962
14	37.059±1.013^{c}	0.192±0.014^{ab}	0.967
21	45.202±3.258^{b}	0.158±0.014^{bc}	0.975
28	57.823±4.242^{a}	0.149±0.025^{c}	0.957

$^{a–d}$ Mean±standard deviation values in same column with different lowercase superscripts are significantly different ($p<0.05$).

Psychrophilic bacteria may have contributed to spoilage during refrigeration, with some potentially being pathogenic. Additionally, the protein present in the yogurt, along with the increased syneresis during storage, may have facilitated further microbial growth (Linton, 1996).

Sensory evaluation

The microbiological analysis limited the sensory evaluation of the goat milk yogurt jelly drink to 14 days for food safety purposes. The sensory scores, summarized in Table 5, remained above 5.0, with no significant differences during this period, reflecting positive attributes. The product had acceptable appearance, aroma and flavor, with high scores for jelly texture, ease of sucking and swallowing, aligning with the rheological findings. Overall satisfaction remained high, suggesting stability and palatability throughout storage for 14 days.

Table 3: Texture parameters of goat milk yogurt jelly drink during storage.

Texture parameter	Storage time (days)				
	1	7	14	21	28
Hardness (N)	0.35±0.02^{a}	0.31±0.02^{b}	0.29±0.01^{b}	0.39±0.01^{b}	0.23±0.02^{c}
Adhesiveness (mJ)	0.10±0.05^{a}	0.14±0.04^{a}	0.09±0.02^{b}	0.07±0.02^{b}	0.07±0.02^{b}
Cohesiveness	0.43±0.018^{a}	0.34±0.001^{b}	0.34±0.026^{b}	0.36±0.035^{b}	0.37±0.011^{b}
Gumminess (N)	0.15±0.006^{a}	0.11±0.004^{b}	0.14±0.012^{a}	0.11±0.006^{b}	0.09±0.003^{c}

$^{a–c}$ Mean±standard deviation values in same row with different superscripts are significantly different ($p<0.05$).

Table 4: Microbial counts of goat milk yogurt jelly drink during storage.

Storage time (days)	Coliform bacteria (MPN/g)	Total bacteria (cfu/g)	Yeast and mold (cfu/g)
1	<3	<10	<10_est*
7	<3	<10	<10_est
14	<3	<10	<10_est
21	<3	1.7×10^7	<10_est
28	<3	5.8×10^7	<10_est
Standard value**	<3	1×10^4	100

*Estimated counts.

** Total bacteria, coliform, and yeast and mold standard counts refer to Thai Community Product Standards Liquid Jelly (Office of Community Product Standards, 2004).

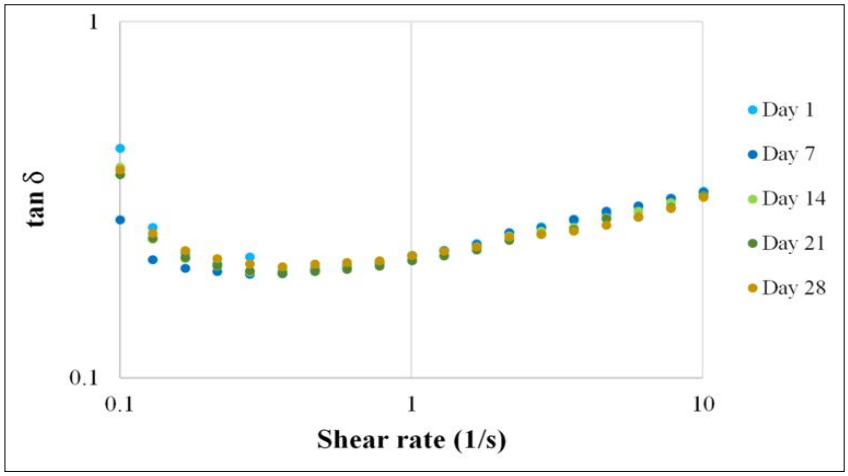


Fig 4: Tangent of phase angle of goat milk yogurt jelly drink during storage.

Table 5: Sensory scores of goat milk yogurt jelly drink during storage.

Sensory characteristic	Storage time (days)		
	1	7	14
Appearance during squeezing^{ns}	8.94±0.81	8.80±0.92	8.40±0.97
Yogurt odor^{ns}	8.00±1.41	7.70±1.16	8.40±1.26
Sourness^{ns}	8.00±1.22	7.30±2.06	7.20±1.87
Sweetness^{ns}	7.44±1.51	6.90±2.28	6.00±2.11
Jelly texture^{ns}	8.22±1.20	7.60±1.71	7.90±1.10
Ease of sucking^{ns}	8.94±1.38	8.80±1.48	9.10±0.99
Ease of swallowing^{ns}	9.06±1.13	8.60±1.50	9.10±0.88
Overall satisfaction^{ns}	8.61±0.93	8.00±1.33	7.80±1.40

^{ns} Mean± standard deviation values in same row are not significantly different ($p>0.05$).

This product holds high potency as a healthy option for consumers and is especially suitable for people with dysphagia. However, its short shelf life may pose a concern. Some potential methods to extend the shelf life of cultured milk beverages include applying heat treatment, aseptic processing, adding preservatives and adjusting packaging materials. However, these methods can alter the product's physical and sensory characteristics to some extent (Krishna *et al.*, 2019).

Natural approaches, such as changing fermented cultures or adding essential oils during processing, might improve the beverage's shelf life, with minimal impact on its overall characteristics. It would be worthwhile to explore extending the shelf life of goat milk jelly drinks by using specific fermented cultures, such as *L. acidophilus* or *B. bifidus*, instead of *Lactobacillus delbrueckii* ssp. *bulgaricus* (Krishna *et al.*, 2019). Additionally, it could be beneficial to incorporate essential oils, such as thyme, marjoram and sage, that are known for their antibacterial properties (Otaibi and Demerdash, 2008). This will be the next step in our research.

CONCLUSION

This research successfully developed a novel goat milk yogurt jelly made from a blend of goat milk yogurt and hydrocolloids (carrageenan, konjac glucomannan, xanthan gum and pectin). The product had a homogeneous texture, light viscosity, pseudoplastic flow behavior and viscoelastic properties. It maintained acceptable total bacterial counts for up to 14 days of refrigerated storage, with the sensory evaluations indicating consistent quality and a positive reception over time, correlating with its rheological properties. Extending its shelf life may enhance its potential for a successful market launch.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

All animal procedures for experiments were approved by the Committee of Experimental Animal Care and Handling Techniques Animal Care Committee (COE No. COE66/35)

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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