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Evaluation of the Physicochemical Properties and Sensory Attributes of Yoghurt Made from Mixtures of Goat's and Cow's Milks

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Abstract

The objective of the study was to evaluate the effect of cow's milk added to goat's milk on physicochemical properties and sensory attributes of yoghurt. Yoghurts prepared from five different proportions of cow's milk and goat's milk were stored at 4-6ºC for 1, 7, and 14 days and then evaluated for their physicochemical (total solids, protein, pH, and acidity) and physical properties (viscosity and water holding capacity), and sensory characteristics (acceptability). The total solids of the evaluated yoghurts significantly increased, but the protein content decreased when the amount of cow's milk increased in the mixtures of milk. The results showed that the pH value of the yoghurt made from only goat's milk was higher, while the titratable acidity was lower than those of the yoghurts made from the mixtures of goat's and cow's milks. The yoghurt obtained from the mixture of milks containing 80% goat's milk and 20% cow's milk exhibited the highest viscosity and water holding capacity among the evaluated yoghurts. All the yoghurts received similar scores for color, odor, and texture after all periods of storage, while the highest score in terms of flavor was received for the yoghurt made from the mixture of milks containing 60% goat's milk and 40% cow's milk. Addition of cow's milk to goat's milk was shown to significantly contribute to the viscosity, water holding capacity, and flavor of the resulting yoghurts.

Keywords

Goat's milk, cow's milk, yoghurt, physicochemical properties, sensory properties

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Introduction

Yoghurt is a popular dairy product around the world and commonly made from cow's milk. In recent years, however, the demand for goat's yoghurt has increased because goat's milk is widely recognized for its high nutritional value, easy digestibility, and hypoallergencity (Bruzantin *et al.*, 2016; Feng *et al.*, 2019).

In general, goat's milk contains total solids, protein, fat, lactose, minerals, and vitamins, all of which are similar to those of cow's milk (Domagała, 2009). However, the individual components are significantly different between cow's and goat's milks (Turkmen, 2017). Goat's milk has a lower level of αs1-casein than that of cow's milk, leading to a softer firmness of the coagulum obtained from goat's yoghurt and is less viscous than yoghurt obtained from cow's milk (Vargas *et al.*, 2008; Bruzantin *et al.*, 2016). Therefore, yoghurt made from only goat's milk could not be classified as set-type yoghurt (Miocinovic *et al.*, 2016). On the other hand, goat's milk contains caprylic, capric, and caproic acids, all of which impact its unpleasant flavor in comparison to cow's milk, leading to its restricted acceptance by many consumers (Gomes *et al.*, 2013; Feng *et al.*, 2019).

Recently, several studies have used skim milk powder, whey protein concentrate (Martín-Diana *et al.*, 2003; Herrero & Requena, 2006), microbial transglutaminase (Ardelean *et al.*, 2012), honey (Machado *et al.*, 2017), or grain flour (Nakthong, 2012) to improve the texture properties of goat's milk yoghurt. In addition, the physicochemical and sensory characteristics of dairy beverage products made from mixtures of cow's milk and goat's milk have been also investigated (Gokhan *et al.*, 2003; Vargas *et al.*, 2008). To date, few studies have reported the effect of cow's milk on the physicochemical properties and sensory attributes of goat's milk yoghurt in Vietnam.

Goat population ranks fifth on the list of domesticated animals in Vietnam after buffalo, cattle, pigs, and poultry (Thu, 2017). The number of dairy goats was 204 heads in 2014 and in recent years, this number has markedly increased in both small households and industries because of the increasing demand for goat's milk products (Thu, 2017). Currently, many customers in Vietnam have a preference for yoghurt made from goat's milk; however, the manufacturing of goat's milk yoghurt throughout the year is limited because of low animal productivity. Therefore, it might be a viable and interesting opportunity for the dairy market to make yoghurt from a mixture of goat's and cow's milks. This process may improve the yoghurt's physicochemical and sensory properties and increase the value of goat's milk products (Gomes *et al.*, 2013).

This study aimed to investigate the physicochemical, viscosity, water holding capacity, and sensory properties of yoghurt made from different proportions of goat's milk and cow's milk.

Materials and Methods

Materials and microorganisms

Fresh cow's milk was collected from farmers (Phu Dong, Hanoi, Vietnam) and pasteurized goat's milk (100% goat's milk) was a product of the Ba Vi Milk Joint Stock Company (Hanoi, Vietnam). Yoghurt cultures of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* spp. *bulgaricus* were obtained from Vinamilk plain yoghurt (Ho Chi Minh City, Vietnam). Sucrose was a product of the Bien Hoa Sugar Joint Stock Company (Bien Hoa, Dong Nai, Vietnam).

Preparation of the yoghurt

The yoghurts were prepared as described in **Figure 1**. Briefly, five mixtures of milk, (i) 100% goat's milk; (ii) 90% goat's milk and 10% cow's milk; (iii) 80% goat's milk and 20% cow's milk; (iv) 70% goat's milk and 30% cow's milk; and (v) 60% goat's milk and 40% cow's milk, v/v, were mixed with 7% (w/w) of sucrose and then pasteurized at 90°C for 10min. After homogenization at 16000rpm for 1min × 3 using an Ultra Turrax, the mixtures of milk were cooled to 42°C at room temperature and then inoculated with 3% of plain yoghurt (w/w) containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii* spp. *bulgaricus*. The inoculated mixtures of milk were thoroughly mixed and then poured into sterilized plastic jars with caps and incubated at 42°C for around 8h until the pH reached 4.2. All the jars were stored in a refrigerator at 4-6°C for 14 days.

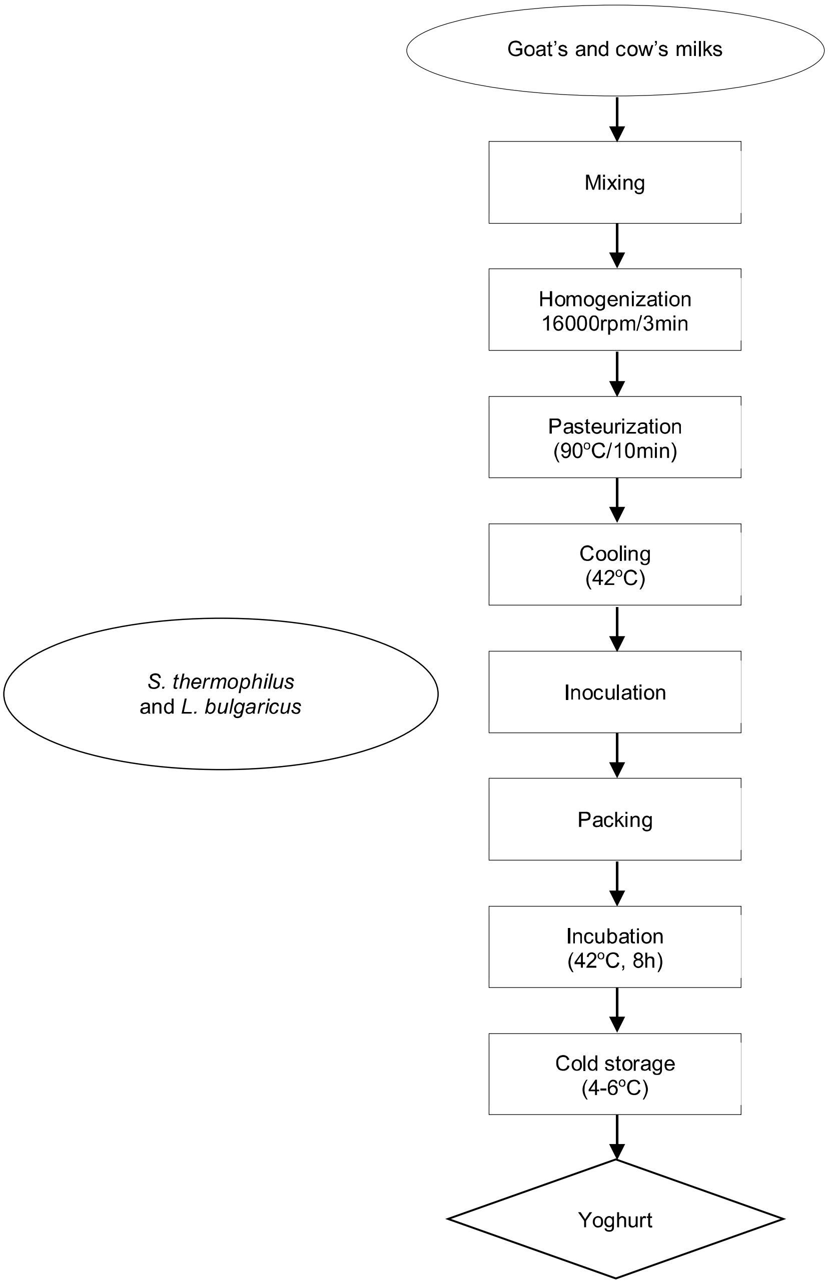

Figure 1. The production of yoghurt

Chemical analysis

Total solids were analyzed according to ISO 6731:2010 (IDF 21:2010). Protein was determined using the Kjeldahl method (ISO 8968 1:2014 (IDF 20-1:2014)). The pH was measured using a pH meter (ORION 230A+). The titratable acidity was obtained by titrating 100mL of a yoghurt sample thinned with 2 parts distilled water, with 0.1 N NaOH, using 5 drops of phenolphthalein as an indicator. The titratable acidity was expressed as ºT. The analyses were carried out in triplicate.

Viscosity measurement

The viscosity of the yoghurt was measured using a Brookfield viscometer (Dv+I Brookfield, USA) according to Doan *et al.* (2009) and Gomes *et al.* (2013). Yoghurt samples were placed into tubes and then measured using a spindle S64 rotated at 12rpm. The sample temperature was about 6°C. Data were recorded in Pa.s after 60s.

The assay was carried out after 1, 7, and 14 days of cold storage in triplicate.

Water holding capacity

The water holding capacity (WHC) was measured according to Parnell-Clunies *et al.* (1986) with minor modifications. In brief, 20 grams of yoghurt were placed into centrifugal tubes and immediately spun at 3000×*g* for 10min at 6°C. The supernatants were carefully removed and the centrifugal tubes were weighed. The WHC was expressed as the percent of the pellet weight relative to the original weight of the yoghurt. The assay was performed in triplicate after 1, 7, and 14 days of cold storage.

Sensory attributes

The sensorial acceptability of the yoghurts was assessed according to the description of Masamba & Ali (2013). Ten experienced members used a five-point hedonic scale (1-very unacceptable; 2-slightly unacceptable; 3-neither unacceptable or acceptable; 4-slightly acceptable; 5-very acceptable) to assess the texture, flavor, color, and odor of the yoghurts after 1, 7, and 14 days of storage.

Data analysis

Data were analyzed using one-way ANOVA to identify significant differences in the concentration of cow's and goat's milks. All the data were expressed as a mean ± standard deviation of the three replicates. The means of the results were compared using the Tukey test at $P \leq 0.05$.

Results and Discussion

Total solids and protein

The total solids and protein in the milk and yoghurt mixtures are shown in **Table 1**. As indicated, an insignificant difference in total solids was observed among the mixtures of milks, while protein content was found to significantly increase when the concentration of cow's milk increased in the mixture. These changes may have been because the cow's milk contained the same total solids content as the goat's milk but had a higher protein content than the goat's milk. For the yoghurts, the protein content was also observed to increase when the amount of cow's milk added to the goat's milk increased, whereas the total solids were found to significantly decrease after 14 days of storage.

pH and titratable acidity

The pH and titratable acidity of the yoghurts are shown in **Table 2**. As indicated, the concentration of the cow's milk significantly affected the pH and titratable acidity of the yoghurts. The pH value was highest for GY100 followed by GY80, GY90, GY70, and GY60, while the titratable acidity was lowest for GY100 followed by GY80, GY90, GY70, and GY60 throughout the period of cold storage. This finding suggests that the goat's milk was alkaline and had a buffering capacity. Moreover, the goat's milk may have contained a higher calcium content in comparison to the cow's milk, therefore the high pH values found in the

Table 1. Total solids and protein of the milk and yoghurt mixtures

	Milk		Yoghurt at 14 days of storage	
	Total solids (%)	Protein (%)	Total solids (%)	Protein (%)
GM100	$12.15^{a} \pm 0.12$	$3.13^{e} \pm 0.05$	$20.90^{a} \pm 0.14$	$2.91^{d} \pm 0.13$
GM90	$11.58^{a} \pm 0.21$	$3.36^{d} \pm 0.07$	$19.59^{ab} \pm 0.59$	$3.22^{c} \pm 0.80$
GM80	$12.56^{a} \pm 0.18$	$3.50^{c} \pm 0.03$	$18.75^{bc} \pm 0.59$	$3.37^{c} \pm 0.04$
GM70	$12.37^{a} \pm 0.16$	$3.71^{b} \pm 0.01$	$17.78^{c} \pm 0.34$	$3.61^{b} \pm 0.01$
GM60	$12.29^{a} \pm 1.25$	$3.96^{a} \pm 0.06$	$17.53^{c} \pm 0.14$	$3.82^{a} \pm 0.08$

Note: GM100: 100% goat's milk; GM90: 90% goat's milk + 10% cow's milk; GM80: 80% goat's milk + 20% cow's milk; GM70: 70% goat's milk + 30% cow's milk; and GM60: 60% goat's milk + 40% cow's milk. Means with different letters in the same column are significantly different (P <0.05).

Table 2. pH and titratable acidity of the yoghurts

	pH			Titratable acidity		
	Day 1	Day 7	Day 14	Day 1	Day 7	Day 14
GY100	4.23^{Aa} ± 0.01	4.17^{Ba} ± 0.00	4.13^{Ca} ± 0.01	74.70^{Bb} ± 0.60	82.00^{Bc} ± 1.70	97.30^{Aa} ± 6.40
GY90	4.20^{Ac} ± 0.01	4.15^{Bb} ±0.01	4.10^{Cb} ± 0.01	75.70^{Cb} ± 0.60	84.00^{Bcb} ± 1.00	100.00^{Aa} ± 1.00
GY80	4.21^{Ab} ± 0.00	4.15^{Bb} ± 0.00	4.08^{Cc} ± 0.00	77.00^{Cb} ± 1.00	86.30^{Bb} ± 1.50	100.30^{Aa} ± 2.30
GY70	4.19^{Ac} ± 0.00	4.13^{Bc} ± 0.01	4.06^{Bd} ±0.01	81.70^{Ca} ± 1.20	86.30^{Bb} ± 0.60	103.30^{Aa} ± 2.10
GY60	4.17^{Ad} ± 0.01	4.09^{Bd} ± 0.00	4.05^{Cd} ± 0.00	82.00^{Ca} ± 1.00	90.70^{Ba} ± 0.60	104.00^{Aa} ± 2.60

Note: GY100: yoghurt made from 100% goat's milk; GY90: yoghurt made from 90% goat's milk + 10% cow's milk; GY80: yoghurt made from 80% goat's milk + 20% cow's milk; GY70: yoghurt made from 70% goat's milk + 30% cow's milk; and GY60: yoghurt made from 60% goat's milk + 40% cow's milk. Means with different lowercase letters in the same column are significantly different (P <0.05). Means with different uppercase letters in the same row are significantly different (P <0.05).

yoghurts containing higher amounts of goat's milk may have been associated with the formation of calcium phospho-caseinate (Gomes *et al.*, 2013).

As shown in **Table 2**, during cold storage, a significant decrease in pH and an increase in acidity were observed in all the evaluated yoghurts. These results are in agreement with those reported by Küçükçetin *et al.* (2011).

Viscosity

The viscosities of the yoghurts are shown in **Table 3**. As indicated, the viscosity was strongly affected by the concentration of cow's milk. After 1 day of storage, the viscosity of the yoghurt obtained from GM60 was lower than that of the yoghurts obtained from GM70, GM80, GM90, and GM100. These results are in disagreement with those obtained by Küçükçetin *et al.* (2011). It is known that yoghurt texture is highly dependent on the total solids, protein content, and type of milk. Goat's milk has a slightly lower casein content than cow's milk, and a very low proportion or the absence of α_{s1}-casein results in having a higher degree of casein micelle dispersion (Herrero & Requena, 2006). These characteristics could be responsible for the differences observed in the viscosity values among the yoghurts. However, it should be noted that the mineral compounds, especially the calcium content in milk, play an important role in the stability of the proteins and in some of their characteristics (Tsioulpas *et al.*, 2007). Several studies have reported that cow's milk has a lower calcium content than goat's milk (Amigo & Fontecha, 2011; Turkmen, 2017), so the addition of cow's milk to goat's milk leads to a decrease in the calcium content in the mixtures of milks. Although protein is a significant contributor to the development of texture in yoghurts, minor changes in the calcium content of the milks in the present study could mediate changes in the protein and mineral equilibria of milk which may also alter the yoghurt properties (Cheng *et al.*, 2002).

Table 3. Viscosity of the yoghurts after cold storage

	Viscosity (Pa.s)		
	Day 1	Day 7	Day 14
GY100	1.83^{Cb} ± 0.03	2.54^{Bb} ± 0.09	3.95^{Aa} ± 0.19
GY90	1.66^{Ccd} ± 0.08	2.95^{Ba} ± 0.07	3.32^{Ab} ± 0.07
GY80	2.35^{Ca} ± 0.05	2.54^{Bb} ± 0.06	2.90^{Ac} ± 0.06
GY70	1.83^{Cbc} ± 0.05	2.07^{Bc} ± 0.12	2.48^{Ad} ± 0.05
GY60	1.58^{Cd} ± 0.01	1.97^{Bc} ± 0.07	2.37^{Ad} ± 0.11

Note: GY100: yoghurt made from 100% goat's milk; GY90: yoghurt made from 90% goat's milk + 10% cow's milk; GY80: yoghurt made from 80% goat's milk + 20% cow's milk; GY70: yoghurt made from 70% goat's milk + 30% cow's milk; and GY60: yoghurt made from 60% goat's milk + 40% cow's milk. Means with different lowercase letters in the same column are significantly different (P <0.05). Means with different uppercase letters in the same row are significantly different (P <0.05).

During storage at 4°C, the viscosity significantly increased for all the yoghurt samples. This finding is in agreement with the results reported by Küçükçetin *et al.* (2011).

Water holding capacity

The WHC of the yoghurt samples is presented in **Table 4**. It can be seen that the WHC of the yoghurts was significantly affected by the amount of cow's milk added to the goat's milk. After 1 day of storage, the difference in the WHC between GY100, GY90, GY80, and GY70 was not statistically significant. However, the WHC of these yoghurts was significantly higher than that of GY60. The WHC values found in GY100, GY90, GY80, and GY70 may be related to the higher calcium content in the goat's milk and the WHC of calcium due to the occurrence of ionic interactions between the caseins within the protein network (Gomes *et al.*, 2013). In addition, protein denaturation, low pH, high acidity, and the intensity of the heat treatment also influence the process of whey separation (Park, 2006; Jacob *et al.*, 2011).

During storage, the WHC values were found to decrease for all the yoghurt samples. This finding is similar to the results reported by Domagała (2009). This effect could be explained by the idea that a part of the proteins might have been enzymatically hydrolyzed, leading to a disruption of the protein network that weakened the gel structure, or the protein network might have been accommodating during storage, leading to the expulsion of the whey initially retained among the protein chains (Tribst *et al.*, 2018). In addition, a decrease in the WHC during storage in all the yoghurt samples may have been due to the progressive enhancement of cross-linking in the casein matrix, causing a continual shrinkage of the gel during the storage period (Gomes *et al.*, 2013).

Sensory attributes

The sensory attributes of the yoghurts after 1, 7, and 14 days of storage are shown in **Table 5**. The change in concentration of cow's milk in the mixture of milks did not result in significant variations on the assessors' preferences for color, odor, and texture of the yoghurts after all the periods of storage, but a difference in flavor was observed among the evaluated yoghurts. Flavor is considered to be the most important parameter for consumer acceptance and the purchasing decisions for yoghurt. This attribute may be directly related to the caprylic, capric, and caproic acids in goat's milk (Gomes *et al.*, 2013; Feng *et al.*, 2019). **Table 5** shows that the scores for flavor ranged from 2.9 to 4.6, from 3.3 to 4.4, and from 3.1 to 4.5 after 1, 7, and 14 days of storage, respectively. The highest score was received from GY60 followed by GY70 after all the periods of storage, while the scores for GY80, GY90, and GY100 were similar and lower than those of GY60 and GY70.

Table 4. Water holding capacity of the yoghurts (WHC)

	Water holding capacity (%)		
	Day 1	Day 7	Day 14
GY100	$76.89^{Aa} \pm 1.48$	$71.42^{Bab} \pm 0.88$	$64.53^{Cb} \pm 0.88$
GY90	$79.99^{Aa} \pm 3.34$	$73.79^{ABa} \pm 1.10$	$69.30^{Ba} \pm 1.22$
GY80	$80.35^{Aa} \pm 2.22$	$68.72^{Bb} \pm 1.99$	$63.39^{Cb} \pm 0.91$
GY70	$75.25^{Aab} \pm 2.83$	$69.58^{Bb} \pm 1.42$	$64.27^{Cb} \pm 1.48$
GY60	$67.67^{Ab} \pm 5.68$	$57.46^{Bc} \pm 1.10$	$54.65^{Bc} \pm 0.91$

Note: GY100: yoghurt made from 100% goat's milk, GY90: yoghurt made from 90% goat's milk + 10% cow's milk, GY80: yoghurt made from 80% goat's milk + 20% cow's milk, GY70: yoghurt made from 70% goat's milk + 30% cow's milk, GY60: yoghurt made from 60% goat's milk + 40% cow's milk. Means with different lowercase letters in the same column are significantly different (P < 0.05). Means with different uppercase letters in the same row are significantly different (P <0.05).

Table 5. Sensory attributes of the yoghurts

	Sensory attributes			
	Color	Odor	Flavor	Texture
1 day of storage				
GY100	3.1[a]	2.8[a]	2.9[c]	2.9[a]
GY90	3.2[a]	3.0[a]	3.5[bc]	3.9[a]
GY80	3.2[a]	2.8[a]	3.5[bc]	3.6[a]
GY70	3.3[a]	3.0[a]	4.1[ab]	3.4[a]
GY60	2.8[a]	3.3[a]	4.6[a]	3.6[a]
7 days of storage				
GY100	3.8[a]	2.5[a]	3.3[b]	3.3[a]
GY90	3.2[a]	2.6[a]	3.5[ab]	2.9[a]
GY80	3.8[a]	2.4[a]	3.3[b]	3.3[a]
GY70	3.4[a]	2.9[a]	4.0[ab]	3.0[a]
GY60	3.8[a]	3.1[a]	4.4[a]	3.5[a]
14 days of storage				
GY100	4.0[a]	3.3[a]	3.6[ab]	3.7[a]
GY90	3.5[a]	2.5[a]	3.1[b]	3.2[a]
GY80	3.3[a]	2.3[a]	3.5[ab]	3.3[a]
GY70	3.4[a]	3.2[a]	4.2[ab]	2.6[a]
GY60	3.1[a]	3.3[a]	4.5[a]	3.7[a]

Note: GY100: yoghurt made from 100% goat's milk; GY90: yoghurt made from 90% goat's milk + 10% cow's milk; GY80: yoghurt made from 80% goat's milk + 20% cow's milk; GY70: yoghurt made from 70% goat's milk + 30% cow's milk; and GY60: yoghurt made from 60% goat's milk + 40% cow's milk. Means with different letters in the same column and the same day of storage are significantly different (P <0.05).

Conclusions

This study demonstrated that the different proportions of cow's and goat's milks affected the physicochemical, viscosity, and WHC properties of yoghurt. However, this factor did not cause noticeable changes in most of the sensory attributes of the yoghurt except for flavor. For practical application, the addition of cow's milk to goat's milk can contribute to the improvement of yoghurt quality with greater physicochemical properties and flavor in comparison with yoghurt made from goat's milk only.

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