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Production and properties of yoghurt made using mixture of cows and goats milk

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Abstract

The effect of adding goat milk as cow milk substitute in the base formula of yoghurt on the acceptability and different properties of the resultant product was investigated. Set traditional yoghurt samples were made using fresh raw goat (G) and cow milk (C), and milk treatments obtained from three mixtures of goat milk added to the cow milk in gradual mixing ratios, named T1 (25% G + 75% C), T2 (50% G + 50% C) and T3 (75% G + 25% C) as given by experimental design respectively. The yoghurt treatments were analyzed in fresh, 7 and 14 days of cold storage (5±1°C). The obtained findings reveal that the added ratio of goat milk to the blend of yoghurt had a non-significant influence on total solids and protein contents and caused a gradual increase in the ash and fat. On the other hand, lactose, acidity, serum separation values and viability of lactic acid starter in resultant products were decreased. Using goat milk as a cow milk substitute for up to 50% of cow milk yoghurt preparation had a non-significant effect on the acceptability of yoghurt. The differences in the sensory properties were observed by using goat milk as a cow milk substitute higher than 50% of cow milk. It can be concluded that yoghurt products can be made by adding goat milk as a cow milk substitute for up to 50% without significant changes in physicochemical, microbiological and organoleptic properties.

Keywords: Yoghurt, Goat milk, Utilization.

1. Introduction

Goats provide several benefits for small communities, including cheap short-generation intervals, high production costs, minimal feeding needs, and the provision of a consistent supply of modest amounts of milk suited for instant family use [1–2]. The manufacture of this kind of milk must be a good technique for addressing undernutrition issues. Despite the far greater amount of cow milk accessible, its cheaper manufacturing and hence lowing market price, goat milk production, marketing, and its derivatives are thus a key speciality in the whole dairy industry sector [1]. Because of enormous quantities of undocumented home consumption, particularly in developing nations, goat milk output is likely to be substantially greater than these official numbers [1]. Goat milk is proven to be an excellent replacement for cow milk in cases when bovine milk creates an allergic response. Goat milk products are thought to have the highest commercial potential of any dairy product; hence various properties of goat milk are now the subject of considerable scientific attention [3]. Dairy manufacturing is interested in goat milk due to its nutritional characteristics, and it is recognized as a nutritious food. Some goat milk features are preferable to other milk types, like increased allergic tolerance among youngsters and a high percentage of smaller fat globules, which improve digestion [4]. Goat milk is a

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functional and nutraceutical property because it provides nutritional and extra health benefits to consumers, leading to an increase in demand for goat milk and dairy products manufactured from it. Although goat's milk is qualitatively comparable to cow's milk, variances in its quantitative composition and the structure of essential components, such as fat and protein, translate into differing qualitative attributes of the completed goods. The curd texture is the most noticeable variation in fermented dairy beverages. It has been discovered that goat milk yoghurt gel is more delicate and has a lower viscosity than yoghurt manufactured from cow milk. Furthermore, during goat's milk yoghurt fermentation, a much lesser quantity of volatile aromatics (acetaldehyde, diacetyl) and carbon dioxide are created. Goat's milk has a greater protein, nitrogen, and vitamin content, which results in a faster rise in acidity in fermented beverages [5-6]. Furthermore, goat milk has somewhat less casein than cow milk, with a small proportion or lack of αs-casein, a greater casein micelle diffusion degree, and distinct fat globule shape and size [7–9]. All of the above parameters affect the rheological qualities of the coagulum in semi-liquid goat milk [1]. yoghurt manufacturing from goat milk has a weaker gel and a harsher "goaty flavor," which differs from the normal flavours of cow's and buffalo's milk yoghurt [1]. Many aroma components have been identified as responsible for the distinct "goaty flavor": octanoic acid, 4-methyl octanoic acid, 4-methyl octanoic acid, and nonanoic acid. Lipolysis produces these fatty acids [10]. This study aims to look into the use of goat milk in manufacturing dairy products like yoghurt from various goat and cow milk mixes.

2. Materials and Methods.

2.1. Materials

2.1.1. Ingredients

Fresh cow's milk used in this study was obtained from A local herd of cows being raised at a research station, Animal Health Research Institute, Giza Governorate, Egypt. then kept frozen at -18°C until use. Fresh goat's milk used in this study was obtained from the herds of barqi goats, Sidi Barrani district, Marsa Matrouh Governorate, Egypt, and then kept frozen at -18°C until use. Skim milk powder (1% fat, 36% protein, 51% lactose and 97% T.S.) manufactured in Finland was obtained from the local market in Cairo Governorate, Egypt.

Table (1): Chemical compositions of cow and goat milks

Properties	Treatments	
	Cow's milk	**Goat's milk**
TS (%)	12.40^{A}	12.23^{A}
Fat (%)	3.40^{B}	3.90^{A}
Ash (%)	0.71^{B}	0.81^{A}
Protein (%)	3.31^{A}	3.20^{A}
Lactose (%)	4.56^{A}	4.03^{B}
Acidity (%)	0.17^{A}	0.16^{A}
pH value	6.60^{A}	6.69^{A}

A, B, C: Means with the same letter for the same row are not significantly different.

2.1.2. Bacterial starter cultures

Freeze-dried bacterial culture (YC-X11 DIP 50u) contains *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* (1:1), which was obtained from Chr. Hansens Laboratiers, Denmark, prepared as the mother culture by adding 1% lyophilized cell culture into 12% sterilized reconstituted skim milk powder and incubated at 42°C for 4-6 h before 24 h.

2.2. Experiment of procedures

2.2.1. Preparation of set yoghurt made using mixture of cows and goats milk

Set traditional yoghurt samples were made using fresh raw goat and cow milk. Five treatments of milk were prepared before the production of the yoghurt sample. The first and last treatments were pure raw cow (C 100%) and goat (G 100%). Other treatments obtained from three mixers of goat milk added to the cow milk in gradual mixing ratios, named T1 (25% goat's milk + 75% cow's milk), T2 (50% goat's milk + 50% cow's milk) and T3 (75% goat's milk + 25% cow's milk) as given by experimental design respectively. All milk was fortified with 2% SMP, then heat treated at 85ºC for 15 min, cooled to 42ºC and inoculated with a 3% yoghurt starter culture. The inoculated yoghurt samples were filled into plastic cups (100 ml) and incubated at 42ºC till coagulation (pH 4.7), then cooled to 4ºC. Three replicates of manufacturing were done for each treatment. The resulting yoghurts were stored at 4ºC for 14 days. The yoghurts were analyzed in fresh, 7 and 14 days of cold storage.

2.2.2. Analytical methods

Total solid, ash, fat, total protein, lactose and titratable acidity contents in different samples of milk and yoghurt were determined as the method described by AOAC [11]. The pH values were measured electronically using a lad pH meter with a glass electrode (Hanna model 8417 digital pH meter). The susceptibility of yoghurt to syneresis (the quantity of whey drained from a known sample weight) was determined using a drainage method according to Hassan et al. [12]. *Lactobacillus bulgaricus* count was enumerated on the selective medium for lactobacilli (MRS agar) at 37°C for 48 h, while *Streptococcus thermophilus* count was enumerated on the M17 agar medium at 37°C for 48 h. according to De MAN et al. [13] and Terzaghi and Sandine [14] The counts of yeast & moulds in different samples were determined according to ISO [15] using a Molt agar medium incubated at 25°C/120 hr. The bacterial coliform count was carried out according to the ISO [16] using Mac Conkey agar media and incubated at 37°C/24 hr. Ten staff members at the Food Science Department, Faculty of Agriculture, and Ain Shams University did the scoring properties of set yoghurt. Samples were presented to a panel analysis so that the following characteristics were estimated: flavour (50 points), consistency (40 points) and appearance (10 points); a maximum number of points were assigned to each sample according to the scheme of Keating and White [17]**.** Statistical analysis was carried out by SAS Institute (1996), utilizing the General Linear Model (GLM) with treatments as the main effect. Duncan's multiple ranges were employed at $P \leq 0.05$ to differentiate the means of three replicates.

3. Results and Discussion.

3.1. Chemical compositions of Cow and Goat milks

Data obtained in **Table (1)** showed that goat milk had significantly higher fat, protein and ash contents and significantly lower lactose content than cow milk.

3.2. Chemical compositions of yoghurt made using a mixture of cow and goat milk

The chemical properties of yoghurt made using a mixture of cow's and goat's milk are presented in **Table (2)**. Replacement of cow milk with goat milk in yoghurt production had a non-significant effect on total solids and protein contents among all treatments. Therefore, small changes in the total solids and protein values of several yoghurt mixes might be due to the little differences between cow and goat milk in the preparation of yoghurt. These results agree with Park [18], who stated that the total solids of goat, cow and human milk are the same.

Table (2): The chemical composition* of yoghurt was prepared using a mixture of cow and goat milk

Properties (%)	Treatments				
	C	**T1**	**T2**	**T3**	**G**
TS	13.35^{A}	13.12^{A}	13.20^{A}	13.18^{A}	13.39^{A}
Fat	3.25^{B}	3.28^{B}	3.41^{AB}	3.54^{A}	3.77^{A}
Ash	0.74^{B}	0.75^{B}	0.76^{AB}	0.79^{A}	0.84^{A}
Protein	4.51^{A}	4.50^{A}	4.48^{A}	4.43^{A}	4.40^{A}
Lactose	3.84^{A}	3.79^{A}	3.65^{A}	3.60^{A}	3.50^{B}

*: average of three samples
C = yoghurt made from pure cow's milk sample
T1 = yoghurt made from 25% goat's milk + 75% cow's milk
T2 = yoghurt made from 50% goat's milk + 50% cow's milk
T3 = yoghurt made from 75% goat's milk + 75% cow's milk
G = yoghurt made from pure goat's milk sample
A, B, C: Means with the same letter for the same row are not significantly different.

Ash and fat contents were increased by raising the amount of goat milk added to the yoghurt mix. This increase is due to higher ash and fat content in goat milk than in cow milk. Our results agree with Yadav [19], Costa et al. [20] and Park et al. [21], who found that there are higher ash and fat contents for goat milk concerning cow milk. Increasing the ratio of added goat milk in the blend of yoghurt caused a proportional decrease in lactose content in the final product. The increase in lactose content with adding goat milk to yoghurt is because of the lower lactose amount in goat milk compared to cow milk. these results agree with Arora et al. [22], who found that Cow milk contains higher lactose content than goat milk.

As shown in **Table (3)**, replacing goat milk with cow milk in yoghurt preparation resulted in a reduced acidity value and an increase in pH value proportional to the replacement ratio. The decrease in acidity value of yoghurt with adding goat milk compared with yoghurt manufactured with pure cow milk because of the effect of some bioactive compounds in goat milk, such as on the viability of lactic acid starter. Also, the decrease of lactose content in goat milk compared to cow milk may affect the acidity value in the resultant yoghurt. The titratable acidity of yoghurt samples mostly resulted from the degradation of lactose in raw milk used to make the yoghurt mostly lactic acid.

Table (3): Titratable acidity and pH value of yoghurt were prepared using a mixture of cow and goat milk during cold storage at 5±1°C for 14 days**.**

Treat-ments	Storage periods (days)		
	Fresh	7	14
Titratable acidity (%)			
C	0.96^{Ab}	1.16^{Aa}	1.28^{Aa}
T1	0.92^{Ab}	1.11^{Aa}	1.22^{Aa}
T2	0.87^{Ab}	1.05^{Aa}	1.17^{Aa}
T3	0.86^{Ab}	1.02^{Aa}	1.14^{Aa}
G	0.84^{Ab}	0.98^{Aa}	1.11^{Aa}
pH value			
C	4.56^{Aa}	4.20^{Ab}	4.04^{Ab}
T1	4.59^{Aa}	4.28^{Ab}	4.11^{Ab}
T2	4.64^{Aa}	4.39^{Ab}	4.18^{Ab}
T3	4.69^{Aa}	4.45^{Ab}	4.24^{Ab}
G	4.77^{Aa}	4.53^{Ab}	4.28^{Ab}

C = yoghurt made from pure cow's milk sample
T1 = yoghurt made from 25% goat's milk + 75% cow's milk
T2 = yoghurt made from 50% goat's milk + 50% cow's milk
T3 = yoghurt made from 75% goat's milk + 75% cow's milk
G = yoghurt made from pure goat's milk sample
A, B, C: Means with the same letter for the same row are not significantly different
a, b, c: Means with the same letter for the same colum are not significantly different

The more lactose content of the raw milk, the higher the lactic acid produced by lactic acid bacteria used to make the yoghurt. These results agree with Nahar et al. [23] and Abdel Moneim et al. [24], who found that yoghurt made from goat milk showed a significantly lower percentage of acidity compared to yoghurt manufactured from cow milk. Also, Dudal et al. [25] found that goat milk yoghurt (T1) obtained the lowest acidity score compared to all other treatments studied. It is noticed that there was an increase in cow milk's acidity score yoghurt. Generally, the percent titratable acidity gradually increased and pH values gradually reduced in all treatments of yoghurt during the cold storage period; the increase of titratable acidity% during the storage of yoghurt was also found by Abd El-Salam et al. [26], Mehanna et al. [27], Kebary et al. [28] and El-Batawy [29].

3.3. Serum separation

Serum separation, or syneresis, termed the production of a top liquid phase (whey) due to gel shrinkage, is a typical issue in yoghurt, as mentioned by Aryana and Olson [30]. As shown in **Fig. (1)**, yoghurt made from pure cow milk was the highest serum separation during all treatments and throughout the storage period. On the other hand, the lowest serum separation along all treatments was observed in the G treatment (yoghurt made from pure goat milk). It could be observed that adding goat milk as a cow milk substitute in the yoghurt blend caused a significant decrease in the syneresis index of the final product. These results agree with Haenlein [1] and Vargas et al. [31] who found that yoghurt manufactured from goat milk has low syneresis, a weaker gel formation, and a high differs from cow milk yoghurt's normal flavour. Vargas et al. [31] revealed that the incorporation of goat milk into cow milk during yoghurt manufacture, mainly the lower strong casein micelle attractive forces, might be due to their better water holding capacity (WHC) and reduced gel formation, hence retaining the gel matrix has a porous structure value and minimizing natural syneresis.

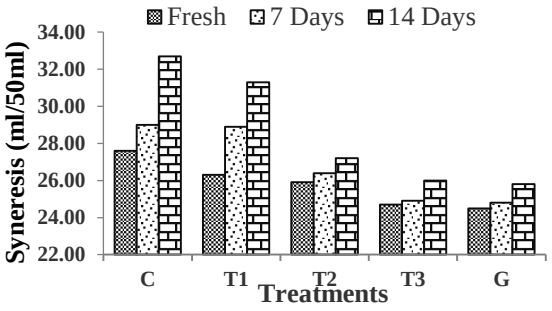

Fig. (1): Susceptibility to Syneresis of yoghurt manufatured using mixture of cow's and goat's milk during cold storage at 5±1°C for 14 days.

During the cold storage period of up to 14 days, serum separation steadily increased in all yoghurt treatments. SI progressed during storage due to the gradual cross-linking strengthening and bonding in the casein micelles, resulting in continual gel contraction throughout storage, as mentioned by Tamime and Robinson [32]. These results are consistent with the results of Vargas et al. [31].

3.4. Microbiological examination

Survivability of *str. thermophilus* and *Lb. delbrueckii* ssp. *bulgaricus* (log cfu/ ml) in yoghurt manufactured using a blend of cow and goat milk during cold storage (5±1 °C) for 14 days is presented in Table (4). The findings observed that yoghurt samples manufactured from pure cow milk recorded the highest count of *str. thermophilus* and *Lb. delbrueckii* ssp. *bulgaricus* among all yoghurt treatments. In comparison, yoghurt product made from pure goat milk was the lowest count of *str. thermophilus* and *Lb. delbrueckii* ssp. *bulgaricus* compared to other treatments. It could be noted that

fortifying the yoghurt blend with goat milk as a cow milk substitute significantly influenced the viability of lactic acid bacteria in the resultant product. The blend of goat milk with cow milk during yoghurt preparation led to a decrease in the growth of *Str. thermophilus* and *Lb. delbrueckii* ssp. *bulgaricus* compared with using pure cow milk. This decrease might be due to the little lactose content in goat milk than cow milk. The lactose content is essential in stimulating and growing the yoghurt's lactic acid bacteria. Our findings agree with Taufiq and Anindita [33], who found that during storage, the total LAB concentration in fermented cow milk was 8.03 ± 0.52 log cfu/mL, whereas it was 7.81 log cfu/mL ± 0.67 log cfu/mL in fermented goat milk. However, the counts of lactic acid bacteria in cows, goat and other yoghurt treatments were higher than the recommended minimum levels (106 cfu/ ml or g) stated by Hekmat and McMahon [34]. *Streptococcus thermophilus* and *Lb. delbruckii* ssp. *bulgaricus* counts decreased progressively in all yoghurt treatments over the cold storage period. The progressive decline in lactic acid bacterial counts was caused by the bacteria's increased sensitivity to acid during prolonged storage. The findings are consistent with those of Oliveira et al. [35], Paseephol and Sherkat [36] and El-Batawy and Khalil [37].

Table (4): Counts (log cfu/gm) of some microbial group's detected yoghurt made using a mixture of cow's and goat's milk during cold storage at 5±1 °C for 14 days

Yoghurt Treatments	Storage period (Day)		
	Fresh	7 Days	14 Days
	Streptococcus thermophillus		
C	7.81^{Aa}	7.8^{Aa}	7.22^{Ab}
T1	7.58^{ABa}	7.51^{Aa}	7.15^{Ab}
T2	7.21^{Ba}	7.18^{Ba}	6.94^{Bb}
T3	7.13^{BCa}	7.01^{Ba}	6.81^{Cb}
G	7.02^{Ca}	6.92^{Ca}	6.41^{Db}
Lactobacillus delbrueckii ssp. bulgaricus			
C	8.25^{Aa}	7.81^{Ab}	7.33^{Ac}
T1	8.21^{Aa}	7.80^{Ab}	7.25^{ABc}
T2	7.92^{Ba}	7.42^{Bb}	7.00^{Bc}
T3	7.73^{ca}	7.25^{Cb}	6.90^{Cc}
G	7.61^{Da}	7.16^{Db}	6.82^{Dc}
Yeasts and molds			
C	ND	1.8^{Ab}	2.1^{Aa}
T1	ND	1.5^{Ab}	2.1^{Aa}
T2	ND	1.2^{Ab}	2.0^{Aa}
T3	ND	1.0^{Ab}	2.0^{Aa}
G	ND	1.0^{Ab}	1.8^{Aa}

*See Table (3) for details.
ND: not detected.

All yoghurt samples (fresh and 14 days refrigerated stored) containing different percentages of cow and goat milk were free from coliform bacteria. This might be owing to the effective heat treatment of the reconstituted milk (90ºC / 10 min) and high sterilization conditions during yoghurt manufacture and cold storage. Furthermore, it might be referred to as the acidity impact in various yoghurts, which plays a significant role in limiting the development rate of coliform bacteria, as reported by Goldberg et al. [38]. Also, yeast & mould were not detected in all fresh samples while in all yoghurt samples after 7 and 14 days from cold storage. Because of post-contamination in these yoghurt samples after yoghurts prepared and filling.

3.5. Organoleptic properties

Table (5) presents the sensory evaluation of yoghurt products made using a mixture of cow and goat milk during cold storage at 5±1°C for 14 days. The results showed that there were differences among all yoghurt treatments. These differences were not significantly between T1 (25% G + 75% C), T2 (50% G + 50% C) and cow yoghurt. The yoghurt samples made from pure cow milk had significantly higher flavour scores than yoghurt prepared from pure goat milk and T3 (75% G + 25% C). A blend of goat and cow milk up to (1:1) had no significant effect on the flavor and texture of yoghurt as compared to yoghurt prepared only from goat milk. It could be reported that using goat milk as a cow milk substitute for up to 50% of cow milk yoghurt preparation had no significant influence on the acceptability of the final product.

The differences in sensory properties were observed using goat milk as a cow milk substitute higher than 50% of cow milk. This might be due to differences in the fatty acid composition of goat's milk, which plays a major role in the appearance of goat taste, resulting in alterations in flavour characteristics as reported by Contarini and Povolo [39] and Chilliard [40]. Our findings are consistent with those of Martín-Diana et al. [41], who observed that yoghurt manufactured from goat's milk had the least amount of flavor and appearance due to its liquid texture and non-typical yoghurt taste. Vargas et al. [31] also reported that the score of all sensory parameters in yoghurt made using different mixtures of goat and cow milk whiteness and creaminess were significantly reduced ($p< 0.05$) afterthe addition of goat milk, but continued to rise ($p< 0.05$) when more was added. They also observed that

goats' milk yoghurt (formulation 100%) was less consistent and more acidic, with an unusual yoghurt taste and flavor. They suggested this is due to thelower quantity of acetaldehyde identified in pure GM yoghurts and their less distinctive flavour. Goat milk contains more short-chain fatty acids (SCFAs) than cow milk, which explains thedistinctive flavour of goat dairy products, as reported by Karademir et al. [42]. Total sensory evaluation results were partially reduced during the fresh and 7 days of the refrigerated storage period and then reduced gradually until the close ofthe storage period (14 days) may be due to development of acid which effect on rheological and sensory properties so, yogurt's shelf life at 4°C could not be extended for longer than 14 days. The findings are consistent with those of Ebrahimi et al. [43] and Farahat and El-Batawy [44].

Table (5): Sensory scores of yoghurt made using mixture of cow's and goat's milk during cold storage at 5±1°C for 14 days.

Criteria	CSP (Day)	Treatments				
		C	T1	T2	T3	G
Flavor (50 points)	Fresh	48.20^{Aa}	48.03^{Aa}	47.84^{Aa}	44.98^{Ba}	43.89^{Ba}
	7	45.24^{Ab}	45.20^{Ab}	44.08^{Ab}	$41.17^{B\,b}$	41.11^{Bb}
	14	$41.72^{A\,c}$	41.60^{Ac}	$41.07^{A\,c}$	38.49^{Bc}	36.43^{Bc}
Consistency (40 points)	Fresh	37.82^{Aa}	36.93^{Aa}	36.20^{Aa}	32.10^{Ba}	30.88^{Ba}
	7	35.85^{Ab}	34.67^{Ab}	34.10^{Ab}	30.45^{Bb}	28.54^{Bb}
	14	33.25^{Ac}	32.03^{Ac}	31.41^{Ac}	28.69^{Bc}	26.01^{Bc}
Appearance (10 points)	Fresh	9.10^{Aa}	9.20^{Aa}	9.30^{Aa}	9.10^{Aa}	9.20^{Aa}
	7	7.19^{Ab}	7.18^{Ab}	7.20^{Ab}	7.16^{Ab}	7.25^{Ab}
	14	7.08^{Ab}	7.10^{Ab}	7.12^{Ab}	7.10^{Ab}	7.13^{Ab}
Total score (100 points)	Fresh	95.12^{Aa}	94.16^{Aa}	93.34^{Aa}	86.18^{Ba}	83.97^{Ba}
	7	88.28^{Ab}	87.05^{Ab}	85.38^{Ab}	78.78^{Bb}	76.90^{Bb}
	14	82.05^{Ac}	80.73^{Ac}	79.60^{Ac}	74.28^{Bc}	69.57^{Bc}

*CSP: Cold storage period, *See Table (3) for details.

4. Conclusions

It could be concluded that yoghurt products can be made by adding goat milk as a cow milk substitute for up to 50% without significant influences in different physicochemical, microbiological and organoleptic attributes.

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