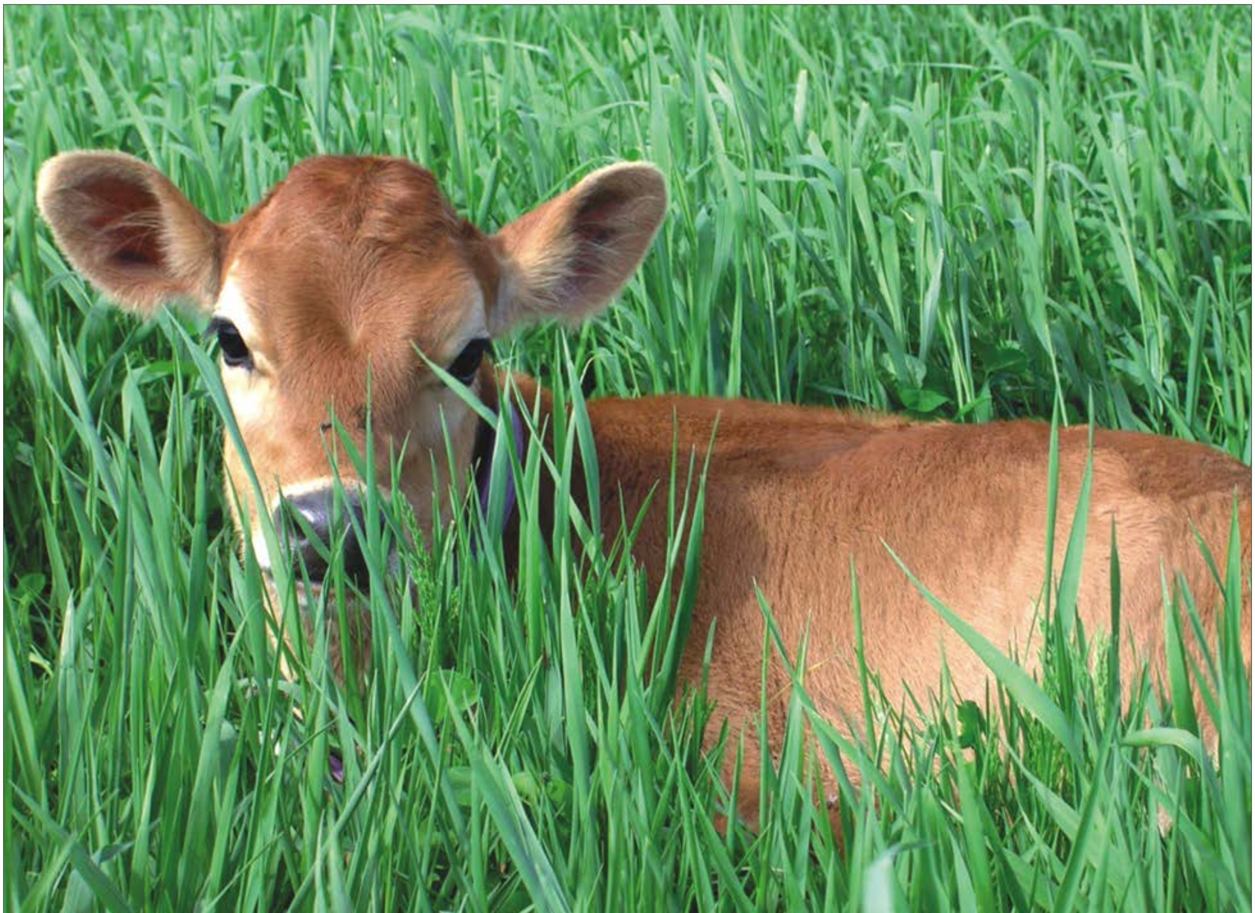

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Research Article
Evaluation of Chemical Composition of Yoghurt Made from Camel and Camel-Sheep Milk Mixtures during Storage

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Abstract
In this study the chemical composition of yoghurt made from camel milk (40, 60 and 100%) was mixed with sheep milk using two different starter cultures were evaluated during storage. The milks were pasteurized at 63°C for 30 min and then cooled to 43°C before adding the starter culture. The incubation was carried out in plastic cups at 43°C. Longer shelf life was obtained for yoghurt samples made from pure camel milk compared to other samples. The total solids, fat, protein and acidity of yoghurt showed significantly ($p<0.05$) higher values for yoghurt made from camel-sheep mixtures milk compared to those made from pure camel milk. Moreover, the storage period revealed significant variations for those constituents. Hence, it is concluded that addition of sheep milk to that of camel improves the composition of yoghurt made from camel milk, which indicated the possibilities of processing and marketing of both milk especially, because the health benefits of camel milk and the fermented products are well documented.

Key words: Camel milk, sheep milk, starter culture, gariss, fermented products, compositional content

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The most common forms of consumption of camel milk are either fresh or fermented (Farah *et al.*, 2007; Suliman and El Zubeir, 2014). The milk composition from dromedary is excellent from the nutritional viewpoint, although it is often described as not easily fermented (Attia *et al.*, 2001; Hassan *et al.*, 2006, 2007; El Zubeir and Ibrahium, 2009). The acceptability of yoghurt made from camel milk needs additional research regarding the consistency of fermented product (Hashim *et al.*, 2009; Abdel Rahman *et al.*, 2009; El Zubeir *et al.*, 2012b). The total solids content of gariss (traditional fermented camel milk) ranged from 10-14.5% (Sulieman *et al.*, 2006; Hassan *et al.*, 2008; El Zubeir and Ibrahium, 2009; Suliman and El Zubeir, 2014). Gariss contained fat of around 2.8-5% (Sulieman *et al.*, 2006, Hassan *et al.*, 2007, 2008; El Zubeir and Ibrahium, 2009; Suliman and El Zubeir, 2014). However, both protein and ash content in gariss were 2.3-6.3% and 0.51-1.7% (Sulieman *et al.*, 2006; Hassan *et al.*, 2007, 2008; El Zubeir and Ibrahium, 2009; Shori, 2012; Suliman and El Zubeir, 2014).

Sheep milk is especially suitable for yoghurt production, because of its high protein and total solids content (El Zubeir *et al.*, 2012b; Erkaya and Sengul, 2012). However, few attempts have been made to systematically study the use of sheep milk in the manufacture of dairy products, even yoghurt (Pandya and Ghodke, 2007). The chemical compositions of yoghurt made from sheep milk were 5.13, 5.65, 4.85, 1.16 and 19.5% for pH, fat, protein, ash and total solids, respectively (El Zubeir *et al.*, 2012b). They added that higher fat content of sheep milk could be a good reason to start new production line, that can produce sheep milk cream simultaneously with yoghurt production.

Quality, safety and acceptability of traditional food may be significantly improved through the use of the starter culture selected on the basis of multi functional consideration (Holzapfel, 2002). Abdel Rahman *et al.* (2009) showed that some microbial and biochemical changes occur during the fermentation of camel milk. Moreover, the use of mixed starter culture showed more superior growth, acid production and proteolytic activities than single starter culture.

Hassan *et al.* (2006, 2007) obtained a shelf life of about 9 days for camel milk gariss that stored at 25 and 37°C. However, further improvement of the keeping quality was obtained by El Zubeir and Ibrahium (2009), when using heat treatment of camel milk and refrigeration for processed gariss samples. They found that gariss from pasteurized camel milk showed high keeping quality, since it revealed a shelf life of 17 days at 8°C compared to those from non pasteurized camel milk that showed a shelf life of 10 days at 8°C. The present study aimed at improving the quality of the chemical composition of yoghurt made from mixture of camel and sheep milk during storage through the fortification of camel milk with sheep milk.

MATERIALS AND METHODS

The experiment was carried out in the Department of Dairy Production, Faculty of Animal Production, University of Khartoum during the period April, 2012-May, 2012.

Source of milk: Camel and sheep milk (10 L for camel and 5 L for sheep) were obtained from a local farm located in Khartoum North. The milk samples were examined by using milk analyzer Lactoscan 90 according to the manufacture instructions (Milkotronic LTD, Europe) to determine fat, protein, lactose, SNF and density of the milk samples. The average composition of camel milk was 4.66, 3.14, 3.35, 1.031 and 8.64% for lactose, fat, protein, density and solids non-fat, respectively, while, sheep milk samples revealed 5.54, 5.39, 4.07, 1.036 and 10.42%, respectively. Mixtures of camel and sheep milk were prepared, in which, (A) camel milk was used as 100%, (B) 60% camel milk and 40% sheep milk and (C) 40% camel milk and 60% sheep milk. The experiment was conducted into triplicate.

Preparation of yoghurt: Milk was pasteurized at 63°C for 30 min according to Attia *et al.* (2001), then cooled to 43°C followed by the addition of one of the following starter cultures (*Streptococcus thermophilus* and *Lactobacillus delbruckii* sub spp., *bulgaricus*, YC-X11 Thermophilic Yoghurt Culture-Yo-Flex CHR HANSEN, Denmark; S1) for texture and CH-1 Thermophilic Yoghurt Culture-Yo-Flex CHR HANSEN, Denmark; S2) for acidity and flavor. Then the incubation was carried out into plastic cups at 43°C until, the formation of the coagulum (5-17 h). After that the yoghurt samples were stored at 4°C for 29 days. The chemical composition evaluation was performed once every 4 days.

Chemical analyses of yoghurt: The fat content was determined using Gerber method and the protein content was determined by using Kjeldahl method (AOAC., 2003). Similarly the total solids and the ash content and the titratable acidity were determined according to AOAC (2003).

Statistical analysis: The data were analyzed using Statistic version 8 (2003). Analysis of variance was run according to the following statistical model shown in equation:

$$Y_{ij} = \mu+T_i+e_{ij}$$

where, Y_{ij} is the observation, μ is overall mean, T_i is the fixed effect of treat (1, 2, 3, ..., 6), e_{ij} is random error term. The significant differences between means were separated by LSD and determined at $p \leq 0.05$.

RESULTS

Total solids content: Data in Table 1 showed the means for total solids content of yoghurt made from camel and camel-sheep milk mixture using two starter cultures during the storage period. The results revealed increasing percentage of total solids content of yoghurt made from camel milk and yogurt made of sheep milk. The higher levels of total solids was obtained in yoghurt samples made from 40% camel milk+60% sheep milk using YC-X11 starter culture. The result indicated significant ($p<0.05$) differences during the storage period, while non significant ($p>0.05$) variations were observed between yoghurt inoculated with different starter cultures.

Fat content: The means for fat content of yoghurt made from camel and camel-sheep mixture milks were illustrated in Table 2. There were significant ($p<0.05$) differences between yoghurt samples during the storage period. The significantly ($p<0.05$) higher level of fat content was found in yoghurt samples made from 60% sheep milk+40% camel milk followed by that made from 40% sheep milk+60% camel milk compared to those made from pure camel milk using YC-X11 and CH-1 starter cultures, respectively.

Protein content: The means for protein content of yoghurt made from camel and camel-sheep mixture milks were illustrated in Table 3. Significant ($p<0.05$) variations between the means of yoghurt samples were found due to the increase in the percentage of sheep milk and also during the progress of the storage period.

Ash content: The result in Table 4 showed no significant ($p>0.05$) differences in ash content between yoghurt samples made from camel and camel-sheep milk mixture by using the two starter cultures during the storage period. The lowest ash value was found in samples of yoghurt made from pure camel milk using CH-1 starter culture. However, the results showed that the higher levels of ash content were at day 21 for all yoghurt samples.

Titratable acidity: Figure 1 showed variations in the rate of increase for lactic acid in the yoghurt samples made from camel and camel-sheep mixture milks during the storage. The result showed gradual increase of lactic acid in yoghurt

Table 1: Comparison of total solids content of yoghurt samples made from camel and camel-sheep milk mixtures during storage

Yoghurt samples	Day 1	Day 5	Day 9	Day 13	Day 17	Day 21	Day 25	Day 29
100% camel milk (As1)	9.13 ± 0.29^{d}	9.15 ± 0.39^{c}	9.18 ± 0.24^{d}	9.91 ± 0.22^{c}	9.55 ± 0.24^{c}	9.39 ± 0.19^{d}	9.18	9.13
100% camel milk (As2)	8.97 ± 0.29^{d}	9.45 ± 0.39^{c}	8.97 ± 0.24^{d}	8.66 ± 0.22^{d}	8.83 ± 0.24^{d}	9.18 ± 0.19^{d}	9.18	8.97
60% camel milk+40% sheep milk (Bs1)	11.03 ± 0.29^{c}	11.49 ± 0.39^{b}	11.41 ± 0.24^{c}	11.28 ± 0.22^{b}	10.93 ± 0.24^{b}	10.79 ± 0.19^{c}	10.93	-
60% camel milk+40% sheep milk (Bs2)	11.25 ± 0.29^{c}	11.68 ± 0.39^{b}	10.98 ± 0.24^{c}	10.91 ± 0.22^{b}	10.96 ± 0.24^{b}	11.97 ± 0.19^{b}	11.25	-
40% camel milk+60% sheep milk (Cs1)	14.17 ± 0.29^{a}	13.07 ± 0.39^{a}	14.58 ± 0.24^{a}	13.53 ± 0.22^{a}	12.56 ± 0.24^{a}	12.96 ± 0.19^{a}	-	-
40% camel milk+60% sheep milk (Cs2)	12.87 ± 0.29^{b}	13.27 ± 0.39^{a}	13.22 ± 0.24^{b}	13.68 ± 0.22^{a}	11.99 ± 0.24^{a}	12.43 ± 0.19^{b}	-	-

Mean values within the same row or column with different superscripts letters are significantly different ($p<0.05$)

Table 2: Comparison of fat content of the yoghurt samples made from camel and camel-sheep milk mixtures during the storage

Yoghurt samples	Day 1	Day 5	Day 9	Day 13	Day 17	Day 21	Day 25	Day 29
100% camel milk (As1)	1.95 ± 0.38^{c}	2.05 ± 0.17^{d}	2.20 ± 0.09^{e}	2.40 ± 0.18^{c}	2.00 ± 0.17^{c}	2.45 ± 0.17^{b}	2.4	2.5
100% camel milk (As2)	2.20 ± 0.38^{bc}	2.40 ± 0.17^{d}	2.55 ± 0.09^{d}	2.35 ± 0.18^{c}	2.40 ± 0.17^{c}	2.45 ± 0.17^{b}	2.45	2.4
60% camel milk+40% sheep milk (Bs1)	2.85 ± 0.38^{bc}	3.05 ± 0.17^{c}	3.80 ± 0.09^{c}	3.45 ± 0.18^{b}	3.10 ± 0.17^{b}	3.05 ± 0.17^{a}	3.05	-
60% camel milk+40% sheep milk (Bs2)	2.95 ± 0.38^{b}	3.25 ± 0.17^{c}	4.20 ± 0.09^{b}	3.35 ± 0.18^{b}	3.65 ± 0.17^{a}	3.25 ± 0.17^{a}	3.25	-
40% camel milk+60% sheep milk (Cs1)	4.40 ± 0.38^{a}	3.90 ± 0.17^{a}	4.55 ± 0.09^{a}	4.35 ± 0.18^{a}	3.50 ± 0.17^{ab}	3.25 ± 0.17^{a}	-	-
40% camel milk+60% sheep milk (Cs2)	4.60 ± 0.38^{a}	4.25 ± 0.17^{b}	4.10 ± 0.09^{b}	3.95 ± 0.18^{a}	3.25 ± 0.17^{ab}	3.15 ± 0.17^{a}	-	-

Mean values within the same row or column with different superscripts letters are significantly different ($p<0.05$)

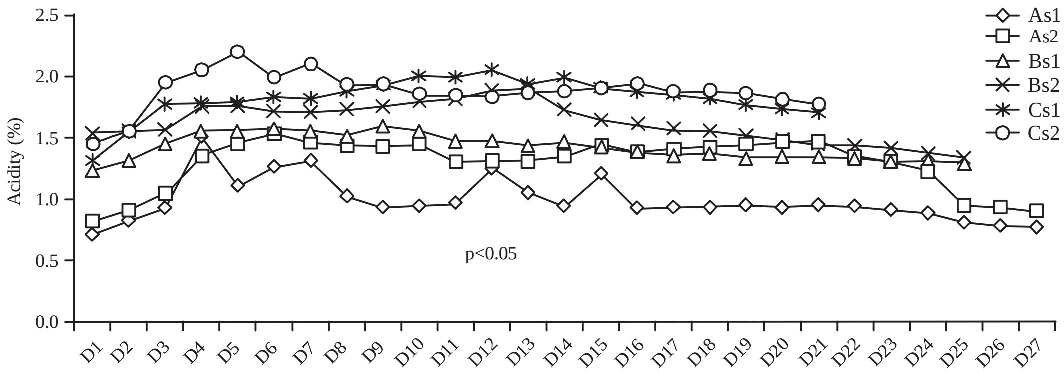

Fig. 1: Variations of the acidity of yoghurt made from camel and camel-sheep milk mixtures during storage

Table 3: Comparison of protein content of yoghurt samples made from camel and camel-sheep milk mixtures during storage

Yoghurt samples	Day 1	Day 5	Day 9	Day 13	Day 17	Day 21	Day 25	Day 29
100% camel milk (As1)	2.76±0.015[cd]	2.59±0.27[c]	2.77±0.22[b]	2.86±0.22[c]	2.86±0.22[bc]	2.59±0.20[b]	2.77	2.52
100% camel milk (As2)	2.51±0.015[d]	2.68±0.27[c]	2.81±0.22[b]	2.93±0.22[c]	2.59±0.22[c]	2.51±0.20[b]	2.51	2.49
60% camel milk+40% sheep milk (Bs1)	3.49 ±0.015[b]	3.61 ±0.27[b]	3.61±0.22[a]	3.78 ±0.22[b]	3.49±0.22[ab]	3.39±0.20[a]	3.22	-
60% camel milk+40% sheep milk (Bs2)	3.04±0.015[c]	3.78±0.27[b]	3.84±0.22[a]	3.93±0.22[ab]	3.78±0.22[a]	3.13±0.20[a]	3.04	-
40% camel milk+60% sheep milk (Cs1)	3.48±0.015[b]	3.93 ±0.27[a]	3.84±0.22[a]	4.32±0.22[a]	3.49±0.22[ab]	3.41±0.20[a]	-	-
40% camel milk+60% sheep milk (Cs2)	3.93±0.015[a]	3.78±0.27[b]	3.84±0.22[a]	4.38±0.22[a]	3.43±0.22[b]	3.31±0.20[a]	-	-

Mean values within the same row or column with different superscripts letters are significantly different ($p<0.05$)

Table 4: Comparison of ash content of yoghurt samples made from camel and camel-sheep milk mixtures during storage

Yoghurt samples	Day 1	Day 5	Day 9	Day 13	Day 17	Day 21	Day 25	Day 29
100% camel milk (As1)	1.02±0.04[a]	0.96±0.05[a]	0.95±0.06[a]	0.97±0.02[a]	1.06±0.04[a]	1.03±0.07[a]	0.96	0.98
100% camel milk (As2)	0.90±0.04[b]	0.95±0.05[a]	0.97±0.06[a]	0.95±0.02[a]	0.99±0.04[a]	1.06±0.07[a]	0.99	1.01
60% camel milk+40% sheep milk (Bs1)	1.03±0.04[a]	0.98±0.05[a]	1.02±0.06[a]	0.94±0.02[a]	1.08±0.04[a]	1.04±0.07[a]	1.02	-
60% camel milk+40% sheep milk (Bs2)	1.00±0.04[a]	1.01±0.05[a]	0.98±0.06[a]	0.99±0.02[a]	1.08±0.04[a]	1.03±0.07[a]	1.02	-
40% camel milk+60% sheep milk (Cs1)	0.99±0.04[ab]	0.99±0.05[a]	0.94±0.06[a]	0.97±0.02[a]	1.06±0.04[a]	1.11±0.07[a]	-	-
40% camel milk+60% sheep milk (Cs2)	0.96±0.04[ab]	0.95±0.05[a]	0.98±0.06[a]	0.94±0.02[a]	1.09±0.04[a]	1.10±0.07[a]	-	-

Mean values within the same row or column with different superscripts letters are significantly different at ($p>0.05$)

samples made from pure camel milk, 60% camel milk+40% sheep milk and 40% camel milk+60% sheep milk by using the YC-X11 and CH-1 starter cultures. The same figure also showed significant ($p<0.05$) variations between all samples of yoghurt made from the different milks with the different starters culture and during the storage period.

DISCUSSION

The result in Table 1 showed significant ($p<0.05$) variations in the total solids content during the storage period. Moreover, the total solids content of yoghurt increased with the increase of the percentage of sheep milk. This result supported with El Zubeir *et al*. (2012b) findings regarding the chemical properties of yoghurt made from camel-sheep milks. El Zubeir *et al*. (2012a) reported that the higher total solids content of yoghurt from sheep indicated the possibilities of adding milk from sheep to bovine or caprine yoghurt in order to standardize total solids instead of importation of skim milk powder for the processing of yoghurt. The lower total solids content of yoghurt made from camel milk could be related to the high water content of camel milk (Shuiep *et al*., 2013). This could explain the watery texture of camel milk yoghurt (El Zubeir *et al*. 2012b).

Table 2 showed significant ($p<0.05$) variations in fat content in yoghurt made from camel and camel-sheep milk mixtures. Samples from pure camel milk had lower values of fat. The composition of yoghurt showed significantly ($p \leq 0.01$) high fat content in yoghurt made from sheep, while camel yoghurt showed significantly ($p \leq 0.05$) lower fat content (El Zubeir *et al*., 2012b). This could be due to the small size of the camel milk fat globules compared with that of bovine milk fat globules (Farah, 1993; El-Zeini, 2006). Moreover, the dromedary camel milk contains smaller amounts of short chain fatty acids and lower content of carotene (Stahl *et al*., 2006). Addition of sheep milk improves the yoghurt quality and increases the percentage of fat in yoghurt made from camel milk. This result was in accordance to El Zubeir *et al*. (2012a).

The values of protein (Table 3) from camel supported the previous reports (Sulieman *et al*., 2006; Hassan *et al*., 2007, 2008; El Zubeir and Ibrahium, 2009; Shori, 2012; Suliman and El Zubeir, 2014). The lower level of protein content in yoghurt made from pure camel milk might be due to the increase of proteolytic activity during fermentation of camel milk (Attia *et al*., 2001). This is because of the relatively high β casein content of camel milk (Kappeler *et al*., 1998). The significant ($p<0.05$) variations in protein content was due to fortification with sheep milk where sheep milk is considered a good raw material for processing of different dairy products (Park *et al*., 2007; Pandya and Ghodke, 2007).

The non significant ($p>0.05$) differences in ash content between yoghurt samples (Table 4) indicated the stability of the product. It was found previously that the composition of yoghurt from camel milk showed significantly ($p \leq 0.05$) lower protein and ash content compared to that made from sheep and goat milk (El Zubeir *et al*., 2012b). However, Suliman and El Zubeir (2014) reported that the ash content of gariss varies according to the processing method.

Figure 1 showed significant ($p<0.05$) variations in the acidity of yoghurt made from camel and camel-sheep milk mixtures by the two starter cultures used, the rate of change in the acidity was slow at the beginning in samples made from pure camel milk. The lactic acid was found to increase with concomitant drop of the pH during fermentation of camel milk inoculated with starter culture (El Zubeir and Ibrahium, 2009; Abdel Rahman *et al*., 2009). Moreover, the rate of increase was slow at the beginning of the incubation compared to that at advancement of incubation. Similarly, Attia *et al*. (2001) concluded that dromedary milk appear less favorable for the lactic fermentation, because the activity of the inoculated lactic starter was lower in camel milk than in bovine milk. On the other hand, sheep milk yoghurt had the highest titratable acidity. This can be due to higher buffering capacity from increasing protein content in the milk (Li and Guo, 2006).

It was observed that yoghurt made from camel milk had longer shelf life followed by that fortified with 40% sheep milk compared to yoghurt made using 60% sheep milk. This fact should be considered for enhancing rural development by initiating processing lines for fermented products from camel and sheep milk, especially in Sudan where, high numbers of camel and sheep are owned by nomads, who have low awareness regarding the processing and marketing of milk.

CONCLUSION

The present study concluded that yoghurt samples from pure camel milk had longer shelf life and that its chemical composition was improved by fortification of sheep milk. This might be because sheep milk had higher fat and total solids content. Hence, the study suggested proper utilization of milk from both camel and sheep in order to ensure security by enhancing rural development.

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