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ORIGINAL RESEARCH

Rheological, textural, colour and sensorial properties of kefir produced with buffalo milk using kefir grains and starter culture: A comparison with cows' milk kefir

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The aim of this study was to compare the rheological, textural, colour and sensory properties of kefir samples produced with buffalos' or cows' milk using two different microbial fermentation sources, namely kefir grains and starter cultures. The buffalo milk kefir had a higher exopolysaccharide content than the cows' milk kefir, and the use of buffalo milk for kefir production had positive effects on the water-holding capacity and firmness value of the resulting kefir samples. The buffalo milk kefir samples had higher viscosity, a higher consistency index, storage and loss modulus values when compared to samples made with cows' milk. The sensory evaluation and colour properties of the kefir samples improved when buffalo milk was used.

Keywords Buffalo milk, Kefir, Rheology, Sensory analysis.

INTRODUCTION

Kefir, an acidic and slightly alcoholic fermented milk product, is produced using a mixture of lactic and acetic acid bacteria and yeasts. It is not only rich in nutrients but also confers protective effects for disorders such as lactose intolerance, intestinal immunity and inflammatory intestinal disorders (Figler *et al.* 2006). Although it is a traditional beverage originating from the Caucasus Mountains, it is often consumed in eastern Europe, south-west Asia and Russia. The increase in kefir consumption can be attributed to its sensory attributes and potential health benefits. In addition, there has been an increase in scientific research prompted by the increasing demand for kefir.

Kefir production is mainly based on the fermentation of milk using starter cultures or kefir grains, which look like small cauliflowers and which contain a complex mixture of lactic acid bacteria, acetic acid bacteria and yeasts. The complex microbiota in kefir grains has a symbiotic relationship that is responsible for the characteristic taste and flavour of kefir (Guzel-Seydim *et al.* 2005). Lactic acid, CO_2 and ethanol are the main fermentation end products responsible for kefir's aroma characteristics (Beshkova *et al.* 2003). Variations in the microbiota of kefir grains may be caused by several factors such as its origin, grain cultivation methods, sanitation conditions and preservation techniques (Miguel *et al.* 2010). These differences may cause problems for the standardisation of kefir production. Lyophilised kefir starter cultures are preferred for industrial production, to obtain a standard product (Fontan *et al.* 2006). Cows' milk is the most common type of milk in industrial production, but different milk types (e.g. ewes', goats' and soy milks) have also been used (Kesenkaş *et al.* 2011). The commercial production of kefir should ensure the product has acceptable flavour, aroma and mouth-feel properties, such as those relating to its rheological characteristics.

The measurement of the rheological properties of fluid foods is important to determine process engineering calculations, final product quality, effects of ingredients on product acceptance and shelf life tests (Dogan 2011). Studies have shown that the specific type of milk (e.g. cows', sheep' or goats') has a considerable effect on the rheological, textural and organoleptic properties of kefir (Wszolek *et al.* 2001; Tratnik *et al.*

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2006). Buffalo milk is the second most commonly produced milk, comprising 13% of milk produced globally (Medhammar *et al.* 2012). There is no study on the use of buffalo milk for kefir production and its effect on the rheological properties or kefir quality. In addition, the effects of using buffalo milk on viscosity and flow properties of kefir using kefir grains or starter culture are not clear. Comparative analysis of kefir produced with buffalo and cows' milk is important for understanding the differences between milk type effects on the composition and physical properties of kefir (Nguyen *et al.* 2014). Kefir manufacture with different milk types can also offer more diverse products with regard to flavour, taste and quality. There is only one study in the literature that has compared kefir made with buffalo and cows' milk, characterising the different chemical properties (Gul *et al.* 2015). The objective of this study was to investigate and compare the effects of cows' and buffalo milk on the rheological, textural, colour and organoleptic properties of kefir made with kefir grains and starter culture.

MATERIAL AND METHODS

Material

Kefir grains were provided by the Pilot Dairy Plant at Ondokuz Mayis University, Samsun, Turkey, and commercial kefir starter culture (according to the supplier, the starter culture contained *Lactococcus* spp., *Leuconostoc* spp., *Streptococcus thermophilus, Lactobacillus* spp. and kefir yeast) was obtained from Danisco Biolacta (Kefir DC1 1000 L; Danisco Biolacta, Olsztyn, Poland). The grains were stored at −18 °C and used after reactivation by successive subcultures in ultra-high-temperature-treated milk (Pınar Company, İzmir, Turkey) obtained from a local market. For the kefir production, the raw buffalo and cows' milks were supplied from Pilot Dairy Plant.

Kefir production

Raw buffalo milk (6.4% fat, 4.71% protein, 17.31% total solid and 6.87 pH) and cows' milk (3.6% fat, 3.36% protein, 11.88% total solid and 6.78 pH) were standardised to 11.5 g/100 g for total solid contents by adding drinking water. Then the milks were heated for 15 min at 90 °C and rapidly cooled to 25 °C. For kefir production with kefir grains, the cooled milks were inoculated with 5% (w/v) kefir grains and incubated at 24 °C for 18 h until the pH decreased to ~4.5. After the incubation step, the kefir grains were separated from the kefir using a sieve in aseptic conditions. For kefir production using the kefir starter culture, the freeze-dried kefir starter culture was added to raw milk at a level of 0.025 g/L milk, then the samples were incubated at 24 °C for 18 h until the pH reached to ~4.5, and then finally the curd was broken. The kefir samples thus produced were transferred to high-density polyethylene bottles and stored at 4 °C until further analysed. The samples were coded as follows: BS (buffalo milk kefir using starter culture), CS (cows' milk kefir using starter culture), BG (buffalo milk kefir using kefir grains) and CG (cows' milk kefir using kefir grains).

After incubation, the protein (3.12–3.18% for buffalo milk kefir and 3.19–3.26% for cows' milk kefir) and total fat (4.15–4.25% for buffalo milk kefir and 3.45–3.5% for cows' milk kefir) content of the kefir samples were determined using the methods described by Bradley *et al.* (1992).

Determination of exopolysaccharide level

The exopolysaccharide (EPS) levels of the kefir samples were determined using the method described by Purwandari *et al.* (2007). Briefly, 30 g of kefir sample was centrifuged (Nüve-Bench Top Centrifuge, NF 1200R Bench Top Centrifuge; Nüve, İzmir, Turkey) at 8000 *g* at 4 °C for 4 min and the supernatant was collected. Two volumes of ethanol and one volume of supernatant were mixed homogenously and stored at 4 °C overnight. The solution was then centrifuged at 2000 *g* at 4 °C for 15 min, and supernatant was discarded. The precipitate was dissolved in 10 mL of distilled water, and 250 mL of 80% trichloroacetic acid was added to precipitate the remaining protein. The mixture was centrifuged at 2000 *g* at 4 °C for 15 min after storage overnight at 4 °C, and the supernatant was collected again. The supernatant was treated with ethanol to induce precipitation, and then, the EPS in the supernatant was collected as described above. Finally, the EPS was dried at 50 °C using a vacuum drier and weighed. The results were expressed as the amount of crude EPS per kg of kefir.

Water-holding capacity analysis

The water-holding capacity (WHC) of the kefir samples was determined using a centrifugal method described by Yang *et al.* (2014). Approximately 30 g of the homogenised kefir sample was weighed into a test tube and centrifuged (Nüve-Bench Top Centrifuge, NF 1200R) at 3250 *g* for 10 min at 4 °C. The separated whey was weighed, and the WHC was expressed as the percentage weight of the whey separated from kefir over the initial weight.

Firmness (gel strength)

The textural measurements of the kefir samples were performed based on the method described by Glibowski and Kowalska (2012) using a TA.XT Plus Texture Analyser (Stable Microsystems, Godalming, UK) equipped with a 2 kg load cell and data analysis software package Texture Expert for Windows (Texture Exponent 32). All measurements were taken at 15 °C in triplicate. Samples were double-punched by a cylindrical probe (1 cm diameter, with a 30-s rest period between) with the crosshead speed 1 mm/s at 15 mm depth. The firmness (or gel strength) of the kefir was defined as a maximal peak value recorded after the first immersion into the sample.

Rheological analysis

Rheological properties of the kefir samples were measured using an Haake Mars III rheometer (Thermo Scientific, Karlsruhe, Germany) with a cone and plate (35 mm diameter, 0.105 mm gap, 2° angle). Temperature was controlled using a circulator water bath at 25 °C.

Steady-state shear properties

The flow behaviour of the kefir samples was measured by recording shear stress values when shearing the samples at linearly increasing shear rates from 1 to 100/s through 100 s. The relationship between shear stress and shear rate was described by the Ostwald–de Waele model (Eqn 1).

$$\eta_{app} = K\gamma^{n-1} \tag{1}$$

where η_{app} is apparent viscosity (Pa s), $\dot{\gamma}$ the shear rate (/s), K the consistency index (Pa s^n) and n the flow behaviour index (dimensionless). The calculations were made using the Rheowin 4 Data Manager software (version 4.20, Haake, Karlsruhe, Germany). The apparent viscosity values of the kefir samples were evaluated at the specified shear rate of 50/s which indicates shear rate in mouth.

Dynamic shear properties

The viscoelastic properties of the kefir samples were measured using small-amplitude oscillatory shear tests at 25 °C. The linear viscoelastic region (LVR) of the samples was previously determined by running stress sweeps test between 0.1 and 1000 Pa, at a frequency of 1 Hz. The frequency sweep test was carried at 1 Pa over a frequency range of 0.1–100 Hz at 25 °C considering stress sweep test results. The oscillatory rheological parameters used to compare the viscoelastic properties of kefir samples were elastic or storage modulus (G') and viscous or loss modulus (G''). G' *and* G'' were calculated by the following;

$$G' = G'' * \cos\delta \tag{2}$$

$$G'' = G * \sin\delta \tag{3}$$

Colour properties

Colour measurements were performed to determine $L*$ (Lightness), $a*$ (red-green) and $b*$ (yellow-blue) values of the kefir samples using a colorimeter (Minolta Chroma Meter, CR-400, Osaka, Japan). The colour of the samples was characterised as chroma ($C*_{ab}$) and whiteness index (WI) as defined by the following equations:

$$\text{Chroma} = C^*_{ab} = \sqrt{a^{*2} + b^{*2}} \tag{4}$$

$$\text{Whiteness Index} = \text{WI} = 100 - \sqrt{(100 - L^*)^2 + a^{*2} + b^{*2}} \tag{5}$$

Sensory evaluation

Sensory analyses of the kefir samples were performed by 12 (seven males and five females) trained panellists. The samples were randomly presented in transparent glass cups to the panellists, and then each panellist tested the samples and recorded their perceptions using a score system. A 10-point hedonic scale ranging from 1 (disliked extremely) to 10 (liked extremely) was used to evaluate consistency, appearance, flavour, odour and overall acceptability.

Statistical analysis

Experiments were carried out with three separate samples, and each analysis was performed in duplicate. All data were analysed using SPSS for Windows version 21.0 (SPSS Inc., Chicago, IL, USA). One-way analysis of variance (ANOVA) and Duncan's multiple comparison test were used to assess the differences between mean values with a significance level of $P < 0.05$.

RESULTS AND DISCUSSION

Exopolysaccharide level, WHC and gel firmness

The EPS content, WHC and gel firmness values of the buffalo and cows' milk kefir samples produced with kefir grains and starter culture are presented in Table 1. The EPS contents of BS and CG samples were the highest and lowest (0.237 and 0.155 g/kg), respectively. Milk type and the culture used for kefir production had significant effects on EPS production. The EPS content significantly increased ($P < 0.05$) with use of buffalo milk for kefir production, which can probably be attributed to the composition (i.e. carbon and the nitrogen content) of the buffalo milk. Kefir samples produced with the starter culture had higher EPS levels than those made using kefir grains ($P < 0.05$). It is known that the content and characteristics of EPS can vary depending on the differences in microbiota of the culture and composition of the medium (Chen *et al.* 2015). Exopolysaccharide influences the texture, stability and sensory properties of fermented milk products such as kefir (Mende *et al.* 2016). In addition, several studies have reported that EPS production affects viscosity, increases WHC, improves stability and promotes the sensory properties of fermented milk products (Kristo *et al.* 2011; Yang *et al.* 2014).

The WHC of fermented dairy products results from the aggregation of protein particles due to gravity (Kesenkaş *et al.* 2011). This is a major visible defect that develops during storage of fermented dairy products that directly affects consumer acceptance (Nguyen *et al.* 2014). In the present study, the WHC values of the kefir samples ranged from 42.61 to 77.35% and the highest value was determined for the BS samples (Table 1). With regard to the samples made using the kefir starter culture, the buffalo milk kefir samples had significantly higher WHC values than those

Table 1 Exopolysaccharide, water-holding capacity and firmness values of kefir samples

Sample	EPS (g/kg)	WHC (%)	Firmness (N)
BS	0.237 ± 0.005^{a}	77.35 ± 0.6^{d}	0.177 ± 0.011^{a}
CS	0.197 ± 0.004^{b}	65.79 ± 2.33^{c}	0.142 ± 0.009^{c}
BG	0.173 ± 0.003^{c}	58.56 ± 0.26^{b}	0.161 ± 0.003^{b}
CG	0.155 ± 0.005^{d}	42.61 ± 0.32^{a}	0.141 ± 0.08^{c}

BS, buffalo milk kefir using starter culture; CS, cows' milk kefir using starter culture; BG, buffalo milk kefir using kefir grains; CG, cows' milk kefir using kefir grains; EPS, exopolysaccharide; WHC, water-holding capacity. Values are means ± standard deviation. Means within the same column with different letters are different at $P < 0.05$.

manufactured from cows' milk ($P < 0.05$). Buffalo and goats' milk have larger casein micelles than cows' milk because their protein networks have smaller pores, higher density and higher WHC (Gomes *et al.* 2013). Additionally, the surface area of the fat globules is another parameter that affects the WHC of fermented dairy products as protein can be absorbed to the surface of fat globules leading to a network that can hold water (Nguyen *et al.* 2014). Nguyen *et al.* (2014) reported that a decrease in yoghurt WHC depended on the increase in the surface area of the fat globules of cows' milk. However, Menard *et al.* (2010) reported a low surface area for the fat globules of buffalo milk: 1.78 vs 1.97 m^2/g of fat for cows' milk. In the current study, the kefir samples manufactured using starter culture also had lower WHC than the ones produced using kefir grains (Table 1). Lucey *et al.* (1998) reported that the WHC in fermented dairy products can be affected from acidity, total solids and milk and culture types. Additionally, Hassan (2008) stated that EPS content could improve the WHC of yoghurt by interacting between proteins and micelles. Thus, the higher EPS level in buffalo milk kefir could be a reason for its higher WHC.

In the current study, the type of milk and culture used for kefir production had a significant factor on the firmness of the samples, as revealed by the texture analysis results ($P < 0.05$), shown in Table 1. The highest firmness value was obtained for the BS sample (0.177 N) although the total solid contents of the buffalo and cows' milk were standardised prior to fermentation. High gel firmness in kefir from buffalo milk could be attributed to its relatively high EPS levels and fat contents. Yang *et al.* (2014) stated that firmness of buffalo milk yoghurt increased with higher levels of EPS, which can be explained by the interaction between proteins and EPS. Ramchandran and Shah (2009) found that a decrease in fat content can result in a fragile texture due to the weaker protein gel in fermented milk. Additionally, Michalski *et al.* (2002) found a positive relationship between fat globule size and the mechanical properties of yoghurt gel. Therefore, higher firmness values in kefir from buffalo can be also explained by the larger size of fat globules in buffalo milk as compared to cows' milk (Menard *et al.* 2010). In addition, α_{s-1} casein plays a very important role in gel formation, namely a higher α_{s-1} casein content can cause a strong texture (Michalski *et al.* 2002). Buffalo milk has higher α_{s-1} casein content (1.42 g 100/mL milk) than cows' milk, which has values of around 1.08 g 100/mL milk (Hussain *et al.* 2012).

Use of the kefir starter culture caused higher firmness than when kefir grains were used ($P < 0.05$; Table 1). Similar results were obtained by Montanuci *et al.* (2012) who found lower firmness values using kefir grains compared to kefir starter culture. During the manufacturing process, a sieve was used to separate this kefir grains from the kefir beverage, which damaged the gel structure so that lower levels of firmness were obtained. Additionally, Tamime and Robinson (1999) stated that the firmness and texture of fermented milk products could be influenced by starter microorganisms due to production of EPS from lactose.

Rheological properties

Steady state

The Ostwald–de Waele model was successfully used to model the rheological properties of the kefir samples. The coefficient of correlation value of model was found to be between 0.972 and 0.991 (Table 2). According to the flow

Table 2 Viscosity, consistency index, flow behaviour index values of kefir samples which obtained from Ostwald–de Waele model system

Sample	η_{app} (50/s)	K (Pa s^n)	n	R^2
BS	0.443 ± 0.041^{a}	9.014 ± 0.896^{a}	0.412 ± 0.017^{a}	0.983
CS	0.185 ± 0.009^{c}	2.947 ± 0.527^{b}	0.348 ± 0.026^{b}	0.991
BG	0.355 ± 0.021^{b}	8.863 ± 0.905^{a}	$0.388 \pm 0.04^{a,b}$	0.972
CG	0.161 ± 0.005^{d}	3.365 ± 0.879^{b}	0.332 ± 0.032^{b}	0.977

η_{app}, apparent viscosity; K, consistency index; n, flow behaviour index; BS, buffalo milk kefir using starter culture; CS, cows' milk kefir using starter culture; BG, buffalo milk kefir using kefir grains; CG, cows' milk kefir using kefir grains. Values are means ± standard deviation. Means within the same column with different letters are different at $P < 0.05$.

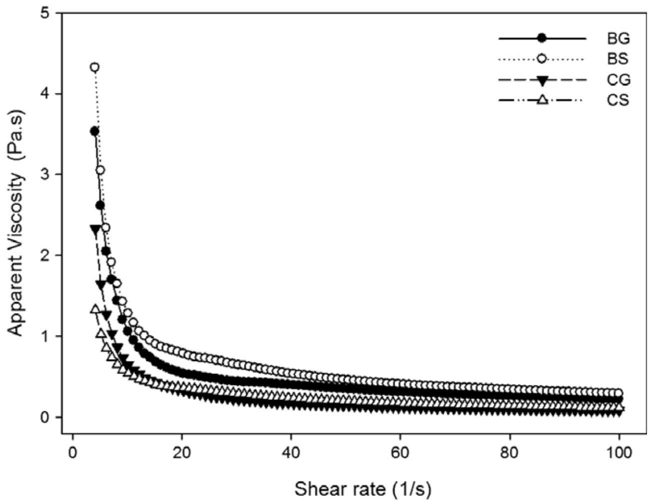

Figure 1 The flow behaviour of the kefir samples. BS, buffalo milk kefir using starter culture; CS, cows' milk kefir using starter culture; BG, buffalo milk kefir using kefir grains; CG, cows' milk kefir using kefir grains.

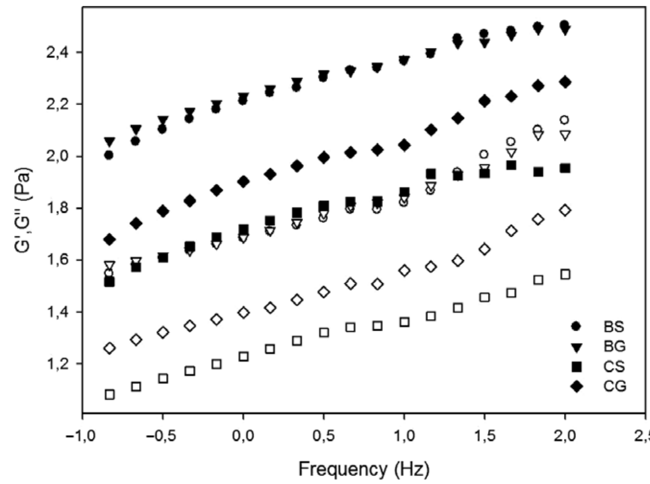

Figure 2 Storage (G') and loss modulus (G'') of the kefir samples. BS, buffalo milk kefir using starter culture; CS, cows' milk kefir using starter culture; BG, buffalo milk kefir using kefir grains; CG, cows' milk kefir using kefir grains.

curves of the kefir samples, viscosity decreased with increasing shear rate, meaning that the kefir behaved as a pseudoplastic fluid (Figure 1). Materials with three-dimensional structure having this type of rheological behaviour are destroyed under shear force. The flow behaviour index (n) provides information about the effects of shear on the system, and three value ranges can be described for n as follows: $n < 1$, the system is usually shear-thinning; $n = 1$, the system shows a Newtonian flow behaviour; and $n > 1$, the system is shear-thickening. The flow behaviour index values of the kefir samples were <1, which indicated that they exhibited shear-thinning behaviour, resulting from the breakdown of the gel structure due to the shear applied to the samples. This type of rheological behaviour is common for fermented milk products because of their weak physical bonds and electrostatic and hydrophobic interactions (Ertekin and Guzel-Seydim 2010).

As can be seen from Table 2, the highest viscosity value was observed to be 0.443 Pa s at 50/s shear stress in the BS sample, while the lowest viscosity value was found to be 0.161 Pa s in the CG sample. The viscosity results for the CS sample were similar to the findings of Dogan (2011), which were reported to be 0.17 Pa s in kefir made with cows' milk using starter culture. The type of milk and fermentation culture (kefir culture or grains) significantly affected the viscosity values of the kefir samples ($P < 0.05$). Using buffalo milk resulted in higher viscosity values than when the kefir was made using cows' milk. Higher viscosity values were attributed to the higher fat content of buffalo milk compared to cows' milk and the higher EPS level of the buffalo milk kefir. Akgun *et al.* (2016) reported that the viscosity of the buffalo yoghurts increased with higher levels of fat. In another study reported by Tamime and Robinson (2007), increasing viscosity was explained by fat globules in the protein network improving WHC, as casein fat globule membrane interactions caused an increase in viscosity due to more stable gel formation. On the other hand, Zhang *et al.* (2012) reported that EPS could improve the viscosity of cows' milk yoghurt, but Yang *et al.* (2014) reported that with increasing EPS addition, the viscosity of the yoghurt decreased.

With regard to viscosity values, the highest consistency index value (K) was determined for the BS samples ($P < 0.05$), indicating that buffalo milk kefir was more viscous. Milk type significantly influenced the K values of the kefir samples ($P < 0.05$). However, the effect of the type of culture or kefir grains for manufacture of kefir on K values was not statistically significant ($P > 0.05$).

Dynamic shear properties

A stress sweep test of the kefir samples was carried out to determine their LVR over a range of 0.1–1000 Pa at constant frequency (1 Hz). Based on these results, 1 Pa was chosen as the fixed stress value and frequency sweep test was conducted at this parameter. The dynamic oscillatory test is applied to determine the viscoelastic properties of food materials. The G' modules, called the storage modulus, indicate the magnitude of stored energy, and the G'' is a measure of the energy that is lost by viscous dissipation with deformation and is called the loss modulus (Bortnowska *et al.* 2014).

Dynamic mechanical spectra of the kefir samples are shown in Figure 2, as a function of angular frequency (Hz). Both G' and G'' values increased with frequency for all the kefir samples. The G' values of all samples at

Table 3 Colour properties of kefir samples

Sample	*L**	*a**	*b**	*C*	*WI*
BS	92.98 ± 0.06[a]	−1.71 ± 0.12[b]	6.47 ± 0.43[b]	6.69 ± 0.45[b]	90.29 ± 0.29[a]
CS	91.80 ± 0.12[a]	−0.873 ± 0.29[a]	10.15 ± 1.04[a]	10.19 ± 1.06[a]	86.9 ± 0.27[b]
BG	92.22 ± 0.18[a]	−1.49 ± 0.23[b]	6.56 ± 0.72[b]	6.73 ± 0.74[b]	89.29 ± 0.41[a]
CG	91.93 ± 0.14[a]	−1.01 ± 0.37[a]	10.61 ± 1.33[a]	10.66 ± 1.35[a]	86.76 ± 0.39[b]

BS, buffalo milk kefir using starter culture; CS, cows' milk kefir using starter culture; BG, buffalo milk kefir using kefir grains; CG, cows' milk kefir using kefir grains; C, chroma; WI, whiteness index. Values are means ± standard deviation. Means within the same column with different letters are different at $P < 0.05$.

each frequency were higher than the G'' values, which meant the kefir samples showed elastic properties. We should also mention that the kefir samples had weak gel formation typical of fermented dairy beverages (Glibowski and Kowalska 2012). The highest G' value of the kefir samples was observed at 1 Hz frequency in the BG sample while the lowest G' value was determined for the CS sample. Similarly, the highest and lowest G'' values were determined in the BG and CS samples, respectively. Storage and loss modulus values of the samples significantly changed depending on milk type ($P < 0.05$), but the use of culture or kefir grains for manufacture of kefir did not affect the modulus values of the samples ($P > 0.05$). The difference between the buffalo and cows' milk kefir was attributed to the higher fat content of the buffalo milk kefir.

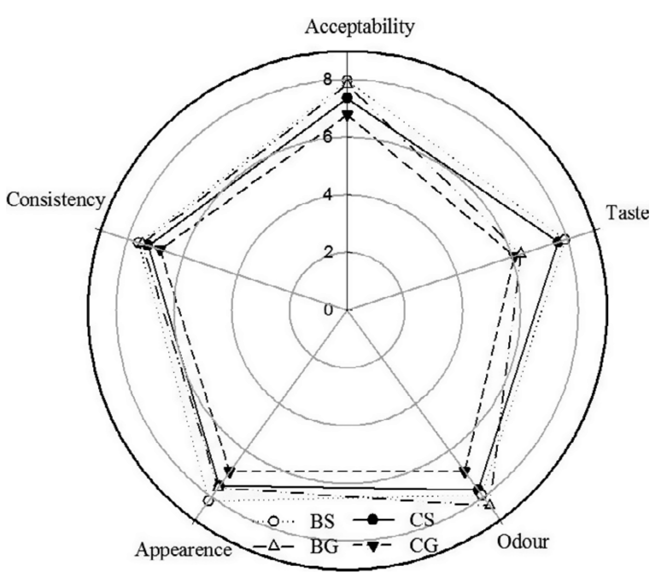

Figure 3 Sensory attributes and overall preference of the kefir samples. BS, buffalo milk kefir using starter culture; CS, cows' milk kefir using starter culture; BG, buffalo milk kefir using kefir grains; CG, cows' milk kefir using kefir grains.

Colour properties

The L^*, a^* and b^* values determined for the kefir samples are shown in Table 3, together with the chroma and WI values. It was observed that kefir produced from buffalo milk appeared whiter than kefir from cows' milk, but this was not significantly different ($P > 0.05$). However, the WI values of the kefir sample manufactured from buffalo milk were higher ($P < 0.05$). This can be explained by the low b^* value (yellow/blueness) of buffalo milk kefir, which contained less riboflavin content than cows' milk one (El-Salam and El-Shibiny 2011). Dimitreli *et al.* (2014) stated that the b^* value varied depending on riboflavin content rather than fat content. The a^* values were negative for all the kefir samples, which appeared slightly green in colour. Values of C^*, the saturation or colour intensity, were significantly affected by the type of milk used for kefir production ($P < 0.05$).

Sensory evaluation

Figure 3 contains the results of sensory evaluation of the kefir samples made from cows' and buffalo milk. The results showed that there were significant differences in sensory scores of the kefir samples ($P < 0.05$). Buffalo milk kefir produced with starter culture was evaluated as having higher consistency, appearance and flavour scores than the other kefir samples ($P < 0.05$). This was in accordance with the higher viscosity and textural properties of the kefir samples; the panellists stated that overall acceptability was very high at 7.95. Similarly, Nahar *et al.* (2007) reported that body and consistency scores were highest in the case of dahi (a fermented dairy product) produced from buffalo milk. The differences in consistency of the kefir samples can be explained by their fat content and some milk components such as casein micelles size, as the protein and total solid contents of cow and buffalo milk were standardised. Additionally, sensory changes relating to EPS level resulted in a firmer body, enhanced creaminess and characteristic ropiness as well as increased WHC (Folkenberg *et al.* 2005). Some panellists stated that kefir from buffalo milk using kefir culture was less drinkable due to its high viscosity, which was probably a result of its high EPS level.

The appearance and taste scores of the kefir samples made with starter culture were higher than those made with kefir grains ($P < 0.05$), and the milk type had no effect on the taste of the kefir samples ($P > 0.05$). However, cows' milk kefir produced with starter culture was found to be more aromatic than the buffalo milk kefir due to the presence of higher levels of foam. Some panellists stated that the buffalo milk kefir samples showed high shininess and creaminess, probably due to their higher EPS and fat levels. The cows' milk kefir samples produced with kefir grains had lower general acceptability than the other kefir samples, while the panellists reported that kefir samples made with kefir grains showed weaker viscosity.

CONCLUSION

The study revealed that the kefir samples produced with buffalo milk had higher EPS, viscosity, storage and loss modulus, consistency index and firmness and lower WHC levels as compared to the cows' milk kefir samples, although the total solid contents of both the buffalo and cows' milk were standardised to 11.5 g/100 g before the fermentation. The buffalo milk kefir samples had better sensory characteristics than the cows' milk kefir samples, except for texture scores. Therefore, buffalo milk should be used for industrial kefir production due to its lower serum separation, which is a problem for kefir during storage. On the other hand, although some panellists reported that buffalo kefir produced using starter culture had a very intensive textural structure and also bearing in mind the high price of buffalo milk, use of a combination of buffalo and cows' milk may be preferred in terms of consumer expectations and lower kefir costs.

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