The objectives of this study were to determine the possibility of manufacturing yoghurt by mixing different percentages of cow milk to camel milk and to detect the effect of this on the physiochemical characteristics of camel milk yoghurt and the sensory evaluation of the yoghurt produced. Camel milk was mixed with cow milk to form 3 treatments: A (75% camel's milk +25% cow's milk), B (50% camel's milk +50% cow's milk) and C (25% camel's milk +75% cow's milk). The result has shown significant differences (p≤0.05) in physiochemical characteristics of the mean value of fat (5.10±0.115; 4.90±0.153; 4.60±0.208), protein (4.33±0.088; 4.07±0.088; 3.57±0.133), lactose (4.027±0.120; 3.97±0.088; 2.80±0.058), T.S. (14.50±0.321; 13.77±0.233; 11.87±0.167) and SNF (9.40±0.208; 8.87±0.120; 7.27±0.058, T.S. (14.50±0.321; 13.77±0.233; 11.87±0.167) and SNF (9.40±0.208; 8.87±0.120; 7.27±0.058) for the three treatments C, B and A, respectively. Camel milk yoghurt treatments have higher moisture content (p≥0.05) (88.13±0.167; 86.23±0.233; 85.50±0.321) for the three treatments A, B and C, respectively, but lower T.S. (14.50±0.321; 13.77±0.233; 11.87±0.167) than pure cow milk yoghurt (15.37±0.219). Increase in lactose (4.027±0.120) was only observed with treatment C compared to cow milk yoghurt (4.06±0.088). The effect of different samples from camel and cow milk yoghurt had no significant difference (p≥0.05) on pH, but significantly affected the acidity (0.79±0.0176; 0.78±0.0173; 0.76±0.0153) of the mixture of camel and cow milk yoghurt treatments A, B and C, respectively compared to cow milk yoghurt (0.74±0.0163). The sensory evaluation of mixed camel and cow milk yoghurt
treatments A, B and C, appeared to be of high significance (p≤0.05) on taste, flavor, smell, texture but no significant difference (p≥0.05) recorded on the color. Index Terms — Yogurt, mixing camel and cow milk, sensory evaluation.

I. INTRODUCTION

The camel is raised in the arid and semiarid zones where feed resources are frequently scarce. Therefore, the changes in camel milk taste are caused by the type of fodder and availability of drinking water. In an environment where other species would not survive or not give sufficient milk, camel milk is considered a very important element in the diet of most camel herders (Zakaria Farah, 1996). Konuspayeva et al. (2009) stated that the dromedary camel milk protein contents range from 2.15 to 4.90%. The two main components of protein in camel milk are casein, which is the major part, and whey protein. Casein protein ranges from 1.63 to 2.76% of the protein which constitutes 52 to 87% of the total milk protein, while whey protein (0.9%) resembles 20 to 25% (Khaskheli et al., 2005). The fat level of the dromedary camel varies from 1.2 to 6.4% and a constructive association between protein and fat contents of camel milk was observed (Haddadin et al., 2008). Konuspayeva et al. (2009) reported that the fat contents can be reduced from 4.3 to 1.1% in the milk of thirsty camels. The total amount of minerals of dromedary camel milk (0.60 to 0.90%) is generally presented as total ash. This variation in the mineral level was explained to be due to the differences in feeding, breed, water intake and analytical procedures (Haddadin et al., 2008). In the manufacturing of dairy products pH plays a significant role to determine the end product quality. The pH of camel milk ranges between 6.5 and 6.7 (Khaskheli et al., 2005). The titratable acidity of camel milk is the measure of lactic acid formed in camel milk. The min. titratable acidity, expressed as % lactic acid (% m/m) is 0.6% (CODEX, 2003).

Unprocessed camel milk remains fit for consumption for four to five days, although its acidity increases significantly during this period (Eyassu, 2008). Camel milk can be processed into various types of products e.g. yoghurt, butter etc. Naturally fermented camel milk products namely susac and shubat are produced in Kenya, Somalia and Sudan (Alhadrami, 2003) and "gariss" (fermented sour camel milk) in Sudan (Abdelgadir et al., 1998). Fermented camel milk has a high biological value due to the high content of antimicrobial factors such as lysozme, lactose and immunoglobins (Elagamy, 1994).

Yoghurt is a product of the lactic acid fermentation of milk by addition of a starter culture containing Streptococcus thermophilus and Lactobacillus delbrueckii ssp. bulgaricus. In
some countries less traditional microorganisms, such as *Lactobacillus helveticus* and *Lactobacillus delbrueckii* ssp. *lactis*, are sometimes mixed with the starter culture (McKinley, 2005).

The main processing steps in the manufacture of these products include milk standardization, heat treatment, and homogenization, addition of starter culture and fermentation, then cooling and finally storage of end product. Many other processing steps e.g. (Addition of sugar or fruit) are practiced for some products (Lucey, 2002).

The preparation and consumer acceptability tests of fermented camel milk (*Suusa*) were studied by Farah *et al.* (1990) who found that the consistency of fermented milk (under lab conditions) was thin and a precipitate in the form of flecks was formed rather than a coagulum after fermentation. These studies had clearly stated the difficulty of producing fermented camel milk products with high consistency due to the problem associated with milk coagulation. Camel milk contains good amounts of lysozyme, lactoferrin, Lactoperoxidase, immunoglobulin G and secretory immunoglobulin A. These antimicrobial factors are present at significantly greater concentrations in camel milk and are more heat stable compared with those in cow and buffalo milks (El-Agamy *et al.*, 1992). Camel milk is often mixed with fresh or other cultured species (cows, goats and sheep) particularly when intended to make products such as butter and cheese (Eyassu, 2008).

This study investigated the specific changes that can take place on the physiochemical characteristics and sensory evaluation in yoghurt made from mixing different percentages of cow milk with camel milk.

II. MATERIALS AND METHODS

Materials

Fresh camel milk was obtained from the Camel Research Center, University of Khartoum (Shambat) and fresh cow milk was obtained from Animal Production Department dairy farm, College of Agriculture Studies, Sudan University of Science and Technology (Shambat). Fresh milk samples were taken in clean plastic containers to National Food Research Center Laboratory (NFRCL) in Khartoum (Shambat) for determination of physiochemical components. Skim powder milk was obtained from local market.

The procedure of yoghurt production
Yoghurt was prepared according to (Lee and Lucey, 2010) and (Dirar, 1993) procedures. Raw camel and cow milk were filtered and the total solids were increased to 15% by adding skimmed powder milk. The milk was heated at 85 °C for 30 min as described by Dirar (1993), and rapidly cooled to 43 °C. Then the starter culture of *Streptococcus salivarius* subspecies *thermophilus*, *Lactobacillus delbrueckii* subspecies *bulgaricus* was added at the rate of 3% and blended thoroughly.

**Physiochemical analysis of milk and yoghurt**

Chemical composition of milk and yoghurt (fat, protein, lactose, TS, SNF, Ash, Ca, P and moisture) and physical characteristics (pH, Acidity and density) were analyzed at NFRCL. Then samples were stored in a refrigerator for subsequent processing. All chemicals and media used in this study were of reagent grade.

Fat was determined by Gerber method described by AOAC (1995). Total nitrogen was measured by Kjeldahl method according to AOAC (1995) and protein % was calculated as N% × 6.38. Lactose was determined by Anthrone Method (Richard, 1959). Total solids content was determined according to AOAC (1995) using a forced draft oven at 100 °C for 3 hrs. The total solids (T.S.) content was calculated as follows: T.S.% = W1/W2 X 100. Where: W1=Weight of sample after drying; W2=Weight of sample before drying. Solids non-fat (S.N.F) content was determined from the following equation SNF (%) = % T.S.% - Fat%.

Ash content was determined by gravimetric method AOAC (1995) using a muffle furnace at 550-600 °C for 3 hrs until ash was carbon free. Moisture content was determined according to AOAC (1995) by drying samples overnight at 105°C. For calcium and phosphorus determination samples were asched in the furnace at 550 °C for 16 hrs and Calcium was determined using an atomic absorption spectrometer and phosphorus was measured at 400 nm by spectrophotometer.

Density of the milk samples were determined by milk analyzer using (Lacto scan Milktotronic LTD, Supply 230 VAC) (University of Khartoum). Total titratable acidity was determined according to AOAC (1990) method. The pH was determined by electric pH meter (HANNA-pH, 209, Germany).

**Experimental treatments of yoghurt:** Camel milk was mixed with cow milk to form 5 treatments: A (75% camel's milk +25% cow's milk), B (50% camel's milk +50% cow's milk),
Treatment A: 75% camel's milk + 25% cow's milk.

450 ml camel's milk + 150 ml cow's milk from the prepared yoghurt were measured and mixed (600 ml), packed in plastic cups (200 ml capacity) for analysis and (25 ml capacity) for panel test and incubated at 43 °C for 6 hours. Then the yoghurt was transferred to refrigerator at 4 °C for 2 days. The yoghurt samples physiochemical component were analyzed and sensory evaluation done and replicated for each treatment. Samples from each batch were stored for 10 days to determine their acidity and pH after storage period.

Treatment B: 50% camel's milk + 50% cow's milk.

300 ml camel's milk + 300 ml cow's milk from the prepared yoghurt were measured and mixed (600 ml), then packed in plastic cups (200 ml capacity) for analysis and (25 ml capacity) for panel test and incubated at 43 °C for 4 hours. Then the yoghurt was transferred to refrigerator at 4 °C for 2 days. The yoghurt samples physiochemical component were analyzed and sensory evaluation done, replicated for each treatment. Samples from each batch were stored for 10 days to determine their acidity and pH after storage period.

Treatment C: 25% camel's milk + 75% cow's milk.

150 ml camel's milk + 450 ml cow's milk from the prepared yoghurt were measured and mixed (600 ml), then packed in plastic cups (200 ml capacity) for analysis and (25 ml capacity) for panel test and incubated at 43 °C for 4 hours. Then the yoghurt was transferred to refrigerator at 4 °C for 2 days. The yoghurt samples physiochemical component were analyzed and sensory evaluation done, replicated for each treatment. Samples from each batch were stored for 10 days to determine their acidity and pH after storage period.

Treatment D: pure camel's milk (100%).

600 ml camel's milk from the prepared yoghurt, packed in plastic cups (200 ml capacity) for analysis and (25 ml capacity) for panel test and incubated at 43 °C for 6 hours. Then the yoghurt was transferred to refrigerator at 4 °C for 2 days. The yoghurt samples physiochemical component were analyzed and sensory evaluation done, replicated for each treatment. Samples from each batch were stored for 10 days to determine their acidity and pH after storage period.
Treatment E: pure cow's milk (100%).
600 ml cow's milk from the prepared yoghurt packed in plastic cups (200 ml capacity) for analysis and (25 ml capacity) for panel test and incubated at 43 °C for 3 hours. Then the yoghurt was transferred to refrigerator at 4 °C for 2 days. The yoghurt samples physiochemical component were analyzed and sensory evaluation done, replicated for each treatment. Samples from each batch were stored for 10 days to determined their acidity and pH after storage period.

Sensory evaluation of yoghurt
Sensory profiling of the milk samples was conducted, using conventional profiling, by panelists. Twelve panelists were selected among the staff and students of the Animal Production Department, College of Agriculture, Sudan University. The panelists were given a hedonic questionnaire to test taste, texture, color, flavor and overall acceptability of coded samples of different treatments.

Statistical analyses: Data generated was subjected to statistical analysis system program (Statistical Package of Social Science (SPSS) version 11.5, using Analysis of Variance, Independent T test for fresh milk and Completely Randomized Design (CRD) for yoghurt and means separated by Duncan’s Multiple Range Test (DMRT).

III. RESULT
The effect of mixing different percentage of cow milk to the chemical composition of camel milk yoghurt
The result has shown significant differences (p≤0.05) in physiochemical characteristics of the mean value of the protein (3.57±0.133; 3.57±0.133; 4.33±0.088; 3.23±0.0881 & 4.67± 0.088), fat (4.60±0.208; 4.90±0.153; 5.10±0.115; 4.27±0.203 & 5.33±0.145), lactose (2.80±0.058; 3.97±0.088; 4.027±0.120; 3.43±0.291 &4.06±0.0881), T.S. (11.87±0.167; 13.77±0.233; 14.50±0.321; 11.83±0.176 & 15.37±0.219) and SNF (7.27±0.145; 8.87±0.120; 9.40±0.208; 7.57±0.376 & 10.03±0.088) for the 5 treatments A, B, C, D and E, respectively. Camel milk yoghurt treatments have higher moisture content (p≥0.05) (88.13±0.167; 86.23±0.233; 85.50±0.321; 88.17±0.176 & 84.63±0.219) for the 5 treatments A, B, C, D and E, respectively, but lower T.S. (11.87±0.167; 13.77±0.233; 14.50±0.321; 11.83±0.176) than pure cow milk yoghurt (15.37±0.219) (Table 1).
Table 1: Physiochemical analysis of cow and camel milk yoghurt

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Treatments (Means ± SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A (75% camel +25%cow)</td>
</tr>
<tr>
<td>Moisture (%)</td>
<td>88.13±0.167</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>3.57±0.133</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>4.60±0.208</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>0.83±0.009</td>
</tr>
<tr>
<td>Lactose (%)</td>
<td>2.80±0.058</td>
</tr>
<tr>
<td>S.N.F (%)</td>
<td>7.27±0.145</td>
</tr>
<tr>
<td>Ph</td>
<td>5.33±0.033</td>
</tr>
<tr>
<td>Acidity As lactic acid (%)</td>
<td>0.76±0.006</td>
</tr>
<tr>
<td>Ca++(mg/100g)</td>
<td>81.67±1.333</td>
</tr>
<tr>
<td>P (mg/100g)</td>
<td>74.67±0.882</td>
</tr>
</tbody>
</table>

Different superscript letters (a to d) within the same raw showed significant differences among the groups (P<0.05). L.sig = Level of significant.

The effect of different samples of camel and cow yoghurt on pH and acidity

The effect of different samples from camel and cow milk yoghurt had no significant difference (p≥0.05) on pH, but significantly affected the acidity of mixture of camel and cow milk yoghurt treatments (Table 2). The high acidity was observed in pure camel milk yoghurt (0.81±0.0175) (Treatment D) then Treatment A (0.79±0.0176) then Treatment B (0.78±0.0173) then Treatment C (0.76±0.0153) and the last one was Treatment E (pure cow milk yoghurt) (0.74±0.0163) Table (2).

Table (2): Effect of different samples of camel and cow yoghurt on pH and acidity

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Treatments Means ±SE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A (75% camel +25%cow)</td>
</tr>
<tr>
<td>Ph</td>
<td>5.16±0.2823</td>
</tr>
<tr>
<td>Acidity</td>
<td>0.79±0.0176</td>
</tr>
</tbody>
</table>

Different superscript letters (a to b) within the same raw showed significant differences among the groups (P<0.05).

The Sensory Evaluation Analysis of Yoghurt

The sensory evaluation of mixed camel and cow milk yoghurt treatments appeared to have high significance (p≤0.05) on taste (4.78±0.016; 5.88±0.216; 8.28±0.303; 3.79±0.167 &
8.39±0.398), flavor (5.05±0.144; 5.80±0.173; 8.05±0.419; 4.98±0.419 & 8.47±0.376), smell (5.37±0.433; 5.97±0.203; 8.25±0.304; 4.70±0.058 & 8.67±0.651), texture (3.49±0.341; 4.36±0.151; 8.70±0.462; 2.41±0.384 & 9.13±0.203) and overall acceptability (4.47±0.088; 5.70±0.058; 8.75±0.202; 3.80±0.231 & 9.40±0.058) of the mixture of camel and cow milk yoghurt and pure camel and cow milk yoghurt treatments (A, B, C, D & E), respectively, but no significant difference (p≥0.05) had been recorded on the color (Table 3).

In this study the best value for taste, flavor, smell, texture and overall acceptability were obtained by yoghurt made from pure cow milk (Treatment E) followed by the 25% camel milk +75% cow milk yoghurt treatment (Treatment C) then 50% camel milk + 50% cow milk yoghurt (Treatment B), then 75% camel milk + 25% cow milk yoghurt (Treatment A). Pure camel milk yoghurt (Treatment D) scored less acceptability (Table 3).

**Table (3): Sensory Evaluation of Camel and Cow Milk Yoghurt**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Treatment means± SE</th>
<th>Level of sig</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A (75% camel +25%cow)</td>
<td>B (50% camel +50%cow)</td>
</tr>
<tr>
<td>Taste</td>
<td>4.78±0.016</td>
<td>5.88±0.216</td>
</tr>
<tr>
<td>Color</td>
<td>6.39±0.756</td>
<td>6.48±0.419</td>
</tr>
<tr>
<td>Flavor</td>
<td>5.05±0.144</td>
<td>5.80b±0.173</td>
</tr>
<tr>
<td>Smell</td>
<td>5.37bc±0.433</td>
<td>5.97b±0.203</td>
</tr>
<tr>
<td>Texture</td>
<td>3.49b±0.341</td>
<td>4.36±0.151</td>
</tr>
<tr>
<td>Overall acceptability</td>
<td>4.47d±0.088</td>
<td>5.70c±0.058</td>
</tr>
</tbody>
</table>

Different superscript letters (a to e) within the same raw showed significant differences among the groups (P<0.05)

**IV. DISCUSSION**

In this study the physiochemical properties of camel milk yoghurt increased with the percent increases of cow milk. This finding was in line with Ahmadoon (2012) who reported similar observations with the exception of fat. Eissa et al (2011) and Mohamed (1999) reported that the fat content of camel yoghurt and mixed camel and cow milk yogurt remained stable during the preserving period.

The increase in lactose in this study was only observed with (25% camel +75% cow) treatment. This finding was also stated by Ahmadoon (2012) who reported similar observations. This study revealed that the effect of different samples from camel and cow
milk yoghurt did not significantly affect the pH, but significantly affect the acidity of pure and mixture of camel and cow milk yoghurt treatments. These findings were in agreement with Eissa et al (2011) who stated that there were increases in acidity and decreases in pH with the storage period in camel milk yoghurt. The changes in pH and acidity during the preservation may be due to the effect of yoghurt microflora on its nutrient composition (Eissa et al, 2011).

In this study the best value for taste, flavor, smell, texture and overall acceptability were obtained by yoghurt made from pure cow milk and high percentages of cow milk mixed with camel milk. The lower scores of flavor and taste preference of the camel milk yoghurt over those of the mixed camel and cow milk yoghurt presented in this study were in agreement with Ahmadoon (2012) who reported similar observations and also with Eissa et al (2011) who reported lower consumer preferences for camel milk yoghurt during organoleptic test. The low organoleptic properties of camel yoghurt might be attributed to microbial growth inhibitors and the higher level of poly unsaturated fatty acids (Gran et al., 1991).

In this study, while there was no significance for colour of the mixed camel and cow milk yoghurt, different results of sensory evaluation were obtained by Ahmadoon (2012) who found that yoghurt produced from camel milk revealed high acceptability for colour to the mixed camel and cow milk yoghurt and by El-Zubeir et al (2012) who reported that the sensory evaluation of the yoghurt produced from camel milk revealed high acceptability for colour to powder milk yoghurt.

The best value for texture in this study was obtained by yoghurt made from pure cow milk and high percentages of cow milk mixed with camel milk. Sensory evaluation obtained by El-Zubeir et al. (2012) revealed that the yoghurt made from camel milk was watery texture than the mixed camel and cow milk yoghurt. This was related to the low total solids content and high moisture of the yoghurt made from camel milk (El-Zubeir et al, 2012) and because the acidity in the whole camel milk decreases very fast (Hassan et al., 2006).

V. CONCLUSION AND RECOMMENDATIONS

It could be concluded that camel milk got lower physiochemical and sensory quality compared to cow milk, so mixing high percentages of cow milk (75%) to camel milk (25%) in yoghurt production, improved physiochemical properties (protein, fat, lactose, pH) and sensory evaluation (flavour, overall acceptability) of camel’s milk yoghurt.
It is recommended that research in yoghurt produced by mixing camel milk with milk from other species of food animals needs to be encouraged to detect the effect of mixing on the therapeutic quality of camel milk, since most of the camel milk consumers prefer the camel milk for its therapeutic effect.

V. REFERENCES


