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Research Article

Effect of Fortifying Camel's Milk with Skim Milk Powder on the Physicochemical, Microbiological and Sensory Characteristics of Set Yoghurt

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Abstract: The present study was carried out in the milk processing unit at college of animal production Science and Technology, Sudan University of Science and Technology during January-May 2012. The effect of fortification with skim milk powder (0, 5 and 7%) to the camel's milk on the quality of yoghurt during storage was investigated. Fresh camel's milk was purchased from Alaas farm at Khartoum North. Nine litres of raw camel's milk were divided into three portions. The first treatment was used as control. To the other two treatments 5 and 7% of skim milk powder was added to the camels milk respectively, then the milk in each treatment was heated in a water bath at 85°C for 30 min. Milk samples were cooled to 43°C and 2% of commercial yoghurt starter culture was added and packed into plastic cups (200 g capacity) in triplicates. The plastic containers were incubated at 39°C until coagulation occurred (16 h) thereafter samples from different treatments were stored at 4°C for 0, 5and 10 days. Yoghurt Samples were taken for chemical, microbiological and sensory analysis.The results indicated that yoghurt treated with 7% skim milk powder had the highest viscosity value ($p \leq 0.01$) during storage period. The control yoghurt had the highest pH value ($p \leq 0.01$) during storage period in comparison with other treatments. In this study no significant differences in chemical composition of the yoghurt from different treatments during storage were observed. The yoghurt sample treated with 7% skim milk powder was significantly higher ($p \leq 0.05$) in total bacterial count (7.70×10^6 cfu/mL than the control yoghurt (5.29×10^6 cfu/mL). No variations were observed in lactic acid bacteria count. Coliforms and *E.coli* bacteria were not detected in tested samples. The results indicated that yoghurt treated with 7% skim milk powder had the highest ($p \leq 0.01$) flavour. Also there was significant difference ($p \leq 0.05$) in overall acceptability in tested treatments. It is concluded that camel milk yoghurt showed high coagulation time and the addition of skim milk powder to camel milk improved some physical properties of the yoghurt.

Keywords: Camel's milk, chemical, microbiological, sensory, skim milk powder, yoghurt

INTRODUCTION

The total population of the Dromedary species (domestic) worldwide is estimated to be about 15 million head (Mukasa-Mugerwa, 1981). Camels are considered to be a good source of milk and meat and are used for other purposes such as transportation and sport racing. Camel milk has an important role in human nutrition in the hot regions and arid countries. The general composition of camel milk varies in various part of the world with range of 3.07-5.50% fat, 3.5-4.5% protein, 0.7-0.95% ash and 3.4-5.6 % lactose, 12.1-15% total solid (El-Agamy *et al*., 1998). Camel milk contains more proteins and whey protein than cow milk (Farah, 1993; Walstra *et al*., 1999).

Camel milk was reported to contain various vitamins, such as vitamin C, A, E, D and B group, camel milk is known to be a rich source of vitamin C; the vitamin content was reported to be three times to five times higher than that in bovine milk (Stahl *et al*., 2006). Fermented camel milk products have various names in various parts of the world, in Sudan *gariss* is a special kind of fermented camel milk popular among the nomads of Sudan, it is prepared by fermenting the camel milk in large skin bags or si'ins, which contain a large quantity of a previously soured product (Dirar, 1993). Abdel Rahman *et al*. (2009) indicated that the camel milk fermented by mixed yogurt culture was the most accepted while the one fermented by *Lactococcus lactis* was the least.

Farah *et al*. (1990) studied the preparation and consumer acceptability tests of fermented camel milk (*Suusa*). They found that the consistency of fermented milk (under lab conditions) was thin and a precipitate in the form of flocks was formed rather than a coagulum after fermentation. These reports clearly show the

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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 were present at significantly greater concentrations in camel milk and were more heat stable compared with those in cow and buffalo milks (El-Agamy *et al*., 1992). The broad objective of the study was to determine the suitability of adding different levels of cows' skim milk powder to camel's milk on yoghurt quality.

MATERIALS AND METHODS

Materials: Camel milk was obtained from Alaas farm during January-May 2012. In this study three treatments were carried out as follows: First treatment is the control in which fresh camel milk was processed into yoghurt. In the second and third treatments fresh camel's milk was fortified with 5 and 7% cow skim milk powder respectively and processed into yoghurt. Commercial yoghurt culture and cow skim milk powder obtained from the local market. Then yoghurt samples stored at a refrigerator (4°C) for 10 days.

Yoghurt making process: Yoghurt was prepared as described by Dirar (1993). Nine litres of raw camel's milk were divided into three portions. The first portion was used as control. To the 2nd and 3rd portions 5 and 7% of skim milk powder was added to each, respectively then the milk in each treatment was pasteurized in a water bath at 85°C for 30 min. Then cooled to 43°C, thereafter inoculated with 2% of commercial yoghurt culture and packed into plastic cups (200 g capacity) in triplicates for each treatment and incubated at 39°C until coagulation occurred (16 h), thereafter samples from different treatments were stored at 4°C for 0, 5 and 10 days. Samples from different treatments were taken for chemical, microbiological and sensory analysis.

Chemical analysis: The methods described by Bradley *et al*. (1992) were used for estimating the percentages of fat (Gerber methods). Protein (Kjeldahl method), total solids (dry oven), ash (muffle furnace) and pH using a pH-meter (HANNA-pH 210, Germany) for milk and cheese were determined according to AOAC (1990). The lactose content was evaluated by subtracting the sum of proteins%, fat% and ash% from total solids% (Haj *et al*., 2007). The viscosity was measured by a viscometer (Haake georz auee, Germany). Duplicate analyses for each determination were performed.

Sensory evaluation: Sensory profiling of the yoghurt samples was conducted, using conventional profiling, by untrained panellists. Ten panellists were selected among the faculty, staff and students of the Faculty of Animal Production, Sudan University. The panelists were given a hedonic questionnaire to test taste, texture, colour, flavour and overall acceptability of coded samples of different treatments. Both fresh samples and those stored for different period of time (0, 5, 10 days) of yoghurt types were tested. They were scored on a scale of 1-7 (1 = not acceptable, 7 = acceptable). Each attribute was evaluated in triplicate and the values were then averaged (Larmond, 1977).

Microbiological tests: Ten grams of yoghurt sample were placed in 90 mL sterile 0.1% peptone water and shaken to prepare 10^{-1} dilution. Then a decimal dilution series were prepared in 0.9% NaCl saline solution. Aliquots (0.1 mL) were used to inoculate on to the surface of agar media a spread plate technique. Additionally, aliquots (1.0 mL) were used in an agar pour plate procedure for total viable count of bacteria, lactic acid bacteria. The agar media employed were: plate count agar incubated both aerobically and un aerobically; MRS agar containing 10 mg/mL nystatin selective for lactic acid bacteria; M-17 agar selective for Streptococcus spp, nutrient milk agar for total spores; Media after inoculation were incubated at 37°C and examined after 24-48 h. Gram staining, spore staining, presence of active enzymes and growth in air tests were employed to identify the genera of bacteria. Viable cells and spores were enumerated as cfu/g. Total coliforms count was done by inoculating 1.0 mL aliquot from a suitable dilution in MacConkey broth and incubated at 37°C for 48 h. Tubes producing acid and gas were used for further tests. Aliquots from acid and gas positive test were inoculated into brilliant green bile lactose broth; one set of tubes was incubated at 37 °C for 48 h and the other at 44.5°C for 24 h. For further confirmation of faecal coli forms (Escherichia coli), tubes giving positive reaction at 44.5°C were streaked onto Eosin Methylene Blue (EMB) agar. Positive test colonies were then counted as cfu/g (Harrigan and McCance, 1976).

Statistical analysis: Statistical analysis was done using SPSS (1998). Version 10, Complete Randamized Design (CRD) and General linear models were used to estimate the effect of different levels of skim milk level, storage periods and interactions between them on the chemical, microbiological quality and sensory characteristics of camels milk yoghurt. LSD was used for mean separation between the treatments. The level (skim milk powder) of significance α $p<0.05$ was used in this study.

RESULTS AND DISCUSSION

Chemical composition of fresh camel milk: Data in Table 1 showed the chemical composition of fresh camel milk. The average chemical composition of

Table 1: Chemical composition of fresh camel milk

Components %	Camel milk
Protein	2.8
Fat	4.4
Lactose	4.3
T.S	10.3
Ash	0.82
Ph	6.5
Viscosity	62

camel milk used for yoghurt processing were in line with the results of Gran and Sheriha (1986) who found that, the general composition of camel milk varies in various part of the world with range of 3.07-5.50% fat, 3.5-4.5% protein, 0.7-0.95% ash and 3.4-5.6% lactose,12.1-15% total solid

Effect of different levels of skim milk powder and storage period on the chemical composition of yoghurt: Chemical compsition of yoghurt made from camels milk fortified with different levels of skim milk powder was shown in Table 2. The results showed that no significant ($p<0.05$) differences were found between means of the total solids, total proteins, fat contents,lactose contents , ash, pH and viscosity of all camel milk yoghurt samples .

Effect of different levels of skim milk powder and storage period on the pH of yoghurt: The pH of yoghurt decreased significantly ($p\leq0.01$) in all samples as affected by time (Table 2). The highest pH value (5.3) was obtained by the control yoghurt at day zero time ($p\leq0.01$) while the lowest one (4.9) was obtained by yoghurt treated with7% skim milk powder after 10 days of storage (Table 2). Our results of pH values decrease from high to low levels which were in line with those of El-Agamy *et al*. (1992) who reported that during storage period, the pH value of all samples decreased progressively due to presence of lactic acid bacteria but this might be due to the presence of antimicrobial agents in camel milk.

Effect of different levels of skim milk powder and storage period on the viscosity of yoghurt: The results in Table 2 show the viscosity of the yogurt made from camel milk with different treatments. There were high significant differences in the viscosity of all types of yoghurt ($p\leq0.01$), the highest ($p\leq0.01$) viscosity value (436.17) was obtained in yoghurt treated with 7% skim milk powder at day zero, while the lowest viscosity value (242.33) was recorded by control yoghurt ($p\leq0.01$) at day ten these results were in agreement with those of Chawla and Balachandran (1994), who reported that skim milk powder addition is widely used in the industry to increase the SNF level in liquid milk for producing quality dairy products. Milk proteins and lactose are two constituents on SNF which affect sensory quality as well as some physico-chemical characteristics of products. An increase in SNF in milk contribute to increase in protein which in turn may contribute to refinement in taste with improved consistency, viscosity and reduced whey separation in fermented product. Also the results were consistent with those of Todoric and Bajic (1979) who demonstrated that the addition of dry skim milk powder to yoghurt improved viscosity and prevented whey separation, but accelerated acid production.

Effect of different levels of skim milk powder and storage period on microbial composition of camel yoghurt: Table 3 shows the changes in microbiological content of yoghurt during storage. There were

Table 2: Effect of storage period and different levels of skim milk powder on physicochemical analysis of camel yoghurt

Treatment parameters	Physicochemical composition (%)							
Storage period in days	Type	Total solid	Protein	Fat	Lactose	Ash	Viscosity	pH
0	Control	13.77	3.63	4.10	6.97	1.09	296.50	5.33
	5 %	13.80	3.60	4.10	7.00	1.12	372.50	5.33
	7 %	15.40	3.63	4.23	7.03	1.05	511.50	5.33
5	Control	15.00	3.63	4.03	5.37	1.07	231	5.20
	5 %	15.03	3.63	4.	5.33	1.10	322	5.20
	7 %	15.10	3.63	4.03	5.17	1.17	421	5.13
10	Control	14.93	3.46	4	5.20	1.05	199.50	5.03
	5 %	14.97	3.50	4	5.13	1.10	226.50	4.90
	7 %	15.03	3.50	4.10	5.17	1.13	376	4.90
Main effect								
	Control	14.32	3.62	4.14	7.00	1.09	393.50^{a}	5.33^{a}
Time	5	15.04	3.63	4.02	5.29	1.11	324.67^{b}	5.18^{b}
	10	14.98	3.49	4.03	5.17	1.10	267.33^{c}	4.94^{c}
Standard error		0.75	0.21	0.06	0.66	0.04	0.93	0.04
p-value		0.75	0.86	0.25	0.11	0.91	< 0.01	< 0.01
	Control	14.57	3.58	4.04	5.84	1.07	242.33^{c}	5.19
Type	5	14.60	3.58	4.03	5.82	1.11	307^{b}	5.14
	10	15.18	3.59	4.12	5.79	1.12	436.17^{a}	5.12
Standard error		0.75	0.21	0.06	0.66	0.04	< 0.001	0.04
P-value		0.81	0.99	0.48	0.99	0.69	< 0.01	0.49

^{a,b,c} :Means with different superscript in the same column are significantly different at $p<0.05$

Table 3: Effect of the storage period and different levels of skim milk powder on the microbiological quality of camel yoghurt

Treatment parameters					
Storage period in days	Type	Total bacterial count (CFU/mL)	Lactic acid bacteria (CFU/mL)	Coliforms MPN/mL	E.coli MPN/mL
0	Control	4.34	4.27	-ve	-ve
	5 %	7.71	7.04	-ve	-ve
	7 %	7.80	7.23	-ve	-ve
5	Control	7.29	7.29	-ve	-ve
	5 %	7.83	7.17	-ve	-ve
	7 %	7.96	7.97	-ve	-ve
10	Control	4.25	5.94	-ve	-ve
	5 %	7.39	8.56	-ve	-ve
	7 %	7.32	8.94	-ve	-ve
Main effect					
Time	0	6.62	6.18	-ve	-ve
	5	7.69	7.48	-ve	-ve
	10	6.32	7.81	-ve	-ve
p-value		0.31	0.13		
Type	Control	5.29^{b}	5.83	-ve	-ve
	5 %	7.64^{a}	7.60	-ve	-ve
	7 %	7.70^{a}	8.05	-ve	-ve
P-value		< 0.001	0.38		

^{a,bc}: Means with different superscript in the same column are significantly different at p<0.05

Table 4: Effect of storage period and different levels of skim milk powder on sensory evaluation of camel yoghurt

Treatment parameters	Sensory evaluation characteristics					
storage period in days	Type	Colour	Flavour	Taste	Texture	Overall acceptability
0	Control	6.20	4.20	3.60	4.20	4.80
	5%	6.20	4.40	4.20	3.60	4.60
	7%	7.00	5.60	4.00	2.80	5.20
5	Control	6.40	4.60	3.40	2.80	4.80
	5%	6.80	4.80	3.80	2.80	5.20
	7%	6.60	5.00	4.20	2.80	5
10	Control	6.40	4.00	4.00	2.40	4.80
	5%	6.60	5.40	4.20	3.20	5.60
	7%	6.60	6.20	4.20	4.40	6
Main effect						
Time	0	6.47	4.73	3.93	3.53	4.87^{b}
	5	6.60	4.80	3.80	2.80	5.00^{b}
	10	6.53	5.20	4.13	3.33	5.47^{a}
p-value		0.90	0.34	0.61	0.27	<0.031
Type	Control	6.33	4.27^{b}	3.67	3.13	4.80^{b}
	5%	6.53	4.87^{b}	4.07	3.20	5.13^{ab}
	7%	6.73	5.60^{a}	4.13	3.33	5.40^{a}
p-value		0.41	<0.001	0.33	0.91	< 0.04

$^{a\ bc}$: Means with different superscript in the same column are significantly different at p<0.05

significant differences (p≤0.05) in all treatments of yoghurt, the highest total bacteria count ($7.70\times10^{6)}$ was obtained by yoghurt made with 7% skim milk powder at day five while the lowest ones (5.29×10^{6}) was scored by control yoghurt at day ten of processing .The results revealed that the total bacteria count showed minimum rate of growth at the beginning of the incubation during storage period. These results supported those of Attia *et al*. (2001) who stated that the activity of the starter in dromedary camel milk was characterized by a longer lag phase and by an earlier decline phase than bovine milk. This might be due to the presence of growth inhibiting factors in the camel's milk (Attia *et al*. (2001). Moreover there were no significant differences (p<0,05) in lactic acid bacterial count in all treated yoghurt samples during storage period , the plain yoghurt may contain up to one billion live L.bulgaricus and S. thermophillus cell per mL. As storage period progressed the yoghurt samples become older, therefore these bacteria dead and their number were declined to few millions per ml (Kosikowski, 1977). On the other hand, the E.coli and the Coliforms bacteria were absent during storage period. the results were in accordance with those of Gran *et al*. (1990) who stated that camel yoghurt was negative coliforms bacteria in all stage, this may be referred to the absent of contamination in milk or presence of inhibiting growth agents in the camel milk.

Effect of different levels of skim milk powder and storage period on sensory evaluation of camel yoghurt: Yoghurt made from camel milk was analyzed for sensory evaluation as shown in Table 4.

The results showed that no significant differences were found in the means of colour, taste and texture in all camel yoghurt samples.

Flavour: Data in Table 4 show the change in flavour of yoghurt during storage. There were high significant differences $p \leq 0.01$) in the flavour of tested samples, the highest flavour scores (5.60) was obtained by yoghurt made with 7% skim milk powder while the lowest one was (4.27) obtained by control yoghurt ($p \leq 0.01$). One of the very important factors determined the specific identity of fermented milk products was presence of the flavouring compounds (Oberman, 1985). Our results demonstrated that the yoghurt samples had the high flavour scores at the end of storage ,these results were similar with those reported by Kilara and Shahani (1978) who said that some of the high flavor scores of the yoghurt samples at the end of storage period, might be referred to the low rate of fermentation in the beginning of the storage period, this might be due to the presence of antimicrobial agents and inhibiting growth factor but as the storage period advanced lipolytic and Proteolytic microorganisms multiply as the result of fat and protein breakdown.

Overall acceptability: Table 4 shows the change in overall acceptability of yoghurt during storage period. There were significant differences ($p \leq 0.05$) in overall acceptability between all treatments ,the higher overall acceptability (5.40) was obtained in yoghurt made with 7% milk powder at day ten while the lower one scores (4.80) was observed in control yoghurt at day zero. At the end of storage period yoghurt prepared with 7% skim milk powder had the highest scores ,might be due to the presence of antimicrobial agent and inhibiting growth factor that might also increased the shelf –life of yoghurt samples.

CONCLUSION

It has been shown in this work that the coagulation of camel milk required long time (16 h), also yoghurt made from camel's milk revealed a longer shilf life than any other milk, the natural antimicrobial agents in the camel's milk might increase its shelf life. Addition of skim milk powder improved some properties (viscosity) and sensory evaluation (flavour, overall acceptability) of camel's milk yoghurt.

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