Research Article

The potentiality of papaya (*Carica papaya*) fruit pulp on the functional properties and physicochemical content of camel milk yoghurt

Abstract

This experiment was designed in order to assess the addition of papaya fruits pulp on processing properties and compositional quality of camel milk yoghurt. Three treatments consisted of addition of papaya (0%, 3% and 7%) were made. The incubation of yoghurt samples were done using plastic cups at 43 ºC and then stored at 4 ºC, where the chemical components were determined seven times at regular intervals during 21 days. The obtained data revealed that the addition of papaya fruits pulp showed significant (P<0.001) effect on all physicochemical properties of camel milk yoghurt. There were significant increased in total solids, fat and ash content, while significant decrease were found for levels of protein and acidity for the yoghurt samples made from camel milk fortified with papaya. The storage period also showed significant (P<0.001) effect on all physicochemical properties of camel milk yoghurt. The present study concluded that addition of papaya pulp improved processing properties and the chemical constituents of camel milk yoghurt. Effort on raising the awareness among urban consumers about the nutritional and functional contribution of camel milk and products is highly recommended.

Keywords: camel milk, yoghurt, papaya fruit pulp, processing, chemical content, functional food

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Introduction

The nutritional contents of yoghurt showed variations according to the sweeteners and fruits in addition to the duration of fermentation process.[1] The fruits are usually included into yoghurt in refrigerated or frozen form as single or mixtures, however the canned fruits or their juices and syrup were also used.[2] The uses of ripe papaya fruit include juice, mixed beverages, frozen slices, ice cream and other concentrated and canned foods including powder and baby food.[3] The antimicrobial effect of papaya can be utilized in preservation of food.[4] The anti-oxidant properties of papaya, its anti-bacterial and anti-fungal in addition to its anti-inflammatory effects,[5] could be because of its large amout of protien.[6] Moreover papain (a cisteine protease) is developed from the papaya.[7] In addition the high amounts of vegetable pepsin in unripe papaya have a major role for protein digestion in food.[8] Also pectin was found to increase the intestinal tracts viscosity and to reduce the absorption of cholesterol levels from both food and bile resulting in its overall reduction in the blood. Moreover the pectin will be degraded further in the large intestines and colon by the action of microorganisms into the beneficial short chain fatty acids.[9]

The chemical content of camel milk, its properties and suitability for making some dairy products were tried previously.[10-17] Camel milk has low viscosity, total solids and the length of the fermentation process is very long.[18] However camel milk and its products will be increased globally in the basic diet due to its some distinct characteristics to uphold healthy activities in the world population.[19] However camel is not easily converted into fermented dairy products due to the long coagulation time and the slow development of acidity.[10,16,17,20] Hence the main objective of this study is improvement of camel milk yoghurt properties and to add functional value for the product using papaya fruit pulp.

Material and methods

Source of raw materials

Camel milk was brought from a private camel farm in Khartoum North, while the starter culture that consisted of *Streptococcus thermopiles* and *Lactobacillus delbruckii sub sp. Bulgaricus* (YO – mix 505) is a product of Dansco, Denmark). The papaya fruits and gum Arabic were obtained from the local markets in Khartoum North. This experiment was done during the period from May to June 2017.

Preparation of papaya

To prepare papaya (Carica papaya) fruit pulp, it was first washed with clean water. After removing the peels (using a sharp knife), the seeds were removed out manually from papaya and the pulp was extracted. After filtering the fruit pulp using clean cloth mesh of 30 micron size, it was mixed well and homogenized using high speed domestic home homogenizer at 37°C. Then the filtrate was kept in sterile container and refrigerated until it was used for fortification of yoghurt.

Processing of yoghurt

Yoghurt samples were processed using camel's milk with the addition of papaya fruit pulp. The milk was filtered first to remove the impurity and then the papaya pulp was mixed with milk before pasteurization. About 0.3% gum Arabic was added and stirred continuously by a stirrer while the milk was boiled. This was done to prevent cream layer formation. The heated milk was then allowed to cool down at a temperature of 42-43°C and the yoghurt samples were prepared as follows:

i. In the first treatment (control), yoghurt was made using camel's milk only + 0.3% gum Arabic.

ii. In the second treatment, yoghurt was made using camel's milk supplemented by 3% papaya + 0.3% gum Arabic.

iii. In the third treatment, yoghurt was made using camel's milk supplemented by 7% papaya + 0.3% gum Arabic.

Then the starter cultures were added and the incubation was done into plastic cups at 43 ˚C until formation of the coagulum. All the processed yoghurt samples were stored at a refrigerator (4° C) for 21 days, where they were subjected to analysis every 3 days.

Chemical analysis of milk and yoghurt

The Lactoscan (Milkotronic LTD, Europe, made in Bulgaria) was used for camel milk analysis according to the manufacture instruction. The chemical composition (total solids, fat, protein and ash) and titratable acidity of yoghurt samples were determined at 1, 3, 6, 9, 12, 15, 18 and 21 days during the storage. The Gerber method was used for the determination of the fat content and the Kjeldahl method was followed for determining the protein content.[20] The modified method of AOAC was also used to obtain the total solids content and the gravimetric method described in was used for obtaining the ash content.[20] The titration method was used to estimate the titratable acidity.[20]

Statistical analysis of the data

The obtained data were statistically analyzed by Statistical Analysis System (SAS, ver. 9). The effects of both concentrations of papaya and the storage period on camel milk yoghurt compositional content were calculated using General linear model. Means separations were estimated by using least significant difference at P≤0.05.

Results and discussion

Compositional content of camel milk for yoghurt processing

The physicochemical analysis of raw milk obtained from camel showed low total solids and ash content (Table 1). Similar percentage for density, protein and lactose were reported previously.[17] The present obtained values for camel milk fat, protein and ash in samples used for yoghurt preparation supported Khaskheli et al. [21]. Similarly the total solids, fat, protein, lactose and ash for camel milk were reposted as 11.9±1.5%, 3.5±0.1%, 3.1±0.5%, 4.4±0.7% and 0.97±0.07%, respectively.[22] Moreover similar values except for fat content were found, also significant (P≤0.05) differences for camel milk composition between the different systems of management and breeds were reported.[23] Also variations were found in solids not fat of milk from camel in different stages of lactation and parity numbers in addition to influence of management systems.[24] The production systems in addition to the breed, stages of lactation and parity number are the major factors contributing to variations in the chemical composition of camel milk.[25,26] The camel performance is better under traditional management condition explainable by the high biodiversity in the natural pastures.[25]

Table 1 Chemical composition of papaya and fresh camel milk

Item	Total solids (%)	Fat (%)	Protein (%)	Crude fiber (%)	Lactose (%)	Ash (%)	Density gm/cm3
Papaya	12.01	0.38	5.1	2.66	-	1.97	-
Camel milk	11.45	2.35	3.5	-	4.9		1.033

Compositional content of papaya

The chemical analysis of papaya fruit pulp (Table 1) showed that papaya pulp had high crude protein (5.1%), low fat content (0.38%), high ash content (1.97%) and crude fiber (2.66%). The present result, except the content of fat showed higher values than that obtained previously.[27]

Processing properties of camel yoghurt

Figure 1 showed the acidity development of yoghurt during incubation period. The fermentation time take about 16-18 hours. This result supported the previous reports that indicated also long time (about 16 hours) for camel milk coagulation.[10,13,16,18,28-30] The antimicrobial factors associated with both camel milk and papaya pulp might be the reason for this long coagulation time. Similarly the long length of coagulation time was attributed to the presence of growth inhibitors in camel milk that decreased the activity of lactic acid bacteria during fermentation.[31,32] The reduction in lactic acid starter culture was demonstrated previously.[10,28,29] This because of the high antimicrobial components content in camel milk (lactoferrin, lysozyme and immunoglobulins) compared to milk from cows or buffalos.[33]

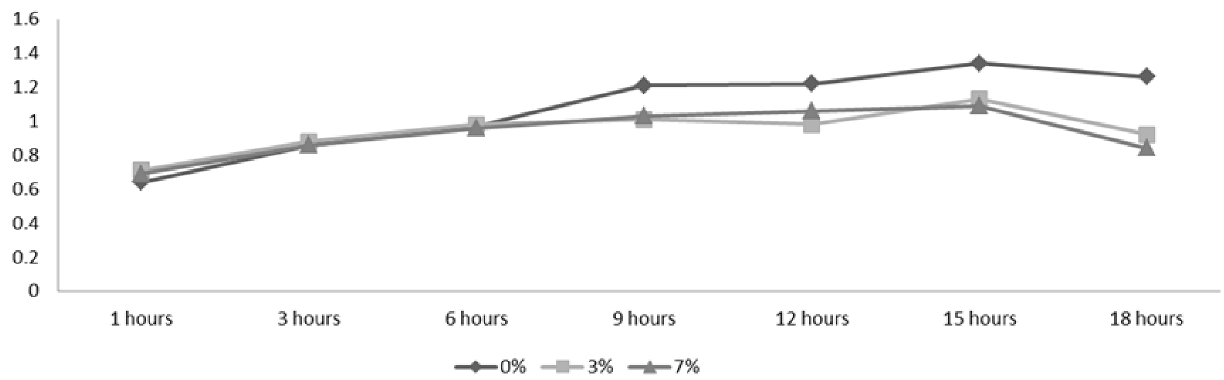

Figure 1 Development of acidity during incubation period of camel milk yoghurt using papaya fruit.

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Initially the acidity was 0.64%, 0.71% and 0.69% in the control yoghurt, yoghurt containing 3% papaya and yoghurt containing 7% papaya, respectively. Then the acidity was increased by the addition of papaya until it reached 1.26%, 0.98% and 0.84%, respectively. This indicated the antimicrobial properties of papaya.[4,5,34] In this study, yoghurt was successfully produced from camel milk. This supported the previous studied which used camel milk to produce different yoghurt types.[13,29,31] However the pure camel milk yoghurt was observed to have very thin and soft texture, which could be due to the lower content of milk total solids.[13,15,29] Papaya was used in the present study as flavors and to enhance the functional quality of the product because of its high fiber content. Moreover it was found to have good function in natural preservative of food as it has antimicrobial, anti-oxidant and anti-inflammatory properties.[5] The use of fruits for the development of functional foods was highlighted before. Thus the present results demonstrate and strengthen the use of camel milk as functional food.[35]

Chemical composition of camel milk yoghurt

Table 2 showed the physicochemical values of camel milk yoghurt as was affected by different levels of papaya concentrations. The data showed that concentration of papaya had significant effect on physicochemical composition of camel milk yoghurt. This supported Matter et al.[27]. Also Roy et al.[36] used different percentage (5%, 10% and 15%) of papaya to manufacture yoghurt from buffalo.[36] The high protien content of papaya,[6] could be one of the resaon. On the other side, significant (P<0.05) differences were found for the compositional content of yoghurt as affected by the types of milk and the starter cultures.[29] High content of total solids, protein and fat were found in camel and sheep mixture yoghurt samples compared to pure camel yoghurt samples. However, the ash content revealed the same value in different yoghurt samples. Also significant (P<0.05) effect for storage period on the physicochemical content were found camel and camel-sheep yoghurt samples.[17]

Table 2 Effect of concentrations of papaya on the physiochemical characteristics of camel milk yoghurt

Physicochemical characteristics (%)	0			3			7			SE	SL
	Min	Mean ±SD	Max	Min	Mean ±SD	Max	Min	Mean ±SD	Max		
Fat	2.1	2.59±0.25	2.9	2	2.53±0.17	2.7	1.4	2.1±0.13	2.6	0.0047	**
Protein	2.6	3.59±1.29	6.9	3	3.43±0.65	5.1	2.8	3.51±0.82	5.1	0.0081	**
T.S	10.06	11.17±0.51	11.86	10.46	11.29±0.67	12.79	9.56	11.03±0.72	12.28	0.01	***
Ash	0.3	0.6±0.12	0.7	0.29	0.6±0.14	0.84	0.29	0.64±0.18	1.05	0.002	**
Acidity	1.42	1.60±0.09	1.72	1.26	1.39±0.09	1.56	1.01	1.37±0.18	1.59	0.0006	***

Means in the same row bearing similar superscripts letters are not significantly different (P>0.05)

*= P<0.05

**= P<0.01

***= P<0.001

SE= Standard error

SL= Significant level

Min= Minimum

Max= Maximum

Fat content

The range of fat content of camel yoghurt was between 2.1% and 2.9%. Similarly lower values of fat content for camel milk yoghurt were observed previously.[17] The result showed that the addition of papaya affected the fat content significantly (P<0.001) as shown in Table 2. The fat content of camel yoghurt revealed its highest value (2.59%) in the pure camel milk yoghurt samples, while the lowest (2.1%) was found in camel milk yoghurt containing 7% papaya. There was slight reduction in the content of fat in the yoghurt containing papaya compared to control camel milk yoghurt. The low fat content in papaya fruit as shown in Table 1 might be the reason. Similarly the fat percentage showed gradual decrease when the pulp concentration in fruit yoghurt was increased which might be due to the very low fat content in papaya fruit pulps compared to the fat content of milk.[36] The reduced fat content of yoghurt containing papaya will be of medical and functional values for consumers with obesity and other cardiovascular disorders. The pectin of papaya fruit has significant role in reducing overall cholesterol levels of the blood, because it increase the viscosity in the intestinal tracts and lowering the absorption of cholesterol from food and bile.[9] Moreover they added that the short chain fatty acids that are released due to the action of microorganisms on pectin showed prebiotic effect in the large intestines and colon. However higher fat content were reported for camel milk yoghurt samples fortified with sheep yoghurt compared to pure camel milk yoghurt samples.[29] This study also suggested that low fat content of camel milk yoghurt would enhance its functional properties. The details on the fatty acids profiles of camel milk and its especial properties were reported.[37,38]

The storage period showed higher significant (P<0.001) variations for the fat content of camel milk yoghurt. The higher fat content (3.35%) was found at day 15 (Table 3). Fat content remained stable during storage period until day 15. The utilizing of fat by the lactic starter cultures of the yoghurt could be he the reason for the increasing and decreasing trend of fat content of papaya frit yogurt during the storage. This result is in line to that reported by Eissa et al.[31] who stated that the content of camel yoghurt fat remained stable during the whole storage period compared to that of cow milk.[31] Furthermore the mixture of sheep milk and camel milk yoghurt revealed significantly (P<0.05) higher fat values in comparison to yoghurt from 100% camel milk when using two different starter culture.[17] The interaction between concentration of papaya and storage period on fat content revealed significant (P<0.001) effect, the fat value was higher for yoghurt samples containing 3% papaya (2.65%) at day 1 and 3 compared to that containing 7% papaya. The reduction observed in the fat content in yoghurt samples supplemented by papaya was sharp at the end of storage period as shown in Table 4. This reduction might be due to degradation effect and release of short chain fatty acids by papaya.[9]

Table 3 Effect of storage period on the physicochemical characteristics of camel milk yoghurt

Physicochemical characteristic	Storage period (days)								SE	SL
	1	3	6	9	12	15	18	21		***
Fat (%)	2.68^{a}	$2.47b^{c}$	2.52^{b}	2.08^{e}	2.35^{cd}	3.35^{cd}	2.27^{d}	2.52^{b}	0.0125	***
Protein (%)	3.57^{b}	5.7^{a}	3.15^{c}	3.17^{c}	3.17^{c}	3.17^{c}	3.07^{c}	3.08^{c}	0.0216	***
Total solids (%)	10.77^{d}	10.96^{d}	11.12^{c}	10.74^{d}	12.27^{a}	11.21^{c}	11.49^{b}	10.75^{d}	0.027	**
Ash (%)	0.3^{e}	0.64^{bcd}	0.62^{cd}	0.6^{d}	0.73^{a}	0.67^{bc}	0.69^{ab}	0.68^{ab}	0.005	***
Acidity (%)	1.49^{b}	1.40^{cd}	1.50^{b}	1.60^{a}	1.34^{e}	1.49^{b}	1.41^{c}	1.39^{d}	0.0016	

Means in the same row bearing similar superscripts letters are not significantly different (P>0.05).

**= P<0.01

***= P<0.001

SE = Standard error

SL = Significant level

Table 4 Effect of concentrations of papaya on physicochemical characteristics of camel milk yoghurt during storage period

Papaya concentration	Storage period (day)	Fat (%)	Physicochemical characteristics			
			Protein (%)	Total solids (%)	Ash (%)	Acidity (%)
	1	2.85	3.39	11.08	0.3	1.5
	3	2.6	6.9	10.84	0.65	1.61
	6	2.65	2.7	10.96	0.64	1.64
0	9	2.4	3.25	10.64	0.63	1.71
	12	2.65	3.25	11.83	0.59	1.65
	15	2.5	3	11.48	0.64	1.6
	18	2.2	3.1	11.72	0.68	1.62
	21	2.85	3.1	10.79	0.65	1.42
	1	2.65	3.21	10.61	0.3	1.39
	3	2.65	5.1	11.02	0.6	1.34
	6	2.55	3	11.09	0.57	1.48
3%	9	2.25	3.25	10.82	0.56	1.55
	12	2.5	3.25	12.73	0.73	1.35
	15	2.5	3.25	11.57	0.68	1.35
	18	2.55	3.1	11.16	0.61	1.33
	21	2.55	3.25	11.35	0.8	1.29
	1	2.55	4.1	10.64	0.3	1.27
	3	2.15	5.1	10.98	0.68	1.25
7%	6	2.35	3.75	11.32	0.64	1.37
	9	1.6	3	10.76	0.61	1.52
	12	1.9	3	12.25	0.86	1.02
	15	2.05	3.25	10.58	0.69	1.51
	18	2.05	3	11.58	0.77	1.28
	21	2.15	2.9	10.11	0.95	1.47
SL		***	***	***	***	***

***= P<0.001

SE= Standard error

LS= Significant level

Protein content

The range estimated for protein content in camel yoghurt samples was 2.6%-6.9% (Table 2). The highest protein content (6.9%) was shown in pure camel milk yoghurt (control samples) compared to 5.1% protein in yoghurt fortified with 3% papaya. Moreover the result (Table 2) showed that addition of different concentration of papaya revealed significant effect at P<0.05 on protein content. The mean and maximum values of the protein content ware found to decrease, while the minimum values showing the increasing trend in yoghurt samples. Similarly it was found that protein content in yoghurt samples was decrease when papaya pulp concentration was increased.[36] The inconsistent increase and decrease in the protein content could justify as was below. The papaya fruit pulp contain few protein compared to raw milk.[36] could be the reason behind lowering of protein in 7% followed by 3% papaya pulp yoghurt compared to pure camel yoghurt. This because the highest value of protein (6.9%), was found in the control camel yoghurt samples. Also it might be because the vegetable pepsin present in unripe papaya is high and it affected protein digestion.[8] The present values for protein content were higher than those found previously.[17] Storage period showed significant (P<0.001) effect on protein, the highest protein content (3.57 %) was found in day 1 (Table 3). The concentrations of papaya during storage period of camel milk yoghurt showed that protein content was high at day 1 and 3 and then decreased in day 6 and increase until the end of storage period in yoghurt supplemented with 3% papaya. However in yoghurt supplement with 7% papaya, the protein was increased at day 3 (5.7%) and decreased until the end of storage period except at day 6 and 15 (Table 4). The variations could be due to fortification with papaya pulp, which is reported as good raw material for dairy products processing.[4,36]

Total solids content

The total solids ranged from 9.56% to 12.79% in yoghurt samples (Table 2). Higher values for total solids in yoghurt samples made by mixing camel' and sheep' milks were obtained in comparison to those made from pure camel milk.[29] Significant (P<0.001) increase was observed for the total solids content due to the addition of papaya. The highest total solids content (11.03%) was found in yoghurt made with addition of 7% papaya and the lowest average (10.06%) was observed in control yoghurt samples (Table 2). This could be due to the high fiber content of papaya (Table 1). Moreover it was reported that the benefits of an adequate intake of dietary fiber are regulation of intestinal transit in addition to prevention or treatment of diabetes, colon cancer and cardiovascular diseases.[39] Similarly it was recommended that milk fat from camel enjoying rich green pasture is considered a good source for the omega-3 fatty acids content, which will have a major influence in reducing serum lipids and the incidence of lipid-related cardiovascular diseases of human.[38] Thus the benefit of incorporation of papaya fruit pulp in camel milk will enhance its functional and medicinal values.

The storage period showed significant (P<0.001) effect on total solids of camel milk yoghurt, as the total solids were found to increase by the progressing of the days of storage. The highest content of total solids (12.27%) was found in day 12, while the lowest (10.74%) was found in day 9 (Table 3). The fluctuations of fat and protein content of the papaya fruit yoghurt might be the reason for the uneven variations of the total solids during the storage of yoghurt. This result supported the values obtained for the total solids content were extremely high in sheep yoghurt compared to those of camel yoghurt.[17] Moreover the interaction between papaya and storage period showed significant (P<0.001) variations on total solids content of camel yoghurt (Table 4). The low total solids content of camel milk is one of major challenges for processing of camel milk into yoghurt that required relatively high solids nor fat for preparation the mix.

Ash content

This result illustrated that the ash content was significantly (P<0.001) increased by the addition of papaya (Table 2). The highest ash content (1.05%) was found in yoghurt containing 7% papaya, followed by those containing 5% papaya concentration, while the lowest (0.70%) was found in the control samples. This might be because of high ash content of papaya pulp (Table 1). However the ash content of yoghurts was found to decrease when increasing the concentration of papaya pulp.[36] The variation could be related to the different variety and geographical location of papaya between Sudan and Bangladesh. The present result disagreed with Ibrahem and El Zubeir who reported that ash content was similar in all types of yoghurt.[29] Also significant (P<0.01) variation on ash content was observed during the advancement of the storage period (Table 3). However non significant effect on ash value in camel–sheep yoghurt using two types of starter culture were reported.[17] The obtained variations could be attributed to the fruit added in the present study. The edible portion of the papaya fruit contains macro (Na, K, Ca, Mg and P) as well as microminerals (Fe, Cu, Zn and Mn)[40] and many vitamins.[41,42]

Interaction between papaya and storage period showed significant (P<0.001) effect on ash content, which was high in the samples of yoghurt containing 3% papaya and yoghurt samples containing 7% papaya (0.95% and 0.80%) respectively, at day 21. The lower ash content (0.3%) was found at day 1 in the control camel milk yoghurt samples compared to those containing 3% and 7% papaya (Table 4). The high ash content of papaya (1.97%) as shown in Table 1 could be the reason.

Acidity

The acidity ranged from 1.01% to 1.72%. The addition of papaya showed significant (P<0.001) effect on acidity, the acidity was found to decrease by addition of papaya (Table 2). Similarly a decrease in the acidity of yoghurt was found as result of increasing the amount of the adding fruit pulp.[27] The decrease in titratable acidity of fruit yoghurt containing papaya was mainly because of low acidity in papaya. Also papain in papaya presents antifungal and antibacterial properties.[34] Similar to the present study, various authors suggested that camel milk was less favorable for lactic fermentation, which was poor compared to cow's milk.[10,28,29] However the fermented camel milk products are the most popular consumed dairy products by nomads in Sudan as well as elsewhere.[43]

This study also showed that storage period had significant (P<0.001) effect on acidity (Table 3). The acidity continued to increase until day 9 except day 3. This might be due to lactose fermentation and conversion to lactic acid.[44] This phenomenon might be because of the production of the lactic acid due to the synergistic growth of lactic acid bacteria (*Lac. spp.* and *Strep. Spp.*[27] Moreover *Streptococcus thermophilus* and *Lactobacillus bulgaricus* exhibited diversity in growth behavior in plain and fruit yoghurt and were dependent on the type and concentration of fruits as well as duration of storage.[35]

Conclusions

From the present study, it could be concluded that the addition of papaya had significant effects on all physicochemical characteristics as well as some and functional properties of camel milk yoghurt. It is recommended to raise the awareness among consumers about the significant of camel milk products contribution as nutritional and functional food. Encouragement of using papaya in dairy products had to be promoted because it has many functional properties in addition to its nutritional value. However more research has to be conducted on using papaya fruit in order to improve and promote the processing properties of camel milk products.

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Conflicts of interest

The authors declare that there was no conflict of interest.

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