VARIATIONS OF MICROBIOLOGICAL QUALITY AND SENSORY PROPERTIES OF CAMEL MILK SUPPLEMENTED WITH PAPAYA (*Carica papaya*) FRUIT PULP DURING THE STORAGE

Ahmed, Fawzia Bahar Eldai Saeed[1] and **El Zubeir**, Ibtisam El Yas Mohamed[2]

[1,2]Department of Dairy Production, Faculty of Animal Production, University of Khartoum, P. O. Box 321, Khartoum, Sudan
Email address: Ibtisam.elzubeir@uofk.edu

Abstract
In this study the effect of addition of papaya (0%, 3% and 7%) fruits pulp on microbiological and sensory properties of yoghurt made from camel milk was investigated. After processing of camel milk yoghurt, the samples were stored at4 ºC for 21 days and the evaluation was conducted every 3 days. Microbiological examinations indicated that the addition of papaya showed highly significant (P<0.001) reduction on total bacterial count (log 1.96 vs. 1.91 and 1.79) and yeast and mould counts (log 1.83 vs. 1.74 and 1.57), while coliform bacteria (log 0.96 vs. 0.72 and 0.87) showed non-significant (P>0.05) variation. Also significant (P<0.001) variations were found for the coliform bacteria and yeast and mould counts using different concentration of papaya and during the storage period, while total bacterial count revealed non- significant (P>0.05) effect. The taste, flavor, texture and overall acceptability were significantly (P<0.001) improved by the addition of papaya fruit.
However, color score was not significantly (P>0.05) affected by the concentration of papaya during the storage period. The present study concluded that addition of papaya pulp improves both the microbial load and sensory attributes of camel milk yoghurt. This study recommends and encourages the use of papaya in dairy products. It is also important to raise the awareness about the functional properties of camel milk.

Key words: Camel milk, yoghurt, papaya fruit pulp, microbiological load, sensory evaluations, functional properties

Received: 24.09.2021 Reviewed: 10.11.2021 Accepted: 11.11.2021

INTRODUCTION

Camel milk is extremely popular and widely consumed by nomadic tribes in Sudan both as fresh raw milk or fermented **(**Abdel Rahman *et al.*, 2009; Suliman and El Zubeir, 2014). The milk of dromedary is considered as nutritious food, particularly when converted into yoghurt (Attia *et al.*, 2001; Hassan *et al.*, 2006; Ibrahem and El Zubeir, 2016b). However, frequently it is described as substance that is not processed easily into yoghurt (Attia *et al.*, 2001; El Zubeir and Ibrahim, 2009). In particular, in order to be accepted by consumers, there is a need to improve its consistency (Hassaïne *et al.*, 2007; Hashim *et al.*, 2009; Abdel Rahman *et al.*, 2009; El Zubeir and Ibrahim, 2009; El Zubeir *et al.*, 2012a,b) and textural attributes including the desired oral viscosity, which is an important criteria for quality and consumers acceptance of yoghurt (Ibrahem and El Zubeir, 2016b).

Papaya fruit is known for its high nutritional and fiber content and is generally consumed ripe due to its characteristics flavor and aroma. Moreover, it is characterized by high content of proteolytic enzyme; papain as well as a similar enzyme called chymopapain; which may play an important role in food digestion (Starleya *et al.*, 1999; Punnagaiarasi, 2016). Moreover extraction of papain from unripe papaya gives around 80–90% activity and showed degradation capability on Levetiracetam and Granisetron HCl drug constituents both of which are known to adversely affect cellular systems (Hitesh *et al.*, 2012).

The inclusion of fruits and medicinal herbal extract into milk during fermentation have notable changes in yoghurt properties such as organoleptic, microbial content and improve therapeutical values of the final products (Shori, 2013). The use of different fruits and additives in fruit yoghurt production has improved its nutritional and sensory properties (Cakmakcı *et al.*, 2012). Recently fruit-based foods have created great interest for the development of functional foods (Sarkar, 2019).

Papaya use in ice cream manufacture as flavors and to enhance the quality of the product because in addition to their availability in Sudan, it can serve as a natural food preservative (Ali and El Zubeir, 2020), because of its antimicrobial, anti-oxidant and anti-inflammatory properties (Vijay *et al.*, 2014). In this study it is meant to evaluate the microbiological quality and sensory characteristics of camel milk yoghurt supplanted with papaya fruit pulp.

MATERIALS AND METHODS

Processing of papaya camel milk yoghurt

This experiment was done during the period from May to June 2017. The detailed description of the processing steps were given by Ahmed and El Zubeir (2021).

Camel milk was used for preparing yoghurt by adding YO – mix 505 starter culture (*Streptococcus thermopiles* and *Lactobacillus delbruckii sub sp. Bulgaricus*) that produced by Dansco, Denmark. Then 0.3% gum Arabic was added and 3 types of yoghurt were processed using of papaya fruit pulp at 0%, 3% and 7%. After the incubation (43˚C for 16-18 hours), the samples were stored at 4 ºC in a refrigerator for 3 weeks and the examination was done every 3 days for the microbiological quality and sensory properties.

Microbiological examination of yoghurt

Sterilization of equipment

Glassware such as flasks, test tubes, Petri dishes, pipettes and bottles were sterilized in a hot oven at 170ºC for 2 hours, whereas distilled water was sterilized by autoclaving at 121ºC for 15 minutes (Marshall, 1992).

Preparation of sample dilution

About eleven grams from a homogeneous yoghurt sample were added to 99 ml of sterile measuring flask, and then shaken to make 10^{-1} dilution. One ml from the dilution was aseptically transferred to 9 ml sterile distilled water. This procedure was repeated to make serial dilutions of 10^{-1} to 10^{-8} (Houghtby *et al.*, 1992).

Preparation of media

Plate count agar was used to determine the total and psychotropic bacterial counts. Yeast extract agar was used to determine the total yeast and mould counts and MaCconkey agar was used for examination of coliform count (Marshall, 1992). All media were obtained in dehydrated form and were prepared according to the manufacturer's instructions. Total bacterial count was done by inoculating 0.1 ml aliquot from 10^{-3}, 10^{-5} and 10^{-6} in a plate count agar and incubated in 37ºC for 48 hours according to Houghtby *et al.* (1992). Coliform count was done by inoculating 0.1 ml aliquot from 10^{0}, 10^{-1} and 10^{-4} in MacConkey agar and incubated at 37 °C for 48 hours (Christen *et al.*, 1992). The psychotropic bacterial count was done by inoculating 0.1 ml aliquot from 10^{-1}, 10^{-2} and 10^{-3} in a plate count agar and incubated in refrigerator at 4ºC for 48 hours (Frank *et al.*, 1992). Yeast and mould count was done by inoculating 0.1 ml aliquot from 10^{0}, 10^{-1} and 10^{-2} in a yeast extract agar and incubated in 37ºC for 48 hours (Harrigan and McCance, 1976).

Sensory evaluation

Yoghurt samples were subjected to sensory evaluation using ten untrained panelists to evaluate color, taste, flavor, texture and overall acceptability of coded yoghurt samples at 1, 3, 6, 9, 12, 15, 18 and 21 days using 5 scales Hedonic Rating Test (excellent = 5, very good = 4, good = 3, fair = 2 and poor = 1) according to Ihekoronye and Ngoddy (1985).

Statistical analysis

Data obtained during this study was analyzed by Statistical Analysis System (SAS, ver. 9). General linear model procedure was used to determine the effect of concentration of papaya and the storage period on microbiological and sensory characteristics of camel milk yoghurt. Means separations were carried out by using least significant difference at ($P \leq 0.05$).

RESULTS AND DISCUSSION

Microbial counts of camel milk yoghurt

The result in Table 1 showed the effect of concentrations of papaya on microbiology of camel milk yoghurt.

Total viable bacterial counts

The results in Table 1 showed that the concentrations of papaya revealed highly significant (P<0.001) effect on total bacterial count. The highest value (log 1.96) was found in the control camel milk yoghurt samples, while the lowest (log 1.79) was found in yoghurt containing 7% papaya. The lower values of total bacterial counts in yoghurt samples supplanted with papaya fruit could be attributed to the high content of phytochemicals in papaya pulps (Leong and Shui, 2002) and its antibacterial property (Chukwuemeka and Anthoni, 2010; Vijay *et al.*, 2014). The addition of papaya reduced content of total bacterial count to log 1.91 and log 1.79 in yoghurt containing 3% and 7% papaya, respectively compared with log 1.96 found in control yoghurt samples. This result agreed with Matter *et al.* (2016) who reported that the total bacterial count in all fruit yoghurt decreased in proportion due to the increase percentage of fruit addition. The present findings supported On the other hand, Benkerroum (2008) reported that camel milk is rich in antimicrobial components compared to milk of other species explains the lower microbial load in camel yoghurt. The inherent antimicrobial activity of camel milk could concur with the highly competitive nature of the lactic acid bacteria of the starter culture to limit the growth of undesirable microorganisms during the fermentation (Benkerroum, 2010). Also the results showed that the storage period had no significant (P>0.05) effect on total bacterial count (Table 2). Mohamed and El Zubeir (2014) found significant reduction of total bacterial count of camel milk subjected to heat treatment compared to raw camel milk. However Shuiep *et al.* (2007) reported that the high total counts indicate low quality of some raw camel milk samples, which may be due to milking procedures. Warsma *et al.* (2015) reported that the total bacterial count in raw camel milk samples collected during winter season was lower than summer season.

Data in Table 3 showed that interaction between concentrations of papaya and storage period had no significant (P>0.05) effect on total bacterial count. The highest total viable bacteria count (log 2.01) was found in yoghurt made using 3% papaya at day 6, while the lowest (log 1.67) was found in yoghurt made with 7% papaya at day 12. The beginning of the incubation period showed minimum rate of growth for total bacterial count. This result agreed with Attia *et al.* (2001) who reported 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. Moreover Ibrahem and El Zubeir (2016b) documented increase of *Streptococuss spp*. count in camel milk yoghurt using two different starter cultures. Also Hassan *et al.* (2007) recorded an increase of total bacterial count during storage period of gariss made at laboratory.

Table 1: Effect of concentrations of papaya on microbiological loads of camel milk yoghurt

Microbiological counts (log)	Papaya concentration			SE	LS
	0	3%	7%		
T.V.B	1.96^a	1.91^a	1.79^b	0.004	***
Coliform bacteria	0.96^a	0.72^b	0.87^{ab}	0.007	N.S
Yeast &Mould	1.83^a	1.74^a	1.57^b	0.005	***
Psychotropic	0	0	0	0	

Means in the same row bearing similar superscripts letters are not significantly different (P>0.05)
****= P<0.001*
SE = Standard error
SL = Significance level

Coliform bacteria counts

Data in Table 1 showed that addition of papaya has no significant (P>0.5) effect on coliforms bacteria of camel milk yoghurt. The addition of papaya reduced content of coliform bacteria to log 0.72 and log 0.87 in yoghurt containing 3% and 7% papaya respectively, compared to log 0.96 in the control camel milk yoghurt samples.

Table 2: Effect of storage period on the microbiological loads of camel milk yoghurt

Microbiological counts (log)	Storage period (days)							SE	LS
	3	6	9	12	15	18	21		
T.V.B	1.84^{ab}	1.98^{a}	1.8^{b}	1.71^{b}	1.88^{ab}	1.97^{a}	1.94^{ab}	0.009	N.S
Coliform bacteria	0.4^{b}	0.75^{a}	1.01^{a}	1^{a}	0.74^{a}	1.03^{a}	1.01^{a}	0.016	***
Yeast & mould	2.15^{a}	2.23^{a}	1.79^{b}	1.42^{d}	1.66^{bc}	1.27^{d}	1.74^{cd}	0.012	***
Psychotropic	0	0	0	0	0	0	0	0	0

Means in the same row bearing similar superscripts letters are not significantly different (P>0.05)
*** = P<0.001
SE = Standard error
SL = Significance level

Table 3: Effect of concentration of papaya on the microbiological loads of camel milk yoghurt during storage period

Papaya concentration	Storage period (days)	Microbiological counts (log)			
		T.V.B	Coliform	Yeast &mould	Psychotropic
0	**3**	1.84	0.57	2.19	0
	6	2.18	1.47	2.45	0
	9	1.91	0.79	2.04	0
	12	1.9	1.01	1.67	0
	15	1.82	0.75	1.68	0
	18	1.96	0.68	1.37	0
	21	2.14	1.42	1.47	0
3%	**3**	1.99	0.13	1.83	0
	6	2.01	0.74	2.15	0
	9	1.8	0.9	1.76	0
	12	1.81	0.82	1.36	0
	15	1.92	0.49	1.53	0
	18	1.97	1.43	1.12	0
	21	1.82	0.8	1.27	0
7%	**3**	1.68	0.51	2.44	0
	6	1.75	0.3	2.1	0
	9	1.69	1.35	1.56	0
	12	1.67	1.17	1.23	0
	15	1.89	0.98	1.79	0
	18	1.98	0.98	1.33	0
	21	1.86	0.82	1.67	0
P		<0.1141	<0.001	<0.0434	0
SL		**N.S**	***	*	0

Mean in the same row bearing similar superscripts letters are significantly different (P>0.05)
***= P<0.001 *= P<0.05
SE= Standard error
LS= Significant level

The count for coliforms is found to be less than the 10 cfu/g as stated in most of the standard regulations. This suggested the antimicrobial activity of papaya and its antioxidant properties (Bari *et al.,* 2006; USDA, 2009; Chukwuemeka and Anthoni, 2010; Vijay *et al.,* 2014; Ali and El Zubeir, 2020).Storage period showed higher significant (P<0.001) effect on coliform. The coliform bacteria in camel milk yoghurt were found to increase by the advancement of the storage period (Table 2). Gnan *et al.* (2013) reported that the increase of the microbial loads during storage was more obvious in goat and cow milk compared to camel milk. This might be because of the presence of protective factors in camel milk. However Hassan *et al.* (2008) and Suliman and El Zubeir (2014) reported the presence of coliform count in gariss processed by nomadic camel herders. Eissa *et al.* (2011) reported that the presence of coliform indicates unsanitary conditions of processing.

Data in Table 3 showed that interaction between papaya and storage period had significant (P<0.001) effect on coliform bacteria. The highest coliform content (log 1.47) was recorded in the control yoghurt at day 6, followed by yoghurt made by addition of 3% papaya (log 1.43) at day 15 compared to that obtained at day 9 (1.35) in yoghurt made with 7% papaya at day 9. However the coliform bacteria revealed no growth in all ice cream samples during the storage (Ahmed and El Zubeir, 2015; Ali and El Zubeir, 2020). The result in this finding may be related to the presence of some contamination in milk during production (Shuiep *et al.* 2007; Mohamed and El Zubeir, 2014). Hence the milk for processing should be free from coliform. However Urano (2003) reported that the preservation of natural indigenous lactic acid bacteria derived from fermented milk has a competitive exclusion of contaminants and pathogens.

Yeast and mould counts

The result showed that yeast and moulds were significantly (P<0.001) affected by the addition of papaya, which reduced yeast and mould counts to log 1.74 and log 1.57 in camel milk yoghurt samples containing 3% and 7% papaya respectively, compared to log 1.83 in the control samples. The highest value (log 1.83) was found in control yoghurt samples, while the lowest (log 1.57) was found in yoghurt containing 7% papaya (Table 1). This might be because papain presents antifungal properties (Chukwuemeka and Anthoni, 2010; Vijay *et al.,* 2014). However Shuiep *et al.* (2007) reported that the yeast and moulds count of raw camel milk samples from the semi intensive system were higher compared to the traditional systems. Also storage period affected (P<0.001) significantly the count of yeast and moulds. Yeast and moulds were increased in day 1 and 2, and then decreased until the end of storage period (Table 2). This result disagreed with Eissa *et al.* (2011) who reported that the yeast and moulds were increased in camel and cow milk yoghurt during storage period.

Interaction between papaya and storage period showed significant (P<0.05) effect for yeast and mould count in camel milk yoghurt. The highest yeast and mould content (log 2.45) was found in control yoghurt samples at day 6, while the lowest (log 1.12) was found in camel milk yoghurt made using 3% papaya at day 18.

Psychotronic bacteria counts

The result showed that psychotropic bacteria were absent in all yoghurt samples. This suggested that the raw milk used for processing is free of psychotropic bacteria. However Mohamed and El Zubeir (2014) reported a mean of 1.7×10^{8} psychotrophic bacteria in camel milk samples. Moreover heating of milk prior to processing could be another factor for eliminating psychotropic bacteria.

Sensory evaluation of camel milk yoghurt

The results showed that the concentrations of papaya revealed high significant (P<0.001) effect on all sensory parameters (color, taste, flavor, texture and overall acceptability) of camel milk yoghurt (Table 4). This result agreed with Cakmakcı *et al.* (2012) who reported that the use of different fruits and additives in fruit yoghurt production has improved its nutritional and sensory properties. All organoleptic scores were increased except color by addition of different concentrations of papaya (Table 4).

Table 4: Effect of concentrations of papaya on sensory characteristics of camel milk yoghurt

Sensory characteristics	Papaya concentration			SE	LS
	0	3%	7%		
Color	1.16^{c}	2.1^{b}	2.88^{a}	0.007	***
Taste	3.11^{a}	2.62^{b}	2.41^{b}	0.009	***
Flavor	3.21^{a}	2.86^{b}	2.25^{c}	0.009	***
Texture	3.1^{a}	3.06^{a}	2.22^{b}	0.009	***
Overall acceptability	3.08^{a}	3.01^{a}	3.24^{b}	0.01	***

Means in the same row bearing similar superscripts letters are not significantly different (P>0.05)
*** = P<0.001
SE = Standard error
SL= Significant level

Table 5: Effect of storage period on sensory evaluation of camel milk yoghurt

Sensory characteristics	Storage period (days)								SE	LS
	1	3	6	9	12	15	18	21		
Color	2.23^{a}	2.26^{a}	2.23^{a}	1.66^{c}	1.9^{bc}	2.06^{ab}	1.9^{bc}	2.1^{ab}	0.052	***
Taste	3.13^{a}	2.9^{ab}	3.1^{a}	2.97^{a}	2.1^{6c}	2.86^{ab}	2.1^{c}	2.5^{bc}	0.075	***
Flavor	2.9^{ab}	2.9^{ab}	3.2^{a}	3.1^{a}	3.13^{a}	2.63^{bc}	1.96^{d}	2.36^{c}	0.074	***
Texture	2.93^{ab}	3.06^{a}	3.1^{a}	3.63^{bc}	3.13^{a}	2.73^{abc}	2.33^{c}	2.43^{c}	0.075	***
Overall acceptability	2.86^{b}	3^{ab}	3.33^{a}	3.03^{ab}	3^{ab}	2.7^{bc}	2.4^{c}	2.3^{c}	0.077	***

Means in the same row bearing similar superscripts letters are not significantly different (P>0.05)
*** = P<0.001
SE = Standard error
SL= Significant level

Color score

The results presented in Table 4 showed that the addition of papaya showed significant (P<0.001) effect on color. The highest color score (2.88) was found in yoghurt containing 7% papaya, while the lowest (1.16) was obtained for control camel milk yoghurt samples. This result suggested that the yellow color of papaya make the camel milk yoghurt more attractive for panelist. This result agreed with Abbas *et al.* (2013) who reported that milk fat of dromedary camels carries a lower level of carotene and lesser concentrations of short chain fatty acids as compared to milk of bovine. According to Morales and Van Boekel (1998); Chye *et al.* (2012), the color of a food is the result of natural products associated with raw material or of colored compounds that are generated. However non significant (P>0.05) differences were found between the color scores of yoghurt samples made from camel and sheep milks (Ibrahem and El Zubeir, 2016b). Mbaeyi-Nwaoha *et al.* (2017) reported that plain yoghurt had the highest score for color and there were significant (P<0.05) differences in the color of the plain yoghurt and the flavored yoghurt samples.

The storage period also had significant (P<0.001) effect on color score. The color was decreased by the progress of storage period (Table 5). However Ibrahem and El Zubeir (2016b) reported that the panelists reported similar score for the color of yoghurts made from camel, sheep and their mixture milks.

Data in Table 6 showed that interaction between papaya and storage period had no significant (P>0.05) effect on color score.

Table 6: Effect of concentrations of papaya on the sensory characteristics of camel milk yoghurt during storage period

Papaya concentration	Storage period (days)	Sensory characteristics				
		Color	Taste	Flavor	Texture	Overall acceptability
0	1	1.4	3.6	3.1	3.5	2.9
	3	1.3	2.6	2.7	3.7	3
	6	1.5	3.6	3.4	3.5	3.8
	9	1	3.4	3.5	2.5	3
	12	1.1	3	3.8	2.8	2.9
	15	1	3.5	3.3	2.8	3.2
	18	1	2.5	2.5	2.7	2.7
	21	1	2.7	3.4	3.3	3.2
3%	1	2.3	2.9	2.9	2.9	3
	3	2.5	3.1	3.1	3.1	3.2
	6	2.3	3.1	3.2	3.2	3.3
	9	1.5	3.1	3.4	3.2	3.5
	12	1.9	2.1	3.1	3.8	3.6
	15	2.1	2.2	2.8	3.4	3
	18	2.1	1.6	2.3	2.6	2.5
	21	2.1	2.9	2.1	2.3	2
7%	1	3	2.9	2.7	2.4	2.7
	3	3	3	2.9	2.4	2.8
	6	2.9	2.6	3	2.6	2.9
	9	2.5	2.4	2.4	2.2	2.6
	12	2.7	1.4	2.5	2.8	2.5
	15	3.1	2.9	1.8	2	1.9
	18	2.6	2.2	1.1	1.7	2
	21	3.2	1.9	1.6	1.7	1.7
SL		N.S	***	***	***	**

Mean in the same row bearing similar superscripts letters are not significantly different (P>0.05)
*** = P<0.001
** = P<0.01
SE= Standard error
LS= Significant level

The results showed that the color score had no significant (P>0.05) differences between control camel milk yoghurt and those made using 3% and 7% papaya. This result agreed with Ibrahem and El Zubeir (2016b) who reported that no significant (P>0.05) differences between yoghurt samples made from camel-sheep mixture milks using YC-X11 and CH1 starter cultures in evaluation of color score during the storage period. The mean scores of color ranged from 1 in the control yoghurt samples to 3.2 in the yoghurt made with 7% papaya. The highest color score was 3.2, which was obtained in yoghurt made with 7% papaya at day 21; while the lowest score (1) was found in the control camel milk yoghurt at 9, 15, 18, and 21days of storage.

Taste score

The results presented in Table 4 showed that the addition of papaya had significant

(P<0.001) effect on taste score. The addition of papaya reduced the score of taste. This result agreed with Matter *et al.* (2016) who reported that the addition of fruit pulp decreased the acidity of yoghurt and acidity was decreased with the increasing of the amount of fruit pulp added. Also the acidity of yoghurt was found to decrease by addition of papaya (Ahmed and El Zubeir, 2021). The decrease in acidity of camel milk yoghurt containing papaya might be due to the low acidity of papaya.

The storage period showed significant (P<0.001) effect on taste score; the best taste score (3.13) was found at day 1, while the lowest (2.1) was estimated at day 12 and 21. The interaction between papaya and storage period showed significant (P<0.001) effect on taste score; the best taste (2.7) for control yoghurt samples was found at day 21. However in yoghurt made with 3% papaya, the best taste (3.1) was found at day 3, 6 and 9, while in yoghurt containing 7% papaya the best taste (2.9) was obtained at day 1 and 15. The pectin and fructose of papaya fruits were found to improve the consistency and viscosity and hence the mouth fell is improved (Roy *et al.*, 2015). This result suggested that papaya can be used in camel milk yoghurt with acceptable taste, which could due to nice flavor valuable of ripe papaya (Saran, 2010). Also sucrose content increases during ripening of papaya and can reach up to 80% of the total sugars (Paul, 1993; OECD, 2010).

Flavor score

The result showed that flavor score were significantly affected (P<0.001) by addition of papaya. The best flavor score (2.25) was found in yoghurt containing 7% papaya (Table 4). FAO and WHO recommend 5-15% of fruit concentration to use in making value-added yoghurt **(**Farahat and El-Batawy, 2013). They reported that papaya and pineapple fruits have been selected as best flavor enhancer fruits used in dahi compared to kiwi and kaki fruits. Ripe papaya fruits and papaya products are consumed by humans for their flavor and nutritional value (Saran, 2010). *Carica papaya* is a source of carotenoids, vitamin, thiamin, riboflavin, niacin, vitamin B-6 and vitamin K (Bari *et al.*, 2006; Adetuyi *et al.*, 2008; USDA, 2009).

The storage period had high significant (P<0.001) effect on flavor score, the highest flavor score (2.36) was found at the end of storage period (Table 5). This result agreed with Kilara and Shahani (1978); Salih and Hamid (2013) who stated 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 also be due to the presence of antimicrobial agents and inhibiting growth factor on papaya (Chukwuemeka and Anthoni, 2010). However as the storage period advanced, lipolytic and proteolytic microorganisms multiply as the result of fat and protein breakdown (Attia *et al.*, 2001; Hassaïne *et al.*, 2007; Seifu *et al.*, 2012). They reported the proteolytic activity of dairy lactic acid bacteria is essential for the development of flavor compounds in different fermented milk products.

The result presented in Table 6 showed that interaction between papaya and storage period had significant (P<0.001) effect on flavor score. The highest flavor score (3.8) was found in control yoghurt samples at day 12, while the lowest (1.1) was obtained in yoghurt made with 7% papaya at day 18. This result contradict with those reported by 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).

Texture score

The results in Table 4 showed that yoghurt made from pure camel milk had watery texture; this may be due to high water content in camel milk. This result supported Hassan *et al.* (2007) and Ibrahem and El Zubeir (2016b) who reported that the fermented camel milk lack firm texture. This is in consistent with El Zubeir and Jabreel (2008) who reported slow fermentation and week coagulation of camel milk. Attia *et al.* (2001) reported that fermented dromedary milk did not produce a curd structure but few dispersed small casein fragments at the surface and a film or firm gel at the bottom of the vessel. Similarly it was reported that yoghurt produced from camel milk (with no additives) was reported to have a thin and very soft texture due to the low total solids content in camel yoghurts (Hashim *et al.*, 2009; El Zubeir *et al.*, 2012a,b; Ibrahem and El Zubeir, 2016b).

Table 6 showed that the effect of concentrations of papaya and storage period had significant (P<0.001) effect on texture; the highest texture score (3.8) was obtained in yoghurt made with 3% papaya at day 12, while the lowest (1.7) was found in yoghurt made with 7% papaya after 18 and 21 days. This result agreed with Roy *et al.* (2015) who reported that fruit pulp helped to maintain textural properties of finished products. Moreover they added that higher solids and fiber content in fruit pulp may be associated with increasing viscosity and consequently improve the textural properties of fruit yoghurt.

Overall acceptability

The result in Table 4 showed that the addition of papaya had significant (P<0.001) effect on overall acceptability of camel milk yoghurt. This result supported Ibrahem and El Zubeir (2016b) who reported that there were significant (P<0.05) variations between mean scores for the overall acceptability for yoghurt samples made from camel milk and camel-sheep milk mixtures during the storage period. The highest overall acceptability (2.24) was found in yoghurt made with 7% papaya. Also Roy *et al.* (2015) found that papaya yoghurt using cow milk with all ratios (5, 10 and 15%) was more accepted. Similarly Nazni and Komathi (2014) reported that for all developed yoghurts, buffalo milk with incorporation of papaya pulp yoghurt has high acceptability. On the other hand, Abu-Alruz *et al.* (2009) reported that papain has been reported to improve meltability and stretchability of Nabulsi cheese with outstanding fibrous structure enhancing superiority in the application in kunafa, pizza and pastries. The overall acceptability was found to increase by the progress of storage period until day 12 and then decreased until the end of storage period (Table 5). The result showed that yoghurt made from pure camel milk had lower acceptability due to the watery texture. This result supported El Zubeir *et al.* (2012a,b); Ibrahem and El Zubeir (2016a,b). Similarly Hashim *et al.* (2009) reported that yoghurt produced from camel milk (with no additives) was found to have a thin and very soft texture due to the low total solids content in camel milk yoghurt. Data in Table 6 showed that the interaction between papaya and storage period had significant (P<0.01) effect on overall acceptability. The results showed that yoghurt containing 7% papaya received higher acceptability than yoghurt containing 3% papaya. A previous study revealed that papaya yoghurt was most accepted yoghurt during storage among other fruits studied by Roy *et al.* (2015).

This study showed an important findings, which indicated that combination of camel milk and papaya for making yoghurt will enhance its health image as both are considered as functional food which supported Ali and El Zubeir (2020) who use papaya in making camel milk ice cream.

CONCLUSION

The addition of papaya fruit pulp improves the microbiological quality and sensory attributes of camel milk yoghurt. Moreover the result showed that yoghurt made with 7% papaya had more acceptability followed by 3% papaya compared to the pure camel milk yoghurt. Hence this study recommended consummation of camel milk products fortified with papaya as nutritional and functional food.

ACKNOWLEGEMENT

Financial support for this work was provided by the Ministry of Higher Education and Scientific Research, Sudan for the project entitled: Value chain and processing of camel milk functional food.

REFERENCES

[1] Abdel Rahman, E.; Hamid, A. and Magdi, A. O. (2009). Microbiological and biochemical changes and sensory evaluation of camel milk fermented by selected bacteria starter cultures. African Journal of

Food Science, 3(12): 398-405. http://www.acadjourn.org/ajfs

[2] Abu-Alruz, K.; Mazahreh, A. S.; Quasem, J. M.; Hejazin, R. K. and El-Qudah, J. M. (2009). Effect of proteases on meltability and stretchability of Nabulsi cheese. Am. J. Agric. Biol. Sci., 4: 173-178. DOI: 10.3844/ajabssp.2009.173.178.

[3] Adetuyi, F. O., Akinadewo, L. T., Omosuli, S. V. and Ajala, L. (2008). Anti-nutrient and anti-oxidant quality of waxed and un waxed pawpaw *(Carica papaya*) fruit stored at different temperatures. *African Journal Biotechnology*, 7, 2920-2924.

[4] Ahmed, A. S. M. and El Zubeir, I. E. M. (2015). Microbiological and sensory properties of low fat ice cream form camel milk using natural additives. Ann. Food Sci. Technol., 16: 236-244.

[5] Ahmed, F. B. E. S. and El Zubeir, I. E. M. (2021). The potentiality of papaya (*Carica papaya*) fruit pulp on the functional properties and physicochemical content of camel milk yoghurt. MOJ Food Processing Technology, 9(2):72-78. DOI: 10.15406/mojfpt.2021.09.00262

[6] Ali, H. J. and El Zubeir, I. E. M. (2020). Microbiological and sensory evaluation of camel milk ice cream using Vanilla, Baobab (*Adanisonia digitata*) and papaya (*Carica papaya*) and papaya (*Carica papaya*) fruits. Annals Food Science and Technology, 21 (2): 326-337.

characteristics of goat's milk dadih incorporated with tropical- fruit purees. International Food Research Journal, 19(4): 1387-1392.

[14] Christen, L. G.; Dandson, M. P.; McAllister, S. J. and Roth, A. L. (1992). Coliform and other indicator bacteria. In: Standard Methods for the Examination of Dairy Products, 16th edition, Marshall, R.T. (Ed). American Public Health Association. Washington, DC, USA.

[15] Eissa, E. A.; Yagoub, A. A.; Babiker, A. A. and Mohamed Ahmed, I. A. (2011). Physicochemical, microbiological and sensory characteristics of yoghurt produced from camel milk during storage. EJEAF Che, 10(6): 2305-2313.

[16] El Zubeir, I. E. M.; Babekir, R. and Shuiep, E. S. (2012a). Chemical properties and acceptability of yoghurt made from camel–sheep milk. Sultanate of Oman 29th .January–1st February In: The 3rd ISOCARD International Conference, 3, pp. 220-221.

[17] El Zubeir, I. E. M.; Basher, M. A. E.; Alameen, M. H.; Mohammed, M. A. S. and Shuiep, E. S. (2012b). Chemical characteristics and acceptability of yoghurt made from non bovine milks. Livestock Research for Rural Development, 24 (3), Available at www.lrrd.org/lrrd24/3/cont2403.htm.

[18] El Zubeir, I. E. M. and Ibrahim, M. I. (2009). Effect of pasteurization of milk on the keeping quality of fermented camel milk (*Garriss*) in Sudan. Livestock

[7] Attia, H.; Kerouatou, N. and Dhouib, A. (2001). Dromedary milk lactic acid fermentation: Microbiological and rheological characteristic. J. Ind. Microb. Biotech., 26(5): 263-270.
http://www.springerlink.com/content/k0ryl98bxc0ngdu9/

[8] Bari, L. P.; Hassen, N.; Absar, M. E.; Haque, M. I. I. E.; Khuda, M. M.; Pervin, S.; Khatun and Hossain, M. I. (2006). Nutritional analysis of two varieties of papaya (*Carica papaya*) at different maturation stage. Pakistan Journal Biological Science, 9:137-140.

[9] Benkerroum, N. (2008). Antimicrobial activity of lysozyme with special relevance to milk. African Journal of Biotechnology, 7: 4856-4867.

[10] Benkerroum, N. (2010). Antimicrobial peptides generated from milk proteins: a survey and prospects for application in the food industry. A review. International Journal of Dairy Technology, 63: 320-338.

[11] Cakmakcı, S.; Cetin, B.; Turgut, T.; Gurses, M. and Erdoğan, A. (2012). Probiotic properties, sensory qualities and storage stability of probiotic banana yoghurts. Turk. J. Vet. Anim. Sci., 36: 231–237.

[12] Chukwuemeka, N. O. and Anthoni, A. B. (2010). Antifungal effects of pawpaw seed extracts and papain on post harvest *Carica papaya* L. fruit rot. Afri. J. Agri. Res., 5: 1531-1535.

[13] Chye, S. J.; Ahmad, R. and Noor Aziah, A. A. (2012). Studies on the physicochemical and sensory Research for Rural Development, 21(2). Available at: http://www.lrrd.org/lrrd21/2/zube21019.htm.

[19] El Zubeir, I. E. M. and Jabreel, M. S. O. (2008). Fresh cheese from camel milk coagulated with Camifloc. Int. J. Dairy Technol., 61: 90-95. DOI=10.1111/j.1471-0307.2008.00360.x&ArticleID=387593

[20] Farahat, A. M. and El-Batawy, O. I. (2013). Proteolytic activity and some properties of stirred fruit yoghurt made using some fruits containing proteolytic enzymes. World Journal of Dairy & Food Sciences, 8 (1): 38-44.

[21] Frank, J. F.; Christen, G. L. and Bullerman, L. B. (1992). Tests for group of microorganisms. In: Standard Methods for the Examination of Dairy Products, 16th ed. Marshall, T. R. (ed). American Public Health Association, Washington, D.C. pp. 271-286

[22] Gnan, S. O.; Gebali, M. K. and Eshelli, M. S. (2013). Bacterial quality and shelf life of pasteurized camel milk in Tripoli, Libya. International Conference on Sustainability of Camel Population and Production, 17-20 February 2013. Faculty of Agricultural and Food Science, King Faisal University, Hafuf Al-Ahssa, Saudi Arabia, P 148.

[23] Gran, S. O.; Mohammed, M. O; Shareha, A. M.and Lgwegba, A. O. L. (1991). Proceeding of the International Conference on Camel Production and Improvement. 10-13 Dec., 1990, Tobruk, Libya, 183-188.

[24] Harrigan, W. F. and MaCane, M. E. (1976). Laboratory Method in Food and Dairy Microbiology. Academic Press INC. London.
[25] Hashim, I. B., Kkhalil, A. H. and Habib, H. (2009). Quality and acceptability of a set-type yoghurt made from camel milk. Journal of Dairy Science 92(3): 857-862.
[26] Hassaïne, O.; Zadi-Karam, H. and Karam, N. (2007). Technologically important properties of lactic acid bacteria isolated from raw milks of three breeds of Algerian dromedary (*Camelus dromedarius*). Afr. J. Biotechnol., 6: 1720-1727.
[27] Hassan, R. A.; El Zubeir, I. E. M. and Babiker, S. A. (2006). Microbiology of camel fermented milk (Gariss) in Sudan. Res. J. Microbil., 1:160-165. http://scialert.net/abstract/?doi=jm.2006.160.165
[28] Hassan, R. A.; El Zubeir, I. E. M. and Babiker, S. A. (2007). Effect of pasteurization of raw milk and storage temperature on the chemical composition of fermented camel milk. Int. J. Dairy Sci., 2 (2): 166-171. http//scialert.net/qredirect.php?doi=ijds.2007.166.171&linkid=pdf.
[29] Hassan, R. A.; El Zubeir, I. E. M. and Babiker, S. A. (2008). Chemical and microbial measurements of fermented camel milk (Gariss) from transhumance and nomadic herds in Sudan. Aust. J. Basic Appl. Sci., 2: 800-804. http,//www.ajbasweb.com/ajbas/2008/800-804.pdf
[30] Hitesh, P.; Bhoi Manojbhai, N.; Borad Mayuri, A.; Dalvadi Ashvin Kumar, A. and Dalsania Kiranben, V. (2012). Extraction and application of papain enzyme on degradation of drug. Pharmaceutikal Sciences, IJPBSI, 2(3):113-115.
[31] Houghtby, A. G.; Maturin, L. J. and Koenig, E. K. (1992). Microbiological count method. In Standard Method for the Examination of Dairy Products, 16th edition, R. T. Marshall. Washington, DC: American Public Health Association, pp: 213-246. http://samples.Sainsburysebooks.co.uk/9780470999721_sample_386290.pdf.
[32] Ibrahem, S. A. and El Zubeir, I. E. M. (2016a). Evaluation of chemical composition of yoghurt made from camel and camel-sheep milk mixtures during storage. Int. J. Dairy Sci., 11(1):35-40. DOI: 10.3923/ijds.2016.35.40
[33] Ibrahem, S. A. and El Zubeir, I. E. M. (2016b). Processing, composition and sensory characteristic of yoghurt made from camel milk and camel–sheep milk mixtures. Small Ruminant Research, 136:109-112. DOI:10.1016/j.smallrumres.2016.01.014
[34] Ihekoronye, L. J. and Ngoddy, P. O. (1985). Integrated Food Science and Technology for the Tropics. Edu., MacMillan Publishers, London.
[35] Kilara, A. and Shahani, M. K. (1978). Lactose activity of cultured and acidified dairy products. J. Dairy Sci., 59: 2031-2035.
[36] Leong, L. P. and Shui, G. (2002). An investigation of antioxidant capacity of fruits in Singapore markets. Food Chem., 76(1): 69-75.
[37] Marshall, R. T. (1992). Media In: Standard Methods for the Examination of Dairy Products. Marshall, R. T. (ed.), 16th edition, Port City Press, Baltimore, Washington.
[38] Matter, A. A.; Mahmoud, E. A. M. and Zidan, N. S. (2016). Fruit flavored yoghurt: Chemical, functional and rheological properties. International Journal of Environmental & Agriculture Research (IJOEAR), 2(5): 60-61.
[39] Mbaeyi-Nwaoha, I. E.; Umeh, L. C.; Igbokwe, C. J.; Obodoechi C. M. and Okoronkwo N. C. (2017). Production and quality evaluation of flavoured yoghurt from graded levels of sweet variety of African Bush Mango "Ugiri" (*Irvingia gabonensis*) juice and pulp. Food Science and Technology, 5(2): 56-69.
[40] Mohamed, I. M. A. and El Zubair, I. E. M. (2014). Effect of heat treatment on keeping quality of camel milk, Annals. Food Science and Technology, 15(2): 239-245.
[41] Morales, F. J. and Van Boekel, M. A. J. S. (1998). A study on advanced maillard reaction in heated casein/sugar solutions: color formation. International Dairy Journal, 8: 907-915.
[42] Nazni, P. and Komathi, K. (2014). Quality characteristics and acceptability of papaya pulp incorporated yoghurt. Int. J. Fd. Nutr. Sci , 3: 158-162. http:/www.ijfans.com/currentissue.html
[43] OECD (2010). Consensus document on compositional consideration for new varieties of papaya *(Carica papaya*): Key food and feed nutrients, anti-nutrient, toxicants and allergens. www.eocd .org /biotrack.
[44] Paul, R. E. (1993). Pineapple and papaya In Biochemistry of fruit ripening. Chapman and Hall Boundary Row. London.
[45] Roy, D. K. D.; Saha, T.; Akter, M.; Hosain, M.; Khatun, H. and Roy, M. C. (2015). Quality evaluation of yoghurt supplemented with fruit pulp (Banana, Papaya, and Water Melon). International Journal of Nutrition and Food Sciences, 4(6): 695-699. doi, 10.11648/j.ijnfs.20150406.25
[46] Salih, M. M. and Hamid, O. I. A. (2013). Effect of fortifying camel's milk with skim milk powder on the physicochemical, microbiological and sensory characteristics of set yoghurt. Advance Journal of Food Science and Technology, 5(6): 765-770.
[47] Saran, P. L. (2010). Screening of papaya cultivars under Doon Valley conditions. Pantnagar J. Res., 8(2):246-247.
[48] Sarkar, S. (2019). Potentiality of probiotic fruit yoghurt as a functional food– A review. J. Nutr. Food Sci., 2: 009.
[49] Seifu, E.; Abraham, A.; Kurtu, M. Y. and Yilma, Z. (2012). Isolation and characterization of lactic acid

bacteria from *Ititu*: Ethiopian traditional fermented camel milk. Journal of Camelid Science, 5: 82-98.

[50] Shori, A. B. (2013). Nutritional and theraputical values of chickpea water extract enriched yoghurt made from cow and camel milk. Am. J. Drug Discov. Dev., 3(2): 47-59.

[51] Shuiep, E. S.; El Zubeir, I. E. M.; El Owni, O. A. O. and Musa, H. H. (2007). Assessment of hygienic quality of camel (*Camelus dormedarius*) milk in Khartoum state, Sudan. Bulletin of Animal Health and Production in Africa, 55:112-117.

[52] Starleya, I. F.; Geisela, M. P. S. and Stephen, W. B. (1999). The treatment of paediatric burns using topical papaya. *Burns.*, 25: 636-639.

[53] Suliman, E. S. K. and El Zubeir, I. E. M. (2014). A survey of the processing and chemical composition of gariss produced by nomadic camel women herders in AlGaderif State, Sudan. Jordan Journal of Biological Sciences, 7(2 96):95-100.

[54] Urano, I. S. (2003). In vitro probiotic properties of indigenous dadih lactic acid bacteria. Asian – Aus. J. Anim. Sci., 16:726-731.

[55] USDA (2009). (United States Department of Agriculture), Agricultural Research service. National Nutrient Data base for standard reference, release 22, Nutrient data laboratory home page, http://www.ars. Usda. Gov./ba/bhnrc/nol.

[56] Vijay, Y.; Pradeep, K.; Goyal, C. S.; Chauhan, A. and Goyal, B. V. (2014). *Carica papaya* Linn: An overview. International Journal of Herbal Medicine, 2 (5): 01-08.

[57] Warsma, L. M. and El Zubeir, I. E. M. (2015). Assessment of bacterial loads of camel milk from farms and sale points in Khartoum State, Sudan. Sudan Journal of Science and Technology, 16(1): 119-120.