Production of Flavoured Fermented Camel Milk

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Abstract: The present study investigated the effect of adding cinnamon (*Cinnamomum verum*) and doum palm fruit (*Hyphaene thebaica*) water extracts (as a natural flavour agent and antioxidant compound sources) on fermented camel milk properties. *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus* were used in the fermentation process. The analyses of chemical and nutritional values of camel milk, cinnamon and doum palm fruit extracts were performed. The samples were analyzed for physicochemical, phenolic compounds, antioxidant activity, minerals, vitamins, rheological, microbiological and sensory properties when fresh and during storage (21 day) at 4±1°C. Flavoured fermented camel milk with concentrated cinnamon and doum extracts caused a significant increase in total phenolic content proportionally with increasing the concentration level of added extracts, while significant decrease was shown during storage period. The antioxidant activity of flavoured substituted fermented camel milk in which concentrated cinnamon and doum extracts were added ranged from 91.39 - 90.31% when 3 and 9% extracts levels were added respectively. Fermented camel milk flavoured with doum extract had higher vitamins content compared with that made by adding cinnamon extract. Minerals content in treatments with doum fruit extract showed the highest contents of potassium (K), sodium (Na), iron (Fe) and zinc (Zn) compared with untreated fermented camel milk. The greatest increase rate observed in potassium (K) in fermented camel milk made by adding3% and 9%cinnamon and doum extracts. Total bacterial count increased in all flavoured fermented milk, while the count of *Str. thermophiles* and *Lb. bulgaricus* increased to maximum at the 14th day of storage period then decreased up to the end of storage period. Increasing levels of cinnamon and doum extracts negatively influenced the sensory scores of some properties of fermented camel milk. The overall results cleared that, it is possible to produce good quality fermented camel milk with good flavour, body & texture, appearance and colour by adding of (cinnamon and doum) extracts as a good functional foods.

Keywords: Camel milk, fermentation, cinnamon, doum palm, nutritional values, phenolic compounds, antioxidant activity, rheological and organoleptic properties

INTRODUCTION

Camel milk is closer to human milk than any other milk. Camel milk is different from other ruminant milk, having low cholesterol, low sugar, high minerals (sodium, potassium, iron, copper, zinc and magnesium), high vitamin C. Camel milk is unique from other ruminant's milk in terms of composition as well as claimed health effects. Camel milk has potential therapeutic characteristics, such as anti-hypertensive, antidiabetic and anti-carcinogenic. It is often easily digested by lactose-intolerant individuals. On the other hand, camel milk also has ability to reduce the elevated level of bilirubin, globulin and granulocytes (Yadav *et al*., 2015). Camel milk is opaque white with normal odour and salty taste. Opaque white colors because of the fats are finely homogenized throughout the milk. Camel milk is unique from other ruminant milk in terms of composition as well as functional as it contains a high concentration of immunoglobulins and insulin. It is high in vitamins (A, B-2, C and E) and minerals (sodium, potassium, iron, copper, zinc and magnesium) and low in protein, sugar and cholesterol (Kamal *et al*., 2007; Al-Hashem, 2009). Traditional preparation of yogurt may be beneficial by including other ingredients such as soya protein, vegetables, sweet potato, pumpkin and plum (Joo *et al*., 2001; Park *et al*., 2003) to enhance the flavour as well as the nutritional quality (Shori and Baba, 2011a).

Cinnamon (*Cinnamomum verum*) is one of the well known, oldest and most flavour filled spices. It belongs to the genus cinnamomum of the Laurel family (*Lauraceae*). Cinnamon has many species that differ in smell, taste and color depending upon the native area or land. Cinnamon helps people with type-II diabetes and improves their ability to respond to insulin, thus normalizing their blood sugar levels. (Khan *et al.,* 2003). Not only it improves the body's ability to utilize blood sugar, but also just smelling the wonderful odor of this sweet spice boosts brain activity. Furthermore, it can also be used for natural birth control. There are a number of uses for cinnamon in the kitchen, and cooking with it makes food a whole lot tastier. It can be added to hot chocolate to give it an added cinnamon flavour. It can be used as an alternative to traditional food preservatives.

Doum palm fruit (*Hyphaene thebaica*) is one of the desert members of the *family* (*Palmae*). It is common in Egypt, West India, several parts of Africa and known as doum or gingerbread palm because the plant has the taste and the consistency of gingerbread (Bonde *et al.,* 1990; Hsu and Coupar, 2006). In Egypt, the doum palm has been cultivated since ancient times. The outer layer of the fruit is edible and can be prepared either in sliced or in a powder form, which is further dried, then added to food as flavouring agent (Aremu and Fadele, 2010). Utilization of doum palm fruit (*Hyphaene thebaica*) in its powder form was applied in some food products as a source of fiber, stabilizer and minerals as well as for its potential healthy effect (Abd El-Rashid and Hassan, 2005). Research on the fruit pulp

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of *Hyphaene thebaica* showed that it contains nutritional minerals, proteins and fatty acids, in particular the nutritionally essential linoleic acid (Cook *et al.,* 2000). It is listed as one of the useful plants of the world that supplies human with dietary fibres, carbohydrates and anti-hyper tension substances (Lokuruka, 2008). Doum fruit is a good source of potent antioxidants (Hsu and Coupar, 2006). Also, aqueous doum palm extracts increased the viability and activity of some certain dairy starter cultures which used in the manufacture of some dairy products especially probiotics (Hassan and Aumara, 2005).

The aim of this study was to develop a new type of flavoured fermented beverage from camel milk with high nutritive and healthy benefits using different levels of cinnamon and doum palm extracts.

MATERIALS AND METHODS

Materials

Fresh camels' milk (CM) was obtained from the camel herd at Maryout Research Station, Desert Research Center (DRC). Milk samples were immediately stored under refrigerated conditions until the transferring it to the laboratory. Cows 'skim milk powder (97% TS) produced in Poland by Varimex Company and commercial grade sugar (sucrose) was obtained from local market. Palsgaard 156 (used as a stabilizer) produced by Danisco Ingredients (Juelsminde, Denmark) by Misr Food Additives Company (MIFAD), Egypt. Cinnamon (*Cinnamomum verum*) and doum palm fruit (*Hyphaene thebaica*) were obtained from the local market. Direct Vat Starter (DVS) yoghurt culture obtained from CHr. Hansen Laboratory Copenhagen, Denmark under commercial name type (DVS-YC-350) containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *Bulgaricus* was used in the fermentation process.

Chemicals

The solvents and acids (El-Nassr Pharmaceutical Chemical Co., Egypt), DPPH (2, 2-Diphenyl-1 Picrylhydrazyl radical) from Sigma- Aldrich, Germany, Folin Ciocalteu reagent (Fluka, France), Gallic acid, and Sodium chloride (Pratap Chemical Industries PVT, India).

Methods

Technological Methods

Preparation of starter culture

Yoghurt culture was prepared separately as mother cultures into 100 ml of previously reconstituted and sterilized (121°C/15 min) cow's skim milk powder by using 0.03% (w/v) inoculums after cooling to 42°C. The starter culture was incubated at 42°C until curdling of milk. The yogurt formed was refrigerated at 4°C and used as starter culture within 7 days (Rashid *et al*., 2007).

Cinnamon and doum palm fruit concentrated extract preparation

Cinnamon (*Cinnamomum verum*) and doum palm fruit (*Hyphaene thebaica*) powder was mixed each one alone with sterile H_2O at the ratio of 1: 10 in a 250 ml bottle. The final volume of both plant extracts was 0.1 g/ml. The mixture was left for 12 hours (Shori and Baba, 2011a) in water bath (70°C) followed by centrifugation (6000 rpm, 15 mins). The supernatant was collected and concentrated in a rotary evaporator, then used as an herbal concentrated extract in making of herbal-fermented beverage.

Preparation of fermented camel milk beverages

Fresh camel milk, 3% cow skim milk powder and 0.5% (w/v) Palsgaard 156 were mixed and homogenized at 55-60% for 2 min., using high speed mixer (2400 rpm/min) (T25B, IKA, Labortechnik, Germany), heated in a water bath at 85±1°C for 5 min. After cooled to 45°C, inoculated with 3% (v/v) of DVS mother culture followed by incubation at 42±1°C until pH reached to 4.5-4.6, then immediately cooled to 5±1°C for 4hr. Sucrose solution was added at the level of 6% (wt of sucrose/wt of water and heated at 85±1°C /5 min, then cooled) and blended well with fermented camel milk and different ratios of cinnamon (C) or doum palm (D) concentrated extract. Mixture was divided into equal portions, the first was used to prepare control (Cn), while other portions were used to prepare flavoured fermented beverages with addition of various (%) of cinnamon and doum palm extracts. 1% (C1), 2% (C2), 3% (C3) cinnamon extract and 5% (D5), 7% (D7), 9% (D9) doum palm extract. Previous treatments considered the acceptable samples chosen after preparing various pretreatments. Samples were mixed well individually, then packed in 100 ml sterilized glass bottles and stored at 4±1°C. All treatments were analyzed at zero time, 7, 15 and 21 days of storage periods.

Analytical methods

Chemical composition

Total soluble solids (TSS), total solids (TS), total nitrogen (using micro-Kjeldahal method), fat (using Gerber method), ash contents; as well as pH values and titratable acidity were determined in camel milk and different fermented beverages according to the methods of AOAC (2012). Total carbohydrates were calculated by difference, according to Guzman (1999). Total phenolic compounds and antioxidant properties in the extracts were determined according to Li *et al*. (2009).B Complex vitamins were determined according to the method described by Batifoulier *et al.* (2005). Iron, Potassium, Sodium and Zinc concentration were determined by atomic absorption (Thermo-Tarrell, Ash, Smith-Hieftje (1000) in their digested solutions according to A.O.A.C (2000).

Rheological properties

The rheological properties of the prepared blends were studied to investigate the flow behavior of blends which is an important factor for beverages. Rheological parameters (Texture factor, Flow behavior index, viscosity) of fermented camel milk blends were measured using Brookfield Engineering labs DV-III Rheometer. The blend was placed in a small sample adapter and a constant temperature water bath was used to maintain the desired temperature. The viscometer was operated between 10 and 50 rpm and shear stress, shear rate, viscosity data were obtained directly from the instrument, the SC4-21 spindle was selected for the measurement. Rheological measurements were made at different concentrations of fermented camel milk and different time of shearing (Khalil, 2013).

Microbiological examination

The total viable bacterial count (T.V.B.C) was determined according to Marshall (1992). Lactobacilli count was estimated on the selective medium for Lactobacilli (MRS) and Streptococci count on M_{17} agar medium (IDF, 1997).

Organoleptic properties

Fermented camel milk samples flavoured by cinnamon and doum palm extracts were evaluated during storage for, appearance, acidity, body and texture by 10 qualified panelists of staff members of Food Technology Research Institute (FTRI) Agric. Research Center (ARC), Giza, Egypt. Results were recorded in a score sheet described by Kebary and Hussein (1999).

Statistical analysis

All experiments were conducted in triplicates by means of Analysis of variance (ANOVA) with Statistical Analysis System. Duncan's Multiple Range test was used when significant (at $P < 0.05$) mean comparison was performed.

RESULTS AND DISCUSSION

Chemical composition of camel milk, concentrated cinnamon and doum palm extracts

Results in Table (1) indicate that the composition of camel milk was 12.15%, 3.32%, 3.60%, 0.97%, 4.26%, 6.6, 0.16%, 87.94% and 7.98 mg/100 g for total solids, protein, fat, ash, total carbohydrates, pH, acidity, antioxidant activity (AOA) and total phenolic compound content (as Gallic acid equivalent mg/100 g), respectively. These results agree with those reported by Farag *et al.* (2015) and Kula and Tegegne (2016). The composition of camel milk varies due to difference of geographical origin but other factors such as the physiological stage, feeding conditions, seasonal or physiological variations, genetic or health status of camel have also a paramount importance (Konuspayeva *et al.,* 2009).

Table (1): The chemical composition of camel milk

Ingredients	T.S %	Protein %	Fat %	Ash %	Total carbohydrate %	pH value	Titratable acidity %	Antioxidant activity (AOA)	Phenolic (compound) mg/100g
Camel milk	12.15 ±0.4	3.32 ±0.1	3.60 ±0.1	0.97 ±0.03	4.26 ±0.3	6.6 ±0.03	0.16 ±0.08	87.94 ±3.40	7.98 ±0.1

Mean of triplicate determinations ±SD.

Doum fruit possesses good functional properties which can be used for various important applications in food industry. It can therefore be concluded that the doum fruit provides essential nutrients and possesses important functional properties which if well exploited can help to address many food related problems like diabetic and hypertensive patients (Aboshora *et al.,* 2014). The total soluble solids (TSS), ash, total phenolic compound (expressed as mg Gallic acid equivalent/ gm), antioxidant activity (AOA%), pH value and total acidity content of concentrated cinnamon and doum palm extracts are shown in Table (2). The results indicated that the TSS content of cinnamon and doum palm concentrates were 10.50 and 24.73% respectively. The content of ash, AOA, total acidity, pH and total phenolic compound were 2.25%, 98.69%, 0.15 %, 4.27 and 23.94 mg/100 gm, in concentrated cinnamon extract, respectively. Also, the data in the same table showed that the ash, AOA, total acidity, pH and total phenolic compound were 2.32%, 95.60%, 0.31%, 4.30 and 24.1 mg/100 gm in concentrated doum palm extract, respectively. The aqueous extract of doum fruits and cinnamon showed an antioxidant activities; this is due to the substantial amount of their water-soluble phenolic contents.

Table (2): Chemical composition of concentrated cinnamon and doum palm extracts (on dry weight basis*)

Ingredients	TSS %	Ash %*	Phenolic compounds mg/100g*	AOA %	pH value	Titratable acidity%*
Cinnamon extract	10.50 ±0.7	2.25 ±0.08	23.94 ±0.15	98.69 ±3.13	4.27 ±0.03	0.15 ±0.09
Doum extract	24.73 ±0.5	2.32 ±0.06	24.1 ±0.12	95.60 ±3.56	4.30 ±0.02	0.31 ±0.15

Mean of triplicate determinations ±SD.

Changes in titratable acidity and pH values of flavoured fermented camel milk

Changes in Titratable acidity and pH values of all treatments are illustrated in Table (3). It was noticed that all pH values of different fermented camel milk samples significantly $p < 0.05$ decreased with increasing the cold storage period as a result of further fermentation of lactose into lactic acid. Due to the acidity development, the total bacterial count was decreased. Mehanna *et al.* (2002) and Ibrahim and Khalifa (2015) found that, the addition of stabilizers caused the highest acidity and the lowest pH of camel milk yoghurt compared to control and the pH value decline, may be due to continued fermentation by the lactic acid bacteria.

Table (3): Changes in acidity % and pH values during cold storage of fermented camel milk as affected by using different levels of cinnamon and doum palm extracts

Storage period	Cn.	C1	C2	C3	LSD(CI) Treatments	D5	D7	D9	LSD (D) treatments
Titratable acidity%									
Fresh	0.80^{Ac}	0.82^{Ac}	0.83^{Ac}	0.83^{Ac}	**0.033**	0.81^{Bc}	0.83^{Ac}	0.83^{Ac}	**0.025**
7 days	0.81^{Bc}	0.85^{Ab}	0.84^{Abc}	0.85^{Ab}	**0.015**	0.81^{Bc}	0.84^{Ac}	0.84^{Ac}	**0.018**
14 days	0.87^{Ab}	0.87^{Aab}	0.85^{Ab}	0.86^{Ab}	**0.020**	0.84^{Bb}	0.87^{Ab}	0.88^{Ab}	**0.019**
21 days	0.93^{Aa}	0.89^{Ba}	0.90^{Ba}	0.90^{Ba}	**0.014**	0.87^{Ba}	0.91^{Ba}	0.92^{Ca}	**0.015**
LSD storage	**0.024**	**0.026**	**0.02**	**0.014**		**0.018**	**0.015**	**0.018**	
pH value									
Fresh	4.60^{Aa}	4.58^{Aa}	4.56^{Aa}	4.54^{Aa}	**0.070**	4.85^{Aa}	4.59^{Ba}	4.60^{Ba}	**0.079**
7 days	4.58^{Aab}	4.55^{Aa}	4.53^{A}	4.52^{Aab}	**0.058**	4.83^{Aa}	4.58^{Ba}	4.60^{Ba}	**0.034**
14 days	4.55^{Aab}	4.53^{Aab}	4.51^{Aab}	4.50^{Aab}	**0.070**	4.80^{Aab}	4.55^{Ba}	4.58^{Bab}	**0.067**
21 days	4.50^{Ab}	4.49^{Ab}	4.47^{Ab}	4.47^{Ab}	**0.057**	4.77^{Ab}	4.55^{Ba}	4.55^{BCb}	**0.053**
LSD storage	**0.084**	**0.054**	**0.056**	**0.056**		**0.053**	**0.059**	**0.036**	

a, b, c & d and A, B, C & D: means with the same letter among the storage period and treatments respectively are not significantly different ($p<0.05$). Cn: Control.
C1, C2 and C3: fermented camel milk with 1, 2 and 3% Cin. extract respectively.
D5, D7 and D9: fermented camel milk with 5, 7 and 9% Doum. extract respectively.

The phenolic compounds and antioxidant activity of flavoured fermented camel milk

The total phenolic compounds (PCs) and antioxidant activity (AOA%) of fermented camel milk treatments as influenced by different levels of concentrated cinnamon or doum extracts are given in Table (4). The attained results cleared that using flavoured amounts of cinnamon and doum extracts significantly increased the PCs and AOA of the resultant mixs. So the treatments D9 attained the highest values of PCs and AOA of cinnamon concentrated extract, respectively. Data given in Table 4 indicated that fermented camel milk (Cn) had total phenol content (2.42 mg/100g). Adding concentrated doum and cinnamon extracts to fermented camel milk caused a significant increase in total phenol contents proportional directly with increasing the flavouring level. The highest values were noticed at 3 and 9% (5.69 and 10.75 mg/100 g) concentrated cinnamon and doum extracts compared with control (2.42 mg/100 g). Same trend was observed in antioxidant activity (AOA) of the produced fermented camel milk. Increasing the level of flavouring, the high value of antioxidant activity (AOA) of fermented camel milk samples was observed and there were significant differences between samples.

Table (4): Changes in phenolic compounds and total antioxidant activity of fermented camel milk as affected by adding different levels of concentrated cinnamon and doum extracts during storage

Storage period	Cn.	C1	C2	C3	LSD (CI) Treatments	D5	D7	D9	LSD (D) treatments
					Phenolic compounds (mg/100gm)				
Fresh	2.42^{CDa}	4.12^{Ba}	5.63^{Aa}	5.69^{Aa}	**0.200**	7.81^{Ca}	8.78^{Ba}	10.75^{Aa}	**0.221**
7 days	1.94^{CDb}	3.05^{Bb}	4.74^{Ab}	4.78^{Ab}	**0.131**	5.47^{Cb}	6.58^{Bb}	8.93^{Ab}	**0.315**
14 days	1.72^{CDc}	2.31^{Cc}	4.49^{Bc}	4.64^{Ac}	**0.122**	5.04^{Cc}	5.51^{Bc}	7.53^{Ac}	**0.011**
21 days	1.30^{Dd}	2.13^{Cd}	3.11^{Bd}	3.25^{Ad}	**0.012**	4.55^{Cd}	4.75^{Bd}	6.52^{Ad}	**0.150**
LSD storage	**0.095**	**0.150**	**0.166**	**0.116**		**0.298**	**0.243**	**0.118**	
					Total Antioxidant activity%				
Fresh	85.43^{Ca}	88.14^{Ba}	90.70^{Aa}	91.39^{Aa}	**1.659**	87.70^{Ba}	88.44^{Ba}	90.31^{Aa}	**1.259**
7 days	85.49^{Ca}	87.49^{Ca}	88.34^{Bb}	92.17^{Aa}	**0.829**	85.39^{Db}	88.33^{Ba}	89.63^{Ab}	**0.937**
14 days	80.50^{Db}	82.31^{Cb}	85.37^{Bc}	86.95^{Ab}	**1.210**	81.20^{Cc}	$83. 45^{Bb}$	84.60^{Ac}	**0.945**
21 days	78.46^{Cc}	81.30^{Bb}	82.67^{ABd}	84.29^{Ac}	**1.724**	80.80^{B}c	83.75^{Ab}	84.71^{Ac}	**1.088**
LSD storage	**1.902**	**1.834**	**0.483**	**0.814**		**0.747**	**0.540**	**0.270**	

a, b, c & d and A, B, C & D: means with the same letter among the storage period and treatments respectively are not significantly different (p<0.05). Cn: Control.
C1, C2 and C3: fermented camel milk with 1, 2 and 3% Cin. extract, respectively.
D5, D7 and D9: fermented camel milk with 5, 7 and 9% Doum. extract, respectively

The antioxidant activity of flavoured fermented camel milk with concentrated cinnamon and doum extracts ranged from 91.39 to 90.31% for 3 and 9% flavouring level respectively, compared with control had (AOA) 85.43%. The high value of antioxidant activity for flavoured fermented camel milk samples could be attributed to the high total phenol content of concentrated doum and cinnamon extracts. These results are in agreement with (Hsu *et al.,* 2006) who mentioned that the aqueous extract of doum fruit contains high levels of phenols and possesses significant antioxidant and anticancer activities. This is due to the substantial amount of their water-soluble phenolic compounds (Hsu *et al.,* 2006). Data in the same Table showed significant decrease in total phenolic compounds during storage periods. During 21 days of cold storage the total phenolic compounds and antioxidant activity of all samples significantly ($P < 0.05$) decreased up to the end of storage period. Meanwhile, decreases in phenolic compounds content did not lead systematically to a decrease of the antioxidant activity. In fact, the degradation products of phenolic compounds can also have an antioxidant activity sometimes higher than the initial phenolic compounds (Buchner *et al.,* 2006; Murakami *et al.,* 2004). While in other cases, the antioxidant activity is reduced.

Vitamins content of flavoured fermented camel milk treatments

Nicotinic, thiamine, B6, folic, B12 and riboflavin contents of raw milk and the fermented camel milk as affected by using different amounts of cinnamon and doum palm extracts are given in Table (5). The attained results cleared that the content of all vitamins decreased in fermented camel milk than camel milk, This finding is consistent with those reported by Oberman (1985) and (Magdi, 2010) who found that lactic acid bacteria fermentation resulted in a marked decrease in vitamin B6, B12 and vitamin C level, while only small changes in vitamin A, B1, B2 and niacin took place. Baranova *et al.* (1998) also reported that fermentation of goat milk by selected lactic acid bacteria significantly decreased vitamin C, but resulted in slight decrease in B1 and B2 and did not influence tocopherol contents. An increase in folic acid content and a slight decrease in vitamin B12 were found in fermented milk compared to raw milk (Alm, 1984).

Table (5): Vitamins content (mg/100g) in fermented camel milk products as affected by using different percentages of cinnamon and doum extracts

Storage period	Raw Milk	Treatments*						
		Cn	C1	C2	C3	D5	D7	D9
Nicotinic	175.78	95.95	98.00	92.81	87.14	99.00	94.90	97.28
Thiamine	52.12	28.45	29.06	27.52	25.84	29.35	28.14	28.84
B6	0.28	0.15	0.15	0.15	0.14	0.16	0.15	0.15
Folic	16.95	9.25	9.45	8.95	8.40	9.54	9.15	9.38
B12	19.45	10.62	10.85	10.27	9.64	10.96	10.50	10.77
Riboflavin	29.48	16.09	16.44	15.57	14.62	16.60	15.92	16.32

*Cn: Control.
C1, C2 and C3: fermented camel milk with 1, 2 and 3% Cin. extract, respectively.
D5, D7 and D9: fermented camel milk with 5, 7 and 9% Doum. extract, respectively.

Fermented camel milk flavoured with doum extract had higher vitamins content compared to that made with cinnamon extract. The treatment C1 had the higher content of all vitamins and C2, C3 respectively affected by using more amounts of cinnamon extracts. The Treatment D5 had the higher content of all vitamins and D9, D7 respectively affected by using higher amounts of doum extracts. This may be due to different concentrations of plant extracts.

Mineral content of flavoured fermented camel milk treatments

The total amount of minerals is generally presented as total ash and in case of dromedary camel milk this value ranged between 0.60 to 0.90 percent (Konuspayeva *et al*., 2009). Fluctuations in mineral level were proposed to be due to the differences in feeding, breed, water intake (Haddadin *et al*., 2008). Camel milk has a good source of minerals; Al haj and Al Kanhal (2010) found that the mean values were as follows: calcium, 114±13; potassium, 156±38; sodium, 59±16; iron, 0.29±0.09; magnesium, 10.5±1.8; manganese, 0.05±0.03 and zinc, 0.53±0.08 mg/100g. Doum fruit is a good source of essential minerals such as potassium, sodium, iron, calcium, magnesium and phosphorus**.** Aboshora *et al*. (2014) observed that the fleshy part of the doum fruit contained substantial amounts of essential minerals as follows: potassium 2947.6, sodium 184.35, iron 3.52 and zinc 0.77 mg/100g. Meanwhile, Gul and Safdar (2009) reported that the cinnamon contained iron (7.0 mg/g), Zinc (2.6 mg/g) and Potassium (134.7 mg/g). Among the minerals cinnamon contained the highest amount of potassium and lowest amount of sodium. Ereifej *et al.* (2015) showed that the content of mineral in cinnamon was potassium 127.4, sodium 12.0, iron 8.1 and zinc 1.3 mg/100 g. Camel milk, fermented camel milk (control) and flavoured fermented camel milk with doum and cinnamon were analyzed for potassium, sodium, iron and zinc as presented in Table (6).

Table (6): Mineral content (mg/100g) of fermented camel milk as affected by adding different levels of concentrated cinnamon and doum extracts (on dry weight basis)

Minerals (mg /100 g)	Treatments							
	Camel milk	Control	C1	C2	C3	D5	D7	D9
K	1225.51	692.62	711.71	722.35	750.94	1352.38	1630.99	1828.83
Na	708.31	447.4	442.39	436.88	433.51	481.23	494.29	496.6
Fe	3.87	2.53	2.82	3.13	3.40	3.16	3.52	3.69
Zn	1.80	1.13	1.16	1.23	1.30	1.34	1.40	1.45
Na/K	0.58	0.65	0.62	0.60	0.58	0.36	0.30	0.27

Cn: Control.
C1, C2 and C3: fermented camel milk with 1, 2 and 3% Cin. extract, respectively.
D5, D7 and D9: fermented camel milk with 5, 7 and 9% Doum. extract, respectively.

Results showed that minerals content were varied according to the raw materials and the levels of extracts added. Minerals content of fermented camel milk made with doum fruit extract showed the highest contents of potassium (K), sodium (Na), iron (Fe) and zinc (Zn) compared with control. Sodium (Na) of control and fermented camel milk flavoured with cinnamon extract was decreased from 447.4 to 433.51 mg/100 g, while potassium (K) of fermented milk with cinnamon extract increased from 692.62 to 750.94 mg/100 g. Addition of cinnamon and doum extracts increased the macro minerals concentration in produced fermented camel milk relative to the control sample. The greatest increase observed in potassium (K) was noticed in C3 and D9 fermented camel milk. Sodium concentration increased in the fermented camel milk samples with doum from 447.4 to 496.6 mg/100 g. Doum fruit and cinnamon contains higher amounts of essential minerals. These results are due to the doum fruit and cinnamon is good sources of these minerals. The Na/K ratio less than one with increasing the added levels (1-3% cinnamon and5-9 % doum extracts). Imbalance in this ratio can not only lead to hypertension but also contribute to a number of other diseases, including: heart disease and stroke, Kidney stones, Memory decline, Cataracts, Ulcers and stomach cancer and rheumatoid arthritis. These results are in agreement with Aremu *et al*. (2006). Concerning to micro minerals concentrations, data showed slight increase in iron (Fe) and zinc (Zn) levels in treated fermented milk. From the above mentioned data, the produced fermented camel milk have good amount of potassium (K), so they are considered an advantage for people suffering from blood pressure problems.

The Rheological characteristics of flavoured fermented camel milk treatments

Many factors affect the consistency such as well as the rheological properties of fermented milk products. Among these factors, pH value, dry matter and protein contents (Torre *et al*., 2003). Table (7) showed that treatments with higher levels content of doum extract tended to have lower rheological parameters (flow behavior and viscosity) between treatments and during storage except texture factor values this may be as a results of higher TSS content in doum extract (24.73%) than cinnamon extract (10.50%). Using higher levels of cinnamon extract increased all the rheological characteristics except viscosity values. Also, storage period attend to decreased viscosity values.

Table (7): Changes in rheological characteristics of fermented camel milk as affected by adding different levels of cinnamon and doum palm extracts during storage period

Storage period	Cn	C1	C2	C3	LSD (CI) Treatments	D5	D7	D9	LSD (D) treatments
					Texture factor				
Fresh	0.25^{Ad}	0.08^{Bd}	0.06^{Bd}	0.09^{Bd}	**0.06**	0.77^{Ac}	0.64^{Bc}	0.65^{Bd}	**0.04**
7 days	7.99^{Aa}	0.79^{Db}	2.18^{Ca}	2.76^{Ba}	**0.13**	4.18^{Da}	5.85^{Ca}	7.00^{Ba}	**0.16**
14 days	7.16^{Ab}	0.31^{Dc}	0.78^{Bc}	0.69^{Cc}	**0.06**	3.98^{Cb}	4.65^{Bb}	4.64^{Bc}	**0.52**
21 days	5.82^{Ac}	1.56^{Ca}	1.04^{Db}	1.66^{Bb}	**0.09**	4.03^{Bb}	5.87^{Aa}	5.81^{Ab}	**0.11**
LSD storage	**0.132**	**0.08**	**0.06**	**0.06**		**0.09**	**0.11**	**0.52**	
					Flow behavior index				
Fresh	0.92^{Da}	1.12^{Ca}	1.20^{Aa}	1.15^{Ba}	**0.012**	0.67^{Ba}	0.67^{Ba}	0.59^{Ca}	**0.012**
7 days	0.31^{Cb}	0.36^{Bd}	0.31^{Cd}	0.60^{Ac}	**0.014**	0.31^{Bb}	0.31^{Bc}	0.35^{Ab}	**0.012**
14 days	0.29^{Dc}	0.55^{Cb}	0.65^{Bb}	0.84^{Ab}	**0.013**	0.29^{Cc}	0.32^{Bb}	0.36^{Ab}	**0.016**
21 days	0.31^{Cb}	0.45^{Ac}	0.38^{Bc}	0.39^{Bd}	**0.011**	0.27^{Bd}	0.22^{Cd}	0.30^{Ac}	**0.013**
LSD storage	**0.01**	**0.014**	**0.011**	**0.015**		**0.013**	**0.012**	**0.016**	
					Viscosity (40 speed) m Pas				
Fresh	21.0^{Ad}	21.0^{Ac}	21.0^{Ad}	18.3^{Bd}	**1.78**	18.3^{Bc}	16.0^{Cb}	13.5^{Dc}	**1.90**
7 days	67.6^{Aa}	57.5^{Ba}	50.3^{Ca}	40.1^{Da}	**1.94**	22.5^{Ba}	18.5^{Da}	20.5^{Ca}	**1.78**
14 days	55.0^{Ab}	41.1^{Bb}	41.0^{Bb}	37.8^{Cb}	**2.14**	20.3^{Bb}	17.8^{Ca}	16.1^{Cb}	**2.05**
21 days	48.3^{Ac}	40.5^{Bb}	36.2^{Cc}	33.3^{Dc}	**1.76**	18.3^{Bc}	17.8^{Ba}	13.3^{Cc}	**1.51**
LSD storage	**2.14**	**1.65**	**2.03**	**1.78**		**1.94**	**1.53**	**1.61**	

a, b, c & d and A, B, C & D: means with the same letter among the storage period and treatments respectively are not significantly different ($p<0.05$). Cn: Control.

C1, C2 and C3: fermented camel milk with 1, 2 and 3% Cin. extract, respectively.

D5, D7 and D9: fermented camel milk with 5, 7 and 9% Doum. extract, respectively

Similar results were reported by Akalin *et al.* (2008) who found that the viscosity of probiotic yoghurt significantly decreased with decrease in fat content. Khalil (2013) reported that using higher ratio of pomegranate juice significantly decreased all the rheological characteristics except the flow behavior index of the resultant yoghurt drink. Texture of yoghurt drink is influenced by various factors such as quality and composition of milk and its protein and fat contents, heat treatment, combination of lactic acid bacteria used, acidification rate and storage time (Sodini *et al.,* 2004; Purwandari *et al.,* 2007). Ibrahim and Khalifa (2015) found that camel milk yoghurt containing stabilizer had higher viscosity than the control samples. On the other hand, hardness and viscosity increased along with the acidity increase in all samples during storage as reported by (Kavas, 2016). According to Tamime and Robinson (1985), the symbiotic relationship between the starter culture strains is broken down with increasing serum separation.

Microbiological properties of flavoured fermented camel milk treatments

The strains used, interaction between species presents, culture conditions, chemical composition of the fermentation medium , final acidity, availability of nutrients, growth promoters and inhibitors, concentration of sugars, milk solid contents, dissolved oxygen, level of inoculation, storage temperature and incubation temperature play a major role in the survival of bacteria in fermented dairy bio-products (Young and Nelson, 1978). Total bacterial counts in all treatments made from camel's milk are presented in Table (8). It was found that using amounts of cinnamon and doum extracts caused an increase of total bacterial count in all flavoured fermented milks, but the counts of flavoured fermented milk were higher than control samples. This may be due to the antibacterial effect which was found in camel milk Gran *et al.* (1991). Total bacterial count of all treatments increased to maximum at 14 day of storage period then decreased up to the end of storage period; these results are in line with those reported by Young and Kyung (1995) and Bozanic *et al.* (2000). Also the count of *Str. Thermophiles* and *Lb. bulgaricus* increased to maximum at 14 day of storage period then decreased up to the end of storage period.

Table (8): Microbiological properties (log cfu/g) of fermented camel milk as affected by adding different levels of cinnamon and doum extracts during the storage period at 4±1°C

Storage period	Cn.	C1	C2	C3	LSD (CI) Treatments	D5	D7	D9	LSD (D) treatments
					T.V.B.C				
Fresh	6.75^{Aa}	6.70^{Ab}	6.89^{Ac}	6.72^{Ac}	**0.298**	6.83^{Ab}	6.80^{Ab}	6.95^{Ac}	**0.236**
7 days	6.87^{Ba}	$6.94A^{Bab}$	7.11^{Ab}	6.85^{Bbc}	**0.217**	6.89^{Bab}	6.95^{ABab}	7.11^{Ab}	**0.163**
14 days	6.99^{Aa}	7.15^{Aa}	7.43^{Aa}	7.03^{Aa}	**0.951**	6.99^{Aa}	7.11^{Aa}	7.35^{Aa}	**0.951**
21 days	6.82^{Ba}	6.83^{Bb}	7.01^{Abc}	6.92^{ABab}	**0.134**	6.78^{Bb}	6.88^{Bb}	7.16^{Ab}	**0.144**
LSD storage	**0.969**	**0.272**	**0.163**	**0.134**	**-----**	**0.133**	**0.163**	**0.152**	
					Lb. delbruecki* ssp. *bulgaricus				
Fresh	8.01^{Cb}	8.33^{Bb}	8.79^{Ab}	8.71^{Ab}	**0.188**	8.16^{Bb}	8.70^{Ab}	8.77^{Ac}	**0.188**
7 days	8.24^{Cab}	8.51^{Bb}	8.78^{Ab}	8.81^{Ab}	**0.188**	8.32^{Bab}	8.72^{Ab}	8.82^{Abc}	**0.249**
14 days	8.48^{Ba}	8.77^{Aa}	8.91^{Aab}	8.98^{Aa}	**0.267**	8.48^{Ba}	8.80^{Aab}	8.94^{Ab}	**0.230**
21 days	8.12^{Cb}	8.81^{Ba}	8.99^{Aa}	9.12^{Aa}	**0.163**	8.51^{Ca}	8.93^{Ba}	9.10^{Aa}	**0.163**
LSD storage	**0.249**	**0.249**	**0.134**	**0.163**		**0.249**	**0.163**	**0.163**	
					Str. thermophiles				
Fresh	8.17^{Cb}	8.47^{Bb}	8.76^{Ab}	8.73^{Ab}	**0.188**	8.49^{Bb}	8.72^{ABa}	8.77^{Ab}	**0.249**
7 days	8.30^{Bab}	8.52^{Bab}	8.81^{Aab}	8.87^{Aab}	**0.249**	8.62^{Bb}	8.82^{Aa}	8.90^{Aab}	**0.188**
14 days	8.42^{Ca}	8.76^{Ba}	8.94^{Aa}	8.94^{Aa}	**0.133**	8.84^{Ba}	8.94^{Aa}	8.95^{Aa}	**0.095**
21 days	8.30^{Cab}	8.6^{Bab}	8.84^{Aab}	8.77^{ABb}	**0.188**	8.51^{Bb}	8.79^{Aa}	8.80^{Aab}	**0.188**
LSD storage	**0.188**	**0.249**	**0.163**	**0.163**		**0.163**	**0.231**	**0.163**	

a, b, c & d and A, B, C & D: means with the same letter among the storage period and treatments respectively are not significantly different ($p<0.05$). Cn: Control.

C1, C2 and C3: fermented camel milk with 1, 2 and 3% Cin. extract, respectively.

D5, D7 and D9: fermented camel milk with 5, 7 and 9% Doum. extract, respectively

This result was in agreement with previous study that found *Cinnamomum verum* enhanced *Lactobacillus* spp. counts more in camel-milk yogurts than in cow-milk yogurts with respect to growth during fermentation (Shori and Baba, 2011b). Also, aqueous doum palm extracts increased the viability and activity of some certain dairy starter cultures which used in the manufacture of some dairy products especially probiotics (Hassan and Aumara, 2005). Viable LAB was higher in camel-milk than in cow-milk yogurts and this may be partly explained by the higher free amino acids in camel milk than in cow milk (Mehaia and Al-Kanhal, 1992), and higher milk proteolysis *by L. delbrueckii* spp. *bulgaricus* in camel milk than in cow milk (Abu-Tarboush, 1996). Both factors contribute to apparent higher digestibility of camel milk than cow milk which readily supported growth and metabolism of LAB during fermentation and refrigerated storage.

Organoleptic properties of flavoured fermented camel milk treatments

Consumer acceptance of healthy food products is strongly dependent on the sensory characteristics of these products (Ares, 2011). The organoleptic properties of the prepared fermented milk as shown in Table (9) showed that increasing levels of cinnamon and doum extracts negatively influenced the sensory scores of some properties of fermented camel milk

Table (9): Organoleptic properties of fermented camel milk as affected by adding different levels of cinnamon and doum extracts during the storage period at 4±1°C

Storage period	Cn	C1	C2	C3	LSD (CI) Treatments	D5	D7	D9	LSD (D) treatments
Flavour (45)									
Fresh	43A^{Ba}	44^{Aa}	44^{Aa}	43^{Aa}	**2.491**	44^{Aa}	42^{ABa}	40^{Ba}	**3.646**
7 days	43^{Aa}	44^{Aa}	44^{Aa}	43^{Aa}	**1.882**	44^{Aa}	41^{Ba}	39^{Cba}	**1.883**
14 days	42A^{Bab}	43^{Aa}	43^{Aab}	42^{Aab}	**1.883**	44^{Aa}	41^{Ba}	38^{Cbc}	**1.883**
21 days	41^{ABb}	42^{Aa}	42^{Ab}	41^{Ab}	**1.883**	43^{Aa}	40^{Ba}	37^{Cc}	**1.883**
LSD storage	**1.882**	**2.491**	**1.882**	**1.883**		**2.49**	**3.26**	**1.88**	
Body and texture (35)									
Fresh	33^{Aa}	34^{Aa}	34^{Aa}	33^{Aa}	**2.306**	34^{Aa}	32^{ABa}	30^{Ba}	**2.306**
7 days	33^{Ba}	34^{Aa}	34^{Aa}	32^{Ba}	**1.882**	34^{Aa}	32^{Ba}	30^{Ca}	**1.883**
14 days	33^{Aba}	34^{Aa}	34^{Aa}	32^{Ba}	**1.883**	33^{Aa}	32^{Aa}	30^{Ba}	**1.883**
21 days	32^{Aba}	34^{Aa}	34^{Aa}	32^{Ba}	**1.883**	33^{Aa}	31^{Ba}	30^{Ba}	**1.883**
LSD storage	**2.491**	**1.882**	**1.631**	**1.883**		**1.883**	**1.630**	**1.882**	
Acidity (10)									
Fresh	9^{Aa}	9^{Aa}	9^{Aa}	8^{Aa}	**1.697**	9^{Aa}	8^{ABa}	7^{Ba}	**1.883**
7 days	8^{Aba}	9^{Aa}	9^{Aa}	8^{Aa}	**1.883**	9^{Aa}	8^{ABa}	7^{Ba}	**1.883**
14 days	8^{Aab}	9^{Aa}	8^{aAb}	7.3^{Aa}	**2.174**	8^{Aab}	8^{Aa}	6^{Bab}	**1.883**
21 days	7^{Ab}	8^{Aa}	7^{A}b	7^{Aa}	**1.883**	7^{Ab}	7^{Aa}	5^{Bb}	**1.883**
LSD storage	**1.88**	**1.882**	**1.719**	**2.174**		**1.631**	**1.883**	**1.883**	
Appearance (10)									
Fresh	9^{Aa}	9^{Aa}	9^{Aa}	8^{Aa}	**1.631**	9^{Aa}	8^{ABa}	7^{Ba}	**1.631**
7 days	9^{Aa}	9^{Aa}	9^{Aa}	7^{Aa}	**1.883**	9^{Aa}	8^{ABa}	7^{Ba}	**1.883**
14 days	9^{Aa}	9^{Aa}	9^{Aa}	7^{Aa}	**1.883**	9^{Aa}	8^{ABa}	7^{Ba}	**1.883**
21 days	8A^{ba}	9^{Aa}	9^{Aa}	7^{Aa}	**1.883**	9^{Aa}	8^{ABa}	7^{Ba}	**1.883**
LSD storage	**1.882**	**1.631**	**1.882**	**1.880**		**1.882**	**1.631**	**1.882**	
Total (100)									
Fresh	94^{Ba}	96^{Aa}	96^{Aba}	92^{Ca}	**1.883**	96^{Aa}	90^{Ca}	84Da	**1.883**
7 days	93^{Bab}	96^{Aa}	95^{Aab}	90^{Cb}	**1.883**	96^{Aa}	89^{Ca}	83Da	**1.883**
14 days	92^{Bb}	95^{Aa}	94^{Ab}	88^{Cc}	**1.883**	94^{Ab}	89^{Ca}	80^{Db}	**1.883**
21 days	89^{Bc}	93^{Ab}	92^{Ac}	87^{Cc}	**1.883**	92^{Ac}	86^{Cb}	79^{Db}	**1.883**
LSD storage	**1.883**	**1.882**	**1.882**	**1.882**		**1.882**	**1.882**	**1.882**	

a, b, c & d and A, B, C & D: means with the same letter among the storage period and treatments respectively are not significantly different ($p<0.05$). Cn: Control.
C1, C2 and C3: fermented camel milk with 1, 2 and 3% Cin. extract, respectively.
D5, D7 and D9: fermented camel milk with 5, 7 and 9% Doum. extract, respectively

The maximum attainable score was given for appearance of all fresh samples, whereas after 21 days of storage the samples flavoured with the highest amount of cinnamon and doum extracts ranked the lowest score for appearance. No significantly differences were noticed in Body and texture of fresh and stored fermented milk samples. These are in agreement with those obtained by Joseph and Olugbuyiro (2011) who revealed that, flavour had significant influence ($p < 0.05$) on overall acceptability of stirred yoghurt. In recent years, there has been increasing interest in the use of natural food additives into the diet Memnue *et al*. (2012).

The presence of *Cinnamomum verum* effect on sweetness was reduced in cow-milk yogurt, but increased in camel-milk yogurt (Shori and Baba, 2011b).Doum palm fruit flesh possesses good functional properties as its high water and/or oil absorption capacity Aboshora *et al*. (2014). Similar results were obtained by (Attia and Dhouib, 2001) who observed that the fermentation of camel milk by starter culture did not reveal a good curd formation but indicated a fragile and heterogeneous structure. Also, using different fruit additives gives more fermented camel milk choices to the consumer. The sensory scores of all the samples in the present study decreased during storage period. This is may be due to the acidity development or the production of microbial metabolits and the low of pH value which slightly affected the rheological and sensory properties of the product. Saitmuratova and Sulaimanova (2000) found that the carbohydrates content of fermented camel milk was 3 - 5 times lower than those of unfermented camel milk. These results are in accordance with that reported by Toba *et al.* (1983) who found a decrease in the lactose content from 6.53 to4.22% and increase in glucose and galactose in yogurt prepared by *L. bulgaricus* and *S. thermophilus.* Shori and Baba (2011b) reported that *Cinnamomum verum* did not affect the organoleptic properties in camel-milk yoghurt.

CONCLUSION

The present study increased the knowledge about the camel milk. Also, it could be concluded that, camel milk can be considered as a good source of minerals and vitamins. Moreover, camel milk could meet a big part of the daily needs of humans from these nutrients because camel milk has most the essential nutrients. In addition, fermented camel milk flavoured with cinnamon or doum extracts provided it with total phenolic compounds, antioxidant, good properties and higher acceptable sensory values.

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إنتاج لبن ابل متخمر مطعم ببعض النكهات

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يهدف البحث إلي دراسة تأثير إضافة المستخلصات المائية لكل من القرفة والدوم كأحد المصادر الطبيعية للمواد الفينولية ومضادات الأكسدة إلي لبن الإبل علي خواص اللبن المتخمر الناتج. تمت دراسة الخواص الكيميائية والقيمة الغذائية لكل من لبن الإبل ومستخلصات القرفة والدوم. كذلك تم تقدير الخواص الفيزوكيميائية، المركبات الفينولية، النشاط المضاد للأكسدة، المعادن، الفيتامينات، الخواص الريولوجية، الميكروبيولوجية والحسية للعينات الطازجة وأثناء فترة التخزين حتى ٢١ يوم عند٤±١°م. أظهرت النتائج انخفاض قيم درجة الحموضة لكل المعاملات أثناء فترة التخزين، كما أدت زيادة النسبة المضافة من مستخلصات القرفة والدوم إلي زيادة معنوية في محتوي المواد الفينولية وكذلك زيادة النشاط المضاد للأكسدة في معاملات لبن الإبل المتخمر من ٩١.٣٩ - ٩٠.٣١% بالنسب ٣ و ٩% علي التوالي من مستخلص القرفة والدوم. أظهرت التحليلات أن لبن الإبل المطعم بمستخلص الدوم أعلي في محتوي الفيتامينات وكذلك محتوي المعادن من البوتاسيوم، الصوديوم، الحديد والزنك مقارنة بالكنترول. أيضاً ظهرت أعلي القيم في مستوي البوتاسيوم في المعاملات المطعمة بمستخلصي القرفة (٣%) والدوم (٩%) علي التوالي. لوحظ كذلك انخفاض في قيم الخواص الريولوجية في معاملات نكهة الدوم فيما عدا معامل القوام. وأظهرت نتائج الفحص الميكروبيولوجي زيادة في العدد الكلي البكتيري في المعاملات المنكهة مقارنة بالكنترول، بينما لوحظ زيادة في بكتريا حامض اللاكتيك (*Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus*). حتى ١٤ يوم من التخزين يتبعه تناقص حتى نهاية فترة التخزين. أوضحت الدراسة أيضاً أن زيادة نسبة المستخلصات المضافة لكل من القرفة والدوم اثر سالباً في بعض خصائص لبن الإبل المتخمر الحسية. من النتائج تقترح الدراسة إمكانية إنتاج لبن ابل متخمر كغذاء وظيفي ذو نكهة طبيعية جيدة بإضافة أي من مستخلصي القرفة والدوم بنسب ١% و ٥% علي التوالي.