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PROCESSING AND QUALITY OF LOW FAT ICE CREAM FROM CAMEL MILK USING NATURAL ADDITIVES FOR CONTRIBUTION AS A FUNCTIONAL FOOD

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Amna S.M. Ahmed

Ibtisam E.M. El Zubeir

Department of Dairy Production
Faculty of Animal Production
University of Khartoum
PO Box 321, Khartoum, Sudan
e-mail: Ibtisamelzubeir17@gmail.com

Abstract

Purpose

This study was designed to process ice cream from camel milk using natural additives (vanilla, coconut, gum Arabic and honey) in order improve its taste and aroma.

Design/Methodology/Approach

Three types of camel milk ice cream were tried using vanilla, coconut, and a combination of both.

Findings

The successful processing of ice cream from camel milk indicated the possibility of using camel milk to produce special ice cream, which would fulfil the requirements of functional food. The quality and acceptability of the different types of ice cream were shown.

Originality/Value of the paper

Gum Arabic and honey as ice cream stabilisers and sweeteners, respectively, could be used in camel milk ice cream to strengthen the health benefits of camel milk and to satisfy special needs diets.

Research Implications

Further work should be done on the processing of camel milk using the available raw materials in Sudan for sustainable development.

Keywords

Camel milk, ice cream, natural additives, functional food.

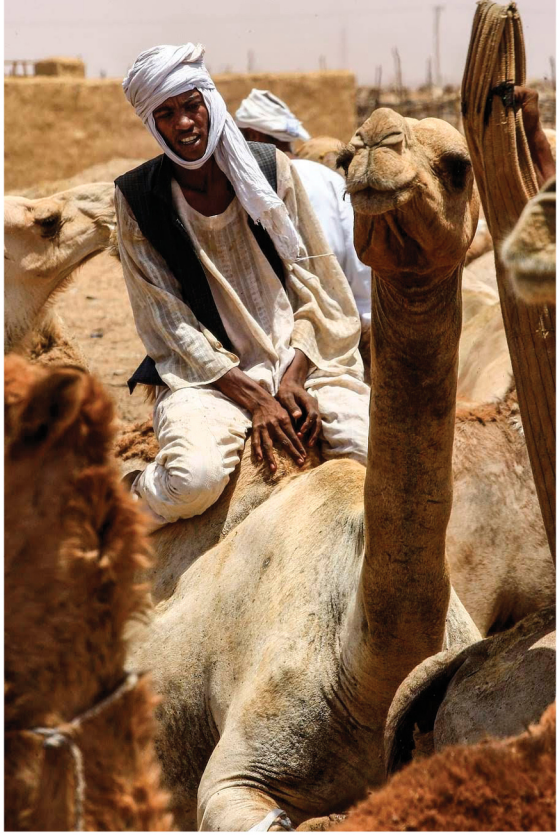
Introduction

Sudan has 4.8 million head of camels; this number rates the country second worldwide after Somalia (MOARF, 2016). Also in Sudan, most camel milk produced is consumed locally and does not reach the urban markets; this is because most camel herds are located in the arid and desert areas, which are far from the consumers (Musa et al., 2006; El Zubeir and Nour, 2006; Suliman and El Zubeir, 2014; El Zubeir, 2015).

Functional foods are defined as ingredients through which additional health values have been added to foods (Hilliam, 2000). Açu et al. (2017) concluded that the incorporation of goat's milk, some prebiotics and probiotic cultures, in addition to raspberry and blackberry fruit sauces in ice cream, was important in terms of providing alternative and delicious functional products, both for the food industry and consumers. The most prominent outcomes of phenolic incorporation were sharp improvements in antioxidant and antidiabetic activities, as well as the phenolic content of ice creams (Çam et al., 2013).

Camel milk can be a functional food because it has important nutritional and functional values, and it could provide particular health benefits (Ahmed and El Zubeir, 2015b; Dowelmadina et al., 2019). Dowelmadina et al. (2018) found variations of fatty acids in the composition of Arabi camels' milk from Sudan compared to other milks consumed by humans. Also, a high vitamin C content was reported for camels' milk compared to cows' milk (Farah et al., 1992; Mohammed and El Zubeir, 2016).

Ice cream is a quality nutritious frozen dairy dessert with a high calorific food value (Del Giovine and Piccioli Bocca, 2003; Khillari et al., 2007; Temiz and Yesilsu, 2010). Ice cream contains a variety of ingredients in addition to milk, including cream and sugar. It is a popular dairy product worldwide, and its production and consumption are rapidly increasing. A substantial part of the milk produced in many countries is utilised for the manufacture of frozen desserts (Elahi et al., 2002). Ice cream is a complex system consisting of air cells, ice crystals, fat globules (partially concealed or aggregated), surrounded by sugar, protein, salts and water matrix. Each one of the ingredients in the



formulation influences ice cream's properties (Goff, 2002; Soukoulis et al., 2008). Moreover, ice cream may also contain other food products such as fruit, which enhances its nutritive value; consequently, ice cream influences the mind because of its organoleptic characteristics and its importance as thermoregulatory food in the fight against heat (Del Giovine and Piccioli Bocca, 2003).

Ice cream has a fundamental role in children's diets as they consume great amounts of it. However, the presence of additives, particularly dyes, can introduce a risk factor (Del Giovine and Piccioli Bocca, 2003). The addition of chemical additives, such as industrial colours and flavours, to food might create a health risk to consumers (Penman et al., 2006). Therefore, the use of natural additives in an ice cream mix may play an important role in reducing the amount of chemical additives (Penman et al., 2006). Also, Del Giovine and Piccioli Bocca (2003) reported that the use of natural additives in ice cream may play an important role for children's diets. The present review, therefore, highlights the properties of ice cream processed from camel milk using some natural additives: vanilla, coconut, Gum Arabic and honey. Gum Arabic and honey as ice cream stabiliser and sweetener, respectively, could be used in camel milk ice cream to strengthen the health benefits of camel milk (Ahmed and El Zubeir, 2015a, 2015b). The ice cream processed from camel milk was made, and its chemical, microbial and acceptability was evaluated during eight weeks of storage.

Materials and Methods

Ice cream manufacturing:

The experimental procedures were done in the specialised small processing unit located in Khartoum North during the period from June 2012 to August 2012. Fresh raw whole camel milk (15 litres) was obtained from a local farm at Khartoum North.

Ice cream samples were processed using camel milk and three flavours were added (vanilla, coconut, and a mix of the two), using the same percentage of Gum Arabic, honey, sugar and low fat cream powder. The method used for preparation of camel milk ice cream was described by Ahmed and El Zubeir (2015b). The mix was made by the incorporation of 105 grams of Gum Arabic (0.7%), 1,350 grams of honey (9%), 900 grams of sugar (6%) and 1,650 grams of low fat powder cream (11%), with 10.995kg camel milk for the manufacturing of ice cream. In addition, 2 pods (4 grams) of vanilla and grated coconut (80 grams) were used.

Chemical composition of camel milk and honey:

The chemical composition of the camel milk sample was analysed by Lactoscan (Milkotronic Ltd, Europe) as described in the accompanying technical manual. The chemical composition of the honey sample was analysed by a proximate analysis procedure (AOAC, 2003).

The chemical, microbial and sensory evaluations were undertaken during the storage of the ice cream.

Chemical analysis of ice cream:

The chemical tests were done weekly in duplicate at the laboratory of the Department of Dairy Production, Faculty of Animal Production, University of Khartoum. The protein content was determined using the Kjeldahl method, the total solids content was determined using a forced draft oven method, and the ash content was determined using a gravimetric method (AOAC, 2003). However, the Gerber method described by Bradley et al. (1992) was followed for the determination of the fat content of the ice cream samples.

Microbiological examination of ice cream:

The equipment, including flasks, Petri dishes, test tubes and pipettes, was sterilised using a hot air oven (160°C for 60 minutes). The media were prepared according to the manufacturers' instructions, and sterilised by autoclaving at 121°C for 15 minutes. The media were then allowed to cool at 45-46°C before pouring into the Petri dishes (Singleton, 1992).

The preparation of samples was done as described by Marshall (1992). A representative sample of ice cream (1 gram) was mixed serially (10^1-10^6) diluted, and 1ml from each of the selected dilutions, after thorough mixing, was carefully transferred into the Petri dishes using a sterile pipette. The plate count agar was used for the enumeration of total bacterial count (Houghtby et al., 1992) and psychotropic bacterial count (Frank et al., 1992), and MacConkey agar was used for the enumeration of coliform bacteria (Christen et al., 1992).

The plates for total bacterial count, coliform and psychotropic bacteria were incubated at 37°C for 48 hours, 37°C for 48 hours, and 7±1°C for 10 days, respectively (Marshall, 1992).

Sensory evaluation:

Ten untrained panellists, who were familiar with dairy products, were judged to evaluate the sensory characteristics of the different types of ice cream. The scores for appearance, flavour, texture, taste, and overall acceptability were obtained based on a 5-Scale Hedonic Rating Test (excellent = 5, very good = 4, good = 3, fair = 2, and poor = 1).

Statistical analysis:

Data were analysed using Statistix 8 (2003). Significant differences between means were determined at P≤0.05 and separated by the least significant difference (LSD). The figures were plotted using a Microsoft Excel program.

Results and Discussion

The results for camel milk (Table 1) were in line with those reported by Shueip et al. (2008), Dowelmadina et al. (2014), Ibrahem and El Zubeir (2016), and Mohammed and El Zubeir (2016).

The honey that was introduced as a partial substitute for sugar as a sweetener showed good compositional content (Table 1). This was consistent with the findings of Khaliduzzaman et al. (2012) who reported that honey can be used as sucrose replacer and/or supplement in ice cream formulation. This is because research in dairy technology is trying to develop a health-friendly product using natural sweeteners because of the negative impact of sucrose for diabetes patients.

Table 1: The chemical composition of camel milk and honey used for manufacturing ice cream

Composition (%)	Total solids	Ash	Protein	Fat	Moisture	Sugar
Camel milk	11.4%	0.57%	1.5%	2.5%	91.1%	4.33%
Honey	80%	2.3%	-	-	20%	60%

Source: Ahmed, 2013

Some natural flavours (vanilla and coconut) were used in the present study to produce camel milk ice cream in order to promote camel milk for the production of a functional food (Table 1 and Figures 1-3). A neutral flavour, such as vanilla pods, gives the ice cream made from camel milk a good taste and flavour (Ahmed and El Zubeir, 2015a) because it has a flavouring substance (Goodenough, 1982; Gassenmeier et al., 2008). Also Enig (1999) reported that coconut has fatty acids that provide both energy (nutrients) and raw material for antimicrobial fatty acids and monoglycerides, which are functional components. In addition, the use of extra Gum Arabic as a stabiliser and emulsifier will promote the health benefits of the ice cream produced (Ahmed and El Zubeir, 2015a, 2015b). Gum Arabic is available in Sudan (Elkhidir et *al*., 2010) and has medicinal properties (Gamal el-din et *al*., 2003). Moreover, Gum Arabic has been currently widely used as a stabiliser, a thickener and/or an emulsifier in soft drink syrup, gummy candies, and creams (Verbeken et al., 2003).

Natural additives were used to produce camel milk ice cream in order to promote camel milk for the production of a functional food (Table 1 and Figures 1-3). The successful processing of camel milk ice cream done by Ahmed and El Zubeir (2015a, 2015b), which supported Abu-Lehia et al. (1989), indicates the possibility of using camel milk to produce low fat ice cream. A diet ice cream is useful for children, therefore taking into consideration that selected natural additives for children's food will promote the health benefits of such an ice cream (Ahmed and El Zubeir, 2015b). The combination of camel milk and honey may prove to be an important source of nutrition and protection against microbial infection (Al-Jabri, 2005). Also, the combination of Gum Arabic and honey may give an opportunity for diabetic persons to utilise and use this ice cream (Ahmed and El Zubeir, 2015b). The utilisation of camel milk was found to be effective in the reduction of diabetes among Indian consumers (Agrawal et al., 2007). Also, Dowelmadina et al. (2019) demonstrated that camel milk fat has a wide range

of variation in the levels of omega-3 fatty acids; this might be of help in lowering human serum lipids and decreasing the incidence of lipid-related cardiovascular diseases.

In addition, ice cream from camel milk combined the benefit of both ice cream and camel milk, as was reported by Ahmed and El Zubeir (2015b). Ice cream plays an important role as actual food because of its digestive and metabolic qualities, nutritive qualities, because of its organoleptic characteristics that can influence the mind, and its importance as a thermoregulatory food in the fight against heat (Del Giovine and Piccioli Bocca, 2003).

The ice cream samples prepared during this study (Figure 1) revealed good compositional content; they were kept for a period of eight weeks (at -18°C). Ice cream from camel milk combined the benefits of both ice cream and camel milk to fulfil the requirements of a functional food. The higher rate of Gum Arabic needed to stabilise ice cream from camel milk might be due mainly to the special properties of camel milk (Ahmed and El Zubeir, 2015b). In addition, camel milk was reported to be superior to cow milk in terms of nutrients because it contains good qualities of antibacterial and antiviral protective proteins (El Agamy et al., 1992; El Agamy, 2000).

Significantly ($P<0.05$) higher total solids, protein and fat were found in the ice cream samples flavoured with the combination of vanilla and coconut compared with vanilla ice cream and coconut ice cream samples (Figure 1). Ice cream was produced by adding various functional properties; it was found that fruit sauce fortification had a significant ($P<0.05$) effect on the fat, protein, titratable acidity, pH, ash, saccharose, melting rate, colour, total phenolics, anthocyanidins, flavonoid content and antioxidant capacity (Açu et al., 2017). Because ice cream contains high levels of milk fat (10-16%) it is a source of high quality protein and energy (Temiz and Yesilsu, 2010), and the highest average of protein in camel milk ice cream was found in coconut ice cream (Figure 1). This might be because the protein content of ice cream, which is mostly derived from milk, rates high both in amount and in quality (Arbuckle, 1966). This is nutritionally important in situations demanding urgent energy supply as in the case of babies, children and sportsmen (Şengül et al., 2005). On the other hand, proteins of camel milk are decisive components for preventing and curing food allergies (Beg, 1986; Abu-Lehia, 1987; Martin et al., 1997).

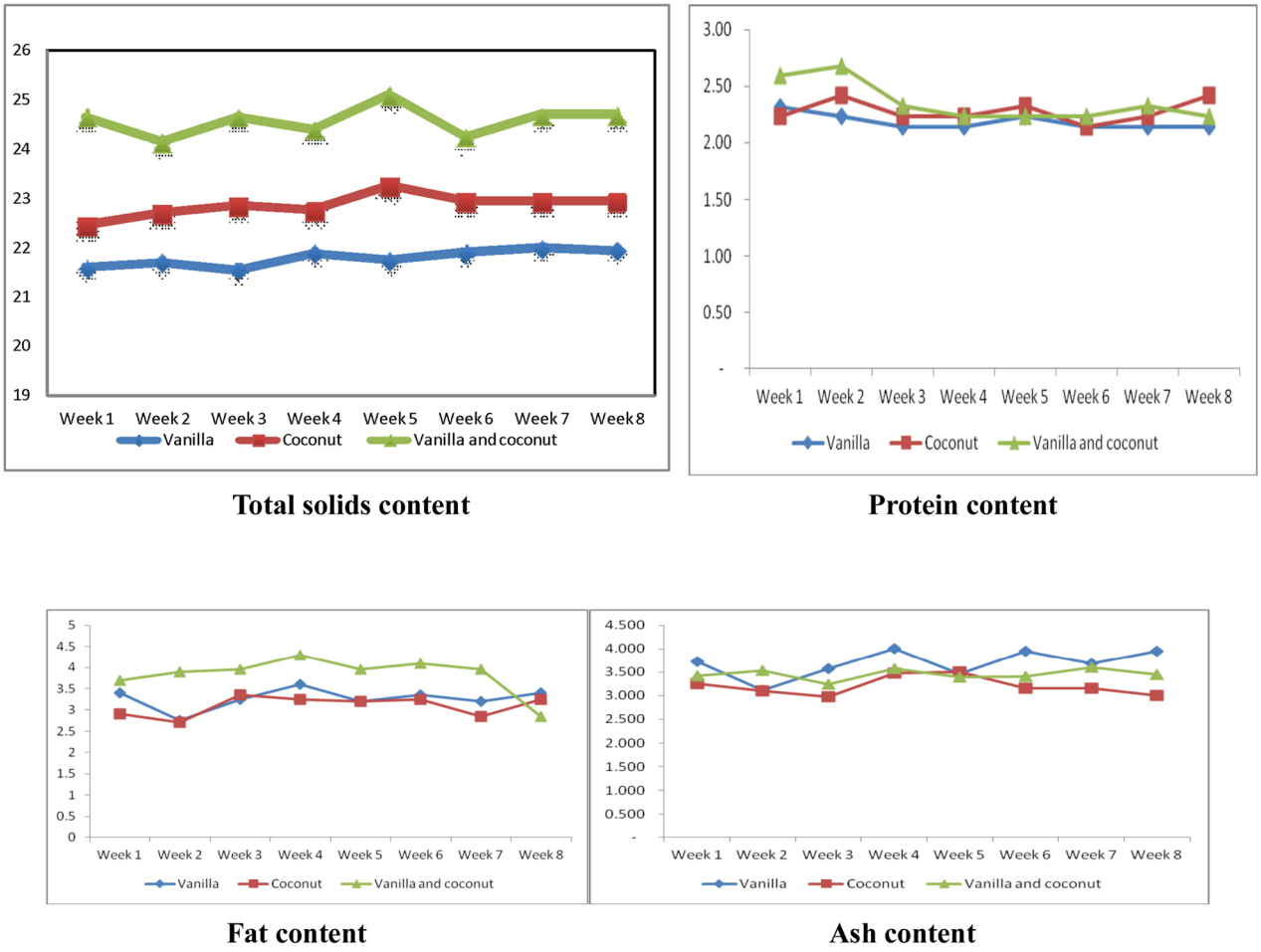


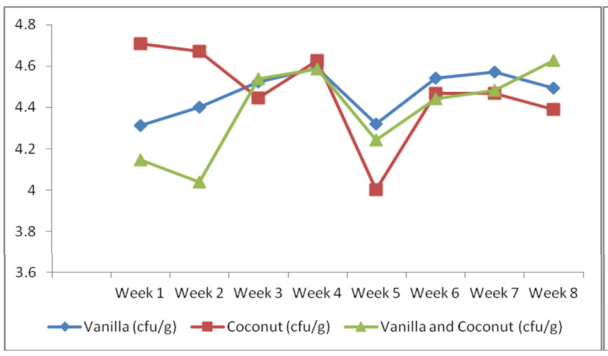
Figure 1: Variation of chemical composition of vanilla and coconut ice cream made from camel milk during storage

Source: Ahmed, 2013

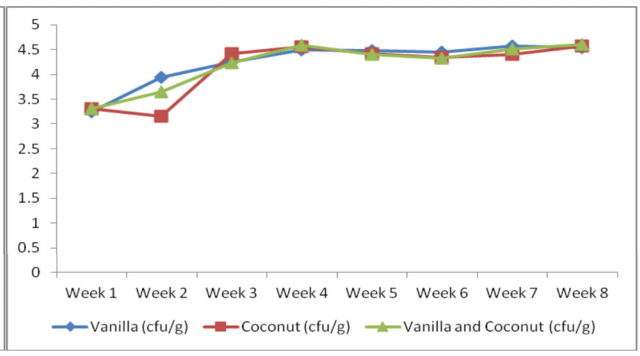
The results indicated a significant ($P<0.05$) difference in ash content of flavoured ice cream made from camel milk due to the honey and flavouring material used (Table 1). The present results of ash content on honey were in accord with Khaliduzzaman et al. (2012), who reported on the use of honey as a replacement for sucrose in ice cream. Also, Dunford et al. (2000) reported on the anti-inflammatory effect of honey.

The microbial counts of ice cream from camel milk:

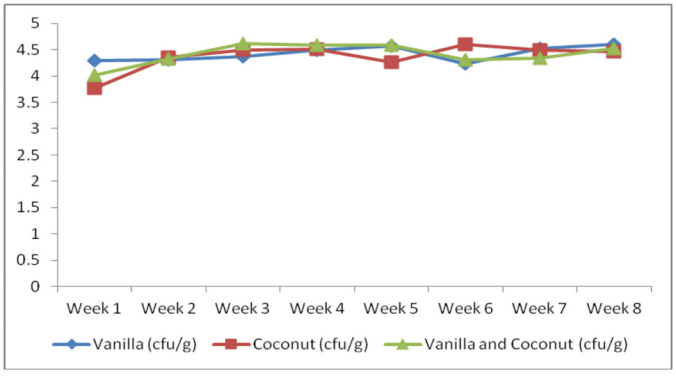
The result of microbial load in ice cream made from camel milk revealed non-significant (P>0.05) variations for total bacterial, yeast and moulds, and psychotropic bacterial counts (Figure 2). This might be because all samples of ice cream were manufactured using the same procedures and kept in similar conditions (Ahmed and El Zubeir, 2015a, 2015b). Bradbear et al. (2004) reported that the high osmotic potential of honey (because of its high concentration of sugar), might lead to the breakdown of bacterial membranes and therefore inhibit microbial growth. Also during the storage period, the ice cream samples showed non-significant (P>0.05) variations in microbial loads (Figure 2). This could be attributed to storage temperature of the ice cream samples that were kept at -18°C.



Total bacterial count



Yeast and moulds count



Psychrotrophic bacterial count

Figure 2: Variation of microbial counts of vanilla and coconut ice cream samples made from camel milk during storage

Source: Ahmed, 2013

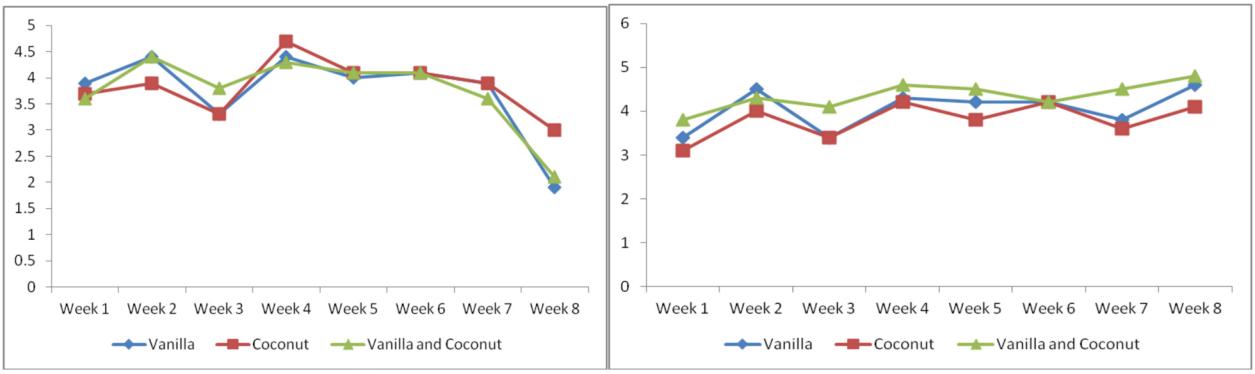
The result of the total bacterial count and psychotropic bacterial count generally showed the lowest values in coconut ice cream compared with other samples during the advancement of storage (Figure 2). This might be due to the antimicrobial substance present in coconut (Enig, 1999). The result of the total bacterial count of ice cream made from camel milk was significantly affected by the type of flavours used (Figure 2). However, yeast and moulds showed non-significant ($P>0.05$) differences in ice cream made from camel milk due to the types of flavour used. El Owni and Khater (2011) found that yeast and moulds counts were significantly affected by flavours used in ice cream. The coliform bacteria were not grown in all ice cream samples during storage; this could be due to the proper pasteurisation of the camel milk (Ahmed and El Zubeir, 2015a). The Sudanese standards stated that the minimum and maximum acceptable microbiological limits for aerobic plate count and coliforms in 25 grams of ice cream should be between 10^4 and 10^5 and 10 to 10^2, respectively (SSMO, 2005).

Sensory attributes of ice cream from camel milk:

All sensory measurements have significant ($P<0.05$) differences for all flavoured ice cream samples. Higher means of texture and colour scores were found in coconut ice cream, while higher flavour, taste and acceptability scores were found in vanilla and coconut ice cream (Figure 3). The neutral flavours, such as vanilla pods, give the ice cream made from camel milk good taste and flavour (Ahmed and El Zubeir, 2015a). Gude (2017) concluded that adding Baobab and Papaya fruit juices (3%) for making ice cream from camel milk improves its organoleptic properties as good flavour was reported. Similarly, El Owni and Khater (2010) reported that colour, texture, taste and overall acceptability were significantly affected by the different flavours used. It was also reported that Gum Arabic is added to produce the same opacity, appearance, mouth feel and palatability as natural fruit juices (Wyasu and Okereke, 2012). Mohammed and El Zubeir (2019) recommend

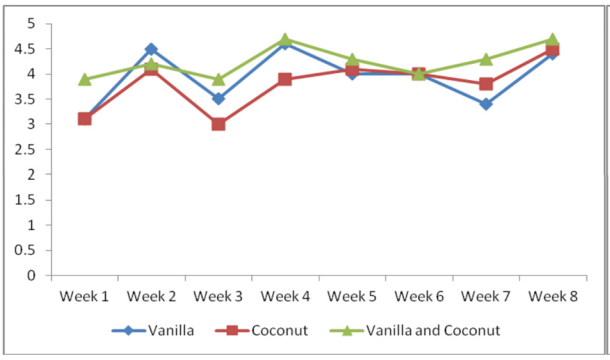
processing and consumption of ice cream flavoured with natural fruits, such as the African fan palm and muskmelon, because of their pleasant flavours; these are available locally. Arbuckle (1966) also reported that the body and texture characteristics are closely associated, and are important in influencing consumer's acceptance of ice cream and related products.

The highest mean value of taste score was obtained for vanilla, followed by the mixture of vanilla and coconut ice cream samples, compared to coconut samples (Figure 3). Ahmed and El Zubeir (2015a) noticed that a combination of vanilla and coconut showed a higher acceptability score for the taste of camel milk ice cream; this was because of a reduction in the sharp salty taste and grassy flavour of camel milk. On the other hand, El Zubeir and Jabreel (2008) reported that, generally, camel milk (generally opaque and white), has an acceptable taste.

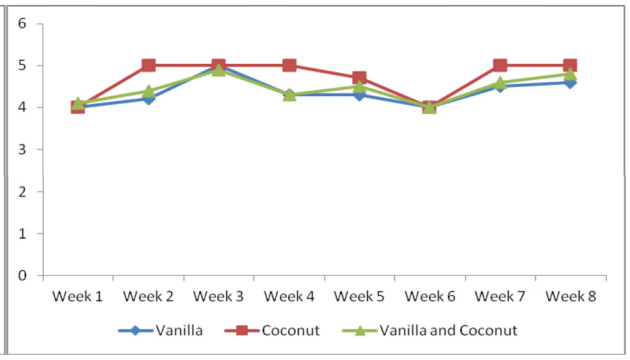


Texture score

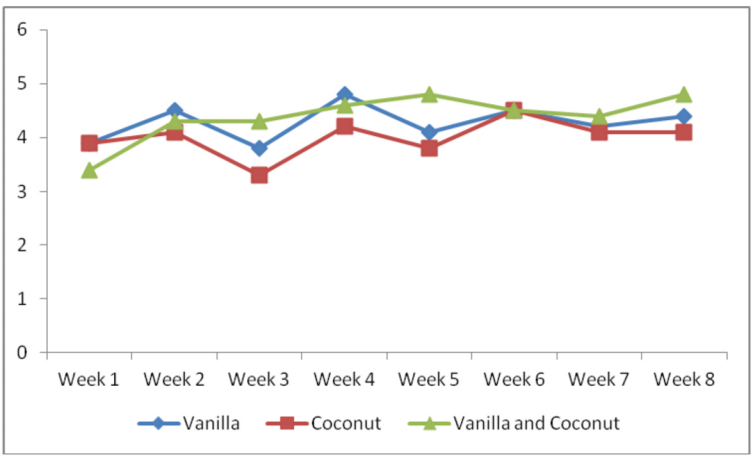
Taste score



Flavor score



Color score



General acceptability score

Figure 3: Scores for the sensory characteristics of vanilla and coconut ice cream samples made from camel milk during storage

Source: Ahmed, 2013

The acceptability scores revealed some significant ($P<0.05$) differences between different types of ice cream during the storage period (Figure 3). The highest mean of acceptability was recorded for vanilla ice cream followed by the combination of vanilla and coconut ice cream. However, the lowest acceptability mean score was recorded for coconut ice cream samples. The neutral flavours, such as vanilla pods, give the ice cream made from camel milk good taste and flavour because it has flavouring substance (Ahmed and El Zubeir, 2015a). This might be due to the popularity of vanillin as flavouring substance of ice cream (Goodenough, 1982; Gassenmeier et al., 2008). Therefore, it is possible to commercialise camel milk from remote areas to urban consumers in a form of functional food. However, the official government authorities have to provide facilities and services, and state regulatory standards for coping with international milk quality standards (El Zubeir, 2015).

This study concluded that ice cream can be processed from camel milk and consumption of ice cream from camel milk is encouraged. Also, Gum Arabic and honey as an ice cream stabiliser and sweetener, respectively, could be used in camel milk ice cream to strengthen the health benefits of camel milk. In addition, special products (low fat ice cream, sugar-free ice cream, etc.) could also be developed and recommended. In addition, using camel milk ice cream among some patients should be tried.

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Biography

Ibtisam E.M. El Zubeir graduated from the Faculty of Veterinary Science; University of Khartoum, Sudan 1989, and then joined the Ministry of Animal Resources as a veterinary officer 1990-1996. After being awarded a PhD, she was appointed as Assistant Professor at the Department of Dairy Production, Faculty of Animal Production, promoted to Associate Professor in 2005 and to full Professor in 2010. Prof. El Zubeir was involved in teaching and supervision for undergraduate and postgraduate students from the Faculty of Animal Production and Faculty of Veterinary Medicine in subjects related to dairy production and milk hygiene and quality. Her research interests are in hygiene and quality control of milk and dairy products, with special interest in camel milk and its products. She has published over 120 scientific papers in national and international journals, and has participated in more than 50 national and international conferences.

Amna Salah Mohammed Ahmed was awarded her BSc (Hon.) in Animal Production in 2009 from the University of Khartoum. She joined the Department of Dairy Production, Faculty of Animal Production, University of Khartoum to read for an MSc in Dairy Production and Technology. Her dissertation was entitled *Processing and Properties of Low Fat Ice Cream from Camel Milk Using Natural Additives*. She was awarded the MSc on 23 December 2013.