10-2021

SENSORY EVALUATION OF CAMEL MILK

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MASTER THESIS NO. 2022: 2

College of Agriculture and Veterinary Medicine

Department of Food Science

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This thesis is submitted in partial fulfilment of the requirements for the degree of Master of Science in Food Science

Under the Supervision of Prof. Afaf Kamal-Eldin

October 2021

Declaration of Original Work

I, Reem Amer Al Kaabi the undersigned, a graduate student at the United Arab Emirates University (UAEU), and the author of this dissertation entitled "*Sensory Evaluation of Camel Milk*" hereby, solemnly declare that this dissertation is my original research work that has been done and prepared by me under the supervision of Prof. Afaf Kamal-Eldin, in the College of Agriculture and Veterinary Medicine at UAEU. This work has not previously been presented or published or formed the basis for the award of any academic degree, diploma or a similar title at this or any other university. Any materials borrowed from other sources (whether published or unpublished) and relied upon or included in my dissertation have been appropriately cited and acknowledged by appropriate academic conventions. I further declare that there is no potential conflict of interest concerning the research, data collection, authorship, presentation, and publication of this dissertation.

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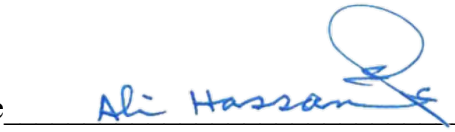
Signature  Date 28/04/2022

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Abstract

Camel milk is one of the most important sources of nutrients for humans in numerous arid and semiarid environments. Consumer acceptability and sensory analysis are decisive for the commercialization of camel milk. It is essential to understand the sensory qualities of camel milk because of its unfamiliarity and its typical sensory profile, which is different from that of bovine milk. This study aimed to evaluate trained panel qualitative description of sensory characteristics as well as consumer acceptability and attitude towards pasteurized non-flavored, flavored, and camel milk powders. In the consumer acceptability test, samples were evaluated based on acceptability with respect to color, texture, mouthfeel, flavor, saltiness, and sweetness and camel milk was less liked compared to bovine milk. The consumer acceptability test results showed that addition of strawberry or chocolate to camel milk significantly improved the scores for color, saltiness, texture, mouth feel, flavor and overall acceptability ($p \leq 0.05$). The QDA test results showed no significant differences in the obtained scores for viscosity, mouth coating, fat feel, and chalky/powdery attributes between the different samples. The consumer survey involved consumers who were familiar to camel milk with the majority (67%) began the consumption of camel milk since childhood. The majority of consumers (90%) were aware about the health benefits of camel milk compared to bovine milk and agreed that camel milk is good for skin, teeth, hair, nails and digestive tract. Consumers indicated that camel milk is salty (42%), smells nice (78%), have good appearance (97%), tastes good (91%), available in different flavors (54%), and has longer shelf life than bovine milk (34%). Most of the consumers (84%) agreed that camel milk has good value for money and is easily available in supermarkets (69%). From the results, it could be concluded that camel milk and milk products are generally acceptable for consumers living in UAE. Promotion of camel milk and products to non-conventional consumers should be done to increase their consumption.

Keywords: Camel milk, sensory evaluation, consumer acceptability, quantitative descriptive analysis, consumer survey

Title and Abstract (in Arabic)

التقييم الحسي لحليب الإبل

الملخص

يعتبر حليب الإبل من أهم مصادر التغذية للإنسان خاصة في البيئات الجافة وشبه الجافة. يعد قبول المستهلك والتحليل الحسي أمرًا حاسمًا لتسويق حليب الإبل. ومن الضروري فهم الصفات الحسية لحليب الإبل وقبول المستهلك له بسبب خواصه المختلفة عن حليب البقر وعدم تعود الكثير من المستهلكين عليه. تهدف هذه الدراسة إلى تقييم مدى قبول المستهلك وموقفه من خصائص الحسية لحليب الإبل الخالي من النكهات وحليب الإبل مع المنكهات والحليب المجفف. تم تحليل مقبولية الحليب باستخدام اختبارات التقييم الحسي كقبول المستهلك، واختبار التحليل الوصفي الكمي (QDA) ، والأستبيان . في اختبار قبول المستهلك تم تقييم كل عينة بناءً على المقبولية من حيث اللون، والملمس، والطعم، والنكهة، والملوحة، ودرجة الحلاوة. أظهرت نتائج التقييم الحسي أن حليب الإبل المنكه بالفراولة والشوكولاتة تحصل على درجة قبول عالية معنوية للون والملوحة والقوام والشعور في الفم والنكهة والقبول العام ($P \leq 0.05$). أظهرت نتائج اختبار QDA عدم وجود فرق في الدرجة التي تم الحصول عليها من حيث اللزوجة وطلاء الفم وملمس الدهون والطباشير في الفم بين العينات. أظهر استطلاع رأي المستهلكين أن جميع المستهلكين المشاركين في الاستبيان كانوا على دراية بحليب الإبل. وأكدت نسبة عالية من المستهلكين (67٪) أنهم بدأوا بتناول حليب النوق منذ الصغر. كان غالبية المستهلكين (90٪) على دراية بالفوائد الصحية لحليب الإبل مقارنة بحليب البقر، واتفقوا على أن حليب الإبل مفيد للبشرة والأسنان والشعر والأظافر والجهاز الهضمي. أشار المستهلكون إلى أن لبن الإبل مالح (42٪)، ذو رائحة طيبة (78٪)، حسن المظهر (97٪) ، مذاقه جيد (91٪) ، متوفر بنكهات مختلفة (54٪) وله صلاحية أطول من حليب الأبقار (34٪). اتفق معظم المستهلكين (84٪) على أن القيمة المادية لحليب الإبل جيدة وأنه متوفر بسهولة في محلات السوبرماركت (69٪). وعليه يمكن استنتاج أن حليب الإبل مقبول عند المستهلك وانه يمكن تسويقهوأن له سمات جودة محددة تؤثر على طلبه. هناك طلب متزايد على حليب الإبل ومنتجات الألبان من قبل المستهلكين، وبالتالي يجب دراسة الأسعار والترويج لألبان الإبل ومنتجاتها للمستهلكين غير التقليديين لزيادة استهلاكهم.

مفاهيم البحث الرئيسية: حليب النوق، التقييم الحسى، قبول المستهلك، اختبار التحليل الوصفي الكمي، استطلاع رأي المستهلكين

Acknowledgements

I would like to extend my deep thanks to my enthusiastic supervisor, Prof. Afaf Kamal-Eldin, Professor in the Department of Food Science, UAEU, for her constant guidance and encouragement throughout this work, without which this work would not have been possible. For her unwavering support, I am truly grateful. I would also like to thank my co-supervisor, Dr. Bhawna Sobti, and all technical staff at the Department of Food Science for their technical supports to accomplish this work. I am also grateful to laboratory specialist Mr. Ismail Mustapha and to the panelists and survey participants who participated in the studies. Finally, I would like to thank my family for supporting me spiritually throughout my life and my years of study.

Dedication

To my beloved family

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List of Abbreviations

ACE	Angiotensin Converting Enzyme
ANOVA	Analysis of Variance
IMCU	International Milk Clotting Unit
ISO	International Organization for Standardization
Kcal	Kilocalorie
MPa.sec	MilliPascal. Second
NaCl	Sodium Chloride
PCA	Principal Component Analysis
QDA	Quantitative Descriptive Analysis
RMA	Rice based Milk Alternatives
SCM	Soy Cow Milk
SPSS	Statistical Package for the Social Sciences
UHT	Ultra High Temperature

Chapter 1: Introduction

1.1 Overview

Camel milk is an essential food product that provides energy and nutrients for populations of rural communities in dry regions of Africa and Middle East (Abdel et al., 2016). Raw or fermented forms of camel milk are widely used for consumption as they are believed to afford better nutritional and functional value than bovine milk (Khalesi et al., 2017). Camel milk has been used as medicine due to bioactive components including high levels of vitamin C (Jilo and Tegegne, 2016; Habib et al., 2013). The presence of lysozymes, hydrogen peroxide, lactoferrin, lactoperoxidase, and immunoglobulins promotes the use of camel milk for the treatment of stomach and intestinal diseases (Konuspayeva et al., 2011). Camel milk lactoperoxidase has inhibitory activities against gram-positive and gram-negative bacteria (Habib et al., 2013). Camel milk was also mentioned to have therapeutic activities against prophylactic malaria, jaundice, gastrointestinal disorder, pneumonia, tuberculosis, and heart disease (Zagorski et al., 1998; Malik et al., 2012; Kaskous and Pfaffl, 2017). Importantly, studies have confirmed that camel milk has therapeutic properties including anti-diabetic and hypoallergic effects (Breitling, 2002; El-Agamy et al., 2009; Mihic et al., 2016; Mirmiran et al., 2017). The mechanism(s) behind the proven anti-diabetic effect of camel milk has not been revealed but increased bio-accessibility of camel insulin or insulin-like proteins (Malik et al., 2012) and stimulating effects of certain camel milk peptides with human insulin receptors (Ayoub et al., 2018) have been suggested.

Compared to bovine milk, camel milk is low in lactose (Elamin and Wilcox, 1992) and three-times higher in vitamin C (Farah and Atkins, 1992). Camel milk also has less lactose and different protein profile than bovine milk, which makes it more tolerable to patients having lactose intolerance and allergy to bovine milk (Shabo et al., 2005). The cholesterol content is low in camel milk and the iron content is ten times higher than that in bovine milk (Sharma and Singh, 2014). Camel milk is also rich in other important minerals including zinc, copper, sodium, magnesium, manganese, and potassium (Al haj and Al Kanhal, 2010). The enhanced amount of oleic acid in camel milk help to decrease blood cholesterol (Konuspayeva et al., 2008).

The sensory characteristics of camel milk are also very different from those of bovine milk. Generally, camel milk is opaque white due to small size fat particle dispersions and have salty taste because of high mineral content (Patel et al., 2016). Raw camel milk have an unpleasant taste and is frothy when shaken faintly (El-Agamy, 2007). The availability of drinking water and type of fodder results in taste change of camel milk. Due to the unique composition of camel milk, the formation of conventional gels through lactic acid fermentation or renin treatments is significantly less efficient than other milks (Attia et al., 2001). The large size and distribution of casein micelles and the absence of β-lactoglobulin and low levels of κ-casein results in watery texture, weak, and poor structure of camel yoghurts (Kamal et al., 2017).

In processed food products, the utilization of camel milk is limited and faces some challenges for processing due to different compositional characteristics compared to milk from other species (Berhe et al., 2018). The camel milk production from camel farms on large scale and the market of camel dairy products have increased in the past decade

(Jianqin et al., 2015). Nowadays milk powder, cheese from camel milk and pasteurized milk are produced and commercialized worldwide (Al-Saleh et al., 2011). The sensory quality and consumer acceptability are important derivers for the commercialization of new food products, and it provides tools to assess sensory parameters for grading and judging of dairy-products (Drake, 2004). Based on the incidence of fixed faults, quality of product is assessed on the basis of individual's model product. Sensory quality is a factor that can be estimated only by people and comprises diverse investigations and implements that can be applied accurately within the hypotheses of cautiously designated testing processes (Clark and Costello, 2008). The sensory evaluation science has developed as a scientific method used to evoke, measure, analyze and interpret the responses of consumers about products as perceived through the senses such as smell, taste, hearing, and touch constitute sensory evaluation (Lawless and Heymann, 2010). Sensory evaluation plays an important role in defining and controlling product quality, new food product development and commercialization (Hailu et al., 2018).

Very little research has been reported about the sensory evaluation of camel milk and its dairy products. Recently it has been demonstrated that compared to bovine milk cheese, the sensory properties of white brined dromedary cheese were more accepted regardless of the storage period (Bouazizi et al., 2021). Mbye et al. (2020) reported that while comparing the sensory quality of camel milk soft unripened cheese with corresponding bovine milk cheese, panelists gave higher scores for the sensory properties of camel milk cheeses prepared using citric acid and concluded that camel milk is good for preparation of soft and spreadable cheese types. Abou-Soliman et al. (2020) investigated the effect of microbial transglutaminase on the sensory properties of camel-milk soft cheese and found

that some sensory properties of fresh soft cheese were improved. Treatment of camel milk with increasing concentrations of lemon juice resulted in coagulated milk cheese with high scores for sensory attributes such as color, flavor, and overall acceptability (Mihretie et al., 2018). It has been demonstrated that camel milk soft brined cheese made by camel chymosin together with 2% or 5% NaCl is salty, sour, and firm (Hailu et al., 2018). The sensory attributes of camel unripened cheese were improved by the addition of chymosin at 70 IMCU/L (Walle et al., 2017). Abd Elhamid and Elbayoumi (2017) investigated the effect of bee pollen on the sensory properties of white cheese made from camel and bovine milk mixture and found no significant effects on the sensory properties of the cheese. Hailu et al. (2014) investigated the effect of using crude extract of ginger (*Zingiber officinale*) as coagulant in manufacturing soft unripened cheese from camel milk then compared it with cheese made using camel chymosin and the result revealed that all sensory attributes were significantly different between cheeses made using ginger crude extract and camel chymosin.

Mohsin et al. (2019) found that addition of xanthan gum along with date paste improved the sensory attributes of camel milk date yoghurt. A study by Mudgil et al. (2018) revealed that inclusion of gelatin in camel milk yogurt improved the aroma of samples and the texture and overall appearance of yogurt while it negatively influenced other attributes such as taste and flavor. Galeboe et al. (2018) found that bovine milk yoghurt received higher scores for color, aroma, sweetness, sourness, mouth feel and overall acceptability than camel milk yoghurt. The treatment of camel milk yoghurt with Gum Arabic at a concentration of 1% improved its sensory properties without affecting the flavor (Jasim et al., 2018). The sensory properties of camel milk yoghurt were improved by mixing it

with various proportions of sheep milk (Ibrahem, and El Zubeir, 2016). Mustafa et al. (2015) evaluated camel milk yoghurt prepared by mixing with different percentages of bovine milk and showed high scores for smell, texture, taste, and flavor, but no significant difference in the color. The organoleptic properties of *Cinnamomum verum* and *Allium sativum* extract added yoghurts from camel milk and bovine milk showed no differences in sourness, bitterness, and overall preference scores between the two groups of yogurts (Shori and Baba, 2012).

Compared to sensory evaluation of camel milk cheese and yoghurts, research on the sensory evaluation of the camel milk itself as compared to bovine milk is very limited. Hashim. (2002) conducted a study to investigate the acceptance rate of camel milk and other products among school students and to check the influence of flavor and hedonic rating for sensory features. The study revealed that camel milk had the lowermost scores for overall acceptance and sensory attributes than bovine milk samples while adding chocolate enhanced all the sensory traits of the camel milk

1.2. Statement of the Problem

Camel milk may be used as an alternative to bovine milk and its products, but it is necessary to understand the sensory qualities of camel milk mainly because of its unfamiliarity and its special sensory profile. Our research hypothesis was that important information can be gained by evaluating product profiling as well as consumer acceptability and attitudes towards camel milk and that this information can be used to improve its processing and promotion to the consumers. This thesis aims to evaluate the consumer acceptability and attitude and the sensory characteristic for camel milk products

(pasteurized milk, flavored pasteurized milk, and milk powders) that are currently commercially available in the UAE market.

The specific objectives of the study were:

1. To evaluate the consumer acceptability of camel and bovine milk products on the basis of acceptability with respect to color, texture, mouthfeel, flavor, saltiness, sweetness,
2. To perform quantitative descriptive analysis of different products of camel and bovine milk samples in terms of appearance, flavor, and mouthfeel, and
3. To conduct a survey study to provide consumers' insights on their motives or attitude towards liking or disliking camel milk.

1.3 Relevant Literature

1.3.1 Camel and Camel Milk

The camel (*Camelus dromedarius*) is a unique livestock species imperatively adapted to the hot and arid environment. Camel produce more milk for an extended time period than other species of domestic livestock in dry lands and arid zones (Hashim et al., 2009). Under desert conditions, the daily milk yield of camel varies from 3.5 L to 40 L under intensive management. The chemical composition and taste of camel milk is greatly influenced by feed and availability of water (Hashim et al., 2009). Figures 1.1 and 1.2 shows the distribution of camel population in the world.

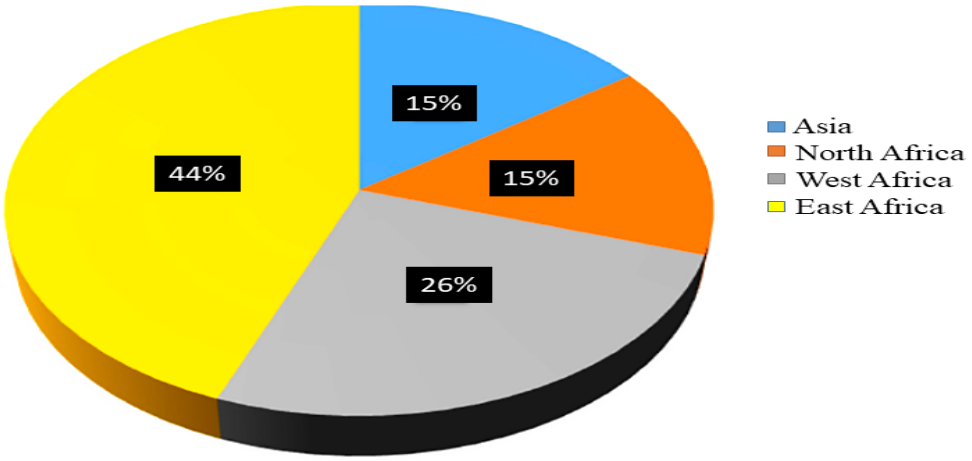

Figure 1.1: Distribution of camel population in the world

(Source: FAOSTAT, 2018; Ali et al., 2019)

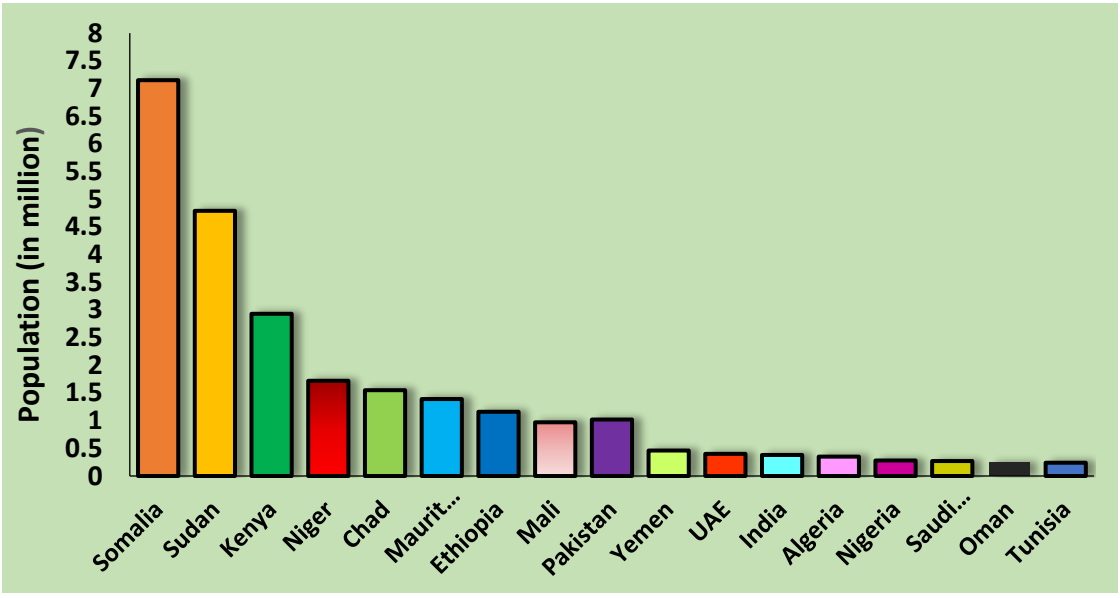

Figure 1.2: The countries in the world according to their camel population

(Source: Ali et al., 2019)

Milk is a broadly used beverage and is an indispensable constituent of the diet of large population in worldwide (Singh et al., 2017). Milk has become an important source of dietary energy, fats, and proteins thus making it wholesome especially for children and older people. The annual camel milk production in the world is estimated to be 2,852,213 tonnes. The top producer of camel milk is Somalia with 953,673 tonnes followed by Sudan (870,000 tonnes), and Kenya (876,224 tonnes) (FAOSTAT, 2018).

1.3.2 Physicochemical Properties of Camel Milk

At 20^{o}C, camel milk shows an average density of 1.029 g cm^{-3} (Laleye et al., 2008) and its viscosity is 1.72-2.04 MPa sec (Khaskheli et al., 2005). The pH of fresh camel milk (6.4-6.7) is slightly lower than that of bovine milk and is similar to that of sheep milk (Singh et al., 2017). Camel milk shows a freezing point of between -0.57^{o}C and -0.6^{o}C. The calorific value of camel milk is lower (665 kcal/L) compared to bovine milk (701 kcal/L), due to lower lactose content. The titrable acidity of fresh camel milk, which is between equivalents of 0.13-0.16 percent lactic acid, is slightly lower than the mean value of 0.17 percent for bovine milk. Skimmed camel milk showed maximum buffering capacity at pH 4.95 compared to skimmed bovine milk with maximum buffering capacity at about pH 5.65 (Al-Saleh and Hammad, 1992).

The casein micelles in camel milk are relatively large casein micelles with relatively low content of κ-casein (Farah and Rüegg, 1989). Camel casein contains two main caseins homologous to bovine α-and β-caseins with different amino acid sequences, electrophoretic mobilities, and poor rennetability (Farah and Farah-Riesen, 1985). Camel milk stability and consistency are determined by the casein micelle size (25 to > 400 nm)

and the dispersion of its fat in the form of small spherical globules of varying sizes (1-5 μm) (El-Zeini, 2006). In bovine milk, the size of fat globules ranged between 2.5 and 5.7 μm (Logan et al., 2014). A higher content of phospholipids and neutral lipids as well lower content of proteins are present in fat globule membrane of camel milk (Farah and Farah-Riesen, 1985) and act as an emulsifying agents. The differences in casein micelles and fat globule sizes between camel and bovine milks are expected to contribute to the differences in color and mouth feel of the two milks. A relatively broad size distribution, with an average micelle diameter ranging from 0.113 to 0.165 μm has been established using electron micrographs of freeze-fractured camel milk samples (Farah and Ruegg, 1989). In bovine milk, the casein micelles are present as uneven colloidal particles which are large, polydisperse and spherical in shape with 50–600 nm in diameter (average ~150 nm).

1.3.3 Composition and Properties of Camel Milk

The composition of the macronutrients in any milk has important effects on its sensory attributes .The chief ingredients of milk are proteins, fat, lactose, and minerals (Schiano et al., 2017). Milks from different animal species vary widely in their proximate composition (Figure 1.3) as well as in the qualities of these components (Table 1.1). The eminent and multifunctional proteins present in milk are vulnerable to the processing conditions by the food industry. In milk, fat globules are mainly composed of triacylglycerol as an emulsion while complex forms of minerals and proteins are present as micelles. The most common carbohydrate in milk is lactose, which is a disaccharide of glucose and galactose (Patel, 2015).

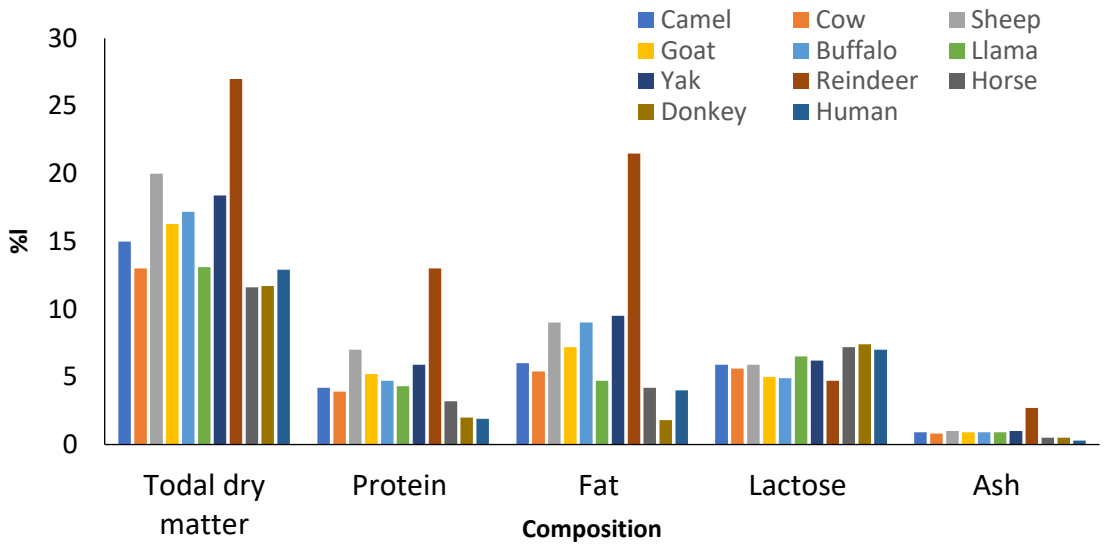

Figure 1.3: Overall composition of mature milk from different mammals

(Source: Guo et al., 2007; Hassan et al., 2009; Medhammar et al., 2012)

Camel milk was described as the white gold of the desert due to valuable nutritional properties (Musaad et al., 2013). It contains higher concentration of vitamin C, high amount of potassium, iron, and antimicrobial substances compared with bovine milk (Kula and Tegegne, 2016). The immune defense mechanism of camel milk is promoted by a number of protective proteins (Kalla et al., 2017). Total milk protein is comprised by casein (1.6-2.76%), which is a major part of protein in camel milk (Khaskheli et al., 2005), and whey proteins (0.63-0.80%) (Nilsson et al., 2020; Mehaia et al., 1995). The major camel milk portion is comprised by α-lactalbumin while β-lactoglobulin, the major whey protein in bovine milk, is absent in camel milk (Laleye et al., 2008). Lactoferrin, serum albumin, peptidoglycan recognition protein, and immunoglobulins are present in the whey proteins of camel milk (Merin et al., 2001).

Table 1.1: Composition of milk from different species

Composition	**Camel**	**Cow**	**Goat**	**Sheep**	**Buffalo**	**Llama**	**Yak**	**Reindeer**	**Horse**	**Donkey**	**Human**
Energy(kJ/L)	3286	2843	2894	4439	4779	3358	4295	8436	2050	1803	2843
Caseins (g/l)	26	28	46.3	46	40		46	80	13.6	10.3	4.2
Whey proteins (g/l)	8.1	7	7	11	6.0				9.1	8	8.3
Casein/Whey ratio (g/l)	3.2	4.7	3.5	3.1	4.6	3.1	4.5	5	1.1	1.2	0.5
Immunoglobulins(g/l)	19.6	1		0.7	10.6				1.6	1.3	1.3
E. Amino acids (g/100g)	1073	1380	1688	2844	1640	1680	2227	4590	936	627	558
Amino acids (g/100g)	3878	4710	5233	8931	5214	5472	6692	14988	3295	2199	1854
Protein (g/100g milk)	4.2	3.9	5.2	7	4.7	4.3	5.9	13	3.2	2	1.9
Cholesterol (mg/100g)	37.1	31.4	18.1	29	18		22		8.8		20
Fat globule (mm)	3	4.6	3.5	3.8	8.7		4.4		3	10	4
SFA (% total fatty acids)	69.9	72.8	73.7	74.6	74	65	65	84	55.8	67.7	45
MUFA (% total fatty acids)	31.1	30.3	30	39.1	29.4	31	3.8	20	36.2	35	45.1
PUFA (% total fatty acids)	11.4	6.3	5.6	7.3	3.9	4	6.2	4	51.3	30.5	19.1

(Source: Guo et al., 2007; Hassan et al., 2009; Medhammar et al., 2012; De Marchi et al., 2011)

Among all-natural fats, camel milk fat is the most intricate one containing approximately 400 different fatty acids with greater concentration of essential fatty acids and long chain fatty acids. The major lipid present in camel milk is triacylglycerols, which comprise saturated and unsaturated fatty acids (66.1% and 30.5%) (Gorban and Izzeldin, 1997). In camel milk the ratio of unsaturated/saturated fatty acid is more advantageous and more comparable to goat's milk which contains fewer short chain fatty acids than bovine milk (Nikkhah, 2011). The white color of camel milk is also due to lower level of carotene and riboflavin (Konuspayeva et al., 2009).

Camel milk contains significantly higher mineral contents than bovine milk (Mati et al., 2017). The iron content in camel is ten times higher than in bovine milk (Sharma and Singh, 2014). The mean values for the concentrations of the important minerals in camel milk were reported in mg/100g as zinc (0.53), manganese (0.05), magnesium (10.5), iron (0.29), sodium (59), potassium (156), and calcium (114), respectively (Sawaya et al., 1984; Gorban and Izzeldin, 1997; Al haj and Al Kanhal, 2010). Gorban and Izzeldin (1997) reported the concentrations of minerals (mg/100g) in bovine milk as: zinc (0.53), manganese (0.02), magnesium (12.0), iron (0.80), sodium (58), potassium (152), and calcium (122). Camel milk is an excellent chloride source because of the feed taken up by camels such as acacia which contains high amount of salts (Khaskheli et al., 2005). Vitamins of B group and from others such as A, D, E, K, C are present in camel milk. The vitamin C content in camel milk is (34.16 mg/L) when compared to bovine milk (Haddadin et al., 2008). In camel milk, the concentration of vitamin A and riboflavin (B2) is less when compared bovine milk. The concentration of vitamin E, pyridoxine (B6) and thiamin (B1) in camel milk is similar to those for bovine milk (Haddadin et al., 2008).

1.3.4 Limitations of Camel Milk Processing

The distinctive physical and functional characteristics associated with the composition of camel milk limit its use in the production of valuable dairy products. Processing difficulties are faced during the processing of camel milk to customary dairy products utilizing the same technologies used for bovine milk (El-Hatmi et al., 2007). Specifically, the production of set yoghurt and camel milk cheese is challenging and was considered as impossible (Kappeler et al., 1998; Kamal-Eldin et al., 2020). The composition of amino-acids and relative distribution in caseins (50–88%) and whey proteins (20–25%) are unlike from those of bovine (Mati et al., 2017; Hailu et al., 2018). The four casein proteins in camel milk are in different relative proportions, which contributes to the poor gelation ability of camel milk (Mohamed et al., 2020). The yield of fresh camel cheese is high due to significant moisture retention and a weak coagulum is formed over a long coagulation time (Mbye et al., 2020). Dispersed flakes are present in camel milk yogurt curd which is fragile and heterogeneous (Berhe et al., 2018). The relative ratio of αS1-, α S2-, β-, and κ-caseins in camel milk is approximately 26:4:67:3 (Mohamed et al., 2020) compared with 38:10:36:12 in bovine milk (Fox and Kelly, 2006). In the whey fraction, camel milk is rich in α-lactalbumin, but is devoid of β-lactoglobulin, the major whey protein in bovine milk (El-Hatmi et al., 2007). Chaperone-like activity of β-casein leads to the anticoagulant property (Mohamed et al., 1990; Zhang et al., 2005).

Butter production from camel milk is also challenging by normal technology. Camel milk fat melts at 41–43^{o}C making it challenging to agitate the cream at 10–14^{o}C, which is the ideal agitating temperature for bovine milk (Berhe et al., 2013). Camel milk shows less

affinity to cream up due to insignificant size of fat globule, impenetrable fat globular membrane, and shortage of agglutinin which causes difficulty in butter production (Farah and Rüegg, 1991; Farah, 1993). The high melting point of camel milk butter is due to the increased percentage of long chain fatty acids in the fatty acid profile.

Spray drying is the frequently used viable method for the production of milk powders. Drying of milk for a small period at a high evaporation rate results in a superior quality product with a reasonably less cost (Boss et al., 2004). Spray-dried milk powders have long shelf life and are easy in storage and handling. When stored in desiccated and appropriate temperature, milk powder has a shelf-life of one year and skimmed milk powder have an excess of 2 years. Microbiological safety and sensory characteristics such as color and flavor are affected by the shelf life of milk powder. The longer shelf life is confirmed by a decrease in % water activity to <0.18% in the spray-dried camel's milk powders (Sulieman et al., 2014). Due to denaturation of proteins, an increase in temperature causes increased insolubility index values, which may confine the usage of milk powders. The bulk density and free fat quantity of spray dried camel milk powder are different from those of bovine milk powders, but the thermodynamic behaviors are similar due to the transfer of fat globules to the surface of milk powder particles (Zouari et al., 2018).

Freeze-drying is a best method for the production of high-quality dry powders. Camel milk powders having nutritional and therapeutic properties can be produced by freeze-drying to a low moisture level (Ibrahim and Khalifa, 2015). Freeze-drying process of skim camel’s milk results in significant biological value, net protein utilization, higher amount of amino acids, and protein efficiency ratio than that of fresh whole milk (Sulieman et al.,

2018). Freeze drying process had a little effect on fatty acid profile and heat sensitive vitamins and prevents denaturation of whey protein and Maillard reactions (Ibrahim and Khalifa, 2015). However, freeze-dried milk powders may suffer from reduced solubility (Suleiman et al., 2018).

1.3.5 The Health Benefits of Camel Milk

Camel milk is claimed to possess a number of therapeutic effects (Table 1.2).

Table 1.2: Therapeutic properties of camel milk

Therapeutic properties	**References**
Anti-carcinogenic	Agrawal et al. (2007); EL-Fakharany et al. (2012); Habib et al. (2013); Krishnankutty et al. (2018)
Anti-diabetic properties	Shabo et al. (2005); Agrawal et al.(2007); Al haj and Al Kanhal (2010); Al-Numair (2010); Sboui et al. (2010); Malik et al. (2012); Ejtahed et al. (2015); Shori, (2015); Abdulrahman et al. (2016); Khalesi et al. (2017); Ayoub et al. (2018)
Hypolipidemic	Al-Numair (2010)
Hypo-allergenic	Shabo et al. (2005); Al haj and Al Kanhal (2010)
Anti-hypertensive	Shabo et al. (2005); Khalesi et al. (2017); Al haj (2017)
Immuno-modulatory	Khalesi et al. (2017)
Therapeutic properties for autism	Bashir and Al-Ayadhi (2014); Gizachew et al. (2014); Kaskous (2016)
Antigenotoxic, anticytotoxic	Khalesi et al. (2017)
Hepatoprotective	Redwan and Tabll, (2007); EL-Fakharany et al.(2012); Ming et al. (2020)
Antioxidant	Jrad et al. (2014); Homayouni-Tabrizi et al. (2017)

Regular intake of 500 mL of camel milk was reported to improve longstanding glycemic control in type 1 diabetic patients with a comparable decrease in the insulin doses of about 30-40% (Agrawal et al., 2007). Studies have also reported that camel milk have significant effect on children suffering from food allergies (Merin et al., 2001). Treatment with camel milk decreases the allergic reactions in children as well as build up their upcoming response to the foods due to the presence of immunoglobulins similar to that of human milk (Shabo et al., 2005). Camel milk was also reported to treat tuberculosis, ulcers, respiratory ailments, and hepatitis (Meiloud et al., 2011). Camel milk is stable at room temperature and up to 30^{o}C for more than eight hours due to high content of lactoferrin and immunoglobulins (Al haj and Al Kanhal, 2010), which prevents the growth of gram-positive and gram-negative bacteria (El-Agamy et al., 2009). After hydrolysis by digestive system enzymes, β-casein and casein peptides have anti- antioxidant and ACE-inhibitory activities (Salmen et al., 2012). Due to the presence of bioactive substances in milk, this primary source of food can be consumed by everyone irrespective of age (El-Agamy et al., 2009).

Consumers' demand for camel milk is due to its health perspective and consequently, camel milk is more costly than bovine milk (Miller et al., 2017; Tudoran and Olsen, 2017). Awareness of consumers, particularly diabetic patients, about the probable positive benefits of camel milk has proven based on its importance. Regular intake of camel milk upturns the level of antioxidant enzymes in the body thereby decreases oxidative stress (Salami et al., 2011), improve glycemic control and decreases the requirement for insulin in Type 1 diabetic patients (Mirmiran et al., 2017).

1.3.6 Sensory Evaluation of Milk

1.3.6.1 Sensory Evaluation

Sensory evaluation of new food products is vital for their commercialization. Sensory analysis of the texture, flavor, and aroma of milk and milk products will identify important quality trends and ensure consumer's satisfaction or leads to process alterations (Karagül-Yüceer and Drake, 2006). There are numerous sensory assessment tools and methods to acquire more evidence and to evaluate the features chosen by the consumers about a food product. Sensory properties are dependent on flavor, aroma, textural, appearance, and rheological factors, which influences consumer acceptance of milk. Figure 1.4 shows the detailed sensory attributes, which is used to categorize properties of specific product desired by the consumer. These recognized features and their apparent intensity can be analyzed from the consumer's personal awareness resulting to a product sensory profile (Hutchings, 1977). It was reported that some consumers showed initial reluctance to camel milk due to its sour and salty taste (Schiano et al., 2017).

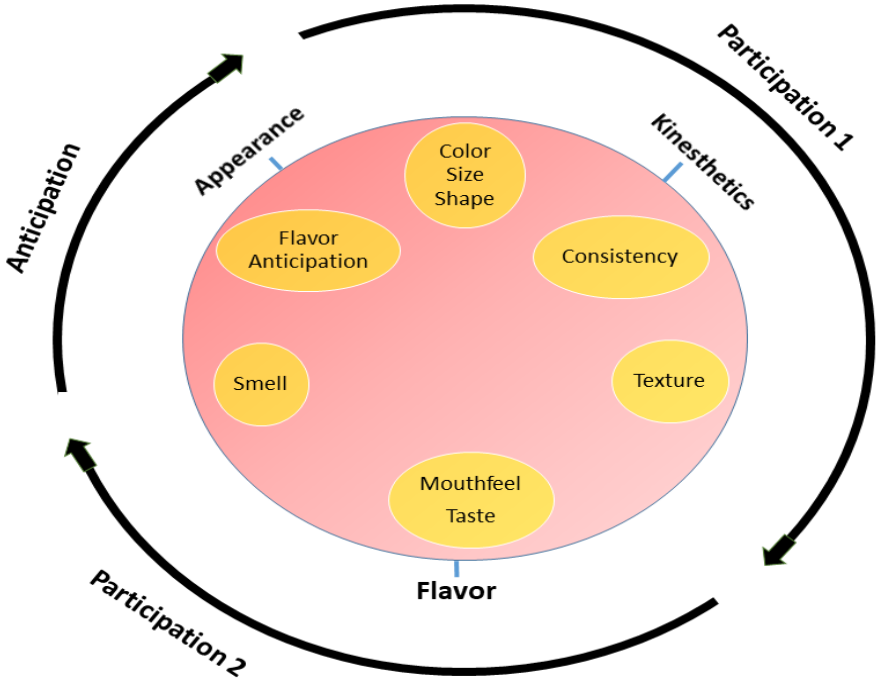

Figure 1.4: The product attribute circle of Kramer modified

(Source: Hutchings, 1977)

1.3.6.2 Methods Used in Sensory Evaluation

Different methods are used for assessing sensory features of foodstuffs. Sensory properties can be determined *inter alias* by using discriminatory or difference test, descriptive, and affective methods (Lawless and Heymann, 2010).

Descriptive test is another method for sensory evaluation that is used for evaluating variations between the samples and their distinguished sensory traits, and influence of

processing and storage methods on their sensory properties (Sharif et al., 2017). The basis of product acceptability can be better understood with descriptive testing and it also helps in assessing factors related to quality control and shelf-life studies. Scoring methods also known as scaling methods is a type of descriptive test. This method is applied to perceive the strength of some attributes and the evaluator can express their decision using an organized or scale (Sharif et al., 2017). The main advantage of scaling methods is that they are useful in creating the size, strength of the changes for a specific attribute and these tests have to be performed by an expert or skilled evaluator.

The consumer acceptability test, also known as consumer affective test, employs untrained panelists to express their liking/disliking of food products and certain quality attributes (Bayarri et al., 2011; Singh-Ackbarali and Maharaj, 2014). Most commonly, the panelists are provided with a 9-point hedonic scale to rank their preferences from dislike extremely to like extremely (Kalva et al., 2014; Sharif et al., 2017). Although the hedonic rating is affected by personal preference and changes in environmental conditions, the relative order of sample preference is generally not affected (Deliza and MacFie, 1996; Lawless and Heymann, 2010). By means of hedonic scales, the acceptability of many products can be compared by panelists. This test is elementary and secure to perform particularly when the popularity of one sample is identified (King et al., 2007; Sharif et al., 2017). The details of consumer acceptability test studies on different types of milks is shown in Table 1.3.

Table 1.3: Examples of consumer acceptability test studies on different types of milks

Types of milk	Characteristics	Types of sensory method	Results	References
Rice based milk	Appearance, aroma, texture, flavor, overall acceptability	Consumer test (with a 9-point hedonic scale)	Lighter colored rice-based milk alternatives (RMAs).	Pramudya and Chung (2019)
Bovine milk + soy-cow milk	Color, flavor, taste, overall acceptability	Consumer test (with a 9-point hedonic scale)	Bovine milk was considered as excellent, soy cow milk (SCM) was considered as very good.	Rahman et al. (2007)
Soymilk + almond milk	Color, taste, flavor, mouth-feel, overall acceptability	consumer test (with 9-point hedonic scale) + triangle test	Almond milk is better than soymilk in all characteristics expect mouth –feel	Alozie Yetunde and Udofia (2015)
Donkey milk	Appearance, taste, aroma, flavour, aftertaste and texture	Consumer test (with a 5-point hedonic scale)	Highly acceptable sensory characteristics scores.	Malissiova et al. (2016)

According to this table, many attributes are used in consumer test such as: flavor, aroma, appearance and mouthfeel. These attributes are mostly included in different studies in sensory evaluation of milk.

Quantitative descriptive analysis (QDA) is a sensory evaluation method that gives quantitative descriptions of products based on the perceptions from a group of qualified trained subjects (Richter et al., 2010). These tests are used in food industry to improve the basic findings of the observed sensory characteristics and the influence of differences in origin and processing of the particular product (Sharif et al., 2017; Juárez-Barrientos et

al., 2019). In these tests, the panelists are powerful instruments that identify and quantify product sensory evaluation.

In a QDA test, a panel of ten to twelve panelists is suggested (Armstrong, 1999). The panelists will train in a number of sessions and develop a lexicon by agreeing on the terminology and scale of evaluation. Panelists analyze sensory strength individually in separate booths without reference assisted as intensities standards have been developed (Armstrong, 1999). The results from QDA are informative for statistical practices to meet project goal and constant measurements on product attributes supports the valuation of subjects consist performing sensory analysis and consumer preference studies. Cheng et al. (2020) conducted a study to investigate how cross-cultural sensory awareness of skim milk powder in Ireland, USA and China is influenced by pasture and non-pasture diets. Optimized descriptive profiling was used by skilled evaluators in Ireland and China, and traditional descriptive analysis for expert panel in the USA for sensory analysis in which the results revealed that diet has an impact on volatile profiles and sensory perception of skimmed milk powder.

In formulated milk products, the overall liking by hedonic scale and intensity of traits was studied with the preference of particular consumers or with an acceptance test (Zhi et al., 2016). Sensory evaluation of 20 milk samples produced by skim milk microfiltration retentate with raw cream revealed that milks with high concentration of casein as a ratio of true protein have reduced yellow color with less transparency and whiter color as confirmed by panelists. The study established that when alterations in appearance between milks were concealed, higher score for throat cling and mouth coating were obtained for milk with high concentration of casein (Misawa et al., 2016). Chapman et al. (2001)

evaluated the efficacy of QDA and principal components analysis (PCA) for assessing unpasteurized milk products, the study revealed that QDA and PCA can be involved in the development of strategic product for the promotion of unpasteurized and other liquid milk products. Oupadissakoon et al. (2009) compared sensory attributes including the flavor difference and texture of 37 available ultra-high temperature (UHT) milk and pasteurized milk from different countries using PCA and hierarchical cluster analysis. The study concluded that increased content of several flavor records usually related to decreased contents of new dairy flavor properties and the production techniques of UHT milk could have much influence than country or amount of fat in defining sensory characteristics. In another study, descriptive panel results of milk flavor and aftertaste in nonfat and whole milk showed that serving temperature have no effect on flavor of milk. The study reported that more score for fat character, sour aromatics, cooked and bitter were obtained for nonfat milk while milk aftertaste at 90 s after swallowing showed that nonfat milk had very less cooked attributes and was less sweet than whole milk (Francis et al., 2005).

Frost et al. (2001) studied the influence of various factors on observed fattiness and sensory attributes of milk, compared them to the actual fat content of 0.1, 1.3, and 3.5% fat milk and it has been demonstrated that in 0.1% fat milk, a combination of thickener, whitener, and cream aroma was effective in representing sensory properties of 1.3% fat milk. For the assessable sensory depiction of fluid milk characteristics, a panel-generated consumer-oriented lexicon method was compared with a traditionally as well as defect oriented sensory terminology system. The results revealed that the panel using the traditional terms was more effective than panel generating their own terminology method

and suggest that for sensory analysis of milk, a descriptive analysis technique is a practical alternative to a traditional defect-oriented system (Claassen and Lawless, 1992).

The worldwide federation of national standard bodies established the International Organization for Standardization (ISO) which prepares international standards through ISO technical committees. The assessment of a multifarious sensory extent requires procedure for recognition of proper evaluators. This effort can be achieved with the help of a trained panel who explain their observations both qualitatively and quantitatively. The quality of the sensory profile is determined by the selection of evaluators which is the initial step of analysis. The evaluators can be selected by a consensus method (International Organisation for Standardization ISO 6564,1985). A scheme for recognizing and choosing descriptors is included which then be utilized for framing the sensory details of a product (International Organisation for Standardization ISO 11035, 1994). The principle of the standard is screening and selection of a set of appropriate descriptors providing enough data about the sensory characteristics of the product under investigation, in order to create a sensory profile. The different steps in the procedure for creating tests through which a detailed explanation of sensory traits of a product have described in this standard (International Organisation for Standardization ISO 11035,1994). The other application of this sensory profile method is describing production standards, for improving and developing products, studying the effect of products ageing and comparing same type of products available in the market. The various steps in the assortment of descriptors for creating a sensory profile are giving instruction to the panel, composing and editing descriptive terms, selecting reference products, training with

repeatability tests and usage of the profile (International Organisation for Standardization ISO 11035,1994).

A sensory investigation panel establishes a true “quantifying instrument”, and therefore the outcomes of the study depends on its members. The enrollment of persons ready to join in a panel then requires to be conducted with attention and to be revealed as an actual asset, both in terms of time and money (International Organisation for Standardization ISO 8586-1,1993). Different types of assessors can perform the sensory analysis. Sensory assessors or native assessors could not meet any specific criterion while assessors already involved in sensory analysis are initiated assessors. On the other hand, assessors are selected for their talent to execute a sensory test while expert sensory assessors are designated evaluators with an established sensory compassion and with extensive training and knowledge in sensory testing who are capable to make reliable and repeatable sensory valuations of several products (International Organisation for Standardization ISO 8586-1,1993). The group of sensory experts in the panel is under monitoring of panel leader who is responsible for training the group of expert sensory assessors and for the selection of tests used, the demonstration of the samples, or for the elucidation of results. The principles for the choice and techniques for the preparation and observation of selected evaluators and skilled sensory assessors is described in international standard (International Organisation for Standardization ISO 8586-1,1993).

The general guidelines for the sketch of test rooms proposed for the sensory investigation of products is provided by International Standard (International Organisation for Standardization ISO 8589, 2007) which is not specific for any product or test type. The details of the essential criteria such as the necessities for creating office, test room and

area of preparation are included in this standard. The space for testing can be comparable for the sensory assessment of food and non-food products. Conversely, it is essential to modify the test rooms for each specific use. Variations to the scheme are frequently desirable for particular products and for exact kinds of testing. This is predominantly if the test rooms are to be utilized for the assessment of non-food products (International Organisation for Standardization ISO 8589, 2007). This International Standard does not refer assessment details for the specific analysis of products in-plant quality-control uses.

1.3.6.2.1 Hedonic Scaling

In applied research, numerous scales have been recognized and developed to evaluate hedonic reactions. Among the methods, the 9-point hedonic scale is an important one frequently used for analyzing consumer choice and acceptability of foods. The motivation for the development of this scale is due to the requirement of ranking method which reduce the restrictions of the inconvenient system of paired comparisons (Peryam and Pilgrim, 1957). The hedonic scale (9 point) is a stable oscillating scale nearby unbiased at the middle and on each side with four positive and four negative classes. The classes are characterized with idioms demonstrating several grades of affect and those markings are organized consecutively to propose a particular scale of responses (Peryam and Pilgrim, 1957). The descriptors are proposed to support not only people to react but also to assist and describe the average response of reactions on the basis of degree of liking/disliking (Peryam and Pilgrim, 1957; Moskowitz, 1977; Lim, 2011).

The unconditional nature and restricted options of 9-point hedonic scale promote it to a friendly scale for both study members and investigators to use. This is one of the main

reasons for the extensive acceptance of the 9-point hedonic scale when compared to other scaling methods. It has been demonstrated that modest classification measures are as complex as additional scaling systems on the basis of differentiation power (Lawless et al., 2010). Hence, when the major disquiet of a study is determining hedonic dissimilarities between food stuffs, the 9-point hedonic scale has been recognized to be a humble and operational quantifying device.

The major limitation of 9-point hedonic scale is that it can produce only interval data due to its disproportion of scale interims and the shortage of a zero point (Peryam and Pilgrim, 1957; Moskowitz and Sidel, 1971). Therefore, the scale cannot contribute the data about proportions of liking/disliking for incitements (Moskowitz and Sidel, 1971; Schutz and Cardello, 2001) or offer important assessments of hedonic opinion between individuals and groups (Lim, 2011). The 9-point hedonic scale stands with small choice for topics to explain the hedonic skills due to its inadequate reaction types (Marchisano et al., 2003; Villanueva and Da Silva, 2009). The scale is exceedingly susceptible to numerous context effects (Schutz and Cardello, 2001) due to the overall trend of subjects to circumvent using extreme classifications and its lesser number of accessible categories (Moskowitz, 1982).

1.3.7 Consumer Surveys

Consumer surveys can be used to express the attitudes of consumers towards sensory properties such as taste, appearance, flavor and texture as well as on value and appropriateness of products (Villegas et al., 2010). Consumer surveys can also include knowledge or believes about the nutritional features or composition and even trade names and prices (Villegas et al., 2010). As with sensory consumer preference tests, the

understanding of how attributes drive liking or disliking is a key issue when presenting new products to the market (Costell, 2002; Drake et al., 2009; Villegas et al., 2010). The key objective of consumer surveys is to direct the identification of drivers of liking/disliking that will help create passion of appreciable features for the consumers (Costell, 2002).

Chapter 2: Materials and Methods

2.1 Milk Samples

Pasteurized camel milk samples including flavored camel milk (dates, zafran, strawberry, and chocolate) and camel milk powders used in this study were commercial products from two industries in United Arab Emirates (Al Ain Farms, Al Ain, Abu Dhabi, and Camelicious, Dubai, United Arab Emirates).

2.2 Ethical Approval

The studies included in this thesis were performed in compliance with the UAEU guidelines and were approved by UAEU Social Science Ethics Committee.

2.3 Consumer Acceptance Test

A total of 120 untrained panelists (43 males and 77 females) ranging in age from 17 to 62 years and consisting of students and staff of United Arab Emirates University (UAEU) were recruited to perform this test using a 9-point hedonic scale (1- dislike extremely, 2- dislike very much, 3- dislike moderately, 4- dislike slightly, 5- neither like nor dislike, 6- like slightly, 7- like moderately, 8-like very much, 9- like extremely). The assessment was carried out in separated sensory evaluation booths at the Department of Food Science, UAEU. Eight products were evaluated by the panelists: bovine milk, bovine milk powder, camel milk, camel milk powder, zafran camel milk, dates camel milk, chocolate camel milk, strawberry camel milk. The products were coded with 3-digit codes and the order of presentation of samples was randomized when offered to the volunteers. Samples (60 mL)

of each sample was served to each panelist and they were asked to evaluate each sample on the basis of liking/disliking with respect to color, texture, mouthfeel, flavor, saltiness, sweetness and overall acceptability.

2.4 Quantitative Descriptive Analysis (QDA)

Sensory profiling of the different products was performed by QDA using 8 panelists consisting of students and faculty members from different colleges in UAEU. Each panelist signed an agreement form before joining the training sessions. The panelists were aware about the sensory evaluation methods for milk and were further trained for 30 h to improve their ability to detect and assess appearance, body/consistency, odor, and flavor/taste. During training, a 10-point numerical scale anchored at both ends with low intensity and high intensity was given to panelists to score the intensity of stimuli where 0 represent not detected and 10 represent the highest possible score. A lexicon of descriptive terms that characterize the sensory properties of camel milk was developed. The important attributes related to four main characteristics of milk such as appearance (foaming, viscosity) and flavor (initial sweetness, fruitiness, mouthfeel, mouth coating, fat feel, chalky powdery feel) were identified by the panel by consensus according to standard procedures (International Organisation for Standardization ISO 11035,1994). References used in the evaluation are explained in the lexicon (Table 2.1).

A panel leader facilitated the discussions leading to the agreement on the appropriate terms and their definitions and standards. Commercial products were used as reference samples and the intensities of the reference sample attributes were agreed upon by panel consensus. 3-Digit random numbers were used to code the test samples and each sample

was evaluated. Partitioned sensory evaluation booths at the Department of Food Science, UAEU, were used for the evaluations. Panelists marked each scale to indicate their rating for each attribute and the intensity was measured starting from the left side of the scale. Panelists cleaned their palates with purified water and white bread to eliminate carryover. A five minute break was given to panelists between samples and at least one hour break between the two daily sessions. The mean scores of each sample attribute were computed and subjected to further statistical analyses.

2.5 Consumer Survey

This study was based on a well-designed questionnaire to obtain information on camel milk and its consumption from consumers. Online survey was created using Google Forms and the link was shared through email to the participants. The survey included 24 questions divided into the following sections: (1) demographics of consumers, (2) familiarity to the camel milk, (3) health and nutrition aspects, (4) convenience and price, and (5) sensory appeal (Table 2.1). The questionnaire was written in both English and Arabic language. Data was collected between July 2020 and December 2020. Data collection was anonymous and participants included no personal identification information such as name or mailing address. The questions used consumer-friendly language to ensure that answers accurately reflected knowledge and perceptions. The questions used for this study were adapted from similar surveys on milk consumption (Vargas-Bello-Perez et al., 2018).

Table 2.1: Survey questions

Questions	**Choices**
Demographics of consumers	
1. What is your sex?	Male, Female
2. What is your age?	20-30 , 30-40 years,40-50 years,
3. What is your job?	50-60 years, above 60 years
4. What is your nationality?	Student, Employee, Others
5. What is your income per month?	UAE, Asian, African, European, American
	Less than 5000 AED, 5000 -10000 AED, 1000-20000 AED, more than 20000 AED
Familiarity	
1. Is camel milk familiar to you?	Yes, no
2. How often do you consume camel milk?	Daily, 1-2 times per week, 2-3 times per month, less than once a month, never
3. Camel milk is what I usually drink?	Yes, no
4. Camel milk I drank when I was a child?	Yes, no
Health and nutrition	
1. Camel milk is nutritious/it keeps me healthy?	Yes, no
2. Camel milk is good for my skin/teeth/hair/nails?	Yes, no
3. Camel milk is good for my digestive tract?	
4. Camel milk contains natural ingredients?	Yes, no
5. Camel milk is healthier than bovine milk?	Yes, no
6. Camel milk is salty?	Yes, no
7. If you know the camel milk is healthier than bovine milk, would you drink it?	Yes, no Yes, no
Convenience and price	
1. Camel milk has longer shelf life than bovine milk?	Yes, no
2. Camel milk is not expensive as compared to bovine milk?	Yes, no
3. Camel milk has good value for money?	Yes, no
4. Camel milk is easily available in supermarkets?	Yes, no
Sensory appeal	
1. Camel milk smells nice?	Yes, no
2. The appearance of camel milk is acceptable?	Yes, no
3. Camel milk tastes good?	Yes, no
4. Camel milk is available in different flavors?	Yes, no

Table 2.2: Survey questions (Translated)

الاسئلة	الخيارات
التركيبة السكانية للمستهلكين	
1. الجنس	ذكر ، أنثى
2. ما هو عمرك ؟	20-30 سنة ، 30-40 سنة، 40-50 سنة، 50-60 سنة ،أكثر من 60 سنة
3. ما هي وظيفتك ؟	طالب ، موظف، أخرى (يرجى تحديد)
4. ما هي جنسيتك ؟	دولة الامارات العربية المتحدة، أفريقي، آسيوي، أوروبي، أمريكي
5. ما هو الدخل الشهري؟	أقل من 5000 درهم، 5000-10000 درهم، 10000-20000 درهم ، أكثر من 20000 درهم
استهلاك حليب الإبل	
1. هل حليب الإبل مألوف (معروف) لك ؟	نعم ، لا
2. كم مرة تستهلك حليب الإبل ؟	يومياً، 1-2 مرات في الأسبوع، 2-3 مرات في الشهر، أقل من مرة في الشهر ، لم أشربه أبداً
3. هل حليب الإبل هو ما تشربه عادة ؟	نعم ، لا
4. هل حليب الإبل هو طعام شربته عندما كنت طفلاً ؟	نعم ، لا
الصحة و التغذية	
1. هل حليب الإبل مغذي \ هل يبقيك صحي؟	نعم ، لا
2. هل حليب الإبل جيد للبشرة\ الأسنان\ الشعر\ الأظافر؟	نعم ، لا
3. هل حليب الإبل جيد للجهاز الهضمي ؟	نعم ، لا
4. هل حليب الإبل يحتوي على مكونات طبيعية؟	نعم ، لا
5. هل حليب الإبل أكثر صحة من حليب البقر؟	نعم ، لا
6. هل حليب الإبل مالح ؟	نعم ، لا
7. إذا كنت تعرف أن حليب الإبل أكثر صحة من حليب البقر، هل ستشربه؟	نعم ، لا
السعر و الملائمة	
1. هل حليب الإبل له صلاحية أطول من حليب البقر ؟	نعم ، لا
2. هل حليب الإبل ليس غالياً مقارنة مع حليب البقر ؟	نعم ، لا
3. هل حليب الإبل له قيمة جيدة مقابل المال؟	نعم ، لا
4. هل حليب الإبل متوفر بسهولة في محلات السوبر ماركت ؟	نعم ، لا
مواصفات حليب الإبل	
1. هل حليب الإبل له رائحة لطيفة ؟	نعم ، لا
2. هل مظهر حليب الإبل مقبول ؟	نعم ، لا
3. هل طعم حليب الإبل جيد ؟	نعم ، لا
4. هل حليب الإبل متوفر بنكهات مختلفة ؟	نعم ، لا

2.6 Statistical Analysis

Data analysis was conducted using SPSS Statistical Software program (version 20.0, SPSS Inc., Chicago, IL) using Tukeys test. Sensory data were statistically tested using ANOVA to determine if statistical difference existed between the means ($p \leq 0.05$).

Chapter 3: Results and Discussion

3.1 Sensory Evaluation of Different Types of Milk Products

3.1.1 Consumer Acceptance

Table 3.1 shows the results of the consumer acceptability evaluation of bovine milk, camel milk, four flavored camel milk samples (*viz*. strawberry, zafran, dates and chocolate), camel milk powders, and bovine milk powder as analyzed by 120 unexperienced panelists. The samples were assessed for the most important traits, i.e. color, taste (saltiness and sweetness), texture, mouthfeel, flavor, and overall appearance.

The sensory evaluation results (Table 3.1) showed that the color acceptability scores for non-flavored bovine and camel milk and milk powders were not different. Camel milk has white color compared to a slightly yellow color of bovine milk due to lower content of β-carotene (Wernery, 2006) and natural homogeneity of the milk fat in small fat globules (Abu-Lehia, 1989). Adding flavors to camel milk improved its acceptability with strawberry and chocolate camel milk receiving significantly higher score for color than zafran and dates others ($p \leq 0.05$). In a previous study, color had the best score during the evaluation of sensory attributes of camel milk with grand mean score of 7.9 and was graded as very good (Ahmed et al., 2014). High scores were also obtained when camel milk was fortified with 10% orange and 15% cherry fruit syrup (Toloun et al., 2013). Camel milk fortified with low concentration of cinnamon and doum extracts were also reported to have good scores for color (El-Deeb et al., 2017). Flavoring camel milk with

chocolate enhanced the acceptability by children of camel milk, specially color and appearance (Hashim, 2002).

The taste, especially saltiness and sweetness, is an important attribute in sensory analysis of milk. Compared to bovine, unflavoured camel milk and milk powder showed lower scores for liking of saltiness and sweetness ($p \leq 0.05$). These results are consistent with camel milk having lower contents of lactose (Elamin and Wilcox, 1992) and higher levels of minerals than bovine milk (Sawaya et al., 1984; Gorban and Izzeldin, 1997). The addition of chocolate, dates, and strawberry to camel milk masked the salty taste and improved the perception of sweetness ($p \leq 0.05$). Ranadheera et al. (2012) found that addition of natural fruit juice enhanced the taste of bovine milk and positively influenced the preference of milk beverages. Camel milk fortified by different concentration of dates was the most acceptable among fermented and other fortified milks in terms of higher rating for smell, taste, and acceptability (Otaibi and El-Demerdash, 2008).

The textural attributes, determined by spoon and by mouthfeel, represent an important sensory characteristic in determining consumer acceptability of dairy products (Bourn and Prescott, 2002). The texture and mouthfeel scores were lower for unflavored camel milk and milk powder than those of bovine milk and powder ($p \leq 0.05$). Again, the addition of chocolate, strawberry, and date flavors improved the texture and mouthfeel of camel milk ($p \leq 0.05$). The addition of sugar, stabilizer, and fruit flavor to milk was reported to alter the appearance and texture (Lee and Lucey, 2010). Visual and texture attributes explains the ability of consumer to differentiate between fat contents of milk (McCarthy et al., 2017). The more sweet-related attributes have been reported with milk containing higher

fat when compared with lower fat milk with low fat content as well as less cooked flavors (Francis et al., 2005).

Similarly, the score value for flavor was found to be lower in camel milk and powder compared to bovine milk and powder ($p \leq 0.05$), which is in agreement with Ahmadoon (2012) and Eissa et al. (2011). Also, the addition of strawberry, chocolate, and dates significantly improved the flavour of camel milk ($p \leq 0.05$). Yam and Khomeiri (2015) reported that additives such as syrup plays a crucial role on improving the sensory properties of camel milk. It was also shown that flavor intensity of milk products and consumer acceptance increased with added cherry and orange syrups (Yam and Khomeiri, 2015).

The overall acceptability results were consistent with the above findings, i.e. unflavored camel milk and camel milk powder were less accepted than their corresponding bovine products and that the addition of strawberry, chocolate, and dates improved their acceptance ($p \leq 0.05$). A previous study with children also showed that camel milk had the lowermost scores for sensory traits and overall acceptance than fresh bovine milk and dried bovine milk powder (Hashim, 2002). The low organoleptic properties of pasteurized camel milk are due to different compositional characteristics compared to bovine milk (Berhe et al., 2018). The addition of flavors to camel milk is expected to provide a pleasant aroma and enhance its flavor and overall acceptability (El-Aziz et al., 2012). Flavoring of camel milk with chocolate enhanced sensory attributes such as taste, aroma and overall acceptance of milk (Kumar and Mishra, 2004). Shukla et al. (1991) also reported that addition of stabilizers at higher concentration than 0.3% can negatively influence the sensory characteristics of milk.

Table 3.1: Consumer test and acceptability of different types of milk products

Sample name	Color	Saltiness	Sweetness	Texture	Mouthfeel	Flavor	Overall acceptability
Bovine milk	6.9 ± 2.0^{ab}	5.7 ± 2.2^{cd}	5.9 ± 2.2^{c}	6.6 ± 2.0^{cd}	6.1 ± 2.4^{c}	5.9 ± 2.4^{c}	6.1 ± 2.2^{c}
Camel milk	6.8 ± 2.0^{ab}	4.7 ± 2.2^{b}	4.6 ± 2.2^{b}	5.9 ± 2.3^{bc}	5.2 ± 2.4^{b}	4.5 ± 2.4^{b}	4.8 ± 2.3^{b}
Bovine milk powder	5.7 ± 2.1^{a}	5.1 ± 2.3^{bc}	4.9 ± 2.3^{b}	5.7 ± 2.4^{b}	5.3 ± 2.6^{b}	4.8 ± 2.5^{b}	4.9 ± 2.4^{b}
Camel milk powder	5.9 ± 2.7^{a}	3.0 ± 2.0^{a}	2.9 ± 2.1^{a}	4.8 ± 2.5^{a}	3.3 ± 2.4^{a}	2.7 ± 2.1^{a}	2.8 ± 2.1^{a}
Strawberry camel milk	8.3 ± 8.5^{c}	6.1 ± 2.0^{d}	6.3 ± 2.1^{cd}	7.1 ± 1.7^{df}	6.7 ± 1.9^{cd}	6.4 ± 2.2^{c}	6.5 ± 2.0^{cd}
Zafran camel milk	5.8 ± 2.1^{a}	5.1 ± 2.3^{bc}	5.0 ± 2.3^{b}	5.9 ± 2.4^{bc}	5.0 ± 2.6^{b}	4.7 ± 2.7^{b}	4.8 ± 2.6^{b}
Dates camel milk	6.8 ± 1.8^{ab}	6.0 ± 1.9^{d}	6.4 ± 2.0^{cd}	6.8 ± 1.8^{df}	6.6 ± 1.9^{cd}	6.6 ± 2.1^{cd}	$6.4^{cd} \pm 1.9$
Chocolate camel milk	7.4 ± 1.8^{bc}	6.3 ± 2.0^{d}	6.9 ± 2.0^{d}	7.4 ± 1.6^{f}	7.1 ± 1.8^{d}	7.3 ± 1.8^{d}	7.2 ± 1.7^{d}

9-point hedonic scale was used with 1- dislike extremely, 2- dislike very much, 3- dislike moderately, 4- dislike slightly, 5- neither like nor dislike, 6- like slightly, 7- like moderately, 8-like very much, 9- like extremely. Data is presented as mean ± standard deviation (n=120). Means within each column having different superscript letter are significantly different ($p \leq 0.05$)

3.1.2 Quantitative Descriptive Analysis (QDA)

QDA is widely applied for sensory characterization of dairy products (Cadena et al., 2013; Morais et al., 2014; Gaze et al., 2015). Table 3.2 presents the sensory lexicon developed by 8 panelists in this study for QDA of the tested milk samples. The tested samples included bovine milk (Reference), unflavored camel milk, camel milk powders (spray dried & freeze dried), and bovine milk powder (spray dried), and four flavored camel milk samples (*viz*. strawberry, zafran, dates and chocolate). The assessed sensory characteristics included foaming, viscosity, initial sweetness, saltiness, fruitiness, mouth coating, fat feel, and chalky/powdery feel.

The results of the QDA test (Table 3.3) showed no significant differences in scores of the sensory attributes between the test samples except for the scores of initial sweetness and fruitiness that were improved by the addition of the flavors ($p \leq 0.05$). Bovine milk containing strawberry pulp was most preferred and presented the higher scores in the sensory test (Balthazar et al., 2018). The descriptive analysis method was used in several fluid milk studies to study and characterize samples (Claassen and Lawless, 1992; Phillips et al., 1995; Watson and McEwan, 1995; Chapman and Boor, 2001; Francis et al., 2005; Chung et al., 2008; McCarthy et al., 2017). In fluid milk with varying fat percentage, QDA established that while increasing fat content of milk, the attributes such as opacity, thickness, mouth coating, viscosity, milk fat flavor, and yellow color was also increased (Phillips et al., 1995; Francis et al., 2005; McCarthy et al., 2017). When compared to whole milk, nonfat milk was found to be higher in sour aromatic flavor, less viscous, less sweet, and chalkier (Francis et al., 2005).

Table 3.2: Sensory lexicon developed by panelists for Quantitative Descriptive Analysis (QDA) of milk samples

Attributes	Definition	Reference
Appearance		
Foaming	Presence of bubbles on shaking occupy 1/3 of volume	1= Low (90 % water in skim bovine milk) 9= High (1% soap in skim bovine milk)
Viscosity	resistance to flow on pouring as seen visually	1 = low (skim bovine milk) 9 = high (rainbow milk)
Flavor		
Initial sweetness	Initial sensation of sweetness perceived in the mouth	1 = Low (2% sugar solution) 9 = High (11% sugar solution)
Saltiness	Initial sensation of saltiness perceived in the mouth	1 = Low (0.2% salt solution) 9 = High (0.7% salt solution)
Fruitiness	flavor sensation of fresh fruits	1= low (full fat cream bovine milk) 9= high (100% coconut milk)
Mouthfeel		
Mouth coating	The food sensation that remains in the mouth after drinking	1= Low (water) 9 = High (100% coconut milk)
Fat feel	The intensity of the oily feeling in the mouth.	1= Low (skim boine milk) 9 = High (20% rainbow milk in full fat bovine milk)
Chalky/ powdery feel	A measure of the dry/powdery sensation in the mouth	1= Low (skim bovine milk) 9= High (2% coconut powder in full fat cream milk)

8 panelists participated in the generation of this lexicon

Table 3.3: Mean ratings of different types of milk product using Quantitative Descriptive Analysis (QDA)

Sample name	Foaming	Viscosity	Initial sweetness	Saltiness	Fruitiness	Mouth coating	Fat feel	Chalky/ powdery feel
Bovine milk (Reference)	6.5 ± 2.5^{bc}	4.2 ± 1.4^{a}	2.2 ± 0.8^{a}	2.1 ± 1.5^{a}	1.1 ± 0.3^{a}	4.0 ± 1.6^{a}	5.3 ± 1.6^{a}	1.6 ± 1.0^{a}
Camel milk	7.0 ± 2.0^{bc}	4 ± 1.7^{a}	1.3 ± 0.51^{a}	3.9 ± 1.5^{ab}	1.4 ± 0.7^{a}	3.0 ± 1.0^{a}	3.8 ± 1.9^{a}	2.1 ± 1.3^{a}
Bovine milk powder (spray drying)	5.0 ± 2.6^{abc}	4.6 ± 1.8^{a}	2.7 ± 1.3^{ab}	1.6 ± 1.0^{a}	1.4 ± 0.3^{a}	4.1 ± 1.2^{a}	5.1 ± 1.4^{a}	3.2 ± 2.2^{a}
Camel milk powder (spray drying)	3.6 ± 1.9^{ab}	4.75 ± 1.6^{a}	1.6 ± 1.0^{a}	3.8 ± 1.03^{ab}	1.6 ± 1.1^{a}	4.3 ± 1.9^{a}	4.4 ± 1.9^{a}	2.0 ± 1.4^{a}
Camel milk powder (freeze drying)	2.9 ± 2.5^{a}	$4.0 + 2.3^{a}$	1.3 ± 0.7^{a}	5.0 ± 2.2^{b}	1.5 ± 1.0^{a}	4.5 ± 1.9^{a}	4.8 ± 1.8^{a}	2.3 ± 1.6^{a}
Strawberry camel milk	7.5 ± 1.3^{c}	4.5 ± 2.1^{a}	5.5 ± 2.2^{c}	3.1 ± 1.2^{ab}	6.9 ± 1.8^{c}	4.7 ± 1.8^{a}	3.2 ± 1.3^{a}	1.6 ± 0.7^{a}
Zafran camel milk	6.4 ± 2.5^{bc}	4.2 ± 1.6^{a}	4.9 ± 2.0^{bc}	2.9 ± 1.4^{ab}	3.8 ± 2.1^{b}	4.6 ± 1.9^{a}	4.0 ± 1.3^{a}	1.8 ± 0.7^{a}
Dates camel milk	7.5 ± 1.1^{c}	6.0 ± 1.3^{a}	7.1 ± 1.6^{c}	3.1 ± 1.4^{ab}	5.5 ± 2.0^{bc}	5.0 ± 1.6^{a}	3.9 ± 1.4^{a}	2.3 ± 1.3^{a}
Chocolate camel milk	6.0 ± 2.7^{abc}	5.8 ± 2.5^{a}	4.8 ± 2.3^{bc}	3.6 ± 2.1^{ab}	4.6 ± 2.5^{b}	5.1 ± 2.1^{a}	3.6 ± 1.3^{a}	3.3 ± 2.3^{a}

Results are expressed as mean ± standard deviation (n+8). A 9-point hedonic scale was used with 1- dislike extremely, 2- dislike very much, 3- dislike moderately, 4- dislike slightly, 5- neither like nor dislike, 6- like slightly, 7- like moderately, 8-like very much, 9- like extremely. ^{a,b,c} Means within a column followed by different superscript letter differ ($p \leq 0.05$)

3.2 Consumer Survey

3.2.1 Demographics of Consumers

In the present study, 382 consumers participated in the consumer survey. The majority of the consumers who participated in the survey are UAE nationals (83%) while only 17% participants were expats. The sex of the consumers who participated in the survey was 60% males and 40% were females. Their age ranged 20-60 years with the age group of 20-30 years representing the majority of consumers (40%), followed by 30–40 years old (24%), then the participated consumers are in the age group above 40-50 years old (19%) and the lowest rate (6%) was the above 60 years age group (Figure 3.1). Thus, the participants were dominated by younger age Emirati individuals.

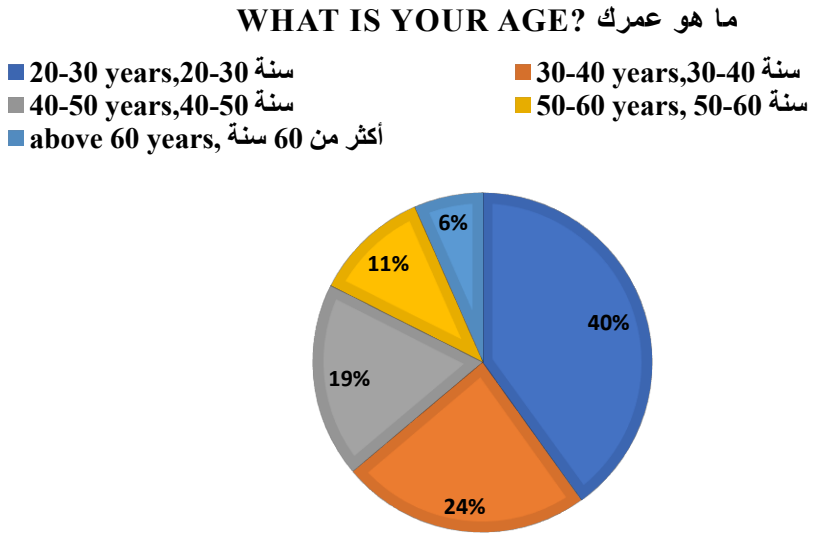

Figure 3.1: Distribution of the age of survey participants

Figures 3.2 and 3.3 shows the jobs and income of the consumers who participated in the survey showing that 62% of consumers were employed, while 16 % of consumers were

unemployed, and 14% of consumers were students. The lowest percentage consumers were retired individuals (8%). The income of majority of consumers (32%) who participated in the survey was more than 20,000 AED while the income of 30% of consumers were less than 5000 AED. 20% of consumers earned an income of 10000-20000 AED and 18% of participants earned an income of 5000-10000 AED.

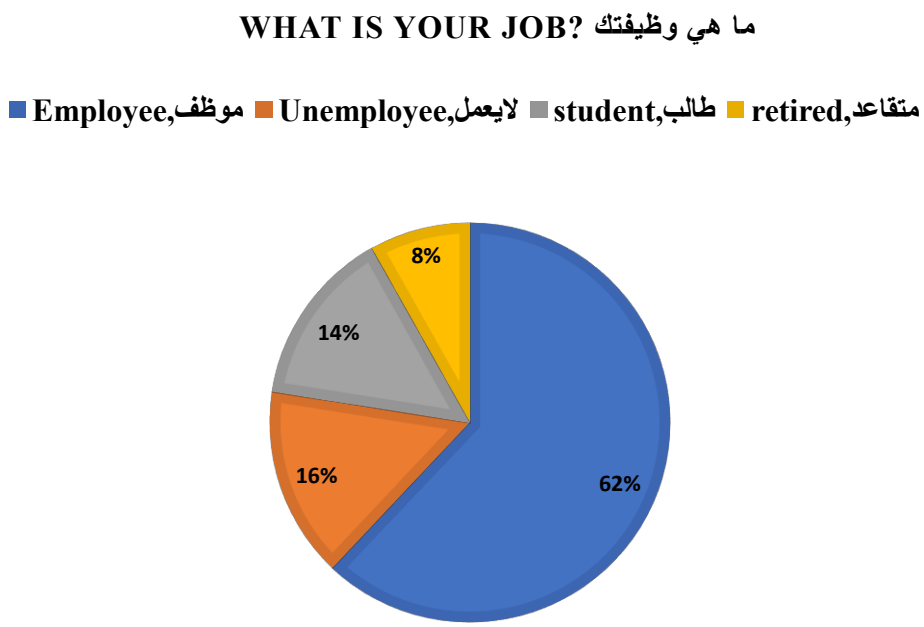

Figure 3.2: Job of the survey participants

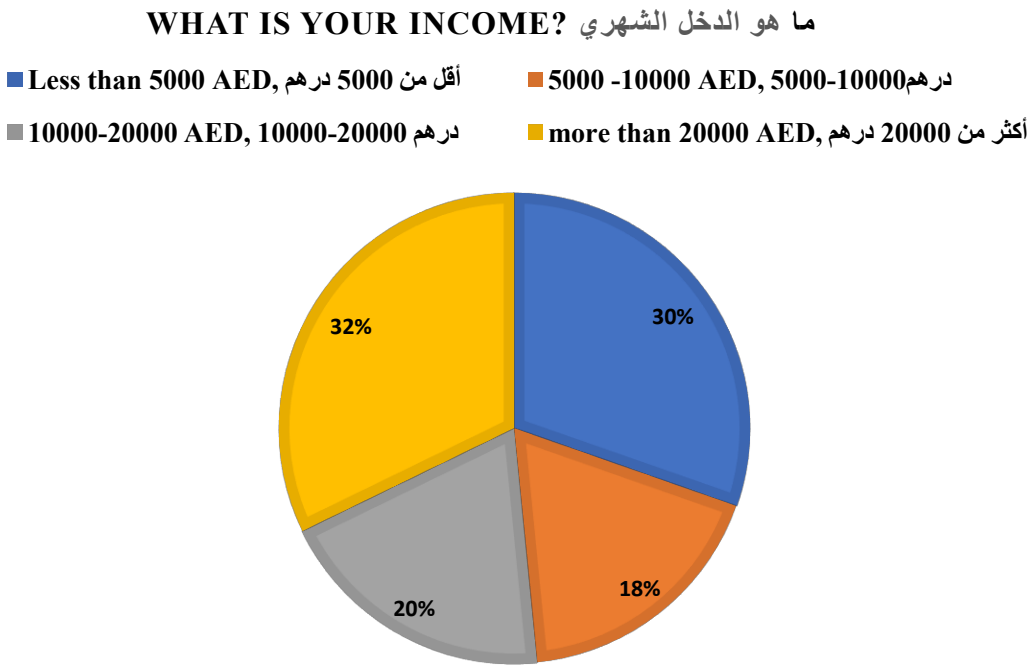

Figure 3.3: Monthly income of the participants

3.2.2 Familiarity, Knowledge, and Attitudes of Participants

Table 3.4 presents the questions related to participant's familiarity, knowledge, and attitudes towards camel milk. The 382 consumers involved in the survey were all familiar with camel milk. The qualitative aspects of consumer experiences are better elucidated using consumer studies (Schiano et al., 2017). The data collected from consumers in the form of comments based on free response, answers to questions, or interviews were organized and grouped. Walsh et al. (2015) used responsive check-all-that-apply question method and established that terms such as happy, safe, warm, and whole with higher hedonic scores are used widely to express consumer responses for light-induced oxidation effects on 2% milks.

Table 3.4: Consumer survey results

Questions	**Answers**
Is camel milk familiar to you?	Yes (382), 100%
Camel milk is what I usually drink	Yes (243) 64%, No (139) 36%
Camel milk is a food I drank when I was a child	Yes (256) 67%, No (126) 33%
Camel milk is nutritious/it keeps me healthy	Yes (332) 87%, No (2) 0%, I don't know (48) 13%
Camel milk is good for my skin/teeth/hair/nails	Yes (270) 71%, No (7) 2%, I don't know (105) 27%
Camel milk is good for my digestive tract	Yes (324) 85%, No (6) 1%, I don't know (52) 14%
Camel milk contains natural ingredients.	Yes (344) 90%, I don't know (38) 10%
Camel milk is healthier than bovine milk.	Yes (289) 76%, No (5) 1%, I don't know (88) 23%
Camel milk is salty.	Yes (159) 42%, No (191) 50%, I don't know (32) 8
If you know the camel milk is healthier than bovine milk, would you drink it?	Yes (338) 89%, No (16) 4%, I don't know (28) 7%
Camel milk has longer shelf life than bovine milk	Yes (131) 34%, No (67) 18%, I don't know (184) 4
Camel milk is not expensive as compared to bovine milk	Yes (132) 35%, No (116) 30%, I don't know (134) 35%
Camel milk has good value for money	Yes (322) 84%, No (60) 16%
Camel milk is easily available in supermarkets	Yes (264) 69%, No (118) 31%
Camel milk smells nice	Yes (298) 78%, No (84) 22%
The appearance of camel milk is acceptable	Yes (369) 97%, No (13) 3%
Camel milk tastes good	Yes (346) 91%, No (36) 9%
Camel milk is available in different flavors	Yes (206) 54%, No (87) 23%, I don't know (89) 23

In the present survey, results showed that 31% of consumers have consumed camel milk less than once in a month while 26% consumers have consumed camel milk daily. Among the consumers, 25% have consumed camel milk 1-2 times per week. Only 18% have consumed camel milk 2-3 times per month (Table 3.4). The present survey showed that 243 consumers (64%) usually consumed camel milk while 139 consumers (36%) did not consume camel milk (Table 3.4). Among the consumers who participated in the survey, 256 (67%) consumed camel milk in their childhood while 126 consumers (33%) responded that they did not consume camel milk at childhood (Table 3.4).

3.2.3 Health and Nutrition

In the present survey, 332 consumers (87%) responded that camel milk is nutritious and it keeps the body healthy, while 48 consumers (13%) are not aware about nutritional effect of camel milk. Among the consumers, only two responded that camel milk is not healthy (Table 3.4). Results of the survey showed that 105 (27%) of participants are not aware about beneficial effects of camel milk while 2% of consumers responded that camel milk is not good for skin, teeth, hair and nails. 270 consumers (71%) responded that camel milk is good for skin, teeth, hair and nails (Table 3.4). Among the participated consumers, 324 (85%) responded that camel milk is good for digestive tract while only 6 consumers (1%) responded that camel milk is not good for digestive tract. 52 consumers (14%) were not aware about the effect of camel milk on digestive tract (Table 3.4).

In the survey, 344 consumers (90%) responded that camel milk contains natural ingredients while 38 consumers (10%) are not aware about the natural ingredients in camel milk (Table 3.4). Among the consumers, 289 (76%) responded that camel milk is healthier

than bovine milk while only 5 consumers (1%) responded that camel milk is not healthy. Survey results showed that 88 consumers (23%) have no opinion about the health benefits of camel milk (Table 3.4).

159 consumers (42%) responded that camel milk is salty while 191 consumers (45%) responded that camel milk is not and 32 consumers (8%) were not aware about the saltiness of camel milk (Table 3.4). Normally camel milk has a sweet and sharp taste but sometimes it is salty (Rao et al., 1970). Tuorila and Cardello (2002) found that unpleasant flavors reduced the acceptance and consumption of foods. Trace elements including sodium, potassium, calcium, magnesium, chlorine, and organic acids also contributes to the taste of milk (Gaucheron, 2005; Schiano et al., 2017).

Among the consumers, 338 (89%) responded to the question that they would like to drink camel milk than bovine milk while only 16 consumers (4%) responded that they are not willing to consume camel milk. 28 consumers (7%) were not familiar about the health benefits of camel milk and bovine milk (Table 3.4).

3.2.4 Convenience and Price

131 consumers (34%) responded that camel milk has longer shelf life than bovine milk while 67 consumers (18%) responded that camel milk has shorter shelf life. Survey results showed that 184 consumers (48%) are not aware about shelf life of camel milk (Table 3.4). Due to health reasons, many customers consume milk with reduced-fat and it has been reported that in every month, 2% milk with reduced fat has outpaced whole milk (El-Agamy, 2007). It was reported that pasteurized camel milk has longer shelf life than bovine milk and can be kept under refrigeration for at least 15 days (Wernery et al., 2007).

At 2°C, camel milk retains its quality for 12 days while bovine milk retains its properties for no more than two days. The presence of antimicrobial proteins such as lactoferrin, lysozyme, and immunoglobulin was considered responsible for the stability of camel milk (El-Agamy, 2007).

Reports have shown that camel milk powder is easy for storage and the shelf-life is around 12 months for whole camel milk powder and more than 2 years for skimmed milk powder (Konuspayeva et al., 2007; Laleye et al., 2008). Milk in powder form maintains sensory properties like aroma and flavour and is microbiologically stable. During the shelf-life of skimmed milk powder, physicochemical properties like oxidation of fat, Maillard reaction, lactose crystallization and particles caking may occur (Farah and Farah-Riesen, 1985). At 7°C, untreated camel milk shows a shelf life of 5 days while when heated at 65°C for 20 minutes and kept at 7°C, the shelf life of pasteurized milk is 22 days. In frozen condition, fresh camel milk can also be put in storage for 12 months (Mohan et al., 2020).

Among the consumers, only 132 (35%) responded that camel milk is more expensive than bovine milk while only 116 consumers (30%) responded that camel milk is not expensive and 134 consumers (35%) are not familiar about the price of camel milk and bovine milk (Table 3.4). Recent studies showed that spray dried camel milk powder is a high-quality product and less expensive than pure camel milk (Ho et al., 2019). The camel milk market is struggling to meet the increased requirement of consumers as their production and contribution to the public is less than the demand. Due to these reasons the price of camel milk is high and camel milk's is promoted as a novel health food having improved sale value.

Survey results showed that 264 (69%) consumers responded camel milk is easily available in the supermarkets in UAE while 118 consumers (31%) responded that camel milk is not easily available in supermarkets (Table 3.4). In the survey, 322 (84%) of consumers responded that camel milk has good value for money while 60 consumers (16%) responded that camel milk has less value for money (Table 3.4). In the pastoral areas, production and marketing of camel milk provides market oriented camel dairy developments, significant impact to individual livelihoods as well as to local and national economies (Gebremichael and Girmay, 2019).

3.2.5 Sensory Appeal

298 consumers (78%) responded that camel milk smells nice while 84 consumers (22%) responded that smell of camel milk is not nice (Table 3.4). Among the consumers, 369 (97%) responded that appearance of camel milk is acceptable while 13 consumers (3%) did not accept the appearance of camel milk (Table 3.4). Camel milk has dark white color with a sweet smell and a sharp taste (Zibaee, 2015). Results showed that 346 (91%) consumers responded that camel milk tastes good while 36 consumers (9%) responded that camel milk taste is not good (Table 3.4). Normally camel milk has a sweet and strident taste, but occasionally it is salty and watery and is frothy when shaken slightly (Farah, 1993). The changes in milk taste depends on availability of drinking water and the type of fodder of camels. Camel's milk is accepted worldwide, even though it is not the primary option for consumers due to its salty taste (Sisay and Awoke, 2015).

The present survey showed that 206 consumers (54%) are aware about the availability of camel milk in different flavors while 87 consumers, (23%) responded that camel milk is

not available in different flavors while 89 consumers (23%) were not aware about flavored camel milk (Table 3.4). Flavoured milk has a nutrient composition similar to that of plain milk and the density of nutrients in flavored milk reduces drawbacks of added sugar. The necessary nutrients of flavored milk, including protein, calcium, potassium, phosphorus, vitamin A, vitamin B12, iodine, and riboflavin are similar to that of plain milk (Nicklas et al., 2013).

Chapter 4: Summary and Conclusions

Milk and milk-derived products have been produced at different scales by dairy industry for many years. Recently there is a growing demand for camel milk and related products across the globe. Diversified products were marketed by camel milk processors and it is anticipated that there will be a steady growth of global camel milk market up to 8.01% reaching 8 billion USD during 2020– 2024. The health benefits of dairy products are broadly considered and frequently highlighted. As the recent development of new milk products became progressive, due to the prominence of nutritional components present in the milk, the dairy industry is moving towards introducing novel products from new sources than bovine. In this regard, camel is undoubtedly a good candidate.

Consumer awareness and responses are imperative, as majority of potential market is not familiar with camel milk. Opinions about specific characteristics of camel milk can encourage the willingness of consumers to purchase the product as according to Lancaster, demand of consumer is associated with the essential properties of goods. The preference of consumer towards a specific product is also related to the approach towards accessible substitutes and it is critical in understanding the acceptance of consumer for a particular kind of food (Mohan et al., 2020). Conducting awareness program is essential to encourage consumers to purchase products that they know less about. Thus, a consumer-oriented approach focussing on the health benefits of camel milk is important for consumer awareness and motivation. There are several methods such as advertising in the newspapers, televisions, radio, and internet to generate consumer knowledge about camel milk (Kadim et al., 2014).

The remarkable properties of camel milk encourage food scientists in the areas where there exist large camel populations to produce and process camel milk. In the present study among the milk samples, the flavored camel milk was accepted by panelists in terms of sensory properties and it could be used as a healthy and functional drink. Consumer survey results can help in establishing awareness among consumers about the health benefits and nutritional properties of camel milk. Based on these findings, there is a need to invest in the camel milk subsector by creating an enabling environment to enhance milk production and marketing. There are some limitations for this study in which majority of participants in the survey are from UAE. Future surveys need to focus on the expats in the country.

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United Arab Emirates University

UAE UNIVERSITY MASTER THESIS NO. 2022:2

Camel milk is used as an alternative to bovine milk and its products. It is necessary to understand the sensory qualities of camel milk mainly because of its unfamiliarity and its special sensory profile. This thesis evaluated the consumer acceptability and attitude and sensory characteristic for camel milk products (pasteurized milk, flavored pasteurized milk, and milk powders) that are currently commercially available in the UAE market.

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