بسم الله الرحمن الرحيم

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Production and evaluation of some quality attributes of goat milk ice cream

إنتاج وتقويم بعض خصائص جودة آيس كريم لبن الماعز

A Dissertation Submitted to Sudan University of Sciences and Technology in Partial Fulfillment for the Requirements of Master Degree in Food Sciences and Technology

By

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Dedication

To my Family,

To my Teachers,

To my Friends,

Acknowledgment

Special praise and thanks to Almighty ALLAH who has led me thus far in my educational career, and for innumerable bounties.

I deeply thank and appreciate my supervisor **Prof. Dr. Yousif Mohamed Ahmed** for his continuous assistance, valuable advices, patience and encouragement throughout the duration of this study.

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Abstract

This study was carried out to investigate the possibility of manufacturing ice cream from goat milk and to evaluate the sensory properties of this product and compare it with the ice cream produced from cow milk. Approximate chemical composition was determinated for cow‘s and goat‘s milk. Ice cream was produced from each of cow and goat milk using milk, cream, starch, sugar, ice cream powder (as stabilizer and emulsifier) and flavor (strawberry) as ingredients. The ice cream was analyzed for the estimation of each protein, moisture content, fat, acidity, pH, ash, TSS and TSNF. Organoleptic properties of cow and goat milk ice cream that (colour, flavour, texture and taste) were evaluated. The cow‘s milk has moisture content, protein, fat, Acidity, pH, lactose, ash, TSS and TSNF of: 87.65%- 3.20%- 3.20%- 0.17%- 6.45- 5.15%- 0.77%-12.35% and 9.15%, respectively. While for goat milk were: 87.90%- 3.55%- 3.50%- 0.18%- 6.25- 4.25%- 0.79%- 12.10% and 8.60%, respectively. The results obtained for cow milk ice cream, were: 4.55%- 60.65%- 10.85%- 0.18%- 6.40- 1.25%- 39.95% and 28.50%, respectively, and for goat milk ice cream, were: 4.90%- 62.10%- 11.30%- 0.20%- 6.15- 1.55%- 37.90% and 26.60%, respectively. Sensory evaluation showed that goat ice cream has better colour and texture where as cow ice cream has better flavour and taste. Therefore, goat milk ice cream can be produced with high nutritive value and good quality attributes similar to ice cream made from cow’s milk.

ملخص البحث

أجريت هذه الدراسة للتحقق من إمكانية تصنيع آيس كريم من لبن الماعز وتقييم الخواص الحسية لهذا المنتج ومقارنته مع الآيس كريم المنتج من لبن البقر.أجري تحليل تقريبي لعينات اللبن كما تم تصنيع آيس كريم من كل من لبن البقر ولبن الماعز بإستخدام {لبن ، كريمة، نشا، سكر، بدرة آيس كريم (كمثبت ومستحلب) ونكهة (فراولة)} كمكونات. كذلك تم إجراء تحليل تقريبي للايس كريم المنتج. ومن ثم تم تقدير الخواص الحسية للايس كريم من حيث (اللون، النكهة، الطعم، الدوام والملمس) وكانت النتائج من حيث (الرطوبة، البروتين، الدهن،الحموضة، الرقم الهيدروجيني، اللاكتوز، الرماد، الجوامد الصلبة الكلية والجوامد الصلبة غير الدهنية) في لبن البقر كما يلي: 87.65% ، 3.20% ، 3.20% ، 0.17% ، 6.45 ، 5.15% ، 0.77% ، 12.35% و 9.15% على التوالي. أما في لبن الماعز فكانت النتائج كالأتي:87.90%، 3.55%، 3.50%، 0.18%، 6.25، 4.25%، 0.79%، 12.10% و 8.60% على التوالي.أما نتائج تحليل الأيس كريم في لبن البقر كانت: 4.55%، 60.65%، 10.85%، 0.18%، 6.40، 1.25%، 39.95% و 28.50% على التوالي، وفي لبن الماعز كانت: 4.90%، 62.10%، 11.30%، 0.20%، 6.15، 1.55%، 37.90% و 26.60% على التوالي. التقييم الحسي أظهر أن الآيس كريم المنتج من لبن الماعز هو الأفضل من حيث اللون والقوائم والملمس اما من حيث النكهة والطعام فالايس كريم من لبن البقر كان الأفضل. لذلك يمكن إنتاج آيس كريم من لبن الماعز ذو قيمة غذائية عالية وصفات جودة جيدة مماثلة للايس كريم المصنع من لبن البقر.

CHAPTER ONE

INTRODUCTION

Billions of people around the world consume milk and dairy products every day. However, consumers, industry and governments need up-to-date information on how milk and dairy products can contribute to human nutrition and how dairying and dairy-industry development can best contribute to increasing food security and alleviating poverty (Muehlhoff *et al*., 2013).

Domestication of animals for livestock has played a key role in the development of human civilizations. The cow has now become the main dairy animal associated with milk, with the term "milk" being almost synonymous with cow milk in most people's minds. Milk contains numerous nutrients and it makes a significant contribution to meeting the body's needs for calcium, magnesium, selenium, riboflavin, vitamin B12 and pantothenic acid (vitamin B5) (Muehlhoff*et al*., 2013).

The milk of different species, either directly or as dairy products, comprises a food of outstanding importance for humans throughout their lives. Milk can be considered a source of macro- and micronutrients, and also contains a number of active compounds that play a significant role in both nutrition and health protection (Boza and Sanz 1997).

Today, goat milk is of particular interest due to its specific composition, which has led to it being considered a high-quality raw material for manufacturing food for infants and the elderly, as well as for certain sectors of the population with particular needs (Ceballos *et al*., 2008).

Ice-cream is a frozen dairy product. It is sold in soft or hard status. The production of ice-cream includes eight steps. Pasteurization, freezing and hardening are the main steps to eliminate the microbiological hazards (Kambamanoli-Dimou, 2000).

The ice cream production has increased rapidly in recent years in many countries of the world. The ingredients and processing steps required to produce good ice cream are well known and are employed worldwide. The trend towards natural products with emphasis on quality has in general led to an increase in the development of new products. Ice cream can be considered as an aerated suspension of crystalized fat and waterin a highly concentrated sugar solution containing hydrocolloids, caseinmicelles and proteins (Temizand YeşilSu, 2010).

The nutritive value of ice cream varies with its composition; however, all the constituents of milk are present in a concentrated form. To ice cream may be added such materials as eggs, gelatin, fruits, nuts, chocolate and bakery products, all of which add to its nutritive value (Prasetya*et al.*, 2011).

The energy value and nutrients of ice cream depend upon the food value of the ingredients from which it is made (Marshall*et al*., 2003).

Goat milk has played a very important role in health and nutrition of young and elderly. Goat milk has also been known for its beneficial and therapeutic effects on the people who have cow milk allergy. These nutritional, health and therapeutic benefits enlighten the potentials and values of goat milk and its specialty products. The chemical characteristics of goat milk can be used to manufacture a wide variety of products, including fluid beverage products (low fat, fortified, or flavoured) and UHT (Ultra high temperature) milk, fermented products such as cheese, buttermilk or yogurt, frozen products such as ice cream or frozen yogurt, butter, condensed/dried products, sweets and candies. In addition, other specialty products such as hair, skin care and cosmetic products made from goat milk recently have gained further attention. Nevertheless, high quality products can only be produced from good quality goat milk. The quality of milk should have the potential to tolerate technological treatment and be transformed into a product that satisfies the expectations of consumers, in terms of nutritional, hygienic and sensory attributes. Taste is the main criteria used by consumers to make decisions to purchase and consume goat milk and its products. Typical goat taste is considered as a quality component in certain goat cheese products. Farmers can produce more value-added products for the economic sustainability of their business and the dairy goat industry in general (Ribeiro and Ribeiro, 2010).

Objectives

The main objective of this study was to use of goat milk in the food industry.

Specific objective

1. To determine the composition of goat milk and some of its properties.
2. To produce an ice cream from goat milk and determine its physico-chemical properties.
3. To evaluate the organoleptic characteristics of the formulated ice cream product.

CHAPTER TWO

LITERATURE REVIEW

2.1 Milk

In the diet of every nation, milk is an indispensable food item and is considered as nature's perfect food for human beings as well as other animals. Mammals secrete milk for the nourishment of their young ones and milk of animals like cattle, buffalo, goat, sheep, camel, yak, llama, mithun, mare etc. are being used as food for human beings (Kutty, 2004).

Milk is considered as a nearly complete food since it is a good source for protein, fat and major minerals. Also, milk and milk products are main constituents of the daily diet, especially for vulnerable groups such as infants, school age children and old age (Gasmalla*et al.,* 2013).

2.1.1 Milk definition

Milk is legally defined as the normal secretions of the mammary gland of mammals. It is a white liquid but it can be slightly yellowish, especially during the summer when the cows are out in the meadow. It is supposed to have atypical clean smell and its consistency is homogeneous (Dhuol and Osman, 2014).

Walstra*et al.,* (2006) reported that, milk is normal, clean and fresh secretions, without any addition or subtraction, extracted from the udder of a healthy cow, and free from colostrum's which is produced during the first seven days after calving.

2.1.2 Milk production

World milk production in 2014 is forecast to grow by 2.4 percent to 792 million tons. While Asiais expected to account for most of the increase, production should rise in all regions.

In Africa, a moderate increase in milk production is anticipated for 2014, assisted by generally favourable weather conditions.

In CentralAmerica, milk output in Mexico, the largest producer in the sub region, could recover following prolonged dry weather which constrained growth in 2013. Production in Costa Rica is expected to show a moderate increase. In NorthAmerica, output in the United States is recovering from the chronically dry conditions of the previous two years and is forecast to increase by 3 percent to 93.9 million tons. Production in Canada is set to remain stable at 8.3 million tons, within the limits set by the milk quota system (FAO, 2014).

Table1: World milk production (thousand tons)

Region	**2010-2012**	**2013**	**2014**
Africa	45 108	47 021	47 293
Americas	178922	184222	188614
Asia	276 764	297 095	305 684
Europe	215 153	216 202	219 933
Oceania	27 590	28 850	30 520
Total	**743537**	**773390**	**792044**

Source: FAOSTAT. (FAO., 2014).

2.1.3 Milk composition

The composition varies among animal species and breeds within the same species, and also from one dairy to the other, depending on the period of lactation and diet (Mourad*et al*., 2014).

The composition of milk is not constant, but shows a wide variation. In the first place the composition depends on the species of animal. But also within a species, big differences between the breeds and between individual animals within a breed. The composition might even change from day to day, depending on feeding and climate. But also during one milking the first milk differs from the last milk drops (Pandy and Voskuil, 2011).

Table2: Composition of milk from different animals

	Cow milk	**Goats milk**	**Sheep milk**
Water	87.2%	85.8%	81.1%
Total solid	12.8%	14.2%	18.4%
Fat	04.0%	04.9%	06.5%
Protein	03.4%	04.3%	06.7%
Lactose	04.5%	04.3%	04.1%
Ash (minerals)	00.9%	00.9%	00.9%

(Pandy and Voskuil, 2011).

2.1.3.1 Water

It exists in continuous phase in which other milk constituents are either dissolved or suspended. Most of the water in milk is found in free form and only a very small portion is in bound form (bound by milk protein, phospholipids) (Kutty, 2004).

2.1.3.2 Milk protein content

Proteins are complex organic compounds. The basic structure of protein is a chain of amino acids. The milk protein has a high biological value, and milk is therefore a good source for essential amino acids. Milk contains a wide array of proteins with biological activities ranging from antimicrobial ones to those facilitating absorption of nutrients, as well as acting as growth factors, hormones, enzymes, antibodies and immune stimulants. The nitrogen in milk is distributed among caseins, whey proteins and non-protein nitrogen (Haug*et al.,* 2007).

2.1.3.2.1 Casein

Casein is the major component of protein found in milk accounting for nearly 70-80% of its total protein and is responsible for the white color of milk. It is the most commonly used milk protein in the industry today. Milk proteins are of significant physiological importance to the body for functions relating to the uptake of nutrients and vitamins and they are a source of biologically active peptides. Similar to whey, casein is a complete protein and also contains the minerals calcium and phosphorous (Deutz*et al*.,1998).

Casein exists in milk in the form of a micelle, which is a large colloidal particle. An attractive property of the casein micelle is its ability to form a gel or clot in the stomach. The ability to form this clot makes it very efficient in nutrient supply. The clot is able to provide a sustained slow release of amino acids into the blood stream, sometimes lasting for several hours. This provides better nitrogen retention and utilization by the body (Walter, 2012).

2.1.3.2.2 Whey protein

Whey protein is one of the two major protein groups of bovine milk, accounting for 20% of the milk while casein accounts for the remainder. All of the constituents of whey protein provide high levels of the essential and branched chain amino acids. The bioactivities of these proteins possess many beneficial properties as well. Additionally, whey is also rich in vitamins and minerals (Hoffman and Falvo, 2004).

Whey protein is more soluble than casein and also has a higher quality rating. It is often referred to as the "Gold Standard" of protein as it is the most nutritious protein available (Zieve, 2009).

2.1.3.3 Milk lactose content

Lactose is the major carbohydrate of milk. This sugar has been found in the milk of nearly all mammals and is unique to milk. Both glucose and galactose are abundant in the mammalian metabolism; lactose is only synthesized in the Golgi vesicles of the lactating cells. This occurs due to the presence of α-lactalbumin, a protein unique to milk. This protein modifies the action of the common enzyme galactosyl-transferase to catalyze the formation of lactose from uridine-diphosphate-galactose and glucose (Walstra*et al*.,2006).

Lactose can be separated from milk or, in industrial practice, from whey, by letting it crystallize. Crystalline lactose is produced in large amounts, and it is mainly used in foods and in pharmaceuticals (Walstra*et al*., 2006).

It is the sugar seen only in milk and hence called as milk sugar. In milk lactose exists in true solution. Chemically lactose is composed of one molecule each of glucose and galactose. Souring of milk is due to the production of lactic acid from lactose by lactose fermenting bacteria and it is important in the preparation of fermented milk products (Kutty, 2004).

2.1.3.4 Milk lipids content

Lipids are esters of fatty acids and related components that are soluble in nonpolar organic solvents and insoluble, or nearly so, in water. Alternatively, the term *fat* is used. But fat is usually considered to consist largely of a mixture of triglycerides, especially when the mixture is partly solid at room temperature (Walstra*et al*., 2006). Nearly all of the fat in milk is in fat globules. It can therefore be concentrated readily by means of gravity creaming, possibly followed by churning. Products rich in fat, such as cream and butter, have a specific and often desired flavor and texture. On the other hand, milk fat is prone to deterioration, leading to serious off-flavors. The consistency of high-fat products greatly depends on the crystallization of the fat. In turn, crystallization behavior of milk fat depends on variation in fat composition and on processing and storage conditions (Walstra*et al*., 2006).

Jahn and Jahn (2010) reported that, milk fat constitutes up to 30% of the milk dry weight, carries 50% of the energy and contains essential water –insoluble vitamins. It is solubilized in the milk in complex fat globules. The majority of milk fat consists of fatty acids esterified to triglycerides.

2.1.3.4.1Constituent fatty acids

The fatty acid pattern is an important factor in determining lipid properties, such as melting range, chemical reactivity, and nutritional value (Walstra*et al.*, 2006)

Fatty acids in goat milk are synthesized in epithelial cells of the mammary gland they are passing over from the blood. Two coenzymes have a major role in the synthesis of fatty acids in goat milk: acetyl-coenzyme A-carboxylase, which participates in the synthesis of fatty acids de novo and fatty acid synthase, which is a complex of enzymatic active substances and is responsible for the extension (elongation) of the fatty acid chain (Chilliard *et al.*, 2003). Fatty acids of exogenous origin are presented via the circulation to mammary epithelial cells either in the form of non-esterified fatty acids or esterified as the acyl groups of the triacylglycerol component of lipoprotein particles. In the mammary gland of ruminant animals, short and medium chain saturated fatty acids are the major products of de novo lipogenesis whereas plasma lipids contribute longer chain and mono unsaturated species. The acetate is the precursor of fatty acids synthesis in ruminants, while in monogastric animals, the precursor is glucose (Clegg*et al.*, 2001).

2.1.3.5 Milk minerals content

Milk contains many minerals. Eckles and Macy (2002) reported that the ash of milk contains potassium, sodium, calcium, magnesium, chlorine, phosphorus, and sulfur in relatively large amounts. Beside other small amount of iron, copper, zinc, aluminum, manganese, cobalt and traces of silicon, boron, titanium, lithium.

Milk ash occurs in milk as mineral salts including Ca, K, Mg, Fe, Ci,Cu and traces of other minerals in the form of citrate, phosphate or oxides are important to influencing the behavior of milk. Milk minerals are of considerable importance nutrients (Arbuckle, 1966).

2.1.3.6 Milk vitamins content

All known vitamins are present in milk, milk is a good source for most vitamins, especially vitamin A and most B vitamins. It is not a good source of vitamins C and E, but these are readily acquired from other foods in most diets. Vitamin-D content is also not high, but a very limited exposure of the skin to sunlight leads to sufficient synthesis by the organism, including man. The contents of some vitamins are reduced by processing or storage (Walstra*et al*., 2006).

Milk is also an important source of vitamin K and dietary water soluble vitamins: B1- thiamine, B2- riboflavin, B6- pyridoxine, B12- cyanocobalamin, niacin and pantothenic acid. There is also a small amount of vitamin C (ascorbic acid) present in raw milk but it is an insignificant amount relative to human needs and is quite heat- labile: about 20% is destroyed by pasteurization. (Goff, 2011)

2.1.3.7 Milk salts content

Milk contains inorganic and organic salts. The concept of ‘salts’ thus is not equivalent to ‘mineral substances.’ Salts are by no means equivalent to ‘ash’ because ashing of milk causes loss of organic acids including citrate and acetate and because organic phosphorus and sulfur are transferred to inorganic salts during ashing (Walstra*et al*., 2006).

2.1.4 Physicochemical properties of milk

The physical state

In milk, lactose and portion of mineral salts are found in true solution, protein and most of minerals in colloidal suspension and fat as emulsion. Water is the continuous phase in which the above constituents are either dissolved or suspended (Kutty, 2004).

2.1.4.1 pH

The pH of normal milk from a healthy animal milks is in the range 6.6–6.7. Milk pH is affected by temperature, generally decreasing with increasing temperature, due to changes in dissociation of ionisable groups (Tamime, 2009).

2.1.4.2 Titrable acidity

According to Harding (1999) the natural acidity of normal milk is less than 0.16% lactic acid or equivalent.

Elmagli and Elzubeir (2006) found that the mean titrable acidity of pasteurized milk was 0.14 to 0.18 %.

2.1.4.3 Taste and odor of milk

Normal freshly drawn milk tastes slightly sweet to most people and has a characteristic, although, not pronounced odor. The odor disappears when milk is allowed to stand a few hours or following cooling and aeration where this practice is followed immediately after milking. It has been shown that the pleasing flavor of milk may be correlated with high lactose and relatively low chloride content (Eckles and Macy, 2002).

2.1.4.4 Boiling point of milk

It is slightly higher than that of water and is a round 100.17°C or 212.3F (Kutty, 2004).

A solution boils at a higher temperature than does the pure solvent, according to the concentration of the dissolved substance. The boiling point of milk is 100.17°C. The milk constituents in true solution are mainly responsible for the elevation of the boiling point above 100°C. Elevation of the boiling point is based on the same principles as depression of freezing point. However, for detecting added water, the freezing point method is far superior on the grounds of accuracy and convenience (Singh*et al*., 1997).

2.1.4.5 Colour

Milk ranges in colour from bluish-white to golden-yellow, depending upon the breed of animal, the kind of feed, and the amount of fat and solids present. In large quantities milk appears entirely opaque while in thin layers it is slightly transparent (Eckles and Macy, 2002).

2.1.5 Nutritional value of milk

Milk is very tasteful and is an excellent source of high quality protein that can be digested easily. Milk also contains lots of important vitamins and minerals. In many countries milk and milk products provide 5 – 10% of the total calories of the daily human diet. It represents one of the best natural sources of essential amino acids for human nutrition. Moreover, milk is an outstanding source of calcium and a good source of phosphorus. As these 2 elements play an essential role in building the bones and teeth in the body, it is clear that milk should be included in the diet of humans in all their stages of life. In fact milk is the most important source of calcium in the diet of almost all people. These nutritional attributes have made milk a mainstay in the diet, particularly of growing children. The nutritional as well as the economic value of milk is directly associated with its solid contents. The higher the solids content thebetter its nutritional value and the more of a milk product can be madeout of it. For example, cheese yields are directly related to the protein and in particular to the casein content of milk (Pandy and Voskuil, 2011).

Milk and dairy foods can increase the nutrient density of the diet and play a vital role in ensuring that dietary intake is nutritionally adequate. They can also help to improve bone and dental health and possibly protect against hypertension, reduce the risk of osteoporosis and colon cancer (Anita, 2001).

2.2 Goat's milk

The goat was probably the first ruminant that was domesticated. Goats originate from Asia and are now spread almost all over the globe. Goats are very hardy animals they thrive in areas where it may be difficult for other animals. Unlike sheep, goats are not flock animals. There are numerous breeds of goat, but no specialized dairy breed. However, Saanen, Alpine, Toggenburg and Chamois breeds have been very successfully selected and bred for increased milk yields. Because of this, they have been exported all over the world for purpose of being crossed with local breeds. Cashmere and Angora are breeds known for the special wool they produce. (Brito*et al*., 2011)

Saanen, originally from Switzerland, where they were bred for odor-free milk, are totally white. Like other Swiss breeds, they may or may not have horns. They are usually short haired. Saanen goats are used around the world as leading milk producers (Brito*et al.*,2011).

Steele (1996) reported the milk yields of 2-4 liter's/day are common with a butter fat content of 4 and average litters of 1.76 are recorded. Mahmoud*et al.*,(2012) concluded that Damascus goats can thrive with suitable milk production efficiency in Sudan.

2.2.1 Nutritive value of goat's milk

Goat milk greatly improves the diet of many rural families. It is traditionally valued for the elderly, the sick, babies, and children who are allergic to cow milk. Goat milk is a nutrient rich food with unique traits. Among its nutritionaland therapeutic properties, goat milk contains high quality proteins and a great content of minerals and vitamins, in addition to better digestibility of lipid fraction and the lower allergenicity of protein fraction, when compared to cow milk. (Brito*et al.*, 2011)

2.2.2 Composition of goat's milk

2.2.2.1 Proteins in goat milk

Cow and goat milks do not differ significantly as far as the protein percentage is concerned and, in contrast to milk fat, the protein content in both species is less amenable to dietary manipulation.However, casein micelles in cow milk are small (60–80nm) when compared to goat milk casein micelles, which range between 100 and 200nm. Another key difference between species is the level of α_{s1}-casein. The level of α_{s1}-casein in goat milk ranges from 0 to 7g/L. This variability is associated with polymorphisms within the alpha αs_1-casein gene, which are very common in goats (Martin*et al.*, 2002).

2.2.2.2 Fats in goat milk

Milk fat affects nutritional value and physical and sensory characteristics, that all in turn affect product quality and acceptability.Lipid composition of goat milk includes simple and complex lipids (mono-, di, tri-acylglycerols, cholesterols, phospholipids and sterols) (Park*et al.*, 2007).

The percentage of total fat in goat and cow milk is quite similar, and the fatty acid composition depends to a large extent on the diet composition in both species. Two characteristics of goat milk fat have important consequences for manufacturing. One is the smaller size of the fat globules in goat milk in comparison to those in cow milk. In both species the fat globules range from 1 to 10m, but the number of fat globules smaller than 5m is ~60% in cow milk whereas it is ~80% in goat milk. Second it contains a higher proportion of medium-chain fatty acids, i.e., caproic(C6:0), caprylic(C8:0) and capric(C10:0), which are partly responsible for the characteristic “goaty” odour of goat milk (Silanikove*et al.,* 2010).

2.2.2.3 Carbohydrates in goat milk

As in cows, lactose constitutes the main carbohydrate in goat milk. Goat milk does contain less lactose than cow milk (on average, 4.1% vs. 4.7%), but cannot be regarded as a dietary solution to people suffering from lactose intolerance (Silanikove*et al*., 2010).

2.2.2.4 Minerals and vitamins

The mineral content of goat milk varies from 0.70 to 0.85%. Compared to human and cow milk, goat milk contains more calcium, phosphorous and potassium. The vitamin content of goat milk is similar to that of cow and human milk (Silanikove*et al*., 2010).

2.2.3 The characteristics of goat’s milk

2.2.3.1 Goat’s milk for lactose intolerant

Approximately 65-75% of people worldwide have decreased intestinal lactase levels, which may lead to lactose intolerance and difficulty in digesting dairy products. Goat milk and goat milk products can be tolerated by most of those who are lactose intolerant. Because unpasteurized goat milk is digested very rapidly, lactose (the main sugar found in milk), does not remain for long periods of time in the intestines, where it can ferment or cause an osmotic imbalance, followed by digestive upset. Additionally, goat milk contains 7% less lactose than cow milk (Attaie, 2000).

2.2.3.2 Goat’s milk soothes the digestive:

Goat milk has more buffering capacity than over-the-counter antacids. Goat milk has long been used and recommended as a supplement to reduce indigestion, and to help soothe irritated areas in the stomach or intestines (Park, 1991).

2.2.3.3 Goat’s milk is an alkalinizer of the system:

Goat milk is a rare dairy food in that it has an alkaline ash. This means that it does not produce acid in the intestinal system. Acidic blood and intestinal pH levels have been associated by researchers with fatigue, headaches, muscle aches and pains, sore pressure points, excess weight, blood sugar imbalances, and excessive yeast populations. Goat milk helps to increase the pH of the blood stream because it is the highest dairy product in the amino acid L-glutamine. L-glutamine is an alkalizing amino acid, often recommended by nutritionists (Mehaia, 1989).

2.2.3.4 Goat’s milk is non-allergenic:

Goat milk does not contain the complex of proteins that are the main stimulants of allergic reactions to cow dairy products. Therefore, it does not stress/depress the immune system. Seven percent (7%) of U.S. children show symptoms of cow-milk allergy such as wheezing, congestion, frequent ear infections, eczema, skin rashes and digestive troubles. In the vast majority of cases, these problems are eliminated when goat milk is substituted for cow's milk (Bishop, 1990).

2.3 Ice cream

Ice cream is an enormously popular food. The term ‘ice cream’ in its broadest sense covers a wide range of different types of frozen desserts (Clark, 2004).

Ice cream is a frozen product containing 10% milk fat, 20% total milk solids, permitted sweeteners, stabilizers, flavours and derived ingredients.Milk, either from cows or goats, is the source of dairy ingredients in ice cream which is composed of water, milk fat and non- fat solids contribute signicantly to the flavour of ice cream. Milk fat is more important than non- fat solids because it provides the rich, full and creamy flavour that ice cream requires. Non- fat solids, on the other hand, have indirect effects on flavour. The protein helps give body and a smooth texture to the ice cream. Lactose displaces water and adds to the sweetness produced largely by added sugars. The mineral salts carry a slightly salty flavour that rounds off the finished flavour of ice cream (Mohd*et al*., 1999).

2.3.1 History of ice cream

Goff (2006) reported that, were popular legends surrounding the discovery of ice. Saltpeter (potassium nitrate) was used for the production of gun powder in China and Chinese found out that by putting saltpeter in water it can absorb lots of heat thus it can create ice in summer. Then some Chinese put sugar in this ice and sell them in summer as food. Macro polo supposedly saw ice cream being on his trip to China, bringing the recipe home to Italy with him when his return from there, Catherine Indian chief are said to have carried the recipe to France when she went there. Ice cream most likely did originate in China, but is unknown how and when the idea found its way in to the western world.

2.3.2 Definition of ice cream

Ice cream is a frozen foam that consists of air cells dispersed in an aqueous matrix (Marshall*et al*., 2003).

The legal definition of ice cream varies from country to country. In the UK ice cream is defined as a frozen food product containing a minimum of 5% fat and

7.5% milk solids other than fat (i.e. protein, sugar and minerals), which is obtained by heat – treating and subsequently freezing an emulsion of fat, milk solids and sugar (or sweetener), with or without other substances. Dairy ice cream most in addition contain no fat other than milk fat, with exception of fat that is present in other ingredients, for example egg, flavouring or emulsifier (Clark, 2004).

Ice cream is a complex colloidal system comprising ice crystals, air bubbles, partially coalesced or aggregated fat globules and a cryo-concentrated aqueous phase (Goff, 2002).

The formation and the stabilization of the different microstructures involve all of the ice cream ingredients. Partitioning of the molecules, i.e., the proteins, the low molecular weight emulsifiers and the fat (free or partially-coalesced), occurs between the different interfaces and the cryo-concentrated phase. At a molecular level, interactions between protein and emulsifier at the fat globule interface, and between protein and fat at the air interface, may take place (Clark, 2004).

2.3.3 Nutritive value of ice cream

The nutritive value of ice cream varies with its composition; however, all the constituents of milk are present in a concentrated form. To ice cream may be added such materials as eggs, gelatin, fruits, nuts, chocolate and bakery products, all of which add to its nutritive value. The energy value and nutrients of ice cream depend upon the food value of the ingredients from which it is made. The milk products that go into the mix contain the constituents of milk, but in different amounts, on a weight basis ice cream contains three to four times as much fat, and about 12-16% more protein than does milk. In addition, may contain other food products, such as fruit, nuts, egg, candies and sugar, and these may enhance its nutritive value. Ice cream contains about four times as much carbohydrate as milk. Ice cream is an excellent source of food energy. The fact that the constituents of ice cream are almost completely assimilated makes ice cream an especially desirable food for growing children and for presons who need to put on weight (Marshall*et al*., 2003).

2.3.4 Ingredients of ice cream

The ingredients of ice cream products can be classified in three groups:

- Major ingredients, present in substantial quantities (at least a few % by weight), such as milk protein, sugar, fat and water.
- Minor ingredients, present in small quantities (less than about 1% by weight), such as emulsifiers, stabilizers, colours and flavours.
- Components such as chocolate, biscuits, wafers, fruit pieces and nuts that are combined with ice cream to make products.

Most ice creams also contain a significant proportion (by volume) of air, although this is not usually thought of as an ingredient (Clark, 2004).

2.3.4.1 Milk fat

Ice cream typically has a fat content of 8-10% by weight, though in premium ice creams it can be as high as 15-20%. Fat performs several functions in ice cream: it helps to stabilize the foam, it is largely responsible for the creamy texture, it slows down the rate at which ice cream melts and it is necessary to deliver flavour molecules that are soluble in fat but not water.

The major sources of fat used in industrial ice cream production are butter fat, cream and vegetable fat (Clark, 2004).

Bolliger *et al*, (2000) reported that fat contributes greatly to the structure of ice cream during freezing and whipping by forming a partially coalesced three dimensional network of homogenized globules that, along with air bubbles and ice crystals, is responsible for stiffness and dryness in the extruded product, as well as melt resistance and smoother texture in the frozen product.

The fat component of frozen dairy dessert mixes increases the richness of flavor, is a good carrier and synergist for add flavor compounds, produces a characteristic smooth texture by lubricating the palate, help to give structure through the process of partial coalescence and foam stabilization (Goff. 2006).

2.3.4.2 Milk solid not fat (MSNF)

The MSNF contains the lactose, casein micelles, whey proteins, minerals (ash), vitamins, acids, enzymes and gases of the milk or milk products from which they were derived. Proteins contribute mush to the development of structure in ice cream, including emulsification, whipping and water-holding capacity.

Emulsification properties of proteins in the mix arise from their adsorption to fat globules at the time of homogenization. Whipping properties of proteins in ice cream contribute to the formation of the initial air bubbles in the mix. The water-holding capacity of proteins leads to enhanced viscosity in the mix, which imparts a beneficial body to the ice cream, increases it's melting time and contributes to reduced iciness (Goff, 2006).

2.3.4.3 Milk protein

The two major functions of milk protein are the stabilization of water-continuous emulsion and foams, as well as the contribution to the unique flavor of ice cream. The sources of milk protein are milk, skimmed milk powder, whey powders and buttermilk. Caseins are surface active colloidal proteins that contain both hydrophilic and hydrophobic ends, allowing them to form micelles. Whey proteins are globular and also surface-active. They are around 3-6 nm while caseins are approximately 100 nm. They have a critical function in stabilizing and forming air pockets in ice cream (Clark, 2004).

2.3.4.4 Sweeteners

Goff (2006)mentioned that the sweeteners improve the texture and palatability of the ice cream and enhance flavors. Their ability to lower the freezing point of a solution imparts a measure of control over the temperature hardness relationship. In determining the proper blend of sweeteners for an ice cream mix, the total solids required from the sweeteners, the sweetness factor of each sugar and the combined freezing point depression of all sugars in solution (including lactose from the MSNF component) must be calculated to achieve the proper solids content, the appropriate sweetness level and a satisfactory degree of hardness. The most common sweetening agent used is sucrose. However, it has become common practice in the industry to substitute sweeteners derived from starch hydrolysate syrup (glucose syrup) for all or a portion of the sucrose. The use of starch hydrolysis products in ice cream is generally perceived to provide greater smoothness by contributing to a firmer and chewier body, to provide better meltdown characteristics, to bring out and accentuate fruit flavors, to reduce heat shock potential, which improves the shelf-life of the finished product, and to provide an economical source of solids.

Sugar is added to adjust the solids content in the ice cream and to give it sweetness according to consumer preference as well lowering the freezing point of the ice cream mix and having an effect on the texture and sensorial characteristics (Kilara and Chandan, 2006).

2.3.4.5 Stabilizers

The basic role of a stabilizer is to reduce the amount of free water in the ice cream mix by binding it as “water of hydration”, or by immobilizing it within a gel structure. Also it is the ability of small percentage of stabilizer to absorb and hold large amounts of bound water, which produces good body, smooth texture, slow melt down and heat shock in the resultant product (Naresh and Shailaja, 2006).

Ice cream stabilizers are a group of ingredients (usually polysaccharides such as guar, locust bean gum, carboxymethylcellulose and xanthan) commonly used in ice cream formulations. The primary purposes for using stabilizers in ice cream are to produce smoothness in body and texture, retard or reduce ice and lactose crystal growth during storage (or mask the effects of crystal growth), especially during periods of temperature fluctuation, known as heat shock, and to provide uniformity to the product and resistance to melting. The mechanism of action of stabilizers in enhancing frozen stability is primarily related to their effect on the ice and unfrozen serum phases. Stabilized ice cream has been observed by microscopy techniques to have smaller ice crystals than unstabilized ice cream after storage at fluctuating temperatures(Goff, 2011).

2.3.4.6 Emulsifiers

In addition to the milk proteins, ice cream also contains other surface active molecules, namely emulsifiers, such as mono- and diglycerides or lecithin (from egg yolk). Despite their name emulsifiers, are actually used in ice cream to de-emulsify some of the fat (Clark, 2004).

Emulsifiers are sometimes integrated with the stabilizers in proprietary blends but their function and action are very different from the stabilizers. They are used to improve whipping quality of the mix;produce a drier ice cream to facilitate moulding,fancy extrusion and sandwich manufacture; provide smoother body and texture in finished product; and produce a product with good stand-up properties and melt resistance.Emulsifiers used in ice cream manufacture today are of two main types: the mono- and diglycerides and the Sorbian esters, such as polysorbate 80, although eggs also provide similar emulsifying properties. Their mode of action is related to their activity at the air-serum and fat-serum interfaces. At the fat- serum interface, they displace proteins from the surface of the fat globules, rendering them more susceptible to partial coalescence and structure formation during the freezing and whipping process (Goff, 2011).

2.3.4.7 Flavouring and coloring materials

2.3.4.7.1 Flavouring:

Ice cream may be flavoured by artificial or natural flavouring (Berger, 2007).

The flavours used in ice cream manufacture are usually supplied as solutions of aroma and taste compound. Some flavour molecules are fat soluble, whereas others are water soluble. This affects the perception of flavour in ice cream. Flavours may be natural, i.e. extracted from sources such as plants, or synthetic. The latter can be nature identical (artificially produced but identical to the naturally occurring form) or artificial (artificially produced and not occurring in nature). They are used to impart flavour to products, to enhance inherent flavours and to ensure uniformity of flavour between batches. The three most important ice cream flavours are vanilla, chocolate and strawberry (Clark, 2004).

2.3.4.7.2 Colours:

The colour of ice cream has a significant influence on the consumer's perception of its flavour and quality. Colours are added to ice cream for several reasons:

To give colour to products that would otherwise be virtually colourless(*e.g.* water ice products).

- To reinforce colours already present, *e.g.* from fruit.
- To ensure uniformity of colour between different batches.

Natural colours extracted from plants have been used as colouring agents for foodstuffs for many years. Synthetic colours based on petrochemical products were developed in the 20th century.

Natural colours have a healthy image and good solubility, but may be expensive (partly because they need to be used in high concentrations) and can suffer from poor stability to heat and light. Artificial colours, such as azo dyes, attract adverse publicity in some countries, whereas in others they are considered acceptable. (Both natural and artificial colours have E numbers.) Commonly used natural colours include anthocyanins (E163) which are red-purple and come from black grapes, elderberries, red cabbages and hibiscus; chlorophylls and chlorophyllins (E 140), which are green-yellow and come from green leaf plants, such as nettle and spinach; turmeric (E l00), which is yellow; and vegetable carbon black (E153), which is black and comes from carbonized vegetable material. Cocoa powder is also used as a colouring agent in ice cream (Clark, 2000).

2.3.4.8 Air

The amount of air dispersed in the ice cream influences quality and affects profits. More air lowers the total cost of ingredients, increasing profits. Too much air can decrease the quality. Air affects the smoothness, texture, price and weight legally no more than 50% of the ice cream can be air and the ice cream weight more than 4.5 pounds per gallon (Clark, 2000).

2.3.5 Ice cream manufacturing process

Goff (2006) reported that, the ingredients are chosen by the manufactures on the bases of desired quality, availability and cost. The ingredients are blended together and produce what is known as the ice cream mix. The basic steps of production in manufacturing ice cream are composition and blending the mix, pasteurization, homogenization, cooking, aging, flavouring, freezing, packaging, hardening and storage.

2.3.5.1 Mix preparation

The first step in the manufacture of ice cream is the preparation of the mix. The mixing process is designed to blend together, disperse and hydrate (dissolve) the ingredients in the minimum time with optimal energy usage. The ingredients must be dosed in accurate amounts in particular order to achieve optimum and constant mix quality and maximam utilization of the ingredients, heating the mix, stirrer to help mixing, heating and stirring are carefully controlled, so that the ingredients are effectively dispersed and dissolved and that heat-sensitive ingredients are not damaged. The liquid ingredients (water, milk, cream etc.) are dosed first, and heating and agitation commence, solid fats are melted before addition. Dry ingredients (sugar, stabilizers, milk powder etc.) are added next (Clark, 2004).

2.3.5.2 Pasteurization

In the vast majority of countries, heat treatment of ice cream mix, to a level sufficient to destroy vegetative pathogens, is mandatory. The minimum permitted heat treatment varies from country to country (Varnam and Sutherland, 2001).

The mix is first pasteurized. Pasteurization is designed to destroy any pathogenic bacteria that may be present, especially from raw milk sources. In addition, it serves a useful role in reducing the total bacterial load and in solubilization of some of the components (proteins and stabilizers). Both batch and continuous (high-temperature, short-time; HTST) systems are in common use. In a batch pasteurization system, blending of the proper ingredient amounts is done in large jacketed vats equipped with some means of heating , usually saturated steam or hot water. The product is then heated in the vat to at least 69℃ and held for 30min to satisfy legal requirements for pasteurization, necessary for the destruction of pathogenic bacteria. Various time-temperature combinations can be used, depending on the legal jurisdiction. Continuous pasteurization is usually performedin an HTST heat exchanger following the blending of ingredients in a large, insulated feed tank. Some preheating to 30-40^{o}C may be necessary for solubilization of the components. Regulations concerning time-temperature combinations for continuous pasteurization usually specify a minimum temperature of 80^{o}C for at least 25 s. holding times much longer than the minimum, e.g. 2 or 3 min, may produce superior mixes that retain many of the advantages of batch pasteurization, but may also leave the mix prone to cooked flavors (Varnam and Sutherland, 2001).

2.3.5.3 Homogenization

The homogenization of the ice cream mix ruptures the original fat globules in milk and results in the formation of smaller globules with new exposed surfaces; these are stabilized by the proteins and the low molecular weight emulsifiers. The mix is also homogenized which forms the fat emulsion by breaking down or reduce the size of fat globules found in the milk or cream to less than 1 ml micron (Goff, 2006).

Homgenization is widely employed in the food industry for emulsion stabilization and to improve the texture, taste and flavor of many products including milk, milk cream and ice cream mixes. Homogenization leads to a reduction in size and an increase in number of solid or liquid particles of the dispersed phase (Innocente*et al* 2002).

The net effects of homogenization are in the production of smaller, more uniform fat droplet size, resulting in a greater stability of fat droplets during ageing, better whipping ability and a smoother, more uniform final product with a greater apparent richness. Homogenization also decreases the potential for undesirable levels of fat churning in the freezer and makes it possible to use products that could not otherwise be used, such as butter and frozen cream (Goff, 2002).

The mix is homogenized usually at temperature from (62-76^{o}C) homogenization increase the formation of clumps of fat globules, increase the viscosity and increasing freezing time in batch freezers (Arbuckle, 1966).

Cooling the mix is immediately after homogenization to 0-4^{o}C is essential, after which it should be held in aging tank tell used. Unless the mix is cooled to temperature of 40^{o}F or lower, it will become very viscous and the ice cream will not melt down smoothly. Also a temperature below 4^{o}Cretards the growth of bacteria (Goff, 2006).

2.3.5.4 Aging of the mix

The mix aging before freezing has been practiced since the inception of the ice cream industry. The change which undoubtedly occur during aging are the fat is solidified, if gelatin has been used as stabilizer it swells and combines with water, proteins of the mix may change slightly, the viscosity is increased largely due to the aging. An aging time of 4 h or greater at 2-4^{o}Cis recommended following mix processing prior to freezing. This allows for hydration of milk proteins and stabilizers, crystallization of the fat globules and a membrane rearrangement, to produce a smoother texture and better quality product. Non aged mix is very wet at extrusion, exhibits variable whipping qualities of the mix are usually improved with aging. Aging is performed in insulated or refrigerated storage tanks or silos, mix temperature should be maintained as low as possible without freezing (Goff, 2006).

2.3.5.5 Freezing and hardening

Following the heat treatment the mix must be cooled. Cooling and aging of the ice cream mix cause crystallization of the fat. Cooling and aging also promote the displacement of the proteins, which are adsorbed onto the fat globules during homogenization, by low molecular weight surfactants in the ice cream mix (Goff, 2002).

2.3.5.5 Freezing processes

The freezing and whipping process is one of the most important unit operation for the development of quality, palatability and yield of finished product, due to the incorporation of air creating the foam, the formation of the ice phase and the partial destabilization of the fat emulsion (Goff, 2002).

The mix is held at 4°C for 24 hours. Longer holding periods should be avoided to prevent spoilage by psychotrophic microorganisms. Cooling the mix to –1 to 2°C in a scraped surface heat exchanger permits the use of shorter aging periods (Varnam and Sutherland, 2001).

2.3.5.6 Hardening of ice cream

Goff (2002) reported that following dynamic freezing ingredient addition and packaging ice cream is immediately transferred to a hardening chamber (-30 ^{o}C or colder) where the majority of the remaining water freezes. Rapid initial freezing is essential to set up as many crystal nuclei as possible so that during the maturation or growth stage their size stays small. In the same context, rapid hardening is also necessary to keep ice crystal size small. When hardening is slow, there is too great opportunity for small ice crystals to melt and water still remaining in the ice cream to migrate to crystal center already formed, resulting in large ice crystals.Many factors need to be considered during the hardening process. The main factors affecting heat transfer are the temperature difference between the product and the freezing medium, the area of product being exposed to the freezing medium and the heat transfer coefficient for the particular operation. Following rapid hardening, ice cream storage should occur at low, constant temperatures, usually -25^{o}C.

Subsequent distribution must maintain these temperatures to protect the structure and textural quality of frozen dairy dessert products. Shelf-life is also dependent upon temperature of storage and distribution.

Goff (2006) found that, after the nuts have been added, the ice cream is packaged and placed in to a blast freezer at (-30 to -40^{o}C) where most of the remainder of the water is frozen. Below about -25^{o}C, ice cream is stable for indefinite periods without danger of ice crystal growth; however, above this temperature ice crystal growth is possible and the rate of crystal growth is dependent upon the temperature of storage this limit the shelf life of ice cream.

2.3.5.6 Ice cream packages

The packaging is an essential part of an ice cream product, as it both protects and helps to sell it. The choice of material and structure of packaging is determined by several considerations, functionality, i.e. to protect and preserve the product, safety, i.e. packaging must be manufacturing in hygienic condition and most not transfer toxic substances to the products (Clark, 2004).

Goff (2006) Concluded that, a package comprises an outer carton formed from a blank having a base panel and several, preferably 4 side wall panels articulated to and fold able in relation to the base paned and inner plastic lining deep drawn in to the carton by vacuum and/or pressure.

2.3.6 Ice cream defects

2.3.6.1 Body and texture defects

Body and texture defects include coarse icy texture, which is due to the presence of ice crystals of such a size that is noticeable when the ice cream is eaten (Flores and Goff, 1999).

Marshall and Arbuckle (1996) demonstrated that a coarse textureis the most frequently cited defect in ice cream. As this defectbecomes pronounced, a gritty or icy mouth is followed by a relativelycold sensation in the mouth caused by excessively large ice crystals.

To achieve small initial ice crystals, the ice cream mix must be rapidly sub cooled to the point of the maximal nucleation rate (Hartel, 1996).

A fluffy texture is a spongy characteristic that is caused by incorporation of large amounts of air as large air cells, low total solids or low stabilizer content.A gummy body defect is opposite of crumbly in that it imparts a pasty or putty like body (Goff, 1998).

A sandy texture is due entirely too fairly large lactose crystals which are slow to dissolve. This defect may be controlled by reducing the milk solids not fat content of the mix, acid standardization, replacing part of the cane sugar content with the dextrose and maintaining uniformly low storage temperature (Arbuckle, 1966).

2.3.6.2 Flavour defects

Flavour defects can be classified in five different ways. This includes the flavouring system, which is that it lacks flavour or the flavour is too high or that the flavour is the unnatural (Goff, 1998).

The dairy ingredient flavour defects include acid, salty, old ingredient, oxidized/metallic, rancid or whey flavour (Smith*et al*., 1999).

The most commonly used system in flavour assessment for ice cream is the dairy ingredient flavour defect system (Flores and Goff, 1999).

Abd El-Rahman *et al.* (1997) claimed off flavours in butterfat can be carried to second products, such as ice cream and affect consumer acceptance. However, milk fat with a high mono unsaturated fatty acid content compared with a high polyunsaturated fatty acid content did not exhibit oxidation problems (Lin *et al.*, 1996a, 1996b).

2.3.6.3 Shrinkage defects

A very troublesome defect in ice cream is shrinkage because there appears to be no single cause or remedy (Goff, 1998).

This defect shows up in hardened ice cream and manifests itself in reduced volumes of ice cream, usually by pulling away from the top and/or sides of the container (Flores and Goff, 1999). They also added that structurally, it is caused by a loss of spherical air bubbles and formation of continuous air channels. Some factors believed to be associated with the defect include that some emulsifier seem to enhance shrinkage, freezing and hardening, both low and high storage temperatures appear to contribute, ultra-smooth ice cream as can be produced in continuous freezer, type of container, partial destabilized protein, season of the year as more shrinkage occurs in winter months and methods of handling in grocery store cabinets (Goff, 1998).

2.3.6.4 Colour defects

The ideal colour is the consistent with the flavour, true in shade and neither too pale nor too intense. Uniform, natural colour is desirable ice cream. An uneven colour results if the colour is not properly added and also it care is not exercised when changing flavour. Excessive colour is the result of adding too much artificial colour to the mix. An unnatural colour describes defects due to insufficient (pale) colour, excess (intense) colour and colors that are not characteristics (true in shade) of the flavour (Arbuckle, 1966).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials

3.1.1 Ice cream raw materials used

To produce ice cream the following ingredients were used:

3.1.1.1 Milk

Fresh goat's and cow's milkswere obtained from Alselate farms Bahri.Goats were of the same herd (Saanengoats) consume the same feed.Cows were of the same herd (Friesian cow) consume the same feed.

3.1.1.2 Milk fat

The cream powder (97% fat) (Dream El Borg for food industries (Egypt)), were purchased from Bahri market.

3.1.1.3 Solid nonfat (SNF)

The starch used in the processing ofthe two milk sampleswaspurchased from Bahri market.

3.1.1.4 Sweeteners

Commercial granulated cane sugar (Kenana Sugar Company), purchased from (Super market Radwan) Bahri market.

3.1.1.5 Stabilizer and emulsifier

The ice cream powder (contain Guar gum E412 and emulsifier (lactic acid ester E472) andothercomponents) (Dream ice cream powderproduced by El Borg for food industries (Egypt)), were purchased from Super market Radwn, Bahri market.

3.1.1.6 Flavour

Liquid Strawberry flavour, commercial strawberry was obtained from Kamena international company. (Obtained from ice cream Adel Bahri).

3.1.2 Chemicals

All chemicals reagents and materials were of analytical grade and were obtained from different chemical companies.

3.2 Methods

3.2.1 Physicochemical analysis of milk and ice cream

3.2.1.1 pH-value

The Hydrogen ions concentration (pH) of samples was determined as described by Ranganna (2001).

Principle: The pH value of samples was measured with a pH-meter **(N0.478530, Hanna, India)**. After calibration of the pH-meter electrodes with buffer solution (pH 4.0 and 7.0), the reading of the sample is recorded as pH value.

Procedure: After calibration of the pH-meter **(N0.478530, Hanna, India)** with buffer solutions (pH 4.0 and 7.0), the electrode of the pH-meter was rinsed with distilled water, immersed in the sample and left to stand until a staple reading was achieved. All the readings were expressed as pH to the nearest 0.01-pH units.

3.2.1.2 Acidity

The acidity of samples was determined according to AOAC (2003). 10 ml of sample were placed in a white porcelain dish and 4 drops of phenolphthalein indicator were added **(BDH Chemicals Ltd. Poole– England)**. Titration was carried out using 0.1 N NaOH **(SDFCL company, Mumbai– India)** until a faint pink colour appeared. The titration figure was divided by ten to get the percentage of lactic acid (1 ml of 0.1 N NaOH sodium hydroxide = 0.009 gm of lactic acid).

Acidity (as lactic acid) %=

3.2.1.3 Total solids content

Total solids (TS) content was determined according to AOAC (2003).Clean aluminum moisture dishes were dried at 105 ^{o}C for 3 hrs. 5 grams of the sample were weighed in dry clean flat bottomed aluminum dish and heated on a steam bath for 15 minutes. The dishes were placed into a forced draft oven at 100 ^{o}C for 3 hrs, then cooled in adesiccator and weighed quickly.

heating, cooling and weighing were repeated until the difference between the two readings was <0.1 mg. The total solids (TS) content were calculated as follows:

$$\textbf{T.S \%} = W1/W2 \times 100$$

Where

W1: Weight of sample after drying

W2: Weight of sample before drying

Solids not fat (%)

Milk ice cream solids not fat were calculated according to procedure described by Davide (1997) using lactometer. Milk samples were taken in a graduated cylinder of 500 ml, until it overflows, with precaution to exclude air bubbles. By holding the clean lactometer from top of the stem it was lowered into the milk and was released at equilibrium position. Scale reading of the lactometer at the point on the scale that touches the upper edge of the meniscus was noted and result were recorded.

$$\textbf{S.N.F (\%) = 0.25R+ 0.22F+0.72}$$

Where:

R= lactometer reading

F= milk fat percentage

3.2.1.4 Fat content

The fat content was determined by Gerber method according to AOAC (2003) as follows:

10 ml sulfuric acid (specific gravity 1.82) was poured into a clean Gerber tube, followed by the addition of 10 ml of milk sample and ice cream sample. Then 1ml of amyl alcohol and distilled water at 20°C was added. The tubes were thoroughly mixed till no white particles were seen. The tubes were centrifuged at 1100 revolution per minute (rpm) for 4 minutes. The tubes were then transferred to water bath at 65°C for 3 minutes. The fat content was immediately read.

3.2.1.5 Protein content

The protein content of samples was determined according to Kjeldhal method **(No 33064, BDH, England)** as described by AOAC (2003).

Principle: The method consists of sample oxidation and conversion of its nitrogen to ammonia, which reacts with the excess amount of sulphuric acid forming ammonium sulphate. After that, the solution was made alkaline and the ammonia was distilled into a standard solution of boric acid (2%) to form the ammonia-boric acid complex which is titrated against a standard solution of HC1 (0.1N).The protein content is calculated by multiplying the total N % by 6.25 as a conversion factor for protein.

Procedure:Digestion: 0.2 mlof each sample was accurately weighed and transferred together with, 4g NaSO4 of Kjeldahl catalysts (No. 0665, Scharlauchemie, Spain) and 25 m1 of concentrated sulphuric acid (No.0548111, HDWIC, India) into a Kjeldahl digestion flask. After that, the flask was placed into a Kjeldahl digestion unit (No.4071477, type KI 26, Gerhardt, Germany) for about 3 hours until a colourless digest was obtained and the flask was left to cool to room temperature.

Distillation:10 ml of 2% boric acid and 3 drops of bromocresol green+ methyl red indicator were added to each receiving flask. The digested samples were transferred from the digestion flask to volumetric flask and the volume was completed to 100 ml by distilled water. The receiving flask was placed on the distillation rack with the tip of the condenser extended below the surface of the acid. Immediately 5 ml of the diluted samples were added from the funnel of the distillation apparatus, then 15 ml Na OH (40%) was gently added. The distillation was continued until the volume in the receiving flasks were 75 ml, then the flask were removed from the distillatory.

Titration: The samples in the receiving flask were titrated against 0.1 N HCL. The colour was change from green to purple. The protein content was calculated as follows:

N %=

P%= N % × 6.38

Where

T: Titration reading

W: Weight of original sample

N: nitrogen %

P: protein %

3.2.1.6 Lactose content

10 gram of sample wasweighted in volumetric flask. The volume of the solution was completed to 100 ml in conical flask. Burrete (50 ml) was filled with the prepared lactose sugar solution. Ten milliliters of sugar solution was transferred into a conical flask containing 10 ml Fehling's solution representing 5 ml of Fehling A (6.928 gm $CuSo_4$ $5H_2O$ per 100ml distilled water) and 5 ml Fehling B (34.6 sodium potassium titrate and 10 gm NaOH per 100 ml distilled water) mixed

well and then heated moderately to boiling on an electrical hot plate heater. The liquid was kept boiling for about 2 minutes then 3 drops of methylene blue indicator (1%) was added. The titration was then completed by the addition of sugar solution drop by drop until the color of the indicator disappeared and red brick color appeared.

The lactose sugar was calculated from the following equation according to, AOAC (2003).

Lactose sugar %=

3.2.1.7 Ash content

The ash content was determined by gravimetric method AOAC (2003). 5 gm of the samples were weighed in a porcelain crucibles, then placed in a muffle furnace **(No. 20.301870, Carbolite, England)** at 550-600^{o}C for 3 hours until ashes were carbon free. The crucibles were then cooled in a desiccator and weighed. The ash content was calculated using the following equation:

$$\textbf{Ash \%=}\ W1/W2 \times 100$$

Where

W1: weight of ash

W2: weight of sample

3.2.1.8 Moisture content

The moisture content was determined according to the standard method of the (AOAC, 2003).

Aluminum dish and its lid were weighed, 2 gm of sample were weighed and were put it in dry clean dish. (W1), then the dish was transferred to moisture oven at 105^{o}C. and was left for 8 hours, then removed and it was put in a desiccator for ½ hours, the sample was weighed and placed, again in the oven **(No. 03822, FN 400,**

Turkey) for 30 minutes, the procedure was repeated three times till constant weight was obtained (W2). The different between weighing was calculated.

Moisture %=

Where

W1: weigh of sample before drying

W2: weigh of sample after drying

3.2.1.9 Minerals content

Ten milliliters (10 ml) of HCL (2N) were added to the remaining ash sample and placed in a hot sand path for about 10-15 min. After that, the sample was diluted to 100 ml in a volumetric flask and filtered. The trace elements Calcium (Ca^{++}) and Phosphorus (P^{++}) were determined as described by (Chapman and pratt 1961).

3.2.2 Ice cream manufacturing

The ice cream from both types of milks was made using the method shown in fig.1. The ice cream from cow's milk was used as control.

Production of ice cream

The milk (5 kg) was received anddivided into four parts, the first part was mixed by using Single mixer **(Panasonic-China serial No J 345)** with 250 g cream powder, the second part was mixed by using **(Panasonic – China MX –J 189)** with 250 g ice cream powder (sugar, coconut oil, palm oil, milk protein, emulsion E472, Guar gum E412 and vanilla), the third part of the milk was mixed with 1.5 kg of starch, the last part of the milk was mixed by using **(Panasonic – china MX –J 189)** with 1 kg of sugar, then the pasteurization process was carried out and thenthey were blended together by the blender by using Electrical blender **(AFTRON Model No AFHM 0300)**this is followed by an aging process at 4^{o}C for 24 hours, 5 ml of strawberry flavor and 5ml of red colour **(Kamena international company)** was added to the final blend after that the ice cream blend was transferred to the ice cream machine **(CARPIGIANI - Italy)** for 15 min, finally the produced ice cream was packed in plastic cups and stored in the deep freezer **(LIBHER – KOREA)**(-18^{o}C) for 12 hr. The ice cream became ready for consumption.

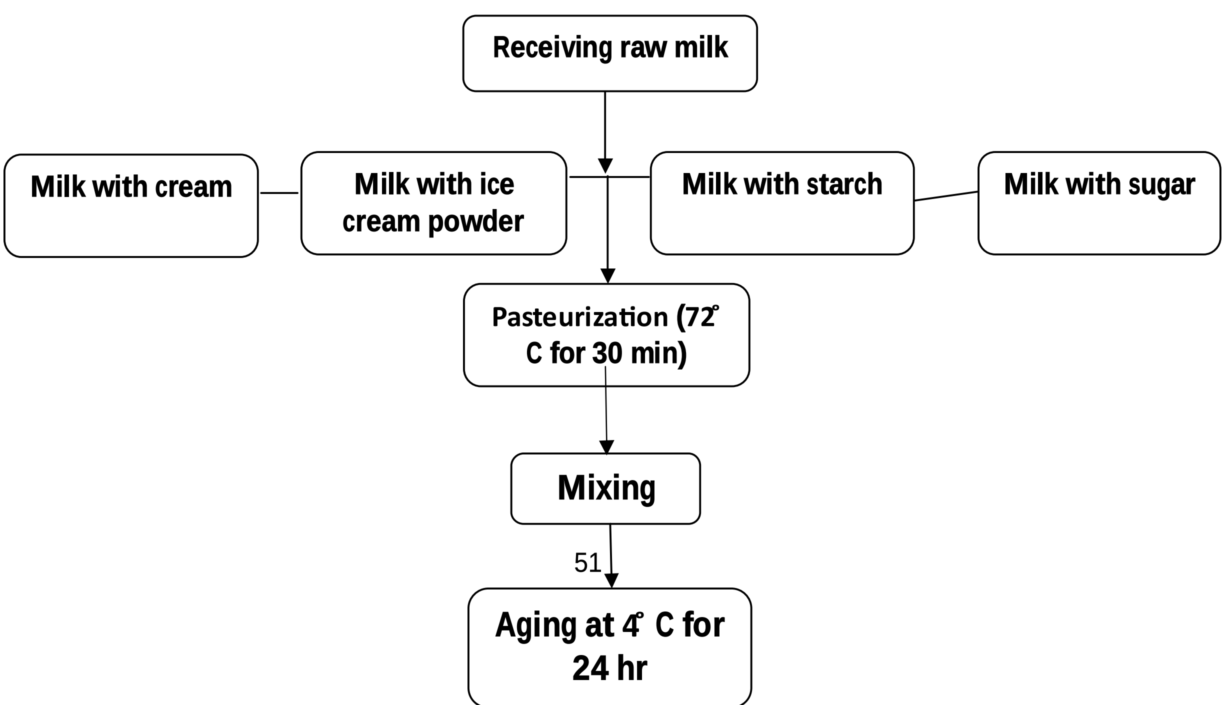

Fig 1: Ice cream processing diagram

3.2.3 Sensory evaluation

The evaluation of sensory properties and consumer acceptance was done as described by **Ranganna (2001).** In this method 50 persons (32 female, 18 male), their ages ranged between 18-36 years. Including students from Sudan University of Science and Technology and trained panelist from National Food Research Center. The evaluation was done for five sensory properties which were:

Colour, Flavour, Body and Texture, Taste and over all acceptability. Using the following scales: 5= excellent, 4= very good, 3= good. 2= acceptable, 1= unacceptable.

3.2.4 Statistical analysis

The results were subjected to Statistical Analysis System (SAS 9.2) by using One-Factor Analysis of Variance (ANOVA). The Mean values were also tested and separated using Duncan's Multiple Range Test (DMRT) as described by Steel, *et. a1.,* (1996).

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Physicochemical characteristics of milk

4.1.1 Moisture

The result of moisture content illustrated in table 3 in goat milk was found to be 87.90%,this was higher than 85.8% reported by Pandy and Voskuil (2011). And moisture content of cow milk was 87.65% this was in a good agreement with 87.2% reported by Pandy and Voskuil (2011). The differences may be due to the differences in breed, climate or fodder type.

4.1.2 Protein

The result of protein content illustrated in table 3 in goat milk was found to be 3.55% and this was in a good agreement with3.2% reported by Mahmood and Usman(2010) and good agreement with 3.1% which was reported by Helmut and Gregor(2012). And protein content of cow milk which was 3.20% this was in agreement with 3.4% reported by Mahmood and Usman (2010) and Pandy and Voskuil, (2011).

4.1.3 Fat

The present study revealed that the fat content of goat milk is 3.5% this is lower than 3.9% reported by Mahmood and Usman (2010) and 3.7% reported by Helmut and Gregor(2012). On the other hand the fat content of cow milk which is 3.2% which is lower than 4.00% reported by Mahmood and Usman (2010). These differences could be due to the differences in feed, breed and climate.

Table 3: Proximate composition, pH and titrable acidity of cow's and goat's Milk

Parameter	Source of milk	
	Cow	Goat
Moisture content (%)	87.65^{a} ±0.64	87.90^{a} ±0.28
Fat content (%)	3.20^{a}	3.50^{a}

	±0.14	±0.14
Crude protein (%)	3.20[a] ±0.14	3.55[a] ±0.21
Ash content (%)	0.77[a] ±0.01	0.79[a] ±0.01
Lactose (%)	5.15[a] ±0.69	4.25[b] ±0.06
Total soluble solids (%)	12.35[a] ±0.64	12.10[a] ±0.28
T.N.F (%)	9.15[a] ±0.49	8.60[b] ±0.28
pH-value	6.45[ab] ±0.07	6.25 [ab] ±0.07
Titrable acidity (as % lactic acid)	0.17[a] ±0.01	0.18[a] ±0.01

Values are mean±SD

Means bearing different superscript in a row are significantly different ($P \leq 0.05$).

4.1.4 Lactose

Lactose content of goat milk was 4.3% this in a good agreement with 4.4% reported by Mahmood and Usman (2010) and 4.3% reported by Helmut and Gregor(2012). Lactose content of cow milk was 4.8% this is higher than 4.5% reported by Asif *et al*. (2010) and Pandy and Voskuil, (2011). This different could be due to lactation period.

4.1.5 Total solids

The total solids percentage of goat milk was found to be 12.1% this is in agreement with 12.2% reported by Helmut and Gregor (2012) and lower than 12.8% reported byMahmood and Usman (2010). The total solids of cow milk was 12.4% this is lower than 12.9% is reported by Mahmood and Usman (2010). This different could be due to various reasons such as breed differences and lactation period.

4.1.6 pH

The present study revealed that the pH of goat milk is 6.3 compared with 6.6 reported by Mahmood and Usman (2010) and Helmut and Gregor (2012). And the pH of cow milk was 6.5 in good agreement with the pH 6.6 reported by Mahmood and Usman (2010).

4.1.7 Acidity

The result of titratable acidity of goat milk is 0.18 this which is higher than 0.16 reported by Mahmood and Usman (2010). The differencemay be duetoseveralreasons, includingdifferences intemperature ormicrobial contaminationmay occurincreases theacidity of themilk. And the titratable acidity of cow milk was 0.18 in good agreement with the titratable acidity of 0.17 reported by Mahmood and Usman (2010).

4.1.8 Ash

The ash content of goat milk was 0.79% which is agreement with 0.75% reportedby Mahmood and Usman (2010), and lower than 0.90% reported by Pandy and Voskuil, (2011). The ash content of cow milk was 0.77% which is higher than 0.60% reported by Mahmood and Usman (2010), and lower than 0.90% reported by Pandy and Voskuil (2011). These differences could be due to the differences in fodder type.

4.1.9 Minerals content

Table (4) shows the minerals content ofgoat milk was very rich in calcium (120.00mg) and phosphorous (96.50mg) which are agreement with (134.00mg) for calcium and (92.00mg) for phosphorous reported by Park *et,al* (2007). The mineral content of cow milk was calcium (117.00mg) and phosphorous (94.00mg) which are agreement with (122.00mg) for calcium and (90.00mg) for phosphorous reported by park *et,al* (2007).

Table 4: Calcium and Phosphorus content of cow’s and goat’s milk

Mineral (mg/100g)	Source of milk	
	Cow	Goat
Ca^{++}	117.00[a] ±2.83	120.00[b] ±1.41
P^{++}	94.00[a] ±1.41	96.50[b] ±0.71

Values are mean±SD

Means bearing different superscript in a row are significantly different (P≤0.05).

4.2 Physicochemical characteristics of ice cream

Table 5 shows the physicochemical characteristics of ice cream from goat Milk and cow milk:

4.2.1 Protein

The protein content of ice cream as in (table 5) in goat milk ice cream was 4.9%, this is higher than 3.1% reported by Silva *et al*. (2010). And in cow milk ice cream protein was 4.55% which is slightly higher than 4.20% reported by Temizand YeşilSu(2010) and higher than 3.80% reported by Rossa *et al*. (2012). That is may be due to the addition of the recipe constituents (whole milk and ice cream powder).

4.2.2 Fat

The fat content of goat milk ice cream was found 11.3% this was higher than that reported by Silva *et al*. (2010) who found that 2.00% this difference may be due to the fat content of the cream fat substitute which was used in the preparation of the goat milk ice cream. Fat content in cow milk ice cream was found 10.85% this was good agreement with 10.0% reported by Temizand YeşilSu(2010).

4.2.3 Total solids

Total solid in goat milk ice cream was 37.9% in good agreement with 38.1% reported by Silva *et al*. (2010). The Total solid in cow milk ice cream was 39.95% this is higher than 31.2% reported by Temizand YeşilSu(2010), and higher than 33.2% reported by Rossa *et al*. (2012). That is may be due to the addition of the recipe constituents (whole milk, cream and ice cream powder).

Table 5: Proximate composition, pH and titrable acidityof ice cream

Parameter	Source of milk	
	Cow	Goat
Moisture content (%)	60.65[a] ±0.21	62.10[b] ±0.42
Fat content (%)	10.85[a] ±0.21	11.30[b] ±0.14
Crude protein (%)	4.55[a] ±0.07	4.90[a] ±0.14
Ash content (%)	1.25[a] ±0.07	1.55[a] ±0.07
Total soluble solids (%)	39.95[a] ±0.21	37.90[b] ±0.42
T.N.F (%)	28.50[a] ±0.14	26.60[b] ±0.28
pH-value	6.40[a] ±0.14	6.15[a] ±0.07
Titrable acidity (as % lactic acid)	0.18[a] ±0.01	0.20[a] ±0.01

Values are mean±SD

Means bearing different superscript in a row are significantly different ($P \leq 0.05$).

4.2.4 pH

The pH in goat milk ice cream was 6.15 compared with 6.6 reported by Silva *et al.* (2010). And pH in cow milk ice cream was 6.4 compared with 6.7 reported by Temizand YeşilSu(2010), and lower than 6.9 reported by Rossa *et al*. (2012).

4.2.5 Ash

Ash content in goat milk ice cream was 1.55% which is higher than 0.7% reported by Silva *et al*. (2010).Ash in cow milk ice cream was 1.25% which is higher than 0.82% reported by Temizand YeşilSu(2010), and higher than 0.94% reported by Rossa *et al*. (2012). The differencemay be dueto thedifference inthe milk or the proportion ofthe existingashin the usedmilkinice creammanufacturing.

4.2.6 Minerals content

minerals content ofgoat milk was very rich in calcium (139.50mg) and phosphorous (121.00mg) which are agreement with (134.00mg) for calcium and (92.00mg) for phosphorous reported by Park *et,al* (2007). The mineral content of cow milk was calcium (117.00mg) and phosphorous (94.00mg) which are agreement with (122.00mg) for calcium and (97.00mg) for phosphorous reported by park *et,al* (2007).

Table 6: Calcium and Phosphorus content of ice cream

Mineral (mg/100g)	Source of milk	
	Cow	Goat
Ca^{++}	136.50[a] ±0.71	139.50[b] ±0.71
P^{++}	118.00[a] ±1.41	121.00[b] ±1.41

Values are mean±SD

Means bearing different superscript in a row are significantly different (P≤0.05).

Table 7: Sensory evaluation of ice cream

Quality attributes	Source of milk	
	Cow	Goat
	Scores	
Colour	3.85[a] ±0.86	3.97[a] ±1.00
Flavour	3.70[a] ±0.85	3.55[a] ±1.13
Body and texture	3.45[ab] ±0.96	4.02[ab] ±0.80
Taste	3.97[a] ±0.92	3.65[a] ±1.17
Overall acceptability	3.90[a] ±0.81	3.90[a] ±1.01

Values are mean±SD

Means bearing different superscript in a row are significantly different ($P \leq 0.05$).

4.3 Sensory evaluation of ice cream

4.3.1 Consumer acceptance

The consumer acceptance showed an acceptability for all samples.

4.3.2 Statistical analysis

One- way ANOVA and two sample paired test were performed to examine significant differences between normally distributed data. Tukey's-test was used to perform multiple comparisons between means within each specific growth medium. Probability level of less than 0.05 was considered significant ($p<0.05$). All data were analyzed using MINITAB statistical software (2006).

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

From the results obtained in this study we can conclude that:

Goat milk ice cream can be produced and it is good in quality and acceptable as cow milk ice cream.The ice cream produced from goat milk has the recommended, physico-chemical and organoleptic characteristics. Andthe losses of goat milk can be minimized by processing it into different products one of which is ice cream which is considered the most popular dairy product.

5.2 Recommendations

- Encouragement the use of goat milk in industrial foods such as ice cream.
- Improve the formula and recipe of ice cream from goat milk and suggest goat milk icecream standards.

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Appendix

Appendix (1): Sheet of the organoleptic evaluation of ice cream

Name…………………. Date …………………

Sample No	Sample code	Colour	Flavour	Body & texture	Taste	Over all acceptability
1	I 12					
2	I 14					

Key:

Excellent = 9.

Very good = 7.

Good = 5.

Fair = 3.

Poor = 1.

Comments: