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Assessment of the effect of addition of Baobab *(Adansonia digitata* L.) fruit pulp on properties of camel milk yoghurt

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الآية

قال تعالى:

لَكُمْ فِي الأَنْعَامِ لَعِبْرَةً نُسْقِيكُمْ مِمَّا فِي بُطُونِهِ مِنْ بَيْنِ
فَرْثٍ وَدَمٍ لَبَنًا خَالِصًا سَائِغًا لِلشَّارِبِينَ).

صدق الله العظيم

سورة النحل الآية (66)

Dedication

To my Family,

To my Teachers,

To my Friends,

Acknowledgment

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

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Abstract

This study was carried out to investigate the effect of Baobab fruit pulp on the physicochemical and microbiological properties of yoghurt made from camel milk and cow milk. Yoghurt was made from camel milk and cow milk with Baobab fruit pulp (5g/L, 10g/L, 15g/L, and 20g/L). Starter culture was added at rate of 3 % (v: v) and stored for 10 days at 4°C. Physicochemical and microbial (acidity, pH, total solids, solids not fat, ash, protein, Fat, lactose, moisture, crude fiber, syneresis, calcium, sodium, phosphorus, potassium, viscosity and total bacterial count of yoghurt), analysis was carried out during storage period of 0, 6 and 10 days.

Results of physicochemical analysis of cow and camel milk yoghurt showed that addition of Baobab fruit pulp resulted in an increase in fiber, protein, fat, total solids, ash, calcium, phosphorus, potassium and sodium content of yoghurt it has caused an increase in titrable acidity, and decrease in lactose, pH and syneresis of yoghurt. Total bacterial count has decreased. Viscocity of camel and cow milk yoghurt increased with increasing Baobab fruit pulp.

It has resulted in improvement of physicochemical properties of camel and cow milk yoghurt. Baobab fruit pulp can be used in camel milk and cow milk yoghurt to decreased syneresis and to adjust the viscosity to make good gel yoghurt from camel and cow milk.

ملخص الدراسة

أجريت هذه الدراسة لإختبار أثر لب ثمار التبلدي على التحليل الفيزيوكيميائي والخصائص الميكروبية للزيادى المصنع من لبن الإبل والأبقار. تم تصنيع الزبادي من لبن الإبل والأبقار بإضافة لب ثمار التبلدي (5 جم/ لتر، 10 جم/ لتر، 15جم/ لتر، و 20 جم/ لتر). أضيف البادئ بمعدل 3% (حجم: حجم) وتم حفظه لمدة 10 أيام عند درجة حرارة 4 مº. أجرى تحليل الخصائص الفيزيوكيميائية والميكروبية (الحموضة،الرقم الهيدروجيني، المواد الصلبة الكلية، المواد الصلبة غير الدهون، الرماد، البروتين، الدهون، اللاكتوز، الرطوبة، الألياف الخام، انفصال الشرش، الكالسيوم، الصوديم، الفسفور، البوتاسيوم، اللزوجة، وعدد البكتريا الكلي للزبادي). أثناء فترة تخزينية تتراوح ما بين0و 6 و 10 أيام.

أظهرت نتائج التحليل الفيزيوكيميائي للزبادي المصنع من لبن الأبقار والإبل عند إضافة لب ثمار التبلدي زيادة في البروتين، الدهن، المواد الصلبة الكلية، الرماد، الصوديم، البوتاسيوم، الكالسيوم، الفسفور، الحمضية والإنخفاض في الرقم الهيدروجيني، اللاكتوز وانفصال الشرش. كما إنخفض عدد البكتريا الكلي وزادت لزوجة الزبادي المصنع من لبن الأبقار والإبل بزيادة لب ثمار التبلدي.

تحسين الخصائص الفيزيوكيميائية للزبادي المصنع من لبن الأبقار والإبل بإضافة لب ثمار التبلدي.ويمكن إستخدامها لب ثمار التبلدي في الزبادي المصنع من لبن الإبل والأبقار لتقليل الشرش وضبط اللزوجة لعمل مادة هلامية.

CHAPTER ONE

INTRODUCTION

Baobab (*Adansonia digitata*) is a very old fruit producing tree, (Savadogo *et al* 2011) belongs to the family, Bombacaceae, sub-family of malvaceae (Adubiaro *et al,*2011),which consists of around 20 genera and 180 species. It is a deciduous tree that was originally located in Africa but can still be found in large quantities in America, India, Malaysia and hosts of other countries. Oyeleke *et al,*(2012) added that it is found in many countries of South Africa (Zimbabwe, Mozambique, South Africa), West Africa (Mali, Benin, Senegal, the Ivory Coast, Cameron, Burkino Faso), and East Africa Kenya, Uganda, Sudan, Tanzania) (Saifeldin *et al,*2013).

It is a big tree that grows principally in Africa and can live up to 1000 years (Cissé *et al,*2013).The trees are tolerant to high temperatures and long spans of drought, and are grown for their sour fruit and leaves. The fruit consists of large seeds embedded in a dry, acidic pulp and shell, (Osman, 2004).

Is characterized by swollen, relatively short, bottle shaped trunk (about 15 m in height) in which spongy fibers store water for the dry season. (Oscar, 2012).Baobab pulp is used in juice production while the seed and the seed oil are used in soup preparation as flavouring agents, (Oyeleke *et al,*2012).

The Baobab fruit pulp which is primarily used as drinks and licked in raw form has been reported to provide both soluble and insoluble fibers which constitute about 50grams/100grams of the pulp (Adekunle1 *et al,*2013).

Baobab fruit pulp is a relatively poor source of manganese (Emmy, *et al,*2010).It also has numerous health benefits which can be related to the presence of bioactive compounds (terpenes, saponins, tannins and many more) that are isolated from its various parts like leaves and fruits (Singh *et al*, 2013).

The pulp is therapeutically employed as febrifuge, analgesic, anti-diarrhea, anti-dysentery and for treatment of smallpox and measles, (Silvia, 2002).

Milk is a white creamy suspension secreted by all species of mammals to Supply nutrition and immunological protection to their infants. In its

Processed form may be whole full fat, semi skimmed and low fat milk (NZFSA, 2003). Milk contains the main nutrients such as: proteins, fats, carbohydrates, minerals and vitamins, necessary to the early life stages: the high nutritional quality of milk facilitates to achievement of individuals' nutritional daily requirements (Shah, 2007). Camel milk is extremely popular and widely consumed by nomadic tribes in Sudan both as fresh raw milk and as soured milk especially in the east and west regions (Abedrahaman. *et al,*2010).

In Zimbabwe, exotic fruits and flavourants are mainly used to flavour yoghurts, no studies have been done to investigate the use of Baobab as yoghurt flavor. Manufacturing of the Baobab flavoured yoghurts could increase the income of rural people who are involved in the harvest of the fruit and processing of the pulp. In addition, the Baobab flavoured yoghurt would diversify the few exotic Yoghurt flavours currently on the market and may also benefit the consumers nutritionally and pharmacologically as the Baobab pulp is a rich source of micronutrients and phytochemicals, (Chipurura, *et al,*2014).

Objectives are to:

- Produce camel milk yoghurt with added Baobab fruit pulp.
- Evaluate the effect of Baobab fruit pulp on the physicochemical properties of yoghurt made from camel milk.

CHAPTER TOW

LITERATURE REVIEW

2. Botanical aspects:

2.1. Origin of the name of the plant

The origin of the vernacular name “Baobab” is uncertain. However, most scientists believe it is derived from the Arabic name buhibab meaning fruit with many seeds. The genus name Adansonia is used in honour of Michel Adanson (1727–1806) who brought seeds to Paris in 1754 and who was the first person to provide a comprehensive description accompanied by a drawing of the plant after a trip to West Africa (Senegal). The species name digitata (hand-like) was selected in reference to the shape of the leaves. Several names are used to describe the Baobab depending on its geographical location and include “magic tree”, “chemist tree”, “symbol of the earth”, “upside-down tree” and “monkey bread of Africa” amongst numerous others, (Kamatou *et al*,2011). Other common names are the dead-rat tree because its fruits look like dead rats hung with their tails on the tree, An elephant tree because of its size among many other common names but the most popular one, Baobab might have been driven from an Arabic word ‘buhibab’ meaning, fruit with multiple seeds (Imoro and Barnes 2013).

2.2. Botanical description of Baobab tree:

Baobab (*A. digitata* L.), a tree plant belonging to the Malvaceae family, is widespread throughout the hot, drier regions of tropical Africa. It is a deciduous, massive and majestic tree up to 25 m high, which may live for hundreds of years. The trunk is swollen and stout, up to 10 m in diameter, usually tapering or cylindrical and abruptly bottle-shaped; often buttressed. Branches are distributed irregularly and large,(Kaboré *et al*,2011).

Table 2.1. Common names for African Baobab (Kaboré *et al,*2011)

Language	Country	Name
English	United States of America and United Kingdom	Baobab, Monkey bread tree, Ethiopian sour gourd, Cream of tartar tree, Senegal calabash (fruit) and Upside-down tree
French	France	Baobab, pain de singe (fruit), arbre aux calebasses, arbre de mille ans andcalebassier du Senégal
Portuguese	Portugal	Cabaçevre
Arabic	UnitedArab Republic	Buhibab,hamao-hamaraya, gangoleis (fruit)
More	Burkina Faso	Trega, twega, toayga
Dogon	Mali	Oro
Bambara	Niger	Konian
Dierma	Mali	Sira
Peulh	Mali	Babbe, boki and olohi
Hausa	Nigeria, Niger	Kouka, kuka
Wolof	Senegal	Goui, gouis, goui, lalo and boui
Amhara	Ethiopia	Bamba
Yao	Malawi	Mlonje
Kamba	Kenya	Mwambo
Swahili	Somalia to Mozambique	Mbuyu, majoni ya mbuyu (Tanzania)
Zulu	South Africa	Isimuhu and umshimulu
Hindi	India	Gorakh-imli and hathi-khatiyan

The tree structure has the following characteristics:

Bark: smooth, reddish brown or greyish with a purplish tinge or rough and wrinkled like an elephant's skin.

Leaves: alternate and hand-shaped with 3–9 subsessiles tapering leaflets, about 10 x 5cm at the ends of branches; digitaly foliate, simple leaves on young plants Inflorescences: axially, large, white, 12 cm across; sepals cup-shaped, 5-cleft, hairy; petals 5, leathery and ultimately reflexed, hairy inside; stamens many steminal columns dividing into many filaments of 1-celled anthers; styles long 7–10-rayed; life span of the Flowers are not more than 24 hours.

Fruit: the capsule hangs singly on a long stalk. It has an ovoid, woody shell 20–30 cm long and is up to 10 cm in diameter, which is covered on the outside with greenish-brown felted hair this shell contains numerous hard, brownish seeds, round or ovoid, up to 15 mm long, which are embedded in a yellowish-white, floury acidic pulp (Gebauer, *et al*,2002)

Ecology and Distribution:

The eight species of Baobabs reside in the single genus, Adansonia. Madagascar is their centre of diversity, with six species endemic to the island. These include *A. grandidieri*, *A. madagascariensis*, *A. perrieri*, *A. rubrostipa*, *A. suarezensis* and *A. za* . *Adansonia digitata*, the African Baobab, has a wide distribution from as far north as the Sahel to a few degrees south of the Tropic of Capricorn in the south of the continent. This species has also been introduced into Madagascar and other parts of the world. The remaining species, *A. gregorii*, occurs in the northwestern part of Australia, in the Kimberley ranges (Cruywagen, *et al*,2010)

Adansonia. digitata is widespread throughout the hot, drier regions of tropical Africa. It extends from northern Transvaal and Namibia to Ethiopia, Sudan

and the southern fringes of the Sahara. In Sudan, the Baobab is most frequently found on sandy soils and by seasonal streams ‘khors’ in short grass savannas. It forms belts in Central Sudan, in Kordofan, Darfur, Blue Nile, Upper Nile and Bahr El Ghazal. It is often found associated with the tamarind, *Tamarindus indi*ca L. Areas where the Baobab can be grown are restricted to those with not more than one day of frost per year ,(Kaboré, *et al,*2011).The Baobab trees can reach an age of several hundred or thousand years under suitable conditions. Baobab tree is characterized by an extensive root system and high water holding capacity which greatly contributes to its ability to survive well in dry climates and also resists fire, (Ilori, *et al,*2013). This adaptation allows it to grow in zones with 100-1000 mm annual rainfall, but trees are often stunted in the lower rainfall areas. It characteristically occurs on free-draining sandy-textured soils but not on deep sand, where it is unable to get enough moisture or anchorage. It is insensitive to soil pH and tolerates shallow lateritic soils. It is also found on rocky hillsides, in calcareous soils, on sites receiving run-off, or where water accumulates. Measurements on exposed roots show that they are relatively shallow (<1.8 m) but spread out to a distance greater than the height of the trees. Such an extensive shallow root system is probably the best adaptation to exploiting the low annual rainfall, most of which falls in the form of infrequent heavy showers. In Sudan reported that the Baobab tree spends only four months of the year in leaf and this is possible because some photosynthesis takes place in the trunk and branches during the eight-month leafless period, (Imoro and Barnes, 2013), using water stored in the trunk. Many of the larger Baobabs have hollow centers due to natural causes or as a result of human intervention. The Baobab was found to be among the most effective at controlling its water loss. Daily shrinkage of the trunks was measured, giving a daily estimate of approximately 400 liters water deficit when they are in leaf. Seasonal shrinkage indicates a loss of up to 1500 liters of water during dry periods .distinguished four principal growth phases in the development of *A. digitata*:

sapling phase (up to 10–15 years), cone phase (up to 60–70 years), bottle phase (up to 200–300 years) and an old age phase (up to 500–800 years). Initially the trees grow extremely fast, especially in the cone phase, but very slowly during the greater part of their life. In Sudan, flowering was found to occur between May and July and fruiting extends from August to October The Baobab is pollinated by bats (Galago crassicaudatus) and insects but is also adapted for wind pollination .Although the Baobab is one of the most familiar trees in the drier parts of Africa, very little work has been done on its ecology or physiology. Flowering normally takes place between October and December in southern Africa, with fruiting from April to May. In West Africa, flowering is usually between May and June. The fruits are large (up to 24 x 12 cm) and oblong in shape, hanging from long stalks. They are greenish-grey when young and brownish when mature (Adejuyitan, *et al,*2012).

2.3. Pollination, dispersion and cultivation:

The white flowers are pollinated by fruit bats that feed on the nectar at night. *A. digitata* is widely spread over the African savanna through natural reproduction (seeds). Many animals will eat the fruit contents once the outer shell has withered and broken, and may at the same occasion assist in seed dispersal (Kamatou, *et al,*2011). In nature, dormancy is broken by passage through the digestive system of large mammals. In cultivation, dormancy may be broken by immersing the seed in hot water for several minutes or by chopping the seed (Gebauer, *et al,*2002) found that the most effective method to break the dormancy was scarification, and cultivation requires that the seeds be treated before sowing. The seeds generally take three to five weeks to germinate, while plants grown from seed start flowering after eight to twenty-three years. The flowering period of Baobab which is very long can be reduced to less than five years by grafting. Young trees grafted from elite trees with desirable characteristics develop faster than trees grown from seed.

Therefore, good possibilities for future vegetative cultivation and commercialization of Baobab products can be expected. The probability of seed germination of Baobab is very low (10%) and studies have shown that the probability of germination will increase up to 85% if the seeds are soaked before sowing. In Burkina Faso, people have started planting Baobab trees. In the past few years, consumer products derived from the seed oil and fruit pulp have been exported to European and USA markets and the demand for these products are increasing. An increased demand can lead to overexploitation of the plant therefore it is important to determine the factors that could lead to the successful cultivation of this commercially important tree. Ecological niche modelling studies were undertaken to determine factors that are crucial to the cultivation of Baobab and results indicated that annual precipitation and seasonal temperature fluctuations were two key factors The results of the ecological modelling also predict that Baobab could be widely cultivated in most countries in southern Africa and in the Sudano-Sahelian zone of West Africa from Senegal to Sudan. Furthermore, the modelling prediction showed that Angola and Somalia are highly suited for cultivating Baobab in Africa, while India was determined to be the most suitable country for Baobab cultivation outside Africa. However, many other factors such as pollinator agents, radiant energy, soil aeration and structure, soil reaction, biotic factors (allelopathy, heavier fertilisation), mineral nutrient supply and pollination agents should be incorporated in the model in order to determine more accurately the potential area of Baobab cultivation.

2.3 Biological Activity:

2.3.1 Anti-oxidant properties:

Baobab fruit pulp has a particularly high antioxidant capability mainly because of its high natural vitamin C content (Singh, *et al*,2013)

The Baobab fruit looks like a coconut, but has six times the vitamin C of an orange, ten times the antioxidant level of oranges, six times more antioxidants than Cranberries, Blueberries, Blackberries, apple and strawberry showed that the Baobab fruit has the maximum content of vitamin C at 150 - 499mg/100g, out of all fruits investigated. This compared to a vitamin C content of 53 mg/100g in oranges as well as documented sources of vitamin C, (Adedayo, *et al,*2011and Addai, *et al,*2014) .

Vitamin C Healing Effect:

Vitamin C is a powerful antioxidant and extremely important in human nutrition. Vitamin C has been shown to be related to low blood pressure, enhanced immunity against many tropical maladies, lower incidence of cataract development and lower incidence of coronary disease (Kaboré, *et al,*2011). The daily recommended intake for healthy, non-smoking adults is 65 mg; smokers need more vitamin C than non-smokers. While 65 mg/day is the minimum recommended intake, a full saturation of the total pool of vitamin C in the body is about 140 mg/day. Convalescents recovering from infectious diseases or nursing mothers benefit significantly from daily intakes exceeding 250 mg. using the average vitamin C content of Baobab fruit, 2800 mg/kg, the recommendations can be converted into amounts of Baobab powder. The daily recommended dose of vitamin C can be obtained from 23 g of Baobab powder. The daily saturation of the vitamin C pool in the body requires 50 g of Baobab powder; the special dosage for convalescents is 90 g (Emmy *et al,*2010).

The high vitamin C and antioxidant content of the fruit pulp may have a role to play in the extension of shelf-life for foods and beverages, as well as cosmetics. The food/beverage industry could introduce Baobab fruit pulp into foods in order to act as a preserving ingredient by preventing oxidation of lipids in the food (Kaboré *et al,*2011)

Antioxidants have the potential of preventing oxidative stress related diseases such as cancer, aging, inflammation and cardio-vascular diseases as they eradicate free radicals which contribute to these chronic diseases (Addai, *et al*,2014)

2.3.2Anti-inflammatory properties:

Inflammation is a common underlying cause of many diseases, infectious and otherwise and tissues although a controlled acute inflammatory reaction is a normal immune response to infection and injury. In order to address the prospect of medicinal plant applications to the treatment of inflammatory conditions, we have devised cell culture systems in which specific viruses and bacteria can induce substantial amounts of pro-inflammatory or anti inflammatory cytokines. Plant extracts can be evaluated for inflammatory properties in such a system and direct antiviral effects can also be tested against the same viruses (Selvarani and James, 2009).

The anti-inflammatory activity of the fruit extracted with hot water was tested in vivo using the rat paw formalin-induced oedema test. The extract tested at a dose of 400 and 800 mg/kg inhibited formalin-induced oedema. After 24 h administration of the aqueous extract, the mean swelling of the foot was 1.81 and 1.75 mm for 400 mg/kg and 800 mg/kg, respectively, in comparison to the negative control (6.35 mm) (Kamatou , *et al*,2011) Leaves are applied locally for a variety of inflammatory conditions, insect bites and guinea worm sores (Emmy, *et al*,2010).

2.4 Phytochemistry:

Several classes of compounds have been identified from various parts of Baobab (fruit pulp, seed oil, leaves, and roots) including terpenoids, flavonoids, sterols, vitamins, amino acids, carbohydrates and lipids (Chauhan *et al*,, 1984, Chauhan *et al*,, 1987,Shukla *et al*,, 2001) .The chemical structures of selected compounds are shown in Fig. 1.

Table 2.2: Selected traditional medicinal uses of the *A. digitata* tree in Africa (Kamatou *et al* 2011).

Therapeutic uses	Plant part used	Country	Preparation
Fever, diarrhoea	Seeds	South Africa	Mixed with water
Dysentery, fever	Seeds, fruits	Cameroon,Central African Republic	Decoction
Malaria, fever	Leaves	Sierra Leone	-
Coughs	Powdered seeds	South Africa	-
Diarrhoea,fever, inflammation, Kidneyand bladder diseases,blood clearing, asthma	Leaves	South Africa	Infusion
Fever, dysentery	Leaves, roots	Sudan	-
Anaemia	Bark	Nigeria	Aqueous extract
Malaria	Bark, Leaves	Nigeria	Powdered bark Mixed with porridge
Diarrhoea,fever, inflammation, kidney and bladder diseases,bloodclearing, asthma	Leaves	Tanzania	Decoction, infusion
Dysentery, fever, haemoptysis, diarrhea	Fruits, seeds	Tanzania	Decoction

Refreshing, tonic, diuretic,cystitis, dysentery,hepatic disorders,hypogalactia	Flesh with peel	Burkina Faso	Decoction
Toothache, gingivitis	Leaves	Burkina Faso	-
Diarrhoea, worms	Leaves, seeds, fruit pulp	Côte d'Ivoire	-
Wound healing	Stem bark	Mali	Decoction
Diaphoretic,fever remedy	Leaves	Kenya	Decoction
Diaphoretic, kidney and bladder diseases, asthma, insect bites	Leaves	-	-
Microbial diseases	Fruits	Nigeria and Senegal	-

Ten aromatic compounds including isopropyl myristate and nonanal were identified in the fruit pulp using GC–MS (Cisse *et al,*, 2009). Several compounds have been isolated from the pericarp using column chromatography and include: (–) -epicatechin, epicatechin-(4β→8)-epicatechin (B2), epicatechin (4β→6)-epicatechin (B5), epicatechin-(2β→O→7, 4β→8)-epicatechin (A2), and epicatechin-(4β→8)- epicatechin-(4β→8)-epicatechin (C1) (Shahat, 2006). Epicatechin is a flavonol (flavonoid) found in many plants such as grapes, cocoa and tea. This class of compound may prevent coffee berry disease by inhibition of appressorial melanisation. Epicatechin is known to exhibit strong anti-oxidant activity and can also promote survival in diabetic mice (Lee *et al,*, 2003 , Si *et al,*,2011). Other compounds such as 3,7-dihydroxy-flavan-4-one-5-O-β-D-galactopyranosyl (1→4)-β-D-glucapyroside and a flavonone 3,3′,4′-trihydroxy flavan-4-one-7-O-α-L-rhamnopyranoside and quercetin-7-O-β-D-xylopyranoside were isolated from the roots of A. digitata(Kamatou, et al,2011) . Compounds such as campesterol, cholesterol, isofucosterol, β-sitosterol, stigmasterol and tocopherol (α, β, γ, and δ) have been detected in the seed oil. Investigated the lipid composition of the seed oil using GC–MS. The major hydrocarbons in the seed oil were n-alkanes (57.3%) and squalene (39.5%). Fatty acids present in the seed oil include linoleic and oleic acids in high concentration as well as lesser amounts of palmitic, linolenic, stearic and arachidic acids (Yazzie *et al,*, 1994; Glew *et al,*, 1997; Kamatou, *et al,*2011; Sidibe and Williams, 2002; Osman, 2004; Nkafamiya *et al,*, 2007). . The presence of organic acids such as citric, tartaric, malic, succinic and ascorbic acid in the fruit pulp was first highlighted in the early fifties. The pulp represents 14 to 28% of the total fruit weight and the pulp water content is low (less than 15%) (Soloviev et al,, 2004). Studies have shown that the fruit pulp contains high amounts of carbohydrate (≈70%), crude fibre (≈11.2%), a low amount of ash (≈5.7%) and protein (≈2.2%), and a very low amount of fat (≈0.4%) (Lockett et al,, 2002). Several amino acids such as alanine, arginine,

glycine, lysine, methionine, proline, serine, valine (from fruit pulp) , vitamins (B1, B2, B3, A, C) (from fruit pulp and/or leaves) and minerals (Cu, Fe, K, Mg, Mn, Na, P, Zn) (from fruit pulp) have also been identified(Kamatou, *et al*,2011).

2.5 Chemical Composition:

2.5.1 Fruits:

The fruit is a large, egg shaped capsule (often>120 mm), covered with yellowish brown hairs. The fruit consists of a hard, woody outer shell with a dry, powdery substance inside that covers the hard, black kidney-shaped seeds, (Adubiaro, *et al*,2011).

The Baobab fruit is composed of an outer shell (epicarp) (45%), fruit pulp (15%) and seeds (40%). The woody epicarp or pod contains the internal fruit pulp (endocarp) which is split in small floury, dehydrated and powdery slides that enclose multiple seeds and filaments, the red fibers that subdivide the pulp in segment,(Ekram, *et al*,2014).

2.5.1.1Fruit Pulp:

The dry Baobab fruit pulp has a slightly tart, refreshing taste and is very nutritious, with particularly high values for carbohydrates, energy, calcium, potassium (very high), thiamine, nicotinic acid and vitamin C(Emmy De Caluwé, *et al*,2010).added that vitamin B1, B2 (Adedayo, *et al*,2011) .

The Baobab fruit pulp is dry, acidulous and mealy, and rich in mucilage, pectins, tartarate and free tartaric acids. The presence of the tartarate gives rise to the name ‘cream of tartar tree’. Pulp sweetness is provided by fructose, saccharose and glucose contents. Fruit pulp is also acidic and this is due to the presence of organic acids including citric, tartaric, malic, succinic as well as ascorbic acid (Ekram, *et al*,2014)

Pulp sweetness is provided by fructose, saccharose and glucose contents. Fruit pulp is also acidic and this is due to the presence of organic acids including citric, tartaric, malic, succinic as well as ascorbic acid, when eaten raw, the pulp is a rich *source* of calcium and vitamins B and C (Emmy, *et al,*2010).

It contains sugars but no starch, and is rich in pectin's. The fruit pulp has very high vitamin C content; almost ten times that of oranges. However, the vitamin C content of the bulk fruit pulp reportedly varies from 1623 mg/kg in one tree to4991 mg/kg in another (Ekram, *et al,*2014)

The fruit consists of large seeds embedded in a sour acidic pulp and shell. (Danbature, *et al,*2014) due to the presence of the organic acids citric, tartaric, malic, succinic and ascorbic, with pH 3.3, the latter source also shows that the pulp is rich in pectin (average 56.2%) (Emmy, *et al,*2010). Fruit pulp proved to be rich in pectin, most of it being water soluble with a low content of propectin, low degree of esterification and intrinsic viscosity values of about one fifth of those of commercial apple pectin (Abdalla, *et al,*2010) added that has high Gelling ability. Pectin is found in most fruits, some in large varying amounts (Ndabikunze, *et al,* 2011).

The fruit pulp contains a high amount of carbohydrate, low protein, and a extremely low fat. Simple sugars in Baobab pulp account for about 35.6% of the total carbohydrate content. This explains the noticeable sweet taste of the pulp. However, the sweetness may vary for different types of pulp.

2.5.1.2 Leaves :

Fresh young leaves have a protein content of 4%, and they are rich in vitamins A and C. In terms of mineral content, Baobab leaf is an excellent source of calcium, iron, potassium, magnesium, manganese, molybdenum, phosphorus, and zinc (Gebauer, *et al,*2002).

Table 2.3: Chemical composition of Baobab fruit pulp :(*Nour, et al*, 1980)

Constituents (dry weight basis)	
Total soluble solids (%)	79.3
Alcohol insoluble solids (%)	57.3
Total sugars (%)	23.2
Reducing sugars (%)	19.9
Total pectin (% galacturonic acid)	56.2
Starch (%)	–
Protein (% N)	2.6
Fat (%)	0.2
Crude fibre (%)	5.7
Ash (%)	5.3
Ascorbic acid (mg/100 g)	300.0
Iron (mg/100 g)	8.6
Calcium (mg/100 g)	655.0
Phosphorus (mg/100 g)	50.8
Moisture	6.7
pH	3.3

2.5.1.3 Seeds:

The vernacular name for Adansonia digitata, Baobab, means ‘fruit with many seeds’ (Ajayi, *et al,*, 2003)

The seeds are eaten raw or are roasted and have a pleasant nutty flavour (Emmy De Caluwé *et al,*2010) Murray *et al,* (2001) reported that Baobab seed flour is an important *source* of energy and protein. The nutritious seeds have high values for proteins, fats (oils), fibre and most minerals. The Baobab seed contains appreciable quantities of oil (29.7%, expressed on a dry weight basis) (Emmy, *et al,*2010) Besides, Baobab seeds have high levels of lysine, thiamine, calcium, and iron (Nnam and Obiakor, 2003). Baobab seed can be classified as both protein- and oil-rich. It is also a very rich source of energy and has a relatively low fat value (Emmy, *et al,*2010)

2.6 Main Uses:

The plant has numerous medicinal and non-medicinal uses in Africa .Every part of the Baobab tree is reported to be useful (Gebauer, *et al,*2002). The Baobab fruit pulp is probably the most important foodstuff. It can be dissolved in water or milk. The liquid is then used as a drink, a sauce for food, a fermenting agent in local brewing, or as a substitute for cream of tartar in baking (Sidibe and Williams, 2002). The pulp has recently become a popular ingredient in ice products in urban areas, in different kinds of juices and jams(Emmy, *et al,*2010).The leaves of the Baobab tree are a staple for many populations in Africa, especially the central region of the continent . During the rainy season when the Baobab leaves are tender, people harvest the leaves fresh. During the last month of the rainy season, leaves are harvested in great abundance and are dried for domestic use and for marketing during the dry season. The leaves are typically sun-dried and either stored as whole leaved or pounded and sieved into a fine powder (Emmy, *et al,*2010). Young leaves are widely used, cooked as spinach, and frequently dried, often powdered and

used for sauces over porridges, thick gruels of grains, or boiled rice (Sidibe and Gebauer *et al,,* 2002). Baobab seeds can be eaten fresh, or they may be dried and ground into a flour which can either be added to soups and stews as a thickener, or roasted and ground into a paste, or boiled for a long time, fermented and then dried for use (Sidibe and Williams, 2002; FAO (1988) cited in (Nnam and Obiakor, 2003) The seeds are characterized as a potential protein source. In Sudan they are pounded whole into a coarse meal and added to soups and other dishes like 'Burma' (Dirar, 1993). In some areas roasted seeds are used as a coffee substitute.

2.7 Camel:

The total population of camels in the world is about 19 million of which 14 million are in Africa, The vast majority of camels are dromedaries (one-humped camel) are found particularly in desert areas (Alwan and Zwaik 2014) and the total number of the camels is estimated by the Ministry of Agriculture in 2010 to more than 300000 heads, (Oulad, *et al*,2013). There are about 18 million camels in the world. Nowadays, camel milk production is in progress in many countries in both Asia and Africa due to increased demand (Al-Otaibi and El-Demerdash 2013). Camelids are classified into two groups: the Old World camelids that contain the dromedary (Camelus dromedarius) of northern Africa and southwest Asia, and the Bactrian camel (Camelus bactrianus)of eastern Asia (Gabriel, *et al*,2007) .The dromedary is the only species capable to valorize this desert ecosystem (Oulad, *et al*,2013) Camels are traditionally used for transport, its role in supplementing animal proteins for human in terms of meat and milk is presently attracting the attention of scientists in this part of the world, (Salihu, *et al*,2009). Camels provide mankind with a range of products and services, e.g. wool, meat, milk and draught power (Ishag, *et al*,2010). Camels are unique animals in many aspects and cannot be compared with other farm animals in their physiological responses and adaptation to arid environments . In arid zones, from north-

western India and the lowlands of Afghanistan to the extremity of the Arabian Peninsula and Somalia to the south and westward across the African deserts, the Arabian camel is found to be a better provider of food than cattle and sheep, which are severely affected by the heat (Mahmoud, *et al*,2012).

2.7.1 Camel in Sudan:

Sudan is rated second in numbers of camel population in the world after Somalia with an estimation of 4078 thousand head, concentrated in two main regions; the Eastern states (Butana plain and Red Sea mountains) and Western regions (Darfour and Kordofan). The camel ecotypes in Sudan serve numerous functions in their respective production systems (e.g. milk, meat, racing, and riding, packing) and are bred and selected for sustainable performance, (Ishag, *et al*,2010).

According to recent estimates of livestock , there are about 40 million heads of cattle, 50 million heads of sheep , 43 million heads of goat and 4 million heads of camel camels in the Sudan are spread in a belt configuration, it extends between latitudes 12-16N (Eisa and Mustafa, 2011) distributed as follows: Kordufan State 36.81%, Darfur State 23.70%, Gedaref State 5.18%, Kassala State 13.47%, Red Sea State 7.01%, Blue Nile State 4.48%, Sinnar State 2.45%, Gezzera State 2.59%, White Nile State0.74%, Northern State 1.03%, River Nile State 2.40% and Khartoum State 0.14% (Hashim, *et al*,2015) Camels in Sudan and elsewhere are classified as pack (heavy) and riding (light) types according to their function. Recent studies had been made to classify the camels according to their performance like dairy camels, meat camels, dual purpose camels and racing camels (Hashim, *et al*,2015)

2.7.2 Camel milk:

Camel milk is usually opaque-white in colour and has an acceptable taste .

The milk normally has a sweet and sharp taste, but sometimes can also have a salty taste due to the type of plants eaten in the desert by the camels (Obaid, *et al,*2014) The changes in taste are mainly caused by the type of fodder and availability of drinking water (Omar and Hanhad 2010). Camel milk has properties that it can be kept for long periods than cow's milk when refrigerated and even with the desert heat it does not spoil shortly (Al-Otaibi and El-Demerdash 2013).

She-camel's milk contains all essential nutrients as cow's milk and also has a high biological value due to the higher content of antimicrobial factors such as lysozyme, lactoferrin and immunoglobulin's, the ability to alter the activity of these anti-microbial factors in milk could have an impact on shelf-life of raw milk and development of additional health and functional foods based upon these factors, (Abolghait, *et al,*2011). In the traditional pastoral communities, camel milk is consumed fresh or fermented (Salma, *et al,*2010).

2.7.2.1 Camel milk production

Camels are known to occupy the arid and desert countries; these pastoralist areas and conditions make it difficult to estimate camel milk production. Other major factors including breed, stage of lactation, feeding and management conditions play important role too in the inconsistency of data. However, the current unofficial data in the literature on camel milk production are scarce and are based on observations of particular research stations and rarely based on pastoral areas (Omar and Hamad, 2010). According to the latest FAO statistics, camel (both species) milk production in the world is reported to be about 5.3 million tonnes per year; only 1.3 million tonnes are consumed by humans whereas the remaining amount is fed to calves. Somalia is currently expected to be the biggest producer of camel milk worldwide followed by Saudi Arabia (FAO, 2008)Under these harsh conditions, camels have the capability to produce more milk than any other species and for longer periods of time , while their feed requirements are

modest(Omar and Hamad, 2010) . Each camel (both species) produces between 1000 and 2000 L of milk per lactation period of 8e18 months (FAO, 2006). Their daily milk production average is estimated to be between 3 and 10 kg during a lactation period of 12e18 months (Omar and Hamad, 2010) . The yield could increase to 20 L per day under improved feed, husbandry practice, water availability and veterinary care (FAO, 2006). In Sudan camel, average milk production was 5-10kg/day (Eisa and Mustafa, 2011). Fresh and fermented camel milks have been used in different regions in the world including Sudan as a treatment for a series of diseases such as dropsy, jaundice, tuberculosis, asthma and leishmaniasis or kala-azar (Mustafa, *et al*,2014).

2.8 Camel milk composition and properties:

Camels' milk is generally opaque white. Types of fodder and the fluctuation in lactose, fat, mineral and protein content of the milk would account for the milk at times tasting bitter while at other times sweet. Normally it has a sweet and sharp taste and can sometimes be salty. The taste is affected by nutritional and environmental factors. While slightly saltier than cow's milk, camel milk is highly nutritious. At times the milk tastes watery. In certain countries there are prejudices among the urban population concerning camel milk. It is considered as having an unpleasant taste. It is frothy when shaken slightly (Adugna and Asresie, 2014) .Camel milk is frothy when shaken The average density of camel milk is 1.029 g cm_3and has been reported to be less viscous than bovine milk slightly (Omar and Hamad 2010) the viscosity of camel milk at 20 °c is 1.72 mpa s ,where as the viscosity of bovine milk at the same dry matter content and under the same conditions is 2.04 mpas (Khasheli, *et.al*, 2005).

The pH of camel milk ranges from 6.5 to 6.7 with an average pH around 6.6. It can increase up to 7.2 in case of clinical mastitis(Adugna and Asresie, 2014)

The density varies from 1.025 to 1.032 with an average of 1.029 (Adugna, *et al,* 2013).

Camel milk composition was found to be less stable than other species such as bovine. Previous findings pointed out that the variation in camel milk composition could be attributed to many factors such as analytical measurement procedures, geographical locations, feeding conditions, type of samples and breeds in addition to other factors including milking (Dowelmadina, *e .al* 2014)frequency, stage of lactation and parity numbers Camel milk contains 2.9 to 5.5% fat, 2.5 to 4.5% protein, 2.9 to 5.8% lactose, 0.35 to 0.90% ash, 86.3 to 88.5% water, and 8.9 to 14.3% solid-non-fat (SNF) (Dowelmadina, *e .al* 2014). Camel milk has similar protein content, lower lactose content, and lower fat containing less saturated fatty acids and greater total cholesterol, compared with cow's milk (Eshraga, *et al,*2011). Camel milk has greater contents of vitamin C, ash and sodium, potassium, phosphorus, zinc, iron (10 times as rich in iron as cow's milk) and manganese than cow's milk (Marwa, *et al,*2013).

2.9 The main constituents of camel milk:

Al though over all composition of camel milk is similar to cow's milk some differences exist in the molecular composition of protein, lipids and the minerals balance (Hashim, *et. al,* 2009).

2.9.1 Protein:

The mean composition of protein and nitrogen fraction of camel milk are generally similar to those of cow's milk, the average values for the casein and whey protein content vary from 1.9 to 2.3 percent and 0.7 to 1.0 percent, respectively. The nitrogen content of casein is a little lower than cow's milk reaching 71 to 79 percent of total protein nitrogen compared with 77 to 82 percent (Jenness and Sloan, 1969; Mehaia, 1987; Farah, 1993). Casein fractions have been isolated in camel milk and found to be homologous with

bovine casein. The balance between the different casein fractions is very different and mainly identified by a low amount of kappa casein of only about 5 percent of the total casein compared with about 13.6 percent in bovine casein. (Jardali, 1988; Jardali and Ramet, 1991; Farah, 1993). The molecular weight and amino acid composition of the casein fractions are different from those of cows' milk (Sawaya *et al*,,1984; Larsson-Raznikiewicz and Mohamed, 1986; Farah and Ruegg, 1989; Mohamed, 1990; Farah, 1993). The state of the casein micelle structure has seldom been investigated. Most results, however, conclude that the size distribution of casein particles in camel milk is significantly broader than in cow's milk exhibiting a greater number of large particles. The average micelle diameter of camel milk was found to be about double that of cow's milk at 320 nm and 160 nm respectively (Sawaya *et al,* 1984; Larsson- Raznikiewicz and Mohamed, 1986; Farah and Ruegg, 1989; Jardali and Ramet, 1991; Jardali, 1994).The quantity of whey protein is higher in camel milk than cow milk, at 0.9 to 1.0 percent and 0.7 to 0.8 percent respectively. Individual fractions have been identified according to chromatographic and electrophoretic mobility and to the primary sequence of their amino acid chains. Two types of alpha-lactalbumin similar to bovine milk have been isolated. Beta- lacto-globulin has not been clearly identified (Beg *et al*, 1987; Farah, 1986). Two novel camel milk whey proteins, unlike any known bovine milk whey proteins have been separated and characterized (Beg *et al*,, 1987). The heat stability of camel milk whey proteins was found to be considerably higher than in cow's milk (Farah, 1986; Farah and Atkins, 1992).

2.9.2 Fat content:

Farah and Ruegg (1991), illustrated that the creaming of camel and cow milk and the fat content of camel milk varies greatly from 1.10- 5.50 percent depending on the breed and feeding condition Studies on the structure and composition of globules revealed two main characteristics. Whereas previous

results have found small fat particles in camel milk (Gouda *et al,*, 1984; Knoess *et.al*. 1986), other work indicates that fat globule size distribution is similar to cow's milk, with an average of 2.9 micrometer (Wahada *et.al.* 1988; Farah and Ruegg, 1991; Farah, 1993). The fat membrane appears to be thicker than in other types of milk and closely bound to proteins (Rao *et al,*.1970; Knoess *et.al*. 1986; Farah, *et.al.*1990; Farah and Ruegg, 1991). The creaming properties of camel milk fat globules are poor, resulting from a deficiency in agglutinin that cause very slow creaming rate at all temperature (Farah and Ruegg, 1991). A factor specific to camel milk fat is the low percentage of short chain C4 to C12 fatty acids. The concentration of long chain fatty acids such as palmitic and stearic are however, relatively high. As a consequence, the physical properties of the triglycerides are characterized by much higher melting and crystallization points than cow's milk (Abu-Leiha 1987; Abu-Leiha, 1989; Farah, *et.al.*1989; Farah and Ruegg, 1991).

2.9.3 Lactose:

Lactose is the characteristic sugar of milk, and for most purposescan be considered as the only carbohydrate present (Johnson, 1987). Lactose content range from 2.9-5.8% (Yagil, 1987), from 3.3 - 5.8 (Wilson, 1984), and 4.4%, 5.6% according to Saway *et al,* (1984) and Sohail, (1983) respectively. Abu-Leiha (1989) observed that at parturition lactose content was 2.68% and gradually increased to reach 4.4% at the third day, it continued to increase slightly after the third day of lactation until it reached 5.58% at the tenth day.

The lactose content of (dromedary) camel milk varies from 2.40to 5.80%, and the average is 4.4 ±0.7 percent (konuspayeva *et al* ,2009). The wide variation of lactose content could be due to type of plants eaten in the deserts (khaskheli *et al,* 2005)

Camel usually prefer halophytic plants such as a triplex, Salosa and Acacia to meet their physiological requirements of salts (Omer *et al,* 2010).

2.9.4 Minerals:

The total content of minerals is usually expressed as total ash; this amount varies from 0.60 to 0.90 % in Dromedary camel milk and the average is 0.79-0.0 percent (Omer, *et al*, 2010).

The minerals Na, K, Fe, Cu and Mn in Dromedary camel milk were substantially higher than bovine milk and the phosphorus content of camel is higher than that of cows, buffaloes, sheep and goats (Ahamd, *et al*, 2010)

2.9.5 Vitamins content:

The total vitamin content of milk is highly variable and depends on the vitamin status and the feeding regime of the mother (with the level of water-soluble vitamins being more influenced by the feed than the level of the fat-soluble vitamins) (Claeys *et al* , 2014). Camel milk was reported to contain various vitamins, such as vitamin C, A, E, D and B group (Haddadin *et al*,, 2008).

The vitamin content of camel milk differs from cow's milk in that it includes a higher level of vitamin C and niacin (Omer, *et . al*, 2010)

2.10 Medicinal properties and uses of camel milk:

Also, camel milk is known for its medicinal properties, which are widely exploited for human health, as in several countries from the ex-Soviet Union and developing countries. Camel milk is considered to have anti-cancer, hypo-allergic and anti-diabetic properties ; it contains the double amount of insulin of cow milk (Wernery, *et al,*2008) A high content in unsaturated fatty acids contributes to its overall dietary quality (Konupayeva, *et al,*2009).

2.11Yogurt:

Yogurt is defined as the product being manufactured from milk-with or without the addition of some natural derivative of milk, such as skim milk

powder, whey concentrates caseinates or cream- with a gel structure that results from the coagulation of the milk proteins, due to the lactic acid secreted by defined species of bacteria cultures. Furthermore, these bacteria must be “viable and abundant” at the time of consumption (Sfakianakis and Tzia 2014).

According to the Code of Federal Regulations of the United States Food & Drug Administration (FDA), yogurt can be defined as a food produced by culturing one or more of the optional dairy ingredients namely, cream, milk, partially skimmed milk, and skim milk, used alone or in combination with a characteristic bacterial culture that contains lactic acid producing bacteria, *Lactobacillus bulgaricus* and *Streptococcus thermophilus*(CFR, 2008).

Yogurt should contain at least 3.25% of milk fat and 8.25% of Milk Solids Non Fat (MSNF) with a titratable acidity of not less than 0.9 percent, expressed as lactic acid (CFR, 2008) .

Yoghurt is one of the most popular fermented dairy products widely consumed all over the world. It's obtained by lactic acid fermentation of milk by the action of a starter culture containing streptococcus thermophilus and lactobacillus delbrueckii ssp. Bulgaricus. The role of these two genera in yoghurt manufacture can be summarized as milk acidification and synthesis of aromatic compounds (Chougrani, *et al*,2009).

The origin of yogurt is dated back to the 6000 B.C. when the Neolitic people in the Central Asia transformed from a status of a food gatherer to a food producer where they began the practice of milking their animals, (Weerathilake , *et al*,2014).

The natural yoghurt is characterized by a smooth and viscous gel like texture and has a delicate walnutty flavor. In fact, the fermentation of lactose by lactic acid bacteria results in the production of lactic acid, carbon dioxide,

acetic acid, diacetyl, acetaldehyde and several other components giving a characteristic flavor to yoghurt (Ahmad, *et al,*2013).

Being nutritionally rich in protein, calcium, riboflavin, vitamin B6 and vitamin B12, yoghurt is considered to have more nutritional benefits than milk (Ilze and Dace K. 2013).

The product is accepted by consumers due to its flavor and aroma, mainly attributed to acetaldehyde and texture (Ashu, *et al,*2013).

The manufacturing processes of yogurt differ depending on the country, but it always comprises a lactic fermentation that brings milk to gelification due to destabilization of the protein system. It is normally retailed in one of the three physical states, namely set (undisturbed gel in the retail pot), stirred (the acid gel formed during incubation in large fermentation tanks is disrupted by stirring) or fluid (drinking yoghurt), (Tulay 2013).

2.11.1 Yoghurt starter culture:

Micro-organisms are important in dairy products. One of the most important groups of acid producing bacteria in the food industry is the Lactic Acid Bacteria (LAB) which are used in making starter culture for dairy products. The proper selection and balance for starter culture is critical for the manufacture of fermented products of desirable texture and flavor, (Ahmed and Kanwal 2004).

2.11.2 Health benefits s of yoghurt:

The nutrient composition of yogurt is based on the nutrient composition of the milk from which it is derived, which is affected by many factors, such as genetic and individual mammalian differences, feed, stage of lactation, age, and environmental factors such as the season of the year. Other variables that play a role during processing of milk, including temperature, duration of heat exposure, exposure to light, and storage conditions, also affect the nutritional

value of the final product. In addition, the changes in milk constituents that occur during lactic acid fermentation influence the nutritional and physiologic value of the finished yogurt product , (Oskar, *et al,*2004). The specific health benefits depend on the strain and viability of the culture in yoghurt (Hassan and Amjad 2010) ,the source and type of milk solids that may be added before fermentation, and the temperature and duration of the fermentation process (Oskar, *et al,* 2004).

Yogurt is considered as healthy food due to its high digestibility and bioavailability of nutrients and also can be recommended to the people with lactose intolerance, gastrointestinal disorders such as inflammatory bowel disease and irritable bowel disease, and aids in immune function and weight control , Because of these health benefits associated with yogurt consumption, there is an increasing trend for yogurt and is the fastest growing dairy category in the market in particular, standard yogurt and yogurt drinks (Weerathilake, *et al,*2014).

Yoghurt is more nutritive than milk in vitamin contents for its digestibility. It is also used as sources of calcium and phosphorous. It is believed that yoghurt has valuable "therapeutic properties" and helps in curing gastrointestinal disorders. Yoghurt may aid digestion, ease diarrhea, boost immunity and protect against cancer (Hassan and Amjad 2010)

Being nutritionally rich in protein, calcium, riboflavin, vitamin B6 and vitamin B12, yoghurt is considered to have more nutritional benefits than milk (Ashraf and. Shah 2011).

Benefits of (LAB) bacteria in yogurt on the gastrointestinal function and health: Yogurt and (LAB) bacteria contribute to several factors that enhance the gut function and health: the make of gastrointestinal flora, the immune response against pathogens. Gut micro flora plays a major role against exogenous infectious bacteria through colonization resistance. Most of the bacteria that cross the barriers of stomach and small intestine will be live, metabolically active and colonized with in the gut ecosystem (Bourlioux *et al,*, 2003).

2.11.3 Manufacturing of yoghurt:

The process of yoghurt making is an ancient craft which date back thousands of years, and over the last few decades the process has become more rational due to improvements in such disciplines as microbiology, engineering and chemistry (Peiman , *et al*, 2011).

The main processing steps of yoghurt making:

The main processing steps in the manufacture of these products include milk standardization, heat treatment, homogenization, addition of starter culture and fermentation, next cooling and finally storage of end product. Many other processing steps (e.g. Addition of sugar or fruit) practiced for some products (Lucey, 2002).

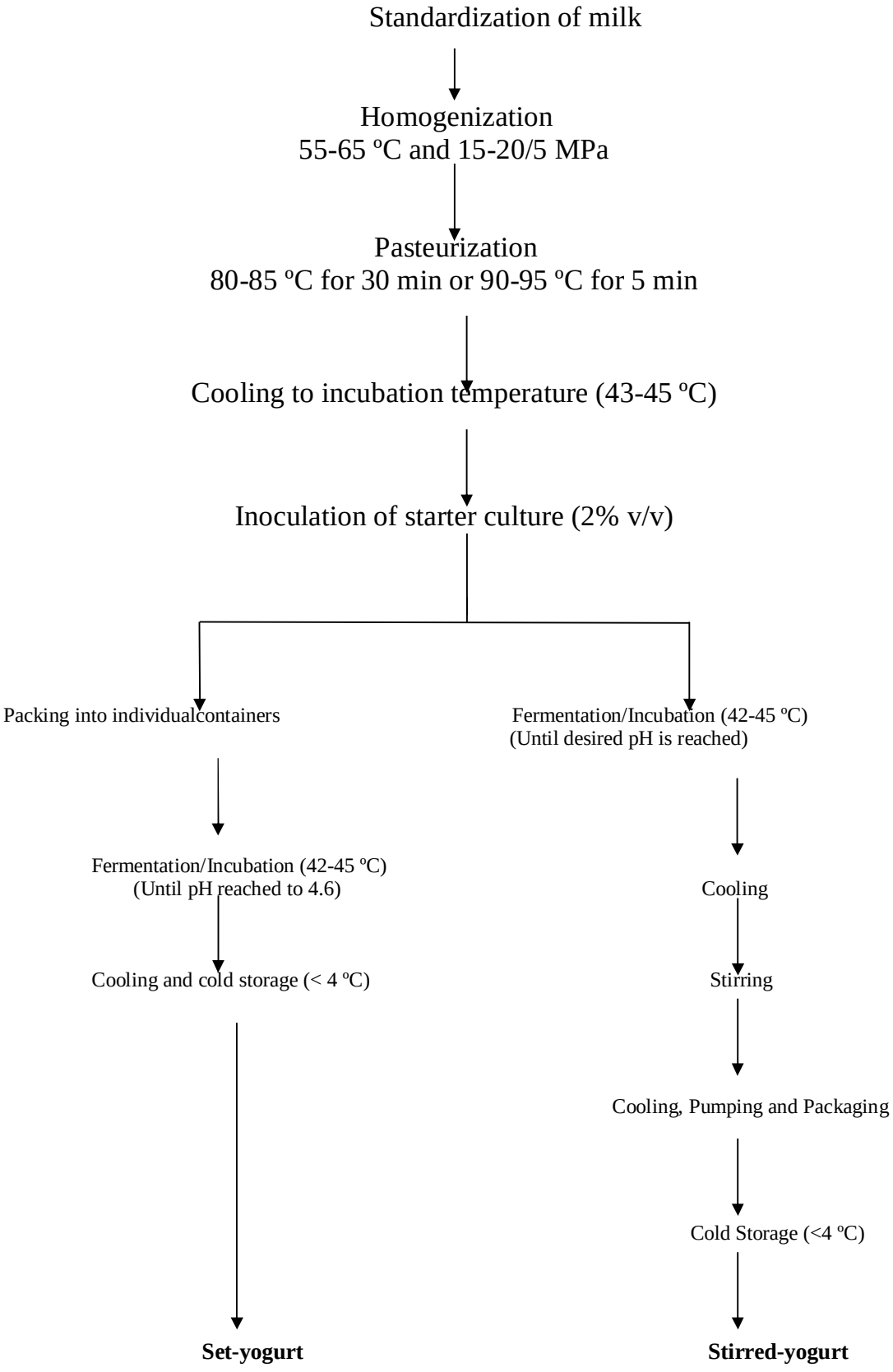
2.11.3.1 Milk Standardization:

In yoghurt production we have to consider important basics in manufacture, that is the fat content should be standardized to the level preferred by the market, and also the total solid is often being increased by adding dried skim milk, condensed milk or skim milk or liquid milk .this procedure gives high total solids (Smith and Hui, 2004), and the increase in milk solids is to get amore firm coagulum, (Hassan, 2010).

2.11.3.2 Homogenization:

Homogenization treatment reduces the diameter of fat globules to less than 1μm and ensures uniform distribution throughout the food matrix, thus considered as an important processing step especially for yogurt with high fat content. Consequently, it results no distinct creamy layer on surface of the yogurt and improves consistency of the yogurt (Weerathilake, *et al* 2014). The use of homogenization prevents fat separation (creaming) during fermentation or storage, reduces whey separation, increases whiteness (Lee and Lucey, 2010)

Figure2.1 The production steps in manufacture of stirred- and set yogurt are illustrated by (Weerathilake, *et al*,2014).



2.11.3.3 Heat Treatment:

It is generally considered that the heat treatment of milk is an essential step in yogurt manufacturing process that greatly influences the microstructure and physical properties of yogurt. Heat treatment has a number of beneficial effects as it will destroy the microorganisms present in milk or yogurt mixture which can potentially interfere with the controlled fermentation process, will denature the whey proteins that will give the final product a better body and texture, and will release the compounds in milk that stimulate growth of the starter culture microorganisms. In addition, it will help some ingredients to achieve the required state to form gels and protein lattice, that affects the final texture and viscosity of the product while aids in removing dissolved oxygen in the milk and thereby assists the starter culture growth as they are sensitive to oxygen (Weerathilake, *et al*,2014**).**

2.11.3.4 Fermentation process (Inoculation and incubation)

After heat treatment, the milk base is cooled to the incubation temperature used for growth of the starter culture an optimum temperature of the thermophilic lactic acid bacteria, i.e., *Streptococcus* subsp. *thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*, is around 40- 45°C. Bacterial fermentation converts lactose into lactic acid, which reduces the pH of milk. During acidification of milk, the pH decreases from 6.7 to ≤4.6, (Lee and Lucey, 2010).

2.11.3.5 Cooling

When yogurt has reached the desired pH (4.5-4.6), it will then often blast chilled to refrigerated temperatures (<10 ºC) in order to stop the fermentation process and thereby stops further acid development (Weerathilake, *et . al* 2014).

2.11.3.6 Shelf life of yoghurt

The shelf life of fresh yoghurt may be only a couple of weeks for unprotected operations and up to 6 weeks or more for well – operated , ultraclean operations and short , even if stored at low temperatures this may be due to the sanitary problems usually associated with its production and due to unhygienic handling of the product, which increases microbial contamination (Multag and Hassan , 2008). The high microbial load of yoghurt, coupled with the packaging and storage conditions, result in the formation of off – flavors and undesirable physicochemical changes that eventually lead to rejection of the product (Muir and Banks, 2000). One of the most accepted ways extend the shelf life o perishable food products are through the use of bio- preservatives (Multag and Hassan, 2008).

2.11.3.7 Factors affecting the quality of yoghurt

There are many factors affecting the quality of yoghurt, but the most important factors are :types and composition of milk, heat treatment, starter cultures ,storage period of yoghurt and the additives In yoghurt, (Deeth, *et al,*, 1981).

2.12 Camel Milk Yoghurt

Farah *et al,* (1990) studied the preparation and consumer acceptability tests of fermented camel milk (*Suusa*). They found that the consistency of fermented milk (under lab conditions) was thin and a precipitate in the form of flocks was formed rather than a coagulum after fermentation. These reports clearly show the difficulty of producing fermented camel milk products with high consistency due to the problem associated with milk coagulation. Camel milk contains good amounts of lysozyme, lactoferrin, Lactoperoxidase, immunoglobulin G and secretory immunoglobulin A; these antimicrobial factors were present at significantly greater concentrations in camel milk and

were more heat stable compared with those in cow and buffalo milks (El-Agamy *et al*,,1992).

2.13.Nutritional Value of Camel Milk Yoghurt

Yoghurt is a pure, non-allergic, organic health product with antibacterial qualities. It contains non-saturated fatty acids, Vitamins B and C and iron. And the Approximate minimum per 100g value of camel yoghurt found to be energy 202kj, fat 2.5g, protein 3.0g Carbohydrate 4.8g and calcium 0.132g,(Price, Weston, 2008).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials:

Fruits were collected from bahry market; The pulp was separated from the seeds, mixed .and passed through a British Standard sieve No 125. Fresh camel milk was obtained from Camel Research Center University of Khartoum (Shambat) and fresh cow milk was obtained from Animal Production Department dairy farm, College of Agricultural Studies, Sudan University of Science and Technology (Shambat). Fresh milk samples were taken in clean plastic containers to National Food Research Center laboratory for f physiochemical analysis.

3.2 Methods:

3.2.1 Physicochemical analysis of Baobab fruit pulp:

3.2.1.1 Determination of Moisture content:

Moisture content was analyzed according to AOAC (2005). Baobab fruit sample (3g) was transferred in pre-weighed flat bottom aluminum dish, and transferred to hot air oven(101±1°C) for 4±1 h. Dried sample was then placed in desiccator (1h) having silica gel as desiccant. The weight of dish with dried sample was taken and calculation was made by applying the following formula:

$$\text{Moisture (\%)} = \frac{W2-W3}{W2-W1} \text{ X } 100$$

W1 = weight of empty dish.

W2 = weight of dish + sample.

W3= weight of dish + dried sample

The dry matter (DM) as percent was calculated by subtracting the percentage of moisture content from 100%.

3.2.1.2 Determination of crude protein:

The crude protein of the sample was determined using modified Kjeldhal method described by AOAC, (2000) whereby 2g of the samples were transferred into a clean 250ml Kjeldah digestion flask. 2g of the catalyst mixture was added and 25ml of concentrated H_2SO_4 was also added. The mixture was digested for about 5hours when the pale-blue colour appeared. The content of the digestion flask was transferred to 100ml volumetric flasks and adjusted to the mark. A blank was also prepared the same way. 20ml of 2% boric acid was transferred into a conical flask and 4 drops of a mixed indicator(Bromo crysol green and methyl red)were added. A 50ml burette was filled with 0.01M HCI. The distillation assembly was turned on but the steam trap was left opened. The condenser tip was immersed into the boric acid. 10ml of blank digest was introduced from the sample introduction cork and the funnel was rinsed with 3ml of distilled water and then 25ml of 30% NaOH was introduced. The cork was closed after rinsing with 2ml of distilled water and the steam trap was also closed. When the colour of the boric acid was changed, the condenser tip was washed with distilled water and the boric acid mixture in the flask was titrated with standard 0.01M HCI until the colour disappeared. The procedure was repeated two times with the blank and two times with the sample digests and the averages of the titers were calculated.

Calculation:

$$\text{Nitrogen (\%)} = \frac{Vol\ (sample - blank)\ HCl\ x\ normality\ of\ HCl\ x\ 0.014\ x\ 100}{\text{Weight of sample}}$$

$$\text{Protein (\%)} = \text{N (\%)} \times 6.38$$

3.2.1.3 Determination of crude fat:

The crude fat in the product was determined according to the standard analytical method of A.O.A.C, (2003).

Principle:

The method determines the substances which are soluble in petroleum ether (B.P, 40 – 60ºC) and extractable under the specific conditions of Soxhlet Extraction method. The dried ether extract is weighted and reported as percentage of the dry matter as crude fat.

Procedure: A sample of 5gm ± 1mg was weighed into an extraction thimbles (30 100 mm) and covered with cotton that previously extracted with petroleum ether. Then, the sample and a pre-dried and weighed Erlenmeyer flask containing about 100 ml petroleum ether (No 1622, BDH, England) were attached to the extraction unit (Electrothermal, England) and the temperature was adjusted to produce about 150 to 200 drops of the condensed solvent per minute for 16 hours. At the end of the distillation period, the flask was disconnected from the unit and the solvent was redistilled. Later, the flask with the remaining crude ether extract was put in an oven at 105 ºC for 3 hours, cooled to room temperature in a desicator, reweighed and the dried extract was registered as crude fat (% DM) according to the following formula:

Calculation:

$$\text{Crude fat [\%DM]} = \frac{\text{dry extracted weight (g)} \times 100 \times 100}{\text{sample wt (g)} \times [100 - \text{sample moisture (\%)}]}$$

3.2.1.4 Determination of Ash content:

This was done according to Danbature, *et al*,(2014) whereby 5g of the samples were placed into each of the pre-weighed porcelain crucibles and ashed in a furnace at 600ºC for about 7hours when the ash was completely

white. The porcelain crucibles were then removed from the furnace, allowed to cool in a descicator and were reweighed

$$\% \text{ Ash of the sample} = \frac{(C2 - C3)}{5\text{g}} \times 100$$

C1 = weight of empty crucible

C2 = weight of crucible + sample

C3 = Weight of crucible + ash

3.2.1.5 Determination of crude fiber:

Percentage crude fiber was determined using the method described by Danbature, *et al,*(2014) with modifications where by 3g of fat free samples were weighed (cake from extraction). Two 500ml digestion flasks were prepared one containing 200ml of dilute (1.25g/100ml) H_2SO_4 and another containing 200ml dilute (1.25g/100ml) NaOH. Each was connected to a condenser, and was allowed to boil. 3g of samples were transferred to the boiling H_2SO_4 solution and allowed to continue boiling for 30 minutes. The solution was filtered through linen using Buchner set under light vacuum. It was washed with hot water until it was acid free. The residue was transferred to hot NaOH solution in the second flask. The solution was then brought to boil and left to continue boiling for 30 minutes. The flask was shaken intermittently to subdue the frothing that occurs during boiling. The digest was also filtered through Buchner funnel whereby a piece of muslin cloth was placed on the Buchner funnel and over the lining of the ashless filter paper and was snugly fitted. 10% of hot solution of K_2SO_4 was added to facilitate the filtration and dilute H_2SO_4 was added to reduce the time for filtration. The residue was washed repeatedly with hot water to make the residue free from NaOH and the filtrate was tested with phenolphthalein indicator. The residue was dried along with the filter paper at 100^{o}C and was reweighed. The weight of the filter paper was subtracted to obtain weight of the residue (crude fiber and some minerals). The residue was transferred along with the paper to tared

silica crucible and the content was ignited at 450-500^{o}C in a muffle for 30 minutes. The crucible was cooled in a descicator and weighed for ash.

$$\text{Crude fiber \%} = \frac{W_1 - W_2}{S(100-M)X100}$$

Where:

W_1: Weight of sample before ignition

W_2: Weight of sample after ignition

S: Original weight sample

M: Moisture content of sample

3.2.1.6 Determination of pH:

pH was determined by electric pH meter (Hanna instrument pH 209) . 10ml of milk were pipetted into the tube, then the pH meter was adjusted with buffer pH 4, the pH meter was placed into the sample and the pH was directly read.

3.2.1.7 Determination Titratable acidity (TA):

Acidity was determined by the AOAC method No. 947.05 (AOAC 2000). Nine mL of milk sample was taken in a titration flask and 2-3 drops of phenolphthalein were added to it. The sample containing indicator was titrated against 0.1N NaOH until light pink end point appeared and for few seconds. Volume of 0.1 N NaOH used was recorded to determine acidity of milk in terms of lactic acid by using, the following expression:

% Acidity (as lactic acid) = Volume of NaOH used X 0.1

3.2.2 Determination of Minerals:

The amount of minerals present in the sample was determined as described by AOAC (2005). The ash of the sample obtained was digested by adding 5ml of

2M HNO_3 to it in the crucible and heat to dryness on a heating mantle. 5ml of 2M HNO_3 was added again, then boiled and filtered through a whatman No.1 filter paper into a 100ml volumetric flask. The filtrate was marked up with distilled water and made ready for reading of concentration on the atomic absorption spectrophotometer.

3.2.2.1 Minerals determination (P, K ,Ca ,Fe)

Minerals content of the sample were determined according to Jones, (2001). For P determination one gram of sample was weighed in a crucible and ignited at 550ºC, in a muffle furnace till a light grey ash was formed. Then 5 ml of 5N HCL was added to the ashed sample, it was then put in a sand bath for 10 minutes, then filtered into a 50 ml volumetric flask. The filter paper was washed with H_2O ; washing were collected in the same flask, then diluted to volume with H_2O. Five ml of the ash extract was transferred into 50 ml volumetric flask, 10 ml ammonium molbdate vandate reagent (22.5g NH_4 $Mo_7O.2H_2O$ in 400 ml H_2O+ 1.25g ammonium vanadate in 300 ml boiling distilled water) and 250ml conc. HNO_3 was added, mixed and completed to one liter, then mixed again after 30 minutes. The intensity of colour was red at 470 nm wavelength UV. 1120- 02 by atomic absorption Spectrophotometer, SHIMADZU model A-A 6800.

Potassium determination:

One ml of mineral extract was put into a 50 volumetric flask, diluted to volume (100 ml) with distilled water, and then taken potassium for determination by Flame photometer.

Calculation:

$$\text{Potassium} = \frac{\text{Flame photometer reading} \times \text{dilution factor} \times 10}{\text{molecule weight} \times 100}$$

3.3 Physicochemical analysis of raw milk (cow and camel):

3.3.1Determination of pH:

The pH of the mixture was measured by using a recalibrated pH meter model (HI 8521 microprocessor bench pH / MV meter). This has been calibrated with two standard buffers pH 4 and pH 7 the pH meter was placed into the sample, and the pH was directly read.

3.3.2Titrable acidity (TA)

Titrable acidity was measured as described by Hooi *et al*, (2004) .Ten gram of milk was placed in a bearker and titrated with 0.1 N sodium hydroxide (Fisher Scientific) solution using phenolphelein as indicator end point of TA was calculated as follows:

$$TA\% = \frac{9x0.1ml\ of\ NaOH}{Milk\ weight}$$

3.3.3 Determination of total solids:

Total solids (TS) content was determined according AOAC (2003). Clean aluminum moisture dishes were dried at 105 ^{o}C for 3 hrs. Five 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. The dishes were transferred to desiccators, cooled and weighted. Heating, cooling and weighting were repeated several times until the difference between successive weighting was less than 0.1mg .The total solids (T.S) content were calculated as follows:

$$T.S\% = \frac{W_1}{W_2} * 100$$

Where:

W_1= Weight of sample after drying

W_2=Weight of sample before drying

3.3.4 Determination of Solid-non fat:

Solids –non-fat (S.N.F) content was determined from the Following equation:

$$SNF\ (\%) = \%\ T.S\% - Fat\%$$

3.3.5 Determination of fat content:

Fat content was determined by Gerber method as described by AOAC (2003).Ten milliter of Sulphuric acid(specific gravity 1.820 at 155ºC)were measured into Gerber butyrometers, and mixed well , 10.94mL of milk sample was slowly added into butyrometers tube. One milliter of amyl alcohol was added and lock stopper was inserted securely with the stoppers end up .The Gerber tubes were grasped and shacked with precaution until the sample was completed digested .The Gerber tube were centrifuged at 1100 rpm for 4minutes. Butyrometer was then placed in a water bath at 65°C for at least 3 minutes. The fat percent was finally read out directly from the Column.

3.3.6 Determination of moisture content:

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

Principle:

The moisture content in a weighed sample is removed by heating the sample in an oven (under atmospheric pressure) at 105 ± 1Cº.Then, the difference in weight before and after drying is calculated as a percentage from the initial weight.

Procedure:

A sample of 5 gm ± 1 mg was weighed into a pre-dried and tarred dish. Then, the sample was placed into an oven (Kat-NR.2851, Elektrohelios, Sweden) and left to dry at 105±^{1o}C until a constant weight was obtained. After drying, the covered sample was transferred to a desiccator and cooled to room temperature before reweighing. Triplicate results were obtained for each

sample and the mean value was reported to two decimal points according to the following formula:

Calculation:

Moisture content [%

$$\text{Moisture content [\%]} = \frac{[m2-m3]}{[m2-m1]} \times 100$$

Where:

m1 = mass of dish + cover

m2 = mass of dish + cover + sample before drying

m3 = mass of dish + cover + sample after drying

3.3.7 Determination of lactose content:

Preparation of solution:

The standard solution was prepared by dissolving 5mg lactose in to 95ml of distilled water to give 5% (w/v) solution of monohydrate. One ml of this solution was diluted with 500ml volumetric flask to give 75mg Lactose /ml standard solution. The Anthrone reagent was prepared by dissolving 150mg of Anthrone into 100 ml of 70% (w/v) sulfuric acid.

The solution was then cooled and stored overnight.

Procedure:

One ml of milk and yoghurt was pipetted into a 500ml flask with distilled water. The solution was then mixed thoroughly and 0.5ml was transferred to boiling tube (sample) standard stock solution (0.5ml) was transferred to a second boiling(blank).To each tube 10ml ice cooled Anthrone reagent was added. The tube were then transferred to boiling water bath for 6 min then transferred to an ice bath and held for 30 min.

The optical density (O.D) was read at 625nm Lactose content (in mg/100 ml) was calculated as follows:

$$\text{Lactose g/100ml} = \frac{\text{O.D of sample} - \text{O.Dof blank}}{\text{O.D of standard} - \text{O.D of blank}} \text{x} 4.75$$

Where:

O.D =Optical density

3.4 Physicochemical analysis of yoghurt:

3.4.1 Production of yoghurt

5 liter of cow's Milk and 5 liter camel's milk divided in to five treatments (A : control , B :5g of Baobab fruit pulp , C :10g of bBaobab fruit pulp, D:15g of Baobab fruit pulp and E :20g of Baobab fruit pulp).

3.4.1.1 Treatment:

Milk was pasteurized at 85 ºC for 30 min. As described by (Dirar 1993) and cooled to 43 ºC. Then the starter culture of (*Lactobacillus bulgaricus and Streptococcus thermophilus)* at the rate of 2% added and blended thoroughly, measured and mixed ,then the amount of whole sample became cow's milk and 1000ml camel's milk,1000ml,packed in plastic cups (200ml capacity) for analysis and incubated at 43 ºC for (4-6 hours). Then the yoghurt transferred to refrigerator at 4 ºC for 1 days. The yoghurt samples physiochemical component were analyzed and Sensory evaluation done, replicated for each treatment. Samples from each batch were storage for 10 days to determine their total solid, acidity and pH after storage period.

3.4.2 Determination of protein:

The crude protein was determined by the micro-Kjeldahl method according to AOAC(2003) as follows:

Digestion:

Two gram of sample was weighed and placed in small digestion flask (50ml), about 0.4 gram catalyst mixture (96% anhydrous sodium sulphate and 3.5%copper sulphate) was added and 3.5ml of approximately 98%of H_2SO_4 was added. The contents of the flask were then heated on an electrical heater

for 2hours till the colour changed to blue-green. The tubes were then removed from digester and allowed to cool.

Distillation:

The digested sample was transferred to the distillation unit and 20ml of 40%sodium hydroxide were added. The ammonia was received in 100ml of 2%boric acid plus 3-4 drops of methyl red indicator. The distillation was continued until the volume reached 50ml.

Titration:

The content of the flask were titrated against 0.02 N HCL. The titration reading was recorded. The crude protein was calculated using the following equation (calculated on dry matter basis):

$$CP\% = \frac{(T - B) \times N \times 14 \times 100 \times 6.25}{Ws} \times 1000$$

Where:

CP= crude protein

T= Titration reading

B= Blank titration reading

N= HCl normality

Ws= sample weight

1000= to convert to mg

3.4.2 Determination of Ash:

The ash content was determined by gravimetric method AOAC (2003).Five grams of the samples were weighed in porcelain crucibles, then placed in a muffle furnace at 550-600 ^{o}C for 3 hrs until ashes were carbon free . The

porcelain crucibles were then cooled in desiccators and weighed. The ash content was calculated using the following equation:

$$\text{Ash\%} = \frac{W_1}{W_2} x100$$

Where:

W_1= Weight of ash

W_2=Weight of sample before ashing

3.4.3 Determination of fiber:

It was determined according to AOAC (2003). Tow gm of defatted sample were weighed, 150 ml of H_2SO_4 (CONC.7.3 ml/L) were added and then heated to boiling the mixture was boiled for 30min and then filtered . The residue was washed three times with hot water , and then 150ml of preheated KOH (12.89 mg/L) were added and then heated to boiling . The system was boiled for 30 min and then filtered , the residue was washed three times with hot water, and it was dried under suction and then in an oven at 150^{o}C overnight .The residue was weighed then placed in muffle furnace at 550 ^{o}C for 3hr till a light grey ash was formed then weight to a constant weight.

$$\text{Crude fiber \%} = \frac{(W_1 - W_2)}{S(100 - M)X100}$$

Where:

W_1: Weight of sample before ignition

W_2: Weight of sample after ignition

S: Original weight of sample

M: Moisture content of sample

3.4.4 Determination of syneresis:

Wheying off is made by a measuring cylinder taking the whey separated from the set youghurt. It was measured by sucking the water on the surface of the curd and pouring it in the cylinder according to (A.O.A.C, 2000).

3.4.5 Determination of viscosity:

Measurements of viscosity were done with Brookfield DV-E Viscometer. Spindle No 3at 20 rpm was used for a glass tube and anormalized ball equipped with a chronometer at 25°Cand was expressed as mPas. Every experiment was repeated 3 times to have some meaningful results, as described by Denin *et al*,, (2001).

Viscosity was monitored during storage at 4^{o}C after 1day.

3.5 Microbiological analysis of yoghurt:

3.5.1 Preparation of Serial dilution of samples:

One ml of each milk sample and1gm of yoghurt sample was weighed aseptically and added to test tube containing 9ml of sterile diluents(1% pepton solution) and well mixed to give 10^{-1}; using sterile pipette , 1ml of the last dilution was transferred to test tube containing 9ml of sterile diluents and well mixed to give 10^{-2} in the same way continued to the prepare other serial dilution (Harrigan, 1998).

3.5.2Sterilization of glassware:

Glassware was washed thoroughly, left to dry and sterilized in a hot air oven at 160 C^{0} for at least 3 hours (Harrigan and McCance, 1976). Instruments such as loops, needles, forceps, spoons and Knives were sterilized by flaming directly after dipping in spirit.

3.5.3 Culture media used:

3.5.3.1 Nutrient agar (Oxoid):

The nutrient agar was used for cultivation of bacteria. Twenty- eight grams of dehydrated nutrient agar were suspended in a liter of distilled water, steamed to dissolve completely, the pH was adjusted(NaOH) to 7.4 then the medium was sterilized by autoclaving at 121˚C for 15 minutes (Harrigan and McCance, 1976).

3.5.3.2 Plate count agar (Oxoid):

The plate count agar medium was used to determine total bacterial count. Seventeen and half grams of this media were suspended in a liter of distilled water, dissolved by bringing to boiling with frequent stirring, mixed and distributed into conical flasks sterilized by autoclaving at 121˚C for 15 minutes (Harrigan and McCance, 1976).

3.5.4 Microbial tests:

3.5.4.1 Total bacterial count:

One ml of each serial dilution was transferred aseptically in to sterile Petri dishes. 15ml of plate count agar were added. The inoculums was mixed with medium and allowed to solidify. The plates were then incubated at 37˚C for 24 hrs. Plates were examined and the colonies on every plate were counted (limener CRUNA,CR870 FA)then the total viable count was determined as colony forming unit per ml (cfu/ml) (Harrigan, 1998).

3.6 Statistical analysis

Data generated were subjected to SAS (version 4.1) the following designs were used (two –factor RCD (ANOVA) was assessed for the experiment of the effect of source of milk and levels of Baobab fruit added where factor A= source of milk and factor B = level of addition (0,1,2,3,4%).

Three –factor RCD (ANOVA)was assessed for the experiment of the effect of source of milk , levels of Baobab fruits added and storage period (shelf life), where factor A= source of milk (cow, camel) , factor B= levels of addition (0,1,2,3,4%) and factor C=storage period (0,6,10 days).

Means were separated using DMRT as described by Snedecor and Cochran (1987).

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Physicochemical analysis of Baobab fruit pulp:

Results of physicochemical analysis are shown in table 4.1

4.1.1 Moisture content

The moisture content in Baobab fruit powder was 6.33% the value its lower than Oyeleke *et al* (2012) and Oscar *et al* (2012) and Gebauer, . *et al* (2002) Savadogo *et al*(2011) who reported ,7.22% ,and in agreement with Nour *et al* (1980) who reported 6.7%.These differences can be attributed to soil, climate, and strain(Osman 2004).

4.1.2 Protein

Protein content in Baobab fruit powder in this study was 4% this result is higher than Osman (2004) who reported 3.2 % and Oyeleke *et al* (2012) how reported 3.5%,and Adedayo (2011) who reported 2.2% and Nour *et al* (1980) The incidence of soil and climatic conditions, and ripeness stage at harvest were factors that could explain these variations (Lockett *et al,* 2000).

4.1.3 Fat

Fat content in Baobab fruit powder in this study was 1% its higher than Oyeleke *et al* (2012) who reported 0.4%,Therefore, the observed variations may result from the analytical methods used, but also from the different Baobab ecotypes and species studied (Ibrahima *et al* 2013).

4.1.4 Ash

Ash content in Baobab fruit powder in this study was 3.5 % it was higher than Oscar (2012) and Eldoom (2014) who reported 1.33 % and lower than Nour *et al* (1980), Osman (2004), Adedayo (2011) who reported 4.5%,5.3%

respectively and ranged with Oyeleke *et al* (2012) The incidence of soil and climatic conditions, and ripeness stage at harvest were factors that could explain these variations (Lockett *et al,* 2000).

4.1.5 Crude Fiber

Crude Fiber content in Baobab fruit powder in this study was 37.33% this result it was higher than Osman (2004), Oyeleke *et al* (2012), Nour *et al* (1980) Murray *et al,* (2001),. who reported 5.4%, 6.1% 5.7%,45.10 % respectively, These differences may be the species, maturity of the fruits, and environmental soil and climate(Murray *et al,* 2001).

4.1.6 Calcium

Calcium content in Baobab fruit powder in this study was 285.67 mg/100g this result it was higher than Oyeleke *et al* (2012), Lockett *et al,* (2000), 211 mg/100g and lower than Ibrahima *et al,*(2013) , Osman (2004), Nour *et al* (1980). who reported 345 mg/100g, 295 mg/100g655 mg/100g respectively, It may be associated, at least in part, with the soil type and origin of samples(Ibrahima *et al* 2013).

4.1.7 Phosphorus

Phosphorus content in Baobab fruit powder in this study was 114.67 mg/100g this result was higher than Oyeleke *et al* (2012) and Obizoba and Amaechi (1993); Saka and Msonthi ,(1994); Glew *et al,* (1997); Sena *et al,* (1998) and Ibrahima *et al,*(2013) who reported 80 mg/100g It may be associated, at least in part, with the soil type and origin of samples(Ibrahima *et al* 2013).

4.1.8 Iron

Iron content in beabab fruit powder in this study was 7 mg/100g this result it was lower than Nour *et al*(1980) ,Osman (2004), Ibrahima *et al,*(2013) who reported 8.6 mg/100g ,9.3 mg/100g ,10 mg/100g respectively. And highest

than Oyeleke *et al* (2012) who reported 5.85 mg/100g It may be associated, at least in part, with the soil type and origin of samples (Ibrahima *et al* 2013).

4.1.9 pH

The pH of beabab fruit powder in this study was 4.13%, this result is lower than that of Oyeleke *et al* (2012) who reported 5.60 % and higher than Ndabikunze *et al* (2011) and, Nour *et al*(1980). Who reported 3.3 %, Pedoclimatic conditions and storage conditions of the pulp were among factors that might explain such variations(Ibrahima *et al* 2013).

4.1.10 Titrable Acidity

The titrable Acidity of beabab fruit powder in this study was 0.37% this result is lower than that Oyeleke *et al* (2012) who reported 0.36 %, Pedoclimatic conditions and storage conditions of the pulp were among factors that might explain such variations (Ibrahima *et al* 2013).

Table 4.1: Physicochemical analysis of Baobab fruit pulp:

Moisture%	6.33±0.3
Protein%	4±0.0
Fat%	1±0.0
Ash%	3.5±0.176
Crude Fiber%	37.33±0.33
Calcium mg/100g	285.67±0.33
Phosphorus mg/100g	114.67±0.67
Potassium mg/100g	2.36±0.0058
Sodium mg/100g	7±0.0
pH%	4.13±0.033
Acidity%	0.37±0.003

4.2 Physicochemical analysis of cow and camel milk

Table 4.2 shows results of physicochemical analysis of cow and camel milk

4.2.1 Moisture

The moisture content in camel milk its 89.07% this result was in agreement with Ahmed *et al*, (2014),who reported 87.5-91.6%,and Alwan *et al* (2014)and highest than Meiloud *et al* (2011). The difference can be due to seasonal variations, geographic variations and availability of drinking water (Park and Haenlein, 2006).

4.2.2 Protein

Protein of camel milk in this study was 3.06%which is lower than 3.46%that reported by Shamsia(2009), and lower than 3.56 %,3.44 respectively reported by Desouky *et al*(2015), Desouky *et al* (2013) ,and higher than 2.50% reported by Meiloud *et al* (2011) ,and ranged with Konuspayeva *et al* (2009) reported (2.15to 4.90%) these differences can be due to differences in feeding, lactation period and breed(Adugna and Asresie 2014).

4.2.3 Fat

Fat content of camel milk in this study was 3.13% which is lower than4.0 %, 3.5%,4.0% respectively that reported by Shamsia (2009) , Al-Haj *et al* (2010) and Rathore *et al* (2011), and higher than 3.00% that reported by Alwan *et al* (2014), and in agreement with Lafta *et al* (2014) who reported 3.57-4.03% . The difference can be due to difference in feeding condition and breed(Gaili *et al*,, 2000; El-Hatmi *et al*, 2004).

4.2.4 Ash

Ash content of camel milk in this study was 0.76% this result is in agreement with Lafta *et al*(2014) who reported 0.77 -0.82% and lower than Desouky *et al*(2015) who reported 0.85% and Elamin and Wilcox (1992) reported 0.80% and Al-Haj *et al* (2010) reported 0.79%. These variations could be due to

several factors including analytical measurement procedures, water availability, stage of lactation, age, breeds and number of calving.

4.2.5 Lactose

Lactose content of camel milk in this study was 3.96%,this result is in agreement with 2.40 to 5.80% reported by Konuspayeva *et al* (2009) and lower than 4.86% reported by Shamsia (2009), Rathore *et al* (2011),4.91 % by Meiloud *et al* (2011) and 4.62% by Hashim *et al,* (2009) .The differences may be due to the direct effects of the feeding regime, availability of drinking water, in addition to some individual factors including genetics (Yagil and Etzion, 1980; Yagil, 1994).

4.2.6 Total solids (T.S)

Total solids content of camel milk in the present study was 10.93%, the result is in agreement with 9.7±0.3 to 12.5±0.7% that reported by Ahmed *et al* (2014) and lower than 11.9%, 12.56% 12.05%,13.2% respectively reported by Dowelmadina *et al* (2014), Al-Haj and Al-Kanhal, (2010), Desouky *et al* (2015) ,Desouky *et al* (2013) and Shamsia (2009).theses differences in total solids content might reflect the differences in water drinking , availability and seasonal changes (Haddadin, *et al* 2008)

4.2.7 Solids-Not-Fat (S.N.F)

Solids-Not-Fat content of camel milk in the present study was 7.79%, the result is in agreement with 7.1and 9.5.8% reported by Guliye *et al,* (2000) and Mal *et al,(*2006, 2007), and higher than 7.3% reported by Ahmed *et al* (2014), and lower than 8.99% reported by Dowelmadina *et al,*(2014). These variations could be due to several factors including analytical measurement procedures, water availability, stage of lactation, age, breeds and number of calving (Musaad *et .al*. 2013).

4.2.8 Phosphorus

Phosphorus content of camel milk in the present study was 81 mg/100g ,this result is higher than 76% reported by Shamsia (2009) and Rathore *et al* (2011). These variations could be due to several factors including analytical measurement procedures, water availability, stage of lactation, age and breeds(Musaad *et al,*, 2013).

4.2.9 Potassium

Potassium content of camel milk in the present study was 62 mg/100g which is lower than 156 mg/ 100 ,179 mg/ 100 respectively reported by Khaskheli *et al,* (2005)and Shamsia (2009). These variations could be due to several factors including analytical measurement procedures, water availability, stage of lactation, age and breeds (Musaad *et al,*, 2013).

4.2.10 Calcium

Calcium content of camel milk in the present study was 94.33 mg/100g which is lower than 114 mg/ 100 g, 109 mg/ 100 respectively reported by Khaskheli *et al,* (2005) and Shamsia (2009) the difference might be due to seasons (Ahmed *et al,*2014).

4.2.11 Sodium

Sodium content of camel milk in the present study was 48 mg/100g which is lower than Rathore *et al* (2011) who reported 58 mg/100g. These variations could be due to several factors including analytical measurement procedures, water availability and stage of lactation(Ahmed *et al,*2014).

4.2.12 pH

pH content of camel milk in the present study was 6.46% which is higher than 6.38 % reported by Zeineb *et al* (2013) and lower than Desouky *et al* (2013) and Shamsia 6.6 % (2009) and agreement with Yamina *et al* (2013)

who reported 6.493% and ranged with Lafta (2014) who reported 6.22-6.70 %. Differences may be due to breeds and analytical procedure(Yagil and Etzion, 1980; Yagil, 1984).

4.2.13 Titrable Acidity

Titrable Acidity content of camel milk in the present study was 0.19 % which is higher than Zeineb *et al* (2013) and Shamsia (2009) who reported 0.162% and lower than Ahmed (2014) who reported 0.21% and ranged with Lafta (2014) who reported 0.16-0.19%. the difference may be due to breed and lactation period (Yagil and Etzion, 1980; Yagil, 1984).

Table 4.2: Physicochemical analysis of cow and camel milk

	Camel
Moisture%	89.07±0.036
Protein%	3.06±0.033
Fat%	3.13±0.088
Ash%	0.76±0.0088
Lactose%	3.96±0.088
T.S.S %	10.93±0.036
S.N.F %	7.79±0.058
Phosphorus mg/100g	81±0.57
Potassium mg/100g	62.66±1.76
Calcium mg/100g	94.33±0.33
Sodium mg/100g	48±0.57
pH%	6.46±0.066
Acidity%	0.19± 1.9

4.3 Physicochemical and microbiology analysis of cow and camel milk yoghurt:

4.3.1 The moisture content:

The result in table (4.3) showed significant difference ($p<0.05$) between cow and camel milk yoghurt, however there are significant difference between the different level of Baobab fruit (1, 2, 3, 4%), it had decreased from 88.89-86.75 this result is not in agreement with Olugbuyiro and Oseh (2011) there moisture content of the samples ranged from 78.2-87.1% decreased of moisture compared to control yoghurts may be due to the higher protein and fat content of the treated yoghurt compared to control yoghurt (Ibrahim and Khalifa 2015).

4.3.2 Protein content:

As shown in table (4.4)the protein in 0%,1%,2%,3%,4%sample of Baobab fruit yoghurt of cow and camel milk there were significant differences ($p<0.05$) , however there are significant difference in protein between the different level of Baobab fruit (1, 2, 3, 4%). The highest protein in level 4%, this result is in agreement with Codex regulations for yogurt stating that the minimum milk protein content is 2.7% (except for concentrated yogurt where the minimum protein content is 5.6% after concentration),and (Ibrahim1and Khalifa (2015)).This increase in protein may be due to addition of Baobab fruit pulp(4%).

4.2.3 Fat content:

The result in table (4.5) showed no significant different($p<0.05$) in fat content between plain cow and camel yoghurt , the fat it was increase gradually (3.15-4.25)% in different level of Baobab fruit pulp (1%, 2%, 3%, 4%) in both yoghurt, this result in line (Mehanna, *et al*, 2013) and agreement with USDA (2001) The highest average fat content is 4.00% while the lowest average fat content is 1.88%. According to USDA (2001), This increase may be due to fat of Baobab fruit pulp(1%).

Table 4.3: Effect of addition of different levels of Baobab fruit Pulp on moisture (%) content of cow an camel milk yoghurt

Sample	Source of milk	
	Cow	**Camel**
A	87.97^{bc}±0.02	88.89^{a}±0.53
B	87.82^{bcd} ±0.02	88.37^{ab}±0.62
C	87.37^{cde}±0.13	87.97^{bc}±0.60
D	87.14^{de}±0.08	87.64^{bcd}±0.61
E	86.75^{e}±0.05	87.32^{cde}±0.49
Lsd 0.05	0.6939^{*}	
SE±	0.2352	

Values are mean ±SD

Mean (s) bearing same superscript (s) in column and row are not significantly (P>0.05) different according to DMRT

Table 4.4: Effect of addition of different levels of Baobab fruit Pulp on crude protein (%)of cow an camel milk youghurt

Sample	Source of milk	
	Cow	**Camel**
A	3.67^{de}±0.04	3.23^{e}±0.32
B	3.83^{cd}±0.00	3.47^{de}±0.38
C	4.25^{abc}±0.12	3.79^{cd}±0.42
D	4.37^{ab}±0.02	3.97^{bcd}±0.44
E	4.59^{a}±0.02	4.21^{abc}±0.40
Lsd 0.05	0.4817^{*}	
SE±	0.1633	

Values are mean ±SD

Mean (s) bearing same superscript (s) in column and row are not significantly (P>0.05) different according to DMRT

Table 4.5: Effect of addition of different levels of Baobab fruit Pulp on fat (%) content of cow an camel milk yoghurt

Sample	Source of milk	
	Cow	Camel
A	3.27^{f}±0.04	3.15^{f}±0.16
B	3.47^{e}±0.07	3.45^{e}±0.14
C	3.68^{d}±0.05	3.66^{d}±0.10
D	3.97^{bc}±0.04	3.88^{c}±0.09
E	4.25^{a}±0.05	4.06^{b}±0.10
Lsd 0.05	0.1523^{*}	
SE±	0.05164	

Values are mean ±SD

Mean (s) bearing same superscript (s) in column and row are not significantly (P>0.05) different according to DMRT

4.2.4 Ash content:

The result in table (4.6) showed no significant difference ($p>0.05$) in the ash between plain cow and camel yoghurt , however there was significant difference in ash content from the level of Baobab fruit pulp in both yoghurt it increased gradually(0.816-0.893) in 1,2,3,4%, this is in agreement Joel Ndife (2014) and agree by other researchers (Belewu *et al*, 2010; Eke *et al*, 2013). Increase in Ash may be due to addition of Baobab fruit pulp (3.5%).

4.2.5 Lactose content:

The result in table (4.7)showed no significant different($p>0.05$) in the lactose between plain cow and camel yoghurt , however which significant difference was observed in lactose content from the level of Baobab fruit pulp decreased gradually(4.29-3.42) in 1,2,3,4% Baobab fruit , the result its lower than that reported by Kosikowski (1982) 5.15% , and by Weerathilake *et al* (2014) 7.8%,and in agreement with the results of Ahmad *et al,* (2013). This decrease be due to more availability of lactose to the fermenting microbes (Joel Ndife ,2014)and lactic strains have the ability to ferment lactose into lactic acid, with an increase of acidity and a decrease in pH of fermented milk(Fadela *et al* 2009)

4.2.6 Total solid content:

The result in table (4.8)showed no significant difference ($p>0.05$) in the total solid content between plain cow and camel yoghurt , however there was significant difference in Total solid content from the level of Baobab fruit. It increased gradually(11.21-13.26%) in 1,2,3,4%.this result agreed with (Ibrahim and Khalifa 2015) and in disagreement with (Ahmadoon 2012) the total solid range was (9.4-10.3%).the result is in disagreement with Joel Ndife**(**2014**)** who reported that the total solids decreased in yoghurt samples enriched with coconut-cake by an average of 19.90 -14.77 % and in line with Nuzhat (2003) who reported the total solid of yoghurt increased with addition of apple puree ,this increasr in total solid may be due to higher total solid in Baobab fruit pulp (93.67)%.

Table 4.6: Effect of addition of different levels of Baobab fruit Pulp on ash (%) content of cow an camel milk yoghurt

Sample	Source of milk	
	Cow	Camel
A	0.8167^{i}±0.01	0.8167^{i}±0.01
B	0.8267^{i}±0.01	0.8367^{g}±0.01
C	0.8500^{f}±0.01	0.8567^{e}±0.02
D	0.8600^{d}±0.01	0.8767^{c}±0.02
E	0.8900^{b}±0.01	0.8933^{a}±0.04
Lsd 0.05	0.0005386^{*}	
SE±	0.0001826	

Values are mean ±SD

Mean (s) bearing same superscript (s) in column and row are not significantly (P>0.05) different according to DMRT

Table 4.7: Effect of addition of different levels of Baobab fruit Pulp on lactose (%) content of cow an camel milk yoghurt

Sample	Source of milk	
	Cow	**Camel**
A	4.29^{a}±0.02	4.00^{abc}±0.23
B	4.05^{ab}±0.05	3.89^{bcd}±0.25
C	3.85^{bc}±0.05	3.70^{cde}±0.23
D	3.70^{cde}±0.00	3.59^{de}±0.25
E	3.54^{e}±0.04	3.42^{e}±0.19
Lsd 0.05	0.2799^{*}	
SE±	0.09487	

Values are mean ±SD

Mean (s) bearing same superscript (s) in column and row are not significantly (P>0.05) different according to DMRT

Table 4.8: Effect of addition of different levels of Baobab fruit Pulp on total solids (%) of cow an camel milk yoghurt

Sample	Source of milk	
	Cow	**Camel**
A	12.03^{cd}±0.03	11.21^{e}±0.68
B	12.20^{bcd}±0.04	11.63^{de}±0.62
C	12.64^{abc}±0.13	12.04^{cd}±0.59
D	12.87^{ab}±0.08	12.41^{bcd}±0.58
E	13.26^{a}±0.05	12.73^{abc}±0.44
Lsd 0.05	0.7125^{*}	
SE±	0.2415	

Values are mean ±SD

Mean (s) bearing same superscript (s) in column and row are not significantly (P>0.05) different according to DMRT

4.2.7 Solids-not-fat: SNF content:

As shown in table (4.9)no significant difference ($p>0.05$) in the SNF content between plain cow and camel yoghurt, however was significant difference in TNF content from the level of Baobab fruit it increased gradually (8.05-9.02) in 1,2,3,4%.the result its lower than USDA specification (2001) and FDA (2009), The average range is from 9.49- 18.77%. this increase may be due higher total solid in Baobab fruit pulp (93.67)%.

4.2.8 pH Value:

From Table (4.10) the pH value there is significant difference ($p<0.05$) between plain cow and camel yoghurt, but there was significant difference ($p<0.05$) in pH value from the level of Baobab fruit. It decrease gradually (5.17-4.32) in 1,2,3,4% .Food Standard Code requires that the pH of yoghurt be a maximum of 4.50 in order to prevent the growth of any pathogenic organisms (Donkor *et al,*, 2006),this decrease may be due to add of Baobab fruit pulp which is acidic fruit.

4.2.9Titrable acidity:

It is clear from Table (4.11) no significant differen CE ($p>0.05$) in the Titrable acidity content between plain cow and camel yoghurt , however significant difference is observed in Titrable acidity from the level of Baobab fruit which increased gradually(0.746-0.826%) in 1,2,3,4%.This result is higher than that of Joel Ndife (2014) The Titratable acidity also ranged from 0.52 to 0.67% in the yoghurt samples ,and higher than FDA (2009) requirement. The values obtained for titratable acidity are generally below the standard which is 0.7. This could be due to more availability of lactose to the fermenting microbes (Joel Ndife 2014) and Baobab fruit plup(acidic).

Table 4.9: Effect of addition of different levels of Baobab fruit Pulp on TNF (%) content of cow and camel milk yoghurt

Sample	Source of milk	
	Cow	Camel
A	8.72^{abc}±0.05	8.05^{c}±0.53
B	8.78^{ab}±0.03	8.18^{bc}±0.55
C	8.91^{a}±0.07	8.37^{abc}±0.52
D	8.94^{a}±0.09	8.52^{abc}±0.52
E	9.02^{a}±0.01	8.67^{abc}±0.34
Lsd 0.05	0.6046^{*}	
SE±	0.2049	

Values are mean ±SD

Mean (s) bearing same superscript (s) in column and row are not significantly (P>0.05) different according to DMRT

Table 4.10: Effect of addition of different levels of Baobab fruit Pulp on pH-value of cow and camel milk yoghurt

Sample	Source of milk	
	Cow	Camel
A	5.17^{a}±0.04	5.05^{b}±0.11
B	482^{c}±0.02	4.87^{c}±0.04
C	4.60^{e}±0.00	4.71^{d}±0.09
D	4.47^{f}±0.04	4.59^{e}±0.05
E	4.32^{g}±0.02	4.46^{f}±0.08
Lsd 0.05	0.09329^{*}	
SE±	0.03162	

Values are mean ±SD

Mean (s) bearing same superscript (s) in column and row are not significantly (P>0.05) different according to DMRT

Table 4.11: Effect of addition of different levels of Baobab fruit Pulp on titratable acidity (%) of cow and camel milk yoghurt

Sample	Source of milk	
	Cow	**Camel**
A	0.7567^{i}±0.01	0.7467^{i}±0.02
B	0.7667^{g}±0.01	0.7600^{h}±0.01
C	0.7800^{f}±0.00	0.7833^{e}±0.01
D	0.8000^{d}±0.00	0.8067^{c}±0.02
E	0.8200^{b}±0.00	0.8267^{a}±0.02
Lsd 0.05	0.0005386^{*}	
SE±	0.0001826	

Values are mean ±SD

Mean (s) bearing same superscript (s) in column and row are not significantly (P>0.05) different according to DMRT

4.2.10 Syneresis:

The syneresis of cow and camel yoghurt in table (4.12)there were no significant difference (P>0.05) between plain cow and camel yoghurt, but the syneresis decreased (0.85-0.10) in all samples with the addition different level of Baobab fruit pulp 1,2,3,4% that means significant different in level of Baobab fruit in yoghurt. this result disagrees with the results of Masood (1997). Which is 1.09-3.14. **(ml/450g)** and nuzhat (2003) who reported the addition of apple puree increase the synersis of apple stirred yoghurt. Serum separation occurs in fermented milk products due to the aggregation and sedimentation of casein particles during storage. The use of the Baobab fruit pulp was found to be necessary to prevent serum separation in fermented milk (Lucey *et al*,, 1999;Towler, 1984). When the Baobab fruit pulp were added to yoghurt, serum separation was reduced compared to that in yoghurt without any Baobab fruit pulp .

4.2.11 Crude fiber:

The result in table (4.13) no significant difference (p>0.05) between the plain cow and camel milk yoghurt in Crude fiber , but crude fiber is highly significant in different level of Baobab fruit (1, 2, 3, 4%),and increased gradually(0-37.67)mg/100g from the level, this result agreement with Sanful Rita,(2009); Belewu *et al*, (2010).this increased of crud fiber may be due to higher fiber in Baobab fruit pulp (37.33%).

4.2.12 Viscosity:

The result in table (4.14) show significant difference (p<0.05) between the plain cow milk and camel milk yoghurt in viscosity, and asignificant in difference between level of Baobab fruit pulp (1, 2, 3, 4%). and increased gradually(1000-6500c.p), this result is higher than that of Alaa and Salah (2015) and in agreement with Koksoy and Kilic, (2004); Güven (1998). The increase of viscosity in camel and cow milk yoghurt containing different ratios of Baobab fruit (contain high ratios of pectin) may be due to the interaction between the pectin and casein particles thus contributing a strong gel when the concentration was doubled (Koksoy and Kilic, 2004).

Table 4.12: Effect of addition of different levels of Baobab fruit Pulp on wheying-off (ml/100 ml) of cow and camel milk yoghurt

Sample	Source of milk	
	Cow	Camel
A	0.85^{a}±0.05	0.79^{a}±0.02
B	0.60^{b}±0.00	0.60^{b}±0.0
C	0.45^{cd}±0.0	0.50^{bc}±0.10
D	0.25^{ef}±0.05	0.33^{de}±0.14
E	0.10^{g}±0.00	0.20^{fg}±0.10
Lsd 0.05	0.1204^{*}	
SE±	0.04082	

Values are mean ±SD

Mean (s) bearing same superscript (s) in column and row are not significantly (P>0.05) different according to DMRT

Table 4.13: Effect of addition of different levels of Baobab fruit Pulp on crude fibre (mg/100g) of cow and camel milk yoghurt

Sample	Source of milk	
	Cow	Camel
A	0.00^{f}±0.00	0.00^{f}±0.00
B	31.34^{d}±0.34	29.67^{e}±1.73
C	33.67^{c}±0.67	31.89^{d}±1.34
D	36.17^{b}±0.50	33.89^{c}±96
E	37.67^{a}±0.34	36.34^{ab}±0.58
Lsd 0.05	1.433^{**}	
SE±	0.4824	

Values are mean ±SD

Mean (s) bearing same superscript (s) in column and row are not significantly (P>0.05) different according to DMRT

Table 4.14: Effect of addition of different levels of Baobab fruit Pulp on viscosity (c.p) of cow and camel milk yoghurt

Sample	Source of milk	
	Cow	**Camel**
A	4000.00^{d}±0.00	1000.00^{f}±0.00
B	7000.00^{d}±0.00	1833.33^{e}±288.68
C	5000.00^{c}±0.00	3666.67^{d}±577.35
D	6000.00^{b}±0.00	4833.33^{c}±288.68
E	6500.00^{a}±0.00	5833.33^{b}±288.68
Lsd 0.05	411.4^{**}	
SE±	139.4	

Values are mean ±SD

Mean (s) bearing same superscript (s) in column and row are not significantly (P>0.05) different according to DMRT

4.2.13 Calcium:

The result in table (4.15) show no significant difference ($p>0.05$) between the plain cow and camel milk yoghurt in Calcium, there is significant difference between levels of Baobab fruit pulp (1, 2, 3, 4%). It increased gradually (91.11-213.20) this result is higher than that of Zekai Tarakçı and Beşir Dağ (2013)and Hernandez and Park (2014) and in agreement with De la Fuente *et al* (2003),this increase in Calcium may be due to higher of Calcium in Baobab fruit pulp 285.67 mg/100g.

4.2.14 Phosphorus content:

The results in table (4.16) show significant different($p<0.05$) between the plain cow and camel yoghurt in phosphorus, and significant in difference btween levels of Baobab fruit pulp (1, 2, 3, 4%) between (80-141.70). This result is higher than that Zekai Tarakçı and Beşir Dağ (2013)and Hernandez and Park (2014) and in agreement with De la Fuente *et al* (2003). This increased may be due to the Baobab fruit pulp 114.67 mg/100g.

4.2.15 Potassium content:

The results in table (4.17) shows no significant difference ($p>0.05$) between plain cow and camel milk yoghurt in Potassium, significant different between levels of Baobab fruit pulp (1, 2, 3, 4%).Between (84.84-116.20)mg/100g this result is lower than that Hernandez and Park (2014). This increased may be due to the Baobab fruit pulp 2.36 mg/100g

4.2.16 Na content:

The result in table (4.18) shows no significant difference ($p>0.05$) between the plain cow and camel milk yoghurt in Na, but Na significant in difference between levels of Baobab fruit pulp (1, 2, 3, 4%).It increased between (57-81.84) mg/100g,this result its higher than that of Cichoscki *et al*, (2002) and Zekai Tarakçı and Beşir Dağ(2013), This increase may be due to the Baobab fruit pulp which contains 7 mg/100g.

Table 4.15: Effect of addition of different levels of Baobab fruit Pulp on Ca (mg/100g) of cow and camel milk yoghurt

Sample	Source of milk	
	Cow	**Camel**
A	118.70^{de}±1.67	91.11^{e}±7.15
B	144.70^{cd}±3.00	$121.40d^{e}$±6.28
C	164.80^{bc}±2.17	151.10^{cd}±7.23
D	188.70^{ab}±1.67	$178.90a^{bc}$±9.83
E	$196.40a^{b}$±4.52	213.20^{a}±4.57
Lsd 0.05	31.80^{**}	
SE±	10.78	

Values are mean ±SD

Mean (s) bearing same superscript (s) in column and row are not significantly (P>0.05) different according to DMRT

Table 4.16: Effect of addition of different levels of Baobab fruit Pulp on P (mg/100g) of cow and camel milk yoghurt

Sample	Source of milk	
	Cow	Camel
A	94.84^{d}±2.84	80.00^{e}±6.93
B	107.20^{c}±1.50	93.55^{d}±9.74
C	125.80^{b}±3.84	110.60^{c}±5.87
D	134.70^{ab}±3.67	126.30^{b}±9.64
E	141.70^{a}±2.34	134.90^{ab}±7.61
Lsd 0.05	6.841^{**}	
SE±	2.319	

Values are mean ±SD

Mean (s) bearing same superscript (s) in column and row are not significantly (P>0.05) different according to DMRT

Table 4.17: Effect of addition of different levels of Baobab fruit Pulp on K (mg/100g) of cow and camel milk yoghurt

Sample	Source of milk	
	Cow	**Camel**
A	84.84^{e}±0.84	85.56^{e}±10.80
B	95.00^{cde}±3.33	89.89^{de}±9.05
C	101.20^{bc}±1.84	96.45^{bcd}±7.42
D	105.00^{bc}±2.00	102.30^{bc}±4.93
E	116.20^{a}±3.12	106.00^{b}±4.06
Lsd 0.05	6.851^{**}	
SE±	2.322	

Values are mean ±SD

Mean (s) bearing same superscript (s) in column and row are not significantly (P>0.05) different according to DMRT

Table 4.18: Effect of addition of different levels of Baobab fruit Pulp on Na (mg/100g) of cow and camel milk yoghurt

Sample	Source of milk	
	Cow	**Camel**
A	64.17^{de}±1.50	57.00^{e}±8.95
B	67.67^{cd}±1.00	64.56^{de}±6.20
C	72.34^{bcd}±2.67	68.00^{cd}±5.05
D	76.34^{ab}±2.67	71.56^{bcd}±3.57
E	81.84^{a}±0.84	74.11^{abc}±3.79
Lsd 0.05	7.407^{**}	
SE±	2.511	

Values are mean ±SD

Mean (s) bearing same superscript (s) in column and row are not significantly (P>0.05) different according to DMRT

4.2.17 Total viable count of bactereia CFU/g:

The result in table (4.19) show no significant difference ($p>0.05$) between plain cow and camel milk yoghurt in total viable count of bactereia, however there is significant difference between levels of Baobab fruit pulp (1, 2, 3, 4%). It was decreased. This result is lower than that of Lourens-Hattingh and Viljoen, (2001); El Bakri and Zubeir, (2009). The microbial status of the yoghurts were within acceptable standard <1x106 cfu/ml.t,thes decrease may be due to inhibit of growth bactereia because of acidic media and found antioxidant in Baobab fruit pulp .

4.2.18 Effect of Storage period on pH value:

The result in table (4.20) show no significant difference ($p>0.05$) between the cow and camel yoghurt in storage period on pH value, however its was decreased the pH in different level of Baobab fruit (1, 2, 3, 4%), this result it is agreement with Hala Gindeel (2012) and Dankow *et al* (1999) and Eissa *et al* (2011). decreases in pH with the storage period in cow and camel milk yoghurt, also similar changes were observed by Vargas *et al* (2008) and Gũler (2007) in yoghurt products, and Chipurura *et al* (2014) who reported that Baobab flavoured yoghurt had lower pH when compared to the plain yoghurt. This decrease may be due to addition of Baobab fruit pulp which is acidic.

4.2.19 Titrable acidity:

The result in table (4.21) show no significant difference ($p>0.05$) between the cow and camel milk yoghurt in titrable acidity, however, pH increased in different levels of Baobab fruit pulp (1, 2, 3, 4%),), this result is in agreement with Hala Gindeel (2012) and Dankow *et al* (1999) and Eissa *et al* (2011)increases in acidity with the storage period in cow and camel milk yoghurt and Chipurura *et al* (2014) who reported that Baobab flavoured yoghurt had higher total titratable acid when compared to plain yoghurt . This could be due to more availability of lactose to the fermenting microbes (Joel Ndife 2014) and Baobab fruit plup (acidic).

Table 4.19: Effect of addition of different levels of Baobab fruit Pulp on total viable count of bacteria (cfu/g) of cow and camel milk yoghurt

Sample	Source of milk	
	Cow	**Camel**
A	3586.67^{a}±15.28	3546.67^{a}±15.28
B	3396.67^{bc}±51.32	3433.33^{b}±11.55
C	3366.67^{c}±25.17	3386.67^{c}±2082
D	3266.67^{d}±25.17	3286.67^{d}±11.55
E	3176.67^{e}±15.28	3206.67^{e}±23.09
Lsd 0.05	41.14^{**}	
SE±	13.94	

Values are mean ±SD

Mean (s) bearing same superscript (s) in column and row are not significantly (P>0.05) different according to DMRT

Table 4.20: Effect of addition of different levels of Baobab fruit and storage period on pH- value of cow and camel milk yoghurt

Sample	Source of milk					
	Cow			Camel		
	Storage period (days)					
	0	6	10	0	6	10
A	$5.17^{a}\pm0.0$	$5.00^{ab}\pm0.0$	$4.62^{efg}\pm0.0$	$5.05^{a}\pm0.0$	$4.85^{bcd}\pm0.0$	$4.67^{de}\pm0.0$
B	$4.82^{cd}\pm0.0$	$4.70^{cde}\pm0.0$	$4.47^{ghi}\pm0.0$	$4.87^{bc}\pm0.0$	$4.67^{def}\pm0.0$	$4.54^{efgh}\pm0.0$
C	$4.60^{efg}\pm0.0$	$4.49^{fghi}\pm0.0$	$4.22^{klm}\pm0.0$	$4.71^{cde}\pm0.0$	$4.57^{efgh}\pm0.0$	$4.40^{hijk}\pm0.0$
D	$4.47^{ghi}\pm0.0$	$4.27^{jkl}\pm0.0$	$3.92^{n}\pm0.0$	$4.59^{efgh}\pm0.0$	$4.43^{ghij}\pm0.0$	$4.25^{jkl}\pm0.0$
E	$4.32^{ab}\pm0.0$	$4.0^{lmn}\pm0.0$	$3.74^{o}\pm0.0$	$4.46^{ghi}\pm0.0$	$4.26^{jkl}\pm0.0$	$4.06^{mn}\pm0.0$
Lsd 0.05	0.1633^{*}					
SE±	0.05774					

Values are mean ±SD

Mean (s) bearing same superscript (s) in column and row are not significantly (P>0.05) different according to DMRT

Table 4.21: Effect of addition of different levels of Baobab fruit and storage period on titratable acid camel milk yoghurt

Sample	Source of milk				
	Cow			Camel	
	Storage period (days)				
	0	6	10	0	6
A	0.7567^{u}±0.0	0.7600^{t}±0.0	0.7867^{n}±0.0	0.7467^{v}±0.0	0.7633^{s}±0.0
B	0.7667^{r}±0.0	0.7800^{p}±0.0	0.8067^{i}±0.0	0.7600^{t}±0.0	0.7767^{q}±0.0
C	0.7800^{p}±0.0	0.7900^{m}±0.0	0.8200^{g}±0.0	0.7833^{o}±0.0	0.7933^{l}±0.0
D	0.8000^{j}±0.0	0.8167^{h}±0.0	0.8400^{c}±0.0	0.8067^{i}±0.0	0.8200^{g}±0.0
E	0.8200^{g}±0.0	0.8367^{d}±0.0	0.8500^{b}±0.0	0.8267^{f}±0.0	0.8400^{c}±0.0
Lsd 0.05	0.0005165^{*}				
SE±	0.0001826				

Values are mean ±SD

Mean (s) bearing same superscript (s) in column and row are not significantly (P>0.05) different according to DMRT

4.2.20 Total solids:

The result in table (4.22) show significant difference ($p<0.05$) between the cow and camel milk yoghurt in total solids, however, the total solids increased in different levels of Baobab fruit pulp (1, 2, 3, 4%) during storage(11.21-13.66)% . This result it is not in line with Nuzhat (2003) who reported the total solid of yoghurt decreased in all treatment during storage, and in disagreement with Dawla and Abdall (2002) this increase in total solid may be due to not adjusted of total solid in all sample and the Baobab fruit pulp which is 93.7 %.

Table 4.22: Effect of addition of different levels of Baobab fruit and storage period on total solids (%)of cow and camel milk yoghurt

Sample	Source of milk					
	Cow			Camel		
	Storage period (days)					
	0	6	10	0	6	10
A	12.03^{fghjk}±0.0	12.11^{efghi}±0.0	12.20^{defghi}±0.0	11.21^{k}±0.0	11.27^{jk}±0.0	11.53^{ijk}±0.0
B	12.20^{defghi}±0.0	12.28^{defghi}±0.0	12.37^{defghi}±0.0	11.63^{hijk}±0.0	11.67^{hijk}±0.0	11.89^{ghijk}±0.0
C	12.64^{bcdefg}±0.0	12.70^{bcdeg}±0.0	12.85^{bcdef}±0.0	12.04^{fghijk}±0.0	12.10^{efghi}±0.0	12.23^{defghi}±0.0
D	12.87^{bcdef}±0.0	12.97^{abcde}±0.0	13.02^{abcd}±0.0	12.41^{cdefgh}±0.0	12.46^{jcdef}±0.0	12.58^{bcdefg}±0.0
E	13.26^{efghi}±0.0	13.34^{ab}±0.0	13.66^{a}±0.0	12.73^{bcdefg}±0.0	12.85^{abcdef}±0.0	12.97^{bcde}±0.0
Lsd 0.05	0.7119^{*}					
SE±	0.2517					

Values are mean ±SD

Mean (s) bearing same superscript (s) in column and row are not significantly (P>0.05) different according to DMRT

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Baobab fruit pulp can be used in camel milk and cow milk yoghurt to prevent serum separation and to adjust the viscosity. When used at sufficient level, Baobab fruit pulp reduced serum separation to negligible levels and increase the viscosity. Viscosity of yoghurts increased with higher dosage of Baobab fruit pulp . There were significant reductions in pH, syneresis and total bacterial count of yoghurt with the increase in level of Baobab fruit pulp. Baobab fruit pulp (10g, 15g and 20g) provided the highest viscosity and prevented the serum separation in camel milk and cow milk yoghurt. The result of this investigation highlighted the possibility of processing camel yoghurt with Baobab fruit pulp.

5.2 Recommendations

- Addition of 15g Baobab fruit pulp is recommended in camel milk yoghurt and 5g Baobab fruit pulp in cow milk yoghurt manufacturing.
- Further research is needed to improve the production procedures of Baobab fruit pulp yoghurt to produce the preferred characteristic in the final product.
- Encouraging production of dairy product from camel milk.

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