

**SENSORY AND PHYSICOCHEMICAL EVALUATION OF
“BURKINA” MADE WITH COMPOSITE
(COW AND TIGER NUT) MILK**

**THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF
GHANA, LEGON IN PARTIAL FULFILLMENT OF THE
REQUIREMENT FOR THE AWARD OF MPhil HOME SCIENCE
DEGREE**

BY

PEARL NYARKO-MENSAH

(10384854)

May 2018

DECLARATION

I, Pearl Nyarko-Mensah hereby declare that except for the references which have been duly cited, the work in this thesis, **“SENSORY AND PHYSICOCHEMICAL EVALUATION OF “BURKINA” MADE WITH COMPOSITE (COW AND TIGER NUT) MILK”** was done entirely by me in the Department of Family and Consumer Sciences, School of Agriculture, College of Basic and Applied Sciences, University of Ghana, Legon. This work has never been presented either in whole or in part for any other degree in this University or elsewhere.

.....
Pearl Nyarko-Mensah

(STUDENT)

.....
Professor Angelina O. Danquah

(SUPERVISOR)

.....
Professor Firibu K. Saalia

(SUPERVISOR)

.....
Dr. Niilante Amissah

(SUPERVISOR)

ABSTRACT

“Burkina”, a popular fermented milk beverage containing fermented millet agglomerates, is consumed in West Africa. Consumer behaviour towards “Burkina”, perceptions on its safety and potential for causing food borne illness, affects the distribution and sales of the product. Tiger nut, an underutilized crop in West Africa, with a rich nutty taste and unique mouthfeel has been incorporated into formulations for fermented milk products such as yoghurt, but not “Burkina”. The objectives of this study were to develop “Burkina” with tiger nut milk as a composite ingredient, determine consumers’ behaviour towards “Burkina” and “Burkina” made with composite (cow and tiger nut) milk and determine the physicochemical properties, consumer preference and microbiological quality of the product. “Burkina” was prepared with (0 %, 2 % and 4 %) milk fat, with or without 40 % Tiger nut milk (TNM) and analysed in triplicate for pH, colour, proximate composition and minerals. Students and staff of the University of Ghana were carefully selected for Consumer Focus Group Discussions (CFGDs) using a recruitment questionnaire and an interview guide respectively. Consumer preference for “Burkina” was also determined using an untrained panel. Standard methods for microbiological analysis were used. Descriptive statistics involving frequencies and central tendency were employed in data analysis and reporting. Data collected from the study was subjected to Analysis of Variance (ANOVA) in Statistical Analysis Software (SAS/STAT, University Edition). The global theme obtained from the CFGDs was segregated into sub-themes and the results were thematically analyzed using Attride-Stirling’s method with the aid of ATLAS.ti.7 software. The addition of TNM increased the carbohydrate, protein, fat and ash content of “Burkina”, but moisture content decreased. The pH was acidic (3.78 – 3.98) and was unaffected by the addition of TNM. The L value of “Burkina” decreased (became darker) with the addition of TNM, while mineral values (K, Na, Mg, P) increased but Ca levels decreased as tiger nuts contain less Ca than milk. There were no counts for

salmonella, *coliforms*, *E. coli* and *Staphylococcus aureus* but there were low counts for yeast and molds (within the acceptable range) in “Burkina” with TNM. “Burkina” flavour was unaffected by the addition of TNM. However “Burkina” with TNM had lower ratings for overall acceptability, aroma, colour, after taste and mouthfeel. Affordability and vendor proximity were major facilitators of “Burkina” patronage, while packaging was an average facilitator. Product safety and storage temperature were major barriers to the purchase and consumption of “Burkina”. The results suggest alternative uses for tiger nuts. Optimizing the amount of TNM added to “Burkina” may create “Burkina” with an enhanced nutritional profile and improved sensory properties. It may also increase the consumption of dairy milk beverages for improved nutrition, while improving upon the quality, safety and appeal of “Burkina” among Ghanaian consumers.

DEDICATION

This thesis is dedicated to the Almighty God, the Nyarko-Mensah family and my supervisors.

It is also dedicated to all researchers and entrepreneurs in this area of research, as well as all those who contributed in diverse ways to make this research come to fruition.

ACKNOWLEDGEMENTS

I wish to express my sincerest gratitude to my Father in Heaven for granting me the grace, strength and wisdom to complete this research. I also express profound gratitude to my supervisors; Dr. Niilante Amissah, Professor Angelina Danquah and Professor F. K. Saalia, for their encouragement, and immense contribution to this work. My appreciation goes to Dr. M.Y.B. Adjei and Dr. A. Parry-Hanson Kunadu from the Department of Nutrition and Food Science for their contributions.

I am indebted to the **A. G. Leventis Foundation** for providing me with the grant for this research. Special thanks go to Dr. Ernest Afrifa-Anane of the Regional Institute for Population Studies, Mr. Crossby Osei Tutu Junior, Mr. Reuben Acheampong, Ms. Nayram Doe, Ms. Matilda Twumasi and Ms. Jacqueline Baaba Acquah of the Department of Family and Consumer Sciences for their support in diverse ways to make this research successful.

I wish to express my gratitude to my Dad, Mr. Gerald Nyarko-Mensah who contributed to the success of my research. I am also very grateful to my Mom, Mrs. Thelma Nyarko-Mensah and my siblings, Samantha and Jewell, for their unwavering support. My appreciation goes to Mr. Daniel Apartey of Ghana Atomic Energy, Dr. Lawrence Abbey and Dr. Charlotte Oduro-Yeboah of Food Research Institute for their assistance with the Microbiological Analysis, Proximate Analysis, Mineral Composition and colour analysis.

My deepest gratitude to all Lecturers at the Department of Family and Consumer Sciences whose contribution in one way or the other led to the completion of this research.

TABLE OF CONTENTS

CONTENT	PAGE
DECLARATION	i
ABSTRACT	ii
DEDICATION	iv
ACKNOWLEDGEMENTS	v
TABLE OF CONTENTS	vi
LIST OF TABLES	xii
LIST OF FIGURES	xiii
LIST OF ACRONYMS	xiv
CHAPTER ONE	
1.0 INTRODUCTION	1
1.1 Background Information	1
1.2 Statement of the Problem	4
1.3 Aim of the Study	4
1.4 Objectives of the Study	4
1.5 Hypotheses	5
1.6 Significance of the Study	5
CHAPTER TWO	
2.0 LITERATURE REVIEW	6
2.1 Milk	6

2.1.1 Composition of Milk	6
2.1.2 Health Benefits of Milk	9
2.1.3 Uses of Milk	11
2.1.4 Dairy Products	11
2.1.4.1 Fermented Milk	12
2.1.4.1.1 “Burkina”	13
2.1.4.2 Cheese (“Wagashie”)	14
2.1.4.3 Yoghurt	14
2.2 Tiger Nuts	15
2.2.1 Composition of Tiger Nuts	17
2.2.2 Health Benefits of Tiger Nuts	18
2.2.3 Uses of Tiger Nuts	20
2.2.3.1 Tiger Nut Oil	21
2.2.3.2 Tiger Nut Flour	22
2.2.3.3 Tiger Nut Milk	23
2.3 Other Vegetable Milk	24
2.4 Composite Milk	25
2.4.1 Products from Composite Milk	27
2.5 Microbiology of Milk and Dairy Products	28
2.6 Sensory Evaluation of Milk and Dairy Products	28

2.7 Packaging of Milk and Dairy Products	29
--	----

CHAPTER THREE

3.0 MATERIALS AND METHODS	31
3.1 Materials	31
3.1.1 Ingredients	31
3.1.2 Tools, Equipment and Chemicals	31
3.2 Methods	31
3.2.1 Preparation of Tiger Nuts for Milk Extraction	31
3.2.1.1 Cleaning and Soaking of Tiger Nuts	31
3.2.1.2 Tiger Nut Treatment	32
3.2.1.3 Milling of Tiger Nuts and Extraction of Tiger Nut Milk	32
3.2.2 Pearl Millet Treatment and Agglomeration	33
3.2.3 Production of “Burkina” Made with Cow’s Milk	35
3.2.4 Preparation of “Burkina” Made with Composite (Cow and Tiger Nut) Milk	35
3.2.5 Packaging and Storage of “Burkina” Samples	36
3.3 Colour Determination of “Burkina” Samples	36
3.4 Determination of pH for “Burkina” Samples	37
3.5 Proximate and Mineral Composition of the Homogenous and Composite Blends of “Burkina”	37
3.5.1 Protein Determination	38

3.5.2 Ash Determination	39
3.5.3 Moisture Determination	39
3.5.4 Fat Determination	40
3.5.5 Carbohydrate Determination	40
3.6 Mineral Composition of the Homogenous and Composite Blends of “Burkina”	41
3.7 Microbiological Analysis of “Burkina” Samples	41
3.8 Sensory Evaluation	42
3.8.1 Focus Group Discussion	42
3.8.2 Consumer Acceptance Test	42
3.9 Study Design and Data Analysis	43
 CHAPTER FOUR	
4.0 RESULTS AND DISCUSSION	44
4.1 Proximate Composition of “Burkina” Samples	44
4.1.1 Moisture Content	45
4.1.2 Fat Content	45
4.1.3 Carbohydrate and Protein Content	46
4.1.4 Total Ash Content	46
4.2 Mineral Composition of “Burkina” Samples	47
4.3 pH of “Burkina” Samples	48

4.4 Microbiological Wholesomeness of “Burkina” Samples	49
4.5 Instrumental Colour Analysis of “Burkina” samples	51
4.6 Consumer Focus Group Discussion and Sensory Evaluation of “Burkina” Samples	52
4.6.1 Consumer Focus Group Discussion	52
4.6.1.1. Perceptions of Fermented and Flavoured Milk	53
4.6.1.2 Perceptions of Whole and Skimmed Milk	55
4.6.1.3 Perceptions of “Burkina”	57
4.6.1.4 Facilitators to the Purchasing and Consumption of “Burkina”	60
4.6.1.5 Barriers to the Purchasing and Consumption of “Burkina”	61
4.6.1.6 Perceptions of “Burkina” with Tiger Nut	63
4.6.2 Sensory Evaluation of “Burkina” samples	65

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS	67
5.1 Summary	67
5.2 Conclusion	68
5.3 Recommendations	68
REFERENCES	69
APPENDICES	

Appendix 1:	Recruitment Questionnaire for Focus Group Discussion on “Burkina” Product	79
Appendix 2:	Consent Form	82
Appendix 3:	Analysis of Variance Results for Sensory Attributes	85
Appendix 4:	“Burkina” Themes and Codes for FGD	86
Appendix 5:	Discussion Guide for Focus Group Discussion	88

LIST OF TABLES

TABLE	PAGE
Table 1: The Milk Chemical Composition of Some Mammalian Milk (%)	9
Table 2: Proximate Composition of “Burkina” Samples	44
Table 3: Mineral Composition of “Burkina” Samples	48
Table 4: Mean pH of “Burkina” samples	49
Table 5: Microbiological Analyses of “Burkina” Samples (Mean Counts)	50
Table 6: Mean Colour (L, a, b) and ΔE Values for “Burkina” Samples	51
Table 7: Characteristics of FGD Participants	52
Table 8: Mean Sensory Scores of “Burkina” Samples	66

LIST OF FIGURES

FIGURE	PAGE
Figure 1: Types of Tiger Nuts Grown in Ghana	16
Figure 2: Examples of Products made with Tiger Nuts	21
Figure 3: Concept of Composite Dairy Foods including Milk Composites	27
Figure 4: Flow Chart Showing Tiger Nut Milk Extraction Process	33
Figure 5: Flow Chart Showing the Production of Fermented Pearl Millet Agglomerates	34
Figure 6: Understanding the Desirability of “Burkina”	53
Figure 7: Perceptions of Flavoured and Fermented Milk	55
Figure 8: Perceptions of Skimmed and Whole Milk	57
Figure 9: Respondents Perceptions on “Burkina”	59
Figure 10: Facilitators to the Purchasing and Consumption of ‘Burkina’	61
Figure 11: Barriers to the Purchasing and Consumption of “Burkina”	63
Figure 12: Perceptions of “Burkina” with Tiger Nut Milk	64

LIST OF ACRONYMS

AAS	Atomic Absorption Spectrophotometer
BA	Blood Agar
ANOVA	Analysis of Variance
CFDGs	Consumer Focus Group Discussions
FAO	Food and Agriculture Organisation
FCM	Full Cream Milk
FCMT	Full Cream Milk with Tiger Nut Milk
FGD	Focus Group Discussion
GSA	Ghana Standard Authority
HCl	Hydrochloric Acid
MC	Maconkey Agar
NaOH	Sodium Hydroxide
OA	Osteoarthritis
OGY	Oxytetracycline Glucose Yeast Extract
PCA	Plate Count Agar
PET	Polyethylene Terephthalate
SM	Skimmed Milk
SMT	Skimmed Milk with Tiger Nut Milk
SSM	Semi-skimmed Milk

SSMT	Semi-skimmed Milk with Tiger Nut Milk
TNM	Tiger Nut Milk
UHT	Ultra High Temperature
USA	United States of America
USDA	United States Department of Agriculture
WHO	World Health Organisation
XLD	Xylos Lysine Deoxycholate Agar

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

The addition of milk to diets is being advocated to improve human nutrition. Milk is known to deteriorate quickly in high temperatures and therefore requires processing to extend shelf-life, to enable the final product reach distant markets. Once milk is processed, its shelf life may be extended to two weeks, depending on milk quality, packaging and storage temperature (Bille *et al.*, 2000). Products obtained from cow's milk include ice cream, cheese, yoghurt and milk-based desserts. Some of these products are made through fermentation, separation of milk components or both (Pamplona-Roger, 2006).

“Burkina”, also known as “Brukina”, is a fermented dairy beverage that contains fermented millet agglomerates (Caiquo & Mensah, 2013). “Burkina” has its origins from ‘Burkina’ Faso and its original name is 'Deger' (Appiah, 2013). Some West African countries also refer to the beverage as “nunu de fura” (Caiquo & Mensah, 2013). “Burkina” is popular among consumers in Ghana especially within Accra because of its resemblance to fresh yoghurt. “Burkina” forms part of a family of fermented beverages (such as yoghurt, kefir, koumiss, sour milk), which dates back to early civilization around 10,000 BC, when human beings progressed from hunting and gathering to food processing (Rašić & Kurmann, 1978; Pederson, 1979). The beverage is popular in Northern Ghana and is making inroads in popularity in Southern Ghana, especially in Accra where it is sold in Supermarkets, Stores and at Traffic Lights (GNA, 2013). The main ingredients for the preparation of “Burkina” are fresh or powdered cow milk or a combination of both, millet (pearl millet), sugar and sometimes salt for taste (Osei-Onomah, 2014). “Burkina” drinks are packaged and sold in

transparent plastic bottles or polyethylene bags (Appiah, 2013). The beverage can be consumed immediately after processing or stored in a refrigerator for a maximum of two weeks (Appiah, 2013; Johnson *et al.*, 2013). “Burkina” production results in a stable and viscous final product. “Burkina” produces a mouth feel of a thick smooth (yoghurt-like) texture with small lumps and a grainy feel of millet (Caiquo & Mensah, 2013). Due to the fermentation of millet and milk, this beverage has a rather sour taste with pH of 4.6 (Caiquo & Mensah, 2013). “Burkina” has a network of aggregated casein particles (casein micelles) held together in chains. It also has a suspension of tiny particles of millet (Caiquo & Mensah, 2013). “Burkina” is a very nutritious beverage, consisting of proteins, essential vitamins (Vitamin A, B₆, B₁₂, D, riboflavin, pantothenic acid, niacin, thiamine, folate), dietary fiber, carbohydrates, fat, as well as minerals (calcium, magnesium, manganese, potassium, iron, phosphorus, zinc and copper). Some studies have even proven the probiotic potential (due to the fermentation process) of ‘Burkina’ (Caiquo & Mensah, 2013). “Burkina” may however cause food poisoning when it is prepared and packaged under unhygienic conditions (Amadou *et al.*, 2011). Most vendors, unfortunately, have little or no knowledge about food safety and hygiene practices posing a health hazard to consumers (FAO/WHO, 2012).

Tiger nut (*Cyperus esculentus*), locally known in Ghana as “Atadwe”, is an underutilised crop with potential for utilization in food products due to its nutrient composition and health benefits. Tiger nuts are a rich source of phosphorus, potassium, magnesium, iron and zinc (Chiemela *et al.*, 2010). There are two main types grown in Ghana; the Kwahu type (yellow and brown in colour) and the Fante type (brown in colour). Some of the health benefits of tiger nuts indicated by researchers include; its aid in the reduction of hypertension, cardiovascular diseases and stroke (Belewu & Belewu, 2007; Esteshola & Oraedu, 1996), aid in the prevention of digestive tract disease such as colon cancer (Caiquo & Mensah, 2013),

ideal for diabetics (Type 2), celiac and lactose intolerant people (Chevailler, 1996; Lu & Wang, 2017), remedy for indigestion, flatulence and diarrhoea (Chevailler, 1996), and promotion of good skin, bone development, fertility and muscle contraction (Chevailler, 1996). Tiger nuts have been incorporated into many food products such as: biscuits and cakes from tiger nut composite flour (Ade-Omowaye *et al.*, 2008, Chiemela *et al.*, 2010, Frimpong, 2016), yogurt (Sanful, 2009), drinks (Abraham, 2013), fortified weaning foods (Ikepeme *et al.*, 2012), desserts (Nyarko-Mensah *et al.*, 2015) and cheese (Tijani, 2014). Some researchers [Sanful, (2009); Tijani, (2014)] posited in their studies that panelists in sensory tests of dairy products that incorporated tiger nuts showed a preference for products with up to 50 % tiger nut.

Pearl millet (*Pennisetum glaucum*), is an indigenous cereal crop grown in West Africa for its edible grains and straw (Desikachar, 1996). Pearl millet is also a useful food which can be made into fermented “Burkina”s (*roti*), fermented foods (*kisra* and *gallettes*), thin and thick porridges (*toh*), steam-cooked dishes (*couscous*); non-alcoholic beverages, and snacks (Desikachar, 1996). The millet grains are also used as feeds for local animals. Pearl millet is used as brewer’s grain as it is richer in calcium, magnesium, iron and copper than most cereals but poorer in potassium, sodium, lead and manganese (Chukwu & Abdulir, 2008).

This study sought to prepare “Burkina” which is safe for consumption, incorporate tiger nut milk into the formulation and processing of “Burkina” and to determine the physicochemical and sensory properties of “Burkina” made with or without tiger nut milk.

1.2 Statement of the Problem

“Burkina” is a popular fermented dairy product that contains fermented millet agglomerates. However, recent research has shown that depending upon the processing and packaging conditions used, “Burkina” may be unsafe for consumption with the potential for causing food borne illnesses due to contamination during and after processing. Preparing “Burkina” under hygienic conditions may improve the safety of ‘Burkina’ and incorporating tiger nut in the final product may also create a new product with sensory properties that may appeal to Ghanaian consumers. Incorporation of tiger nut milk into “Burkina” will not only increase the nutritional value of the product but may also add on to the health benefits as well. This may improve the patronage of ‘Burkina’ and increase the utilization of tiger nuts.

1.3 Aim of the Study

The aim of the study was to incorporate tiger nut milk into the processing method for “Burkina” prepared under hygienic conditions and determine the physicochemical and sensory properties of “Burkina” with incorporated tiger nut milk.

1.4 Objectives of the Study

The specific objectives were to:

1. Develop “Burkina” with tiger nut milk as a composite ingredient.
2. Determine the physicochemical and sensory properties of “Burkina” and “Burkina” made with tiger nut milk.
3. Determine consumers’ perception on ‘Burkina’ and ‘Burkina’ made with tiger nut milk.

1.5 Hypotheses

H₀₁: The addition of tiger nut milk to the processing of “Burkina” does not affect the physicochemical properties of “Burkina”.

H₀₂: The addition of Tiger nut does not influence the sensory characteristics of “Burkina” made with composite milk.

1.6 Significance of the Study

This study is significant because it may contribute to:

1. Documenting an optimized protocol for processing and packaging “Burkina” with tiger nut milk to improve product shelf life and consumer safety.
2. The addition of value to cow milk and tiger nuts and encourage an increase in the consumption of cow milk and tiger nuts (an underutilized crop in Ghana).
3. Providing opportunities for entrepreneurship and income generation from both cow milk and tiger nuts.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Milk

Mammalian females have a mammary gland with a lactating function which is to secrete a white liquid known as “milk” (Grădinaru *et al.*, 2015). All mammalian females, including humans, will normally produce milk to feed their offspring until they are ready for solid food. Milk is one of the major foods for humans, and an important preliminary base in different human productive activities (Robinson, 1994). Milk consists of major ingredients (water, lipids, sugar and proteins) and minor ingredients (minerals, vitamins, hormones and enzymes). The concentration of these ingredients vary among species, with the major ones being lipids (2 % – 55 %), proteins (1 % – 20 %), lactose (0 % – 10 %) (FitzGerald & Meizel, 2003). Cattle are the primary source of mammalian milk in most parts of the world, except the Indian subcontinent and portions of the Mediterranean region, Middle East and Africa, where buffalos, sheep and goats make a vital contribution to national milk production (Tamime, 2006). The Middle East, Northern and Eastern Africa’s deserts use camels for their milk production. Reindeer in Lapland, and mares in Central Asia are the other species used in obtaining milk (Tamime, 2006).

2.1.1 Composition of Milk

Milk contains water, fat, protein, carbohydrate (lactose), and minerals (ash) as its major components (Robinson, 1994). However, there are other extremely important micronutrients such as vitamins, essential amino acids, and trace minerals. Several other chemicals (over 250) have also been recognised in milk (Robinson, 1994). The Food and Drug Authority of

United States stated that milk used for beverages should contain at least 8.25 % milk solids and at least 3.25 % milk fat (Fox, 2003).

Species, geographic position, and new-born needs influence milk composition. Milk is as enriched in its composition as new-born requirements for a quick gain in weight are. The milk sugar proportion is related to brain development, and milk fats are in a higher concentration in animals located in cold areas (Maloş *et al.*, 2002). With the exception of the iron, copper and Vitamin C content, milk could be considered a complete food for human nutrition needs (Banu, 2002; Rusu, 2005).

Water represents the largest component of milk, being important for its solvent properties and a good vehicle for other milk ingredients (Fox, 2003). Fats or oils, which are known collectively as lipids, are components of biological fluids, tissues and foods which are dissolvable in an apolar solvent (Fox, 2003). Milk fats are the most adaptable compounds, being under the influence of species, breed, lactation stage, feeding, season, and health condition (Rotaru & Moraru, 1997; Şindilar 1998). Milk nitrogen compounds can be protein or non-protein. Milk and dairy products contain all essential amino acids and represent an important source of proteins of high nutritive value. The protein content greatly affects the properties of milk and milk products more than any other constituent (Fox, 2003). A major milk protein is casein, which exists as a multi-subunit protein complex dispersed throughout the fluid phase of milk. Under certain conditions the casein complexes are disrupted, causing curdling of the milk. Curdling results in the separation of milk proteins into two distinct phases, a solid phase (the curds) and a liquid phase (the whey) (Fox, 2003). Casein and whey proteins are the main groups of proteins which make up about 80 % and 20 % respectively of total milk protein. The acid whey contains two groups of proteins;

lactalbumins and lactoglobulins (Fox, 2003). Milk carbohydrates consist of lactose and other sugars in a low amount (such as glucose, galactose). They are the second largest compounds in milk (Banu 2002; Iurcă 1998; Mihaiu & Mihaiu 1998). Despite their large numbers, milk enzymes are in small concentrations, located at the lipoprotein membrane of fat globules, at the casein micelle, or in solution. Milk contains almost all of the liposoluble (A, D, E, K) and hydrosoluble (B and C) vitamins in their well-proportioned amounts (Grădinaru *et al.*, 2015). Milk pigments are from inner and outer origins. The most crucial pigments of animal origin, lacto Flavin and riboflavin colour milk in a greenish-blue and yellowish-beige, respectively. The outer layer pigments are taken from animal feed or due to milk adulteration with milk microorganisms containing pigment (Grădinaru *et al.*, 2015). The most important outer layer pigment is carotene. On the other hand, xanthophyll and chlorophyll can also be found in milk. Gases such carbon dioxide, nitrogen and oxygen are in larger quantities than ammonia and hydrogen sulphide in freshly milked milk (Grădinaru, 2015). Milk minerals are characterised either by soluble or insoluble salts (chlorides, phosphates, citrates), or by bound-forms by milk proteins, especially caseins (Banu, 2002; Ciotău 2006). Table 1 shows the composition of fresh fluid milk and other dairy products.

Table 1: The Chemical Composition of Some Mammalian Milk (%)

Species	Fats	Proteins	Lactose	Minerals	Total Solids	Water
Cow (Holstein)	3.5	3.1	4.9	0.7	12.2	87.8
Cow(Jersey)	5.5	3.9	4.9	0.7	15.0	85.0
Sheep	5.3	5.5	4.6	0.9	16.3	83.7
Goat	3.5	3.1	4.6	0.8	12.0	88.0
Human	4.5	1.1	6.8	0.2	12.6	87.4

Source: Jensen, 1995.

2.1.2 Health Benefits of Milk

According to Antinoro (2012), potassium, an important component of milk, can provide health benefits such as; protection against muscle wasting, osteoporosis, cardiovascular diseases and kidney stones. Milk consumption has been attributed to its crucial role in bone health. The role milk plays in the development of knee osteoarthritis (OA) was observed radiographically by Bing *et al.* (2014). From the study, it was concluded that regular milk intake was positively connected to a decreased progression in OA in women (Bing *et al.*, 2014).

Fat content ranges from 2.8 % to 8.1 %, depending on the breed of the cattle, nutritional aspects, individual characteristics, lactation period, milk production hygiene and season. It is also one of the most crucial constituents in bovine milk (Miciński *et al.* 2018). According to Miciński *et al.* (2018) the exceptional nutritional value of bovine milk can be accredited to the presence of short and medium-chain fatty acids which are important sources of energy for

the muscles, heart, liver, kidneys, blood platelets and nervous system. Bovine milk does not pose an obesity risk; prevents ulcerative colitis, cancer, atherosclerosis and hypertension; has anti-inflammatory and antibacterial effects, and boosts natural immunity. Miciński *et al.* (2018) postulated that milk contains cholesterol. The cholesterol is a lipid derivative which steadies and hardens the cell membranes, forms the cell cytoskeleton, protects nerve fibers and acts as a precursor of steroid hormones, bile acids and vitamin D₃. Bovine milk lipids, on the other hand, do not exert hypercholesterolemic or atherogenic effects in the human body (Miciński *et al.*, 2018). The American Heart Association however stated that, milk comprises saturated fat, which can raise the levels of cholesterol up. According to the USDA National Nutrient Database, a one-cup serving of whole milk comprises 9 grams of total fat, which includes 6 grams of saturated fat (Miciński *et al.*, 2018). Reduced fat milk, such as skimmed milk (2 %), contains about half the amount of total and saturated fat as whole milk. The fats drop to 2.4 grams of total fat and 2 grams of saturated fat in 1 % fat milk. The American Heart Association has therefore suggested limiting saturated fat intake to less than 7 percent of total daily calories (Miciński *et al.*, 2018).

Some claims have been made about the likely health benefits that could theoretically be derived from the intake of raw milk as against that of pasteurized milk (Miciński *et al.*, 2018). However, recent scientific reviews by different international groups have posited that there is no reliable scientific evidence to back the proposed health benefits of raw milk. For instance, it has been said that milk has probiotic effects. According to Sanders (2008), the term "probiotic" should be used only for products that contain enough live microbes which have been acknowledged in target-host research to convene a health benefit. Probiotics must be recognized to the level of strain, must be characterized for the specific health target, and

must be formulated into products using strains and doses shown to be effective. Sanders (2008) therefore postulated that raw milk does not meet this definition.

2.1.3 Uses of Milk

Milk can be manufactured into various products such as cream, butter, yogurt, kefir, ice cream, and cheese. It can again be used to make casein, whey protein, lactose, condensed milk, powdered milk, and many other food-additives and industrial products by modern processing (Harness, 2018). It can also be used as a skin softening ingredient for facial or full body treatment and as a mild makeup remover as it contains naturally cleansing enzymes. Since the creamy base of milk makes it a great moisturizer, it is a substitute for shaving cream and is also helpful to areas often irritated by shaving (Harness, 2018). Other uses for milk include; shining up leather bags or shoes, polishing of silverware, and removing ink stains from clothing. Milk, when used as a marinade on fish, masks the 'fishy' aftertaste and makes it taste fresh in the mouth (Harness, 2018).

2.1.4 Dairy Products

Dairy products are a type of food produced from or containing the milk of mammals, primarily cattle, water buffalo, goat, sheep and camel (Lu & Wang, 2017). Examples of dairy products include: powdered milk or milk powder (which is produced by evaporating water from whole, reduced fat or skimmed milk); condensed milk (milk concentrated by evaporation); infant milk (which is powdered milk with specific additives for feeding infants); skimmed milk containing about 0.1 % fat and is made when all the cream (milkfat) is removed from whole milk; buttermilk which is the liquid left over after producing butter from cream and is often dried as livestock feed (Lu & Wang, 2017). Examples of other dairy products include cheese,

produced by coagulating milk, separating curds from whey and letting the curds ripen, generally with specific bacteria and sometimes moulds; Butter, consisting mostly of milk fat is produced by churning cream; Ghee, which is a form of clarified butter, made by gentle heating of butter and removal of the solid matter, and Cream cheese produced by the addition of cream to milk which is then curdled to form a rich curd or cheese. Curds are the soft, curdled part of milk (or skim milk) used to make cheese (Tijani, 2014). Yoghurt is made from milk fermented by *Streptococcus salivarius spp thermophilus* and *Lactobacillus spp bulgaricus* and sometimes with an additional bacteria, such as *Lactobacillus acidophilus* (FitzGerald & Meisel, 2003). Ice cream is made from cream that is frozen slowly with milk, flavours and emulsifying additives (dairy ice cream). Ice milk is a low-fat version of ice cream. Whey is the liquid milked from curds and used for further processing or as a livestock feed (Wong, 2013).

2.1.4.1 Fermented Milk

Fermented milk products are dairy products that have been cultured with lactic acid bacteria such as *Lactobacillus*, *Lactococcus* and *Leuconostoc* (Caplice & FitzGerald, 1999). Fermentation is used for many purposes, which include, extending the shelf life of foods, producing desirable taste and flavour, enhancement of nutritional value, producing required physicochemical properties, improvement of food safety and food security (Caplice & FitzGerald, 1999). Fermented food and beverages were first produced thousands of years ago and remain an important part of man's diet, supplying about 20 % - 40 % of food worldwide (Campbell-Platt, 1994). A range of different *Lactobacilli* strains have been grown in laboratories allowing for a vast range of cultured milk products with varied tastes (Campbell-Platt, 1994).

According to Guarner & Schaafsma (1998), probiotics are live microbes which positively influence the intestinal microflora of their host. Fermented dairy foods including yoghurt and cheese are a preferred medium for health promoting bacteria as they contain lactose and peptides (Schiffrin & Blum, 2002). They provide the most suitable nourishment for the conveyance of these beneficial bacteria to the human gut, once the environment is suitable to sustain these cultures (Ricke & Pillai, 1999; Schiffrin & Blum, 2002). The consumption of fermented dairy foods as functional foods is currently on the increase because of the live bacteria, as well as their highly digestible nature (FitzGerald & Meisel, 2003).

2.1.4.1.1 “Burkina”

“Burkina” is a fermented food drink made from millet and cow milk. The product originated from Burkina Faso, hence the name, and was initially confined to the three Northern regions of Ghana but is now seen all over the streets of Accra and other regional capitals of Ghana (Caplice & FitzGerald, 1999). The product is also referred to as “deger” or “nunu de fura” in some parts of West Africa. “Burkina” emerged from two already existing indigenous products namely “nunu” which is a spontaneously fermented milk and “fura”, a traditional food made from spontaneously fermented millet (Caplice & FitzGerald, 1999). Mashing and mixing the two together and adding sugar and sometimes spices gave rise to the drink now known as “Burkina” (Caplice & FitzGerald, 1999). The cooking, fermentation and pasteurisation processes involved in the production of “Burkina” when done hygienically, give rise to a microbiologically safe product with a refrigerated shelf life of about two weeks (Campbell-Platt, 1994). “Burkina” is a nutritious product rich in proteins, carbohydrates, minerals and essential vitamins. Some studies have confirmed the probiotic nature of “Burkina” owing to the fermentation process (Caiquo & Mensah, 2015; Caplice & FitzGerald, 1999).

2.1.4.2 Cheese (“Wagashie”)

Cheese is a dairy food obtained from milk that is produced in a vast range of flavours and textures. Cheese is obtained from the coagulation of casein (milk protein) with rennet (enzyme) after acidification and comprises of proteins and fat from milk, usually from cows, buffalo, goats, or sheep (Sessou *et al.*, 2015). Curds are separated from whey and pressed into a more solid form. Cheeses may have molds on the rind, the outer layer, or throughout; depending on the type. Majority of cheese melt at cooking temperature (Sessou *et al.*, 2015). Different types of cheese are produced worldwide from various countries. The styles, textures and flavours of cheese depend on the extent of pasteurization, the butterfat content, ageing, processing, bacteria and mold content (Rusu, 2005).

“Wagashie” is a type of cheese made from cow’s milk. It is a speciality of northern Benin in West Africa and is commonly made by the Fulani people. It is relatively soft in texture and mild in flavour and is frequently used in cooking. It is commonly sold in the Northern regions of Ghana (Arthur, 2016). The name is not to be confused with “Wagashi” which refers to a type of Japanese confectionary (Morisaki & Suda, 2017). “Wagashie” is a generally creamy to white soft cheese that is brine pickled and without a rind. The cheese is salty and slightly sour and sold in pieces of ½ pound (0.227 kg) to 1 pound (0.454 kg) (Arthur, 2016).

2.1.4.3 Yoghurt

Yoghurt is known to be one of the popular fermented foods which contains *Lactobacillus sp.* (Analie & Bennie, 2001). Examples of such products are yoghurt mousse, reduced probiotic yoghurts, fat content yoghurts, drinkable yoghurts, yoghurt shakes, yoghurt ice-cream etc. (Fizman & Salvador, 1999). The balance of microflora in the gut is believed to be improved by live bacteria in yoghurt, as it competes with the pathogens in the gut for nutrients and

space, thereby enhancing one's health (Fuller 1989; Fuller, 1992; Ledenbach & Marshall, 2009). During the reduction process involved in the conversion of bile into non-carcinogenic bile acids by the probiotics in yoghurt, harmful compounds like nitrites and nitrates are disengaged before they convert to nitroamines (Commane *et al.*, 2005). Liong & Shah (2006), posited that the consumption of yoghurt can aid in the reduction of cholesterol in the blood; as the live cultures in yoghurt are able bind the bile acids or assimilate the cholesterol or both (Guarner & Schaafsma, 1998). People who are either lactose intolerant or have some kind of protein allergy can consume yoghurt as the culturing process makes it much easier to digest (Bertrand-Harb *et al.*, 2003).

2.2 Tiger Nuts

Tiger nut (*Cyperus esculentus L.*), is a member of the family Cyperaceae. Though popularly called "chufa" in many places it has other common names, such as earth nut, tiger nut, yellow nutsedge and "Zulu" nut. It is also called "ayaya" in Hausa and "ofio" in Yoruba (Umerie & Enebeli, 1997; Pascual *et al.*, 2001). Tiger nut is known to have trade names like yellow nutgrass, ground almond, Zulu nut, edible rush, chufa and rush nut (Esteshola & Oraedu, 1996). It belongs to the same genus as the papyrus plant (very common plant in seasonally flooded wetlands) and is a multicultural perennial crop (Bamishaiye, 2011). In the tropics, it is found largely in India and West Africa (Cobley, 1962). Tiger nuts were used to preserve the bodies of Egyptian Pharaohs (Watt & Breyer-Brandwijk, 1962). The tuber has been acclimatized in Ghana, Nigeria and Sierra Leone (Anon, 1992).

The brown and yellow varieties of the tiger nuts can be found on the Nigerian market (Okafor *et al.*, 2003). The yellow variety is highly desired because it is larger, more attractive, sweeter

and juicier. Its milk also contains higher protein and lower fat levels, as well as less anti-nutritional factors; especially polyphenols (Consejo, 2006).

In Ghana tiger nut is called “atadwe” by the “akans”, “atangme” by the “Gas”, “fie” by the “Ewes” and “nansaxa” by the “Dagombas” (Dokosi, 1998). The black and brown varieties are the main types cultivated in Ghana. Based on shape, colour and size of the nuts, Tetteh & Ofori (1998) identified seven types, designated as Kwahu I, II, III and IV and Fanti I, II and III. Anyidoho (2006) observed that the brown types were only planted in the forest areas of Kwahu in the Eastern Region while both the brown and the black types were planted in Bawjiase in the Central Region of Ghana. Tiger nuts are grown at places like Aduamoa in the Kwahu South District, Asukese, Odomasua, and Demso in the Afram Plains, Agona Kwanyaako, Bawjiase, and Elmina in the Central Region, and around Techiman in the Brong-Ahafo Region.



Fante type of tiger nut



Kwahu type of tiger nut

Figure 1: Types of Tiger Nuts Grown in Ghana

2.2.1 Composition of Tiger Nuts

The average nutritional figures for the tubers have been quoted as protein, 3.77 % - 6.72 %; crude fiber, 4.81 % - 8.91 % and sucrose, 19.02 % - 13.4 % by Coskuner *et al.*, (2002) and Pascual *et al.*, (2001) respectively. Excluding histidine, Bosch *et al.*, (2005) has reported that tiger nuts contain higher essential amino acids (mg/g protein) than those recommended by the FAO/WHO for meeting the nutritional needs of adult. Tiger nuts have a good amount of some essential minerals like magnesium, 43 μ g/g; potassium, 265 μ g/g; zinc, 158 μ g/g and 20-28 % of a yellowish non-drying oil (Fatoki *et al.*, 1995). Dubois *et al.*, (2007) have also reported that the main fatty acids present in tiger nut oil are 14:0 (0.2 %), 18:0 (3.2 %), 20:0 (0.4 %), 16:1 (0.3 %), 18:1 (72.6 %), 18:2 (8.9 %), and 18:3 (0.4 %), similar to olive and hazelnut oils.

Ezeh *et al.*, (2014) posited that the fatty acid profiles of tiger nuts, olive, avocado and hazel nut oils are similar. The fatty acid profile of tiger nuts is also highly stable due to its low content of tocopherol, phytosterol and polyunsaturated fatty acid. The phospholipids composition is also higher (3.1 % – 5.4 %) compared with soy bean oil. According to Ezeh *et al.*, (2014), raw tiger nut contains 76.60 mg of iodine and 0.03 mg KOH/g oil of acid values; while roasted tiger nut oil was found to contain vanillin and to a smaller extent 2, 3-dihydro-3, 5-dihydroxy-6-methyl-4H-pyran-4-one and 5-ethylfurfural. These compounds in the roasted tiger nut oil contribute to the overall aroma of the oil. Tiger nut is also suitable for use as fuel in the coating industry due to its low viscosity. Tiger nut oil has a good nutritional value with the potential of being beneficial to its farmers, dealers and processors once it is exploited (Ezeh *et al.*, 2014).

2.2.2 Health Benefits of Tiger Nuts

Cyperus esculentus, which is high in dietary fibre is suitable for the management of many diseases including coronary heart disease, colon cancer, and gastrointestinal disorders. In addition, these tubers are said to be carminative, emmanogogue, aphrodisiac, diuretic, tonic, and stimulant (Adejuyitan, 2011). It has also been stated that tiger nut has been used in the treatment of heavy digestion, flatulence, diarrhoea (as it contains digestive enzymes like catalase, lipase and aminase) and excessive thirst. Tiger nut milk without sugar is recommended for diabetics due to the content of carbohydrates and Arginine (liberates the hormone that produces insulin) (Adejuyitan, 2011). The high non-soluble fiber content of the tiger nuts helps diabetics to regulate their sugar levels in the blood. Recent studies have demonstrated that the fiber does not elevate the sugar levels in the blood as carbohydrates do (Tiger Nut Traders S.L, 2010).

The health advantages include decline of low density lipoprotein-cholesterol, which is suitable for sportsmen and women and people who want to lose weight. It is a measure for preventing cysts, prostate cancer, hernia, rectum deformation as it is known to promote urine production, and to prevent fibrosis as well as blockage at the tip of the fallopian tube (Bamishaiye, 2011). Nursing mothers are also advised to eat the soaked tubers as it will enhance breast milk production (El-Shenaway, 2012). The fibre content is higher than that of the oat bran, cabbage, carrot, plums and chia seeds and helps in the prevention of constipation. It also serves as an appetite suppressant, which will enable body weight management (Tiger Nuts Traders S.L, 2010).

Cardiologists have also recommended eating non-saturated fats of vegetable fats. Tiger nut oil, having a similar lipid profile as olive oil, is considered as one of the healthiest oils (Tiger Nuts Traders S.L, 2010). Also, tiger nuts help to control blood pressure and prevent cancer and heart diseases. Tiger nut contains high amounts of arginine. This helps the body produce nitric oxide that leaves the blood vessels dilated and promotes normal blood flow (Tiger Nuts Traders S.L, 2010). Tiger nut helps to reduce the risk of heart diseases since it contains vitamin E and high amounts of oleic acids. The vitamin E protects the human body from the formation of free radicals which are harmful and can cause the death of the body cells (Tiger Nuts Traders S.L, 2010).

Another health benefit of tiger nut is its natural source of magnesium. The human body obtains 13 % to 17 % of the daily recommended dose of magnesium when 100 g of tiger nut is consumed. This mineral remains active in the body and contributes to over 300 biochemical reactions in one's body (Tiger Nuts Traders S.L, 2010). Consuming 25 g of tiger nuts provides the body with 139 mg of potassium, which is the same quantity a potato or an avocado will give; but exceeds the potassium levels of a banana. Potassium is known to promote proper functioning of cells and organs in the body. It also regulates the contractions of the muscles responsible for digestion (Tiger Nut Traders S.L, 2010). Proteins are important for the human body. Diverse studies have shown that tiger nut has an amount of protein which is 8 % higher than wholemeal wheat. Also, tiger nuts contain more amino acids than the World Health Organisation standards for proteins (The Tiger Nut Traders S.L, 2010).

Finally, with a few tiger nuts, a healthy vegetable milk, which is lactose-free and rich in Vitamin C, Vitamin E and calcium, can be prepared in the kitchen. Consuming tiger nuts can

cure diarrhoea and flatulence, help prevent colon cancer and heart attacks among others (Bamishaiye, 2011).

2.2.3 Uses of Tiger Nuts

In Spain and Latin American countries, tiger nut is used in making the popular milk drink 'horchata de chufa' (Coskuner *et al.*, 2000; Cortes *et al.*, 2004). It is a characteristic product of Spain and of great monetary importance. Production is estimated at 40 - 55 million litres per year (Arranz *et al.*, 1998). In the United States of America however, tiger nut has been used mainly to attract and feed water fowls, cranes and ducks (Mosquera *et al.*, 1996). In Africa, tiger nuts are an important food crop for many people. They are eaten raw after washing or after it has been softened by soaking in water. It has also been reported to be roasted and chewed like roasted groundnuts or grated and used for the production of ice creams, biscuits or as a substitute for coffee (Abbiw, 1990; Dokosi, 1998). They are also used to produce non-alcoholic milky looking beverages (Sanful 2009; Ukwuru & Ogbodo, 2011). Common products derived from raw tiger nuts are skinned tiger nuts, peeled tiger nuts, tiger nut flour, tiger nut milk and tiger nut oil. The tiger nut milk may be made into cheese, yoghurt and ice cream, either as a pure product or composite product by combining with cow milk. Tiger nut flour may be combined with other ingredients to manufacture products such as tiger nut cheese cake (Ukwuru & Ogbodo, 2011).

Figure 2 illustrates some products made from tigers:



Figure 2: Examples of Products made with Tiger Nuts

2.2.3.1 Tiger Nut Oil

To ensure that the tiger nut oil maintains all of its unique nutritious qualities, tiger nut oil extraction is done by a cold process. Over 4000 years ago, the Egyptians used tiger nut oil in preference to olive oil; as it is generally considered as a healthier substitute (Ukuru *et al.*, 2011). The oil, golden brown in colour, has a rich nutty taste and can serve as a constituent of

beauty products. The high oleic acid and low acidic nature of the oil is excellent for the skin. The oil can also be used for cooking (Ukuru *et al.*, 2011). The colour and the nutty aroma make it ideal for frying and for use as bio-diesel. The oil is resistant to chemical decomposition at high temperature and the quantity needed for oil captivation is lower as compared with other oils (Lasekan & Abdulkarim, 2012). Tiger nut oil is very suitable for making cosmetics because of its high Vitamin E content which is an antioxidant and prevents ageing of the cells. Some of the cosmetics made from the tiger nut include bath milk and soap (Lasekan & Abdulkarim, 2012). The major benefit of Vitamin E in cosmetics is that it helps in the healing process of the skin. As Vitamin E is captured by the epidermis layer of the skin, it can be used for treating sun burn or in sunscreen to shield from the sun. Another benefit is that, it can be used in the treatment of scars, acne, and wrinkles as it speeds up cell regeneration. It also helps the skin to retain its natural moisture content (Lasekan & Abdulkarim, 2012).

2.2.3.2 Tiger Nut Flour

Tiger nut flour has an exceptional taste, which is ideal for different uses such as biscuits, cakes, “Burkina” and other pastries (Ade-Omowaye, 2008). To produce flour out of tiger nuts, the nuts are cleaned, sorted to select the good ones, washed, oven dried and milled into flour. Tiger nut flour is a rich source of oil and some valuable mineral elements such as iron and calcium, which are essential for body growth and development. It also contains a moderate amount of protein (Oladele & Aina, 2007). According to Oladele and Aina (2007), the low bulk density, setback and breakdown viscosities displayed by tiger nut flour enables its use without fear of retrogradation.

2.2.3.3 Tiger Nut Milk

The tiger nuts are pressed for its milk and used to make a beverage known as “horchata de chufa” in Spain or “kunnu aya” in Northern Nigeria (Belewu & Abodunrin, 2006). Tiger nut can be processed into varieties of tiger nut milk products like natural tiger nut milk, pasteurized tiger nut milk, sterilized tiger nut milk, ultrahigh temperature tiger nut milk, condensed tiger nut milk and concentrated tiger nut milk. Tiger nut milk can be used by people having milk allergies such as galactosemia, and lactose intolerance (Ukwunu & Ogbono, 2011). Yoghurts are also produced from tiger nut milk through a fermentation process. It can also be made into pudding for dessert.

Tiger nut milk is also very popular in some South American countries (Cortes *et al.*, 2004; Corrales *et al.*, 2012). The refreshing non-alcoholic beverage of milky appearance is normally produced from dried nuts which are ground and extracted with water (Kay, 1987). The milk beverage has a pH in the range 6.3 - 6.8 and is rich in starch (Cortes *et al.*, 2004, Belewu & Belewu, 2007). Heating the tiger nut milk beverage above 72 °C therefore results in changes in the physical and organoleptic characteristics due to the gellification of the starch (Cortes *et al.*, 2004). The physical, chemical and sensory characteristics of the tiger nut milk beverage have been found to depend on factors, such as the variety of tuber and procedure for beverage production (Belewu & Belewu, 2007; Navarro *et al.*, 1984). The nutritional value of a typical fresh tiger nut milk with 10 % sugar added has been reported as 3 % fat, 1 % protein, 3 % starch, and other carbohydrates making up 20 % (De Venanzi, 1991). The composition of fatty acids in the drink have been found to be comparable with that of olive oil, with oleic acid constituting about 75 % while palmitic and the other unsaturated fatty acids mainly linoleic and linolenic comprise 12.5 % and 10 % respectively (Belewu & Belewu, 2007). In a study on the composition of tiger nut milk by Cortes *et al.*,

(2004) arginine, glutamic acid and aspartic acids were the major acids recorded. The following essential amino acids; isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine were also found to be in appreciable quantities. The flavour of horchata de chufa has been described by researchers as nutty, pleasant and refreshing, chalky coconut, and vanilla-like (Reid *et al.*, 1972; Barber, 1981; Linssen *et al.*, 1989; De Venanzi, 1991).

2.3 Other Vegetable Milk

The use of plant materials in the production of dairy-like milk is one possibility that has been identified as a means of meeting the ever increasing demand for proteins, vitamins, minerals, carbohydrates and health beneficial ingredients that would have been derived from consuming dairy milk (Edwards, 1998). Non-dairy or vegetable milk are the general names of plant based milk, which are obtained by water extraction of plant materials such as oil seeds and 41 legumes with a colour unique to every plant material (Edwards, 1998). Vegetable milks are colloidal emulsions and suspensions which have particles or droplets with at least one linear dimension in the size range of 1 nm to about 1 mm (Dickinson, 1992). The composition of the emulsion is usually the small fat or oil droplets, stabilized with surface-active agents such as proteins and lipids. The suspensions, however, are the undissolved solid particles, such as protein, starch, fiber and other cellular material, which are present in the aqueous solution (Dickinson & Stainsby, 1988). While the insoluble particles in the solution can aggregate and form sediments, the less stable droplets in emulsion can also merge and increase in size over time (Dickinson & Stainsby, 1988). Non-dairy milk has attracted a lot of interest because of its potential as a low cost and healthy alternative to cow milk (Wong, 2013; Diarra *et al.*, 2005). In comparison to cow milk, they have no significant quantities of

cholesterol or lactose, which makes them an attractive alternative for people conscious of their health and/or diet, vegetarians, and those who are lactose intolerant (Benward & Benward, 2000). The intensification in the demand for non-dairy milk products by consumers has led to the development of alternatives to animal milk products such as infant formulas (Benward & Benward, 2000); low sugar and low calorie milks for dietetic and diabetic purposes (Demirag *et al.*, 1999); and non-dairy fermented products (Martensson *et al.*, 2000; Shirai *et al.*, 1992).

Vegetable milk has been used for a long time in many societies, both as a standard drink, and as an alternative to dairy milk. Common examples include soy milk, almond milk, rice milk and coconut milk (Purdy, 2017). This kind of milk contains no lactose or cholesterol, and is typically fortified with calcium and vitamins, particularly vitamin B₁₂. However, there are differences in their protein content depending on the plant source (Wong, 2013).

In the United States, soy milk was long the most common non-dairy milk, at the same time, around 2010, almond milk became quite well known, and eventually outperformed soy milk in 2013 (Wong, 2013). Other common vegetable milk in the US are rice and coconut milk. Vegetable-based milk make up 9.3 % of the aggregate milk market. In Europe soy and oat milk are prominent (Purdy, 2017). There is likewise hemp milk, cashew nut milk, hazelnut milk, and milk from peas and lupin. Vegetable milks are utilized in the production of ice-cream, vegetable cream and yoghurt (Purdy, 2017).

2.4 Composite Milk

According to the European Commission, “Composite Products” are defined in Article 2(a) of Commission Decision 2007/275/EC as “a foodstuff intended for human consumption that

contains both processed products of animal origin and products of plant origin and includes those where the processing of primary product is an integral part of the production of the final product". For this guidance, the composite products of animal origin must be processed before being mixed with that of plant origin. 'Dairy products' means processed products obtained from the processing of raw milk or from the further dispensation of such processed products (United Kingdom Food Standards Agency, 2017).

Milk product is a product obtained by any processing of milk, which may contain food additives, and other ingredients functionally necessary for the processing (Purdy, 2017). Composite milk product is defined as "a product of which the milk, milk products or milk constituents are an important part in terms of amount in the final product, as consumed, provided that the constituents not derived from milk are not intended to take the place in part or in whole of any milk constituent" (Codex Alimentarius Standard 206. 2014). From the above definition, milk from non-dairy sources such as tiger nut milk does not by itself constitute composite milk and will be termed as such only when the tiger nut milk is mixed with processed milk of animal origin.

Composite milk may also consist of a combination of milk from different animal sources (cow, sheep, goat), different plant sources or both animal and plant sources in varying proportions (Wong, 2013). This is usually done for different purposes depending on the intended use. Some composite milk is developed to reduce lactose intolerance and others are formulated to suit product specifications or achieve a desired nutritional or physicochemical specification. Others are produced to provide several food options for the consumer (Wong, 2013).

2.4.1 Products from Composite Milk

Figure 3 illustrates the concept of composite dairy products and shows the various combinations of milk sources and non-milk sources that may be possible. The *composite milk product* “Burkina” covered by this study comprises processed cow milk and tiger nut milk as the milk sources and millet as the non-dairy source. The two milk sources combined constitute *composite milk* as per the definition in section 2.4 above. Cheese is a dairy product made from milk by coagulating the milk protein (casein). It is made up of milk proteins and fat. Amid generation, the milk is fermented, and a catalyst (rennet) is added to facilitate coagulation. The solids are separated and squeezed to form the product (Tijani, 2014). Herbs, flavours or wood smoke might be utilized as flavour enhancing agents. The yellow to red shade of numerous cheeses are made by including annatto. Different food items, such as dark pepper, garlic and cranberries, might be added to a few cheeses to produce a desired flavour (Fankhauser, 2007). Other products made with composite milk include Ice cream, Yoghurt, and Flavoured Milk (Fankhauser, 2007).

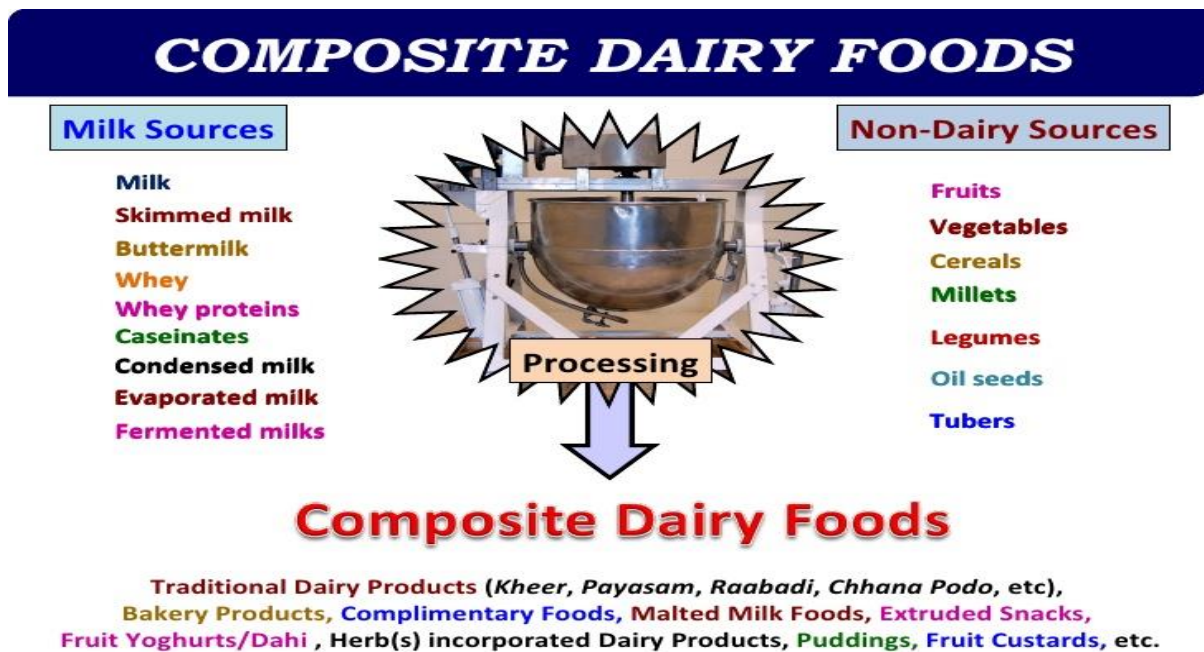


Figure 3: Concept of Composite Dairy Foods including Milk Composites

Source: <https://www.slideshare.net/oshnic/composite-dairy-foods/1>

2.5 Microbiology of Milk and Dairy Products

The constituents of milk, water, fats, proteins and vitamins allow for the growth of a variety of bacteria, especially psychotropic bacteria that are able to grow under cold conditions (Speake, 2015). Raw milk, pasteurized milk, cheese, and other dairy products support different and diverse groups of microorganisms which cause product spoilage. Light can also contribute to the spoiling of dairy products (Speake, 2015). There are many techniques, however, such as pasteurization and special packaging, which are used to protect these dairy products from adverse effects of microbial growth and light (Speake, 2015). Farmers, dairy processors, and consumers use many methods to measure the degree of spoilage and gauge milk quality. Preventing microbial growth and extending shelf life can alleviate cost for producers, retailers and consumers, but can also limit the environmental impact of dairy production and consumption (Lu & Wang, 2017). Spoilage microorganisms include aerobic psychotropic gram-negative bacteria, yeasts, molds, hetero-fermentative lactobacilli, and spore-forming bacteria. Psychrotrophic bacteria can produce large amounts of extracellular hydrolytic enzymes, and the extent of recontamination of pasteurized fluid milk products with these bacteria is a major determinant of their shelf life (Lu & Wang, 2017). Fungal spoilage by dairy foods is manifested by the presence of a wide variety of metabolic by-products, causing off-odours and flavours, in addition to visible changes in colour or texture (Ledenbach & Marshall, 2009).

2.6 Sensory Evaluation of Milk and Dairy Products

Alvarez (2015) suggest that descriptive sensory evaluation methods which are used to evaluate the characteristics of milk and dairy products to monitor processing conditions and determine product quality are a valuable tool, especially for industry, because they are fast,

practical, and simple. They further suggest that the sensory evaluation methods of dairy products are evolving like other techniques (Alvarez, 2015). Sensory quality is the ultimate measure of product quality and success. Sensory analysis comprises a variety of powerful and sensitive tools to measure human responses to foods and other products. Selection of the appropriate test, test conditions, and data analysis, result in the generation of reproducible, powerful, and relevant results (Drake, 2010). Appropriate application of these tests enables specific product and consumer insights and the interpretation of volatile compound analyses to flavour perception (Drake, 2010).

2.7 Packaging of Milk and Dairy Products

The type of packaging material used for dairy products is of critical importance because of its impact on quality, safety, cost, and marketing of dairy to consumers. Recent interest has shifted towards novel applications such as smart or intelligent packaging, modified atmosphere and active packaging, and sustainability (Karaman *et al.*, 2015). The addition of shelf life extending compounds to packaging films rather than directly to food can be used to provide continued inhibition for product stabilization. For further processed foods with greater than one-week shelf life, active packaging can provide an added level of protection downstream in the distribution cycle (Dawson, 2011). Direct addition of antimicrobials for instance, will have a strong initial effect but will have little effect later in the distribution cycle since the antimicrobial will react with food components or be absorbed into the food bulk. For non-fluid foods, the deteriorative reactions occur primarily at the food surface. Thus, less antimicrobial compounds will be needed when used in the package since the compound will be released at the location of need, the food surface (Dawson, 2011).

According to Bertelsen (2012), prior to commercial use of bio-based primary packaging materials several concerns must be addressed. First of all, the bio-based material must remain stable during storage of the food products, maintaining the mechanical and/or barrier properties. Ideally, the materials should biodegrade efficiently on disposal. Thus, environmental conditions conducive to biodegradation must be avoided during storage, whereas optimal conditions for biodegradation must exist after discarding (Dawson, 2011). In order to reduce deterioration of the food products it is also important that the bio-based packaging material meets the requirements of the individual food products (Bertelsen, 2012)

CHAPTER THREE

3.0 METHODOLOGY

3.1 MATERIALS

3.1.1 Ingredients

The ingredients used included milk powder, tiger nuts, pearl millet and sugar. These were purchased from a local market in Accra.

3.1.2 Tools, Equipment and Chemicals

Some examples of tools, equipment and chemicals used in the “Burkina” production include; a home food processor, stainless steel food containers, sieves, sensory cups, spoons and Milton sterilizing tablets which were purchased from local vendors.

3.2 METHODS

3.2.1 Preparation of Tiger Nuts for Milk Extraction

3.2.1.1 Cleaning and Soaking of Tiger Nuts

The tiger nuts were thoroughly washed under running water to remove dirt and carefully hand-sorted to separate wholesome tiger nuts from unwholesome ones and other unwanted material like stones. Tiger nuts with bruises and those that were soft, mouldy, had holes in them or were discoloured, were discarded. This was done to reduce microbial load, remove bad tiger nuts and ensure product quality and safety (Nyarko-Mensah *et al.*, 2015).

3.2.1.2 Tiger Nut Treatment

The soaked tiger nuts were washed again, sterilised with Milton solution for 15 minutes (one Milton Tablet per 5 L of water, per manufacturer's instruction), blanched in boiling water (100 °C) for 5 minutes and allowed to cool. This was done to further reduce the microbial load on the tiger nuts. Blanching tiger nut tubers helps to improve the colour and enhance the flavour of the milk extract (Frimpong, 2016). It also reduces aggregation and settling of the biological polymers of the milk extract; thereby improving its colloidal stabilisation (Nyarko-Mensah *et al.*, 2015).

3.2.1.3 Milling of Tiger Nuts and Extraction of Tiger Nut Milk

The sterilised tiger nut tubers were placed in an H-Kitchen Universal Fritter Model QS513 and milled at high speed for 10 minutes. Milled tiger nut tubers (400 g) were weighed and 400 mL of purified water was added to the tiger nuts. The tiger nut slurry obtained was filtered through a 200 µm mesh nut milk bag (30.48 cm x 30.48 cm) to obtain tiger nut milk. The filtrate was filtered again with a 200 µm mesh nut milk bag to obtain a tiger nut milk colloid (Nyarko-Mensah *et al.*, 2015). The filtered tiger nut milk was heated to a temperature of 56 °C for 15 seconds to reduce microbial load and enhance filtrate flavour and taste (Figure 4). The process for milling the tiger nuts and extracting the tiger nut milk is outlined in Figure 4.

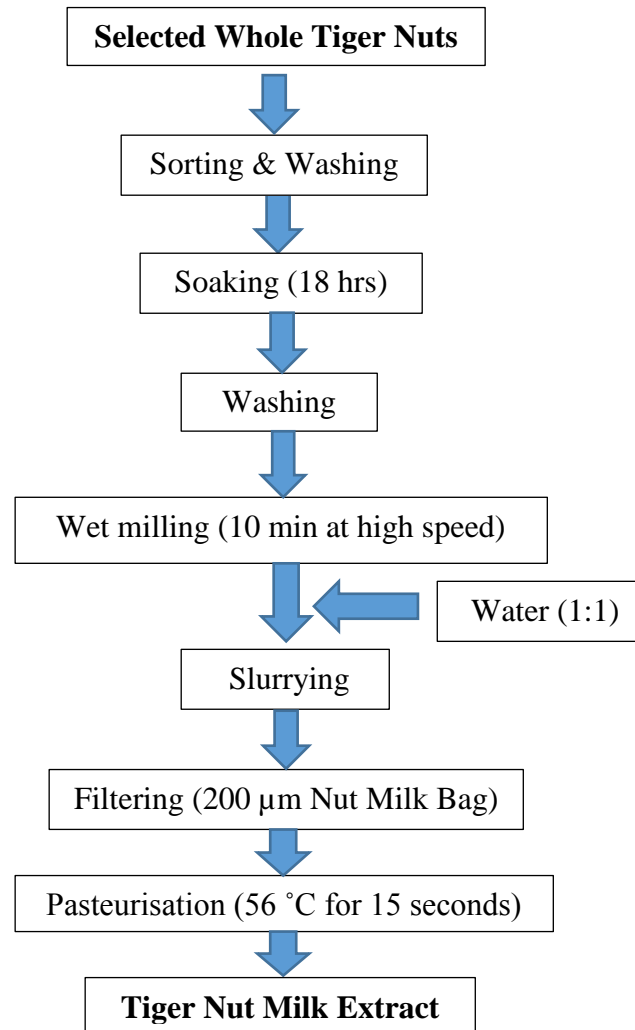


Figure 4: Flow Chart Showing Tiger Nut Milk Extraction Process

3.2.2 Pearl Millet Treatment and Agglomeration

The Pearl millet were sorted to remove unwanted material, washed under clean running water and soaked for 24 hours to remove anti-nutrients and aid digestion. The pearl millet was washed again and wet milled with a hand mill into a coarse flour which was exposed to air to ferment for 2 hours. Water was added to the pearl millet flour (10 mL : 100 g) and agglomerated by hand in a 1 mm mesh sieve. The agglomerate was then steamed for 30

minutes and allowed to cool (Figure 5). The production of Pearl millet agglomerates is outlined in Figure 5.

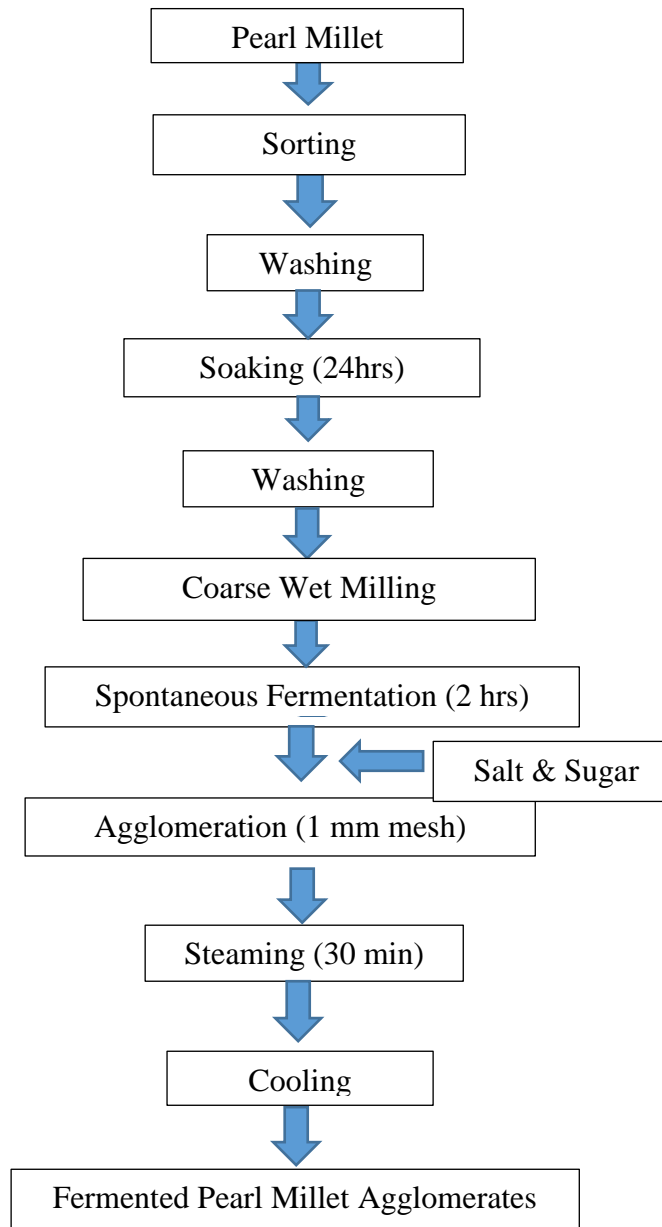


Figure 5: Flow Chart Showing the Production of Fermented Pearl Millet Agglomerates

3.2.3 Production of “Burkina” made with Cow’s Milk

“Burkina” was produced using the method of Otwe (2015) with modifications (which are described below). Three different samples of “Burkina” were prepared using whole milk powder, semi-skimmed milk powder and skimmed milk respectively. Each one of these was classified as a homogenous mixture. Milk powder [whole or semi-skimmed (234 g)] was added to 900 mL of purified water to form reconstituted whole and semi-skimmed milk respectively. “Burkina” from skimmed milk was prepared using Ultra-High Temperature (UHT) pasteurised skimmed milk. The milk (whole, semi-skimmed and skimmed) were pasteurised at 72 °C, cooled to 43 °C and inoculated with 90 g of culture. The culture was obtained from a commercial “Burkina” product. The inoculated milk (whole, semi-skimmed and skimmed) were incubated at 35 °C for 9 hours to form ‘nunu’ milk which varied in thickness and colour (based on the fat content of the milk). Fermented products were homogenized with a 20 µm mesh sieve to obtain a fine consistency. Fermented Pearl Millet agglomerates (20 g) and sugar (8.5 g) were added to each of the ‘nunu’ milk samples. The product was kept refrigerated until used.

3.2.4 Preparation of “Burkina” made with Composite (Cow and Tiger Nut) Milk.

“Burkina” made with composite milk was made using the method of Otwe (2015) with modifications (which are described below). Milk powder [whole or semi-skimmed (140.4 g)] was added to 540 mL of purified water and stirred to obtain 600 mL of reconstituted whole or semi-skimmed milk. The skimmed milk “Burkina” product was made using Ultra-High Temperature (UHT) pasteurised skimmed milk. The reconstituted whole milk, reconstituted semi-skimmed milk or UHT skimmed milk were pasteurised at 72 °C for 15 seconds. Tiger

nut milk extract was prepared as indicated in figure 4 (refer to section 3.2.1.3). Composite milk was prepared by adding 400 mL (40 %) of tiger nut filtrate to 600 mL (60 %) of whole, semi-skimmed and skimmed milk. The composite milk was inoculated with 90 g of the commercial “Burkina” culture and incubated at 35 °C for 9 hours to form ‘nunu’ milk. The ‘nunu’ milk obtained varied in thickness and colour and was homogenised with a 20 µm mesh sieve to obtain a finer consistency. After homogenisation, 20 g of millet agglomerates (see section 3.2.2) and 8.5 g of sugar were added to the composite milk, stirred and kept refrigerated until analysed for colour, proximate and mineral composition, microbiology and sensory attributes.

3.2.5 Packaging and storage of “Burkina” samples

The “Burkina” samples made with or without tiger nut were packaged in 330 mL polyethylene terephthalate (PET) bottles, sealed and refrigerated at 6 °C until analysed.

3.3 Colour Determination of “Burkina” samples

The difference in colour of the homogenous and composite “Burkina” samples were measured using a modified method of Yadav *et al.* (2012). Colour of the samples were determined with a Hunter Lab Colour Analyzer (CR310 Chromameter, Konica Minolta, Tokyo, Japan 76981007) to obtain the L (lightness), a (redness) and b (yellowness) values. ‘L’ ranges from 0 (black) to 100 (white) and both ‘a’ and ‘b’ values range from negative (-) to positive (+). Ten millilitres of each sample was taken and evenly spread in a petri dish. The colour analyser was calibrated with a standard white tile background. The standard values for the calibrations were as follows: $L = 97.63$, $a = -0.48$, $b = + 2.12$

The probe was placed on the petri dish containing the “Burkina” sample to obtain the L.a.b. values. ΔE value (size of total colour difference) was determined using the equation below:

$$\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}$$

(Morrison & Laignet, 1983)

Where ΔL = Sample L value – Standard value, Δa = Sample a value – Standard value and Δb = Sample b value – Standard value. The ΔE value however does not give information on how the colours differ.

3.4 Determination of pH for “Burkina” Samples

“Burkina” pH was determined according to the method of Chinma *et al.* (2010) with modifications in the volume of sample used (30 ml instead of 50 ml). Standard buffer solutions of pH 4, 7 and 10 were used to calibrate the Mettler Toledo Seven Compact pH meter. “Burkina” samples (30 mL per sample) were measured and poured aseptically into 50 mL beakers. The pH meter was dipped into the beaker containing the samples and readings were recorded. Recalibration of the pH meter was done after each reading was taken to ensure accuracy of results.

3.5 Proximate and Mineral Composition of the Homogenous and Composite Blends of “Burkina”

The protein, ash, moisture and fat content of the “Burkina” samples were determined using the Kjeldahl, mojonnier, dry ashing, air-oven, and dye-binding assay methods respectively. Crude carbohydrate was determined from the difference between the sum of the other

components and 100 %. The other minerals (phosphorus, magnesium, potassium and sodium), were determined using Atomic Absorption Spectrophotometry (AAS).

3.5.1 Protein Determination.

To determine the protein content of the “Burkina” samples, the following analyses were done using the Association of Analytical Communities (AOAC) 991.20 (2005) method: “Burkina” sample (1 g) without moisture was digested with 20 mL of concentrated sulphuric acid (H_2SO_4) and heated on a digester until the solution changed from black to greenish blue; indicating the end point of the reaction. This reaction was enhanced with a catalyst (500 g of potassium sulphate, 8 g of copper sulphate and 8 g of selenium powder). Ammonium sulphate was obtained from this reaction.

Protein distillation and titration involved the separation of the ammonium salt from the concentrated H_2SO_4 . In strong alkaline solution, gaseous ammonia is purified and trapped in standard acid solution. The reagents used were 0.01 N hydrochloric acid (HCl) and 40 % sodium hydroxide (NaOH). Tashiro Indicator (1 g Methyl red + 0.5g Methylene blue dissolved in 200 mL of 70 % ethanol) was used to determine the end point of titration. To begin the process, purified water was used to clean the distillation apparatus for a few minutes. The Kjeldahl extract was then diluted with 30 ml purified water. Boric acid 2 % (5 mL) was poured into a conical flask and 2 drops of Tashiro indicator was added to it and placed under a condenser (the tip of the condenser dipped into the receiving acid in order to avoid any ammonia loss). The digestion tube was attached to the distilling end. A 5 mL aliquot of the digested sample was measured and 5 mL of 40 % NaOH was added from an automatic burette. Distillation continued for about 4 minutes; producing 40 mL of distillate. The conical flask was lowered and the tip of the condenser was washed into the conical flask

for 1 minute. The distillate was removed and titrated with 0.01 N HCl to a green end point.

The percentage nitrogen (% N) was calculated as:

$$\% N = (B - T) \times 0.01N \text{ HCl} \times \text{Vol Ext} \times 100 \times 14/W \times \text{Aliquot} \times 1,000)$$

$$\% N = (0 - T) \times 0.01N \text{ HCl} \times 40 \text{ mL} \times 100\% \times 14/1,000 \text{ mg} \times 5 \text{ mL} \times 1,000)$$

Where: B is the titration value for blank

T is the sample titration value.

W is the weight of “Burkina” sample in milligram.

To convert to crude Protein, the % N was multiplied by 6.25.

3.5.2 Ash Determination

In determining the ash content of the samples, AOAC 945.46 (2005) method was used. An empty crucible was weighed and the value **x** recorded. “Burkina” sample (10 g) was placed in the crucible and the weight of the crucible and sample **y** was recorded. The crucible was then placed in a furnace for 24 hours at 600 °C. The weight of the crucible and ashed sample **m** was determined after 24 hours. Percentage ash was calculated using the formula below:

$$\text{New \% ash} = \frac{m-x}{y-x} \times 100$$

3.5.3 Moisture Determination

AOAC (2005) method was adopted for this analysis. The weight of an empty aluminium dish **x** was determined. “Burkina” sample (10 g) was weighed and placed in the dish and the weight **y** recorded. The aluminium dish containing the “Burkina” sample was placed in an

oven at 105 °C for 24 hours then cooled at ambient temperature. Then the weight of the aluminium dish with “Burkina” sample was determined and the value **m** recorded. Percentage moisture was calculated using the formula below:

$$\text{New \% moisture} = \frac{y-m}{y-x} \times 100$$

3.5.4 Fat Determination

AOAC 989.05 (2005) method was used to determine fat content. An empty thimble was weighed and the value recorded as **a** before it was filled with 10 g of the “Burkina” sample and the weight recorded as **b**. The thimble was covered with cotton, and weighed before extraction and the value recorded as **c**. The thimble was then suspended in the chamber of an extractor containing petroleum spirit at 50 °C. The extraction was done for an hour before the thimble was brought out and dried at ambient temperature. The weight of the dried sample after extraction was recorded as **d**. Percentage fat was calculated using the formula below:

$$\% \text{ fat} = \frac{c-d}{b-a} * 100$$

3.5.5 Carbohydrate Determination

The percentage of protein, ash and fat were summed up and subtracted from the difference between a hundred percent and percentage moisture as indicated by Harold *et al.* (1981). Percentage carbohydrate was calculated using the formula below:

$$\% \text{ Carbohydrate} = (100 - \% \text{ moisture}) - (\% \text{ Protein} + \% \text{ Ash} + \% \text{ Fat})$$

3.6 Mineral Composition of the Homogenous and Composite Blends of “Burkina”

The mineral content of the various “Burkina” samples was determined using the Atomic Absorption Spectrophotometry method. Samples were analyzed in solution form. To analyze for a given element, a lamp was chosen that produced a wavelength of light that is absorbed by the element being analysed for. Sample solutions were aspirated into the flame. If any ions of the given element were present in the flame, they would absorb light produced by the lamp before it reached the detector. The amount of light absorbed depended on the amount of the element present in the sample. Absorbance values for unknown samples were compared to calibration curves prepared by running known samples.

3.7 Microbiological Analyses of “Burkina” samples

Microbiological analyses of the samples were done using the AOAC International (2002) method. Petri dishes used for the analyses were all autoclaved for an hour before they were used. The media used were Plate Count Agar (PCA) for total counts, Macconkey Agar (MA) for coliform counts, Blood Agar (BA) for *Staphylococcus aureus* counts, Oxytetracycline Glucose Yeast Extract (OGY) for yeast and mold counts, Xylose Lysine Deoxycholate Agar (XLD) for *salmonella* counts and Eosin Methylene Blue Agar (EMB) for *E.coli* counts. Each one of them had specific weights measured and diluted with distilled water according to the manufacturer’s instructions. The diluted media were heated on a Bunsen burner and placed in a water bath at 45 °C to prevent them from setting. Peptone (7.5 g) was diluted with 500 mL of water to form an isotonic peptone water solution; of which 90 mL was pipetted into smaller volumetric flasks and 9 mL into several test tubes. The removable pipette tips, the test tubes and flasks containing the peptone water were autoclaved for an hour as well. To avoid

contamination during analysis, the outer layer of the container with the “Burkina” sample was first cleaned with cotton soaked in alcohol before opening it. “Burkina” sample (10 g) was then weighed into a stomacher bag and 90 mL of peptone water added and homogenized with a stomacher blender. Appropriate six-fold serial dilutions were prepared. The pour plate method was used. With this, a bacterial solution was poured into an empty plate to be inoculated. Melted nutrient agar was poured into the empty plate and swirled for uniformity.

3.8 Sensory Evaluation

3.8.1 Focus Group Discussion

A Focus Group Discussion (FGD) was done with 41 panelists at the Department of Family and Consumer Sciences Product Development Laboratory. The FGD was a qualitative study that was geared towards understanding the desirability of “Burkina” and consumers’ perception on drinking “Burkina” made with flavoured milk. The discussion also focused on the packaging and safety of “Burkina”. The FGD was done with an interview guide. The 41 panelists were split into six different Focus Groups and asked to sign an informed consent form before the discussions began. Each Focus Group consisted of a minimum of 6 participants and a maximum of 8 participants. The participants were informed that the discussion would be audio recorded and were given an opportunity to ask for clarification before their session began.

3.8.2 Consumer Acceptance Test

A consumer acceptance test was done with 43 untrained panelists who were either consumers or non-consumers of “Burkina”. A preference test was used to measure factors such as the

appearance, colour, aroma, taste, mouthfeel and flavour. The test consisted of rating each “Burkina” product, based on the factors above, using a 9-point Hedonic scale. Panelists were presented with 50 mL “Burkina” samples made with whole milk, semi-skimmed or skimmed milk and Tiger nut composite versions of these milk types. The samples were coded with random 3 digit codes and served simultaneously. Instructions were given to the panelists to cleanse their palate with water before and after assessing each sample. The evaluations were conducted in a well-lit room with white fluorescent lights.

3.9 Study Design and Data Analyses

A two factor experimental design (2^3) was used for this study. With the exception of Sensory Evaluation, all experiments were carried out in triplicates. Analysis of Variance (ANOVA) was performed with significance of means tested at the 95 % confidence limit using the Statistical Package for Social Sciences (SPSS) version 24.0 (Softonic International S.A). Illustrations with tables were done using Microsoft Office Excel 2013. Thematic analysis of consumer focus group discussion was carried out using the Attride-Stirling 2001 method, with the aid of ATLAS.ti.7.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Proximate Composition of “Burkina” Samples

The proximate composition of the “Burkina” samples determined included moisture, ash, protein, fat and carbohydrate. The values were reported as percentage dry-matter basis except for moisture content values. Table 2 shows the proximate composition of the “Burkina” samples.

Table 2: Proximate Composition of “Burkina” samples

Sample	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Carbohydrate (%)
FCM	80.18 ± 0.39 ^a	3.81 ± 0.42 ^b	5.85 ± 0.02 ^c	2.74 ± 0.11 ^c	7.42 ± 0.23 ^a
FCMT	75.42 ± 0.41 ^b	4.91 ± 0.03 ^a	7.91 ± 0.18 ^a	4.04 ± 0.14 ^a	7.72 ± 0.19 ^a
SSM	84.89 ± 0.62 ^a	3.45 ± 0.09 ^b	4.61 ± 0.19 ^d	1.31 ± 0.09 ^d	5.74 ± 0.18 ^b
SSMT	78.03 ± 0.81 ^b	4.46 ± 0.14 ^a	6.46 ± 0.20 ^b	3.44 ± 0.08 ^b	7.61 ± 0.15 ^a
SM	86.29 ± 0.69 ^a	3.11 ± 0.17 ^b	4.04 ± 0.13 ^d	1.04 ± 0.12 ^d	5.52 ± 0.27 ^b
SMT	79.71 ± 0.69 ^b	4.11 ± 0.11 ^a	6.13 ± 0.15 ^b	3.03 ± 0.13 ^b	7.02 ± 0.22 ^a

FCM (Full Cream Milk), SSM (Semi-Skimmed Milk) and SM (Skimmed Milk) are homogenous “Burkina” samples while FCMT (Full Cream Milk with Tiger Nut), SSMT (Semi-Skimmed Milk with Tiger Nut) and SMT (Skimmed Milk with Tiger Nuts) are “Burkina” samples containing 40 % tiger nut milk. Values are means and standard deviations of triplicate analysis. The values were reported as % dry matter, except for moisture content values. Means in the same column with the same letter are not significantly different; $p \leq 0.05$.

4.1.1 Moisture Content

Moisture content of the “Burkina” samples was determined as the mass of water in a given mass of “Burkina” samples removed by evaporation. The moisture content of the samples ranged from 75.42 % - 86.29 %. “Burkina” samples with tiger nuts, [Full Cream Milk with Tiger Nuts (FCMT), Semi-Skimmed Milk with Tiger Nuts (SSMT) and Skimmed Milk with Tiger Nuts (SMT)] had lower moisture levels ($p \leq 0.05$) compared with “Burkina” samples without Tiger Nuts [Full Cream Milk (FCM), Semi-Skimmed Milk (SSM) and Skimmed Milk (SM)] (Table 2). There was no effect of milkfat levels [Full cream (4 %), Semi-Skimmed (2 %) and Skimmed (0 %)] on “Burkina” moisture levels.

4.1.2 Fat Content

The incorporation of tiger nut milk into the “Burkina” samples led to an increase in “Burkina” fat levels ($p \leq 0.05$). “Burkina” samples with tiger nuts (FCMT, SSMT and SMT) had higher fat levels ($p \leq 0.05$) compared with “Burkina” samples without tiger nuts (FCM, SSM and SM). It was observed from Table 2 that the incorporation of 40 % tiger nut milk into the “Burkina” samples increased the fat content of the product. This can be attributed to the fact that tiger nut is rich in fatty acids (Dubois *et al.*, 2007; Ezeh *et al.*, 2014). The fat levels were within the range 1.4 % – 4.5 % as reported by Chinedu *et al.*, (2012). The fat content of the samples may be a useful indicator of their flavour and may influence the processing, packaging and storage of the “Burkina” products (Chinedu *et al.*, 2012).

4.1.3 Carbohydrate and Protein Content

The carbohydrate content of “Burkina” samples was estimated by difference after the sum of all the other proximate analysis components (Table 2) had been subtracted from 100 %. “Burkina” samples with tiger nuts had higher carbohydrate contents ($p \leq 0.05$) compared with “Burkina” samples without tiger nuts. Carbohydrate content of “Burkina” without tiger nuts made from semi-skimmed and skimmed milk were lower than in the full cream version without tiger nuts ($p \leq 0.05$). The carbohydrate content of the samples ranged from 5.52 (SM) – 7.72 % (SST) and are within the range reported by Frimpong (2016).

Incorporation of tiger nuts into “Burkina” resulted in higher protein levels. Protein levels were higher in “Burkina” made with tiger nuts ($p \leq 0.05$) compared with “Burkina” made without tiger nuts. “Burkina” made with full cream milk had higher protein levels ($p \leq 0.05$) than “Burkina” made with skimmed and semi-skimmed milk (Table 2). Higher carbohydrate and protein levels may make tiger nuts useful for food fortification programs (Grosso *et al.*, 2008). Carbohydrates contribute to the taste and flavour of the products and help in the development of the characteristic colour of the products (Grosso *et al.*, 2008).

4.1.4 Total Ash Content

The total ash was determined by the combustion of the “Burkina” samples (with and without tiger nuts) and measured as the mineral content of the milk samples (Blitz *et al.*, 2009). The total ash content determined for the six samples differed significantly ($p \leq 0.05$) as observed in Table 2. Incorporation of tiger nuts into “Burkina” resulted in higher ash levels ($p \leq 0.05$). All “Burkina” samples with tiger nuts (FCMT, SSMT and SMT) had higher ash levels ($p \leq 0.05$) than “Burkina” samples without tiger nuts (FCM, SSM and SM). Tiger nuts are

high in minerals such as magnesium, potassium and phosphorous (Abraham, 2013) which would contribute to the high ash levels. There was no effect of milk fat levels on the ash content of “Burkina”. Minerals are important in food for their nutritional and physiological roles. However, some of them (such as magnesium and zinc) catalyse oxidative activity in foods containing fat and often cause undesirable colour changes, oxidize ascorbic acid and create off-flavours and taste defects through fat oxidization in foods such as milk products (Blitz *et al.*, 2009).

4.2 Mineral Composition of “Burkina” Samples

The mineral composition determined included potassium, sodium, magnesium, phosphorus and calcium. Table 3 shows the results obtained from the analyses. It is observed in Table 3 that the mineral content of the “Burkina” samples were high even though there were significant differences across all the minerals examined ($p \leq 0.05$). This is not surprising as both cow and tiger nut milk are well known for their high mineral content (Sanful, 2009). The variations in the minerals examined can be attributed to several factors such as the incorporation of tiger nut milk to some of the samples. Tiger nut milk has high mineral content, so it can be observed from Table 3 that the tiger nut composite milk samples (FCMT, SSMT, and SMT) had relatively higher mineral values with the exception of calcium. Milk is known to be rich in calcium. It is therefore not surprising that the “Burkina” samples without tiger nut had higher values than those made with composite milk. Minerals are important in food for their nutritional and physiological roles. However, they can be a disadvantage as they can cause off flavours and colours when there is poor handling or storage (Blitz *et al.*, 2009).

Table 3: Mineral Composition of “Burkina” Samples

Sample	Potassium (mg/L)	Sodium (mg/L)	Magnesium (mg/L)	Phosphorus (mg/L)	Calcium (mg/L)
FCM	18.39 ± 0.39 ^b	2.22 ± 0.06 ^a	1.786 ± 0.00 ^c	12.20 ± 0.28 ^d	38.40 ± 0.91 ^a
FCMT	21.35 ± 0.13 ^a	1.99 ± 0.01 ^b	4.69 ± 0.25 ^b	12.63 ± 0.17 ^d	24.50 ± 5.10 ^b
SSM	18.79 ± 0.42 ^b	1.31 ± 0.04 ^c	2.65 ± 0.05 ^d	13.50 ± 0.22 ^c	31.63 ± 2.56 ^a
SSMT	21.40 ± 0.29 ^a	2.16 ± 0.22 ^a	5.28 ± 0.12 ^a	14.80 ± 0.17 ^b	25.47 ± 1.15 ^b
SM	15.36 ± 0.45 ^c	0.71 ± 0.16 ^d	3.09 ± 0.23 ^c	15.03 ± 0.42 ^a	36.65 ± 1.15 ^a
SMT	22.34 ± 0.59 ^a	1.17 ± 0.05 ^c	4.73 ± 0.04 ^b	13.07 ± 0.68 ^c	21.42 ± 1.06 ^b

Means in the same column with the same letter are not significantly different; $P \leq 0.05$. FCMT = full cream milk with 40 % tiger nuts, SSMT = semi-skimmed milk with 40 % tiger nuts, SMT = skimmed milk with 40 % tiger nuts, FCM = full cream milk, SSM = semi-skimmed milk, SM = skimmed milk.

4.3 pH of “Burkina” Samples

The pH of the “Burkina” samples was acidic (3.78 – 3.98) but was not affected by fat content or the addition of tiger nut milk (Table 4). The pH of food is very important in food applications, food preservation, food packaging and storage (Egbebi & Bademosi, 2011; Fekria *et al.*, 2012). The pH of food products also influences sensory parameters such as taste, colour, texture, and flavour (Andrés-Bello *et al.*, 2013). During food processing, pH affects many processes such as coagulation, enzymatic activities, mortality of microorganisms, and chemical reactions such as fermentation. Thus the knowledge of pH effects and its control during processing are important for product safety and quality (Andrés-Bello *et al.*, 2013).

Table 4 depicts the mean pH of “Burkina” samples:

Table 4: Mean pH of “Burkina” Samples

“Burkina” Sample	pH
FCM	3.85 ± 0.53
FCMT	3.98 ± 0.24
SSM	3.91 ± 0.12
SSMT	3.82 ± 0.09
SM	3.93 ± 0.05
SMT	3.78 ± 0.45

Values are means and standard deviations of triplicate analysis. FCMT = full cream milk with 40 % tiger nuts, SSMT = semi-skimmed milk with 40 % tiger nuts, SMT = skimmed milk with 40 % tiger nuts, FCM = full cream milk, SSM = semi-skimmed milk, SM = skimmed milk. Skimmed milk contains 0 % milk fat, semi-skimmed milk contains 2 % milk fat and full cream milk contains 4 % milk fat

4.4 Microbiological Wholesomeness of “Burkina” Samples

“Burkina” samples were analysed to ascertain microbiological wholesomeness. This was to ensure that the samples could be consumed without adverse effects such as food poisoning or food infection due to the presence of harmful microorganisms in the “Burkina” samples.

Table 5 shows the mean count of microorganisms in the “Burkina” samples.

Microbiological counts were observed in the “Burkina” samples (Table 5). However, these counts were not significant to pose a health risk to consumers. The products were considered to be safe for consumption because the counts did not exceed the maximum permissible amount stated by the Ghana Standards Authority (GSA, 2010). There was a significant difference ($p \leq 0.05$) between samples containing tiger nut milk and samples without tiger nut milk. Samples containing tiger nut milk were the only samples to have counts for yeast and molds. Since the tiger nut tubers, which are already rich in nutrients, were respiring when stored, the combination of heat, moisture and nutrient provided the congenial environment for yeast and mold growth. However, the counts did not exceed acceptable amounts considered to be safe for human consumption (GSA, 2010).

Table 5: Microbiological Analyses of “Burkina” Samples (Mean Counts)

Agar/Microorganism	FCM	SSM	SM	FCMT	SSMT	SMT
PCA	9.8×10^3	8×10^3	8.7×10^3	9×10^3	9.4×10^3	8.8×10^3
Coliform	0	0	0	0	0	0
<i>Staph. aureus</i>	0	0	0	0	0	0
Salmonella	0	0	0	0	0	0
<i>E. coli</i>	0	0	0	0	0	0
Yeast & mold	0	0	0	1.0×10^3	1.1×10^3	1.0×10^3

4.5 Instrumental Colour Analysis of “Burkina” samples

L value is measured from 0 – 100, with 0 representing black and 100 representing white on the scale. L values were significantly lower ($p \leq 0.05$) for “Burkina” made with composite milk. The addition of Tiger nut milk resulted in a darker “Burkina” drink (Table 6). The ‘b’ values were all positive (Table 6), indicative of the fact that the “Burkina” samples had shades of yellow colouration. However, ‘a’ values were both positive and negative (Table 6), indicative of the fact that “Burkina” samples had shades of red and green (Minolta, 1991).

There were higher ‘b’ values in the composite “Burkina” samples compared with their respective formulations without Tiger Nuts. This may be due to the transfer of some pigment colour from the outer layer of Tiger nuts. The Tiger nut variety used had yellowish colour which may have contributed to the higher ‘b’ values recorded (Minolta, 1991). The mean colour (L, a, b) and ΔE values for “Burkina” sample are shown in the table below:

Table 6: Mean colour (L, a, b) and ΔE values for “Burkina” samples

“Burkina” Samples	L	A	b	ΔE
FCM	83.29 \pm 0.23 ^a	-3.01 \pm 0.32 ^a	13.53 \pm 0.24 ^a	18.50
FCMT	81.39 \pm 0.14 ^b	-2.28 \pm 0.21 ^b	14.97 \pm 0.06 ^b	40.71
SSM	86.58 \pm 0.08 ^c	-2.87 \pm 0.13 ^b	12.80 \pm 0.11 ^c	15.55
SSMT	82.32 \pm 0.07 ^d	2.84 \pm 0.05 ^c	14.55 \pm 0.15 ^b	19.99
SM	88.58 \pm 0.15 ^c	2.22 \pm 0.16 ^d	12.68 \pm 0.28 ^e	14.09
SMT	81.39 \pm 0.14 ^d	2.28 \pm 0.21 ^d	14.43 \pm 0.06 ^b	20.56

Values are means and standard deviations of triplicates. Means in the same column with different superscripts are significantly different ($p \leq 0.05$) FCMT = full cream milk with 40 % tiger nuts, SSMT = semi-skimmed milk with 40 % tiger nuts, SMT = skimmed milk with 40% tiger nuts, FCM = full cream milk, SSM = semi-skimmed milk, SM = skimmed milk

4.6 Consumer Focus Group Discussion and Sensory Evaluation of “Burkina”

Samples

Participants in the Focus Group Discussions (FGD) were between 18 and 50 years old with most of them between 18 – 24 years old. There were twice as many females as males in the FGD. The participants were students, workers or National Service personnel of the University of Ghana. The characteristics of the participants are elaborated in Table 7 below:

Table 7: Characteristics of FGD Participants

Characteristics	No. of Participants N = 41
<i>Sex</i>	
Male	13
Female	28
<i>Age</i>	
18-24	30
25-30	7
31-40	4
<i>Occupation</i>	
Student	29
Staff	6
Teaching Assistant/National Service Personnel	6

4.6.1 Consumer Focus Group Discussion

The consumer focus group discussion centered on the panelists’ understanding of the desirability of “Burkina” and their perception on drinking “Burkina” with flavoured milk. The

results for this discussion were coded into a global theme (Understanding the desirability of “Burkina”). The global theme was then broken down into sub-themes (Figure 6).

Figure 6 demonstrates the key points associated with understanding the desirability of “Burkina”.

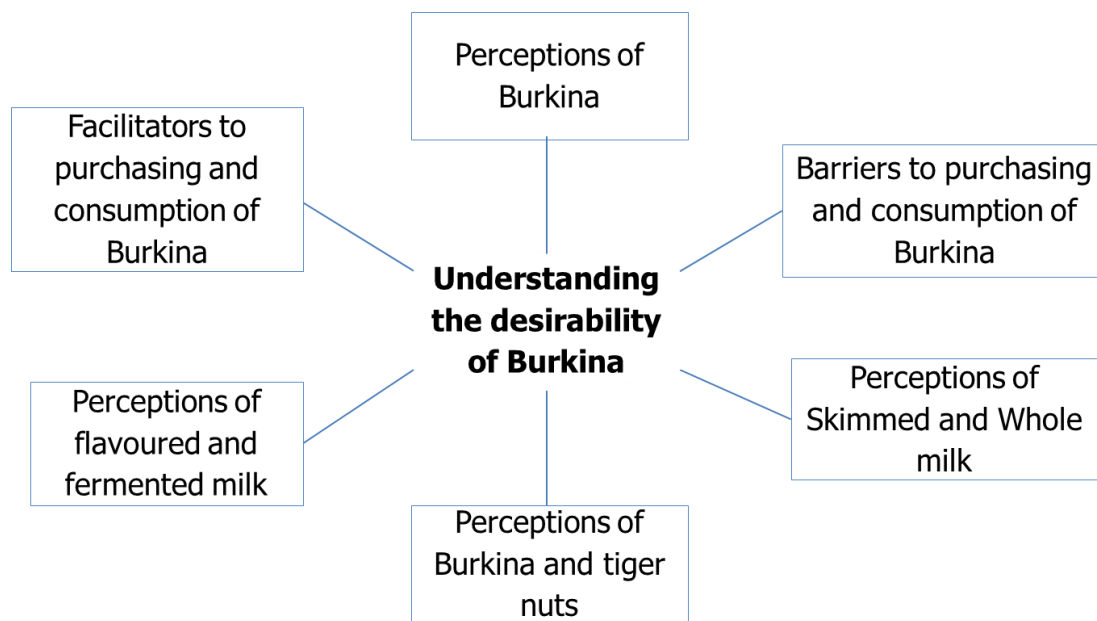


Figure 6: Understanding the desirability of “Burkina”

4.6.1.1 Perceptions of Flavoured and Fermented Milk

To determine whether consumers really understood what constituted “Burkina” milk beverage and their perception on flavoured “Burkina”, the panelists were asked what they understood by the terms ‘fermented’ and ‘flavoured’ milk. It was observed that five out of six focus groups pointed out that fermented milk was milk that had either gone bad or expired. One of the focus groups mentioned that the milk is usually unrefrigerated, another focus group mentioned that there was bacterial action. Two of the focus groups raised sourness as an attribute of fermented milk. It was generally observed that some points raised in a

particular focus group were also raised in a different focus group. Some focus groups also raised certain points which were unique to their group. A panelist from Focus Group 1 said:

“I think that it is milk that has ‘expired’ and has lost its taste and has become sour; the original taste is no longer there” {Focus Group 1}.

Another panelist in Focus Group 3 explained fermented milk as:

“It is a sort of milk that bacteria action has worked on and it is milk that has stayed over its required period and due to respiration, it has changed its form, from one state to another affecting the taste and sometimes the appearance and texture of it” {Focus Group 3}.

Based on themes (Figure 6) derived from these focus groups, it can be said that most of them knew what the term means since Benítez-Páez and Sanz (2017) and Roginski (2003) have mentioned sourness, bacterial action and similarity to milk going bad as some characteristics of fermented milk.

Flavoured milk, on the other hand was described as ‘milk with additives added’ by one focus group and ‘milk with added flavour’ by five of the groups. Some panelists defined it as:

“Anything being added is flavoured milk and it gives a particular scent” {Focus Group 4}.

“Additives or preservatives added to it” {Focus Group 2}.

Figure 7 indicates the responses given by the focus group panelists on their perception on flavoured and fermented milk.

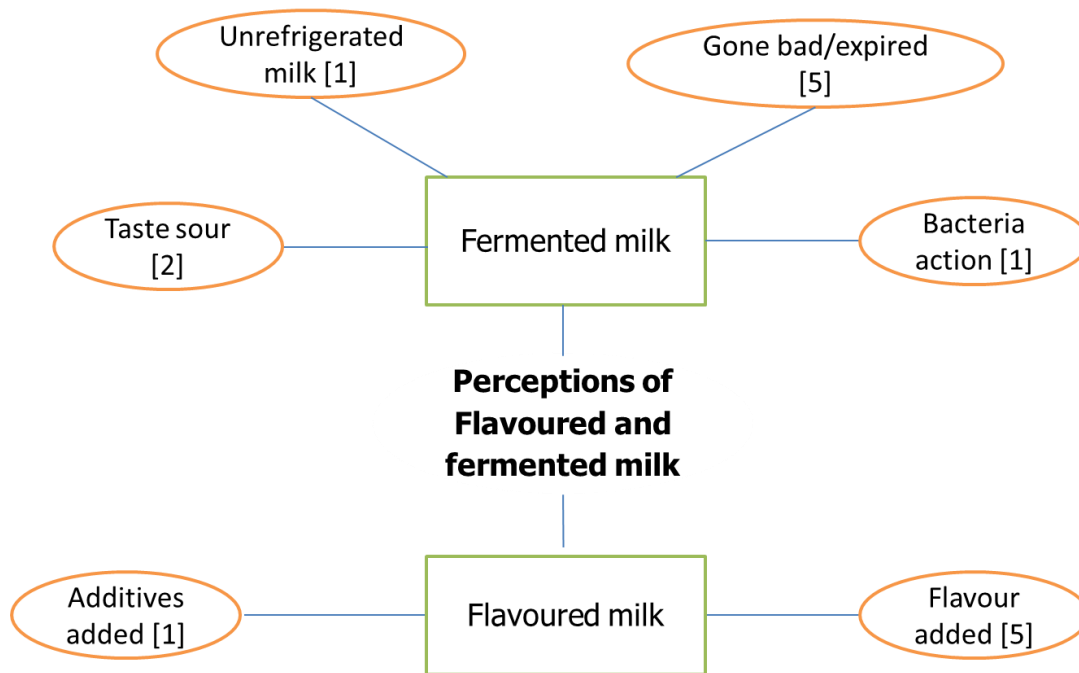


Figure 7: Perception of Flavoured and Fermented Milk

Numbers in brackets represent the total number of focus groups with similar themes. Note that the themes with figures attached may appear in more than one focus group.

4.6.1.2 Perceptions of Whole and Skimmed Milk

Majority of the focus groups (5) described skimmed milk as ‘milk with its fat extracted from it’ and one other group described it as ‘milk without cholesterol’. The focus group with a misconception about the term mentioned that it is ‘milk that has been pasteurized’. A panelist from focus group 3 in describing skimmed milk said:

“I think it is milk with fat taken out of it, but I think it is boiled and after a while, when a layer is formed on top of the milk, the layer is removed because that layer is normally the fat” (Focus Group 3)

A different panelist from focus group 1 also said:

“It doesn’t have fat and doesn’t have too much cream” (Focus Group 1)

Whole milk on the other hand was described as ‘raw unprocessed milk’ (3 FGD), ‘creamy milk’ (1 FGD) or ‘milk with its fats intact’ (4 FGD) (Figure 7). Some excerpts from the focus group discussions are as follows:

“If skimmed milk means all the fats have been removed from it, then full milk has all the fats intact.” (Focus Group 2)

“Full cream milk is the raw milk from the cow that has gone under no form of processing.” (Focus Group 6)

Two of these definitions were right as Lu & Wang (2017) described skimmed milk as “milk which tends to contain around 0.1 % fat and is made when all the cream (also called milkfat) is removed from whole milk”. Lu & Wang (2017) also described whole milk as “milk with all the cream intact”. The definition of full cream milk from the panellist from Focus Group 6 could be classified as a misconception since Lu & Wang’s definition did not state that full cream milk is unprocessed milk.

Figure 8 indicates the perceptions the panellists had on whole and skimmed milk:

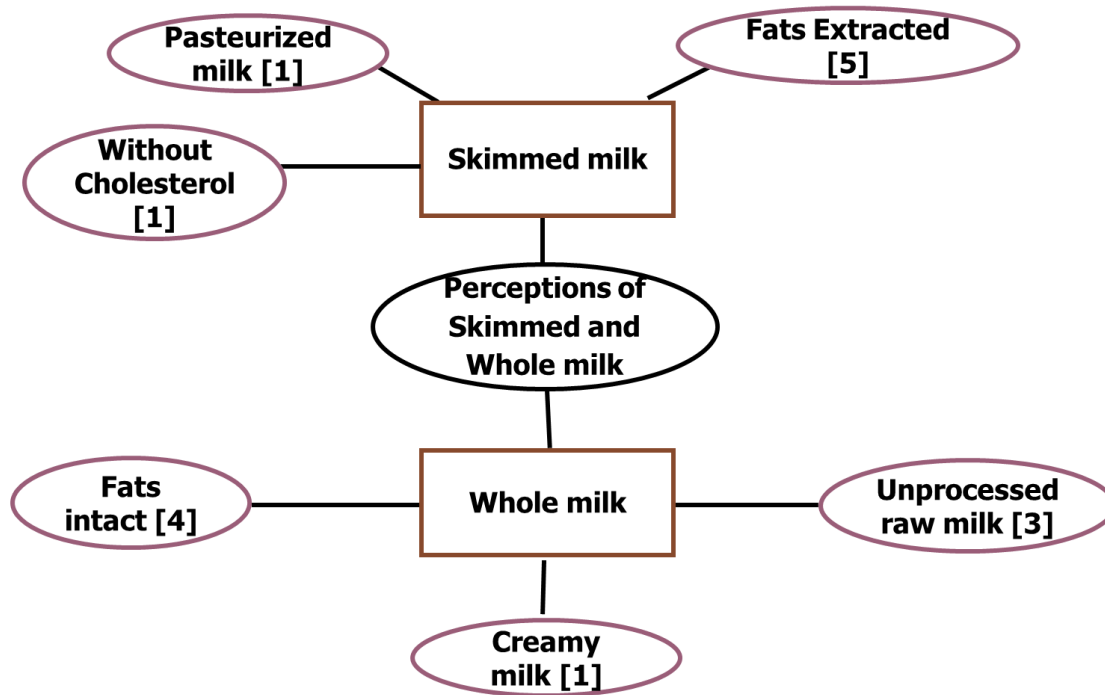


Figure 8: Perceptions of Skimmed and Whole Milk

Numbers in brackets represent the total number of focus groups with similar themes. Note that the themes may appear in more than one focus group.

4.6.1.3 Perceptions of “Burkina”

The following themes arose when the panelists were asked about their perceptions, source and packaging of “Burkina”: “Burkina” composition, flavouring, colouring, texture, and source, as well as beliefs associated with the packaging, purchasing and consumption of “Burkina”. All six focus groups described “Burkina” as a milk beverage containing millet. Below are some statements made by the focus group panelists to buttress the above point:

“I know it’s a local name for milk and millet. It is a milk and millet meal”. (Focus Group 3)

“The millet is what makes it ‘Burkina’, milk without millet is not ‘Burkina’” (Focus Group 4)

When asked about the type of flavoured “Burkina” the panelists would want to try, the following flavours came up: vanilla, banana, strawberry, chocolate, pineapple, tiger nut.

Four of these groups mentioned that the milk used for “Burkina” production could be either fresh or in a powdered form:

“I think its fresh milk but they sometimes add powdered milk” (Focus Group 2).

Other attributes mentioned in the various focus groups included a white or creamish colour (run across all groups) and its thickness compared with porridge. Two of the focus groups however associated “Burkina” as a Northern food or food made by mostly northerners:

“It’s a Northern food”. (Focus Group 5)

The panelists also mentioned that they purchased their “Burkina” products from either University of Ghana campus (5 Focus groups), on the streets in traffic, at Madina or Kaneshie.

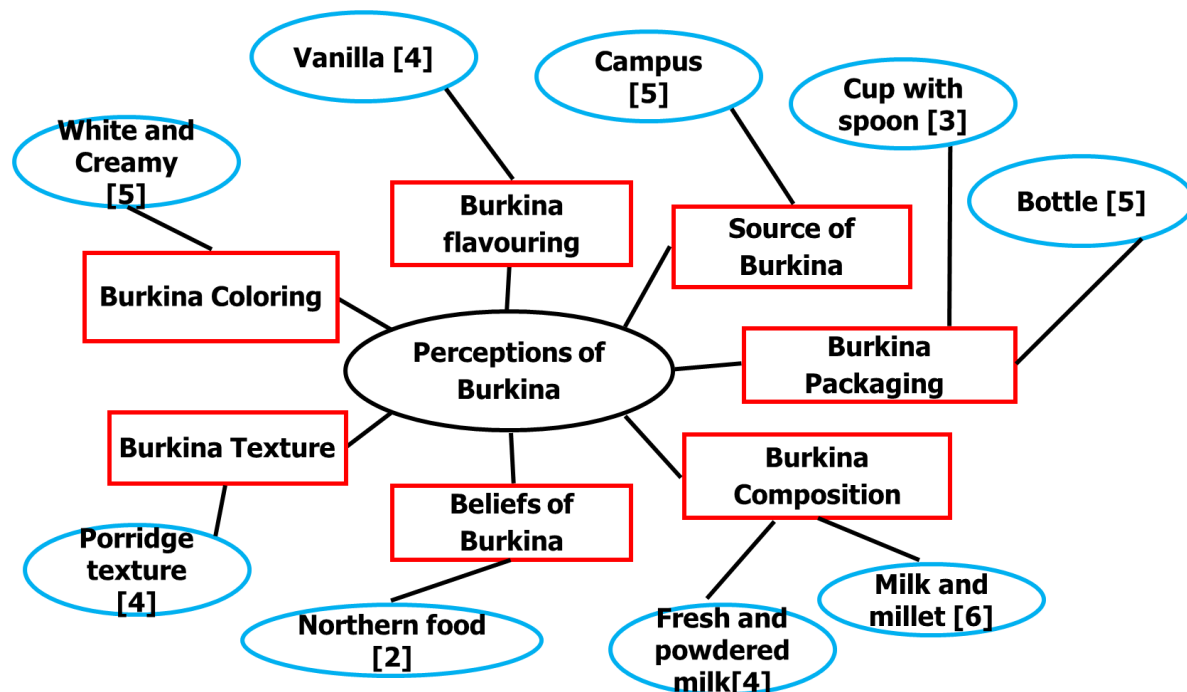
The above descriptions about “Burkina” is however in line with the definition that Caiquo & Mensah (2013) gave which is: “Burkina” produces a mouth feel of a thick smooth (yoghurt-like) texture with small lumps and a grainy feel of millet’. Research conducted by Osei-Onumah (2014), also indicated that “Burkina” can be made with either fresh milk, milk powder or both. Caplice & FitzGerald (1999) also posited in their research that “Burkina” is a beverage that is indigenous to the three northern regions and is currently sold on the streets of Accra. Since Northerners are known to be the main producers of “Burkina”, it was not surprising that one of the panelists mentioned that it was a northern food and others also said it was sold at Madina and Kaneshie.

When asked about panelists’ take on ‘Burkina’ made with skimmed milk, some groups felt it will be a healthier option. Other groups also mentioned that it might be tastier and lighter. The panelists associated skimmed milk with low fat content and believed that the reduction was a healthier option.

Five of the focus groups mentioned that “Burkina” is usually packaged in a plastic bottle and sold on ice in ice chests or bigger plastic containers. Three groups however mentioned they would like to try “Burkina” packaged in a cup. One person from focus group five stated that:

“If they have a small ice chest and it is covered. Plastic bottles are also fine.”(Focus Group 5)

The thematic mapping on the panelists’ perceptions of “Burkina” is presented in Figure 9.



Numbers in brackets represent the total number of focus groups with similar themes. Note that the themes with figures attached may appear in more than one focus group.

Figure 9: Respondents’ Perceptions on “Burkina”

4.6.1.4 Facilitators to the Purchasing and Consumption of “Burkina”

All focus groups indicated that there were certain facilitators that promoted the purchase and consumption of “Burkina”. Proximity and affordability were major facilitators as they were mentioned by five of the focus groups (Figure 10). Below are some of the statements made by the panelists:

“I don’t think I will walk all the way to night market for it but if it’s near me obviously I will buy it.” (Focus Group 3)

“if it is by my office and it is at an affordable cost, I will buy it every day, more than once a day.” (Focus Group 2)

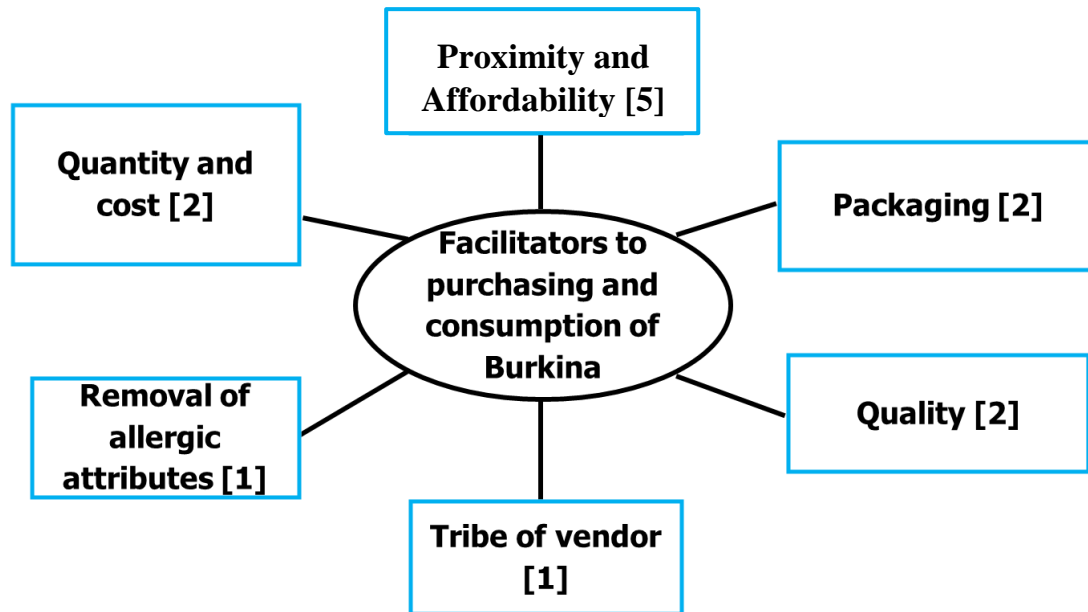
Two focus groups mentioned packaging as a facilitator, as it influences the aesthetics of the products and the desire to purchase it. Two focus groups also mentioned the quantity, quality and cost of the product as a facilitator. There was a group that mentioned allergies as one of the factors that will serve as deterrence to the consumption of “Burkina” but then the FGD stated that once the allergen is removed the desire to consume “Burkina” will be present:

“I have allergies, so I can’t take so much, but if it is removed, I will double it.”(Focus Group 1)

One group also mentioned that they will consider the tribe of the seller before purchasing the product.

“I will buy ‘Burkina’ from the Northerner, if there are two people selling ‘Burkina’. I won’t buy from any other person aside Northerners” (Focus Group 2)

Facilitators to purchasing and consumption of “Burkina” are summarized in Figure 10.



Numbers in brackets represent the total number of focus groups with similar themes. Note that the themes may appear more than one focus group.

Figure 10: Facilitators to the Purchasing and Consumption of “Burkina”

4.6.1.5 Barriers to the Purchasing and Consumption of “Burkina”

Certain barriers deter people from consuming “Burkina”. Some of these barriers were made known by the panelists during the focus group discussion (Figure 11). All focus groups mentioned the safety and hygienic state of the product as the major barrier since most people are sceptical when it comes to “Burkina” consumption. One Focus Group mentioned that they would not buy from the streets because they do not trust the source of the “Burkina”:

“I just cannot buy from people by the road side, I don’t trust their source of production”

(Focus Group 3)

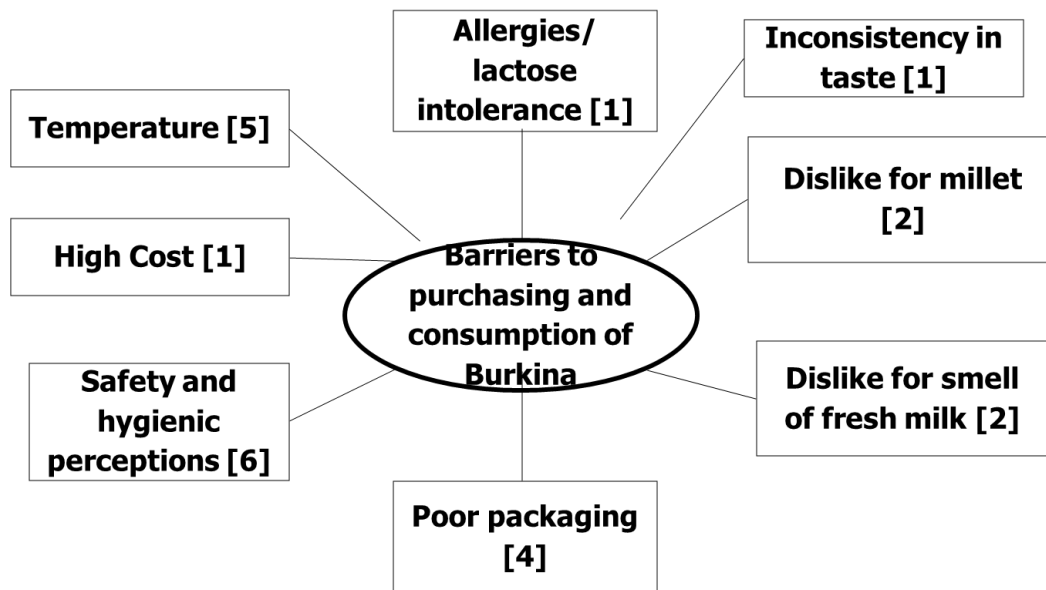
The next major barrier is the temperature of the product. This barrier was observed in five of the focus groups. The panelists in those groups explained that they will prefer their product cold since it appealed to their taste and the product's cold state will reduce the rate of microbial activity.

The third major factor which was observed in four of the focus groups was the poor packaging of the product:

“I think I wouldn't buy if they are using a plain rubber. But if it comes in a good packaging I'll buy it.” (Focus Group 3)

Consumers have the behaviour of opting for products with attractive packaging. It is therefore expected that such a barrier would be brought up. Two of the focus groups mentioned that their dislike for millet and the smell of fresh milk will prevent them from buying and consuming “Burkina”. It was observed in a single focus group that lactose intolerance or the presence of any allergen and inconsistencies in the taste of “Burkina” would deter them from “Burkina” consumption.

These barriers have been summarized in Figure 11 below:



Numbers in brackets represent the total number of focus groups with similar themes. Note that the themes may appear more than one focus group.

Figure 11: Barriers to the Purchasing and Consumption of “Burkina”

4.6.1.6 Perceptions of “Burkina” with Tiger Nut

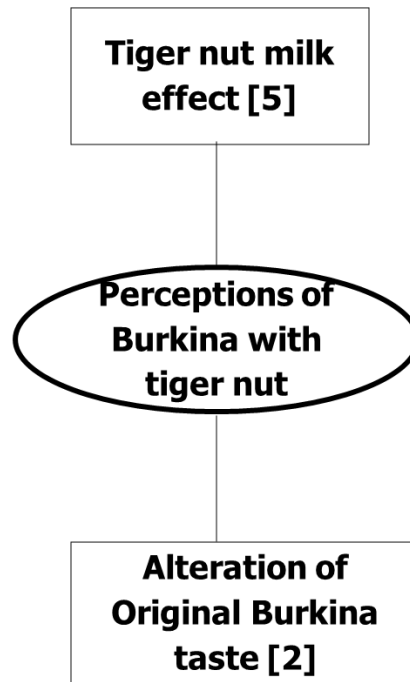
The panelists in the focus groups were asked about their perception on consuming “Burkina” incorporated with tiger nut milk (Figure 12). Five groups mentioned they will love the product since they will be tasting the rich nutty taste the tiger nuts would add. Below are some statements made by two different 63 panelists from focus groups 5 and respectively:

“Since there is tiger nut milk already, it is possible to have tiger nut ‘Burkina’ and the taste will be interesting.” (Focus Group 5)

“This might be great because I have heard of tiger nut milk” (Focus Group 4)

Two of the focus groups however mentioned that the original “Burkina” taste would be altered and were a bit sceptical about trying such a product.

“it will alter the taste of the original ‘Burkina’.” (Focus Group 1)



Numbers in brackets represent the total number of focus groups with similar themes. Note that the themes may appear more than one focus group.

Figure 12: Perceptions of “Burkina” with Tiger Nut Milk

4.6.2 Sensory Evaluation of “Burkina” Samples

Sensory scores given by panelists ranged from 6.15 - 8.83 an indication of different levels of liking. “Burkina” samples had significant differences in all sensory attributes but flavour. The mean liking scores for the homogenous and composite “Burkina” samples were significantly different with the exception of flavour. This could be attributed to the fact that most of the panelists liked the rich nutty flavour of the tiger nuts. Results in Table 8 also indicated that the means from the mouthfeel of “Burkina” made with composite milk were significantly different as these products had a decreasing level of thickness as the milk fat content decreased. Amongst the “Burkina” samples made with composite milk, the product containing the full cream milk was rated the highest (7.54) since the panelists preferred a thicker beverage (Table 8). The homogenous “Burkina” sample however had its mouthfeel rated as the best (8.85) since it was perceived to feel thicker, creamier and smoother on the tongue. The pH of a product is known to have an influence on the level of sourness and the aftertaste of a product (Andrés-Bello *et al.*, 2013). Though the pH of the “Burkina” samples were not significantly different from each other, the panelists preferred the aftertaste/sourness of the samples without the tiger nut milk most. Though the homogenous “Burkina” samples had the highest rating from the panelists, incorporation of tiger nut milk into “Burkina” is recommended as it would provide consumers with additional minerals. Also, consumers can also enjoy the health benefits associated with consuming tiger nuts.

Table 8 shows the mean liking scores of the sensory attributes and the mean overall acceptability scores for the six (6) “Burkina” samples.

Table 8: Mean Sensory Scores of 'Burkina' Samples

Attribute	SM	SMT	SSM	SSMT	FCM	FCMT
Overall acceptability	8.05 ^a	6.99 ^c	8.23 ^a	7.46 ^b	8.26 ^a	7.46^b
Colour	7.23 ^b	5.14 ^d	8.02 ^a	5.53 ^d	8.08 ^a	6.15^c
Aroma	7.78 ^b	6.28 ^c	8.08 ^a	6.30 ^c	7.77 ^b	6.77^c
Flavour	8.02 ^a	8.23 ^a	8.15 ^a	8.21 ^a	8.83 ^a	8.15^a
Mouth feel	8.30 ^a	6.09 ^c	8.54 ^a	6.28 ^c	8.85 ^a	7.54^b
Aftertaste/ sourness	8.38 ^a	6.30 ^c	8.69 ^a	6.84 ^c	8.54 ^a	7.15^b

9 = Like Extremely; 5 = Neither Like nor Dislike; 0 = Dislike Extremely (means in the same row with the same letter are not significantly different; $P \leq 0.05$). FCMT = full cream milk with 40 % tiger nuts, SSMT = semi-skimmed milk with 40 % tiger nuts, SMT = skimmed milk with 40 % tiger nuts, FCM = full cream milk, SSM = semi-skimmed milk, SM = skimmed milk

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

This research studied the incorporation of tiger nut milk into the production of “Burkina”, as well as homogenous “Burkina” samples (“Burkina” without tiger nut milk), at different levels of milk fat content. The study developed a process for incorporating tiger nut milk into the process for making “Burkina” and followed a one factor design in which the tiger nut milk (40 %) was incorporated into “Burkina”. The “Burkina” made from homogenous and composite milk had three fat contents, full cream milk, semi-skimmed and skimmed milk. The tristimulus colour (L.a.b - values), pH, mineral and proximate compositions, microbiology and sensory characteristics of both homogenous and composite mixtures of “Burkina” were analysed. Moisture content increased with decreasing amount of fat content. Mineral content was higher in “Burkina” with incorporated tiger nut milk compared with “Burkina” from homogenous milk. “Burkina” pH, which was acidic, was not affected by fat content or the addition of tiger nut milk. The significantly lower Tristimulus L values and the relatively higher ‘b’ values for “Burkina” made with tiger nut milk (40 %) implied that the colour was affected by the addition of tiger nut milk (40 %) to the “Burkina”. There were no counts for salmonella, coliforms, *E. coli* and *Staphylococcus aureus* but there were acceptable low counts for yeast and molds in “Burkina” containing tiger nut milk. Though all six “Burkina” samples were generally accepted by the panelists, the “Burkina” samples without tiger nut milk had the highest rating.

5.2 Conclusion

Composite milk can be formulated using Tiger nut milk and cow's milk. "Burkina" made with composite tiger nut milk and cow's milk had improved physicochemical attributes. Results from the proximate and mineral analyses of "Burkina" containing tiger nut milk indicated an increase in the protein, carbohydrate, fat and other mineral composition with the exception of calcium content. The results from the consumer FGD indicated that "Burkina" is a fermented milk beverage which should contain agglomerated millet. Certain factors such as packaging, proximity to source of "Burkina", food safety, income and colour of the beverage influence the rate of consumption of the beverage. Also, "Burkina" incorporated with tiger nut milk was perceived to be a healthy option as well as the ones made with skimmed milk. Consumers also loved the rich nutty taste of the "Burkina" with tiger nut milk. Incorporation of tiger nut milk into "Burkina" will increase the nutritional content of the product and provide consumers with the health benefits associated with tiger nuts. .

5.3 Recommendations

1. This research focused only on the physicochemical and sensory properties of "Burkina" made with tiger nut milk. The effect of short and long-term storage should therefore be conducted on "Burkina" samples to estimate the shelf life of the product in order to determine how storage affects the physicochemical and sensory attributes of "Burkina".
2. This research focused only on substituting cow's milk with tiger nut milk. The Focus Groups suggested flavour options such as banana, strawberry, chocolate and pineapple for "Burkina". It is therefore recommended that future research develop "Burkina" with several flavour options.

REFERENCES

1. Abbiw, D. (1990). Useful Plants in Ghana, Intermediate Technology Publications Ltd., Southampton Row, London, pp 30.
2. Abraham, R.E. (2013). Developing a Stable Refrigerated Beverage from a Ghanaian Tiger Nut Dessert. University of Ghana, Unpublished Undergraduate Thesis.
3. Adejuyitan, J. A. (2011). Tiger nut Processing: Its Food Uses and Health Benefits. *African Journal of Food Technology*, 6 (3): 197-201.
4. Ade-Omowaye, B.I.O., Akiwande, B.A. Bolarinwa, I. F. & Adebisi, A.O. (2008). Evaluation of Tigernut (*Cyperus esculentus*) - Wheat Composite Flour “Burkina”. *African Journal of Food Science*, 2: 87-91.
5. Alvarez, B. (2015). Sensory Evaluation of Milk and Milk Products. 467-487.10.1002/9781118810279.ch19.https://www.researchgate.net/publication/316397900_Sensory_Evaluation_of_Milk_and_Milk_Products [accessed Jun 04 2018].
6. Amadou, I., Gbadamosi, O. S., & Guo-Wei, L. (2011). Millet-Based Traditional Processed Foods and Beverages- A Review. *Cereal Food World*, 56 (3): 115-121.
7. Analie, L.-H. & Bennie, C. V. (2001). Yogurt as probiotic carrier food. *International Dairy Journal*, 11, 1-17.
8. Andrés-Bello, A., Barreto-Palacios, V., García-Segovia, P., Mir-Bel, J., & Martínez-Monzó, J. (2013). Effect of pH on Colour and Texture of Food Products. *Food Engineering Reviews* 5(3), 158–170.
9. Anon, A. (1992). Cyperules The new Encyclopedia Britannica, Macropaedia Chicago. Vol.3 (15th Edn), p. 185.
10. Antinoro, L. (2012). “Increasing Dietary Potassium — Find Out Why Most People Need to Consume More of This Mineral”. *Today’s Dietitian*, 14 (12) :50.
11. Anyidoho, I.E. (2006). Nutritional Quality of Tiger nut Porridge. Thesis presented to the Science Laboratory Technology Department, School of Applied Sciences. Accra Polytechnic, Accra, Ghana.
12. AOAC. (2005). Official Methods of Analysis of AOAC International. Gathersburg, Maryland, 18: 4-83.
13. Appiah, S. (2013). Latest millet smoothie in town: online Daily Graphic, 29 Jun. 2013. Retrieved on 13th September, 2017 at 15:37pm from: <http://m.ghheadlines.com/agency/dailygraphic/2013069/518580/'Burkina'-latest-millet-smoothie-in-town>

14. Arranz J.J., Coppieters W., Berzi P. et al. (1998). A QTL affecting milk yield and composition maps to bovine chromosome 20: a confirmation. *Animal Genetics* 29, 107–115.
15. Arthur, A. B. (2016). Optimising the Wagashie (A Traditional Cottage Cheese) Process and Sensory Quality. University of Ghana. Unpublished Mphil Thesis.
16. Bamishiaye, E.I. (2011). Tiger Nuts, Its Derivatives and Benefits. *African Journal of Food, Agriculture, Nutrition and Development*, 11 (5): 5157-5170.
17. Banu, C. (2002). Food chemistry. Agir Publishing House, București
18. Barber, S. (1981). Recent contributions to research in the Valencia region on local products in food science and technology. *Revista de Agroquímica y Tecnología Alimentaria* 21, 175-184 clxi
19. Belewu, M.A. & Abodunrin, A.O. (2008). Preparation of Kunun from unexploited rich food source: Tiger nut (*Cyperus esculentus*). *Pakistan Journal of Nutrition* 7: 109-111
20. Belewu, M.A & Belewu, K. Y. (2007). Comparative physicochemical evaluation of tiger nuts, soy bean and coconut milk sources. *International Journal of Agricultural Biology*, 5: 785-787.
21. Benítez-Páez, A. & Sanz, Y. (2017). Fermented Foods in Health and Disease Prevention. Institute of Agrochemistry and Food Technology, Spanish National Research Council (IATA-CSIC), Paterna-Valencia, Spain, 159-172
22. Benward, M. F., & Benward, W. (2000). Healthy Baby Infant Formula Milk and Healthy Baby Toddler Formula Milk, United States Patent No., 6,063,433.
23. Bertelsen, G., Hugaard, V.K., & Hansen, T.H. (2012) Potential of biobased materials for food and dairy packaging. *Journal of Animal Science*, 79, 234-249.
24. Bertrand-Harb, C., Ivanova, I. V., Dalgalarondo, M. & Haertl, T. (2003). Evolution of b-lactoglobulin and a-lactalbumin content during yoghurt fermentation. *International Dairy Journal* 13, 39-45.
25. Bille, G. P & Vovor, N. M., Goreseb, J. and Keya, L. E. (2000). Evaluating the feasibility of adding value to goat's milk by producing yoghurt using low cost technology method for rural Namibia. *Journal of Food Technology in Africa*, 5:10. DOI: [10.4314/jfta.v5i4.19272](https://doi.org/10.4314/jfta.v5i4.19272)
26. Bing, L., Driban, J.B, Duryea, J., McAllindon, T., Lapane, K. & Eaton, C. (2014). *Milk Consumption and Progression of Medial Tibiofemoral Knee Osteoarthritis: Data from the Osteoarthritis Initiative*. Downloaded from <https://doi.org/10.1002/acr.22297> Published April 2014
27. Blitz, H. D., Grosch, W., & Shieberle, P. (2009). Food Chemistry, 4th edition, Springer-Verlag, Berlin Heidelberg. p. 421, 428.

28. Bosch , L., Alegria, A. & Farre, R. (2005). RP-HPLC Determination of Tiger Nut and Orgeat Acid Contents. *Sage Journal of Food Science and Technology International*.
29. Caiquo, B.A. & Mensah, M.A. (2013). ‘Burkina’ Beverage: A Fermented Milk Product. *Milk and Dairy Technology*, 2, 67-70.
30. Campbell-Platt, G. (1994). Fermented foods- a world perspective. *Food Research International* **27**, 253.
31. Caplice, E. & FitzGerald, G. F. (1999). Food fermentations: role of micro-organisms in food production and preservation. *International Journal of Food Microbiology* **50**, 131-149.
32. Chevallier, A. (1996). The Encyclopaedia of Medicinal Vegetables. *Dorley Kindersley Press, London*. (48-51).
33. Chiemela, E. C., Abu, J.O. & Abubakar, Y.A. (2010). Effects of Tiger nut (*Cyperus esculentus*) flour addition on the quality of wheat based cakes. *International Journal of Food Science and Technology*, 45 (8), 1746-1752.
34. Chinedu, S. N., & Nwinyi, C. O. (2012). Proximate analysis of *Sphenostylis stenocarpa* and *Voadzeia subterranean* consumed in South-Eastern Nigeria. *Journal of Agricultural Biotechnology and Sustainable Development*, 4(1), 1-12.
35. Chinma, E.C., Abu, J.O. & Abubakar, Y.A. (2010). Effect of tiger nut (*Cyperus esculentus*) flour addition on the quality of wheat- based cake.
36. Chukwu, O. & Abdul-Kadir, A. J. (2008). Proximate Chemical Composition of Acha (*Digitaria exilis* and *Digitaria ibuara*) Grains. *Journal of Food Technology*, 6 (5): 214-216.
37. Ciotău C. (2006). Contributions to appreciate the quality and hygienic condition of some types of milk powder produced by Rarăul, Câmpulung Moldovenesc. PhD thesis, Veterinary Faculty of Iași,. [in Romanian]
38. Cobby, S. L. (1962). Introduction to the botany of tropical crops. London, Longman.
39. Codex Alimentarius Commission (2014). Joint FAO/WHO food standards programme FAO/WHO coordinating committee for Asia, discussion paper on development of code of hygienic practices for the street-vended foods (Asia). Agenda Item 7b.Nineteenth Session. Tokyo, Japan, 3–7 November 2014.
40. Commane, D., Roisin H., Colette S. & Ian R. (2005). Review: The potential mechanisms involved in the anti-carcinogenic action of probiotics. *Mutation Research* **591**, 276-289
41. Consejo, R. (2006). De Chufa de Valencia Horchata de chufas. Retrieved on 4th December, 2012 from <http://www.chufadevalencia.org>.

42. Cortés, C., Esteve, M. J., Frgola, A., & Torregrosa, F. (2004). Physical and chemical properties of different commercially available types of “horchata de chufa”. *Italian Journal of Food Science* 1, 113-121.
43. Coskuner, Y., Ercan, R., Karababa, E., & Nalizcan, A.N. (2002). Physical and chemical properties of chufa (*Cyperus esculentus* L.) tubers grown in the Cukurova region of Turkey. *Journal of the Science of Food and Agriculture* 82, 625-631
44. Dawson, P. (2011) Active packaging: Films and coatings for extended shelf life. *J. Anim. Sci.* Vol. 79, Suppl. 1/*J. Dairy Sci.* Vol. 84, Suppl. 1/*Poult. Sci.* Vol. 80, Suppl. 1/54th Annu. Rec. Meat Conf., Volume II, 124-141.
45. Demirag, K., Elmaci, Y., & Altug, T. (1999). Formulation and quality evaluation of reduced sugar and reduced calorie Kazandibi. *Journal of Food Quality* 22(1), 101–108
46. Desikachar, H.S.R. (1996). Processing of maize, sorghum and millet for food uses. *J. Sci. Ind. Res.*, 34, 231-237.
47. De Venanzi, F.A. (1991). Chufa composition and horchata quality. Master of Science Thesis, University of Florida, Gainesville.
48. Diarra, K. Nong, Z.G. and Jie, C. (2005). Peanut Milk and peanut milk based products production: A review. *Critical Review of Food Science Nutrition* 45, 405-423
49. Dickinson, E. (1992). An introduction to food colloids. Melbourne: Oxford University Press.
50. Dickinson, E. & Stainsby, G. (1988). Emulsion stability in advances in emulsions and foams. London: Elsevier Applied Science.
51. Dokosi, O.B. (1998) Herbs of Ghana. Ghana University Press, Accra, pp.548, 549 clxvii
52. Dubois, V., Breton, S., Linder, M., Fanni, J. & Parmentier, M. (2007). Fatty acid profiles of 80 vegetable oils with regard to their nutritional potential. *European Journal of Lipid Science and Technology*.109: 720–32
53. Drake M.A. (2010) Sensory analysis of dairy products. *Journal of Dairy Science*, Volume 90, Issue 11, 4925 – 4937. Retrieved on December 4, 2017, from <https://doi.org/10.3168/jds.2007-0332>
54. Edwards, E.V. (1998). Milk Recipes from Nut & Seeds. Brushton, New York, Teach Services, Inc.
55. Egbebi A.O. & Bademosi T.A (2011). Chemical compositions of ripe and unripe banana and plantain. *International Journal of Tropical Medicine and Public Health* 1(1), 23-31.

56. El-Shenawy, M., Abd El-Aziz, M., El-Kholy, W. I. & Fouad M.T., (2012). Probiotic Yoghurt Manufactured with Tiger-Nut Extract (*Cyperus esculentus*) as a Functional Dairy Food. *Journal of Agricultural Research and Natural Resources*, 1(2): 20-31.
57. Esteshola, E. & Oraedu, A. C. I. (1996). Fatty acid composition of tiger nut tubers (*Cyperus esculentus L.*), baobab seeds (*Adansoria digitate L.*) and their mixture. *Journal of American Oil Chemists' Society*, 73 (2): 225-257
58. Ezeh, O., Gordon, M., & Niranjani, K. (2014): Tiger nut oil (*Cyperus esculentus L.*): A review of its composition and physico-chemical properties. *European Journal of Lipid Science and Technology*. April 2014. <https://doi.org/10.1002/ejlt.201300446>
59. Fekria, A. M., Isam, A. M. A., Suha, O. A., & Elfadil, E. B. (2012). Nutritional and functional characterization of defatted seed cake flour of two Sudanese groundnut (*Arachis hypogaea*) cultivars. *International Food Research Journal*, 19(2), 34-45.
60. Fankhauser, D. B. (2007). "Fankhauser's Cheese Page". Archived from the original on September 25, 2007. Retrieved on September 23, 2007, from <https://web.archive.org/web/20070925001225/http://biology.clc.uc.edu/Fankhauser/Cheese/CHEESE.HTML>
61. FAO/WHO (2012). Joint FAO/WHO food standards programme FAO/WHO coordinating committee for Asia discussion paper on development of code of hygienic practices for the street-vended foods (Asia). Eighteenth Session Tokyo, Japan, 5 -9 November 2012.
62. Fatoki, O. S., Omode, A. A. & Olaogu, K. A. (1995). Physicochemical Properties of some Underexploited and Non-conventional Oilseeds. *Journal of Agriculture and Food Chemistry* 43, 2850-2853.
63. Fox, P. F. (2003). Milk proteins: general and historical aspects. In: Fox, P.F., McSweeney, P.L.H. (Eds.), *Advanced Dairy Chemistry*, Vol. 1, Proteins Part A, (3rd Edn.). Kluwer/Plenum, New York, pp. 1-48.
64. Fiszman, S. M., & Salvador, A. (1999). Effect of gelatin on the texture of yoghurt and acid heat induced milk gels. *Food Research and Technology* **208**, 100-105.
65. FitzGerald, R. J., & Meisel, H. (2003). "Milk protein hydrolysates and bioactive peptides" 3rd/Ed. Kluwer Academic/Plenum Publishers, New York/Boston/Dordrecht/London/Moscow.
66. Frimpong, R.Y. (2016). Physicochemical and Sensory Evaluation of Biscuits made from Defatted Tiger Nut and Wheat Composite Flour. University of Ghana, Unpublished Masters Thesis.
67. Fuller, R. (1989). Probiotics in man and animals. A review. *J. Appl. Bacteriol* **66**, 365378.

68. Fuller, R. (1992). "History and development of probiotics. In: Probiotics," Chapman & Hall, New York.
69. GNA. (2013). FDA trains “Burkina” drink producers in Accra: Online Ghana Business News, 5th September, 2013. Retrieved from <https://www.ghanabusinessnews.com/2013/09/05/fda-trains-'Burkina'-drink-producers-in-accra/> on 13th September, 2017.
70. GSA. (2010). Annual Report for the Year Ending 2009, Accra, Ghana.
71. Grădinaru, A.C., Creangă, Ș., & Solcan, G. (2015). Milk – a review on its synthesis, composition, and quality assurance in dairy industry. *HVM Bioflux*;7(3):173-177.
72. Grosso, N. R., Resurreccion, A.V. A., Walker, G. M., & Chinnan, M. S. (2008). Sensory Profiles and Hexanal Content of Cracker-Coated and Roasted Peanuts stored under different temperatures. *Journal of Food Processing and Preservation* 32, 1-23.
73. Guarner, F., & Schaafsma, G. J. (1998). Probiotics. *Int J Food Microbiol* 39, 237-8.
74. Harness, J. (2018). 20 Cool Uses for Milk. Lifehack. Retrieved on May 20th 2018 from <https://www.lifehack.org/articles/lifestyle/20-cool-uses-for-milk.htm>
75. Ikepeme, E. E., Ekpryoung, I.O & Igile, G.O. (2012). Nutritional and Sensory Characteristics of an infant food based on soybean (*Glycine Max*) and tiger nut tubers (*Cyperus esculenta*). *British Journal of Applied Science and Technology*, 2 (4): 356-366.
76. Iurcă, I.M. (1998). Milk and milk products. I.C.P.I.A.F. Publishing House, ClujNapoca,.
77. Jensen, R.G. (1995). The Composition of Bovine Milk Lipids. *Journal of Dairy Science*;85(2):295–350.
78. Johnson, S., Leeming, D., Williamson, I., & Lyttle, S. (2013). Maintaining the ‘Good Maternal Body’: Expressing Milk as a Way of Negotiating the Demands and Dilemmas of Early Infant Feeding. *Journal of Advanced Nursing*, 69 (3): 590-599.
79. Karaman, A.D., Özer, B., Pascall, M. A. & Alvarez, V. (2015). Recent Advances in Dairy Packaging, *Food Reviews International*, 31:4, 295-318, DOI: 10.1080/87559129.2015.1015138
80. Kay, D.E. (1987). Revised by E.G.B. Gooding Cwp and Product digest N0.2, London TDRI. Tropical Development and Research institute 127 clerkenwell Road, London EC1R 5DB.
81. Lasekan, O.O. & Abdulkarim, M. (2012). Extraction of Oil from Tiger Nut (*Cyperus esculentus*) with Superficial Carbondioxide (SC-CO₂). *LWT- Food Science and Technology*, 47 (2): 287-292, DOI: 10.1016/j.lwt.2012.01.021

82. Ledenbach L.H., & Marshall R.T. (2009) Microbiological Spoilage of Dairy Products. In: Sperber W., Doyle M. (eds) Compendium of the Microbiological Spoilage of Foods and Beverages. Food Microbiology and Food Safety. Springer, New York, NY https://doi.org/10.1007/978-1-4419-0826-1_2
83. Linssen, J.P.H., Cozijnsen, J.L.& Pilnik, W. (1989). Chufa (*Cyperus esculentus*): A new source of dietary fiber. *Journal of Science Food & Agriculture* 49, 291-296.
84. Liong, M. T., & Shah, N. P. (2006). Effects of *Lactobacillus casei* symbiotic on serum lipoprotein, intestinal microflora, and organic acids in rats. *Journal of Dairy Science*. **89**, 1390-1399.
85. Lu, M. & Wang, N. S. (2017). Bovine Milk. *Journal of Food Science, Technology and Nutrition*,10: 151-178. Woodhead Publishing Series, New York <https://doi.org/10.1016/B978-0-08-100502-6.00010-8>
86. Maloş G, Maloş IG, Diaconescu A, & Ianiţchi D. (2002). Milk processing and cheese. UASMV Publishing House, Bucureşti,. [In Romanian]
87. Martensson, O., Oste, R., & Holst, O. (2000). Lactic acid bacteria in an oat-based non-dairy milk substitute: fermentation characteristics and exopolysaccharide formation. *Lebensmittel- Wissenschaft-und-Technologie* 33(8), 525–530
88. Micinski, J., Zwierzchowski, M., Ireneusz, M., Kowalski, J., Bogusław, P., & Juozas, R. (2018). The Effect of Bovine Milk Fat on Human Health. *Journal of Polish Annals of Medicine*, 19, 170 – 175.
89. Mihaiu M, & Mihaiu R. (1998). Milk and its quality control. Risoprint Publishing House, Cluj – Napoca,
90. Morisaki, M. & Suda, F. (2016). The Changing Valuation of the Japanese Confectionery Wagashi. *Journal of Research in Social Social Sciences*, 10, 2-21.
91. Morrison, W. R. & Laignet B. (1983). An Improved Colorimetric Procedure for Determining Apparent and Total Amylose in Cereal and Other Starches. *Journal of Cereal Science*, 1:9-20.
92. Mosquera, L.A., Sims, C.A., Bates, R.P & Okeefe, S.F. (1996). Flavor and Stability of Horchata De Chufas. *Journal of Food Science* 61, 856-861
93. Navarro, J.L. Schwartz, M., Gasque, F., Alberola, J., Perez, R. & Lafuente B. (1984). Influencia de la e'oca de recoleccion de la chufa (*Cyperus esculentus* L.) sobre las características analíticas y sensoriales de la horchata. *Revista de Agroquímica y Tecnología de los Alimentos* 24, 199-203
94. Nyarko-Mensah, P., Anokye Mensah, S.& Mireku, D. (2015). Processing and Packing Tiger nut (*Cyperus esculentus*) Dessert for an Extended Shelf Life. University of Ghana, Unpublished Undergraduate Thesis.

95. Okafor, J. N. C., Mordi, J. I., Ozumba, A. U., Solomon, H. M. & Olatunji, O. (2003). Preliminary studies on the characterization of contaminants in tiger nut (Yellow variety). In Proceedings of 27th annual Nigerian Institute of Food Science and Technology (NIFST) Conference.13-17 October, pp. 210-211.
96. Oladele, A.K.and Aina, J.O. (2007). Chemical Composition and Functional Properties of Flour Properties from Two Varieties of Tiger Nut (*Cyperus esculentus*), *African Journal of Biotechnology*, 6 (21): 2473-2476.
97. Osei-Onomah, S. (2014). Applying a Consumer Led Product Development Process to Develop a Traditional Milk Based Drink ('Burkina'). BSc. Thesis, University of Ghana, Ghana. Pp. 1
98. Otwe, R. (2015). Processing Options for 'Burkina' Milk Beverage. University of Ghana. Unpublished Undergraduate Dissertation.
99. Pamplona-Roger, D. G. (2006): Encyclopedia of foods and their healing power. A Guide to Food Science and Diet Therapy, Volume 1. Page 184, milk processing
100. Pascual, B., Maroto, J. V., SanBautista, A., Alagarda, J. & Lopez-Galarza, S., (2001). Morphological and productive characteristics of nine "chufa" (*Cyperus esculentus* L. var. *sativus* Boeck.) clones. *Acta-Horticulturae* 1(614) : 85-88.
101. Pederson, C.S. (1979) *Microbiology of Food Fermentations*, 2nd Edition, AVI Publishing Company Incorporated, Westport, CT.
102. Purdy, Chase (2017). "A tech startup is making convincing cow-free milk by genetically engineering yeast". Quartz. Retrieved on 20th December, 2017, from <https://qz.com/1161955/perfect-day-is-making-convincing-cow-free-milk-by-genetically-engineering-yeast/>
103. Rašić, J. L. & Kurmann, J. A. (1978) *Yoghurt – Scientific Grounds, Technology, Manufacture and Preparations*, Technical Dairy Publishing House, Copenhagen.
104. Reid, W.S., Hergert, G.B., & Fagan, W.E. (1972). Development of a prototype mechanical harvester for chufa (*Cypersu esculentus* L. car. *Sativus* Beek). *Canadian Agricultural Engineering* 14(2), 89-95
105. Ricke, S. C., & Pillai, S. D. (1999). Conventional and Molecular Methods for Understanding Probiotic, Bacteria Functionality in Gastrointestinal Tracts. *Critical Reviews in Microbiology* 25, 19-38.
106. Robinson, R.K. (1994). *Modern dairy technology*.1,2.Elsevier, New York, 1994
107. Roginski, H. (2003). Fermented Milk: Products from Northern Europe. *Encyclopaedia of Food Sciences and Nutrition*, 2 : 2375-2383
108. Rotaru G, & Moraru C. (1997). *HACCP-Hazard Analysis Critical Control Point*. Academica Publishing House, Galați,.

109. Rusu V. (2005). Research on technological, quality, and of hygiene aspects of cheeses produced in the mountains of Northern Moldova. PhD thesis, Veterinary Faculty of Iași,
110. Sanders, M. E. (2008). Probiotics: definition, sources, selection, and uses. *Clin Infect Dis* 46 Suppl 2:S58-61; discussion S144-51.
111. Sanful, R.E. (2009). The Use of Tiger Nut (*Cyperus esculentus*), Cow Milk and Their Composite as Substrate for Yoghurt Production. *Pakistan Journal of Nutrition*, 8 (6): 755-758.
112. Schiffrin, E., & Blum, S. (2002). Interactions between the microbiota and the intestinal mucosa. *Eur J Clin Nutr* 56, 60-4.
113. Sessou, P., Farougou, S., Azokpota, P., Youssao, I. & Yèhouenou, B., Ahounou, S. & Sohounhloue. (2015). https://www.researchgate.net/publication/256437594_Endogenous_methods_for_preservation_of_wagashi_a_Beninese_traditional_cheese [accessed Jun 04 2018].
114. Shirai, K., Gutierrez-Duran, M., Marshall, V. M. E., Revah-Moiseev, S., & Garcia-Garibay, M. (1992). Production of a Yoghurt-like product from plant foodstuffs and whey. Sensory evaluation and physical attributes. *Journal of the Science of Food and Agriculture* 59(2), 205-210
115. Şindilar E. (1998). The hygienic control of animal origin products and byproducts.2, Moldogrup Publishing House, Iași,.
116. Speake, S. W. (2015). Debating Milk: Milk as Nutritious and Safe. University of Alberta. Unpublished Doctoral Thesis.
117. Tamime, AY. (2006). Brined cheeses. Blackwell Publishing, Ames, Iowa.
118. Tetteh, J.P. & Ofori, E. (1998). A Baseline Survey of Tiger Nut (*Cyperus esculentus*) Production in the Kwahu South District of Ghana. *Ghana Journal of Agriculture and Science*, 31: 211-216.
119. Tiger nuts Traders, S.L., (2010). Retrieved from <http://www.tigernuttraders/>
120. Tijani, F. (2014). Evaluation of the Potential of Adding Tiger Nut Milk and Soy Milk into Cheese Making. University of Ghana, Unpublished Masters Thesis.
121. Ukwuru, M.U. & Ogbodo A.C. (2011). Effect of Processing Treatment on the Quality of Tiger nut Milk. *Pakistan Journal of Nutrition* 10, 1, 95-100
122. Ukwuru, M.U. Ibeneme C.L. & Agbo G.I. (2011). New product development from tiger nut (*Cyperus Esculentus*) and their sensory, proximate and microbiological evaluation *Pakistan Journal of Nutrition* 10(2), 101-105

123. Umerie, S. C. & Enebeli, J. N. (1997). Malt caramel from made from millet and sorghum. The nuts of *Cyperus esculentus*. *International Journal of BioResource Technology*, 8: 215-216.
124. United Kingdom Food Standards Agency (2017). Composite products questions and answers. Codex Alimentarius Standards STAN-206-1999. General Standard for the use of Dairy terms. Retrieved on November 12, 2017, from <https://www.food.gov.uk/sites/default/files/media/document/compositeproductsqanda.pdf>
125. Watt, J.M. & Breyer-Brandwijk, M. G. (1962). *The Medicinal and Poisonous Plants of South Africa*. 2nd Improved Impression (2000). Briza Publications, Pretoria.
126. Wong, V. (2013). "Soy Milk Fades as Americans Opt for Drinkable Almonds". *BusinessWeek*. Retrieved on 5th May, 2018, from <http://www.businessweek.com/articles/2013-08-21/soy-milk-fades-as-americans-opt-for-drinkable-almonds#r=hpt-fs>
127. Yadav, D. N; Thakur, N., & Sunooj, K.V. (2012). Effect of Partially De-Oiled Peanut Meal Flour (DPMF) on the Nutritional, Textural, Organoleptic and Physico-Chemical Properties of Breads. *Food and Nutrition Sciences*. 3:471-476.

APPENDICES

**Appendix 1: RECRUITMENT QUESTIONNAIRE FOR FOCUS GROUP
DISCUSSION ON 'BURKINA' PRODUCT**

Thank you for showing an interest in this project. Kindly read this information sheet carefully before deciding whether or not to participate. If you decide not participate, there will be no disadvantage to you of any kind and we thank you for considering our request.

The aim of this project is to select, recruit and screen potential panelists to be a 'selected participant' of a Focus Group Discussion under the project topic '**Physicochemical and Sensory Evaluation of 'Burkina' made with Composite Milk**'. By participating in this focus group discussion, you will get the emotional benefit that comes with giving your candid opinion on developing a 'Burkina' product which will have nutritional and some health benefits to the general populace.

This test will take place at the Product Development Laboratory of the Department of Family and Consumer Sciences Annex on **Wednesday, 18th April** and **Thursday, 19th April, 2018** (**3 sessions each day**). The schedule for each session is as follows (**Circle the most convenient time for you**):

DATE	SESSION	TIME
Wednesday, 18th of April, 2018	1 st	8am-10am
	2 nd	12pm-2pm
	3 rd	3pm-5pm
Thursday, 19th of April, 2018	1 st	8am-10am
	2 nd	12pm-2pm
	3 rd	3pm-5pm

Please **circle or tick** the appropriate response to all questions asked and **fill in** the open ended questions.

A. DEMOGRAPHIC INFORMATION

1. Age Group

- 18-24
- 25-30
- 31-40
- 41-50
- 51-60

2. Gender

- Male
- Female

3. Occupation

- Lecturer
- Teaching and Research Assistant
- Student (please indicate level).....
- Other (please specify).....

4. Place of residence (please specify).....

B. SCREENING (Kindly circle answer where appropriate)

1. Which of these foods are you allergic to? **(circle as many as apply)**
 - a. Milk b. Millet c. Sugar d. None
2. Are you lactose intolerant?
 - a. Yes b. No c. Maybe

Kindly **end here** if you **did not** select “None” and “No” for **questions 1** and **2** respectively.

3. Which of the following products do you consume? **(check all that apply)**

Product	frequency					Most preferred (check only one)
	Daily	Weekly	Biweekly	Monthly	Once a Year	
Fresh milk (pasteurised)						
Processed Milk (Secondary Processing)						
Fermented Milk						
Yoghurt						
Cheese						
Ice cream						
Other (please specify)						

4. What do you like about the product(s) you selected?

.....

5. What do you like about your most preferred or liked dairy product?

.....

6. Have you heard of the name ‘Burkina’?

- a. Yes b. No c. Maybe

7. Have you consumed ‘Burkina’ before?

- a. Yes b. No c. Maybe

If the answer to question 7 is no, please skip to section C.

8. Is 'Burkina' a product that you enjoy consuming?
a. Yes b. No c. Maybe

9. How often do you consume 'Burkina'?
a. Daily b. Weekly c. Monthly d. Once a year e. Twice a year
10. How much 'Burkina' can you consume at a sitting?
a. 330 ml b. 500ml. c. 1 litre d. other (please specify)
11. How do you like your 'Burkina' in terms of level of sweetness?
a. Very sweet b. Moderately sweet c. Less sweet d. No sweetness
12. How do you like your 'Burkina' in terms of sourness?
a. Very sour b. Moderately sour c. Less sour d. No sourness

SECTION C

Please provide us with your names, telephone numbers and email addresses so that we can reach you to remind you when the test date is almost due.

Name

.....

Telephone number

Email address

.....

.....

THANK YOU FOR YOUR PARTICIPATION!!!!

Appendix 2:

CONSENT FORM

Project Title: Physicochemical and Sensory Evaluation of “Burkina” made with Composite (Cow and Tiger Nut) Milk.

Principal Investigator:

Pearl Nyarko-Mensah

Address:

Department of Family and Consumer Sciences, College of Basic and Applied Sciences, University of Ghana, Legon, Accra.

General Information about Research

The sensory aspect of this study seeks to involve the use of human subjects to investigate the acceptability of the ‘Burkina’ product as the panelists express the views and perception. This will involve you participating in a moderated focus group discussion on ‘Burkina’ in a relaxed atmosphere. The responses obtained from you will help us to optimize the product. This discussion will last for at most 120 minutes but not less than 45 minutes. Prior to the evaluation, the researcher will give you a few instructions and also an opportunity to ask questions related to the test. You will be served with samples to taste so you can indicate your degree of likeness for them. Kindly read this form and ask any questions before agreeing to be part of the study.

Possible Risks and Discomforts

This study will take place in the Food Product Development Laboratory at the Department of Family and Consumer Sciences Annex. There are no possible risks from tasting ‘Burkina’ samples unless you are allergic to milk and/or are lactose intolerant.

Possible Benefits

By participating in this consumer test, you will get the emotional benefit that comes with giving your candid opinion on developing a ‘Burkina’ product which will have nutritional and some health benefits to the general populace.

Confidentiality

The data you provide to us will be kept confidential by the research team. You will never be personally identified in any work published as a result of your participation in any consumer test without your prior consent. We will protect your personal information and not hand this to any third party.

Compensation

At the end of the study, you will be given a token to show our appreciation for your time spent on the project. This may be fruit juice/ice cream with meat pie or biscuit. You should

understand that there is no economic benefit to you for participating in a sensory study, only the emotional benefit of knowing that you have contributed significantly to the development and improvement in the quality of our underutilized crops. This benefit cannot be overlooked.

Additional Cost

There is no additional cost to you for participating in a sensory study organized by the Department of Family and Consumer Sciences.

Voluntary Participation and Right to Leave the Research

Although we will like that you stay for the duration of the test, you should know that your participation is purely voluntary hence you have every right to withdraw without penalties. This will not negatively affect your personal relationship with the investigator, the department or the university as a whole.

Termination of Participation by the Researcher

It is possible that for some tests you sign up to participate in, some exclusion criteria will exempt you from participating. You will be notified of such studies at the onset. If in the middle of a test the investigator realizes that you are not capable of completing a test the investigator may ask you to discontinue the test. This does not have any negative consequence on your relationship with the investigator, the department or the university. You should understand that such decisions are made purely on the basis of preserving the scientific quality of the data we collect from our volunteering participants and have no personal bias to you.

Notification of Significant New Findings

To preserve the scientific quality of the data we collect in sensory testing, we are unable to disclose too much information about the products we test at the onset of the project. However, if your interest in the product is raised through your participation in the project, we can provide additional information about the product to you at the end of the project. You will have to leave your details with the investigator to share such information about the product with you at the end of the study.

Contacts for Additional Information on product

For information and questions about this study please contact:

Pearl Nyarko-Mensah

Department of Family and Consumer Sciences,

University of Ghana

Email: pnnyarko-mensah@st.ug.edu.gh

Tel: 0206595106

VOLUNTEER AGREEMENT

The above document describing the benefits, risks and procedures for the sensory evaluation of foods has been read and explained to me. I have been given an opportunity to have any questions about the research answered to my satisfaction. I agree to participate as a volunteer.

Date

Name and signature of volunteer

If volunteers cannot read the form themselves, a witness must sign here:

I was present while the benefits, risks and procedures were read to the volunteer. All questions were answered and the volunteer has agreed to take part in the research.

Date

Name and signature of witness

I certify that the nature and purpose, the potential benefits, and possible risks associated with participating in this research have been explained to the above individual.

Date

Name & Signature of Person Who Obtained Consent

Appendix 3: Analysis of Variance Results for Sensory Attributes

Appearance / color	P- values
40% TN added to SSM vs SSM only	0.000
40% TN added to FCM vs FCM only	0.000
40% TN added to SM vs SM only	0.000
Taste	
40% TN added to SSM vs SSM only	0.000
40% TN added to FCM vs FCM only	0.162
40% TN added to SM vs SM only	0.000
Mouthfeel	
40% TN added to SSM vs SSM only	0.000
40% TN added to FCM vs FCM only	0.389
40% TN added to SM vs SM only	0.000
Aroma	
40% TN added to SSM vs SSM only	0.000
40% TN added to FCM vs FCM only	0.510
40% TN added to SM vs SM only	0.000
Flavor	
40% TN added to SSM vs SSM only	0.000
40% TN added to FCM vs FCM only	0.073
40% TN added to SM vs SM only	0.000

- TN means tiger nut
- SSM means semi skimmed milk
- FCM means full cream milk
- SM means skimmed milk
- P- value was compared to level of significant or alpha 0.05.

APPENDIX 4: “Burkina” Themes and Codes for FGD

Code-Filter: All

HU: 'Burkina'
File: [C:\Users\Grace\Desktop\Ernest docs\People\Pearl Malaika\MPhil analysis\Burkina'.hpr7]
Edited by: Super
Date/Time: 2018-05-08 08:15:10

Barriers to purchase - allergies/lactose intolerance
Barriers to purchase - dislike for millet
Barriers to purchase - dislike of scent of fresh milk
Barriers to purchase - packaging
Barriers to purchase - poor taste
Barriers to purchase - quantity vrs cost
Barriers to purchase - safety and hygienic perceptions
Barriers to purchase - temperature
'Burkina' - milk and millet
'Burkina' color - white
'Burkina' color - white and creamy
'Burkina' flavor - banana, chocolate, strawberry
'Burkina' flavor - chocolate
'Burkina' flavor - fanice
'Burkina' flavor - no flavor
'Burkina' flavor - strawberry.
'Burkina' flavor - vanilla
'Burkina' flavor - vanilla, banana, strawberry, chocolate pineapple.
'Burkina' ingredients - Milk, millet, sugar
'Burkina' ingredients - sorghum
'Burkina' make_ fresh milk
'Burkina' make_ fresh milk and powdered milk
'Burkina' make_ powdered and processed milk
'Burkina' make_ thickness
'Burkina' taste_ sour
Consume 'Burkina'_ desire for it
Difference - powdered milk expensive
Difference_ depends on amount of milk added
Difference_ no difference
Difference_ powdered tastes nicer
Difference_ color powdered milk yellow,
Difference_ fresh milk taste nicer
Fermented milk - bacteria action on milk
Fermented milk - gone bad/expired
Fermented milk - milk unrefrigerated
Fermented milk - taste sour
Flavored 'Burkina'_ depends on flavor
Flavored 'Burkina'_ fruity
Flavored 'Burkina'_ like for it
Flavored 'Burkina'_ promotes variety
Flavored milk - additives added
Flavored milk - something added
Flavoured milk - flavour added
Handle - Keep in freezer
Milk flavors - Apple, mango, chocolate, strawberry
packaging - bottle
Packaging - cup with spoon
Packaging - ice chest

Packaging - tetrapack

perceived texture of 'Burkina' - btwn countre milk and koko

perceived texture of 'Burkina' - countre milk

perceived texture of 'Burkina' - koko

perceived texture of 'Burkina' - koko and tom brown

Perception of 'Burkina' - milk drink

Perception of 'Burkina' - Northern food

Perception of 'Burkina' with Skimmed milk - fat removed

Perception of 'Burkina' with Skimmed milk - healthier

Perception of 'Burkina' with Skimmed milk - light texture

Perception of 'Burkina' with Skimmed milk - tastier

Perception to purchase - high cost

Perception to purchase - packaging

Perception to purchase - proximity, affordability and desire

Perception to purchase - quality

Perception to purchase - remove allergic attributes

Perception to purchase - tribe of vendor

Perception_ 'Burkina' with tiger nuts - likeness

Perception_ 'Burkina' with tiger nuts - taste altered.

Perception_ 'Burkina' with tiger nuts - tiger nut milk

Preference for 509

Preference for 509 and 019

Safety - Not safe

Skimmed milk - fats extracted

Skimmed milk - no idea

Skimmed milk - pasteurized milk

Skimmed milk - without cholesterol

Source of 'Burkina'_ both stationary and mobile vendors on the street

Source of 'Burkina'_ Campus

Source of 'Burkina'_ campus and market

Source of 'Burkina'_ markets

Source of 'Burkina'_ Muslim community

Source of 'Burkina'_ On the street

Storage - a week

Storage - drink it immediately

Storage - less than a week

Whole milk - fats intact

Whole milk - unprocessed raw milk

Whole milk - very creamy

Appendix 5: Discussion Guide for Focus Group Discussion

Introduction

My name is Pearl Nyarko-Mensah and I will be your moderator for today. The purpose of this discussion is to talk about Burkina and to understand your opinion on the desirable attributes of Burkina and what you would consider as a good packaging for the safety of the product.

Information about characteristics and unique attributes of this product are needed to improve the product and to complete the research.

Your views and concerns will provide this information which is guaranteed absolute confidentiality. However, the discussion will be recorded to make sure every information is captured.

RULES

1. This discussion will last between 75 to 90 minutes depending on your cooperation and the kind of information we get.
2. There are no right or wrong answers. Every answer is correct.
3. As much as possible let us respect each other's views and comments because these views are helpful in the modification of our product.
4. Please avoid interrupting each other when talking to ensure clarity.
5. All phones should be put on silence so as to prevent interference with the recorder.
6. Please be audible and speak with confidence.
7. Any questions before we begin the discussion?

We will like to start by getting to know your names.

QUESTIONS

Perception on Milk and Burkina

1. What do you know about skimmed milk and whole milk?
2. What do you understand by the term fermented milk?
3. What do you understand by the term flavoured milk?
Probe: Kindly give some examples and the type of flavours. Fanyogo, Vita milk, Country milk, etc.
4. In your opinion, what is Burkina? What do you know about the ingredients used in making Burkina?
Probe for what type of milk: fresh milk or powdered milk or both milk.
5. Are there any differences between the fresh milk and powdered milk Burkina?
Probe: taste, colour, texture, etc
6. What are the key quality attributes that make a Burkina product?
Probe: millet added, texture, sourness, tingling effect, colour, etc.
7. Where do you normally get Burkina from? Where do you get the Burkina you consume from?
8. What is your take on having Burkina made with skimmed milk?

9. Are there any barriers to the purchase and consumption of Burkina? What are some of the barriers to the purchase and consumption of Burkina?

Probe: safety, proximity, cost, temperature, religious beliefs, allergies etc

10. If the barriers are removed, will it affect your purchase and consumption of Burkina and by how much? Why?

11. How will you feel about having flavoured Burkina?

12. What kinds of flavoured Burkina will you like to consume?

Probe: banana, tiger nuts, strawberry, guava, etc.

Probe for tiger nuts if it is not mentioned.

13. Do you consume tiger nuts? In what form do you consume the tiger nuts? *Mention the forms*

14. What is your opinion about tiger nut flavoured Burkina?

Packaging and Safety

1. How do you handle the Burkina you purchase? For how long do you store the Burkina you purchase?

2. What is your take the Burkina samples sold on the streets? Would you say they are safe for consumption? Why?

3. What will you say will be an ideal packaging for Burkina with regards to food safety?