CONSUMPTION PATTERN, STANDARDIZATION OF RECIPES AND NUTRIENT COMPOSITION OF SOME FOODS FROM LIMA BEANS (*PHASEOLUS LUNATUS*) IN KADUNA STATE

By

Charity Baliyat,DANKAT

DEPARTMENT OF BIOCHEMISTRY

FACULTY OF LIFE SCIENCES

AHMADU BELLO UNIVERSITY

ZARIA

MAY, 2017

CONSUMPTION PATTERN, STANDARDIZATION OF RECIPES AND NUTRIENT COMPOSITION OF SOME FOODS FROM LIMA BEANS (*PHASEOLUS LUNATUS*) IN KADUNA STATE

By

Charity Baliyat DANKAT, B.SC BIOCHEMISTRY (MAIDUGURI) 2010

P13SCBC8047

A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES,

AHMADU BELLO UNIVERSITY, ZARIA

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD

OF A

MASTER OF SCIENCE DEGREE IN NUTRITION

DEPARTMENT OF BIOCHEMISTRY,

FACULTY OF LIFE SCIENCES

AHMADU BELLO UNIVERSITY, ZARIA

NIGERIA

MAY, 2017

DECLARATION

I hereby declare that the work in this dissertation entitled "CONSUMPTION PATTERN, STANDARDIZATION OF RECIPES AND NUTRIENT COMPOSITION OF SOME FOODS FROM LIMA BEANS (*PHASEOLUS LUNATUS*) IN KADUNA STATE" has been performed by me in the Department of Biochemistry under the supervision of Mr. O. A. Owolabi and Prof. K. M. Anigo. The information herein derived from literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at any university to the best of my knowledge.

_____	_____	_____
Charity Baliyat DANKAT	Signature	Date

CERTIFICATION

This dissertation entitled "CONSUMPTION PATTERN, STANDARDIZATION OF RECIPES AND NUTRIENT COMPOSITION OF SOME FOODS FROM LIMA BEANS (*PHASEOLUS LUNATUS*) IN KADUNA STATE" by Charity, Baliyat DANKAT meets the regulations governing the award of the degree of MASTER of Science of the Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

Mr. O. A. Owolabi	_____	_____
Chairman, Supervisory Committee	Signature	Date
Prof. K. M. Anigo	_____	_____
Member, Supervisory Committee	Signature	Date
Prof. M. N. Shuaibu	_____	_____
Head of Department	Signature	Date
Prof. S. Z. Abubakar	_____	_____
Dean, School of Postgraduate Studies	Signature	Date

DEDICATION

I dedicate this work to my parents, Mr. and Mrs T.Y. Dankat for nurturing me to become who I am today despite the challenges of life. I also dedicate this work to my husband, Mr. Thompson Thomas Adegoke for his encouragement, advice and support.

ACKNOWLEDGEMENTS

I appreciate God for the sufficient grace and mercy granted to me throughout my period of study; I ascribe glory, honor and praise to Him alone.

My profound gratitude to my project supervisors, Mr. O. A. Owolabi and Prof. K. M. Anigo for their untiring efforts, corrections, close supervision and suggestions during the course of this work. Your assistance made this work a success.

I thank my Head of Department, Prof. M. N. Shuaibu and the entire academic and nonacademic staff of the Department of Biochemistry for their individual and collective support.

Finally, I appreciate my husband for his relentless sacrifice and efforts towards the success of my work. I will also not forget to appreciate my family members, in-laws' and dear friend, Joan Kaka Dahutu for their prayers and support.

ABSTRACT

This study was conducted to determine the consumption pattern of lima beans (*Phaseolus lunatus*) foods and standardization of the commonly consumed foods among 400 households randomly selected from three Local Government Areas, spread within the three senatorial zones of Kaduna State. The standardized foods were then subjected to proximate, minerals, amino acids, antinutrients and sensory analyses using standard procedures and analytical methods. Data revealed that less than one fifth (13%) of the respondents consumed lima beans at least once a week. The three most commonly consumed foods (lima bean porridge 35%, lima bean-benniseed 8% and lima bean-hungry rice 6%) were standardized. Proximate composition of these foods shows that lima bean-benniseed food had significantly ($P < 0.05$) higher content of crude protein (8.33%), crude fat (13.46%), crude fibre (4.09%) and ash (2.28%) while lima bean porridge had significantly ($P < 0.05$) higher carbohydrate (24.58%) content than the other foods. Lima bean-benniseed recorded higher content of essential amino acids (leucine 6.97g/100g, lysine 7.10g/100g, methionine 2.60g/100g and threonine 3.81g/100g). Mineral content (Mg, Ca, K, Zn) of lima bean-benniseed food was significantly ($P < 0.05$) higher than the other foods. However, lima bean porridge had higher content of iron and sodium. Antinutrients (cyanide, tannin and phytate) content in the standardized foods decreased significantly ($P<0.05$) when compared with raw lima beans. All the foods were considered acceptable however, lima bean-benniseed food with the best nutrient profile and chemical score (100) is consumed by only 8% of the population. Increase consumption of lima bean foods has potential to combat malnutrition and its debilitating effects.

TABLE OF CONTENTS

Page

Cover Page---------- i

Fly Page----------ii

Title Page---------- iii

Declaration---------- iv

Certification---------- v

Dedication---------- vi

Acknowledgements---------- vii

Abstract---------- viii

Table of Contents----------ix

List of Tables---------- xiv

List of Figures---------- xv

List of Plates---------- xvi

List of Appendices---------- xvii

List of Abbreviations---------- xviii

CHAPTER ONE

1.0 INTRODUCTION----------1

1.1 Statement of Research Problem----------3

1.2 Justification of the Study----------3

1.3 Aim and Objectives----------4

1.3.1 Aim----------4

1.3.2 Specific objectives---------- 4

CHAPTER TWO

2.0 LITERATURE REVIEW----------5

2.1 Malnutrition---------- 5

2.1.1 Causes of malnutrition---------- 6

2.1.2 Strategies to improve malnutrition---------- 6

2.2 Legumes---------- 15

2.2.1 Lima beans----------15

2.2.2 Production oflima beans in Nigeria---------- 16

2.2.3 Growing lima beans----------16

2.2.4 Taxonomic hierarchy of lima beans---------- 19

2.2.5 Nutritional composition of lima beans---------- 20

2.2.6 Antinutrient content of lima beans----------20

2.2.7 Health benefits of lima beans----------22

2.3 Food Processing---------- 23

2.3.1 Properties and qualities of food---------- 24

2.4Sensory Evaluation of Food---------- 24

2.4.1 Types of sensory tests---------- 25

2.5 Recipe Standardization----------25

2.5.1 Benefits of standardized recipes---------- 25

2.5.2 Phases of recipe standardization---------- 26

CHAPTER THREE

3.0 MATERIALS AND METHODS---------- 27

3.1 Materials---------- 27

3.1.1 Chemicals---------- 27

3.1.2 Collection of lima bean seeds---------- 27

3.1.3 Study area---------- 27

3.1.4 Study subjects---------- 27

3.2 Methods---------- 29

3.2.1 Sample size---------- 29

3.2.2 Sampling procedure---------- 29

3.2.3 Field data collection---------- 30

3.2.4 Recipe standardization---------- 30

3.2.5 Determination of amino acid profile---------- 31

3.2.6 Determination of proximate composition----------34

3.2.7 Determination of antinutritional factors---------- 38

3.2.8 Determination of mineral content----------40

3.3 Sensory Evaluation----------41

3.4 Statistical Analysis---------- 42

CHAPTER FOUR

4.0 RESULTS---------- 43

4.1 Pattern of Consumption of Lima Bean (*Phaseolus lunatus*) Foods in Kaduna State---------- 43

4.2 Commonly Consumed Lima Bean (*Phaseolus lunatus*) Foods in Kaduna State---------- 43

4.3 Standardized Lima Beans (*Phaseolus lunatus*) Foods in Kaduna State---------- 43

4.4 Nutrient Composition of the Standardized Commonly Consumed Lima Bean (*Phaseolus lunatus*) Foods in Kaduna State---------- 47

4.4.1 Proximate composition---------- 47

4.4.2 Mineral composition---------- 47

4.4.3 Amino acids composition----------47

4.5 Antinutrient Composition of Standardized Commonly Consumed Lima Bean (*Phaseolus lunatus*) Foods in Kaduna State---------- 53

4.6 Sensory Attributes of Standardized Commonly Consumed Lima Bean (*Phaseolus lunatus*) Foods in Kaduna state----------53

CHAPTER FIVE

5.0 DISCUSSION---------- 56

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS---------- 61

REFERENCES---------- 62

APPENDICES---------- 74

LIST OF TABLES

Table Page

1 Chemical Score of Commonly Consumed Standardized Lima Bean (*Phaseolus lunatus*) Foods----------85

2.1 In-depth Nutritional Profile of Lima beans (*Phaseolus lunatus*)----------21

4.1Pattern of Consumption of Lima Bean (*Phaseolus lunatus*) Foods in Kaduna State---------- 44

4.2 Commonly Consumed Lima Bean (*Phaseolus lunatus*) Foodsin Kaduna State---------- 45

4.3 Standardized Lima beans foods recipes in Kaduna State---------- 46

4.4 Proximate Composition of Standardized Commonly Consumed Lima Bean (*Phaseolus lunatus*) Foods in Kaduna State---------- 49

4.5 Mineral Composition of Standardized Commonly Consumed Lima Bean (*Phaseolus lunatus*) Foods in Kaduna state---------- 50

4.6a Essential Amino Acid Composition of Standardized Commonly Consumed Lima Bean (*Phaseolus lunatus*) Foods in Kaduna State----------51

4.6b Non-Essential Amino Acid Composition of Standardized Commonly Consumed Lima Bean (*Phaseolus lunatus*) Foods in Kaduna State----------52

4.7 Antinutrient Composition of Standardized Commonly Consumed Lima Bean (*Phaseolus lunatus*) Foods in Kaduna State---------- 54

4.8Sensory Attributes of Standardized Commonly Consumed Lima Bean (*Phaseolus lunatus*) Foods in Kaduna State---------- 55

LIST OF FIGURES

Figure Page

2.1 Conceptual Framework for Causes of Malnutrition----------13

2.2 Framework for action to achieve optimum fetal and child nutrition and development---------- 14

3.1Map of Kaduna State showing the three senatorial zones---------- 28

LIST OF PLATES

Plate		Page
2.1	Photograph of Lima Bean (*Phaseolus lunatus*) Seeds----------	18
2	Phtograph of Benniseed (*Sesamum radiatum*)----------	83
3	Photograph of Hungry Rice (*Digitaria exilis*)----------	83
4	Photograph of Standardized Lima Beans Porridge Food----------	84
5	Photograph of Standardized Lima Beans-Benniseed Food----------	84
6	Photograph of Standardized Lima Beans-Hungry Rice Food----------	84

LIST OF APPENDICES

Appendix		Page
I	Survey Questionnaire	70
II	Sensory Evaluation form for Lima Beans (*Phaseolus lunatus*) Foods	72
III	Distribution of Respondents by Local Government Areas, Wards and Communities	73
IV	Characteristics of Respondents	74
V	Consumption Pattern of Lima Beans (*Phaseolus lunatus*) Compared with Cowpea (*Vigna unguiculata*) in Kaduna State	75
VI	Essential Amino Acid Requirement for Children 2-5 Years	76
VII	Taxonomic Hierarchy for Benniseed (*Sesamum radiatum*)	77
VIII	Taxonomic Hierarchy for Hungry Rice (*Digitaria exilis*)	78
IX	Photograph of Benniseed (*Sesamum radiatum*) and Hungry Rice (*Digitaria exilis*)	79
X	Photograph of Standardized Lima Bean (*Phaseolus lunatus*) Foods	80
XI	Chemical Score of Commonly Consumed Standardized Lima Bean (*Phaseolus lunatus*) Foods	85

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
AAS	Atomic Absorption Spectrophotometer
Ca	Calcium
FMH	Federal Ministry of Health
FAAS	Flame Atomic Absorption Spectrophotometer
FAO	Food and Agriculture Organization
IFAD	International Fund for Agricultural Development
Fe	Iron
Mg	Magnesium
NNHS	National Nutrition Health Survey
NPC	National Population Commission
K	Potassium
RIG	Random Integer Generator
Na	Sodium
SD	Standard Deviation
SPSS	Statistical Package for Social Sciences
UN	United Nations
UNICEF	United Nations Children Fund
WASH	Water, Sanitation and Hygiene
WHO	World Health Organization
Zn	Zinc

CHAPTER ONE

1.0 INTRODUCTION

Diets usually consist of complex food aggregates and an inadequate diet results in malnutrition (David and Jacobs, 2012). According to the World Health Organization (WHO, 2013), malnutrition is one of the leading causes of death globally. In Nigeria more than half of the children under five years of age are either stunted or wasted (National Nutrition and Health Survey [NNHS], 2015). Food-based approaches such as; dietary diversification, fortification and biofortification are necessary strategies to prevent the debilitating effects of malnutrition by promoting the consumption of foods that are naturally rich in micronutrients. Dietary diversification has been advocated internationally for the improvement of micronutrient intake and status (Hedwig *et al.,* 2012). Dietary diversification reflects household access to variety of foods and can also act as a proxy for individuals' nutrient adequacy. Brian and Leslie(2011) suggested some dietary strategies that could be implemented at the household level to prevent malnutrition, these include; increasing energy and nutrient density of food; increasing the production and consumption of micronutrient dense foods; incorporating enhancers of micronutrient absorption in household diets and employing germination, fermentation, and soaking to reduce antinutrient content of cereals and legumes.

The limiting factors affecting dietary diversification include; poverty, ignorance on dietary pattern, preferences, taboos and the work load of caregivers (Adam, 2005). Most people especially in poor or developing countries base their diets on starchy staples, lacking in important minerals and vitamins which are found in abundance in vegetables, flesh foods and legumes. Oboh *et al.*,(2000) stated that lima beans are important sources of protein and dietary

fibre. It can be substituted for animal protein especially for people who cannot afford to obtain protein from animal sources (Gashaw, 2010). This can help in combating protein malnutrition especially in developing countries and among vulnerable groups. In developing countries, research attention is being paid to better utilization of legumes in addressing protein malnutrition and problems of food security (Subuola *et al.*,2012).Some legumes are commonly used as commercial food crops while some are lesser known, neglected or underutilized outside their indigenous areas.

Lima beans are underutilized in many parts of tropical Africa probably due to its hard-to cook phenomenon or lack of information on its potential as a good food source (Subuola *et al.,* 2012).Lima beans is a leguminous plant that originated from Peru in western South America, its name was derived from Peru's capital city "Lima". In Nigeria lima beans is locally called 'Jinjiyokanpak' in Kataf, 'Waken rumfa' in Hausa language, 'Papala' in Yoruba and 'Agwa' in Igbo. Including legumes either fresh or dried as food promotes health and is important in meeting dietary recommendations to reduce chronic diseases such as diabetes and cardiovascular diseases (Bhandari and Megha, 2014).

Most legumes are poorly utilized due to the presence of antinutritional factors (Egounlety and Aworh, 2003), which can cause stomach cramping, diarrheoa, flatulence and vomiting. Antinutritional factors interfere with nutrient utilization and protein digestibility (Oboh *et al.*,2000). Cooking and some traditional methods of processing cause significant reduction in antinutritional factors (Nakitto*et al.,* 2014). Therefore, as efforts are being made to incorporate foodbased strategies in the fight against malnutrition, there is needtostandardize food recipes and

determine their nutritional composition in order to increase awareness of the nutritional composition of thesefoods.

1.1 Statement of Research Problem

The existence of multiple micronutrient deficiencies is still a major problem in developing countries that can be abated by nutrition intervention (WHO, 2013). Food based strategies such as dietary diversification is still very low in most developing countries, where people feed mostly on starchy staples. This practice makes it difficult for individuals to be adequately nourished with vitamins and minerals that can be found in abundance in fruits, vegetables, flesh foods and legumes.

Animal protein is expensive, therefore there is need to supplement diets with legumes which are cheaper sources of protein and an important source of minerals. Research has also shown that lima beans (*Phaseolus lunatus*) contain some antinutritional factors which can be reduced by different processing techniques (Oboh *et al.,* 2000) thereby improving legumes organoleptic and nutrient quality which makes nutrients bioavailable and help in combating various metabolic disorders.

1.2 Justification of the Study

Very little is known about the intensive utilization of lima beans varieties as a value-added product even though it can be easily grown in home gardens with a well-drained and loose textured soil.

An in-depth study of the utilization and dietary diversification towards lima beans will bring to lime light its contribution to the nutritional well-being of people. Combined processing will

reduce the content of flatus causing oligosaccharide of these beans varieties; this can help to increase its utilization.

Information on the nutrient composition of processed lima beans will serve as a source of developing a food composition database and tables in Nigeria and it will enrich existing food databases. This information will also help in developing therapeutic diets for people suffering from different diseases.

1.3 Aim and Objectives

1.3.1 Aim

The aim of this research is to provide nutritional basis for increase utilization of lima beans (*Phaseolus lunatus*) as a value-added product in households.

1.3.2 Specific objectives are to:

i. determine the consumption pattern of lima beansin Kaduna State.
ii. ascertain the type of foods processed from lima beans and standardize their recipes.
iii. determine the proximate, amino acids,minerals and antinutrient content of standardized foods from lima beans.
iv. evaluate the sensory characteristics and acceptability of the standardized foods from lima beans.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Malnutrition

Malnutrition occurs when the intake of essential macronutrients and micronutrients does not meet or exceeds the metabolic demands for those nutrients (WHO, 2013).Malnutrition sets in when an individual is not getting enough food or not getting the right sort of food, it affects billions of people around the world.Most times the emphasis has been on nutrientsinadequacy (undernutrition), but malnutrition also applies to excess and imbalanced intake (overnutrition).

Undernutritioncan be referred to as protein-energy malnutrition and micronutrient deficiencies. Micronutrient deficiencies have been estimated to affect at least 2 billion people worldwide and leads to hidden hunger (Burchi *et al.,* 2011).Theindicators of undernutrition includes; wasting (low weight for height), underweight (low weight for age) and stunting (low height for age). Undernutrition suffered in early life may lead to permanent impairment such as; reduced cognitive development, reduced economic productivity in adulthood, reduced school performances and educational achievement(Black*et al.,* 2008). On the other hand, the increasing prevalence of obesity and many life-threatening conditions associated with it around the world denotes overnutrition. Generally, malnutrition is linked, either directly or indirectly, to major causes of death and disability particularly for mothers and children. It contributes to the deaths of about half a million children each year (UNICEF, 2013).A malnourished woman is at a higher risk of obstetric complications and delivering a low birth-weight baby.

Nigeria is one of the leading countries with large number of children who are malnourished, 32.9% of children under the age of five are stunted, 7.2% are wasted and 19.4% are underweight

(NNHS, 2015). The ignorance of parents and caregivers about appropriate feeding practices increases poor nutrition, also low-nutrient crops, environmental degradation and high food prices limit access to foods that are rich in vitamins and minerals, thus increasing poor nutrition outcomes among women, children and the society at large.

2.1.1 Causes of malnutrition

Poor nutrition arises from multifaceted and interrelated determinants. These determinants are categorized into; immediate causes, underlying causes and basic causes (Figure 2.1). The immediate causes; inadequate dietary intake and disease, directly affect the individual with disease leading to nutrient loss and poor nutritional status. Children with inadequate nutrient intake will not grow sufficiently and are at risk of irreversible stunting (UNICEF, 2011).

Underlying causes can be grouped into three broad categories:

- Household food insecurity
- Inadequate care
- Unhealthy household environment and poor Public Health services

The basic causes are longer-term such as poverty as a major factor, along with gender inequalities, larger political, economic, social and cultural environments which affect institutions and leadership from community to national level.

2.1.2 Strategies to improve malnutrition

Strategies to prevent and control malnutrition should aim to attack all causes simultaneously since factors at one level affect the factors at other levels (Borgen, 2010). Evidences propose that the following strategies can improve malnutrition (Figure 2.2):

2.1.2.1 Exclusive breastfeeding and complementary feeding

The periods of pregnancy and lactation and the first two years of life pose special nutritional challenges because these are when nutritional requirements are greatest. The World Health Organization (WHO, 2013) recommends that colostrum, the yellowish sticky breast milk that is produced at the end of pregnancy is to be given to newborns within the first hour of birth, aprocess referred to as early initiation of breastfeeding. Infants' breastfed within the first hour of birth are three times more likely to survive than those who have their first breastmilk after a day. Breast milk alone is enough to meet all the nutritional needs of infants for the first six months of life. After six months of age, in order to meet all of a child's nutritional requirements breast milk needs to be complemented by other foods rich in essential vitamins, minerals and nutrients for up to two years or beyond (Federal Ministry of Health [FMH], 2013). Complementary foods continue to serve as important source of nutrients and also improve morbidity and mortality (UNICEF, 2011).

2.1.2.2 Hygiene and sanitation

Hygiene refers to an individual's personal cleanliness while sanitation refers to public cleanliness. Poor Water, Sanitation and Hygiene (WASH) is a major factor causing undernutrition in children, by permitting the spread of infectious diseases such as diarrheoa amongst other indirect effects. The Generation Nutrition Factsheet in 2015 stated three major pathways that lead to undernutrition from poor WASH practices. These are; diarrheoa, environmental enteropathy and intestinal worms. These problems can be prevented through the provision of safe drinking water, hand washing with soap and safe waste disposal system.

WASH interventions can prevent at least 860,000 child deaths from undernutrition per year (Walker *et al.,* 2013).

2.1.2.3 Immunization

Immunization is the process whereby a person is made immune to an infectious disease, typically by the administration of vaccines to stimulate the body's own immune system to protect the person against subsequent infection.Immunization protects children against several deadly diseases (UNICEF, 2013). Early protection through immunization is critical because children who are not immunized are more likely to become undernourished. The immunizations in the child's first year are especially important. It is also essential that pregnant women are immunized against tetanus to protect themselves as well as their newborns.

2.1.2.4 Poverty reduction

Poverty has numerous dimensions. A family can be considered poor because of unmet basic needs, inadequate income or both. Children are often most affected by poverty; it causes lifelong damage to their minds and bodies. Poor families are likely to pass poverty on to their children thereby perpetuating the poverty cycle. Poverty is the major root cause of maternal and child malnutrition, reducing it will go a long way to help in the fight against malnutrition. Poverty reduction must start with children (UNICEF, 2000). The multidimensional nature of poverty implies the absence of one single solution. Poverty reduction can only be achieved through a broad spectrum of activities bolstering universal human rights, fostering economic growth and social development, enhancing national/local capacity and empowering the poor to join central partners in their own development.

2.1.2.5 Nutrition education

Nutrition education involves teaching about the importance of nutrition, providing educational materials that reinforce messages about healthy eating, teaching skills essential for making dietary change, and providing information on how to sustain behavioral change (Fanzo, 2012). Food and Agriculture Organization stresses that nutrition education is a key for developing the skills and motivation needed to eat well, and is especially important in situations where families have limited resources. It is also in those same low-income situations that the challenge of providing nutrition education is often the greatest. Nutrition education can be considered to having three essential phases; a motivational phase, where the goal is to increase awareness and enhance motivation of the intended audience; an action phase, where the goal is to facilitate the ability to take action; an environmental component, where nutrition educators work with policymakers and others to promote environmental supports for action (Contento, 2008).

2.1.2.6 Strengthening health systems

A health system consists of all organizations, people and actions whose primary intent is to promote, restore or maintain good health. Health systems can be strengthened by adopting the six building blocks of a health system framework as postulated by the World Health Organization (WHO, 2007) as follows;

Service delivery: good health services are those which deliver effective, safe health interventions to those who need them, when and where needed with minimum waste of resources.

Health workforce: a well-performing health workforce is one which works in ways that are responsive, far and efficient to achieve the best health outcomes possible, given available resources and circumstances.

Information: a well-functioning health information system is one that ensures the production, analysis, dissemination and use of reliable and timely information on health determinants, health systems performance and health status.

Medical products, vaccines and technologies: a well-functioning health system ensures equitable access to essential medical products such as nutritional supplements, vaccines and technologies of assured quality.

Financing: a good health financing system raise adequate funds for health, in ways that ensure people can use needed services, and are protected from financial catastrophe.

Leadership: this involves ensuring that strategic policy frameworks exist and are combined with effective provision of appropriate regulations and incentives, attention to system design, and accountability.

2.1.2.7 Women empowerment

In most societies, women are the major caregivers for young children and bear primary responsibility for their health and survival (International Fund for Agricultural Development [IFAD], 2012). This makes women empowerment an essential part of human development and for improvements in nutrition (Fanzo, 2012). Empowerment of women includes developing self-reliance, gaining skills and increasing their power to make decisions and have their voices heard. This makes it vital for the society to benefit from increased contributions that women can make to food and nutrition security.

2.1.2.8 Improved agriculture

Agricultural growth is particularly effective in reducing hunger and malnutrition. Agriculture's essential role is to ensure that diverse, nutritious foods, adequate to meet the needs of people of all ages, are available and accessible at all times (IFAD, 2012). Increases in production and productivity can raise incomes, which can be used to purchase food. Biofortification, the breeding of staple food crops to increase the density and bioavailability of micronutrients is a promising intervention and increases the consumption of nutritious food.

2.1.2.9 Micronutrient intervention

Micronutrient deficiencies represent a largely invisible but devastating form of malnutrition. The most common micronutrient deficiencies include; vitamin A deficiency which causes blindness and increased susceptibility to measles and other infections; iron deficiency which causes anaemia; iodine deficiency which causes cretinism, goiter and impaired growth in children (UN, 2008). The sustainable route to long term reduction in micronutrient deficiencies is through increased food consumption, food fortification, supplementation and greater diversity of diets.

Food fortification: this refers to the deliberate addition of micronutrients to foods. Food fortification is a food-based approach where existing food supplies fail to provide adequate levels of nutrients in the diet.

Supplementation: this refers to the provision of relatively large doses of micronutrients, usually in form of pills, capsules or syrups (Allen *et al.,* 2006).

Dietary diversification: dietary diversity refers to increase consumption in the variety of foods across and within food groups capable of ensuring adequate intake of essential nutrients that can

promote good health (Taruvinga and Mucheje, 2013). Many individuals base their diets on starchy staples with inadequate animal products, fresh fruits, legumes and vegetables (Ruel, 2003). The quality of diet is particularly important for reducing stunting in children because inadequate nutrition causes physical, cognitive and immunological deficits (Fanzo, 2012). Increasing dietary diversity is the preferred way of improving the nutrition of a population because it has the potential to improve the intake of many food constituents. Allen *et al.*(2006) stated that efforts are ongoing to help poorer communities identify, and cultivate traditional and wild micronutrient-rich foods as a simple and affordable means of satisfying micronutrient needs.

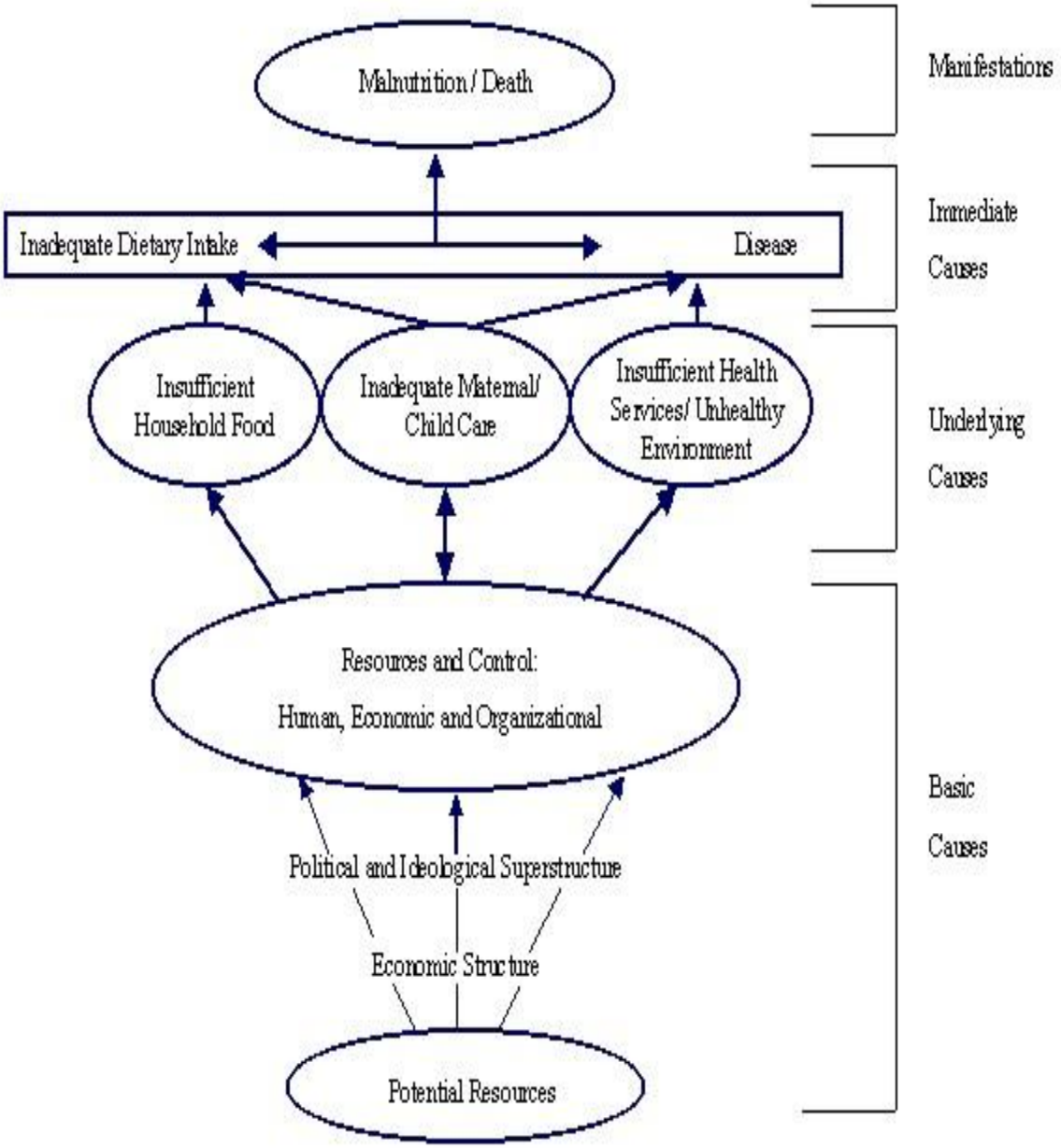


Figure 2.1 Conceptual Framework for Causes of Malnutrition. Source: UNICEF (1990)

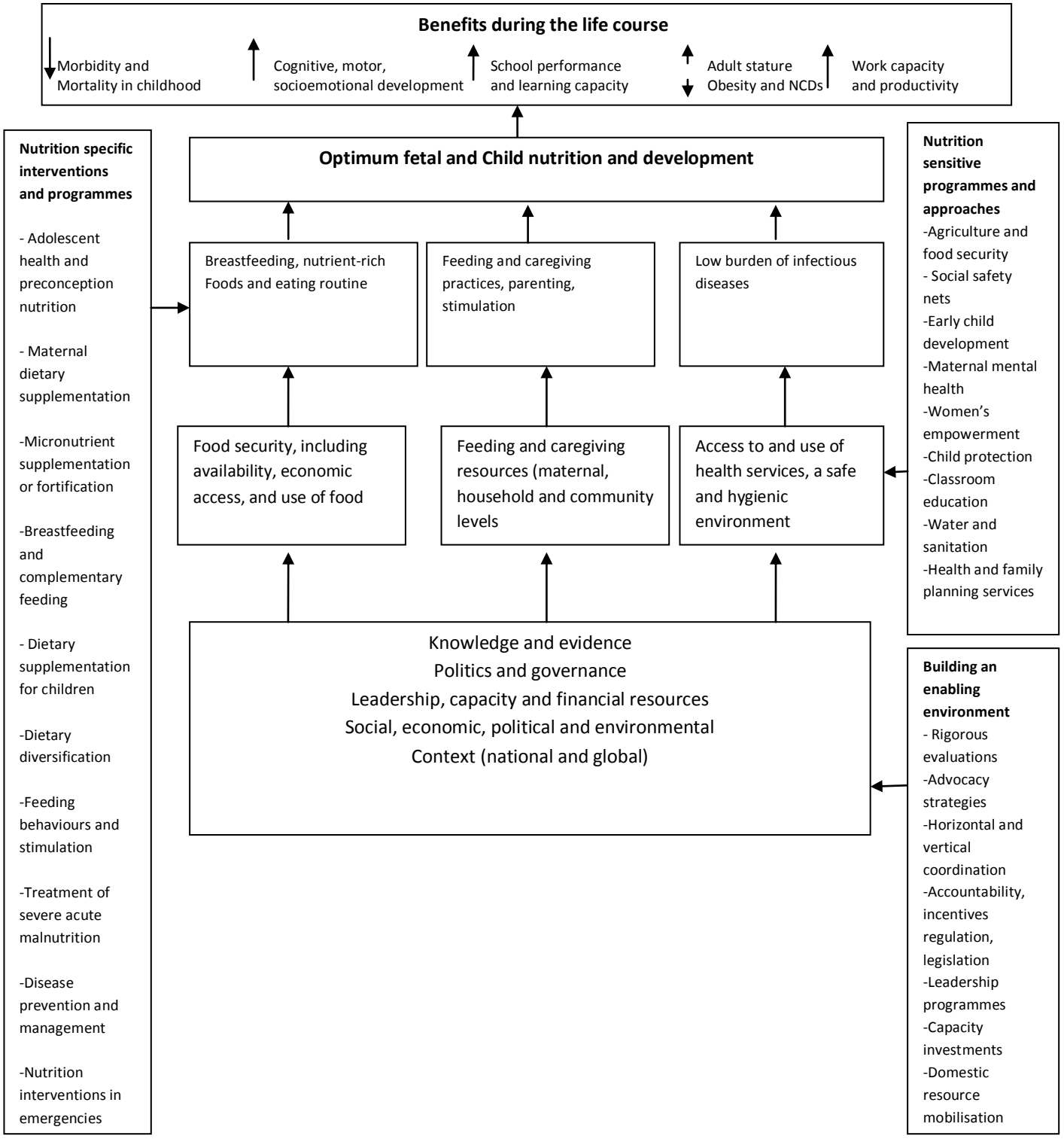


Figure 2.2: Framework for action to achieve optimum fetal and child nutrition and development

Source: Maternal and Child Nutrition Series (2013).

2.2 Legumes

Legumes belong to the family *Leguminosae.* Legumes contain less carbohydrate and more protein than cereals. Legumes are a major source of cheap protein and minerals when compared with animal products such as meat, fish and egg (Subuola *et al.,* 2012) and the less affluent people in many tropical countries especially in Africa and Asia utilize legumes as an alternative to other expensive protein sources. The food legumes can be divided into two groups: pulses and oilseeds. The pulses group includes dry seeds or grains while the oilseeds group is primarily used for their oil contents.Food legumes confer special dietary and agricultural benefits that make them particular valuables (Ani *et al.,* 2014).The more widely consumed legumes include cowpea, pigeon pea, soyabean, bambara-groundnut, African yam bean, groundbean and lima bean (Udenta *et al.,*2014).Flours produced from legumes can be utilized in fortification of local staples. These flours have been used in developing different types of nutritionally improved diets.Legumes can be included in diets to help in alleviating protein deficiency in human nutrition (Oboh *et al.,* 2000).

2.2.1 Lima beans

Lima pods originated in the tropical fertile valleys of Central America as wild cultivars, they are one of the ancient cultivated crops. They are grown as annual crops; varieties can be grown either as bush or as vine (pole) types. In general, bush beans yield small seeds often recognized as sieve, baby lima or butter beans while the vine or pole varieties yield large seeds and categorized as lima beans. Some form of species are erect with trailing branches while others are climbing vines up to four and half meters long.

Lima beans are kidney-shaped and grow within flat oblong pods in either pole or bush bean varieties. Lima beans have a potato-like starchy taste and soft, buttery texture when cooked.Fresh green, small lima is ready for harvest in 65-80 days after seedling, while the large lima takes little longer to mature and can be harvested in 80-90 days after seedling (Nutrition facts, 2016). Harvesting is not time guided and can be done at any time once the pods grow large enough or the pods can be left on the branch to dry out for the purpose of obtaining dry beans.

2.2.2 Production of lima beans in Nigeria

In Nigeria, Lima bean is widely cultivated in the south-western, south-eastern and the middle belt regions of Nigeria. It is cultivated mainly for the dry seeds. This crop is highly underutilized in the country and cultivated in only about 4% land area devoted to grain legumes production in south west Nigeria (Remi and Oloruntoyin, 2007). Some indigenous people, such as the Yorubas process the seeds into pudding and porridge. The seeds can also be processed into soups and stews cooked together with maize, rice or yam. Lima bean has been reported to provide from 25 to 30% of the protein in the diet and efforts are being geared towards the improvement of lima bean cultivars for improved nutritional attributes and desired seed quality (Sunday, 2001).

2.2.3 Growing lima beans

Lima beans grow best in full sun with temperatures between 16 and 21°C. A well-drained loam soil with high level of organic matter is the best for its growth, no high-nitrogen fertilizer and no fresh manure is required because the plants will begin to grow more leaves with little beans. It requires a pH of 6.0 to 6.8; also adequate seedbed preparation allows more uniform seed placement and a greater percentage of emergence for continuous harvest through the growing season(Albert, 2016).

Beans are susceptible to pests and diseases, keeping the garden clean and free of debris will reduce the incidence of pests. Rotating beans so that they do not grow in the same location more than every three years will reduce soil-borne diseases.



Plate 2.1: Lima Bean (*Phaseolus lunatus*) Seeds.

2.2.4 Taxonomichierarchy of lima beans

Kingdom	Plantae- plants
Subkingdom	Viridiplantae
Infrakingdom	Streptophyta – land plants
Superdivision	Embryophyta
Division	Tracheophyta – vascular plants
Subdivision	Spermatophytina – seed plants
Class	Magnoliopsida
Superorder	Rosanae
Order	Fabales
Family	Fabaceae– peas, legumes
Genus	Phaseolus L. – wild bean
Species	*Phaseolus lunatus L.* – sieve bean

(Integrated Taxonomic Information System, 2015.)

2.2.5 Nutritional composition of lima beans

Lima beans are nutrient dense and have a great taste with a creamy texture. These beans are good sources of folate, phosphorus, potassium, thiamin, iron, magnesium and manganese as shown in Table 2.1.The amino acid profile of lima bean shows high levels of essential amino acids (Seidu *et al.*, 2014). Research has also shown that the nutrient value of some lima bean varieties and ranged from 65.60% to 71.51% carbohydrate, 19.33% to 25.43% protein, 3.99% to 4.43% fibre and 3.88% to 4.13% ash. Zinc and iron values ranged from 28.8 to 33.06mg and 57.22 to 60.24mg, respectivelydepending on the variety (Obiakor-Okeke, 2014).

2.2.6 Antinutrient content of lima beans

Lima bean seeds contain anti-nutritional factors such as phytic acids, oxalate, hydrogen cyanide, and tannin which have been observed to inhibit absorption of nutrients and utilization by man and animals (Adegbehingbe, 2014). Phytic acid is able to bind minerals and also reacts with proteins to form complexes which may inhibit peptic digestion (Osagie *et al.*, 1996). Thehydrogen cyanide levels of some lima bean varieties were estimated with high levels at 38.38mg to 43.55mg (Obiakor-Okeke, 2014) which leads to deleterious effects when raw or improperly processed lima bean is consumed. Research by Osagie *et al.*(1996) also shows the presence of 22.40g/kg saponin and 0.14mg/100mg tannin. The antinutrient content of this bean and the hard-to-cook phenomenon are the major constraints to its utilization.Subuola*et al.*(2012) reported that the hard-to-cook phenomenon of this legume is due to the hard testa which has led to long cooking times and utilization of more fuel during preparation. Research has shown that removal of the outer testa, discarding and replacing water at intervals during cooking,

germination, fermentation and soaking will reduce some of lima bean antinutrient effects (Daniel, 2015).

Table 2.1: In- depth Nutritional Profile of Lima Beans

LIMA BEANS (*PHASEOLUS LUNATUS*), RAW, MATURE SEEDS, NUTRITIVE VALUE PER 100 g.	
Nutrients	**Concentration**
Energy	338 Kcal
Carbohydrates	63.38 g
Protein	21.46 g
Total Fat	0.69 g
Cholesterol	0 mg
Dietary Fiber	19 g
Folates	395 µg
Niacin	1.537 mg
Pantothenic acid	1.355 mg
Pyridoxine	0.512 mg
Riboflavin	0.202 mg
Thiamin	0.507 mg
Vitamin A	0 IU
Vitamin C	0 mg
Vitamin E	0.72 mg
Vitamin K	6 µg
Sodium	18 mg
Potassium	1724 mg
Calcium	81 mg
Copper	0.740 µg
Iron	7.51 mg
Magnesium	224 mg
Manganese	1.672 mg
Phosphorus	385 mg
Selenium	7.2 µg
Zinc	2.83 mg
Carotene-ß	0 µg
Carotene-α	0 µg
Lutein-zeaxanthin	0 µg

(United States Department of Agriculture[USDA], 2014)

2.2.7 Health benefits of lima beans

Lima beans has high fibre content and serves as a very good source of cholesterol-lowering fibre and also helps in controlling blood sugar level(Obiakor, 2009). This legume has the potential to improve diet quality and help in maintaining the functions of the digestive system (Garden-Robinson, 2013). Research has shown that eating more beans may reduce disease risk factors (James, 2015). Some of the health benefits of eating lima bean include:

2.2.7.1 Improved heart health: high plasma levels of homocysteine, elevated blood levels of cholesterol and triglycerides are significant contributing risk for cardiovascular disease (Garden-Robinson 2013).A significant reduction in serum lipids has been observed in experimental rats fed with lima bean diet (Oboh and Omofoma, 2008), this suggests that the consumption of lima bean could be recommended to promote cardiovascular health. The significant amount of fibre, folate and magnesiumpresent in lima beancould help in decreasing heart attack risk. Fibre binds with bile acids that are used to make cholesterol and it is being egested from the body along side with faeces.Folate helps to lower homocysteine levels which is a risk factor for heart attack, stroke, and found in 20-40% patients with heart disease (George Mateljan Foundation, 2016). The good supply of magnesium by lima bean is an addition to its benefit in promoting heart health as research shows that lack of sufficient magnesium promotes free radical injury to the heart (Bean Institute, 2016).

2.2.7.2 Decreasing blood sugar levels: diabetes is a chronic metabolic disorder, characterized by high blood glucose (hyperglycemia), associated with impaired carbohydrate, fat and protein

metabolism, resulting from either insufficient or no release of insulin by the pancreas in the body. It is becoming more prevalent throughout the world and a major public health problem in developing countries (Udenta *et al.* ,2014).People suffering from diabetes are usually counseled on moderation of food intake and incorporation of low glycemic index foods that contain slowly digestible carbohydrates and increased consumption of dietary fibre-rich foods. Lima beansare low on glycemic index and its rich-fibre content is a good nutritional component for managing blood glucose level.According to a study by Ojo *et al.*(2013), consumption of heat treated lima beans produced a significant hypoglycaemic effects in diabetic rats. Dietary management of diabetes is aimed at improving health through good nutrition and achieving optimal blood glucose level.

2.2.7.3 Prevents colon cancer: lima beans contain substantial amounts of dietary fibre of about 18.40g/100g (Ezeagu and Ibegbu, 2010).Dietary fibre protects the mucous membrane of the colon by decreasing its exposure time to toxic substances as well as binding to cancer causing chemicals in the colon.Generally, beans are natural sources of antioxidants and phytochemicals, and research shows that regular bean consumption may reduce certain types of cancer including colorectal, breast and prostate.

2.3 Food Processing

The fundamental necessity for food is to sustain life. Food processing combines raw food ingredients to produce products that can be readily utilized by the consumer. The principal reason for food processing is to make it biologically safe to eat, it involves different cooking techniques such as; boiling, frying, grilling, roasting etc. Some other reasons why foods are processed include;

- To maintain or improve its nutritional properties.
- To make it palatable.
- To make foods for special groups of people such as infants, elderly and the sick.
- To increase its shelf life.

2.3.1 Properties and qualities of food

The organoleptic properties of food affect its acceptability to consumers. Food may be liked or disliked as a result of certain expectations of texture, flavour, aroma and appearance or based on religious, cultural, psychological, social and health grounds.

Therefore in food processing, certain quality standards must be maintained in order to meet the demands of consumers who are generally concerned about the quality of food product. The quality and acceptability of food can be tested by trained or semi-trainedpanel who can detect whether a product has attained a necessary standard.

2.4 Sensory Evaluation of Food

Sensory evaluation is a scientific discipline used to evoke, measure, analyze and interpret responses to products that are perceived by the senses of sight, smell, touch, taste and hearing (Stone and Sidel, 1993). Sensory evaluation can be used to:

- Provide feedback data in order to enable informed decisions to be made
- Evaluate food products
- Compare the similarities and differences in a range of dishes
- Analyze food samples for improvements
- Determine the acceptability or unacceptability of food products

- Explore scientific characteristics of food products

2.4.1 Types of sensory tests

1. Preference test: it is designed to find out most preferred product amongst a range of food products. Here people are asked whether they like or dislike a product. This is a subjective test and hedonic scale,paired comparison and scoring can be used for evaluation (Stone and Sidel, 1993).
2. Discrimination test: specific attributes of products is being evaluated. They are objective tests and include triangle, duo trio, ranking and paired comparison (Stone and Sidel, 1993).

2.5 Recipe Standardization

A standardized recipe is a recipe that has been tried, tested, evaluated and adapted for use by a food service(Hemraj*et al.,* 2014). Standardization of recipes is necessary because product will be consistent in quality each time they are prepared using the standard recipes.

2.5.1 Benefits of standardized recipes

Standardized recipes provide many benefits. These benefits include:

- Consistent food quality: This ensures that recipes will be consistent in quality each time they are prepared.
- Predictable yield: Food wastage is avoided when the yield is predicted based on standardized recipe.

- Consistent nutrient content: The consciousness about the nutritional content of food is now the order of the day. Standardized recipes will ensure that nutritional values are valid and consistent.
- Increased consumer satisfaction: Providing a consistent quality of food increases the consumers' satisfaction and increases the utilization of such foods.
- Food cost control: Standardized recipes provide consistent and accurate information for food cost control because the same quantities of ingredients are used each time the recipe is produced.
- Labour cost control: Standardized recipe procedures makes it possible for an efficient use of labour and time

2.5.2 Phases of recipe standardization

There are three phases of recipe standardization: recipe verification, product evaluation and quantity adjustment. Recipe verification consists of reviewing the recipe in detail, preparing it, verifying its yield and recording changes. In the product evaluation phase, sensory evaluation of the product is conducted and the acceptability is decided based on parameters like the appearance, texture, color and tasteof the product. Changing the recipe yield and ingredients amount occurs in the quantity adjustment phase when a recipe has been evaluated positively in the evaluation phase but not in the desired quantity. A recipe may go through these phases several times before becoming standardized at the needed or necessary quantity(Hemraj*et al.*, 2014).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 MATERIALS

3.1.1 Chemicals

All chemicals and reagents used were of analytical grade, purchased from Sigma-Aldrich.

3.1.2 Collection of lima bean seeds

Dry lima beans *(Phaseolus lunatus)* was purchased from Sabo market in Kaduna South Local Government Area of Kaduna State. The seeds were then identified at the herbarium of Department of Botany, Ahmadu Bello University, Zaria, Kaduna state, Nigeria, and voucher number (2403) was deposited. The seeds were then cleaned and sorted by hand. Also, all ingredients for recipe preparation were purchased from the same market in Kaduna State.

3.1.3 Study area

The study was conducted in three randomly selected Local Government Areas, one from each senatorial zone in Kaduna state, Nigeria. Kaduna State is a state in the North West zone of Nigeria. Its Capital is Kaduna and lies on the geographical coordinates of $10^{o}31'23'N'7^{o}26'25'E$. According to the National Population Commission (NPC, 2006), the State has a population of 6,113,503 people and covers an area of 3,080km^2.

3.1.4 Study subjects

The study population consisted of households with at least one under-five child in the randomly selected community.

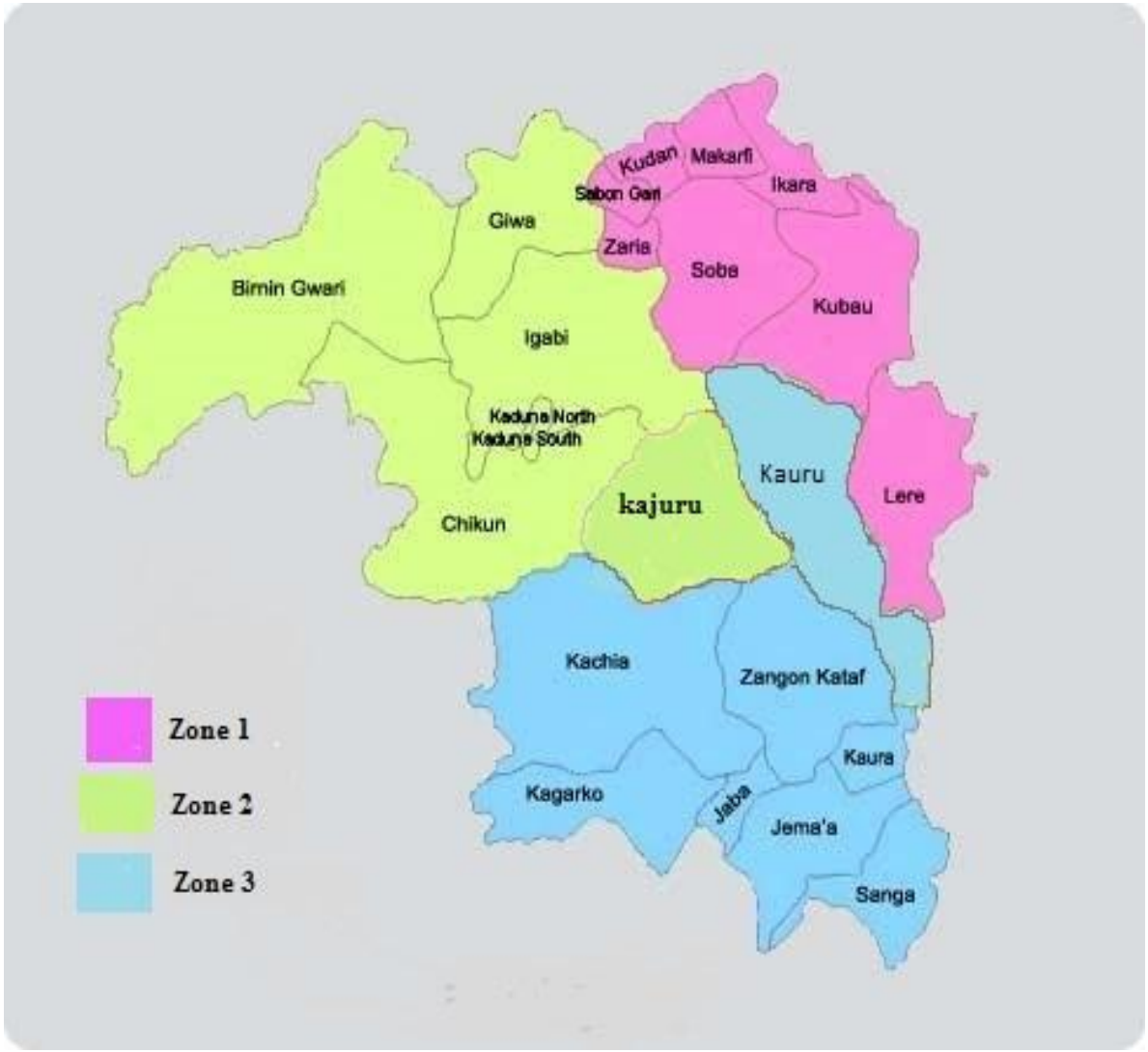


Fig 3.1: Map of Kaduna State showing the three senatorial zones.

Source: http://www.nigerianmuse.com/20100527092749zg/sections/pictures-maps-cartoons/maps-of-various-states-and-their-local-governments-in-nigeria/

3.2 METHODS

3.2.1 Sample size

The sample size was determined using the formula:

$n = t^2 \times p\ (1\text{-}p) / M^2$

Where,

n = required sample size

t = confidence level at 95% (standard value of 1.96)

p = proportion in the target population estimated to have a particular characteristics (set at 0.5 because the proportion is not known)

M = margin of error at 5% (standard value of 0.05).

Adjusted for design defect and non response cases.

3.2.2 Sampling procedure

The following Czara, (2005) multistage sampling procedure was used to select households for the study:

i. The Local Government Areas in each senatorial districts of Kaduna state werelisted alphabetically.

ii. One Local Government Area from each senatorial zone was randomly selected using Random Integers Generator-RIG (True Random Number Service, 2015).

iii. Each randomly selected Local Government Area was then stratified into North and South.

iv. Using the RIG as above, one ward each wasselected per strata of the selected LGA, making a total of two communities/wards per Local Government Area.

v. The households in the selected community were then listed and the eligible ones noted. The number of eligible households required per community/ward was selected using probability proportional to size based on the calculated sample size.

vi. Using the hat method, the number of required household was randomly selected.

3.2.3Field data collection

An in-depth interview was conducted in each community using semi-structured questionnaire to determine the number, frequency and methods of processing different lima beans dishes (Appendix X).

3.2.4 Recipe standardization

Recipe standardization was done according to the method described by Oguntona *et al.* (1999). A total of400 questionnaires were administered to caregivers of households with at least one under five child living in Chikun, Kaura and Sabon Gari Local Government Areas (LGA) ofKaduna State, to obtain information on consumption pattern of lima bean foods. All the completed questionnaires were then sorted and separatedto document the three most preferred foods. The questionnaires were numbered randomly and 20 recipes were selected for each dish.The amount of ingredients used for standardized recipe was obtained by calculating the means of the 20 recipes selected.

Equipment and utensils used for standardization: Kinox Stainless steel pot, Camry Emperors weighing scale, Mettler Toledo weighing scale, Teaspoon, Measuring cup, Serving spoons, Frying pan, Polyster 2/2 gas cooker.

3.2.5Determination of amino acid profile

The Amino Acid profile in the known sample was determined using methods described by Benitez (1989). The known sample was dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the Applied Biosystems PTH Amino Acid Analyzer.

3.2.5.1 Sample preparation

The sample wasdried at 56°C and finely ground to pass through a 20-mesh sieve. The sample was carefully mixed to facilitate homogeneity.

3.2.5.2Defatting of Sample:

The sample was defatted using chloroform/methanol mixture in the ratio 2:1. Exactly 4g of the sample was placed in extraction thimble and extracted for 15 hours in soxhlet extraction apparatus (AOAC, 2006).

3.2.5.3Nitrogen content determination for amino acid profile:

A small amount (200mg) of the ground sample was weighed and placed in the Kjeldhal digestion flask. Concentrated sulphuric acid (10ml) was added. Catalyst mixture (0.5g) containing sodium sulphate (Na_2SO_4), copper sulphate ($CuSO_4$) and selenium oxide (SeO_2) in the ratio of

10:5:1 was added into the flask to facilitate digestion. Four pieces of anti-bumping granules were added.

The flask was then placed in Kjeldhal digestion apparatus and allowed to digest for 3 hours until the liquid turned light green. The digested sample was cooled and diluted with distilled water to 100ml in standard volumetric flask. Aliquot (10m1) of the diluted solution with 10ml of 45% sodium hydroxide was placed into the Markham distillation apparatus and distilled into 10ml of 2% boric acid containing 4 drops of bromocresol green/methyl red indicator until 70ml of distillate was collected.

The distillate was then titrated with standardized 0.01 N hydrochloric acid to grey coloured end point. The percentage nitrogen in the original sample was calculated using theformula:

$$\text{Percentage Nitrogen} = \frac{(a-b)\times 0.01 \times 14 \times V \times 100}{W \times C}$$

Where:

a = Titre value of the digested sample

b = Titre value of blank sample

v = Volume after dilution (100ml)

W = Weight of dried sample (mg)

C = Aliquot of the sample used (10ml)

14 = Atomic weight of nitrogen

3.2.5.4Hydrolysis of the sample

The defatted sample was weighed into a glass ampoule. A total of 7ml of 6NHCl was added and oxygen was expelled by passing nitrogen into the ampoule (this is to avoid possible oxidation of

some amino acids during hydrolysis e.g methionine and cysteine). The glass ampoule was then sealed with bunsen burner flame and placed in an oven preset at $105^0C\pm 5^0C$ for 22 hours. The ampoule was allowed to cool before broken open at the tip and the content was filtered to remove the humins.Tryptophan was destroyed by 6N HCl during hydrolysis.The filtrate was then evaporated to dryness using rotary evaporator. The residue was dissolved with 5ml ofacetate buffer (pH 2.0) and stored in plastic specimen bottles, which were kept in the freezer at 4^oC until analysis.

3.2.5.5Hydrolysis of tryptophan

The defatted sample was weighed into glass ampoule, 10ml of 4.2M NaOH was added and oxygen was expelled by passing nitrogen into the ampoule. The glass ampoule was then sealed with bunsen burner flame and put in an oven preset at $105^0C \pm 5^0C$ for 22 hours. The ampoule was allowed to cool before broken open at the tip and the content was filtered to remove the humins. The filtrate was neutralized with 6N HCl and evaporated to dryness at 40^0C under vacuum in a rotary evaporator. The residue was dissolved with 5ml of acetate buffer (pH 7.0) and stored in plastic specimen bottles, which were kept in the freezer at 4^oC until analysis.

3.2.5.6Loading of the hydrolysate into analyzer

The amount of hydrolysate loaded was 60 microlitre into the amino acid analyzer. This was dispensed into the cartridge of the analyzer. The analyzer is designed to separate and analyze free acidic, neutral and basic amino acids of the hydrolysate.

3.2.5.7Calculating amino acid values from the chromatogram peaks.

An integrator attached to the Analyzer calculates the peak area proportional to the concentration of each of the amino acids.

3.2.5.8 Calculating the chemical score

The chemical score was calculated using the ratio of a gram of the limiting amino acid in the sample to the same amount of the corresponding amino acid in a reference diet multiplied by 100. The scoring pattern suggested by FAO/WHO/UNU (2007) for children 1-2 years of age was used for this purpose.(Appendix XI).

$$\text{Chemical score} = \frac{mg\ of\ amino\ acids\ per\ gram\ test\ protein}{mg\ of\ amino\ acids\ per\ gram\ reference\ pattern} \times 100$$

3.2.6Determination of proximate composition

3.2.6.1 Determination of ash content

The term ash refers to the residue left after combustion of the dried sample and is a measure of the total mineral content. Determination of ash content was carried out according to the method described by AOAC (2000).

Six crucibles were preheated in a muffle furnace at about 550°C. Each crucible was cooled in a dessicator and weighed. Approximately 1g of each sample was weighed into the different crucibles. The crucibles and their contents were then transferred into the muffle furnace and allowed to ash at 550°C for 5 hours. The weights of the crucible and contents were taken and recorded. Percentage ash was calculated using the expression below:

$$Ash\ (\%) = \frac{Weightofash \times 100}{Weightof\ sample\ taken}$$

3.2.6.2Determination of moisture content

The method employed for the determination of moisture content of the sample was that which is based on the measurement of the loss in weight due to drying at a temperature of about 105°C as described by AOAC (2000).

Six watch glasses were washed and dried in an oven at 105°C after which they were cooled and weighed empty. Two grams of each sample was weighed into their respective watch glasses. The watch glasses and their contents were dried in an air circulated oven at 105°C to a constant weight. The watch glasses and their contents were cooled in desiccators and reweighed.

The percentage moisture content of each sample was calculated using the expression;

$$moisture\ (\%) = \frac{(Lossofweightondrying) \times 100}{(Initialsampleweight)}$$

3.2.6.3.Determination of crude lipid content

The lipid content of each sample was determined by the procedure described by AOAC (2000). A clean dry round bottom flask containing anti bumping granules was used and exactly 210ml of petroleum etherwas introduced into the flask which was then fitted with soxhlet extraction unit. The weighed sample was transferred into a thimble and fixed into the Soxhlet extraction unit and a condenser attached to allow for cold water circulation. The heating mantle was then switched on and the heating rate adjusted until the solvent is refluxed at a steady rate. Extraction was carried out for 8hours.

The sample was removed and dried to a constant weight in an oven, cooled in a dessicator and reweighed and the percentage crude lipid content was determined using the formular;

$$lipid\ (\%) = \frac{(weight\ of\ lipid\ extracted\ ) \times 100}{(Weight\ of\ sample\ taken)}$$

Where the weight of lipid extracted was the loss in weight of the sample after extraction, drying in an oven and cooling in a desiccator.

3.2.6.4. Determination of crude fibre content

Crude fibre was determined by the method of AOAC (2000). Two grams of grounded sample (C_1) was placed in a round bottom flask. A total of 100ml of 0.25M H_2SO_4 was then added and the mixture was boiled under reflux for 30minutes. The insoluble matter was washed three times with hot water until it was acid free. It was then transferred into a flask containing 100ml of 0.25M NaOH solution. The mixture was boiled again under reflux for 30 minutes and filtered under suction. The insoluble residue was washed with hot water until it was base free. The insoluble material was transferred to a weighed crucible dried at 130°C and weighed (C_2). It was then ashed in a furnace at 550°C for 2 hours. The furnace was put off and allowed to cool down to 200°C and the sample was removed, cooled and weighed (C_3). The crude fibre content was calculated as loss of weight due to ashing.

Crude fibre (%) = $\frac{(C2-C3\ )\times 100}{C1}$

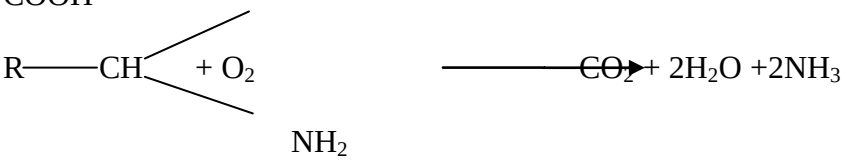
3.2.6.5 Determination of crude protein content

The Kjedahl method of AOAC (2000) was used for crude protein determination.

Steps for determination

A. Mineralization steps of organic substance in boiling sulphuric acid.

$2H_2SO_4 \longrightarrow 2SO_2 + 2H_2O+O_2$



B. Distillation Steps of Ammonium sulphate after alkalisation of the boric acid solution

$(NH_4)_2SO_4 + NaOH \longrightarrow 2Na_2SO_4+2H_2O+2NH_3$

$NH_3 + H_2O \longrightarrow NH_4OH$

$H_3BO_3 + NH_4OH \longrightarrow (NH_4)_3BO_3 + 3H_2O$

C. Titration of ammonium with hydrochloric acid of standardized concentration

$(NH_4)_3BO_3 + HCl \longrightarrow 3NH_4Cl + H_3BO_3$

Method

A total of 2g of each sample was weighed into 100ml Kjedahl digestion flask and a few anti bumping granules wereadded. One gram of the mixed catalyst ($CuSO_4$ and K_2SO_4 in the ratio 8:1 respectively) and 15ml of concentrated sulphuric acid was added. The flask was then placed on a Kjedahl digestion rack and heated until a clear solution was obtained. At the end of the digestion, the flask was cooled and the sample was quantitatively transferred to a 100ml volumetric flask and made up to the mark with distilled water. A total of 10ml of the digest was pipetted into Markham semi micro nitrogen steel tube, 10ml NaOH solution was then added cautiously. The sample was distilled, liberating ammonia into a 100ml conical flask containing 10ml boric acid and a drop of methyl blue indicator until the colour changed from pink to green. The content of the conical flask was then titrated with 0.1M HCl. The end point was indicated by a colour change from green to pink and the volume (v) of the acid for each distillate was noted. Percentage nitrogen per sample was calculated using the expression below:

$$\text{Nitrogen (\%)} = \frac{(M \times V \times 14 \times 100 \times 100)}{(Weight\ of\ sample\ \times 1000 \times 10)}$$

Where, M = Molarity of HCl

14 = Atomic weight of nitrogen.

100 = Total volume of digest.

100 = % conversion.

10 = Volume of the digest taken.

1000 = Conversion to litre.

The crude protein was calculated as:

Protein (%) = 6.25 x % nitrogen.

3.2.6.6 Determination of carbohydrate content

The percentage carbohydrate was obtained by difference thus;

Percentage carbohydrate = 100 - (% ash + %crude fat + %moisture + %crude protein).

3.2.7 Determination of antinutritional factors

3.2.7.1 Determination of cyanide content

The cyanide content was determined according to the method of AOAC (2000). A total of 2g of the sample was weighed into a flask and 100ml of distilled water wasthen added to it and allowed to hydrolyze for 1hour. A total of 10ml of 2.5% NaOH was measured carefully and pouredinto the glass sample holder. The soxhlets apparatus was set up and distilled into the glass sample holder containing the 2.5% NaOH until precisely 70ml was collected. It was then carefully transferred to a 100ml volumetric flask and the glass sample holder rinsed with distilled waterinto the volumetric flask. It was also made up to mark and 25ml of the distillate was pipetted into a conical flask, 2ml of 6M NH_4OH was added as well as 0.5ml of 10% KI solution, it was then titrated with 0.02M $AgNO_3$ to first turbid colour.

Note: 1ml of 0.02M $AgNO_3$ is equal to 1.08g of cyanide.

3.2.7.2 Determination of phytic acid content

The phytic acid was determined using the procedure described by Lucas and Markakas (1975). Exactly 2.0g of each sample powder was weighed into 250ml conical flask, 100ml of 2% concentrated HCl was used to soak each sample in the conical flask for 3hrs. The mixture was filtered and 50ml of each filtrate was placed in 250ml beaker and 107ml of distilled water was added to each solution. 10ml of 0.3% thiocyanate solution was added into each flaskas indicator and titrated with standard iron chloride solution which contains 1.95mg of iron/ml. The end point was a brownish colour persisting for 5minutes. The percentage of phytic acid was calculated using the formula:Phytic acid (%) $=Y \times 1.19 \times 100$

Where Y = titre value x 1.95mg.

3.2.7.3Determination of tannin content

Tannin was estimated according to the method described by Makkar *et al.*(1993).

i. Sample preparation and extraction of tannins

The sample was dried at 55°C and ground to pass through a 1mm sieve. Tannin extraction was done using 400mg of ground sample in a conical flask with 40ml of diethyl ether containning 1% acetic acid (v/v) and mixed to remove the pigment material. The supernatant was carefully discarded after 5minutes and 20ml of 70% aquaeous acetone was added and the flask sealed with cotton plug, covered with aluminium foil and kept in an electrical shaker for 2hours for extraction. It was then filtered through Whatmann No. 1 filter paper and the filtrate was kept in a refrigerator at 4°C until analysis.

ii. Reagents.

- Folin clocalteu reagent (2N) was dilluted with equal volume of distilled water.
- Sodium carbonate (2.5ml).

- Standard tannic acid solution (0.5mg/ml).

iii. Standard calibration curve preparation

From the stock solution of tannic acid (0.5mg/ml), 0, 10, 20, 30, 40 and 50µL was placed in test tubes and their volumes made up to 1ml each. After which 0.5ml of folin clocalteu reagent and 2.5ml of sodium carbonate was added and the whole content of each tube mixed peoperly and after 40minutes, absorbance reading was taken at 725nm in a spectrophotometer.

iv. Method

Fifty microlitres of tannin extracts for each sample wastaken in a test tube and the volume was made up to 1ml with distilled water. Then 0.5ml of Folin clocalteu reagent was added and mixed properly, 2.5ml of sodium carbonate solution was also added, mixed and kept for 40 minutes at room temperature. Absorbance reading was taken at 725nm in the spectrophotometer and the concenterations were obtained from the standard curve. Percentage concenteration of tannin was determined using the expression:

$$\text{Tannin (\%)} = \frac{(An \times C \times Df)}{(As \times W) \times 100}$$

Where,

An = Absorbance value of test sample

As = Absorbance value of standard tannic acid

C = Concenteration of standard tannic acid (mg/ml)

Df = Dilution factor V_{ex}/V_a

W = Weight of test sample (mg)

V_{ex} = Volume of extract

V_a = Volume of extract analysed

3.2.8 Determination of mineral content

Mineral content was determined by the method of AOAC, (2000).

3.2.8.1 Wet digestion of sample

A total of 1g of the powdered sample was taken in digestion glass tube. 12ml of HNO_3 was added to the food samples and the mixture was kept overnight at room temperature. Then 4.0mlof perchloric acid ($HClO_4$) was added to this mixture and kept in the fumes block for digestion. The temperaturewas increased gradually starting from 50°C and increasing it up to 250°C. The digestion was completed in 70- 85 minutes as indicated by the appearance of white fumes. The mixture was left to cool down and the content of the tubes were transferred to 100ml volumetric flasks and the volume of the content was made to 100ml with distilled water. The concentration ofZn, Fe, Ca, Mg, Na and K was read using the flame atomic absorption spectrophotometer (FAAS), AA 500 model.

3.2.8.2 Converting nutrient values from dry to wet basis

The results where converted from dry basis to wet basis using the following formular:

$$\text{Wet basis (mg/100g)} = \frac{DW \times (100 - \%moisture)}{100}$$

Where DW = Dry weight concentration

3.3 SENSORY EVALUATION

The prepared standardized foods were subjected to sensory evaluation according to the method described by Viad (2008). Theevaluation session was carried out by semi-trained panelist consisting of ten members (adults) using 5-points hedonic scale (1-Dislike very much;2 -Dislike; 3 -Neither like nor dislike; 4 -Like; 5-Like very much). The panelist were given sufficient

amount of samples at room temperature in white plastic containers of same size and shape, each panelist was also given a bottle of water to rinse their mouth after tasting each food to prevent carrying over the flavour of one food to another. The evaluation was carried out in a quiet, odour-free and well lighted room maintaining ideal conditions for testing. Each panelist was given a form as shown in Appendix II and asked to evaluate the samples for colour, taste, texture, aroma and overall acceptability.

3.4 STATISTICAL ANALYSIS

Data was analyzed using Statistical Package for the Social Sciences (SPSS), version 20. The results were expressed as mean ± standard deviation except where otherwise stated. The Data was analyzed using descriptive statistics and analysis of variance (ANOVA).Duncan multiple range test was used for multiple mean comparison tests and P values less than 0.05 ($P<0.05$) was taken as significant.

CHAPTER FOUR

4.0 RESULTS

4.1:Pattern ofConsumption of Lima Bean (*Phaseolus lunatus*) Foods in Kaduna State

The pattern of consumption of Lima bean foods in Kaduna State is presented in Table 4.1. The result shows that 54% of the respondents consume Lima bean foodsand those that consume once weekly, monthly and yearly are 11, 24, and 7% respectively.

4.2: Commonly Consumed Lima Beans (*Phaseolus lunatus*) Foods in Kaduna State

Lima bean foods that are commonly consumed in Kaduna State are presented in Table 4.2. It shows the types of foods processed from lima beans with the most preferred being lima bean porridge (35.25%), followed by lima bean-benniseed (8.00%) and lima bean-hungry rice (6.25%).

4.3: Standardized Lima Beans (*Phaseolus lunatus*) Foods in Kaduna State

Three most preferred foods consumed in Kaduna State were standardized as presented in Table 4.3.The table shows the ingredients, quantity of ingredients used, the stepsand time it takes for preparing these foods.

Table4.1:Pattern of Consumption of Lima Bean (*Phaseolus lunatus*) Foods in Kaduna State

Pattern of Consumption		Frequency n=400	Percentage (%)
Household consuming lima bean foods		217	54
Weekly	Once	42	11
	More than once	8	2
Monthly	Once	97	24
	More than once	32	8
Yearly	Once	27	7
	More than once	11	3

Table 4.2: Commonly Consumed Lima Bean (*Phaseolus lunatus*) Foods in Kaduna State.

Lima Bean Foods	Frequency n= 400	Percentage (%)
Lima Bean Porridge	141	35.25
Lima Bean-Rice	1	0.25
Lima Bean-Maize Porridge	13	3.25
Lima Bean-Benniseed	32	8.00
Lima Bean-Hungry rice	25	6.25
Lima Bean-Guinea corn	3	0.75
Lima Bean-Yam	2	0.50

Table4.3: Standardized Lima Bean FoodRecipesin Kaduna State.

Lima bean Porridge Recipe		Lima bean- Hungryrice Recipe		Lima bean-Benniseed Recipe	
Ingredients	**Quantity (n=20)**	**Ingredients**	**Quantity (n=20)**	**Ingredients**	**Quantity (n=20)**
Lima beans (g)	640±0.52	Lima beans (g)	320±5.20	Lima beans(g)	640±0.52
Beef (g)	500±0.81	Hungry rice (g)	330±3.33	Benniseed (g)	201±3.20
Curry (g)	2±0.52	Beef (g)	500±0.94	Beef (g)	500±0.81
Thyme (g)	4±0.94	Curry (g)	4±0.50	Curry (g)	2±0.52
Salt (g)	9±0.38	Thyme (g)	4±0.20	Thyme(g)	4±0.94
Water (ml)	340±0.23	Salt (g)	14±2.40	Salt (g)	9±0.38
Tomatoes (g)	262±0.55	Bouillon cubes	5±1.26	Water (ml)	340±0.23
Onions (g)	272±0.41	Water (ml)	900±2.22	Tomatoes (g)	262±0.55
Palmoil (ml)	400±2.73	Palm oil (ml)	220±3.35	Onions (g)	272±0.41
Red Pepper (g)	37±4.18	Tomatoes (g)	291±1.30	Palm oil (ml)	400±2.73
Bouillon cubes	4±2.07	Onions (g)	251±0.70	Pepper (g)	37±4.18
Groundnut oil (ml)	320±1.11	Pepper (g)	37±4.60	Bouillon cubes	5±0.10
		Groundnut oil (ml)	320±0.40	Groundnut oil (ml)	320±1.11
Preparation		**Preparation**		**Preparation**	
Step 1 Rinsed beans		**Step 1** Cleaned and rinsed hungry rice		**Step 1** Rinsed beans and Par-boiled beans for 1 hour	
Step 2 Par-boiled beans for 1 hour		**Step 2** Par-boiled beans for 1 hour		**Step 2** Seasoned beef with bouillon cubes, thyme, curry, onions, salt and cooked for 40 minutes	
Step 3 Seasoned beef with bouillon cubes, thyme, curry, onions, salt and cooked for 40 minutes		**Step 3** Seasoned beef with curry, thyme, bouillon cubes , onions, salt and cooked for 40 minutes		**Step 3**Drained beans and par-boiled a second time for 20 minutes after which the beans was drained	
Step 4 Drained beans and par-boiled a second time for 20 minutes after which the beans was drained		**Step 4** Drained beans and parboiled a second time for 20 minutes after which the beans was drained		**Step 4**Roasted benniseed for 3 minutes	
Step 5 Poured groundnut oil into frying pan and heated for 2 minutes then fried beef for 15 minutes		**Step 5** Poured groundnut oil into frying pan and heated for 3 minutes then fried beef for 15 minutes		**Step 5** Grinded benniseed	
Step 6 Sliced tomatoes, pepper and onions		**Step 6** Sliced tomatoes, pepper and onions		**Step 6** Poured groundnut oil into frying pan and heat for 2 minutes then put beef into oil and fried for 15 minutes	
Step 7 Poured palmoil into the pot and heated for 2 minutes then added the sliced ingredients and fried for 10 minutes		**Step 7** Poured palmoil into the pot and heated for 2 minutes then added the sliced ingredients and fried for 10 minutes		**Step 7** Sliced tomatoes, pepper and onions	
Step 8 Added 340mls of broth from cooked beef and brought to a boil		**Step 8** Added 900ml of water (beef stock inclusive) and brought to boil		**Step 8** Poured palmoil into the pot and heat for 2 minutes then added the sliced ingredients and fried for 10 minutes	
Step 9 Added beans and allowed to cook 20 minutes		**Step 9** Added beans and hungry rice and cooked for 10 minutes		**Step 9** Added 340mls of broth from cooked beef and brought to a boil	
Step 10 Served beans with fried beef		**Step 10** Served with fried beef		**Step 10** Added beans and allowed to cook for 20 minutes	
				Step 11 Added benniseed to cooked beans and served beans with fried beef.	

Values are mean ± SD.

4.4: Nutrient Composition of the Standardized Commonly Consumed Lima Bean (*Phaseolus lunatus*) Foods in Kaduna State.

4.4.1: Proximate Composition

The proximate composition of standardized lima beans foods is shown in Table 4.4. The result shows that standardized foods hadsignificantly ($P<0.05$) higher moisture and crude fat content than raw lima bean.Lima bean-benniseed food had significantly ($P<0.05$) higher crude fat, crude fibre and ash contents than other foods while lima bean porridge had significantly ($P<0.05$) higher carbohydrate content than lima bean-hungry rice and lima bean-benniseed foods. The protein content of limabean porridge and lima bean-benniseed foods are significantly ($P<0.05$) higher than lima bean-hungry rice food.

4.4.2: Mineral Composition

The mineral composition of standardized lima beans foods is shown in Table 4.5. The result shows that Ca, Mg, K, Fe and Zn content of raw beans was significantly ($P<0.05$) higher than the standardized foods. Lima bean-benniseed foodhad significantly ($P<0.05$) higher content of Ca, Mg, K and Zn than other foods while lima bean porridge food had significantly ($P<0.05$) higher Feand Na content than other food recipes.

4.4.3: Amino Acids Composition

The essential and non-essential amino acids content of standardized lima bean foods is presented in Tables 4.6a and 4.6b The result in Table 4.6a shows that lima bean-benniseed recorded significantly ($P<0.05$) higher content of the essential amino acids leucine (6.97g/100g), lysine (7.10g/100g), methionine (2.60g/100g) and threonine (3.81g/100g) while lima bean-hungryrice

food recorded higher content of isoleucine (4.04g/100g), phenylalanine (4.13g/100g), tryptophan (1.26g/100g), but similar to raw lima bean and lima bean-benniseed in isoleucine content. Glutamic acid (12.94g/100g)and aspartic acid (8.68g/100g) content were higher in lima bean-benniseed food (Table 4.6b).

Table 4.4: Proximate Composition of Standardized Commonly Consumed Lima Bean (*Phaseolus lunatus*) Foods in Kaduna State.

Proximate content (%)	Raw Lima bean	**Lima bean foods**		
		Bean porridge	Bean-hungry rice	Bean-benniseed
Moisture	10.80±0.06[a]	54.28±0.02[b]	67.22±0.02[d]	55.26±0.05[c]
Crude Protein	19.45±0.05[c]	8.30±0.06[b]	4.66±0.04[a]	8.33±0.05[b]
Crude Fat	1.60±0.02[a]	10.61±0.02[c]	8.29±0.00[b]	13.46±0.02[d]
Crude Fibre	6.01±0.01[d]	3.05±0.01[b]	2.25±0.01[a]	4.09±0.02[c]
Ash	4.86±0.05[d]	2.20±0.02[b]	1.58±0.01[a]	2.28±0.02[c]
Carbohydrate	63.29±0.03[d]	24.58±0.05[c]	18.25±0.03[a]	20.70±0.03[b]

Values are mean ± S.D of three determinations(based on wet weight for lima bean foods); abcd= meanvalues with different superscript across the rows are significantly ($P < 0.05$) different.

Table 4.5: Mineral Composition of Standardized Commonly Consumed Lima Bean (*Phaseolus lunatus*) Foodsin Kaduna State.

Mineral Content (mg/100g)	Raw Lima bean	**Lima bean foods**		
		Bean porridge	Bean-hungry rice	Bean-benniseed
Ca	89.00±1.00^{d}	44.58±0.02^{b}	35.26±0.04^{a}	61.40±0.04^{c}
Mg	309.33±0.76^{d}	62.44±0.02^{b}	40.54±0.03^{a}	91.62±0.06^{c}
K	3945.00±5.00^{d}	1016.53±0.50^{b}	544.95±0.42^{a}	1068.52±0.66^{c}
Na	7.25±0.25^{a}	23.88±0.01^{d}	17.45±0.02^{b}	23.25±0.01^{c}
Fe	7.93±0.08^{d}	5.83±0.00^{c}	4.88±0.00^{b}	4.31±0.00^{a}
Zn	1.74±0.01^{d}	0.54±0.00^{b}	0.40±0.00^{a}	0.66±0.00^{c}

Values are mean ± S.D of three determinations (based on wet weight for lima bean foods); abcd= mean values with different superscript across the rows are significantly ($P < 0.05$) different.

Table 4.6a:Essential Amino Acid Composition of Standardized Commonly Consumed Lima Bean (*Phaseolus lunatus*) Foodsin Kaduna State.

Amino acid (g/100g)	Raw Lima bean	**Lima bean Foods**		
		Bean porridge	Bean-hungry rice	Bean-benniseed
Leucine	6.66±0.06^{c}	6.29±0.11^{b}	6.09±0.10^{a}	6.97±0.02^{d}
Lysine	6.97±0.13^{b}	7.05±0.00^{b}	5.51±0.15^{a}	7.10±0.28^{b}
Isoleucine	4.00±0.06^{b}	3.63±0.03^{a}	4.04±0.05^{b}	4.02±0.09^{b}
Phenylalanine	3.74±0.02^{b}	3.93±0.03^{c}	4.13±0.05^{d}	3.52±0.03^{a}
Tryptophan	0.97±0.00^{b}	1.01±0.04^{b}	1.26±0.10^{c}	0.67±0.01^{a}
Valine	3.90±0.10^{a}	4.30±0.00^{b}	4.04±0.05^{a}	4.02±0.13^{a}
Methionine	0.88±0.03^{a}	1.09±0.03^{b}	0.82±0.02^{a}	2.60±0.20^{c}
Histidine	3.34±0.06^{c}	3.27±0.07^{c}	2.83±0.15^{a}	3.08±0.05^{b}
Threonine	3.52±0.10^{c}	2.93±0.10^{a}	3.31±0.10^{b}	3.81±0.11^{d}

Values are mean ± S.D of two determinations; abcd= mean values with different superscript across the rows are significantly ($P < 0.05$) different.

Table 4.6b: Non-Essential Amino Acid Composition of Standardized Commonly Consumed Lima Bean (*Phaseolus lunatus*) Foods in Kaduna State.

Amino acid (g/100g)	Raw Lima bean	**Lima bean Foods**		
		Bean porridge	Bean-hungry rice	Bean-benniseed
Proline	3.44±0.02^{c}	3.01±0.04^{b}	2.94±0.10^{b}	2.84±0.01^{a}
Arginine	5.51±0.00^{ab}	5.65±0.04^{a}	5.87±0.15^{b}	5.46±0.05^{a}
Tyrosine	3.11±0.01^{a}	3.26±0.01^{b}	3.15±0.05^{a}	3.45±0.01^{c}
Cysteine	1.51±0.01^{c}	1.33±0.01^{b}	1.29±0.10^{b}	0.92±0.01^{a}
Alanine	3.46±0.05^{a}	3.99±0.01^{c}	3.69±0.10^{b}	4.54±0.09^{d}
Glutamic acid	12.61±0.04^{b}	12.70±0.53^{b}	11.40±0.05^{a}	12.94±0.09^{b}
Glycine	3.22±0.03^{a}	3.67±0.04^{b}	4.26±0.15^{c}	3.56±0.00^{b}
Serine	4.25±0.04^{d}	3.68±0.11^{b}	3.14±0.05^{a}	3.94±0.04^{c}
Aspartic acid	8.55±0.14^{b}	7.66±0.19^{a}	7.64±0.10^{a}	8.68±0.00^{b}

Values are mean ± S.D of two determinations; abcd= mean values with different superscript across the rows are significantly ($P < 0.05$) different.

4.5: Antinutrient Content of Standardized Commonly Consumed Lima Bean (*Phaseolus lunatus*) Foodsin Kaduna State.

Antinutrient content of commonly consumed standardized lima bean foods is shown in Table 4.7.The result shows that the three standardized recipes hadsignificantly ($P<0.05$) lower levels of cyanide, tannin and phytate than raw lima bean;Lima bean-hungry rice food had significantly ($P<0.05$) lowercontent of tannin than other foods.

4.6: Sensory Attributes of Standardized Commonly Consumed Lima Bean (*Phaseolus lunatus*) Foods in Kaduna State.

The result of sensory evaluation of standardized lima bean foods is presented in Table 4.8.The result shows that lima bean-hungry rice food had higher values for all the sensory attributes while lima bean-benniseed food had significant ($P<0.05$) lower values for colour, taste, aroma and overall acceptability. The aroma and overall acceptability of lima bean porridge was not significantly ($P<0.05$) different from lima bean-hungry rice food.

Table 4.7: Antinutrient Content of Standardized Commonly Consumed Lima Bean (*Phaseolus lunatus*) Foods in Kaduna State.

Antinutrient content (mg/100g)	Raw Lima bean	**Lima Beans Foods**		
		Bean porridge	Bean-hungry rice	Bean-benniseed
Tannin	12.75±0.0^{c}	4.15±0.21^{a}	3.83±0.35^{d}	6.00±0.28^{b}
Phytate	4.88±0.00^{d}	2.93±0.04^{c}	2.20±0.04^{a}	2.59±0.04^{b}
Cyanide	1.15±0.08^{d}	0.29±0.02^{b}	0.43±0.04^{c}	0.14±0.01^{a}

Values are mean ± S.D of three determinations (based on wet weight for lima bean foods); abcd= mean values with different superscript across the rows are significantly ($P < 0.05$) different.

Table 4.8: Sensory Attributes of Standardized Commonly Consumed Lima Bean (*Phaseolus lunatus*) Foods in Kaduna State.

Lima Bean Foods	Colour	Taste	Texture	Aroma	Overall Acceptability
Bean porridge	4.30±0.21^{b}	4.30±0.21^{b}	3.70±0.33^{a}	4.00±0.26^{ab}	4.20±0.29^{ab}
Bean-hungry rice	4.40±0.16^{b}	4.50±0.17^{b}	4.10±0.23^{a}	4.20±0.25^{b}	4.60±0.16^{b}
Bean-benniseed	2.90±0.48^{a}	3.00±0.45^{a}	3.10±0.41^{a}	3.10±0.43^{a}	3.50±0.52^{a}

Means within the same column with different superscripts are significantly ($P < 0.05$) different.
Hedonic Scale: 1-Dislike very much; 2- Dislike; 3- Neither like nor dislike; 4- Like; 5-Like very much

CHAPTER FIVE

5.0 DISCUSSION

Legumes are commonly consumed throughout the world because these economical foods have the potential to improve diet quality and long-term health of those who consume them regularly (Garden-Robinson, 2013). Lima beans have a lot of nutritional potentials and could easily be utilized in many food recipes (Obiakor-Okeke, 2014). The utilization of benniseed and hungry rice in the preparation of lima beans recipe as elucidated in this research is an added advantage to combating malnutrition. Benniseed is an oilseed with significant amount of macronutrients and important minerals with the potassium concentration being the highest while hungry rice provides major dietary component such as protein, crude fat, carbohydrate and essential minerals that compares favourably with other cereals (Robert *et al.*, 2013).The use of plant foods are being encouraged as a means of dietary diversification in combating micronutrient deficiencies (Bamigboye and Adepoju, 2015).

The consumption pattern, taste and ease of cookinglima beanswere also compared with cowpea in this research as shown in Appendix V. The result shows that more people consume cowpea foods because it's easier to cook than lima bean foods,however,most respondents agreed that the taste of lima bean foods is betterthan the taste of cowpea foods.This indicates that the hard-to-cook nature of lima beans limits its consumption despite its taste; therefore, employing faster, cost effectiveprocessing or cooking methods could help to increase the consumption of these beans.

The values of the proximate composition of raw lima beans were in line with the values of some lima beans varieties that have been reported in literature (Obiakor-Okeke, 2014). The moisture

content of the raw beans is lower thanthat of the prepared foods, this may be the basis for its long shelf life and less susceptibility to microbial attack during storage. The increased moisture content (67%) in lima bean-hungry rice suggests that it would not have longer shelf-life compared to the other lima beans foods since the higher the moisture content of a food, the lower its shelf-life as commonly observed with processed foods.Processing of raw lima beans into lima bean foods resulted in significant reduction of nutrient values except for crude fat. The observed reduction in nutrient value is believed to be due to increase in moisture content of the prepared foods because some nutrients leach out into the cooking water. This makes it important for cooking liquid to be consumed whenever possible.Percentage lost of nutrients may also depend partly on destruction of the nutrients by heat and chemical changes such as oxidation (FAO,1990). The increase in crude fat is due to addition of palm oil during recipe preparation which has a total fat value of 153% and about 50% saturated fatty acids (Imoisi *et al.,* 2015). Lima bean-benniseed and lima bean porridge foods can serve as good sources of plant protein since they recorded higher protein content. This justifies their use as a source of cheap protein especially amongst poor populace in Nigeria who consume less of animal protein (Bamigboye and Adepoju, 2015).

Crude fat content is higher inlima bean-benniseed food at 13.46%; this is due to the high fat content (49.51%) of raw benniseed as reported by Adegunwa *et al.*(2012) compared with raw hungry rice and lima beans.Crude fibre content (4.09%) and ash content(2.28%) of lima bean-benniseed food were also higher than other foods which could be an added advantage to the functioning of the digestive system and help in decreasing the risk for developing coronary heart disease and hypertension (Oboh and Omofoma, 2008).The carbohydrate content of all the standardized foods can serve as a major source of energy for the body since carbohydrates are

the body's preferred fuel source. The high ash content for bean-benniseed food provides a measure of the mineral content of these foods (Awogbenja and Ugwuona, 2012).Minerals are inorganic nutrients that are required by the body in small amount and are necessary for the maintenance of certain chemical processes which are essential to life.The values of minerals obtained were in line with results obtained for two cultivars ofbeans as reported by (Bamigboye and Adepoju, 2015). Lima bean-benniseed foodhad higher content of K (1068.52mg/100g). Potassium(K) was the most predominant mineral observed which is in agreement with several reports according toSeidu *et al.*(2014)that potassium is the most predominant mineral element in Nigerian agricultural products. The high potassium content (1068.52 mg/100g) and low Na content (23.25mg/100g)of lima bean-benniseed food could be advantageous in reducing high blood pressuresince the Na/K ratio in the body is important in the prevention and management of high blood pressure. Calcium is essential in bone formation; the high calcium content of this food could serve as a good complementary food for infants.Lima bean porridge food recorded higher iron (Fe) content (5.83mg/100). Iron requirement in the body vary with age and gender, more iron is required during pregnancy, menstruation and growth (Forman, 2008). These foods could serve as an additional source of dietary iron.

Phytic acids are known to interfere with calcium, zinc, magnesium and iron utilization by forming insoluble complexes with these mineral elements (Adegunwa *et al.,* 2012). The amount of cyanide ranged from 0.14mg/100g in bean-benniseed recipe to 1.15mg/100g in the raw sample. The observed result shows that there was a reduction in cyanide content in the standardized foods when compared to raw lima beans. Reduction of cyanide especially in lima bean-benniseed could be as a result of roasting of the benniseed during food preparation which is in accordance with Adegunwa *et al.*(2012) report which elucidated that roasting leads to more

reduction in cyanide content of benniseed compared to other thermal treatments.Low levels of phytate and tannins were reported to lower serum cholesterol (Madukwe *et al.,* 2013). Lima bean-hungry rice with the least phytate content (2.20mg/100g) and lima bean porridge with the least tannin (4.15mg/100g) content could contribute to lowering of cholesterol level in the body.

Amino acids are building blocks of proteins, nine essential amino acids must be provided in the diet. The nutritional value or protein quality of a food depends on its essential amino acid content. This study shows that lima bean-hungry rice food has significantly higher content of isoleucine (4.04g/100g), phenylalanine (4.13g/100g), tryptophan (1.26g/100g), and arginine (5.87g/100g) than the other standardized foods.Histidine, isoleucine and valine values of all the foods in this study were higher when compared to FAO/WHO (1991) (Appendix VI) requirements for children 2-5 years old except for phenylalanine.Leucine, lysine, threonine and methionine content (6.97g/100g, 7.10 g/100g, 3.81g/100g and 2.60g/100g respectively) were higher in lima bean-benniseed food while valine and histidine (4.30g/100g and 3.27 g/100g respectively) content were higher for lima bean porridge food. Lysine is a limiting amino acid in most cereals, it is (0.147g/100g) in hungry riceas reported by Robert *et al.*(2013)and(1.55g/100g) in guinea corn/millet pap (Anigo *et al.,* 2009), lysine value (6.97g/100g) in this studymakes lima beans a good combination for cereal based diet.Glutamic and aspartic acids are most abundant non-essential amino acids in raw lima beans (12.61g/100g and 8.55 g/100g respectively) and the three standardized foods. This is not surprising as most seed proteins have high glutamic and aspartic acids content with limited methionine content (Ezeagu and Ibegbu, 2010). Methionine was observed to be limited in all the standardized foods and the chemical score of the foodswere calculated in order to reveal their protein quality. Lima bean-benniseed food had a chemical score of (100) for the limiting amino acid (methionine) which was higher than the scores for lima

bean-hungry rice (32), lima beans porridge (42) and raw lima beans (34).Generally, the three foods exhibited high amounts of essential amino acids which makes them potential source of high quality protein.

Lima bean-hungry rice food is the most acceptable in terms of colour, texture, taste, aroma and overall acceptabilitywhich could possibly be due to hungry rice fine texture and taste as reported by Robert *et al.* (2013).The colour, taste, texture, aroma and overall acceptability of lima bean porridge is not too different from that of lima beans-hungry rice food which is not supprising because of the soft texture and buttery taste of lima beans (Obiakor, 2009).The least acceptable in terms of all the sensory attributes was bean-benniseed foodwhich could be attributed to roasting of benniseed during recipe preparation and the black coloured variety of benniseed used.

This study revealed that females were the major caregivers in households; this is not surprising because most women bear the primary responsibility for health and survival of young children (IFAD, 2012). Therefore increasing dietary diversification towards lima beans to help in curbing malnutrition and planning diets for people suffering from diseases such as diabetes and high blood pressure could be realized by using women as channels to achieve optimum fetal, child nutrition and development.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

This study has shown that 54% of the household in Kaduna State consume lima bean foods, however only 13% of the population consumes the lima bean foods weekly. Lima bean-benniseed food with the best nutrient profile and highest chemical score is only consumed by 8% of the population. It also suggests that the standardized foods from lima beans possess good nutritional profile to combat malnutrition and its debilitating effects.

6.2 RECOMMENDATIONS

In view of the findings in this study, it is recommended that;

i. Development of extension messages from the research finding should be done to increase the awareness of lima bean foods as important sources of nutrient and its inclusion in preparation of complementary foods for children 6-23 months to combat ravaging malnutrition in our communities.
ii. Studies should be carried out to determine the bioavailability of nutrients from these recipes.
iii. New recipes using lima beans should be developed to increase dietary diversification.

REFERENCES

Adam, D. (2005). Concept of a Nutritious food: toward a Nutrient Density Score. *TheAmerican Journal of Clinical Nutrition*,**82**:721-32.

Adebayo, S.F. (2014). Effect of Soaking time on the Proximate, Mineral Compositions and Antinutritional factors of Lima bean. *Journal of Food Science and Quality Management*,**27**:2224 - 6088.

Adegbehingbe, K.T. (2013). Microbiological and Nutrient studies of fermented cooked Lima bean (*Phaseolus lunatus*) seeds. *Global Journal of Biology, Agriculture & Health Scinces*, **2**(2): 94-101.

Adegbehingbe, K.T. (2014). Effects of fermentation on Nutrient Composition and Antinutrient contents of ground Lima bean seeds fermented with *Aspergillus fumigatus*, *Rhizopus stolonifera* and *Saccharomyces cerevisiae*. *International Journal of Advanced Research*, **2**(7):1208-1215.

Adegunwa,M.O.,Adebowale, A.A. and Salaro, E.O. (2012). Effect of Thermal processing on the Biochemical Composition, Antinutritional factors and functional properties of Beniseed (*Sesamum indicum*) flour.*American Journal of Biochemistry and molecular Biology*,**2**(3): 175-182.

Akande , K.E. and Fabiyi E.F. (2010). Effect of Processing Methods on some Antinutritional factors in Legume seeds for Poultry feeding. *International Journal of Poultry Science*, **9**(10):996-1001.

AlbertStephen. (2016). *How to grow lima beans.* Retrieved March 26, 2016, from http://www.harvesttotable.com/2009/03/how-to-grow-lima-beans/

Alessandro, M. D. K., Henry, B., Flaminio, F., Ratko, B. and Aulikki, N. (1999). Food intake Patterns and 25 years Mortality from Coronary Heart disease: Cross-cultural correlations in the seven countries study. *European Journal of Epidemiology*, **15**:507-515.

Allen,L.H., De Benoist, B.,Dary, O. and Hurrell, R.(2006). *Guidelines on Food Fortification with Micronutrients.* Retrieved from http://apps.who.int//iris/handle/10665/43412.

Alonso, R.,Aguirre,A. and Marzo,F. (2000). Effects of Extrusion and Traditional Processing Methods on Antinutrients and Invitro Digestibility of Protein and Starch in Faba and Kidney beans. *Journal of Food Chemistry*,**68**:159–165.

Ani, D.P., Umeh, J.C. and Waye, E.A. (2014). Economic Benefits of Food Legume Cultivation in Benue State-Nigeria. *Asian Journal of Agriculture Extension, Economy & Sociology*, **3**(6): 654-665.

Anigo, K.M., Ameh, D.A., Ibrahim S. and Danbauchi S.S. (2009). Nutrient Composition of Commonly used Complementary Foods in North Western Nigeria.*African Journal of Biotechnology*, 8(17) 4211-4216. Retrieved from http://www.academicjournals.org/AJB

Association of Organic and Analytical Chemistry (2000). *Official Methods of Analysis of AOAC International* (17thed.). Gaithersburg, MD, USA: AOAC.

Association of Organic and Analytical Chemistry (2006). *Official Methods of Analysis of AOAC International* Washington DC., USA: AOAC.

Apata, D.F. and Ologhobo, A.D. (1994)a. Biochemical Evaluation of some Nigerian Legume seeds.*Journal of Food Chemistry*, **49**:333-338.

Apata, D.F. and Ologhobo, A.D. (1994)b. Proximate Composition of some Nutritionally valuable Minerals and Functional properties of three varieties of Lima beans(*Phaseolus lunatus L.*) flour . *International Journal of Food Science and Nutrition*, **43**:181-191.

Awogbenja, M.D. and Ugwuona, F.U. (2012). Nutrient and Phytochemical Composition of some commonly consumed Traditional Dishes of Nasarawa State, Nigeria.*Journal ofProduction Agriculture and Technology*, **8**(1):30-39.

Bamigboye, A. Y. and Adepoju, O. T. (2015). Effects of Processing Methods on Nutritive Values of Ekuru from two Cultivars of beans (*Vigna unguiculata* and *Vigna angustifoliata*). *African Journal of Biotechnology*, **14**(21): 1790-1795.

Bazzaro, L.A., He J., Ogden, L.G., Loria, C.M. and Whelton, P.K. (2003). Dietary Fiber intake and US men and women: the National Health and Nutrition Examination Survey 1 Epidemiologic Follow-up study. *American International Journal of Medicine*, **163**:1897-1904.

Bean Institute (2016). *Beans and Cancer*. Retrieved June, 2016, from http://beaninstitute.com/beans-cancer/

Benitez, L.V.(1989). Amino acid and fatty acid profiles in aquaculture nutrition studies, In: S.S.Desilva (Ed). Fish Nutrition Research in Asia. Proceeding of the third Asian fish Nutrition Network meeting. *Asian Fish Society special Publication***4**:166

Bhandari, S. and Megha, R. B. (2014). *Micronutrients Deficiency, a Hidden Hunger in Nepal: Prevalence, Causes, Consequences and Solutions.* Retrieved from https://hindawi.com/journals/isrn/2015/276469/

Black, R.E., Allen, L.H., Bhutta Z.A., Caulfield L.E., De Onis, M., Ezzati, M.,…Rivera J. (2008). *Maternal and Child Undernutrition: global and regional exposures and health consequences.* Retrieved from http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(07)61690-0/abstract

Black, R.E. (2010). The Lancet *Maternal and Child Nutrition Series* [Executive Summary].Retrieved from http//.www.GlobalNutritionSeries.org.

Borgen, H. (2010). *Food, Nutrition and Health:Child Undernutrition in the Far-West Terai of Nepal* (Master's thesis). Akershus University College Retrieved from https://oda.hio.no/jspui/bitstream/10642/722/1/maeh_10_borgen.pdf

Brain, T. and Leslie, A. (2011).*Combating Micronutrient Deficiencies: Food-based Approaches.* Available from http://www.fao.org/3/a-am027e/am027e.pdf

Burchi, F. Jessica, F. and Emile, F. (2011). The Role of Food and Nutrition System Approaches in Tackling Hidden Hunger. *International Journal of Environmental Resources and Public Health*,**8**(2): 358-373.

Chukwu, O. and Abdulkadir, A.J. (2008). Proximate Chemical Composition of Acha (*Digitaria exilis* and *Digitaria iburua*) Grains. *Journal of Food Technology*, **6**(5): 214-216.

Contento, R.I. (2008). Nutrition Education: Linking Research, Theory, and Practice. *Asia Pac Journal of Clinical Nutrition* **17**(1): 176-179.

Cuilin, Z., Simin, L., Caren, G. S. and Frank, B. H. (2014). *Dietary fiber intake, Dietary Glycemic load, and the Risk for Gestational Diabetes Mellitus*. Retrieved May, 23, 2016, from http://www.care.diabetesjournals.org/content/29/10/2223.full.

Czaja, R. (2005). Sampling with Probability Proportional to Size. Encyclopedia of Biostatistics, P7.

Daniel, O. K. (2015). *Determination of Compositional Characteristics, Functional Properties and Cluster Analysis of Lima bean Accessions* (*Phaseolus lunatus*). (M.Sc thesis). Kwame Nkrumah University, Kumasi, Ghana. Retrieved from http://dspace.knust.edu.gh/bitstream/123456789/7521/1/DANIEL%20OWUSU%20KYEREMATENG.pdf

David, B.A., Gwendolyne, P.M., Yolanda, M.O., and Sonia, F.B., (2004). Physicochemical Characterization of Lima bean (*Phaseolus lunatus*) and Jack bean (*Canavalia ensiformis*) Fibrous residues. *Journal of Food Chemistry*, **84**:287-295.

David, R. and Jacobs, Jr. (2012). Challenges in Research in Nutritional Epidemiology:Strategies for Disease Prevention. *Journal of Nutritional Health,* **2**:29- 40.

Darbie, M.G., William, T.C. and George B. (2016). *Lima Beans: Commercial Vegetable production.* Retrieved March, 26, 2016 from http://www.agrisk.umn.edu/cache/ARL01959.html

Egounlety, M. and Aworh, O. C. (2003). Effect of Soaking, Dehulling, Cooking and Fermentation with *Rhizopus oligosporus* on the Oligosaccharides, Trypsin inhibitor, Phytic acid and Tannins of Soybean (*Glycine max Merr.*), Cowpea (*Vigna unguiculata L. Walp*) and Groundbean (*Macrotyloma geocarpa Harms*). *Journal of Food Engineering*,**56**:249–254.

Ensminger, A.H. and Esminger, M.E. (1999). Food for Health: A Nutrition Encyclopedia Clovis.*European Journal of Epidemiology*,**15**(6):507-15.

Ezeagu, I. E. and Ibegbu, D. (2010). Biochemical Composition and Nutritional Potential of Ukpa: A Variety of Tropical Lima beans (*Phaseolus lunatus*) from Nigeria.*PolishJournal of Food and Nutrition Science*,**60**(3):231-235.

Fanzo, J. (2012). The Nutrition Challenge in Sub-saharan Africa. Working Paper United Nations Development Programme. *Journal of Nutrition and Food science*,**2**:10. Retrieved fromhttp://dx.doi.org/10.4172/2155-9600.1000170

Federal Ministry for Economic Cooperation and Development. (2012). *Supplementation, Food Fortification and Dietary Diversification: A three-pronged approach to reducing hidden hunger*. Retrieved from https://www.bmz.de/en/zentrales_downloadarchiv/themen_und_schwerpunkte/ernaehrung/food_fortification.pdf

Federal Ministry of Health, Nigeria. (2013).*Malnutrition*: *Nigeria's silent crisis*. Retrieved from http://www.prb.org/pdf15/renew-nigeria-key-messages.pdf

Food and Agriculture Organization of the United Nations. (1990).*Roots, Tubers, Plantains and Bananas in Human Nutrition.* Effects of Processing on Nutrition Value. Available from http://www.fao.org/dorcep/207e/To207E07.htm

Food and Agriculture Organization of the United Nations/World Health Organization. (1991).*Protein Quality Evaluation, Report of a joint FAO/WHO Expert Consultation Rome:* Food and Nutrition Paper. **15** Available from http://apps.who.int/iris/bitstream/10665/38133/1/9251030979_eng.pdf

Food and Agriculture Organization/ World Health Organization/United Nations. (2007). WHO Protein and Amino acid Requirements in Human Nutrition , Report of a joint FAO/WHO/UNU Expert Consultation.Technical Report Series 935.

Food and Agriculture Organization. (2011).*Dietary Protein Quality Evaluation in Human Nutrition.* Available from http://www.fao.org/ag/humannutrition/35978-02317b979a686a57aa4593304ffc17f06.pdf

Forman, A. (2008). Foods with more for less: rich in nutrients, low in calories. *Journal of Environmental Nutrition*, **31**(10):22-25

Garden and Flowers (n.d.). Retrieved March, 14, 2016, from http://www.gardenandflowers.com/about6499118history-lima-beans-plants.html.

Garden-Robinson, J. (2013). *All about Beans Nutrition, Health benefits, preparation and use in menus*. Retrieved from https://www.ag.ndsu.edu/publications/food-nutrition/all-about-beans-nutrition-health-benefits-preparation-and-use-in-menus/fs1643-all-about-beans.pdf

Gashaw, G. (2010). *Effects of Traditional Food Processing Methods on Nutrient Compositions and Anti-nutritional factors of Grass pea(Lathyrus sativusL.) Foods Consumed in Ethiopia*. (M.Sc thesisin Food Science and Nurition). Addis Ababa University, Ethiopia.

Geoffrey, R. H., Enrique B., Roberto C., Jacqueline C., Jacques E., Richard P. G., …Zheng S. (1992). Dietary Intake of Fiber and decreased risk of Cancers of the Colon and Rectum: Evidence from the Combined Analysis of 13 case-control studies. *Journal of the National Cancer Institute*, **84**(24): 50-60.

George Mateljan Foundation. (2016).*Lima Beans In-depth nutrient profile*. Retrieved April 4,2016, fromhttp://www.whfoods.com/genpage.php?tname=foodspice&dbid=59

Hedwig. A., Wilma, H. Oldewage.T.and Abdulkadir, A. E. (2012). Dietary Diversity, Micronutrient intake and their variation among black women in informal settlements in South Africa.*International journal of Nutrition and metabolism*, **4**(2):24-39.

Hemraj, N., Patil. P. and Rajeshree P. (2014). The study on effects of standardized recipes of bakery products in pure region. *International Journal of Multidisciplinary Consortium*, **1**(3):42-50.

How to grow lima beans (n.d.). Retrieved March, 26, 2016, from http://www.gardeninblog.net/how-to-grow/lima-beans/

Imoisi, O. B., Ilori, G. E., Agho, I. and Ekhator, J. O. (2015). Palm oil, its nutritional and Health implications. *Journal of Applied Science and Environment*, **19**(1): 127-133

Integrated Taxonomic Information System (2015). *Phaseolus lunatus L*. Retrieved (April 15, 2016), from the Integrated Taxonomic Information Systen on-line database http:www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN & search_value=26850

Internatiional Fund for Agricultural Development (IFAD)(2012).*Enabling poor rural poor to overcome poverty: Gender Equality and Women's Empowerment*. Retrieved from https://www.ifad.org/documents/10180/5bcb54e2-96d1-4e95-932b-d7ad9761f972

James, R. (2015). *What you should know about diabetes and beans.* Retrieved April, 30, 2016, from http://www.healthline.com/health/diabetes/beans

Kaduna State [Map] (2010). Retrieved Fromhttp://www.nigerianmuse.com/20100527092749zg/sections/pictures-mapscartoons/maps-of-various-states-and-their-local-governments-in-nigeria/

Labaneiah, M.E.O., and Luh B.S. (1981). Changes of Starch, Crude fibre, and Oligosaccharides in Germinating dry beans. *Journal of Cereal Chemistry*,**58**: 135- 138.

Lucas, G.M. and Markakas, P. (1975). Phytic acid and other Phosphorus Compounds of Bean (*Phaseolus vulgaris*). *Journal of Agriculture and Education Chemistry***23**: 13- 15.

Madukwe, E. U., Edeh, R. I. and Obizoba, I. O. (2013). Nutrient and Organoleptic Evaluation of Cereal and Legume based Cookies. *Pakistan Journal of Nutrition***, 12**(2): 154-157.

Makkar, H.P.S., Blummel, M., Borowy, N.K. and Becker, K. (1993). Gravimetric Determination of Tannins and their Correlations with Chemical and Protein Precipitation Methods. *Journal of Science and food Agriculture*,**61**: 161- 165.

Maternal and Child Nutrition Series. (2013). *The Lancet Executive Summary*. Retrieved March, 26, 2016, fromhttp://www.thelancet.com/pb/assets/raw/Lancet/stories/series/nutrition-eng.pdf

Mclntosh M, and Miller C. (2001). A Diet containing food rich in Soluble and Insoluble fiber improves Glycemic control and reduces Hyperlipidemia among patients with type 2 diabetes mellitus. *Nutrition Review*,**59**(2):52-5.

Menotti, A., Kromhout, D., Blackburn, H., Fidanza, F., Buzina, R. and Nissinen, A. (1999). Food Intake Patterns and 25 years Mortality from Coronary Heart Disease: Cross-cultured Correlations in the Seven countries study.*European Journal of Epidemiology*, **15**(6):507-15.

Mercedes, M., Carmen, B., Gemma, A., Mercedes, M. and Pedrosa, C. C. (1999). The Investigation of Antinutritional factors in *Phaseolus vulgaris*. Environment and varietal differences.*Journal ofBiotechnology,Agronomy Social Practice and Environment*, **3**(4): 210-216

Moses, O., Olawuni, I. and Iwouno, J. (2012). The Proximate Composition and Functional Properties of Full Fat flour and Protein Isolate of Lima Beans (*Phaseolus lunatus*). *Open Access Scientific Reports***1**(7):349-355.

Nakitto, M. A., Muyonga, H. J. and Nakimbugwe D. (2014) Effects of Combined Traditional Processing Methods on the Nutritional Quality of Beans.*Journal ofFood Science and Nutriton*, 3(3): 233-41.

National Nutrition and Health Survey. (2015). *2015 Report on the Nutrition and Health situation of Nigeria*. Retrieved from https://www.unicef.org/nigeria/NNHS2015_Final.pdf

National Population Commission. (2006). *Data for National Development*. Retrieved from http://www.population.gov.ng/index.php/censuses

Nutrition Fact? (2016)(*Lima Beans*) (n.d.) Retrieved April, 30, 2016, from http://www.nutrition-and-you.com/lima-beans.

Obiakor, P. N. (2009). *Effects of Processing Techniques on Chemical, Functional and Microbial Properties of Two Varieties of Lima Bean (Phaseolus lunatus) and Maize(Zea mays) flours and Sensory Properties of their Products*. (Ph.D thesis). University of Nigeria, Nsukka. Retrieved from http://repository.unn.edu.ng:8080/jspui/bitstream/123456789/1375/1/OBIAKOR,%20PHILOMENA%20NGOZI.pdf

Obiakor-Okeke, P.N. (2014). Comparative evaluation of Chemical and Functional Properties of some Lima Bean varieties (*Phaseolus lunatus*) Consumed in Arondizuogu, Imo State, Nigeria. *Journal of food and Nutrition Sciences*, **2**(4):168-172.

Oboh, H.A. and Omofoma, C.O. (2008). The Effects of Heat Treated Lima Beans (*Phaseoluslunatus*) on Plasma lipids in Hypercholesterolemic rats. *Pakistan Journal of Nutrition***7**(5):636-639.

Oboh, H.A., Muzquiz, M., Burbano, C., Cuadrado, C., Pedrosa, M.M. , Ayet, G. and Osagie, A.U.(2000). Effect of Soaking, Cooking and Germination on the Oligosaccharide content of selected Nigerian Legume seeds. Plant *foods for Human Nutrition***55**: 97-110.

Oduntan, A.O., Olaleye, O., Akinwande, B.A. (2012). Effect of Plant maturity on the Proximate Composition of *Sesamum radiatum* Schum leaves. *Journal of food studies*, **1**(1): 2166-1073

Oguntona, C. R. B., Odunmbaku, A. J. and Ottun, O. B. (1999). Proximate Composition of Ten Standardized Nigerian Dishes. *Journal of Nutrition and Food Science*, **99**(6): 8-23.

Ojo, R. J., Segilola, L. I., Ogundele, O. M., Akintayo, C. O. and Seriki, S. (2013). Biochemical Evalution of Lima Beans (*Phaseolus lunatus*) in Alloxan Induced Diabetic Rats. *Journal of Agricultural and Biological Science*, **8**(4): 10- 30

Olayiwola, I.O., Folaranmi, F., Adebowale, A., Onabanjo, O.O., Sanni, S.A. and Afolabi W.A.O. (2012). Nutritional Composition and Sensory Qualities of Cocoyam-based Recipes Enriched with Cowpea Flour. *Journal of Nutrition and food science*, **2**(10): 10-16

Onwuka, G., (Ed.). (2005). *Food Analysis and Instrumentation*. Nigeria: Naphohla prints.

Osagie, A.U., Muzquiz, M., Burbano, C., Cuadrado, C., Ayet, G. and Castano A. (1996) Antinutritional Constituents of Ten Staple Foods grown in Nigeria. *Journal of Tropical Science*, **36**:109-115.

Osborne, D.R., and Voogt, P.(Eds.).(1978). *Calculation of Caloric value: The Analysis of Nutrients in foods.*New York: Academic Press.

Phaseolus lunatus seeds (image). Retrieved from http://www.tes.com/lessons/_GP4AGBniCvI0Q/seeds

Pramil, N. S. and Gay, E.F. (2015). *Dietary risk factors for colon cancer in a low-risk population.* Retrieved June, 08, 2016, from http://www.aje.oxfordjournals.org/content/148/8/761

Programming for Nutrition outcomes-optional Session7- Food Based Strategies for Enhanced Nutritional Status. Dietary Diversification and Biofortification. (2012). Retrieved April 30,2015,fromhttp://ble.Ishtm.ac.uk/phiginfile.php/20037/modresource/content/9/OER/PN0101/sessions/S1S7/PN0101-S1S7-030-040html

Raihanatu, M.B., Modu, S., Falmata, A.S., Shetima, Y.A. and Heman M. (2011). Effects of Processing (Sprouting and Fermentation) of Five local varieties of Sorghum on some Biochemical parameter**.** *Nigerian Society for Experimental Biology.* **23**(2): 91-96.

Recipe Standardization Process (n.d.). Retrived December, 12, 2015, from http://www.nfsmi.org/documentlibraryfiles/PDF/20080215091404.pdf.

Remi, S. A. and Oloruntoyin, M. B. (2007). Evaluation and Heritability Studies of Local Lima Bean (*Phaseolus lunatus L·*) Cultivars from South-West Nigeria. *Revista UDO Agricola*, **7**(1): 22-28.

Robert E. B. (2013). Malnutrition and Child Undernutrition and Overweight in low-income and middle–income countries. *Lancet Series*, **382** (9890): 427-51.

Robert, H.G., Emmanuel, P. L., Jack, M. P., John, S., Ronnee, A., Yuan-Chen, W., … Lu-Te C. (2013). Fatty acid, Amino Acid, Mineral and Antioxidant Contents of Acha (*Digitaria*

exilis) grown on the Jos Plateau, Nigeria.*International Journal of Nutrition and Metabolism*, **5**(1): 1-8.

Ruel, M.T. (Ed.). (2003). *Diet Quality and Diet Changes of the Poor: a global research program to improve dietry quality, health and nutrition*. Washington DC: IFPRI.

Sanchez-mata, M.C., Periuela-Teruel, M.J., Camara-Hurtado, M., Diez- Marques, C., and Torija-Isass, M.E. (1998). Determination of Mono- Di-, and Oligosaccharides in Legumes by High Performance Liquid Chromatography using an Amino-bonded silica column. *Journal of Agriculture and Food chemistry*.**46**:3648-3652.

Seidu, K. T., Osundahunsi, O. F., Olaleye, M. T. and Oluwalana, I. B. (2014). Chemical Composition, Phytochemical Constituents and Antioxidant Potentials of Lima Bean seeds coat. *Annals of Food Science and Technology*,**15**(2) :288 – 298.

Shiv, K. R. and Lalan K. (2010). Evaluation of Quality Characteristics of Soy based Millet Biscuits. *Advances in Applied Science Research*, **1**(3): 187-196.

Soetan, K.O. (2008). Pharmacological and Other Beneficial Effects of Anti-nutritional Factors in Plants. *African Journal of Biotechnology*,**7**(25): 4713-4721.

Stone, H and Sidel, J.L. (Eds.). (1993). *Sensory Evaluation Practices.* San Diego: Academic press.

Subuola, F., Yudi, W. and Taiwo, K. (2012). Processing and Ultilization of Legumes in the Tropics. In A. E. Ayman (Ed.), Trends In Vital Food and Control Engineering. (pp 71-84)· Europe:InTech.

Sunday, Y.G. (2001). Quality Attributes of Three New Improved Lines of Nigerian Lima Beans (*Phaseolus lunatus*). *Plant foods for Human Nutrition*, **56**:325-33.

Taruvinga, A. and Mucheje, V. (2013). Determinants of Rural Household Dietary Diversity: The Case of Amatole and Nyandem Districts, South Africa. *International Journal of Development and Sustainability***2**(4): 255-275.

True Random Number Service (2015). Random Integer Generator. Retrieved from September, 11, 2015 from https://www.random.org/integers/

Tunde-Akintunde, T.Y., Oke, M.O. and Akintunde, B.O. (2012). Sesame seed. In U. Akpan (Ed.), *Oilseeds* (pp. 81-98). Europe:InTech.

Udenta E. A., Obizoba I. C. and Oguntibeju O. O. (2014). *Anti-Diabetic Effects of Nigeria Indigenous Plant Foos/Diets*. Available from http://dx.doi.org/10.5772/57240.

United Nations Children's Fund. (1990). *Malnutrition Conceptual framework* (image). Retrieved from https://www.google.com.ng/search?q=unicef+conceptual+framework+1990&tbm=isch&tbo=u&source=univ&sa=X&ved=0ahUKEwi4vJyV2r3RAhXWIFAKHbB_AWUQsAQILg

United Nations Children's Fund. (2000). *Poverty reduction begins with children*. Retrieved from https://www.unicef.org/publications/files/pub_poverty_reduction_en.pdf

United Nations Children's Fund. (2011). *Infant and Young Child Feeding*, Nigeria: UNICEF. Retrieved from https://www.unicef.org/nutrition/files/final_IYCF_programming_guide_2011.pdf

United Nations Children'sFund. (2013). *Improving Child Nutrition: The achievable imperative for Global Progress*, New York: UNICEF. Retrieved from https://www.unicef.org/.../improving_child_Nutrition_en.pdf

United Nations. (2008). *World Food Programme:Food fortification*, Malawi. UNICEF. Retrieved from https://www.m.wfporg/content/food-fortification

United States Department of Agriculture. (2014). *Branded Food Products Database.*Retrieved from https://ndb.nal.usda.gov/ndb/foods/show/48409?manu=&fgcd=&ds=

Venice, K.(2010). *Facts on the Lima Bean plant.* Retrieved March 19, 2015 from: http://www.gardenguides.com/92964-lima-bean-plant.html#ixzz3UGHEHLOO.

Viad B. M., (2008). *A study on Nutrient Profile and Sensory Characteristics of Foods Cooked by Conventional Methods, Microwave Cooking and Solar Cooking*. (Ph.D thesis). University of Saurashtra, Rajkot, India.

Victor, A. (Ed.). (2009). *A quantitative analysis of determinants of child and maternal malnutrition in Nigeria*. Nigeria: IFPRI. Retrieved from http://www.ifpri.org/publication/quantitative-analysis-determinants-child-and-maternal-malnutrition-nigeria-o

Walker, C., Rudan, I., Liu, L., Nair, H., Theodoratou, E., Bhutta, Z. A., … Black, R. E. (2013). Global burden of Childhood Pneumonia and Diarrhoea. *Lancet*, **381**(9875): 1405-1416

World Bank. (2011). *Nutrition at a Glance*. Available from http://sisteresources. World Bank.org/NUTRITION/Resources/281846-1271/963823]]2/Malawi.pdf.

World Health Organization.(2007). *Stengthening Health System to improve Health outcomes.* Retrieved from http://www.who.int/healthsystems

World Health Organization. (2013). *Global Nutrition policy review.* What does it take to scale up nutrition action? Retrieved from http://apps.who.int/iris/bitstream/10665/84408/1/9789241505529_eng.pdf

Yellavila, S.B., Agbenorhevi, J.K., Asibuo, J.Y. and Sampson, G.O. (2015). Proximate Composition, Minerals content and Functional Properties of Five Lima Beans Accessions. *Journal of Food Security*, **3**(3): 69-74.

APPENDICES:

Appendix I

Survey Questionnaire

CONSUMPTION PATTERN OF LIMA BEANS (*PHASEOLUS LUNATUS*) IN KADUNA STATE

(This Questionnaire is to be administered to caregivers in selected households with at least one under-five child)

SECTION A: BACKGROUND INFORMATION

Date...../...../..... Questionnaire No.....

LGA---------- Ward---------- Community----------

Household Address----------
(Be as descriptive as possible)

Interviewer's Name---------- Signature----------

SECTION B: CHARACTERISTICS OF RESPONDENTS

Sex: Male [ ] Female [ ]

Marital status: Single [ ] Married [ ] Divorced [ ]

Ethnic group……. Household size……..
Age ……

SECTION C: LIMA BEANS CONSUMPTION

1. Do you know lima beans? (show a sample) Yes[ ] No [ ]
2. If yes for (1) above, have you ever eaten lima beans? Yes[ ] No [ ]
3. List all the available lima beans foods or food product that you normally consume/prepare.
   a) _____
   b) _____
   c) _____
   d) _____
   e) _____

4. Which of the listed lima bean food/product do you prefer most?
   _____

5. Tell me the number of times you averagely eat lima bean foods/product.
(a) Per week _____
(b) Per month _____
(c) Per year _____

6. Why do you prefer the food you mentioned in (4) above?
   (a) Taste/ Aroma (c) Cultural/Traditional attachment
   (b) Ease of preparation (d)Others
   (specify)_____

7. Compare the lima bean foods/product with cowpea foods/product under the following headings.

	Less	**Same**	**More**
Frequency of consumption			
Taste/palatability			
Ease of cooking			

8. List the ingredients, method and time it takes to prepare your most preferred lima beans food recipe mentioned in (4) above

Name of food recipe	**Description of food**	**Ingredients**	**Quantity**	**Recipe preparation method**

Appendix II

SENSORY EVALUATION FORM FOR LIMA BEANS (*LUNATUS PHASEOLUS*) RECIPES

Recipe: Beans porridge; Beans and Hungry rice; Beans and Benni-seed

Name:

Signature: Date:

SAMPLE	COLOUR					TASTE					TEXTURE					AROMA					OVERALL ACCEPTABILTY				
	1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
A																									
B																									
C																									

1 = Dislike very much; 2 = Dislike; 3 = Neither like or dislike; 4 = Like; 5 = Like very much.

Appendix III

DISTRIBUTION OF RESPONDENTS BY LOCAL GOVERNMENT AREAS, WARDS AND COMMUNITIES

		Frequency	Percentages (%)
LGA	Kaura	134	33.50
	Chikun	133	33.25
	Sabongari	133	33.25
WARD	Agban	88	22.00
	Mallagum	46	11.50
	Kakau	74	18.50
	Rido	59	14.75
	Jama'a	92	32.75
	Samaru	41	0.50
COMMUNITIES	Garaje	88	22.00
	Ung. Shemang	46	11.50
	Ung Sauri/rimi	20	5.00
	Ung Tanko	8	2.00
	Ung Waziri	25	6.25
	Karatudu	21	5.25
	Ung Maigero	36	9.00
	Mahuta	23	5.75
	Zango shanu/Aviation	46	11.50
	Hayin Danyaro	41	10.25
	Aviation site II	46	11.50

Appendix IV

CHARACTERISTICS OF RESPONDENTS

		Frequency	Percentages (%)
SEX	Male	84	21.00
	Female	316	79.00
MARITAL STATUS	Single	52	13.00
	Married	344	86.00
	Divorced	4	1.00
AGE	<20	3	0.75
	21-30	101	25.25
	31-40	173	43.25
	41-50	86	21.50
	51-60	31	7.75
	>60	6	1.50
HOUSE HOLD SIZE	1-3	19	4.75
	4-6	231	57.75
	7-9	97	24.25
	10-12	37	9.25
	13-15	8	2.0
	Above 15	8	2.0
ETHNIC GROUPS	Adara/Kadara	9	2.25
	Bajju	24	6.00
	Fanstwam	9	2.25
	Gbagyi	17	4.25
	Hausa	55	13.75
	Ikulu	6	1.50
	Jaba	26	6.50
	Kaninkon	8	2.00
	Kagoro	36	9.00
	Kataf	67	16.75
	Others	143	35.75

Appendix V

CONSUMPTION PATTERN OF LIMA BEANS (*PHASEOLUS LUNATUS*) COMPARED WITH COWPEA (*VIGNA UNGUICULATA*) IN KADUNA STATE.

		Frequencies	Percentages (%)
Frequency of Consumption	Less	166	76.50
	Same	15	6.90
	More	36	16.60
Taste/palatability	Less	32	14.70
	Same	16	7.40
	More	169	77.90
Ease of cooking	Less	198	91.20
	Same	3	1.40
	More	16	7.40

Number of respondents that consume Lima beans (n=217)

Appendix VI

ESSENTIAL AMINO ACID REQUIREMENT (g/100g Protein)

Amino Acid	Children 2-5 years
Histidine	1.9
Isoleucine	2.8
Leucine	6.6
Lysine	5.8
Methionine	2.5
Phenylalanine	6.3
Threonine	3.4
Tryptophan	1.1
Valine	3.5

FAO/WHO (1991)

Appendix VII

TAXONOMIC HIERARCHY FOR BENNISEED

Kingdom	*Plantae*
Subkingdom	*Viridiplantae*
Infrakingdom	*Streptophyta*
Superdivision	*Embryophyta*
Division	*Tracheophyta*
Sub division	*Spermatophytina*
Class	*Magnoliopsida*
Superorder	*Asteranae*
Order	*Lamiales*
Family	*Pedaliaceae*
Genus	*SesamumL.*
Species	*Sesamum radiatum Schumach*

(Integrated Taxonomic Information System, 2015.)

Appendix VIII

TAXONOMIC HIERARCHY FOR HUNGRY RICE

Kingdom	*Plantae*
Subkingdom	*Viridiplantae*
Infrakingdom	*Streptophyta*
Superdivision	*Embryophyta*
Division	*Tracheophyta*
Sub division	*Spermatophytina*
Class	*Magnoliopsida*
Superorder	*Lilianae*
Order	*Poales*
Family	*Poaceae*
Genus	*Digitaria Haller*
Species	*Digitaria exilis*

(Integrated Taxonomic Information System, 2015.)

Appendix IX



Plate 2: Photograph of Benniseed (*Sesamum radiatum*)



Plate3: Photograph of Hungry Rice (*Digitaria exilis*)

Appendix X

Photograph of Standardized Lima beans (*Phaseolus lunatus*) Foods.



Plate 4: Lima Beans Porridge.



Plate5: Lima Beans-Benniseed.



Plate 6 :Lima Beans-Hungry Rice.

APPENDIX XI

Table 1: Chemical Score of Commonly Consumed Standardized Lima Beans (*Phaseolus lunatus*) Foods in Kaduna State

Amino acid (g/100g)	**Chemical score (%)**			
	Raw Lima bean	Lima bean Foods		
		Bean porridge	Bean-hungry rice	Bean-benniseed
Leucine	106	100	97	111
Lysine	134	136	106	137
Isoleucine	129	117	130	130
Phenylalanine	81	85	90	77
Tryptophan	131	137	170	91
Valine	93	102	96	96
Methionine	34	42	32	100
Threonine	130	109	123	141

FAO/WHO/UNU 100

FAO/WHO/UNU (2007) reference pattern suggested for children of 1-2 years of age in g/100g:valine,4.2; isoleucine,3.1; cysteine + methionine,2.6; leucine, 6.3; lysine 5.2; threonine; 2.7; tryptophan,0.74; tyrosine + phenylalanine 4.6