

**THE POTENTIAL FOR NJAHI (*Lablab purpureus L.*) IN IMPROVING  
CONSUMPTION ADEQUACY FOR PROTEIN, IRON AND ZINC IN  
HOUSEHOLDS: A CASE FOR NANDI SOUTH DISTRICT, KENYA**

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**DECLARATION**

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## **DEDICATION**

*This work is dedicated to my mother Onyango Everlyne and a dear friend Sharon Nagle for having denied themselves to invest in my education.*

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## **ABBREVIATIONS/ACRONYMS**

ANOVA: Analysis of Variance

AOAC: Association of Analytical Chemists

CBS: Central Bureau of Statistics

CIAT: International Centre for Tropical Agriculture

CVD: Cardiovascular Disease

DFSNT: Department of Food Science, Nutrition and Technology

DGP-CRSP: Dry Grain Pulses Collaborative Research Support Program

FA: Field Assistant

FAO: Food and Agriculture Organization

FGD: Focus Group Discussion

GOK: Government of Kenya

HH: Household head

IDA: Iron Deficiency Anaemia

IVPD: *In vitro* Protein Digestibility

KARI: Kenya Agricultural Research Institute

KDHS: Kenya Demographic and Health Survey

KNBS: Kenya National Bureau of Statistics

LSD: Least Significant Difference

NGO: Non Governmental Organization

NPKM: Nitrogen, phosphorus, potassium and magnesium

NS: Not Significant

PEM: Protein Energy Malnutrition

PK: Phosphorus and Potassium

RDA: Recommended Dietary Allowance

SPSS: Statistical Package for Social Sciences

TIA: Trypsin Inhibitory Activity

TIU: Trypsin Inhibitor Units

USDA: United States Department of Agriculture

WHO: World Health Organization

## **DEFINITION OF TERMS**

**Bioavailability:** The degree to which food nutrients are available for absorption and utilization in the body

**Biofortification:** The strategy to increase nutrient density by genetic modification of plants and animals.

**Sites:** Regions in Nandi South district divided in terms of soil fertility gradient

**Food insecurity:** State of inaccessibility in terms of quantity and quality, unavailability, and poor utilization of food to promote good health (FSAU, 2010).

**Fortification:** Addition of one or more nutrients to a food (vehicle) with the main objective to increase the intake of a specific nutrient to improve the nutritional status of the target consumer.

**Household:** People living together and sharing a pot of food at the time of study.

**Livelihood:** Comprises of capabilities, assets (material and social resources) and activities required for a means of living (FSAU, 2010).

**PEM:** Status of human deprivation of protein and energy caused by starvation, or a combination of starvation and catabolic stress.

**Pulses:** A group of edible and mature leguminous plant seeds naturally produced in pods.

**Recommended Dietary Allowances (RDA):** Nutrient levels considered necessary to meet the requirements for majority (97–98%) of healthy people

**Supplements:** Provision of a specified dose of nutrients preparations which may be in form of tablet, capsule, oil solutions or modified food, for either treating an identified deficiency or prevention of occurrence of such deficiency in an individual or community

## **ABSTRACT**

Almost 850 million people in the developing world go without food every day, with one third being Africans living below the poverty line. Up to 12.5 million of these people are Kenyans. This has led to their development of major macro and micro nutrient deficiencies. The deficiencies have stemmed from multifaceted problems namely; low utilization and inadequate intake due to inadequate information on alternative potential food sources and their appropriate utilization. Food based strategies to mitigate these malnutrition problems have been tried by many with varying degrees of success.

The case for lablab, being a multipurpose crop was introduced to solve these challenges in three dimensions namely: Improve soil fertility, Increase yield for cash and as source of food. This study examined its food utilization potential in Nandi South district.

The work was part of a larger intervention project entitled To Reinvigorate Smallholder Mixed Farming Systems in Western Kenya, using lablab under Dry Grain Pulses Collaborative Research Project (DGP-CRSP), in four soil fertility gradient zones in Nandi South.

The study design in Nandi South district was analytical to explore; socio demographic and economic factors as influence protein, iron and zinc intake. Profile the protein content, iron, zinc and anti-nutritive factors and effect of preparations on them. A total of 132 households involving 65 lablab and 67 non-lablab growing households with a total of 800 people were purposively selected for study. Baseline data on demography, socioeconomic characteristics and consumption pattern for protein, zinc and iron foods were collected using pretested questionnaire. Other determinations were nutritive stress factors associated with these foods, protein adequacy, zinc and iron intake.

Proximate composition, zinc and iron were determined for both lablab grains and leaves while cookability and anti-nutrients were analyzed in grains. Further tests done were determination of effect of soaking and cooking periods on zinc, iron and anti-nutrient contents in grains.

The households studied had a mean household size of 6 with a sex distribution of 51% females and 49 % males and a dependency ratio of 87%. The established income of the study population majorly from farming (70%) showed that 85% of them were earning half below the recommended 1 US dollar per person per day.

Using a pretested 24hr recall and a seven day food frequency questionnaire, it was established that the frequency of consumption of protein, zinc and iron rich foods by most of the households was low (less than 3 days in a week). Only cereals and their products had adequately been consumed by more than 80% households within the previous seven days. From the survey, 22%, 13% and 47% of the study population did not meet the recommended requirements for protein, zinc and iron respectively.

Analyses were carried out to establish nutrients and anti-nutrients composition for both lablab grains and leaves. The grain had a mean protein content of 22%, zinc of 34mg/kg and iron of 57mg/kg while on leaves the crude protein was 25%, zinc of 30mg/kg and iron of 28mg/kg.

The effect of soaking and cooking on lablab grain nutrient and anti-nutrient content were determined, *In vitro* protein digestibility increased significantly with soaking time by about 11% and 15% at 12 and 24 hours of soaking respectively also reducing tannins significantly by about 74% and 76% respectively and to undetectable levels for trypsin inhibitor. Soaking the grains for 10, 12 and 24 hours reduced the cooking time by 67%, 70% and 74% respectively. It can be concluded that like any other food legume, Lablab is a good source of dietary protein, zinc and iron but holds a better promise given its multipurpose function.

# CHAPTER ONE: INTRODUCTION

## 1.1 Background Information

Nearly 1 billion people in the world are suffering from protein energy malnutrition (PEM) which has led to the development of a vicious cycle of malnutrition, infections and aggravated poor nutritional condition (FAO, 2006). Almost 850 million people in the developing world go without food every day, one third of whom are Africans living below the poverty line. According to FAO, in the period 2003-2005 an estimated 12.5 million people of the population of Kenya were found to be undernourished (FAO, 2009). Macro and micro nutrient deficiencies in humans mainly result from their low concentrations and bio-availabilities in the diets that are derivatives of soil-plant systems. Nutrient composition and their bio-availability are critical in determining people's nutritional status. Large household sizes lead to straining of resources, unequal intra household food distribution and high dependency ratio, resulting in nutrient deficiencies.

*Lablab purpureus* (Njahi) is an important grain legume and source of dietary protein for vegetarians, as well as people in countries where animal proteins are inaccessible. It is exceptionally nutritious, having about 25% protein content, with moderately well balanced amino acids and high lysine content (6-7%), that can make a perfect complement to cereals. It contains flavonoids which are antioxidants reported to manage cardiovascular diseases (CVD), blood cholesterol, diabetes and obesity (Ramakrishna *et al.*, 2006).

In addition to being a prolific food producer, lablab thrives in relatively acidic soils (pH 5.5) of low fertility common in Kenya's soils; Common legumes are not generally tolerant to these growing conditions. Lablab's penetrating roots draw nourishment from deep below the surface and improve the land's nitrogen content through the action of rhizobia in its root nodules. It is a multipurpose crop as it can be used for food, forage, soil improvement, soil protection and weed

control (Shivashnkar and Kulkarni, 1998). As a result of these advantages, DGP-CRSP introduced Lablab to farmers in Nandi South district in order to; improve soil fertility, as cover crop, human food, forage and cash earner. Being a new legume in the region, its utilization as an important source of cheap protein may be impaired owing to its low adoption and nutritional performance, given certain intrinsic nutrients utilization limitations associated with legumes.

In order to maximise its potential for food, there is a need to determine nutritional information on Lablab grains and leaves as influenced by the household preparation methods for its food utilization.

## **1.2 Problem Statement**

Lablab has a great potential in provision of protein, minerals and dietary fibres when used as food and especially in vegetarian and poor households' diets. Besides aforementioned potential as human food, its use as a forage crop in animal feed has been tried in many countries with success. Lablab is also resilient to poor soils and has proved its worth in improving soil fertility as one of the best nitrogen fixing crops among the legumes. Despite all these advantages, its utilization as a source of protein, minerals and dietary fibre in human diet is low with only a scanty use during special occasions in Central Province of Kenya. This has partly been so because nutritionists and agronomists have found it difficult to give it necessary attention, and advocate for its usage in the diets due to little information on its nutrient composition and quality.

Many rural households in Kenya have low economic accessibility to protein derived from animal sources in their diets and therefore fall back to legumes as the alternative source of protein. The patterns, amounts and frequency of consumption of these legumes are, however, not well established. These legumes contain anti-nutritive factors which are potentially of major concern hindering their efficient nutritional utilization in diets. These includes; cyanogenic glycosides, haemagglutinins and phytic acids which reduce minerals bio-availability by binding them. Trypsin inhibitor and tannins reduce protein digestibility and bioavailability while fructo-oligosaccharides cause flatulence. Also the effect of common legumes preparation methods used in rural households on lablab's nutrient and anti-nutritive factors and their cooking ability has not been well documented hence this study.



### **1.3 Justification**

Lablab provides leaves and grain which promotes food security during both dry and wet seasons. The grains contain high levels of protein about 25% (Ramakrishna *et al.*, 2006) making it more versatile, cheap and one of the best alternative sources of protein comparable to the common bean. Adoption and utilization of lablab as food in households is however low and still marginalized therefore incorporating lablab in farms and household diets will prevent use of expensive and reactive interventions such as fortification and pure supplements which have low coverage in the rural areas (Xiao-E *et al.*, 2007). In order to promote food security and reduce PEM, zinc and iron micronutrient deficiencies, there is need to understand consumption patterns and adequacies for protein, zinc and iron rich foods in households in order to identify deficiencies to be filled in. Establishing and providing nutritional information to promote lablab as a food crop will therefore increase its food utilization base as a food based intervention strategy.

Other than its food utilization potential, lablab is also a drought resistant crop and does well in both wet and dry seasons. It has a higher symbiotic relationship with rhizobia which fixes nitrogen in the soil reducing the need for fertilizer and therefore promotes cheap efficient agricultural practices (Lost Crop of Africa, 2006). It also produces large biomass used as forage to increase milk production, provides cover to prevent soil erosion and inhibits weed which reduces the cost of weeding. This study exploited the potential for lablab for enhancing intake of protein, iron and zinc in households in Nandi South District.

#### **1.4 Aim of the Study**

To establish food utilization value of Lablab as a strategy to improving nutritional status of individuals in Nandi south district

#### **1.5 Purpose of the Study**

To determine the potential of Lablab for enhancing intake of protein, iron and zinc in households in Nandi South District

#### **1.6 Objectives**

##### **1.6.1 General Objective**

To determine factors influencing intake of protein, iron and zinc through consumption of Lablab in households of Nandi south district

##### **1.6.2 Specific Objectives**

1. To determine socio-demography and socio-economic status of Nandi South district households
2. To determine protein, iron and zinc intake adequacies in Nandi South district and contribution made by legumes
3. To determine the proximate composition, zinc, iron and anti-nutritive factors status in Lablab grown in Nandi South district
4. To determine the effect of methods of legumes preparation in households of Nandi south district on protein, iron, zinc status in the menu and cook-ability

#### **1.7 Study Hypotheses**

1. H<sub>0</sub>: There is no significant difference in protein, iron and zinc in experimentally grown lablab in Nandi South district

## CHAPTER TWO: LITERATURE REVIEW

### 2.1 State of pulse production and consumption in Kenya

Nationally, the price of legumes has increased, jumping from KES46 per kilogram in September 2007 to KES 67 per kilogram same month in 2008. Its price also rose again from KES 37 per kilogram in March 2007 to KES 56 per kilogram in March 2008. The demand however is increasing as shown in Table 2.1.

**Table 2.1: Beans production trend 2003 - 2008**

Year	2003	2004	2005	2006	2007	2008
Area(Ha)	879,032	872,070	1,034,477	995,391	846,327	641,936
Prod(90kg bag)	4,763,928	2,576,020	4,175,772	5,908,887	4,775,512	2,944,217
Consumption estimates (90 kg bags)	4,611,000	3,444,400	4,449,450	5,111,100	5,826,700	6,626,400

Source: GOK, (2009)

### 2.2 Lablab

*Lablab purpureus* is a grain legume and a species of bean in the family Fabacea widespread as a food crop throughout the tropics especially in Africa, India and Indonesia (<http://en.wikipedia.org/wiki/Lablab>). Domesticated types are mostly summer growing annuals or occasionally short-lived perennials; and are vigorously trailing and twining herbaceous plants. Seeds of Rongai variety are pale brown coloured, ovoid, laterally compressed, with a linear white conspicuous hilum, 1.0 cm long x 0.7 cm broad, seeds of 'Highworth' black with a linear white hilum. Seeds of other varieties can range from white or cream through to light and dark brown, red to black. Seeds can have a mottled colouring in some domesticated varieties and in all wild material and about 2000-5000 seeds can weigh 1kg (Andrea and Pablo, 2009).

The common name given to Lablab in Kenya is Njahi. Other names include Hyacinth bean, lablab bean, field bean, pig-ears, rongai dolichos, lab-lab bean and poor man's bean.

### 2.2.1 Uses

Lablab is widely distributed in countries of Africa and Asia and also in the US and Australia. These countries have many overlapping uses specific to regions (Schaaffhausen, 1963). Some examples of uses of Lablab include:

**a) Pods** The young pods of the culinary type are popular vegetables in India, Indonesia, the Philippines, and elsewhere in the Asian tropics. They are eaten like green beans or snow peas.

**b) Seeds** In India, the dried seeds are split like lentils and used in making dhal, the major protein source for millions of the populace. They are also sprouted, soaked in water, shelled, boiled, and smashed into a paste, which is fried with spices and used as a condiment. Dried seeds are also fed to livestock but are cooked for about 45 minutes before incorporation into monogastric diets for efficient utilization (Bawa *et al*, 2003). In Africa, lablab seeds are cooked in any of the ways commonly used for beans: boiled with maize, ground and fried, or added to soups. Lablab is not popular among most ethnic groups in Kenya but it is used by Kikuyu in Central Kenya. It is used in a traditional dish called mukimo which is eaten at special occasions like weddings or circumcisions and also by mothers following childbirth, in the belief that it improves her breast milk production (Lost Crops of Africa, 2006 and Imungi & Mbugua, 2010.)

**c) Leaves:** The leaves are occasionally used as a potherb, although they are said to be less palatable and less popular than cowpea leaves. They are used for feeding pigs in Kenya in the form of leaf meal (Beckmann and Clements, 2002). The authors further stated that lablab hay improved and increased live weight and milk yield of cattle from 4-6 to 6-7 litres per day. Fodder

yields of 5 to 10 tons per hectare have been reported from lablab and it is also able to withstand severe cutting (Andrea and Pablo, 2009).

**d) Environmental Protection:** The field-type lablabs are effective for land restoration as they can be grown alone, inter-planted with field crops, or included in crop rotations. They make a good (vegetative) cover crop in coffee and coconut plantations, fruit orchards, and more. They are often planted as a second crop in rice fields after the harvest of the paddy. In each case, they may be grazed after the pods have been harvested for food. This reduces soil erosion and increases soil fertility through nitrogen fixation (Lost Crops of Africa, 2006)

**e) Medicinal uses:** It is believed to carry a tremendous therapeutic potential used in both modern and traditional medicine (Shivashnkar and Kulkarni, 1998). The seeds are used as laxative, diuretic, anthelmintic, antispasmodic, aphrodisiac, digestive, carminative, febrifuge and stomachic (Kirtikar and Basu, 1995). It is also believed that lablab contain fibre effective in managing cancer, diabetes, heart disease and obesity. Kievitone a flavonoids has been found to have a potential to fight breast cancer. Another flavoniod, genistein found in Lablab beans has been hypothesized to play a role in the prevention of cancer and as a chemopreventive and or chemotherapeutic agent for head and neck cancer. Tyrosinase (polyphenol oxidase) component has been found to be effective in managing hypertension (Naeem *et al.*, 2009).

**f) Other Uses:** Certain varieties, “hyacinth bean” is renowned for its long, bright, showy, purple blossoms and is mainly used as ornaments. In a very clever initiative, the Government of Guyana encourages city dwellers to grow ornamental varieties along fence lines to form hedges that provide protein for the family table as well as a pretty prospect for the passerby (Andrea and Pablo, 2009).

**Composition:** Dry seed has 33% starch as the major component, protein 25% of dry weight, a very low fat content of only 0.8% and high dietary fibre constituting 7.2%. With 7.2% fibre lablab would be very ideal for diabetic, obese and hyper-cholestreamia patients. Oligosaccharides are a group of carbohydrates which have been reported to cause flatulence and include raffinose and stachyose found at 3.5%. Other components include phytic acid of 82.0 mg/g, phosphorus 430mg/g and phytates phosphorus 243 mg/g (Ramakrishna *et al.*, 2006). The leaves also are rich in protein (up to 28 percent) and, at least among legumes, they are one of the best sources of iron (155 mg per 100 g of leaves, dry weight) (Lost Crops of Africa, 2006).

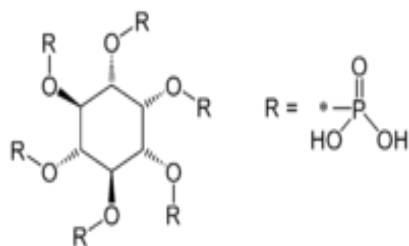
### 2.2.2 Antinutrients

The seeds do contain anti-nutrients such as tannins, phytate, oligosaccharides and trypsin inhibitors which restrict its usage as food.

**a) Flatulence factors (Oligosaccharides):** Oligosaccharides are hydrolysable heteropolysaccharide of monosaccharides that contain from 3 to 6 molecules of simple sugars. The Oligosaccharides raffinose, stachyose and verbascose are present in significant quantities in legume seeds estimated to be 3.5%, and are bonded with a galactosidic bond at  $\alpha$ -1, 6 positions. Digestion of these Oligosaccharides by animals requires a highly specific enzyme not elaborated by the animals themselves but by certain bacteria present in the animal's gut. As a result the oligosaccharide forms a substrate for fermentation by putrefactive anaerobes e.g. coliforms. This leads to the production of primarily toxic gases like hydrogen, CO<sub>2</sub> and methane as waste products. This results in flatulence and general stomach discomfort and can lead to nausea, dyspepsia and ulcers. Special concern for flatulence-producing substances is important when a pulse is promoted for human consumption since this is a common drawback restricting the use of pulses (Smil, 1997).

**b) Phytic acid:** Is myo-inositol hexakisphosphate (IP6) or phytate when in salt form and is the principal storage form of phosphorus in many plant tissues, especially bran and seeds. Inositol concentration in whole grain cereals and legumes has been reported to be approximately 1% (Mbithi, 2000). This molecule is highly charged with six phosphate groups extending from the central inositol ring structure and is an excellent chelator of mineral ions, forms phytates-protein complex and acts as acid chelating niacin (vit B3) whose deficiency causes pellagra. Phytic acid is therefore nutritionally important because of its ability to form insoluble chelates (Mbithi, 2000).

Structural formula for myo- inositol hexaphosphate



[http://en.wikipedia.org/wiki/File:Phytic\\_acid.png](http://en.wikipedia.org/wiki/File:Phytic_acid.png) accessed on 9th .12.2009.

**c) Tannins:** Are water soluble polyphenols that are widely distributed in plant foods, including food grains like sorghum, millet and dry pulses (Mbithi, 2000). They are found in two forms; hydrolysable tannins and condensed tannins which are differentiated by their structure and reactivity towards hydrolytic agents. Hydrolysable are readily cleaved by enzymes and dilute acids, into sugars such as glucose, and a phenolcarboxylic acid such as gallic acid, while condensed tannins are resistant to enzymatic degradation (Mbithi, 2000). Tannins are nutritionally undesirable because of their potential to precipitate proteins (1mole of tannin is reported to bind 12 moles of protein), inhibit enzymes and interfere with utilization of vitamins and minerals (Chung *et al.*, 1998). Tannins are reported to be high in beans with bronze testa

having about 7.8 mg/g of catechin equivalents, 6.65 mg/g in beans with black testa, 2.31 mg/g in white beans and 12.56 mg/g in beans with red colour (Mbithi, 2000).

**d) Proteinase inhibitors:** These are a group of proteins which inhibit proteolysis of food protein by inhibiting the action of trypsin, chemotrypsin and amylase in the small intestine. Laurena *et al.* (1994) reported that among the legumes under their investigation, Lablab bean was found to have the highest trypsin inhibitor activity ranging from 14 to 27units/mg.

## **2.3 Various methods used to reduce/ remove anti-nutrients**

### **2.3.1 Soaking, germination and cooking**

The combinations of soaking and cooking methods have been used since man started consuming pulses as food. Soaking is mostly done overnight and the soaking water discarded before cooking. Oligosaccharides are water soluble; therefore, soaking and discarding the water removes most of these sugars from pulses (Mbithi, 2000). Many authors have observed mixed results on the effects of soaking on phytic acid, Akindahunsi (2004) observed an increase in phytic acid content of African oil beans while Vidal-Valverde *et al.* (1998) in soaking faba beans observed that in either water, acid, or base solutions there were no significant changes in phytic acid levels but Mbithi (2000) observed a significant decrease in phytic acid upon soaking kidney beans. Phytic acid is highly charged with six phosphate groups extending from the central inositol ring structure which makes it more stable. The optimization of germination is needed if meaningful reduction of anti-nutrients is to be realized. Kuo *et al.*, (1988) observed that in several plant species, the levels of sugars have been shown to decrease during germination. The disappearance of these sugars is believed to be the result of de-novo synthesis of  $\alpha$ -galactosidase enzyme to mobilize food reserves for the embryo development. The enzyme hydrolyses stachyose, raffinose and verbascose into sucrose and galactose (Amal *et al.*, 2007).



Ramakrishna *et al.*, (2006) reported that the very high trypsin inhibitory activity in the raw dry Lablab was progressively decreased by 51% during the 12 hour soaking period and further reduced 17% at 32 hour germination period. The study also showed there was a reduction in polyphenols, tannins, phytic acids, phytate phosphorus and residual raffinose during the 32 hrs of germination.

### **2.3.2 Breeding:**

Lowering of anti-nutritional factors seems to be possible by breeding legumes, due to its variation in existing germplasm. Breeding for low phytate seeds is possible, but there are conflicting opinions about the desirability of this because phytate is also a human nutrient, and plays various roles in the life cycle of the plant.

### **2.4 Essential Human nutrients from soil- plant system**

Plants require at least sixteen essential nutrients for growth which undergo biotransformation during plant growth to make their own reserve and animal nutrients. These nutrients include: carbon, hydrogen, and oxygen, obtained in large amounts from air and water, and make up the bulk of plant dry matter in the products of photosynthesis. They are not usually included as “nutrient” elements. Nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), boron (B), molybdenum (Mo), and chlorine (Cl) are mostly absorbed from soil and are required by all plants. Sodium, silicon, and nickel are essential elements for some plant species and have positive or beneficial effects on the growth of other species and human nutrition (Metho *et al.*, 1999). Cobalt is essential for nitrogen fixation by legumes and has an influence on protein content. These nutrients are required by plants in differing amounts and their availability in the soil influences the amounts and quality in the plant material. N, P, and K are primary macronutrients with crop

requirements generally in the range of 50 to 150 lbs/acre. Micronutrient requirements namely Fe, Mn, Zn, Cu, B, Mo, and Cl are generally required in less than 1 lb/acre (Metho *et al.*, 1999).

#### **2.4.1 Zinc and Iron: Requirements for humans**

Zinc is an essential component of a large number (>300) of enzymes participating in the synthesis and degradation of carbohydrates, lipids, proteins and nucleic acids, as well as in the metabolism of other micronutrients (Guthrie, 1999). Iron on the other hand is critical in the production of the body's white blood cells and in the activities of the immune system. Lack of iron causes anaemia and symptoms such as tiredness and irritability. There are two types of iron in food:

- **haem iron** found in meat and offal (essentially the iron from blood and muscle)
- **non-haem iron** derived from some plants, grains and nuts

Pulses have been found to contain considerable amounts of zinc, iron and other micronutrient elements critical for human development, but their bioavailability is hampered by anti nutrients especially phytates.

##### **2.4.1.1 Iron and Zinc deficiency: in humans**

Iron deficiency anaemia (IDA) is a world-wide problem affecting about 3.5 to 5 billion people, and a much larger number has iron deficiency without anaemia (Elifatio, 2006). Iron deficiency refers to depleted body iron stores without regard to the degree of depletion or presence of anaemia, while iron deficiency anaemia refers to severe depletion that results in low haemoglobin concentration (Whitney and Rolfes, 1999). In iron deficiency anaemia, red blood cells are pale and small. They cannot carry enough oxygen from the lungs to the tissue hence energy metabolism falters. Children have especially high zinc needs because of rapid growth rates and synthesis of many zinc containing proteins. Deficiency starts to manifest itself when

the level falls short of body requirement. These are characterized by severe growth retardation and arrested sexual maturation. It also hinders digestion and absorption, causing diarrhoea, which reduces the effectiveness of zinc and all other nutrients. The incidence of infection and impaired immune response also develops. Chronic zinc deficiency damages the central system and brain functioning, leading to anorexia, mental lethargy and irritability (Whitney and Rolfes, 1999). Daily requirements for zinc and iron for selected age group are as showned in table 2.2.

**Table 2.2: Recommended daily allowance (RDA) of Iron and Zinc**

Selected group	Age (yr)	Iron (mg)	Zinc (mg)
Infants	0-0.5	6	5
	0.5+-1.0	10	5
Children	1.0+-10	10	10
Males	11-18	12	15
	19-50+	10	15
Females	11-50	15	12
	51+	10	12
Pregnant women		30	15
Lactating	First 6 months	15	19
	Second 6 months	15	16

Source: Whitney and Rolfes, (1999).

## **2.5. Household food security and PEM**

Food security is achieved when all people, at all times, have physical and economic access to adequate/sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FSAU, 2010). Food security is not the physical availability of any single commodity; such as maize in the Kenyan context, but embraces four key components namely; food availability which can be through own production, purchases, food aid or gifts. The

average food availability among a set of African countries reveals that the average daily caloric intake is below the recommended level of 2100 Kcal (FAO, 2006). Food accessibility and stability is affected by poor transport, high fuel prices and market infrastructure. Either food does not reach those who need it most (from surplus regions) or reaches them at excessively high prices. The food utilization/nutrition aspect is important in Africa because although cereals, pulses, roots and tubers play a central role in food supply, production has generally lagged behind the rate of population growth. Minimal exploitation of available food sources has been made leaving the continent a net importer of expensive agricultural produce. This is partly because priority was put on development of the cereals and pulses (common beans and soya) leaving behind some legumes, root and tuber crops which can survive harsh weather conditions (FAO, 2008). Food insecurity is caused by factors including; poverty, poor economic performance, drought, flood and human conflicts, land degradation, inefficient marketing systems, limited agro-processing or value addition etc.

Food insecurity directly or indirectly leads to protein-energy malnutrition (PEM). It develops in children and adults whose consumption of protein and energy is insufficient to satisfy the body's nutritional needs. While pure protein deficiency can occur when a person's diet provides enough energy but lacks the protein minimum, in most cases the deficiency will be dual. It may also occur in persons who are unable to absorb vital nutrients or convert them to energy essential for healthy tissue formation and organ function. Marasmus is severe wasting and can also occur in adults. It is the result of an inadequate food intake necessary to meet energy expenditure. Kwashiorkor affects only young children and includes severe oedema, fatty infiltration of the liver and a sooty dermatitis. It is likely that deficiency of antioxidant nutrients and the stress of

infection may be involved (Guthrie, 1995). The daily requirement for protein for selected age group is summarized in table 2.3.

**Table 2.3: Adequate protein intake for selected age groups and physiological states**

Selected group	Age	Intake g/kg/day
Infant	9-12months	1.4
Child	1-2 yrs	1.2
	5-6yrs	1.03
	9-10yrs	1.00
Adolescent girls		0.94
Boys	13-14 yrs	0.97
Adults	19+ yrs	0.8
Pregnant	2 <sup>nd</sup> trimester	6+
	3 <sup>rd</sup> ,,	11+
Lactating	0-6 months	16+
	6-12 months	11+

Source: Groff, (1995)

## 2.6 Gaps in Knowledge:

The use of lablab grains and leaves as food is minimal in Kenya. Constraints to utilization, household preparation practices and its potential for contribution to protein, iron and zinc intake in households has not been adequately researched. The majority of research work has dwelt on the determination of total nutrient composition of legumes but not bioavailability. Hence there was need to determine consumption pattern of foods rich in protein, zinc and iron, intake adequacies for protein, zinc and iron in Nandi South District households. Also important to determine were methods for preparation of legumes employed by households and their influence on nutrient bioavailability. This project determined the potential for Lablab in improving consumption adequacies for protein, zinc and iron intake in households of Nandi South District.

## **CHAPTER THREE: METHODOLOGY**

### **3.1 Study Area**

#### **3.1.1 Geographic Condition**

Nandi south district is in great Rift Valley province in Kenya, occupying an area of 1,437.7 sq. km, and it is bordered by Kakamega district to the west, Kapsabet to the north, Kericho to the south east and Kisumu district to the south (see appendix V for map). Geographically, Nandi District is bound by the Equator to the south and extends northwards to latitude  $0^{\circ}34'$  to the north. The western boundary extends to longitude  $34^{\circ} 45'$  east, while the eastern boundary reaches longitude  $35^{\circ} 25'$  to the East (GOK, 2005).

The altitude ranges from 1,400m along the border with Nyando district to 2,400m above sea level in the highlands, with average temperatures of 18-25<sup>0</sup>C. Precipitation is very high and varies from 1,200mm to 2000mm, annually. The month of March marks the onset of rains which continue to November with no clear-cut distinction between the long and short rains and the dry spell usually experienced from end December to March.

#### **3.1.2 Site characterization and selection**

Nandi South has four main agro-ecological zones predetermined by the larger project: Upper Highland (UH) that covers about 5%, Lower Highlands (LH1-2) covering about 24%, Upper Midlands (UM1-2) occupying 56% and lower midland (LM) covering 15%. The four sites, Koibem (high soil fertility), Bonjoge (medium high soil fertility), Kiptaruswo (medium low soil fertility and Kapkarer (low soil fertility) were chosen based on soil organic carbon and total soil nitrogen contents from 65 farms in Nandi south district of western Kenya as shown in Table 3.1.

**Table 3.1: Site soil characterization**

Site (soil)	texture	pH	% C	rating	% N	rating
koibem	clay loam	6.12	3.91	moderate	0.38	high
bonjoge	clay	5.81	3.53	moderate	0.31	high
kiptaruswo	sandy clay loam	5.54	1.87	low	0.26	moderate
kapkerer	clay	5.31	1.44	very low	0.16	moderate

Source: Odundo *et al.*, (2010)

### 3.1.3 Study Population

Nandi South is estimated to have a total population of 336,482 people with human concentration ranging from 285 persons per square kilometre in Aldai division to 162 individuals per km<sup>2</sup> in Tinderet and with an average density of 226 inhabitants per square kilometer. Only a quarter of the households have access to portable water sources within a kilometre, with less than half of them (10%) drawing water from piped sources. The district has a road stretch of 562.8 kilometers of which only 32% is tarmacked. The rugged topography, heavy rains and inadequate funding has left other road networks impassable. There is a fair telecommunication facility owing to the extent of the mobile network coverage. Nearly half of the district's residents are categorized as absolutely poor. Agriculture is the district's main economy, sustaining over 90% of the economically active individuals and accounts for nearly 52% of households earnings generated in the region. The staple foods are maize, beans, finger millet, sorghum, sweet potatoes, bananas and vegetables while the chief cash income earners are tea, sugarcane and coffee. Livestock production is dominated by dairy activities, with most farmers rearing pure breeds or high grade cows. Other livestock enterprises are zebu cattle, sheep, goats and poultry.

## **3.2 Research Methodology**

### **3.2.1 Study population**

The total farming community within the four sites involved a population of 3,137 representing household heads involved in farming activities.

### **3.2.2 Study Design**

The research was analytical involving both laboratory experiments and field cross-sectional study designs. It included quantitative methods (household survey and food frequency) to determine the intake adequacies for protein, zinc and iron and consumption patterns of legumes based diets or foods. A cross-sectional study was designed and executed through household interviews and focus group discussions using pretested questionnaires. The proximate composition and anti-nutrient profile for Lablab grown in Nandi South district was experimentally determined, as well as the influence of household preparation methods on protein, iron zinc and anti-nutrients.

### **3.2.3 Sample**

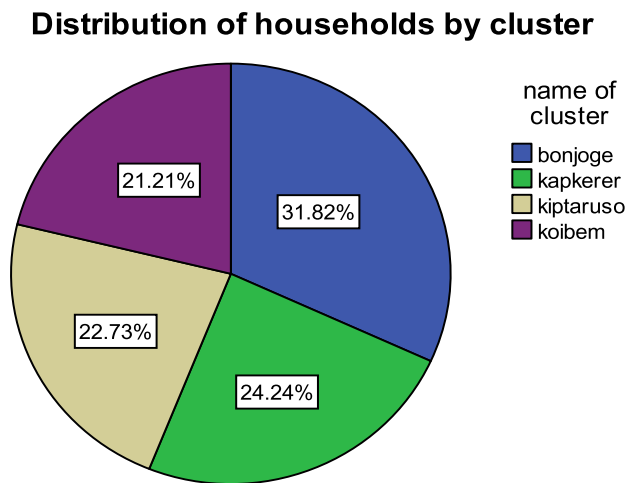
#### **3.2.3.1 Sample Size**

This work was part of a larger DGP-CRSP project working with 65 volunteer lablab growing households and about equal number of non lablab growing households (67) in the project spread across the district were randomly sampled making a total of 132. In each site the numbers of households were determined based on proportion to size as shown in sampling procedure below. The intention was to obtain information on intake adequacies for protein, iron and zinc, constraints to legume utilization, methods of preparation employed by the households and perception on the place of lablab in the household diets.



### 3.2.3.2 Sampling Procedure

Households were chosen purposively for study. Non lablab growing farmers were chosen in proportion to the numbers of lablab growing farmers from each site as shown in Fig 3.1. To avoid bias when choosing the neighbors, the sixth household from the lablab growing farmer in each site was interviewed.



**Fig 3.1: Distribution of households by site**

### 3.2.4 Research Tools and Materials

For a check list and list of tools for research and materials for data collection see appendix II and VII respectively.

### 3.2.5 Data Collection Techniques

Data collection was done through focused group discussions and the administration of semi-structured pretested questionnaires, in both lablab growing and randomly selected non lablab growing households. Laboratory results were obtained using AOAC methods and other tested procedures with slight modification where necessary.

### **3.2.5.1 Food Frequency Sheet**

The questionnaire contained a section with a list of possible food sources of protein, zinc and iron the community was using at the time of research. Food frequency dietary sheet was used to determine how often protein, iron and zinc rich foods are consumed, as a qualitative method of assessing protein, zinc and iron intake adequacy for the community. See food frequency guide in questionnaire appendix VIII.

### **3.2.5.2 Twenty Four-Hour Recall Sheet**

Information on amount of food consumed by households in the last 24 hours was collected using a 24-hr recall sheet. The respondents were interviewed on amount of ingredient and total amount of food prepared, the amount served to the household as well as any amount left-over, in order to determine the amount taken by the household. See questionnaire guide in appendix IX

### **3.2.5.3 Focus Group Discussions**

Two focus group discussion (FGD) sessions with an average of eight participants were conducted, comprising of both the lablab and non lablab growing farmers. An FGD question guide used in the study is shown in appendix X

## **3.2.6 Lab analysis.**

### **Raw materials**

Raw dry Lablab beans and leaves were sourced from harvest of the four experimental sites in Nandi south district and sent to the DFSNT of University of Nairobi laboratory for analysis.

### **3.2.6.1 Grain sample preparation**

Mature well developed grains were cleaned of foreign matter and defective grains. Grains were then washed in running water for not more than one minute to remove surface dust and

contaminants after which they were dried under forced air at 37°C for 5hrs to remove entrapped water on the surface (Mbithi, 2000).

### **3.2.6.2 Determination of proximate composition of Lablab**

The samples were analyzed for crude protein (Kjeldahl), moisture content (air oven), ether extract, crude fibre, total ash, acid insoluble ash and carbohydrates according to AOAC methods (AOAC, 2000).

### **3.2.6.3 Determination of *in vitro* Iron and Zinc extractability**

AOAC method 970.12 (AOAC, 1995) with improvement as described by Kumar and Chauhan (1993) was used to determine iron and zinc extractability. The milled grain sample was digested in 0.03 mol/L of HCl for 3hours at 37°C with constant shaking, filtered and filtrate analyzed for iron and zinc. The concentrations of zinc and iron were read from Atomic Absorption Spectrophotometer (Buck Scientific, 210 VGP, USA) at their specific wavelengths.

### **3.2.6.4 Determination of Tannin**

Tannin was determined according to Vanillin method described by Mbithi (2000). Blank/standard solutions were made by dissolving 100mg of catechin in 100ml methanol in a 250ml volumetric flask. A standard curve between 100-1000µg was prepared by pipetting .1, .2, .4, .6, .8 and 1ml aliquots into test tube. Each of the six samples was brought up to 1ml with the addition of 1% vanillin and 8% HCl and methanol added to develop the pink colour. The readings were read from spectrophotometer (CE 4400, Elegant Technology, England).

### **3.2.6.5 Determination of *In vitro* protein digestibility.**

*In vitro* protein digestibility of lablab was determined by a method described by Mbithi (2000). 250mg of ground Lablab seeds (100 mesh size) in centrifuge tubes were digested using 0.2%

pepsin buffered in 0.1ml  $\text{KH}_2\text{PO}_4$  ( $\text{pH}_2$ ) then shaken in UDY shaker for 3 hours at  $37^\circ\text{C}$ . 5ml of 50% tetrachloroacetic acid was added in each tube and centrifuged at 10,000rpm for 10 minutes. Nitrogen content was determined and % protein expressed as:

$$\text{IVPD (\%)} = \frac{\% \text{ protein(total)} - \% \text{ protein(undigested)}}{\% \text{ protein (total)}} * 100$$

### **3.2.6.6 Determination of phytic acid**

Phytic acid was determined by method described by Latta and Eskin (1980). 100mg of seed flour was extracted using 1ml of petroleum ether in eppendorf tube and defatted for 30min in a sonic bath. The sample was then centrifuged at 13000rpm for 5min, the supernatant was discarded and residue air dried. The air dried residue was then extracted with 1ml of 2.4% HCl for 10min then re-extracted in 1ml of 2.4% HCl for 5min 3 times in ultra sonic bath. All the supernatants were pooled and made up to a known volume (10ml) with distilled water. 0.5ml of extract was diluted to 3ml with distilled water, then Wade reagent (1ml of 0.03%  $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ ) and 1ml of 0.3% sulfosalicylic acid) added. The content was vortexed and centrifuged at 3500rpm for 5min, then absorbance of color reaction products for both samples and standards were read at 500 nm on spectrophotometer (CE 4400, Elegant Technology, England) and expressed as mg phytic acid/100 g dry weight.

### **3.2.6.7 Determination of Trypsin Inhibitor activity**

Trypsin inhibitor (TI) activity was determined by the method of Kakade *et al.*, (1974). The results were expressed as the number of trypsin units inhibited (TU) per milligram of dry sample. One trypsin unit (TU) was arbitrarily defined as an increase of 0.01 absorbance units at 410 nm in 10mins for 10ml of reaction mixture under conditions described.

### **3.2.6.8 Determination of cooking time**

Cooking time for dry and soaked seeds was determined by using Mattson cooker. Twenty three intact seeds were chosen to approximately fit the bean slot size of the apparatus. They were then arranged in the slots and held in place by placing the tip of plunger to sit on top of each bean (Jackson and Marston, 1981). The instrument was then partially immersed in a 2.5L aluminium pan of water and beans cooked on a gas burner. The gas flow rate and burner position were fixed throughout the experiment to give a steady and constant blue flame. It was ensured that the beans remained under boiling water throughout the cooking process by using additional boiling water. Cooking time was recorded as time taken from the initiation of the cooking until 20 of the 23 pins of the instrument dropped and penetrated through 80% of the beans (Nin Wang, 2004).

### **3.2.7 Ethical and Human Rights Consideration in Research**

Before the study began, permission was sought by acquiring a letter of recognition from the university through the Dean, Faculty of Agriculture and KARI Kakamega. On the ground, local authorities (chief and/or village elders) were contacted and the objectives of the study explained.

### **3.2.8 Recruitment and Training of Field Assistants**

Four field and one research assistants with minimum of secondary education certificate were recruited. Each was required to have a good command of the local language, knowledge of eating patterns and familiarity with the local foods. The assistants were recruited after a formal advertisement and interview. Equal opportunity was offered to both male and female applicants. A summary of training module was as shown in appendix VI.

### **3.2.9 Data Quality Control/Assurance**

Laboratory results were immediately entered in preformed dummy Tables then in the computer using SPSS software. Calibration of instruments and plotting of standard curves were done to ensure reliability before data was collected.

In community study, reliable data were collected using easy to understand semi-structured pretested and modified questionnaires. Alongside supervision, the field assistants were trained as described in the training program for three days (appendix I). Training was carried out on measurements of dietary intake, interviewing techniques, code of ethics, data management and proper interpretation of questions to avoid error of individual subjectivity during interview. Filled in questionnaires were stored in safe field bags during field work and in a metal box after field work to avoid any damage. Questionnaires were checked daily for accuracy and completeness.

### **3.2.10 Data Management and Analysis**

#### **3.2.10.1 Data Entry and Cleaning**

Using SPSS 17 software, Excel 2007, Instat plus v 3.36 and Nutrisurvey 2007 data was entered in templates immediately, cleaned and recoded for analysis.

#### **3.2.10.2 Statistical Data Analysis procedures**

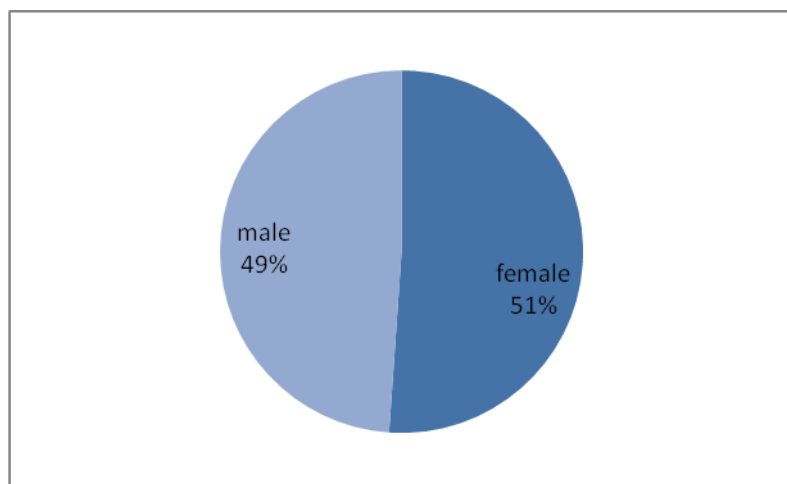
Both descriptive statistics (mean, median, variance, standard deviation and percentages) and analytical statistics (Chi-square, correlation, regression, ANOVA, LSD) were used to analyze data summarized in data analysis matrix in appendix XI. A summary of the research project in the form of a logical framework is shown in appendix IV. The log frame shows outputs and activities of specific objectives as well as verifiable indicators and assumptions made during the study as summarized in appendix III.

## **CHAPTER FOUR: RESULTS**

This chapter presents results on demographic and socio-economic characteristics of the study households and their frequency of consumption of protein, zinc and iron rich foods. Data on constraints to consumption of these foods, adequacy of protein, zinc and iron intake are also presented. Also in the results are laboratory findings namely; proximate composition of both lablab grain and leaves, cookability, zinc, iron and anti-nutrient composition of grain lablab grown in Nandi South district as affected by periods of soaking and cooking.

### **4.1 Demographic and Socio-economic Characteristics**

The assessment covered 132 households constituting 65 lablab and 67 non lablab growing households with a total of 800 people and a mean household size of 6. Sex distribution of the population was 51% females and 49 % males as shown in Fig. 4.1 and per site as shown in Fig 4.2. Table 4.1 shows a summary of the demographic characteristics. Majority of the household heads (70 %) earned their living from farming while only a few (17%) were salaried. The unemployment level was found to be negligible at 4% of the household heads but the study population had a high dependency ratio of 87%.



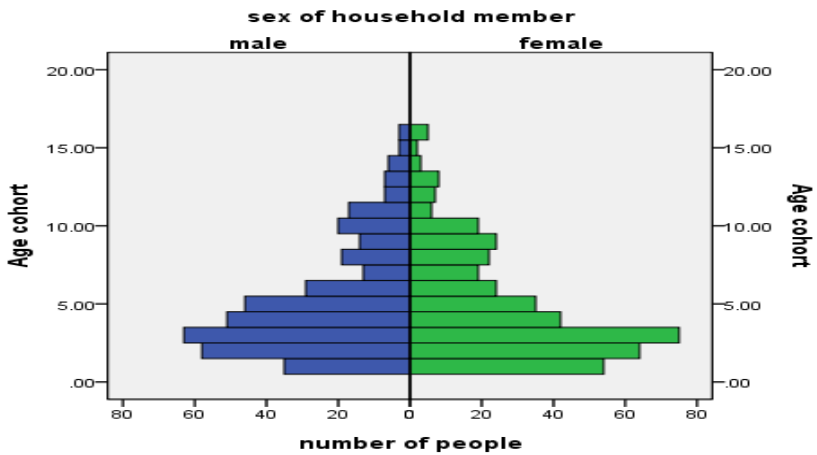
**Fig 4.1: Distribution of population by sex**

**Table 4.1: Demographic and Socio- economic characteristics of study population**

Characteristics	N	%
<b>Gender of household head</b>	<b>132</b>	<b>100</b>
Male	110	83.3
Female	22	16.7
<b>Occupation of household head</b>	<b>132</b>	<b>100</b>
Farmer	92	69.7
Employed/salaried	23	17.4
Businessman/woman	9	6.8
Casual laborer	3	2.3
Unemployed	5	3.8
<b>Main source of livelihood</b>	<b>132</b>	<b>100</b>
Sale of farm produce (crop)	36	27.3
Animal products sale	2	1.5
Business/trade	6	4.5
Mixed farming	68	51.5
Casual labor	4	3.0
Salaried/waged	14	10.6
Remittances	2	1.5
<b>Education level of household head</b>	<b>132</b>	<b>100</b>
Not attended school at all	10	7.6
Literate (adult education)	1	0.76
Dropped from primary	38	28.8
Completed primary school	32	24.2
Dropped from secondary	2	1.5
Completed secondary	34	25.8
College/university	15	11.4

Many household heads are males who are farmers and derive their income from mixed farming. This provides a very good platform for lablab growing and utilization.





**Fig 4.2: Population pyramid**

Scale (yrs)

1= <5	2=5-9	3=10-14	4=15-19	5=20-24	6=25-29
7=30-34	8=35-39	9=40-44	10=45-49	11=50-54	
12=55-59	13=60-64	14=65-69	15=70-74	16=74+	

**Table 4.2: Distribution of the study population by age and dependency**

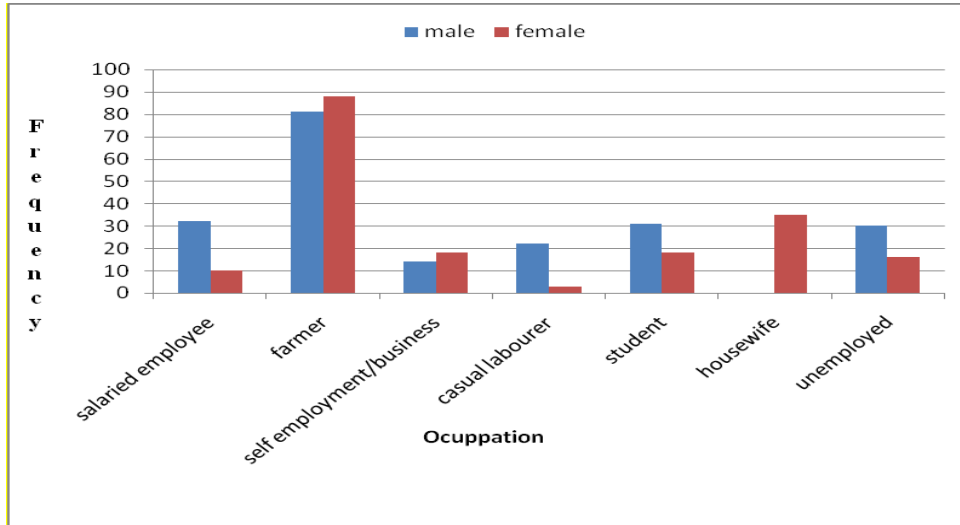
Age category	% (n=800)
0-14 (dependent population)	43.6
15-64 (productive population)	53.6
65+ (dependent population)	2.8

Half the population was economically dependent as shown in Fig 4.3 and Table 4.2., a characteristic of the developing world. This population structure piles a great economic pressure on income and negatively affects accessibility of food, adequate intra-household food distribution and ultimately nutrient intakes.

#### 4.1.1 Occupation and Income

In most cases (N=398) it was found that men were more likely to be in formal employment and in receipt of salaries, in casual employment or unemployed. Women on the other hand did the farming, domestic chores and were more likely to be self-employed than their male counterparts.

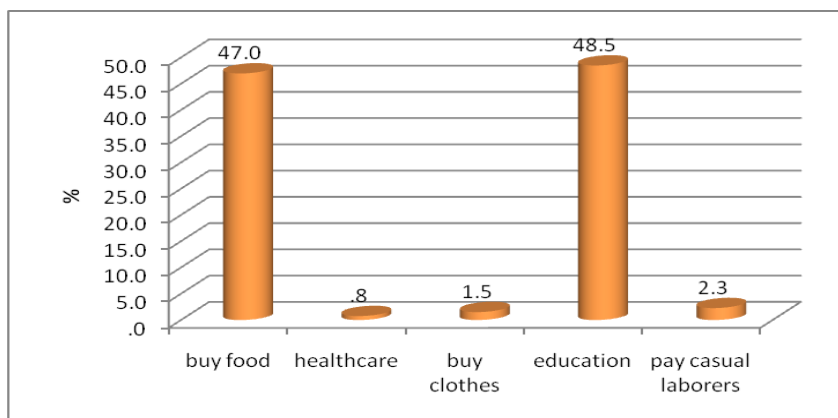
( $\chi^2$ ,  $p < 0.000$ ). Fig. 4.3 shows occupation of household members aged 18 years (the International Labour Organization recommended age for working) and above and category of income respectively. 85% of the population lived on less than US\$1 per person per day.



**Fig 4.3: Occupation of household members aged 18 years and above**

#### 4.1.2 Household income expenditure

The little income earned was largely spent on food as a basic need at 47.0% especially on expensive animal products like meat, fish. This is a characteristic of a poor population. Other income expenditures were negligible as shown in Fig 4.4.



**Fig 4.4: Household income expenditure**

## 4.2 Protein, Zinc and Iron- rich Foods Consumption Frequency and adequacy

The assessment done to find out the frequency of consumption of protein, zinc and iron rich foods showed that the majority of households did not consume (or consumed in less than 3 days in a week) enough of these foods as shown in Table 4.3. Only cereals and their products were adequately consumed by more than 80% households.

**Table 4.3: Consumption Frequency of Protein, Zinc and Iron rich Foods**

Food item	Had not consumed (%)	Had consumed (%)	<3days (%)	≥3days (%)	avg freq <sup>1</sup>
Milk	38.6	61.4	63.0	37.0	2.2
Eggs	30.3	69.7	92.4	7.6	1.5
Fish	59.8	40.2	96.2	3.8	0.71
Chicken	87.9	12.1	100	0.0	0.14
Beef	18.9	81.1	94.4	5.6	1.6
Liver	85.6	14.4	100	0.0	0.14
Organ meat	69.7	30.3	97.5	2.5	0.4
Pulses	20.5	79.5	60.0	40.0	2.8
Mursik <sup>2</sup>	56.1	43.1	89.7	10.3	0.91
Grains/product of	0	100	9.1	80.9	6.1

<sup>1</sup>Average food consumption frequency, <sup>2</sup>locally fermented milk

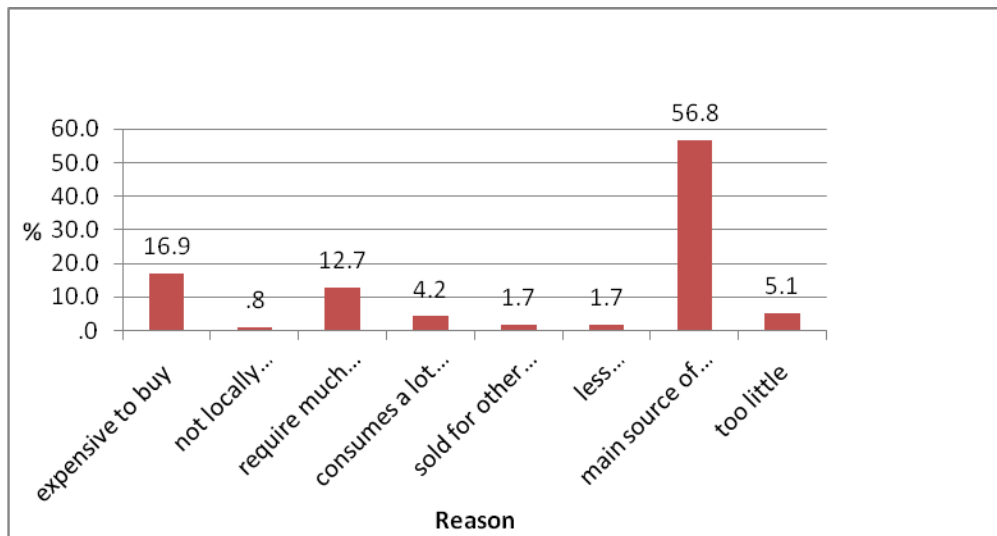
Majority (79%) who consumed milk did it from own production and only about 20% purchased from their neighbours. The 39%, who did not have milk in the previous 7 days, gave the cost as the major constraint to its consumption.

It is also worth noting that the mean frequency of fish consumption was found to be very low, and many households did not consume it per week (0.71). Among those who did not eat fish, 40% and 17% gave the high price and unavailability of fish respectively as the main reasons. 70% of people in the study had eaten eggs in the past seven days of the study. Of these 81.5% and 18.5% had obtained them from own production or purchasing. Only 12% had consumed chicken during the study period. Only 19% of the study population had not consumed beef within the study period. 92% of these stated that meat was expensive to buy. Very few had eaten liver (with an average frequency of .14) less than once a week. Due to high cost, 42% of the study

population did not consume mursik. It was noted that it was expensive to buy while 36% believed it was not locally available. All (100%) of the households had consumed grain and cereals, with the highest frequency consumption of more than 6 days a week. Over 60% consumed pulses from their own stock produced while the remainder purchased from local sources.

#### 4.2.1 Pulses/legumes consumption

As shown in Table 4.3, the majority of households (80%) had consumed pulses during the study period, with many consuming it less than three days a week (60%). 57% of households mentioned storing pulses for future scarcity as the main reason for infrequent consumption. Other reasons for infrequent consumption are as shown in Fig 4.6.



**Fig 4.5: Reasons for infrequent consumption of pulses**

Increased production of lablab will improve the consumption adequacy for legumes and therefore intake adequacies for protein, zinc and iron.

#### **4.2.2 Household intake adequacies for protein, zinc and iron**

The assessment was conducted using 24 hour recall questionnaire in 32 representative households from the four sites to determine the adequacy of the intake of protein, zinc and iron.

The results are shown in Table 4.4:

**Table 4.4: Intake of protein, zinc and iron by households**

<b>Nutrient</b>	<b>% households meeting RDA</b>	<b>% households not meeting RDA</b>
Protein	78.1	21.9
Iron	53.1	46.9
Zinc	87.5	12.5

Majority of the households had inadequate intakes for protein, zinc and iron. There is therefore need for a food based intervention strategy for the inadequacies.

#### **4.3 Households' nutritional knowledge and status of pulses**

Two FGD were held using pretested questionnaire see Appendix X for FGD questionnaire guide. Women who are always responsible for food preparation in their homes were involved in the FGD. A total of 17 participants with 8 and 9 participants in the first and second discussion attended the discussions respectively.

Participants clearly identified that vitamins protect the body against diseases. They also recognized fats and carbohydrates as sources of energy giving and protein for body building. The main source of protein during the discussion were found to be; beef, pulses, eggs, fish and milk.

The community mainly consumed beans and milk about three times a week. According to participants the main types of pulses consumed were Wairimu, Nyayo and Rosecoco.

Nyayo is the preferred variety to the other varieties owing to its high yields. The produced pulses were mainly consumed and generation of income. Some households though exchanged pulses for school fees.

#### **4.4 Main methods of pulses preparation**

From the FGD, pulses were mainly prepared by overnight soaking and boiling. In some households the pulses were not soaked because it led to loss of taste and texture. The main source of energy was firewood, which created concern because of its demand due to high cost of energy needed during cooking. Some participants reported stomach problems as the main hindrance to full utilization. The community believed that nyayo and Lablab require longer cooking time.

Many of the households had never taken lablab as food but regarded it as a soil improver; which is the main reason why Lablab was introduced. They also considered it as a source of revenue when grains are sold at a current price of US\$1.4 per kg. The few households who grew lablab ate grains, but used leaves as animal feed to a small extent or for compost. Compost making was introduced to the community by the DGP-CRSP project as a means to improve the soil.

In addition, some households complained of the smell generated by the cooking and the odour of its vegetation on the farm. These reactions were however, expected because lablab is still new in the region.

#### **4.5 Nutritional composition of Lablab grain and leaf**

The grain and leaf from each site were analysed for proximate and minerals. There were no changes in proximate and mineral composition as influenced by (levels of soil fertilization) site as shown in Table 4.5 and 4.6 respectively.

**Table 4.5: Proximate Analysis of Lablab Leaves and Grain**

Site	Grain %								
	C	N	moistC	CP	CFAT	TTASH	CFB	CBH	Kcal/100g
Koibem	3.91	0.38	12.39	22.68	0.82	3.12	8.46	52.54	308.24
Bonjoge	3.53	0.31	12.16	19.79	0.99	3.295	8.64	54.62	305.51
Kiptarus	1.87	0.26	12.36	20.84	0.83	2.75	8.6	54.62	309.31
Kapkarer	1.44	0.16	12.17	23.73	0.85	2.865	8.72	51.68	309.25
Mean	-	-	12.27	21.76	0.871	3.006	8.605	53.3	308.08
SEM	-	-	0.446	0.061	0.057	0.161	0.046	0.189	0.71
F	-	-	0.1	869.7*	0.287	2.3	5.6	56.9*	6.3
	Leaves								
Koibem	3.91	0.38	3.5	23.29	3.06	6.3	15	48.86	316.1
Bonjoge	3.53	0.31	3.69	25.48	3.06	5.79	15.63	46.36	314.84
Kiptarus	1.87	0.26	2.68	25.66	3.03	6.86	16.76	45.02	309.97
Kapkarer	1.44	0.16	3.74	25.74	2.78	5.31	18.43	43.73	302.86
Mean	-	-	3.4	25.04	2.98	6.07	16.42	45.99	310.94
SEM	-	-	0.053	0.165	0.088	0.19	0.072	0.358	1.16
F	-	-	88.3*	50.7*	2.5	14.5*	429.6*	37.5*	26.9*

Figures are the means of two independent determinations

Site- regions of levels of soil fertilization, C- % carbon content for each site, N-% nitrogen content for each site, Unit of analysis G- Lablab grain, L- Lablab leaves; moistC- moisture content, CP- Crude protein, CFAT- crude fat, TTASH-total ash, CFB- crude fibre, CBH- carbohydrate, Kcal-Kilocalories

**Table 4.6: Mineral Composition of the Lablab grain and Leaf**

Site	Grain		Leaf	
	Zinc	Iron	Iron	Zinc
Site	µg/g	µg/g	µg/g	µg/g
kap	31.96 ± 4.85	51.16 ± 13.23	320.97 ± 101.37	38.26 ± 10.63
Kipt	35.73 ± 4.32	57.61 ± 12.15	210.57 ± 37.82	27.10 ± 5.52
Bonj	33.03 ± 1.72	59.11 ± 6.58	382.14 ± 157.71	26.84 ± 4.55
Koib	34.45 ± 3.42	57.42 ± 9.37	194.84 ± 30.89	26.50 ± 3.28
<b>AVG</b>	<b>34.27 ± 3.67</b>	<b>56.94 ± 10.21</b>	<b>277.13 ± 121.87</b>	<b>29.68 ± 8.10</b>

Sites Kap-Kapkarer, kipt-kiptaruswo, Bonj-Bonjoge, Koib koibem, AVG- average

Source: Personal communication with Lauren and Dry Grain Pulses CRSP Annual Report, (2010).

#### 4.5.1 Influence of soaking time on anti-nutrient and *invitro*-protein digestibility

Table 4.7 shows the results on influence of time for soaking lablab grain on anti-nutrient and *invitro*-protein digestibility. The influence of soaking time on total and extractability of zinc and iron is summarised in Table 4.8.

The results included those of tannins, TIA, phytic acid and *invitro* protein digestibility. Tannin and TIA significantly reduced with increase in soaking time, while phytic acid did not show any clear pattern. There was, however, a significant increase in *invitro*-protein digestibility.

**Table 4.7: Effect of time of soaking and cooking lablab grain on anti-nutrients**

Time (hrs)	tannin mg/100g	TIU/ TU/g	phytic acid g/100g	<i>invitro</i> pd (%)
0	640.30	2160	2.47	40.30
12	164.40	0.00	2.81	50.27
24	152.50	0.00	2.76	67.41
SEM	20.87	23.09	0.031	0.58
F	177.8*	2916*	34.9ns	569.5*

*invitro* pd- *invitro* protein digestibility, tannin, trypsin inhibitor units (TIU) measured across time of soaking of 0,12 and 24 hours. F\* indicate that the difference is statistically significant while ns-not statistically significant.



**Table 4.8: Influence of soaking time on total iron and zinc and their extractability**

Time (hrs)	total Fe	total Zn	Fe exct	Zn exct
	Mg/100g	mg/100g	mg/100g	mg/100g
0	7.32	4.36	0.81	0.38
12	7.14	4.75	0.85	0.43
24	5.78	5.16	0.88	0.4
SEM	5.69	3.025	0.096	0.56
F	2.20	1.70	13.50*	0.87

Fe exct-iron extractability, Zn exct-zinc extractability, % Feexct-% of iron extracted from the total, %Znexc- % of zinc extracted from the total.

Increase in period for soaking grain only increased the extractability (bioavailability) for iron but there was no change for total iron and zinc and extractability of zinc. Soaking as a preparation method did not cause a significant loss of minerals from lablab grain.

#### 4.6 Cookability of Lablab

Table 4.9 shows the results of time taken for lablab grain to cook as influenced by length of soaking time. Cooking time was recorded as time taken from the initiation of the heating until 20 of the 23 pins of the Mattson cooker dropped and penetrated through 80% of the beans. Soaking of the grain significantly reduced the cooking time. After eight hours, further soaking did not significantly reduce the cooking time. It therefore serves a dual purpose of increasing bioavailability of nutrients and reducing cost of energy for cooking lablab.

**Table 4.9: Mean cooking time**

Period of soaking (hours)	0	2	4	8	10	12	24
Mean cooking time (minutes)	207.8±11.56	182±3.40	102.3±5.13	67.95±3.08	67.86±3.62	61.55±1.87	53.68±1.33
% time reduction	0	12.4	50.8	67.3	67.7	70.4	74.2

The temperature of cold and boiling water was 19°C and 93°C respectively.

## **CHAPTER FIVE: DISCUSSION**

The study examined the potential role Lablab crop has to play in improving consumption adequacies for protein, zinc and iron in humans the determinants included; demographic and ecological factors: nutrition and diet-related indicators which were qualitative and semi-quantitative measures of intakes for protein, zinc and iron. Socioeconomic indicators including maternal literacy, occupation and household income and expenditure were also established.

### **5.1 Demographic Characteristics**

The mean household size of 6.1 was found to be larger than the Kenyan national average household size for rural areas of 4.7. Large household size puts immense pressure on limited resources for meeting health and nutritional requirements (CBS, 2009). Sex distribution of the study population was 51.1% females and 48.9% males (1 female: 1 male). These figures are in agreement with the general Kenyan population; 51% females and 49% males (CBS, 2009). Half of the population is below 15 years and the mean age is 22. This youthful age structure is characterized by high fertility and high mortality (CBS, 2004); this age also presents a high dependency ratio which may translate to provision of inadequate diet intake and hence the nutrient concerned.

Males and female significantly differed in education levels inasmuch as the population ratio was 1:1. Males were significantly favored over females. This may imply that the girl child is still neglected and resources are channeled towards the boy child. This has far reaching implications in terms of employment opportunities and economic dependence. Lower education may limit mothers' exposure to general information on nutrition and compromise on choice of food crops to be grown, given that woman is responsible for food production. This would further compromise on food security and nutritional quality in the households. In 2004 KDHS for

example, showed that women with little or no education have low access to media as compared to those who had attained secondary and tertiary education. Maternal literacy is an important indicator for assessing risk in children (WHO, 1996), and this empowers mothers in contributing to nutrients adequacy in the households.

## **5.2 Socio-economic characteristics**

Majority of the households had low income levels and survived on less than half US dollar per person per day half way below the recommended poverty cut-off of 1 US dollar per person per day. This meant that as expected the study households spent higher percentage of income on food and basic needs (WHO, 1996) and could not have adequate capacity to access adequate and quality foods at all times. Majority (70%) were involved in farming while formal employment which should increase monetary income stood at 17%. Accordingly they sourced their food mainly from own farm produce. The pressure to generate income from sale of farm produce or formal employment for paying education or purchase for food meant as expected adopting carbohydrates rich as opposed to protein rich foods which are also rich in zinc and iron. Accordingly the study population was appropriate for carrying out investigation on the potential for lablab production as an interventional strategy to mitigate against food and nutrients (protein, zinc and iron) insecurity.

## **5.3 Protein, Zinc and Iron rich Foods Consumption Frequency**

Majority of the households in Nandi South District derived their protein, zinc and iron from plant sources. This may be attributed to the fact that the income per family is low and animal food sources are expensive. Expenditure priority also explained this, many spent on education rather than on food which came closely second. Because majority of the households were earning less than a dollar a day/person, spending on expensive animal food sources was not a priority. Many

also cited that infrequent consumption of animal sources of protein was because; the animals were regarded as a source of livelihood (an asset) except for milk and related products whose consumption was also low. Plant nutrients have low bioavailability owing to the high concentration of anti-nutrients. This raises the concern of the development of iron, protein and zinc deficiencies as there is dependency on plant nutrient sources. It is also worth noting that income determined to be half US dollar per person per day, food prices which was the main cited reason for inadequate consumption of foods rich in protein, iron and zinc also individual preferences and beliefs, cultural traditions, as well as geographical, environmental, social and economic factors all interact in a complex manner to shape dietary consumption patterns (WHO/FAO, 2003).

#### **5.4 Dietary Intake of protein, Zinc and Iron in Nandi South District**

Survey based on 24 hour recall data found that over half of the study group received adequate amounts of iron, zinc and protein. 47%, 13% and 22% of studied households, however, did not achieve the requirements for iron, zinc and protein respectively. Lablab bares great potential if it is promoted as a multipurpose crop. Having a protein, zinc and iron content of 22%, 34mg/kg and 57mg/kg respectively, confers it potential to supply the inadequacies if incooperated in the menu

#### **5.5 Consumption of pulses in Nandi South District**

The frequency of consumption of pulses is still low and in the region the Lablab's consumption is negligible as opposed to other pulses. From the results Lablab nutrient composition compares well with other legumes providing an average of 22% protein, 308 Kcal/100g, high fibre content and appreciable amount of zinc and iron so it is as valuable as other pulses in improving the consumption adequacies for protein, zinc and iron in households.

## 5.6 Nutritional composition of Lablab grain and leaves

Crude protein, fat and fibre content values of 21.8%, 0.87% and 8.6% were consistent with the results obtained from analysis of raw *D. lablab* (Vijayakumari, 1995) with crude protein at 22.09%, crude fat 0.87% and crude fibre at 7.6% respectively. The mean crude protein concentration of Lablab of 21.8% was within the range of 18-29%, 20.4-28.4% reported by Bourne (1989) and Oktsoi (2009) respectively in their studies involving many bean varieties. The mean crude protein concentration of lablab grain is however slightly lower than 25% which was reported by Osman (2007) and 26.6% (Gowda, 2009), but within the range of common edible legumes.

On dry matter basis, crude protein content of the leaves (25%) was higher than that of the grain. This is because of reduced moisture content increasing the dry matter of the leaf. The grain, however, still remains a better source of protein than the leaf because most locals do not consume dried leaves. At least among legumes, they are one of the best sources of zinc (34mg/kg) and iron (57mg/kg) on grain. On leaves, the concentrations were found to be 27.7mg/kg and 30mg/kg for iron and zinc on dry weight respectively.

Lost Crops of Africa (2006) reported zinc content of ranging from 26.9-42.9mg/kg and iron from 70.0-107.1mg/kg in lablab grain indicating that for zinc, the content fell within the range while iron content was lower than the reported. In a separate study involving 72 bean varieties iron content ranged from 34-89mg/kg with a mean of 55mg/kg, and zinc content ranging from 12-62mg/kg with a mean of 31mg/kg was reported (CIAT, 2004). These values are consistent with those analysed in this study.

### **5.6.1 Effect of preparation method on nutrient and anti-nutrient content of Lablab**

Soaking and cooking have been the main methods used to prepare legumes. Cooking makes the grain more palatable and improves the digestibility of the grain by reducing anti-nutrients. This study showed that soaking in plain water for different periods led to the reduction of trypsin inhibitory activity (TIA) and tannins to non-detectable levels. This may be attributed to the leaching out of the anti-nutrients to the soaking water along the concentration gradient (Osman, 2007). Similar losses of tannin and TIA were observed by Mbithi *et al.*, (2000) in germination of finger millet, Ramkrishna *et al.*, (2006) reported a reduction of TIA by 51% on dry Lablab grain after soaking for 12 hours in soaking studies of Dolichos Lablab. Cooking further reduced TIA. This fact has also been established in soaking jack beans for 24 hours prior to cooking, in which almost all the TIA was destroyed within 15 to 20 minutes of cooking (Babar *et al.*, 1998). Similar reduction of both TIA and tannin were realized by Udensi *et al.*, (2007) on boiling vegetable cowpea, where tannin was reduced by 75% and TIA by 52%. TIA reduction may be attributed to its low molecular weight and therefore solubility and leaching in soaking water and heat inactivation during cooking. Trypsin inhibitors ingested in significant amounts disrupt the digestive process and may lead to undesirable physiological reactions.

Tannin reduction on the other hand may be because of their solubility and therefore leached out in the cooking water (Udensi *et al.*, 2007). Dry lablab had a lower *in vitro* protein digestibility (IVPD) of 40% than reported by Osman (2007) at 88% and Vijayakumari (1995) at 64%. The values compared with those of wild legumes ranging from 63.39 to 83.32% (Vadivel and Janardhanan, 2005). The low values of *in vitro* protein digestibility may be due to the presence of anti-nutritional factors and globulins as the major protein in pulse seed (Sudesh *et al.*, 1989). On soaking and cooking after 24 hours, there was a significant increase of IVPD to 67.4% which

is close to IVPD of 70% on *D. Lablab* (Vijayakumari, 1995). This increase may be attributed to the reduction of TIA, polyphenol and is in agreement with the findings of Yagoub and Abdalla (2007). It is important to soak lablab grains before cooking to improve its protein digestibility. Soaking, however, did not reduce the levels of phytic acid in lablab. Akindahunsi (2004) observed an increase in phytic acid content upon soaking and cooking of African oil beans. Vidal-Valverde et al. (1998) in soaking faba beans in either water, acid, or base solutions concluded that there were no significant changes ( $P < 0.05$ ) in phytic acid levels. Many studies on legumes, cereals, and other oilseeds have showed that phytic acid is highly charged with six phosphate groups extending from the central inositol ring structure which makes it more stable under ordinary processing conditions and that soaking in acidic water may be effective in reducing phytic acid (Thompson, 1990).

The implication of high phytic acid consumption is in the induction of mineral deficiency through the formation of insoluble salts with divalent metals, particularly calcium, magnesium, iron and zinc, making these unavailable to the body (Osman, 2007). In addition to these, antioxidant enzymes requiring zinc as cofactors are not synthesized without zinc, while erythropoiesis may become impaired due to non-iron availability (Ramkrishna, 2006). Phytic acid therefore still poses a challenge in the full utilization of the lablab as a potential nutrient source.

## CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

### 6.1 Conclusions

- The population in Nandi South comprises of large households with individuals living below a per capita income. The main source of income is from farming, with their main source of livelihood being farming.
- Consumption of protein, zinc and iron rich food sources by the study community was low leading to the inadequacies of intakes for these nutrients. Legumes had the highest frequency of consumption and therefore had the largest contribution to protein intake among the protein rich foods.
- Like any other food legumes, Lablab is a good source of dietary protein, zinc and iron but have relatively low protein digestibility and mineral extractability. Soaking and cooking treatment is effective in enhancing; the digestibility of protein, bio-availability of both zinc and iron, elimination of both TIA and tannins of these grains. Soaking and cooking therefore enhances intakes of protein, zinc and iron from lablab.
- The high levels of these nutrients in leaves does bear promise for significantly increasing iron, zinc and protein intake in communities that consume bean leaf as vegetable. There is however need for nutrition education to improve preparation technology to increase bio-availability of nutrients.



## 6.2 Recommendations

- A controlled study beginning with specific soil fertility mapping, controlled planting, agronomy and harvesting for analysis in order to establish the exact influence of soil fertility on nutritional composition of lablab and the resultant nutritional status of the people.
- There is need for promotion efforts in adopting Lablab given its potential impact and soil fertility and as a credible protein source.
- Further studies to be conducted to profile amino acids, other anti-nutrients including cyanogenic glycosides, forms of tannins and phytic acids contents of Lablab and their influence on bioavailability of protein, zinc and iron in the diet.
- Research on readily adoptable methods by the community to effectively reduces anti-nutrients especially phytic acid and to increase protein digestibility of lablab protein. Proposed methods include; solid state fermentation and breeding.

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## 8.0 APPENDICES

### Appendix I: Summary of Field Assistant Training Program

Day	Time	Subject Matter	Learning method	Learning Aids
1	8.30-10.30 Am	<b>Research Ethics:</b> By the end of the session, the Field assistant (F.A) should be able to explain research ethics with regard to dressing code, courtesy, morals, respect of respondent's wish and confidentiality of data collected	One on one Question and answer	Notes
	11.00Am-1.00 Pm 2.00pm 5.00pm	<b>Interviewing Skills:</b> By the end of the session, the F.A should be able to demonstrate good interviewing skills e.g. probing, avoiding leading questions, modest introduction to respondent, avoiding tiring interviews, apologizing when asking too much and translating the questionnaire to local language(s)	Question and answer One on one Assignment Role play	Notes
2	8.30am 10.30am	<b>Focus Group Discussion (FGD):</b> By the end of the session, the F.A should be able to explain what an FGD is, its rationale and process of administration	One on one Demonstration Role play	Notes
	11am-1 Pm	<b>PEM, Iron and Zinc deficiency clinical assessment:</b> By the end of the session, the F.A should be able to demonstrate knowledge on identifying the above	Assignment Question and answer	Questionnaire Field practice
	2.00-5.00pm	<b>Food Frequency:</b> By the end of the session, the F.A should be able to explain what a food frequency is and be able to administer a food frequency questionnaire, as well as understand its rationale, and be able to list examples of protein , zinc and iron rich foods	One on one Question and Answer	Notes Questionnaire Field practice
3	8.00-10.00 Am	<b>24-Hr Recall:</b> By the end of the session, the F.A should be able to demonstrate administration of a 24-hr recall, measure volumes using the provided household measures and read calibrations correctly	One on one Demonstration Question and answer	Questionnaire Notes Exercise Field practice
	11.00Am-5.00 Pm	<b>Pre-test:</b> By the end of the exercise, the F.A should be able to demonstrate knowledge of data collection using the questionnaire	Demonstration Practical	Field practice

## Appendix II: Check List for Tools

Tool	Tool
<p><b>Personnel:</b></p> <ul style="list-style-type: none"> <li>Supervisor</li> <li>Investigator</li> <li>Field assistants</li> </ul> <p><b>Finances</b></p> <ul style="list-style-type: none"> <li>Field transport</li> <li>Miscellaneous</li> </ul> <p><b>House hold measures:</b></p> <ul style="list-style-type: none"> <li>Measuring cylinder (1000ml)</li> <li>Measuring cylinder (100ml)</li> <li>Serving bowls</li> <li>Teaspoons</li> <li>Tablespoons</li> <li>Cups</li> <li>Food scale</li> </ul>	<p><b>other equipment:</b></p> <ul style="list-style-type: none"> <li>Field bags</li> <li>Flash disk</li> <li>Lap top</li> </ul> <p><b>Stationery:</b></p> <ul style="list-style-type: none"> <li>questionnaire</li> <li>notebooks</li> <li>Pens</li> <li>Pencils</li> <li>Erasers</li> <li>Sharpeners, files, clip board</li> </ul> <p><b>Lab measures</b></p> <ul style="list-style-type: none"> <li>Apparatus and instruments</li> <li>Reagents</li> </ul> <p><b>Other materials:</b></p> <ul style="list-style-type: none"> <li>Lablab samples</li> </ul>

### Appendix III: Matrix showing conversion of objectives into variables, outputs and activities

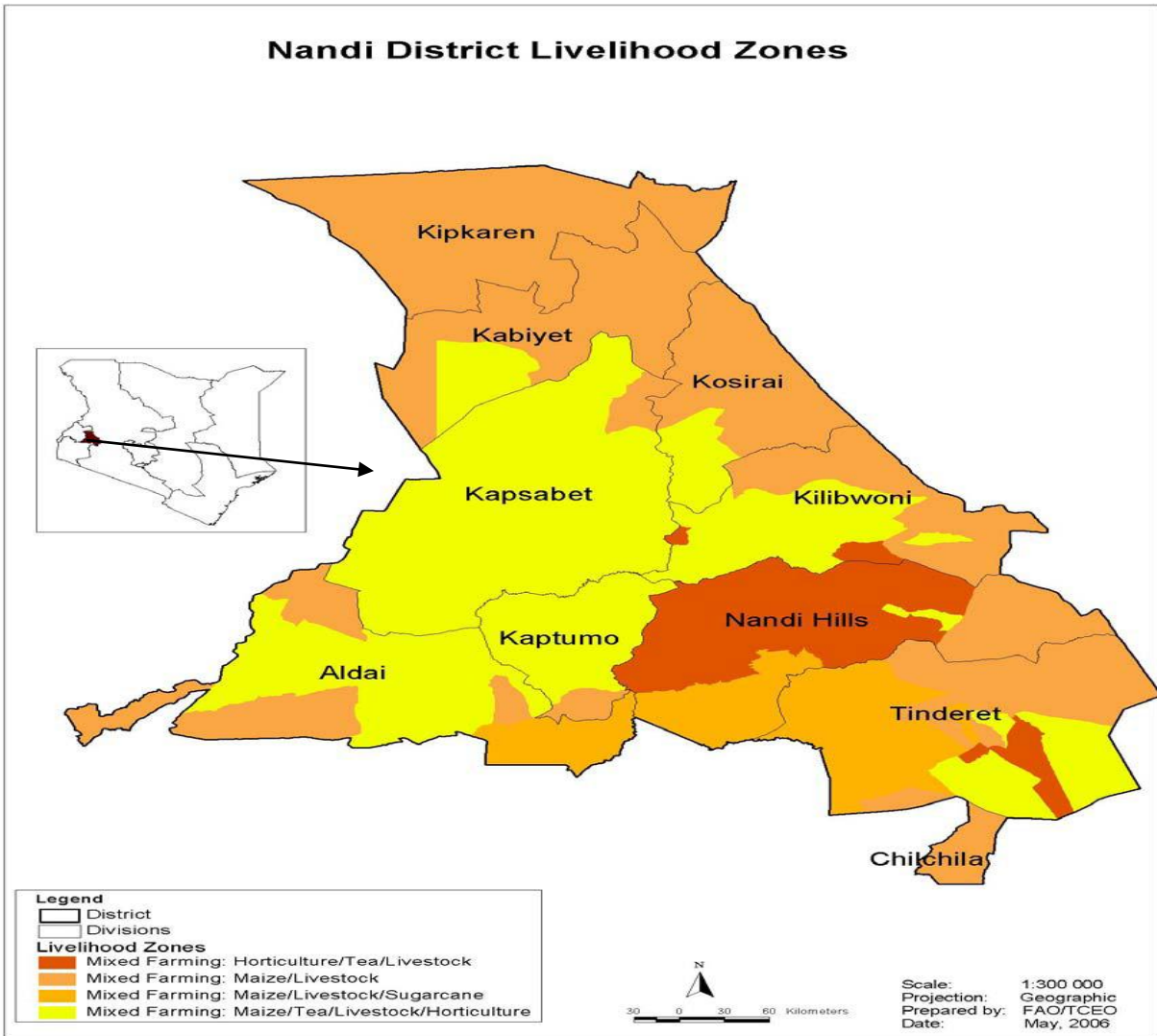
Specific objective	Variable	Type of variable	Activity	Equipment/ resources	Output	Indices	Indicators	Define indicators	Sample unit	Statistical test
1)To determine socio-demography and socio-economic status of Nandi South district households	HH size Age Sex HHH Education level of HHH Source of income	Discrete Continuous Nominal Nominal Ordinal Nominal	Interview Fill questionnaire “ “ “ “ “	Questionnaire Pencil Eraser “ “ “ “ “	Socio-demo-graphic characteristics determined     Socio-economic status determined	Socio-demo-graphic characteristics     Income sources	Small/medium/ big size — —   Income source	1-small(3-4 people) 2-medium(5-6 people) 3-big(>6people) —  1-male 2-female 1-male headed 2-female headed  1-completed primary 2-completed secondary 3- post secondary  1-pastoral 2-agro-pastoral 3-marginal mixed farming 4-mixed farming 5-formal employment/business 6-casual labor/ petty business	HH   HH member HH head  HH head  HH	Descriptive  Mean Mode Median Sd Range Frequencies Proportions CI Ratio
Specific objective	Variable	Type of variable	Activity	Equipment	Output	Indices	Indicators	Define indicators	Sample unit	Statistical test
To determine protein, iron and zinc intake adequacies in Nandi South district and contribution	Protein, zinc and iron intake	Ordinal	Administer 24-hr recall Fill questionnaire, and FGD questionnaire	Questionnaire Household measures	Data on 24-hr recall for 30 HH	Amount of protein, zinc and iron taken in the last 24 hours	Protein, zinc and iron adequacy/ inadequacy/ absent	Total household protein, zinc and iron requirement.	HH	Chi-square

made by legumes			guide							
To determine frequency of consumption of legumes in the house holds	Legume consumption frequency	Ordinal	Interview  Fill questionnaire	Questionnaire	Entries on frequency of legumes consumption for HHs	Frequency of consumption of legumes	Frequent/less frequent/rare /never	3-frequent(>3 times weekly), 2-less frequent(1-3 times weekly), 1-rare(<3 times per week to x1 monthly) 0-never	House hold	descriptive
<b>Specific objective</b>	<b>Variable</b>	<b>Type of variable</b>	<b>Activity</b>	<b>Equipment</b>	<b>Output</b>	<b>Indices</b>	<b>Indicators</b>	<b>Define indicators</b>	<b>Sample unit</b>	<b>Statistical test</b>
3) To determine proximate composition, protein and antinutritive factors status in Lablab grown in Nandi South district	Contents of protein, carbohydrates, oil, moisture, fibre/ash, minerals (zinc and iron) and antinutrients-phytic acid, trypsin inhibitor, tannin.	Nominal	laboratory analysis for proximate analysis, invitro protein digestibility, antinutritive factors	Test tubes, oven, centrifuge, micro-kjeldahl, soxhlet extractor, mason cooker, AAS, Reagents, Dry grain lablab	Results of proximate composition, protein and antinutrients in Lablab grain samples	mg/100g		Data recorded	Grain Lablab	Correlation Regression
4) To determine the effect of methods of legume preparation in households of Nandi South district on protein, zinc and anti-nutritive factors.	Methods	Nominal And ordinal	Fill out questionnaire and lab analysis	Questionnaire and lab instruments (micro-Kjeldahl, AAS, centrifuge, reagents, Dry grain lablab	Entries on various methods employed and lab analysis results for each method identified	Number of methods Mg/100g for protein, zinc, iron and anti-nutrients	Loss of protein and anti-nutrients	Data recorded	Household and grain lablab	Descriptive, correlation, ANOVA and LSD.

## Appendix IV: Log Frame

Narrative Summary	Output	Activities	Inputs	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
<b>Goal:</b> Assess the potential of Lablab (Njahi) in contribution of protein intake of households						
Purpose: <b>specific objective 1</b> Determine socio-demography and socioeconomic status of Nandi South district households	Socio-demography, socio-economic status determined	Interview Fill questionnaire	Questionnaire Pencil Eraser	Filled in questionnaires	Questionnaire	Respondents will be honest and fully cooperate during the exercise.
Purpose: <b>specific objective 2</b> To determine protein, zinc and iron intake adequacies and contribution made by legumes in Nandi South district households	protein intake determined, frequency of consumption of pulses determined	Administer 24 hr recall, Fill questionnaire, Frequency of pulses (lablab) consumption determined	Questionnaire, House hold measures, Interview	Filled in questionnaire	Questionnaire	Respondents honest on previous day's dietary intake, Respondents able to recall frequency of consumption
Purpose: <b>specific objective 3</b> To determine proximate composition, zinc, iron and anti-nutritive factors in lablab grown in Nandi South district.	Determination of proximate composition iron, zinc and anti-nutrients,	Laboratory analysis	Lablab samples, reagents, apparatus, instruments and analysis manual	Filled results' Table	Results Table	Apparatus and instruments will be in right condition, reagents will be pure & right prompt assistance offered during analysis.
Purpose: <b>specific objective 4</b> To determine the effect of methods of legume preparation in households of Nandi South district on protein, zinc, iron and anti-nutritive factors.	Number of methods used, Protein, zinc and iron content	FGD, Lab analysis of protein content in each method.	FGD questionnaire guide, Lablab samples, Reagents and apparatus,	Filled in questionnaire, Filled result Table	Questionnaire , Result Table	Participants will be willing to freely give true information, Apparatus and instruments will be in right condition.

**Appendix V: Map of Larger Nandi district**



## **Appendix VI: Training Module for Training Field Assistant**

### **Topics:**

- Research ethics
- Administering questionnaire
- Conducting interview
- Administering food frequency
- Administering 24-hour recall

### **Objectives**

The main objective of the training is to be able to collect good quality data that is reliable by ensuring the field assistant (F.A) is thoroughly trained.

The sub-objectives of the training are as follows:

- To make F.A aware of research ethics to be followed in the field, including cleanliness, positive attitude and morals to observe during field work
- To orient and make F.A aware of respondent's interests and welfare, through confidentiality of data collected
- To make F.A familiar with data collection techniques using questionnaire
- To make F.A competent in administering a food frequency and 24-hour recall
- To make the F.A competent in administering a food frequency questionnaire

### **Teaching and Learning Methods**

- One on one
- Question and answer
- Assignment
- Role play
- Demonstration
- Practical

### **Learning Materials**

- Notebook
- Pen
- Pencil and Hand outs

## Appendix VII: Research Tools and Materials

Questionnaire Number.....

**UNIVERSITY OF NAIROBI**

**DEPARTMENT OF FOOD SCIENCE, NUTRITION AND TECHNOLOGY**

**APPLIED HUMAN NUTRITION PROGRAMME**

**IDENTIFICATION:** Lablab farmer? (Yes/No) .....

Date.....Location..... Sub location.....Cluster.....HH No.....

Village.....Name of respondent.....Sex.....Name of interviewer.....

### SECTION A: DEMOGRAPHIC CHARACTERISTICS

**Qn.1.** Household Characteristics: details for everyone with whom you share the same pot with, daily

Serial No.	Name	RHHH	Sex	Age (yrs)	Education level	Occupation	Marital status	Religion
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

#### Codes

RHHH	Education level	Occupation	Marital status	Religion
1=HHH	1=college/university	1=salaried employee <sup>1</sup>	1=married	1=Christian
2=spouse or wife	2=completed secondary	2=farmer	2=separated	2=Muslim
3=son	3=completed primary	3=self employment/business	3=widowed	3=Traditionist
4=daughter	4=Dropped from primary	4=casual labourer	4=single	4=others (specify)
5=grandson	5=Attending primary	5=student	5=divorced	
6=grand daughter	6=Attending secondary	6=housewife	6=not applicable	
7=relative <sup>4</sup>	7=Literate e.g. adult education	7 = unemployed <sup>2</sup>		
8=parent	8=Illiterate	8 =others (specify)		
9= others (specify)	9=preschool	9= n/a <sup>3</sup>		
	10=others (specify)			

<sup>1</sup> For both adults and for children above 10 years who are employed

<sup>2</sup> Anyone above 18 years and not in college or employed

<sup>3</sup> For preschoolers below 6years.

<sup>4</sup> Relatives includes uncles, aunts, nephew, nice and steps



**Qn 2.** What is the household's main source of income (Livelihood)?

- 1=Animal and animal product sales      2=Sale of farm produce      3=mixed farming  
 4=Salaried/ waged      5= Casual labor      6=Trade  
 7=Remittances      8=Begging/ gifts

**Qn. 3.** How much income does the household earn per month? (or year if selling annual crops).  
 Ksh. ....

Qn 4. how do you spend the income in order of importance?  
 Buy food      healthcare      buy clothes      education

**Appendix VIII: Food frequency questionnaire**

**SECTION B:**

**Qn.4** Please indicate; how many times in the last seven days did your household eat each of the food I list? (Explain to the mother that you want the no. of days, not the no. of times)

SN	Food item name	Food eaten 1-Yes 0-No	No. of days the food was consumed	Source of food 1=produced 2=purchased 3= gifts	Reasons why not consumed 1=Expensive to buy 2= Not locally available 3= Taboos 4= Doctors instructions 5= Allergy 6= Too long to cook 7= Consume lot of energy 8= Others (specify)	Reasons specifically for pulses
1	Whole milk					
2	Fish					
3	Eggs					
4	Chicken/poultry					
5	Beef					
6	Liver					
7	Offal/organs					
8	Pulses					
9	Termites					
10	Mursik					

**SECTION D: OPINION**

Qn. 6. Why did you opt to/ not to join the KARI lablab project?

.....

.....

**SECTION E: 24 HR RECALL-** Now you will list for me all the meals that were prepared in this household yesterday since you woke up, till evening and all night. (Have the respondent list all meals first, afterwards ask for the ingredients, amounts of each ingredient, then volume of all meal cooked +| remaining

**Appendix IX: 24 Hour Recall**

Dish				Ingredients used in preparation							HH consumption			FINAL EXPRESSION				
Time	Description of Dish	Total amt (ml)	Dis h cod e	Description of ingredients	Amt used (ml)	U n it	s r e	Siz e	Price			Ing co d	Amnt Servd (ml)	Plate waste	Amou nt consu med	Weight of ingredients:		
									HH msr	Mkt size	If boug ht					g	g wast e	g consu med

**Codes**

<u>Time</u>	<u>Unit codes</u>		<u>Level;Heaped</u>	<u>Size</u>	<u>Source</u>	<u>Ingredient code</u>
1=beforebreakfast prepared)	1=gm	7=heap	21;31=tsp	1=small	6=1kg tin	1=own production (separate code list to be
2=breakfast	2=ml	8=slice	22;32=tbsp	2=medium	7=1kg kasuku	2=bought
3=btbreakfastandlunch	3=kg	9=loaf	23;33=tin	3=big	8=2kg kasuku	3=donation/gift

## **SECTION C: FGD QUESTION GUIDE**

### **Appendix X: Focus Group Discussion Question Guide**

**Topic: CONSUMPTION PATTERNS, PRACTICES AND METHODS OF PREPARATION OF PULSES**

**Duration:** 45 minutes

#### **Introduction:**

Introduce team and general purpose of the discussion

#### **Main Discussion**

1. What are the main sources of livelihood in this community?
2.
  - a) What do you understand by the term protein, Iron and Zinc?
  - b) What are their importances in the human body?
  - c) What are the food sources of protein, Zinc and Iron?
  - d) Which of these sources are mainly consumed by people in this area and how often?
3.
  - a) Do people in this area produce pulses?
  - b) If yes, which varieties do you stock or use?
  - c) Which variety is preferred and why? (Proportional pilling)
4. What are the pulses used for in this community?
5. Why are pulses important in human diet?
6.
  - a) How do you prepare pulses before eating?
  - b) What form of energy do you use for preparation?
  - c) What challenges do you face in preparation of pulses for your family?
  - d) Which challenge would you rank the most important? (Proportional pilling)
  - e) How have you tried solving these challenges?
7.
  - a) What potentials do you think Lablab have?
  - b) How have people taken it in this region?

## Appendix XI: Matrix for Data Processing/ Analysis Plan

<b>Objective 1: To determine socio-demography and socio-economic status of households</b>
<b>Variables:</b> family size, sex, age, education level, occupation, religion, marital status of HH members.
<b>Initial processing:</b> Categorize data by cluster, male vs. female, occupation and religion type and level of education.
<b>Basic statistics:</b> frequencies, means, modes and percentages
<b>Advanced statistics:</b> $\chi^2$ , Regression and correlation
<b>Objective 2: To determine protein, zinc, iron intake adequacies in Nandi South district households and contribution made by legumes.</b>
<b>Variables –</b> No. Of days in a week, amounts per meal, number of varieties used, sources of protein, zinc and Iron.
<b>Initial processing:</b> categorize data by number of varieties, methods, uses of legumes, constraints to utilization.
<b>Basic statistic:</b> Frequencies, means, percentages
<b>Advance statistics:</b> Correlation and regression.
<b>Objective 3: To determine proximate composition, iron, zinc and anti-nutritive factors status in Lablab grown in Nandi South district.</b>
<b>Variable:</b> levels of protein, oil, ash/fibre, carbohydrates, moisture content, minerals (zinc and iron), tannin, phytic acid and trypsin inhibitor.
<b>Initial processing:</b> record the results on the templates.
<b>Basic statistics:</b> means and percentages
<b>Advanced statistics:</b> correlation

<b>Objective 4: To determine effect of methods of legume preparation in Nandi South district on protein, iron, zinc and anti-nutrients</b>
<b>Variable:</b> methods of preparation, levels of protein, zinc, iron and anti-nutrients against each method
<b>Initial processing:</b> categorize data by type of methods
<b>Basic statistics:</b> means, frequencies and percentages
<b>Advanced statistics:</b> ANOVA, correlation, regression and LSD.