DEVELOPMENT AND ACCEPTABILITY OF PIGEON PEAS BASED PRODUCTS FOR IMPROVING NUTRITIONAL STATUS OF SCHOOL CHILDREN IN SINGIDA REGION, TANZANIA

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ABSTRACT

Background: In Tanzania, malnutrition among school children is still a major public health problem. Moreover, grain legumes occupy an important place in children of school-age. This study reports on the prevalence of undernutrition, development and acceptability of formulated pigeon peas biscuits, African doughnut and pigeon buns. Material and methods: A cross-sectional study was done which included two designs; Qualitative design included focus group discussions with 48 farmers to determine the utilization of pigeon peas. Quantitative design with the laboratory phase and community survey; For laboratory experiments, biscuits, African doughnut and pigeon pea buns were developed, proximate analysis, vitamin and minerals analysis was determined for the raw and formulated products. Sensory evaluation to assess consumer acceptability and preferences was done which involved 76 school children aged 5- 12 years. Furthermore, 384 pupils were involved in the assessment of nutritional status in which standard procedures were used to measure weight and height, also 32 parents were involved in the provision of promotional materials and cooking demonstrations. Results: Selling was the major form of utilization of pigeon peas in the study area. All the formulated products had the protein, cabohydrates and minerals content which are within the recommended dietary allowance of school-age children. In the study area, the prevalence of wasting in school children was 8.9% and stunting was 18.8%. The biscuits which had a high amount of pigeon peas were highly preferred than any other

products, and it was observed that all the attribute aroma, colour, taste and overall acceptability of the products were significantly different (P≤0.05) in all formulated products. Conclusion: The prevalence of undernutrition among school children was high in Singida region, the formulated pigeon peas-based products can be used to reduce the burden of malnutrition in this area. To establish a causal relationship between formulated pigeon peas products and nutritional status longitudinal design should be done in future studies.

DECLARATION

I, ARAFA KHAMIS MACHANO, declare that the information provided in this dissertation is the result of my own work which has been done after registration for the degree of masters in Human Nutrition at Sokoine University of Agriculture and that it has not been submitted, in whole or in part, in any previous application for a degree; Except where states otherwise by references or acknowledgement.

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Had it not been for all your prayers and benedictions, sincere love and help I would not reach this far.

DEDICATION

I would love to dedicate this work to my family, a special feeling of gratitude to my loving parents who gave me moral lessons on discipline from an earlier age and taught me the value of studying, and to my brothers and sister for believing in me and making my education journey a possibility.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Malnutrition is still prevalent globally with the coexistence of both undernutrition and overnutrition in developing countries affecting all age groups (Dukhi, 2020). Globally in 2019, about 21.3% of children under-five years of age were stunted, compared with one third 32.4% in 2000. Approximately 144.0 million children under-five years worldwide suffered from stunting in 2019, two-thirds of whom lived in Africa and South-East Asia regions. More than 47.0 million children (6.9%) under-five years of age globally suffered from wasting in 2019 (WHO,2020). This is a result of diets being deficient of protein and micronutrients and high in cereal-based foods (Faber, 2019). Undernutrition is common not only to under-five children but can also affect school-aged children (Best *et al.*, 2010).

In Tanzania, undernutrition and micronutrient deficiencies among school children are still a major public health problem. It has been reported that up to two-thirds of children are anaemic and 42.3% of school children are undernourished (Munisi *et al.*, 2014). This is due to an inadequate intake of nutrients as well as infections (Munisi *et al.*, 2016).

Pulses such as pigeon peas are the most economical source of good quality proteins with the potentials to be used as nutritious food (Temba *et al.*, 2016).

One major way of utilizing pulses is through food processing by converting raw materials into semi-finished and finished products that can be consumed (Alemayehu *et al.*, 2019), This improves the nutritional quality of foods and contributes to sustainable food security, improving consumer appeal and acceptability of foods and serving as a means of income generation to smallholder farmers and processors by building marketing capacities and opportunities (Weaver *et al.*, 2014).

Tanzania, Kenya, and Uganda are the largest producers of Pigeon peas in Eastern Africa subregion. In Tanzania, pigeon pea is the third most important legume crop. According to FAOSTAT (2018), the total production of pigeon peas is 315837 tonnes in Tanzania from 19,000 tonnes in 2013, and Singida being among the regions cultivating it which had a total production of 1,500 tonnes.

In the south-eastern part of Tanzania, 80% of farmers are now growing pigeon peas. After harvesting, about 30% is consumed in the household and the rest is sold. In the eastern zone, pigeon pea is mainly harvested and consumed or sold as dry grain, while it is mainly harvested at the green stage and consumed as a vegetable (green peas) in the secondary production areas. In the northern zone districts including Babati, pigeon pea is mainly grown as a cash crop (Mponda *et al.*, 2013).

In developing countries, the diet of school-age children usually lacks fruits, vegetables and animal products leading to inadequate protein and micronutrient intake (Ochola, and Masibo, 2014). Furthermore, lifestyles,

increase in sedentary activities and consumption of high fat and sugar snacks and beverages that are often energy dense but micronutrient poor may results to malnutrition (Fiorentino, 2015). The prevalence of malnutrition for school-age children in Arusha found that 23.7% suffered from at least one form of undernutrition; 16.3% were stunted while 11.3% were wasted, Poor quality of food being the major risk factors for undernutrition (Teblick *et al.*, 2017).

Grain legumes occupy an important place in the nutrition of children of school-age as a rich source of protein generally twice the level found in cereal grains; this could help reduce the problem of malnutrition in school-age children (Chibarabada *et al.*, 2017).

Therefore, with the burden of malnutrition in Tanzania, it is important to increase the consumption of legumes like pigeon peas by developing additional recipe in our daily diets due to the availability of high protein content in pigeon peas which complements well with cereals and help reduce the problem of malnutrition.

1.2 Problem Statement

Pigeon pea is an inexpensive and available source of protein and minerals; however, its utilization is still low due to the presence of inherent constraints such as hard to cook, and flatulence (Adetonah, 2016). However, pigeon peas can be used in improving the nutrition status of children as well as raising the income of women in Tanzania.

School-age children have an increased need for nutrients. This dynamic period of growth and development forms a foundation for good adult health as

children go through physical, emotional and social changes (Ochola and Masibo, 2014). Also, it is believed that the health, physical growth, development and educational performance of school children depend largely on good nutrition.

In addition, more public health efforts are necessary to monitor the nutritional status of school children, and to match their growth requirements, to meet the potential of their future life since their health is also important as that of under-five children (Comandini *et al.*, 2018). Nearly 97% of school children purchase food from street food vendors; on average, about 47% of the children in rural schools do purchase street foods every day compared to more than 80% in schools located in urban and peri-urban areas (Nyaruhucha *et al.*, 2007). The nutritional quality of street foods and drinks consumed by school children have been found adequate as far as energy content was concerned, their overall nutritional intake was inadequate, being poor in protein and micronutrients (Marras, 2018). Most of the school children leave home without eating breakfast, and the main barriers include, long commuting times to get to school by public transport and the early school times, with some pupils required to report at school by seven in the morning (Nyaruhucha *et al.*, 2007).

The prevalence of food insecurity in Tanzania was 9.7% (HBS, 2017); with the high incidence of poverty, and high prevalence of malnutrition (Mwaniki and Makokha, 2013). Current approaches to combat malnutrition have ignored the role that locally available plants can play as sources of protein. Pigeon peas is one of the protein-rich resilient crop grown in Sub-Saharan Africa (Popoola *et al.*, 2019). Therefore can be important in reducing malnutrition in Tanzania as

well as combating the issue of food insecurity. This study was carried out to develop pigeon peas-based products in Singida region capable of increasing consumption of pigeon peas contributing reasonably to the daily recommended nutrient intake of children as well as to improve food security by providing income to women.

1.3 Justification of the Study

This study contributes to the formulation of pigeon peas-based products which will help in reducing the problem of protein-energy malnutrition and micronutrient deficiency which is the major public health problem as well as reducing food insecurity in the region.

Furthermore, knowing the prevalence of malnutrition in school-age children will help in planning and implementation of appropriate prevention strategies. Therefore, the findings of this study will act as a guide for developing diversified products for nutrition and income improvement as well as form a baseline for designing more interventions for people who are suffering from malnutrition.

1.4 Objectives

1.4.1 Overall objectives

The overall objective of this study was to promote the utilization of pigeon peas for improving the nutritional status of school-age children in Tanzania.

1.4.2 Specific objectives

i. **To examine the utilization of pigeon peas among farmers (Parents) in Singida**
ii. **To develop pigeon peas-based products**
iii. **To determine the nutrient content of pigeon peas-based products**
iv. **To evaluate the acceptability of the pigeon peas-based products among school children in Singida**

v. **To assess the nutritional status of school age children**

vi. **To develop promotional materials and cooking demonstration to increase utilization of pigeon peas**

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview of Pigeon Peas

Pigeon peas [*Cajanus cajan*] are a major grain legume grown in semi-arid regions of Sub-Saharan Africa. They are both a food crop (dried peas, flour, or green vegetable peas) and a forage/cover crop and contains high levels of protein and the important amino acids methionine, lysine and tryptophan (Oke, 2014). Moreover, In combination with cereals, pigeon peas make a well-balanced human food. Pigeon pea is an important underutilized legume in Sub-Saharan Africa (Fasoyiro and Arowora, 2013). Pigeon pea grows quickly and tolerates unfavourable conditions including poor soil quality and drought. These characteristics make pigeon pea a great option for increasing family nutritional security and maintaining livestock health, particularly during the lean months between harvests. Also, it fixes soil nitrogen, allowing the poor farmers to improve soil fertility without expensive chemical fertilizers (Gwenambira, 2015).

2.1.1 Nutrition Content of Pigeon Peas

Pigeon peas are nutritionally diverse crops that can be successfully utilized as a food ingredient and they contain 20%–22% of all essential amino acids particularly lysine and 18%–35% protein, desirable in overcoming the incidence of protein-energy malnutrition (Kaushal *et al.*, 2012). They are also rich in dietary minerals such as calcium, copper, phosphorus, magnesium, iron, sulphur, potassium, and water- soluble vitamins such as thiamine, ascorbic acid, riboflavin, and niacin. Pigeon peas are a good source of slow release carbohydrates, making it a suitable raw material for the formulation of low glycemic index food products (Ohizua *et al.*, 2017).

Pigeon pea grains are poorly digestible and can cause flatulence and indigestion for some adults and many infants. For this reason, although they are a good source of nutrients and protein, pigeon pea grains are rarely used in complementary food mixes (Temu *et al.*, 2014). The long cooking time of dried pigeon peas is also an important barrier, especially for urban households with little time (Ronner and Giller, 2013). However, it has potential to be incorporated in snacks and convenience foods that could make it appeal by reducing the long cooking time as well as increase its shelf life (Brennan *et al.*, 2013).

Cereal-based complementary foods tend to be low in energy, proteins and micronutrients, especially zinc and iron (Martin *et al.*, 2010). Formulations can achieve sufficient energy and protein through combining cereals with legumes

such as pigeon peas (Martin *et al.*, 2010; Muhimbula *et al.*, 2011), which have essential nutrients for prevention of malnutrition and micronutrient deficiency.

In Tanzania the prevalence of malnutrition among under five children is unpleasing, the prevalence of stunting, wasting and underweight was 31.8%%, 3.5% and 15%, respectively (TNNS, 2018). Furthermore, In Singida no literature has been found on the prevalence of malnutrition in school age children. The presence of high protein in pigeon peas and other nutrients will help reduce the problem of malnutrition and micronutrient deficiency in various parts of Tanzania.

2.2 Pigeon peas Utilization

Pigeon peas like many other legumes are important grain legumes in East Africa (Njoroge *et al.*, 2014). Foyer *et al.*, (2016) disclosed that pigeon peas are multipurpose crops that is the entire plant can be used for either human or livestock consumption also he emphasized that all parts of the plant are used as food being nutritious as they provide protein and vitamins. The following are various uses of pigeon peas;

2.2.1 Nutritional Potentials

Pigeon peas are a source of protein, minerals and vitamins (B, carotene, and ascorbic acid) (Kunyanga *et al.*, 2013), which are deficient in cereals therefore pigeon pea has a good supplemental value of cereal-based diets. Pigeon pea is a rich source of lysine (14.7 7 g/kg) but deficient in the sulphur-containing amino acids methionine (2.65g/kg) and cysteine (5.47g/kg) (Heuze *et al.*, 2016). With all these attributes, pigeon peas can positively impact on the nutrition and health of

poor people, particularly children (Foyer *et al.*, 2016). The bulk of the diet of the rural and urban poor in Africa consists of starchy foods such as cassava, yams, bananas, millet, sorghum and maize (Simion, 2018). Legumes and legume-derived vegetables modulate glucose, insulin, homocysteine concentration and lipid peroxidation for coronary heart disease patients, leading to 21% and 11% lower risks of coronary heart disease (CHD) and cardiovascular disease (CVD) respectively (Enyiukwu *et al.*, 2018).

2.2.2 Medicines

Pigeon pea is traditionally used as a medicine to treat wounds and sores (Lim, 2012). The treatment of malaria and snake bites is confirmed in the previous studies which were done by (Ayenan *et al.*, 2017), in which Triturate leaves were filtered and added with lemon juice and Triturate fresh leaves was done to treat malaria and snake bite respectively but the treatment of heartache with pigeon peas was not reported elsewhere. Leaves were also used to feed cattle's in the study population, most of the farmers of pigeon peas left leaves in the farm to feed their livestock which help increase the healthiness of the livestock. Similarly, (Odeny, 2007), reported that pigeon peas foliage is an excellent fodder with high nutritional value, and its fodder has been demonstrated to increase the intake of low-quality herbage resulting in high animal live weight.

2.2.3 Foods for human consumption

Pigeon peas are consumed in many forms; as a whole seed, pigeon pea seed has a hard seed coat with slightly acrid taste (Nwosu *et al.*, 2013); the dry pigeon pea

seeds are soaked overnight and cooked with salt and spices. In some parts of Africa, boiled whole seeds are sometimes fried with spices and eaten with cereals and in other parts like Nigeria they use it to prepare snacks (Oniang'o, 2003). A study conducted in Nigeria showed that the dried pigeon pea is cooked whole until tender and mixed with maize, yam or sweet potato. In many parts of Eastern Africa, dhal (pigeon pea stew) is becoming a popular meal. However, according to Ayenan *et al.*, (2017) boiled dried pigeon peas is consumed as the main food in Benin.

2.2.4 Soil fertility

Pigeon peas also plays an important role in improving soil fertility in cereal crops (such as sorghum and maize) farming system when grown via intercropping and crop rotation (Adjei-Nsiah, 2012). Pigeon peas also contributes to the sustainability of cropping systems and soil fertility improvement on marginal lands through nitrogen fixation, provision of ground cover and plant residues, which minimize erosion and subsequent land deterioration. Intercropping of cereals with legumes also increases the productivity per unit of land area to the atmospheric nitrogen biological fixation that takes place in the root nodules of legumes (Ghosh *et al.*, 2007).

2.3 Formulation of food products

Linear programming can be used to formulate minimum cost menu while making sure it meets all the criteria of all macronutrients and micronutrients that has been set by dietary guidelines (Pasic *et al.*, 2011) . It is used in diet problem-solving techniques by creating a optimisation model that contains all the optimalfood, cost and quality of a diet. The Optimization models use an

objective function which is an equation restricted by various constraints (Alaini *et al.*, 2019). Linear programming minimizes the linear function (objective function) given a set of constraints which are used to restrict the required daily allowance for each nutrient. The general equation used is as follows:

Objective function(f) = $W_1 C_1 + W_2 C_2 \ldots + W_n C_n$, where

W is the quantity of item and C is the unit cost.

The basic assumption in this method is that the various relationships between demand and availability are linear (Briend *et al.*, 2003). To obtain the solution, it is necessary to find the solution of the system of linear inequalities (that is, the set of n-values of the variables x_1 that simultaneously satisfies all the inequalities). The objective function is then evaluated by substituting the values of xi in the equation that defines f.

There are various computer programs which are currently using the linear programming model to compute nutritional constrints these includes cost of the diets, nutrisurvey, Microsoft excel and microedit system. In this study Microsoft excel was used to formulate the products. By using linear programming, the majority of populations can benefit from an optimal diet at a minimum cost, which enables them to have an adequate daily nutrition within their financial potentials (Alaini *et al.*, 2019).

Furthermore, In formulation of a product, the basis of complementarities depends on the replacement of cereal grain with legumes; The formulation used in a study done by Gbenga-Fabusiwa *et al.*, 2018 in preparing biscuits of pigeon peas was 75:25 (75% Pigeon Peas flour and 25% Wheat Flour), 50:50 (50%

Pigeon Peas and 50% Wheat Flour), 75:25 (75% wheat Flour and 25% Pigeon Peas Flour). Alozie and Okoronkwo prepared African doughnut, (2018) based on formulation of blending Pigeon pea flour (PPF) and wheat flour (WF) in the ratio of 50:50.

2.3.1 Pigeon pea Based Products

Snack consumption has been increasing as a result of urbanisation and increase in the number of working mothers. Most snacks especially those commercially prepared are made from wheat alone (Ayogu, 2016). This has made most developing countries to be interested in the possibility of replacing the wheat needed for baking foods, wholly or partly, with flour obtained from homegrown products. Complementation of cereal-based foods with protein sources such as legumes has received considerable attention. Legumes are important sources of low-cost vegetable proteins and micronutrients when compared to animal products such as meat, fish, and egg (Pathak and Kochhar, 2018). The expensive nature of these animal foods makes them less preferred to plant sources.

In developing countries, research attention is being paid to better utilization of legumes in addressing protein malnutrition and food security issues. This is because legume protein is high in lysine, which is deficient in most cereals (Olunike, 2014).

2.3.2 Biscuits

Most school children (adolescents inclusive) who skip breakfast consume biscuits as alternative. In some schools, the most frequent snack given to children is biscuits. Some mothers use biscuits to pacify their crying children (Ayogu, *et al.*, 2016).

Biscuits (biscuits) have been suggested as a better use of composite flour than bread due to their ready-to-eat form, wide consumption, relatively long shelf-life and good eating quality. Biscuits are cereal based and are added with pigeon peas to increase the quantities of lysine and, when blended with cereal grainsgramsves mixtures with complementary amino acid profiles and improved protein quality. Biscuits with high sensory ratings have been produced from blends of millet/pigeon pea flour, green gram, and wheat, raw rice and wheat, groundnut, cowpea and wheat, chickpea/wheat and soybean, chickpea, cassava with wheat (McWatters, 2003). A study by Gbenga-Fabusiwa *et al.,* (2018) has shown the complementation of pigeon pea and wheat composite flour in making nutritious biscuits. However, In Tanzania no literature has been found on the production of biscuits from pigeon peas.

2.3.3 Pigeon pea bun (*Bagia*)

Buns are snacks which are also consumed by school-age children; they buy this snack mostly from the vendors. The pigeon pea bun are made up of Pigeon peas flour and in small balls it is fried. No documented study have shown the use of pigeon peas in preparation of this snack. According to Marras, (2018) In Dar es salaam pigeon pea buns are sold by street vendors near school compounds where school-age children can buy them since most of them are given money to buy food rather than being given food from home due to various reasons such as the distance from their residence. Since no known study is done in preparing this product using pigeon peas; this study prepared buns using pigeon peas.

2.3.4 African doughnuts (*Maandazi*)

African doughnut is one of the snack products which have been associated with 'empty calorie or "junk", A study conducted in Nigeria by Alozie and Okoronkwo, (2018) has shown the complementation of pigeon pea and wheat composite flour in making nutritious doughnuts. In Tanzania no known study is done which involves the making of African doughnuts with pigeon peas.

2.4 Nutritional Status

2.4.1 Stunting

Low height-for-age is referred to as stunting and occurs when the Z-score is below the median by more than -2SD. Stunting is seen as a failure to reach linear growth and is prevalent in children with long-term insufficient nutrient intake and frequent infections. If a child is stunted in the period of school-age results to poor performance and absence from schools the prevalence of stunting occurs amongst one-third of the world's children (WHO, 2007).

2.4.2 Wasting

Low weight-for-height, known as wasting, is reflected by a low body mass relative to height and is classified when the Z-score is below the median by -2SD. Low weight-for-height by a percentile lower than -3SD is regarded as severe wasting (WHO, 2007). This is due to acute starvation and disease, which results in severe acute malnutrition especially in a chronically stunted child.

A study which was conducted in Arusha showed that 23.7% of school age children suffered from at least one form of undernutrition. Abou 16% were stunted and 11.3% were wasted (Teblick *et al.*, 2017). Similarly, a study which was conducted in Bumbire island in Tanzania showed that the prevalence of

undernutrition among school age children was high (stunting: 30.7%, underweight 12.9%, wasting 4.5%), while overweight was rare (2.4%) (Comandini *et al.*, 2018). However, there are no reported studies which have been done in Singida to determine the nutritional status of school children.

2.5 Sensory Evaluation

Consumer acceptability and preference are used to determine liking and disliking of consumer, preference of one product over another and consumers intention to use a product (Sharif *et al.*, 2017). There are various methods which can be used to test the acceptability and preferences of consumers such as the use of hedonic scale. For school-age children facial expression may be drawn the scale can be a five, seven or nine-point scale ranging from very happy to dislike. A study which was done Brazil showed that the facial scales were self-administered, since all children were literate. They were than requested to mark the facial expression that best represent their opinion regarding the meatball consumed in the school meal (Latorres *et al.*, 2016).

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of Study Area

The study was conducted in Singida Rural District which is one of the six districts of Singida Region. It is bordered to the east by the Manyara Region, to the south by the Ikungi District, and to the west by the Mkalama District. According to the 2012 Tanzania national census, the population of the Singida Rural District was 225,521 (URT, 2013).

Singida region has a total surface area of 49,438 km^2, out of which 95.5 km^2 or 0.19 percent are covered by water bodies. The remaining 49,342.5 km^2 is land area (URT, 2013). The study was done in two divisions Ilongero which has a population of 10,635 and an area of 58.6 km^2, and Mtinko which has a population of 19,414 and an area of 120 km^2 (NBS, 2012).

Singida was selected because it is among the regions in Tanzania with the highest prevelance of wasting 5.2% (TNNS, 2018), also it's a region where pigeon peas is highly grown since it's a semiarid central zone.

3.2 Study Participants

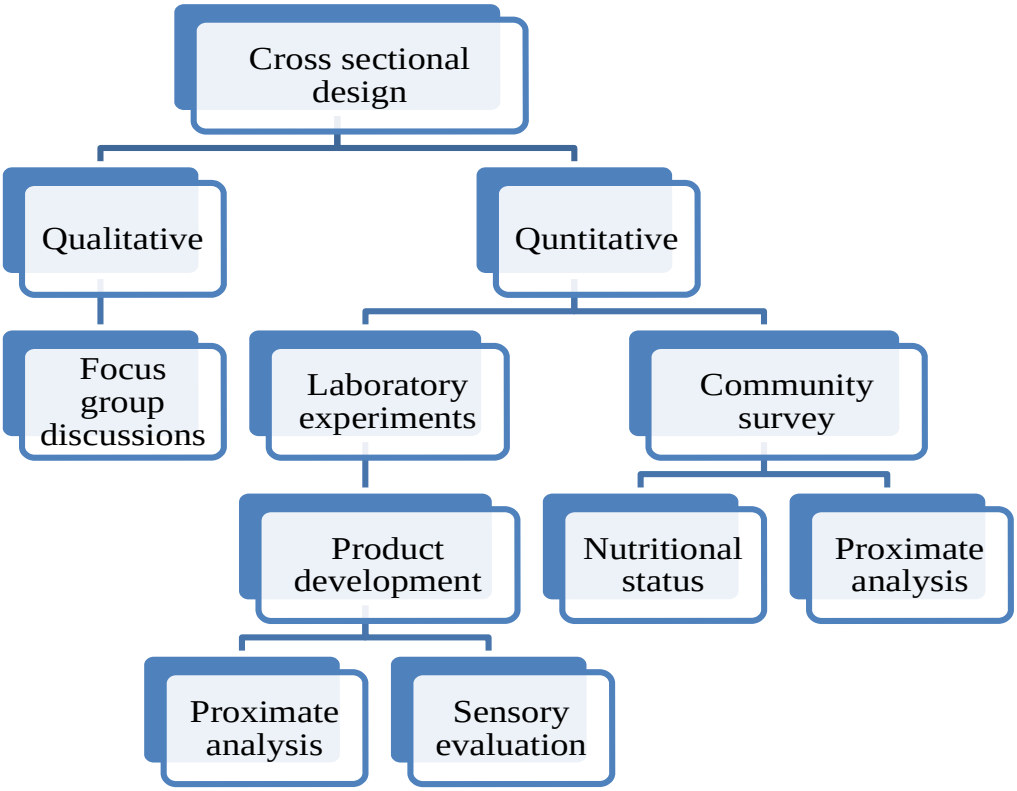
The participants of the study were school-age children 5- 12 years who were studying in primary schools present in the two divisions. Pupils were used to

evaluate the acceptability and preference of the pigeon pea-based products. The nutritional status of school-age children was also assessed.

Parents (farmers) were also involved in this study through focus group discussions to provide information on the utilization of pigeon pea and cooking demonstration of the acceptable products.

The study included school age children both male and females with age ranging from 5 to 12 years, attending primary schools. The study included primary school-age children who were admitted in schools because, 98.7% of children aged 5-12 years are enrolled in primary school compared to those who are not enrolled in schools (UNESCO, 2020), children who were sick during data collection and who are handicapped were excluded because of difficulties in obtaining anthropometric measurements.

3.3 Study Design



3.4 Sample Size Determination

The sample size was computed using Barlett *et al.* (2001),¿ $\frac{Z^2 P(1-p)}{d^2}$

Where

N=estimated sample size,

d= precision level (acceptable error; 0.05).

P= proportion of population (If unknown, 0.5)

Z= Confidence interval (1.96)

N = $\frac{(1.96)^2 \times 0.5\ (1-0.5)}{(0.05)^2}$ = 384

DRP = average dropout rate across all subjects (5%)

Substituting for this will be;

N= (385)/ (1-0.05) = 405

Therefore, a sample size of 405 individuals was used, to assess the nutritional status where 76 pupils were selected from the sample randomly to assess acceptability and preferences of the products. When performing affective tests (acceptance tests, preference tests or hedonic tests); adequate sample size is around 75-150 individuals (Lawless and Heymann, 2010). The reason as to why the panel size in an affective test needs to be large is that individual preference has such a high variability.

3.4.1 Sampling

The region, district, divisions, and villages were purposively selected. These are RECODA programme areas, sponsored by 'Agroecology Hub' in Tanzania. Two divisions Mtinko and Ilongero were selected out of three division in Singida rural districts, from each division six villages were randomly selected from a piece of sheet out of sixteen villages. In Mtinko Division which has seven villages, three villages were randomly selected namely: Malolo, Minyenye and Mtinko. In Ilongero Division, three villages were also randomly selected out of nine villages; namely: Mwahango, Ilongero and Sekotoure.

Two schools out of ninety-five schools were systematic randomly selected from each Division which made a total of four schools (A list of schools were provided by the Education Officer and every tenth school was selected in each division to obtain the four schools which were included in the study), To aquire a sample of 405, stratified sampling technique was used. This is the probability sampling; where a population of pupils in each school was divided into strata being age, gender, and education level, then 101 pupils were selected in each school to

acquire a total of 405, by simple random selection pupils in class one to class six were selected in each class numbers were assigned, starting point being number five onwards, every eleventh pupil was selected to obtain a total of 16-17 pupils in each class) who participated in the assessment of nutritional status. Nineteen pupils were selected in each school (from class four to class six) to make a total of 76 pupils, who participated in sensory evaluation.

Focus group discussions were conducted to gather information about the utilization of pigeon peas in Singida, the discussion was recorded, transcribed analysed and interpreted. Selection of focus group participants was done as follows; A total of forty-eight out of ninety one farmers who are beneficiaries of RECODA programme in the two divisions Ilongero and Mtinko were selected randomly to obtain six groups of eight participants for each group. All participants were women since they were the main producers of pigeon peas in this study area.

Brochures were distributed and participatory cooking demonstrations were done to increase the utilisation of pigeon peas. Thirty two parents participated, (sixteen from each division), in the two cooking demonstration classes, study participants were randomly selected from the groups which are used in teaching farming activities under the RECODA programmes. The list of names was provided by group leaders and participants were chosen after every five names to obtain a sample of eight individuals in each group.

3.4.2 Development of pigeon pea products

The products developed were pigeon pea biscuits, pigeon pea-bun *(bagia*) and African doughnuts (*maandazi*). Three blends were prepared from the composite mixture of pigeon peas flour, amaranth leaves flour and orange-fleshed sweet potato flour in the proportions of F1, 70:20: 5:5 (70% wheat Flour, 20% Pigeon Flour, 5m% Amaranth Flour and 5% Orange Fleshed sweet potato flour), F2 55:30: 8:7 (55% wheat Flour, 30% Pigeon Flour, 8% Amaranth Flour and 7% Orange Fleshed sweet potato flour), and F3 55:30: 8:7 (30% wheat Flour, 57% Pigeon Flour, 0% Amaranth Flour and 13% Orange Fleshed sweet potato flour). Except for pigeon pea buns which was prepared from the composition mixture of proportion F1; 60:30: 5:5 (60% wheat Flour, 30% Pigeon Flour, 5% Amaranth Flour and 5% Orange Fleshed sweet potato flour), F2 70:20: 3:7 (70% wheat Flour, 20% Pigeon Flour, 3% Amaranth Flour and 7% Orange Fleshed sweet potato flour) and F3 80:15: 0:5 (80% wheat Flour, 15% Pigeon Flour, 0% Amaranth Flour and 5% Orange Fleshed sweet potato flour).

3.4.2.1 Formulation of the products

By using nutrient requirements for school-age children the following formulation were obtained using Microsoft excel solver, In this study protein was the objective function that was minimized. The minimum and maximum value of macronutrient and micronutrient based on nutrient requirement of school-age children (WHO, 2003), Tanzania Food Composition Table, (2008) was used to obtain the nutrient content of the ingredients.

Different biscuits formulations were prepared by replacement of wheat flour with pigeon pea flour, amaranth leaves flour, wheat flour and orange fleshed

sweet potato flour at different levels. Pigeon pea flour was added by 20%,30% and 57% respectively, amaranth flour was added by 5%, 8% and 0% in biscuits 1, biscuits 2 and biscuits 3 respectively, whereas orange fleshed sweet potato flour was added by 5%, 7% and 13% in biscuits 1, biscuits 2 and biscuits 3 respectively. Biscuits dough recipe were prepared on a 1000g flour basis which contained the ingredients as shown in Table 1, the nutrient content of these formulations are shown in the results section.

Example wheat

70%=0.7× 1000g flour basis

Table 1: Formulation of pigeon pea biscuits (grams)

Ingredients	Biscuits 1	Biscuits 2	Biscuits 3
Eggs	88	88	88
Wheat	700	550	300
Amaranth leaves flour	50	70	0
Orange Fleshed Sweet Potatato flour	50	80	130
Pigeon peas flour	200	300	570
Cardamom	6	6	6
Sugar	250	250	250
Margarine	250	250	250
Baking powder	6	6	6

3.4.2.2 African doughnuts

By using nutrient requirements of school-age children the following formulation were obtained using Microsoft excel solver, In this study protein was the objective function that was minimized. The minimum and maximum value of macronutrient and micronutrient were set based on nutrient requirement of school-age children (WHO, 2003), Tanzania Food Composition Table, (2008) was used to obtain the nutrient content of the ingredients.

Different African doughnuts formulations were prepared by replacement of wheat flour with pigeon pea flour, amaranth leaves flour, wheat flour and orange fleshed sweet potato flour at different levels. Pigeon peas flour was added by 20%,30% and 57% respectively, amaranth flour was added by 5%, 8% and 0% in African doughnuts 1, African doughnuts 2 and African doughnuts 3 respectively, whereas orange fleshed sweet potato flour was added by 5%, 7% and 13% in African doughnuts 1, African doughnuts 2 and African doughnuts 3 respectively. African doughnut dough recipe were prepared on a 1000g flour basis which contained the ingredients as shown in Table 2, the nutrient content of these formulations are shown in the results section.

Example wheat

70%=0.7× 1000g flour basis

~~Table 2~~Table 3: Formulation of pigeon pea "African doughnuts (*maandazi)* (grams)

Ingredients	African doughnuts (maandazi) 1	Africandoughnuts (maandazi) 2	Africandoughnuts (maandazi) 3
Salt	4	4	4
Wheat	700	550	300
Amaranth leaves	50	70	0
Orange Fleshed Sweet Potato flour	50	80	130
Pigeon peas flour	200	300	570
Cardamom	12	12	12
Sugar	150	150	150
Oil	40	40	40
Yeast	6	6	6
Water	620	650	440

Note: Oils in mls, water in liters

3.4.2.3 Pigeon pea buns (*bagia*)

By using nutrient requirements of school-age children the following formulation were obtained using Microsoft excel solver, In this study protein was the objective function that was minimized. The minimum and maximum value of macronutrient and micronutrient were set based on nutrient requirement of school-age children (WHO, 2003), Tanzania Food Composition Table, (2008) was used to obtain the nutrient content of the ingredients.

Different pigeon buns formulations were prepared by replacement of wheat flour with pigeon pea flour, amaranth leaves flour, wheat flour and orange fleshed sweet potato flour at different levels. Pigeon peas flour was added by 60%,70% and 80% respectively, amaranth flour was added by 5%, 3% and 0% in pigeon buns 1 pigeon buns 2 and pigeon buns 3 respectively, whereas orange fleshed sweet potato was added by (5%, 7% and 5%) in pigeon buns 1, pigeon buns 2 and pigeon buns 3 respectively. Pigeon buns dough recipe were prepared

on a 2000g flour basis which contained the ingredients as shown in Table 2, the nutrient content of these formulations are shown in the results section.

Example wheat

30% = 0.3× 2000g flour basis

~~Table 4~~Table 5: Formulation of pigeon pea buns (*bagia*) (grams)

Ingredients	Pigeon buns 1	Pigeon buns 2	Pigeon buns 3
Salt	40	40	40
Wheat	600	400	300
Amaranth leaves	100	60	0
Orange fleshed sweet potato flour	100	140	100
Pigeon peas flour	1200	1400	1600
Yeast	40	40	40
Garlic	3.5	3.5	3.5

3.5 Data Collection

Objective 1: To examine the utilization of pigeon pea in Singida

Focus group discussions

A checklist of questions was used to guide discussions aimed at getting a deeper understanding and additional insight into the utilization of pigeon peas among individuals residing in the two divisions. It included questions on preparation, consumption, marketing, preferences and other uses of pigeon peas; also, storage, perceptions about legume consumption in general and pigeon pea in particular. The discussion involved parents (farmers) who lived around the study area.

The focus group discussions were done in December 2019. There were 6 focus group discussions; three in each division with 8 participants in each group

(N=48). The focus discussions were facilitated by the researcher who introduced the topics for discussion, and guided members of the group towards effective participation and was assisted by a notetaker who was also responsible for recording the discussion and the observer. The researcher first explained the objectives of the discussions and encouraged everybody to participate in the discussion; the discussion focused on the utilization of pigeon peas. The discussions were conducted in a private, quiet environment in the community locations in their farm field classes, the participants were seated in a circle where they faced each other; the focus group discussions lasted for 45 minutes each and the discussions were recorded on voice recorders with permission of the participants. The voice records collected from focus group discussions were transcribed and translated followed by the formation of code book for result categorization and analysis. The code book contained all the key points obtained in the field based on the specific topic of concern with regards to the objectives.

Objective 2: To develop pigeon peas-based products

Preparation of pigeon peas flour for pigeon biscuits and African doughnuts (maandazi) and pigeon pea buns

Dry pigeon peas were purchased from the local market (Iambi market) in Singida. The pigeon peas were then manually cleaned to remove dirt and stones. Then 10kg of pigeon peas, 5kg at a time were soaked in boiling water for 20 minutes at 120^{o}c and were then sun dried for 2 days. The soaked pigeon peas were then placed in a dehulling machine (model MTPS-18 D/A) and dehulled for 5 minutes, the ones that were completely dehulled were separated from those not dehulled. The dehulled peas were then milled for 6 minutes to obtain pigeon pea flour, which was then sieved using 0.06 mm mesh.

Preparation of amaranth flour

Amaranth leaves were washed with clean water to remove surface soil. The amaranth leaves were blanched; dipped in 5% saline solution for 10 minutes at a temperature of 80^0c to preserve their colour and nutrients. The amaranth leaves were sundried by spreading on solar drier trays and dried in a locally made solar drier for 24 hours. The dry amaranth leaves were milled into a fine powder using a blender (Model: TM910SP)

Preparation of products

2.2. Production of biscuits

Biscuits were prepared by mixing the ingredients listed in Table 1. The sugar and magarine were mixed by using (Dessini DS-269) hand mixture until the mixture was fluffy white, two eggs (88 jjbgrams) were then added until it was well mixed with sugar and magarine. The mixture of flour composite was then added followed by baking powder and cardamom, the mixture was well mixed with hands until a soft dough was formed, round shaped piece of 2 cm of the dough were cut to make the shapes of biscuits. The biscuits were then placed in the oven and baked for 15 minutes at 200ºC. Thereafter, the biscuits were taken out of the oven and left out to cool for 1 hour and then packed in food containers.

African doughnuts (*Maandazi*)

African doughnuts were prepared by mixing the ingredients in Table 2. The composite flours were mixed with oil, sugar, salt, yeast, cardamom and water

until the dough was formed, the dough was then rolled by using a rolling pin to a 6cm size and small pieces of 1.5 cm were kept in a tray; and left to rise. After rising, the pieces were cooked in oil by deep frying at the temperature of 170^0c for 5 minutes in a frying pan and were taken out of the oil, left to cool in room temperature and packed in food containers.

Pigeon pea buns (*Bagia*)

Pigeon peas buns were prepared by mixing ingredients in Table 3. Pigeon peas seeds after being dehulled and soaked overnight were mixed with garlic and blended by a blender (Kenwood BY-J-823) with water 500mls. for one minute then the mixture was kept in mixing bowls and the composite flours and yeasts were added per each sample until one could be able to form small balls of buns. The mixture was then left to rise; small size balls of 2cm were formed and then cooked by deep frying for 15minutes at a temperature of 170^0 C. They were then taken out of oil left to cool for 30 minutes and stored in food containers.

Objective 3: To determine the nutrient content of pigeon peas-based products

All the samples were in powder form and were analysed for moisture content, protein, fat, ash content, fibre and nitrogen free extract by the methods of AOAC (2003) conducted at Sokoine University laboratories; vitamins and minerals were also determined: this included, vitamin C, Beta-carotene, zinc and iron (Fe).

Proximate composition

Determination of moisture content: Moisture content was determined by oven drying method. An amount of 5g of each sample was accurately weighed in a clean, dried crucible (W1). The crucible was kept in an oven at 105°c for 24 hours until a constant weight was obtained. Then the crucible was placed in a desiccator for 30min to cool. After cooling it was weighed again (W2). The percent moisture was calculated by the formula:

$$\%\text{Moisture} = W1 - W2 \times 100 / \text{W.t of sample}$$

Where

W1= Initial weight of crucible with sample

W2= final weight of crucible with sample

W.t = weight of sample

Determination of ash content:

For the determination of ash content, a clean empty crucible was placed in a muffle furnace at 600^0C for an hour, cooled in a desiccator and then the weight of the empty crucible was noted (W1). Five grams of the sample was placed in the crucible (W2). The sample was ignited over a burner with the help of a blowpipe, until it was burnt and turned black. Then the crucible was placed in a muffle furnace at 550^0C for 4 hours. The appearance of grey-white ash indicated complete oxidation of all organic matter in the sample. The furnace was then switched off and the crucible was cooled to room temperature in a desiccator and weighed (W3). Percent ash was calculated using the formula:

——%Ash= differences in Wt of Ash (W3-W1) × 100 / Wt of sample

Where;

Wt= Weight

Determination of crude fat:

A dry extraction method for fat determination was used. Fats were determined by intermittent Soxhlet extraction apparatus by ether extract method; A 3g sample was placed in a fat free thimble and then introduced in the extraction tube. A beaker was weighed and filled with petroleum ether 70mls and fitted into the apparatus; water and heater were turned on to start extraction. After 15 minutes of heating, the thimbles were pulled up disconnected from the beaker for draining for 30 minutes and before the last siphoning. The extract

was then transferred into a clean dish placed in an oven at 110°C for 1 hour and cooled in a desiccator. The percent crude fat was determined by using the formula:

——————————% crude Fat= Wt. of ether extract×100/ W of sample

Determination of crude protein:

Proteins in the samples were determined by Kjeldahl method. A 3g of dried samples were taken in a digestion flask. Adedd 15 ml of concentrated H_2S0_4 and 8g of digestion mixture (k_2S0_4, $CUSO_4$). The flask was shaken in order to mix the contents thoroughly then placed on a heater to start digestion till the mixture became clear (blue-green in colour). The digest was cooled and transferred to a 100ml volumetric flask and the volume was made up to a mark of 100ml by the addition of distilled water. Distillation of the digest was performed in Markam Still Distillation Apparatus. Ten millilitres of the digest were introduced in a distillation tube then 10ml of 0.5 NaOH was gradually added, distillation continued for 10 minutes and NH_3 was collected as NH_40H in a conical flask containing 20ml of 4% boric acid solution with few drops of methyl red indicator. A yellowish colour appeared due to NH_40H during distillation. The distillate was then titrated against standard 0.1 N HCL solutions until it changed to pink colour. The control sample was also done through all steps above. % crude protein content of the sample was calculated using the formula;

% crude protein= 6.25^* ×%N (* correction factor)

%N= (S-B) × N × 0.014×D×100÷ wt. of the sample × v

Where

S= Sample titration reading

B= blank titration reading

N= Normality of HCl

D= Dilution of sample after digestion

V= Volume taken for distillation

0.014= milliequivalent weight of Nitrogen.

Determination of Carbohydrates

The carbohydrate content of the test sample was determined by estimation using the arithmetic difference method described by (Bemiller, 2003). The carbohydrate was calculated and expressed as the nitrogen free extract (NFE) as shown below:

% CHO (Nitrogen free extract) = 100% (a + b + c + d)

Where: A = protein

B = fat

C = ash

D = fibre

Determination of crude fibre: A moisture free and ether extracted sample of crude fibre made of cellulose was first digested with dilute H_2S0_4 and then with diluted KOH solution. The residue collected after digestion was ignited and loss in weight after the ignition was registered as crude fibre.

Reagents

Sulphuric acid

A solution of potassium hydroxide

Acetone (foam suppresser)

Procedures

Accurately 2 g of sample was weighed and transferred to a 9 cm hard filter paper supported on a filter cone in a 60^0C funnel. Extracted with three 25 ml portions of ether and vacuum was applied until the sample was dry. The extracted sample was transferred quantitatively by brushing into a 600 ml beaker of the fiber digestion apparatus. Twenty ml of well-mixed ceramic fiber suspension was added (containing about 1.5 g of fiber - dry weight), 200 ml of boiling sulfuric acid solution, and 1 drop of diluted acetone. A beaker was placed on the digestion apparatus with pre-adjusted heater and boiled exactly for 30 minutes, rotating the beaker periodically to keep solids from adhering to sides. The beaker was removed and contents were filtered through California Buchner funnel precoated with about 0.75 g of ceramic fiber - dry weight; the beaker was rinsed with 50 ml of boiling water, and washed through the funnel. The process was repeated with three 50 ml portions of water, and sucked dry. A fiber mat was returned with a residue to the beaker by blowing back through the funnel. Two hundredml of boiling sodium hydroxide solution was added, returned to heater and boiled for exactly 30 minutes. The beaker and filter were removed as before, washed with 25 ml of boiling sulfuric acid solution, three 50 ml portions of water, and 25 ml of alcohol; mat and residue were removed, and transferred to an ashing dish. Fiber mat and residue were dried at 130°C for 2 hours; Cooled in a desiccator and weighed. Ignited at 600 °C to constant weight for 30 minutes, cooled in a desiccator and weighed.

Calculation

% Crude Fiber (dry basis) = Sample Wt. (g) × Sample Moisture, %) /

(Dry Residue Wt. (g) Ignited Residue Wt. (g) Blank Wt. Loss (g)) ×100×100

Where

Wt= weight of sample

Determination of Vitamin C

Reagents

2,6 dichlorophenol indophenol solution

3% metaphosphoric acid

Stock solution of ascorbic acid

Ascorbic acid standard solution (5 ml)

Procedure

Standard titration

Using an eyedropper, 5 ml of ascorbic acid was added to a 100 ml conical flask solution. With an eyedropper, two drops of indophenol solution were added in the conical flask. The conical flask was shaken to mix the ascorbic acid and indophenol mixture. Indophenol solution was added until the reaction mixture changed colour to blue or purple. The volume of the reaction mixture was recorded at the endpoint. The reaction mixture was discarded and the conical flask was rinsed with about 1 ml of ascorbic acid. The titration was repeated two times to obtain a total of three readings.

Sample titration

The sample solution was added in a 100 ml volumetric flask. The sample was diluted by adding metaphosphoric acid and mixed well. 10mls of this dilute solution was pipetted into a 100 ml conical flask and titrated against the dye

solution till a light pink colour appeared which persisted for 30 seconds, titration was repeated three times and the readings were recorded.

Data processing

i. **The ml of ascorbic acid solution was converted to litres of solution**

ii. **The titration reaction was used (see introduction) to convert moles of vitamin C in the reaction mixture to moles of indophenol at endpoint**

iii. **The average volume of indophenol solution at end point was calculated and then converted to an average volume from ml to litres of indophenol solution**

iv. **The molarity of the indophenol solution was calculated, and it was used to calculate the concentration of vitamin C in the formulated products**

Determination of Beta-carotene

Beta-carotene was determined by spectrophotometry done at Sokoine University of Agriculture in Department of Food Technology Nutrition and Consumer Sciences

This was carried out according to the method of the Association of Official Analytical Chemists (AOAC). In to a conical flask containing 50ml of 95% ethanol,10g of the soaked sample was placed and maintained at a temperature of 70-80C in a water bath for 20 minutes with periodic shaking. The supernatant (liquid lying above solid residue) was decanted, allowed to cool and its volume was measured by means of a measuring cylinder and recorded as initial volume. The ethanol concentration of the mixture was brought to 85% by adding 15ml of distilled water and it was further cooled in a container of ice water for about 5minutes. The mixture was transferred in to a separating funnel and 25ml of petroleum ether was added and the cooled ethanol was poured over

it. The funnel was swirled gently to obtain a homogenous mixture and it was later allowed to stand until two separate layers were obtained. The bottom layer was run off into a beaker while the top layer was collected in to a 250ml conical flask. The bottom layer was transferred in to the funnel and re-extracted with 10ml petroleum ether for 5 times until the extract became fairly yellow. The entire petroleum ether was collected in to 250ml conical flask and transferred in to separating funnel for re-extraction with 50ml of 80% ethanol. The final extract was measured and poured in to sample bottles for further analysis.

Measurement of absorbance

Finally, the volume of extract was measured using a measuring cylinder and the absorbance was measured at 450 nm in a spectrophotometer (Atomic Absorption Spectrophotometer, AA-6800, Shimadzu, Japan) and calculated using equation.

β-carotene(µg/g) = A × Volume (ml) cm × $10^{4\div}$ A 1%1cm × sample weight (g)

Where, A = Absorbance, A 1%1cm = absorption coefficient of carotenoid in solvent used, petroleum ether is 2592, V (ml) = volume of the solution that gives an absorbance of A at a specified wavelength, W = weight (g) of the sample.

Determination of minerals (Fe and Zn)

The mineral contents were determined by Atomic Absorption Spectrophotometer. Five grams of the samples were converted to ash; the known weight of ash was treated with 5 ml of 6 N HCl and dried on the hot plate and 15 ml of 3 N HCl was added and heated on the hot plate until the

solution boiled. The solution was cooled and filtered through filter paper in to 50 ml graduated flask then made up with de-ionized water that was used to determine Zn and Fe. The samples and standards were atomized by oxidizing air-acetylene for Zinc and Iron as a source of atomization energy (AACC, 2000). The absorbencies of both the samples and standards were measured at 248.4 nm and 213.9 nm for Iron and Zinc. The samples' mineral concentrations were determined from a standard graph and expressed as mg/100 g.

Assessment of Nutritional status

The nutritional status of the school-age children was assessed by anthropometric measurements of height and weight. A total of 384 pupils participated in nutrition status assessment; four schools (Mtinko, Malolo, Ilongero, and Mwakabiji) were randomly selected and in each school 96 pupils were randomly selected, 16 pupils from each class, from class one to class 6 with age ranging from 5 to 12 years, gender was also considered.

Weighing was performed on a digital weighing scale (digital electronic SECA scale; Model 8811021659, Germany) without shoes. School uniforms were worn when being weighed. Accuracy was set at 0.1 kg. Height was measured using a stadiometer (model No PE-AIM-101-USA) and recorded to the nearest 0.1cm. Subjects were requested to stand upright without shoes with their back kept against the wall and heels put together in a V-shape and looking forward.

The weight and height measurements obtained were analysed by using WHO

anthro-plus to obtain the BMI for age z-score of school children and height for age of school children (HAZ); Stunting and wasting were defined as having a z score below –2 SD of the WHO standards of height for age and BMI for age respectively. The age of each pupil was obtained from the school records, each class teacher was told to came with the exact birthdate of each of the participating pupils as it was recorded in the particular pupils school documents.

Cut-off points (Source: WHO, 2007)

BMI for age z-score (5 to 19 years)

Nutrition status	z- score
Obese	> +2
Overweight	>+1 to 2 SD
Normal	-2 to≤ +1
Moderately wasted	-3 to < -2
Severely wasted	< -3

Height for age z-score (5 to 19 years)

Nutritional status	Z-score range
Normal	-2 to≤ +3
Moderately stunted	-3 to <-2
Severely stunted	<-3

Sensory evaluation

Consumer acceptability and preferences were evaluated by pupils in Singida region, it involved school children (n= 76) from class four to class six of age between 9 and 12 years. Four schools were included in this study, two from each division and in each school 19 pupils were selected to obtain the desired sample.

The participants evaluated nine coded samples each at a time. The samples were assigned with three-digit random numbers and served to the consumers. Panelists washed their hands with soap and running water before testing of the samples. They then rinsed their mouths after testing each sample to reduce the taste of the previous sample. Participants evaluated the acceptability and preferences of the food products using a hedonic scale ranging from 1 ("dislike very much") to 7 ("like very much") for acceptance test and 1 ("preferred") to 5 ("less preferred") for preference test aiming to understand the acceptability and preferences for one sample over others. Each participant evaluated each sample for overall acceptability, aroma, colour and taste. To make it simple for school children and to encourage their participation, emoji pictures were used as a parameter (hedonic scale) to elicit the degree of likes and dislikes.

Objective 5: Development of promotional materials and cooking demonstration to improve utilization of pigeon peas

Promotional/Educational materials were developed to provide information on the nutritional importance of pigeon pea as well as processing of pigeon peas. The promotional materials included brochures, which provided information to parents on the importance of pigeon peas for health as well as the recipe for making biscuits from pigeon peas. The development process of the bronchures involved several steps used in developing educational materials.

Considering needs assessment

The first step used in developing the brochures was identifying the needs of the people being taught, this included gaining information on the target population, there educational level, economic factors they are engaged in as well as what the

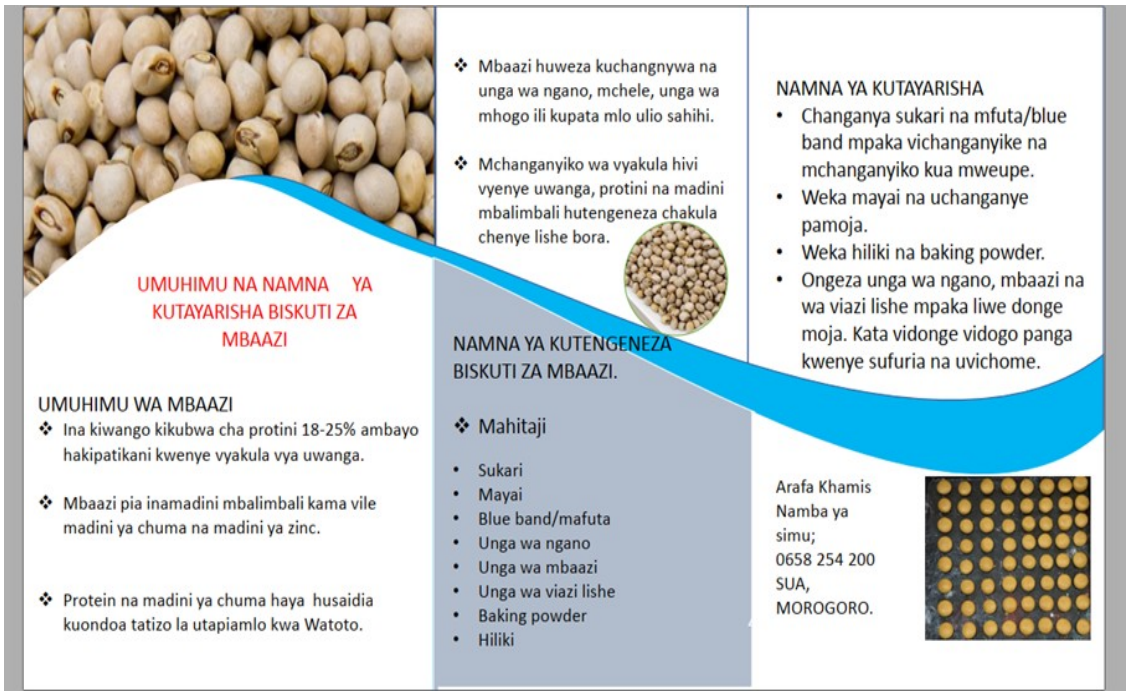
population needs and wants to know to reduce the problem of malnutrition. All this information were obtained through focus groups discussion.

Developing new materials

This includes the objective of the developed brochure and designing of the brochure. The objective of this study brochure was to provide awareness to the community on the importance of pigeon peas to their health as well as elaborating pigeon pea biscuits recipe to increase utilization of pigeon peas and to reduce the burden of malnutrition in children. In designing of the brochure the quality of the text , layout and design was done to meet the requirement of the reader and the quality of the brochure to enhance readability and produce quality brochures.

Evaluation

This is the last step in producing educational materials. This included the assessment of readability, relevance of the information. This was done by providing the educational brochures to colleagues to review the brochures for clarity and accuracy of information.



~~Figure 1~~Figure 2: Bronchure on importance of pigeon peas and biscuits recipe

Cooking Demonstration

Cooking demonstration was done after providing the brochures and explaining on the importance of pigeon peas. It included the demonstration of pigeon pea-based biscuits which were mostly acceptable by the school children. The cooked biscuits were then tasted by the parents to give their acceptability in terms of aroma, taste, colour and overall acceptability.

The cooking demonstration and provision of promotional materials included 32 parents, five males and twenty-seven females. In each of the two divisions Mtinko and Ilongero, participants were divided into of eight participants in each group to participate in cooking demonstration.

The first part of the cooking demonstration was done by the researcher while parents were watching. After that each group of participants prepared the

biscuits in the presence of the researcher to assess their understanding and if they were able to follow all the steps in the cooking procedures.

3.6 Data Analysis

Objective 1: To examine utilization of Pigeon peas in Singida

NVivo version 12 software was used to analyze data obtained from focus group discussions, voice records collected from focus group discussions were transcribed and translated followed by formation of a code book for result categorization and analysis. The code book contained all the key points obtained in the field based on the specific topic of concern with regard to the objectives. The key points assisted in analyzing the data in the software as it categorizes the results based on the colors selected. NVivo software analyzes the data in-form of colored graphical tables for the interpretation.

Data for objective 2, 3 and 4 that is data on the products developed, proximate analysis and sensory evaluation were analyzed by IBM SPSS Statistics version 20. Descriptive analysis was carried out to determine means of height, weight, frequencies and standard deviation of height and weight. Multiple logistic regressions to determine relationships between product acceptability and age of participants were performed. ; chi square test was used as a test of significance for categorical variables, and differences were considered significant at ($P \leq 0.05$).

One-way ANOVA (Analysis of variance) was performed to calculate Mean Ranks and Significance Levels of overall acceptability of pigeon pea-based

products. BMI for age and height for age were analysed by using WHO AnthroPlus by using Z-score and the frequencies.

3.7 Ethical Consideration

–Ethical approval was obtained from Sokoine University of Agriculture and permission letter from Village Executive Officers and/or village chairpersons. Details of the study were explained to the subjects (Parents, teachers and children), before the commencement of data collection to obtain their consent to participate; Oral informed consent was given by the subjects, a school meeting was commencend which involved parents of the pupils, the teachers and the researcher, the parents who agreed and gave the consent for their children to participate in the study were written there names and their children/s name who have eligibility to participate in the study for participation of the study in the next day (Appendix 1).

During data collection children were also asked to give their assent to participate in the study, children who refused to give their willingness to participate in the study were not involved in the study(Appendix 2).

For focus group discussion individuals who are beneficiaries of the project were explained details of the study before the commencement of data collection to obtain their consent to participate, participants who gave consents to participate and agreed to voice recording of the discussions were the ones who were involved in the study (Appendix 3).

Data were kept confidential and communicated without disclosing individual identity

CHAPTER FOUR

4.0 RESULTS

4.1 Utilization of pigeon peas in Singida

The study involved 6 focus group discussions, three from each of the two divisions of Ilongero and Mtinko. Focus group discussions aimed to gain insights on the utilization of pigeon peas among the people of Singida region.

Table 4 shows, forty-eight mothers/caregivers participated in focus group discussions;_ ~~-~~twenty-five participants ranged from 37-46 age group, thirty-nine participants had primary education level and forty-three of them engaged in farming activities only four of them engaged with petty business.

~~Table 6~~Table 7: Characteristics of participants in focus group discussions (N= 48)

Variables	Category	n	%
Age	27-36	17	35.4
	37-46	25	52.1

	47-56	**6**	**12.5**
	Total	**48**	**100**
Education level	**Primary Education**	**39**	**81.2**
	Secondary education	**2**	**4.2**
	Informal education	**3**	**6.3**
	No schooling	**4**	**8.3**
	Total	**48**	**100**
Source of income	**Formal employment**	**1**	**2.1**
	Farming	**43**	**89.6**
	Petty business	**4**	**8.3**
	Total	**48**	**100**

4.1.1 Selling

From both divisions, 44 out of 48 participants who participated in the focus group discussions mentioned selling as the main reason driving their production of pigeon peas. They said that they produce pigeon peas, pack in sacks and sell them to wholesalers. Furthermore, the market of pigeon peas seemed to have increased recently compared to the previous two to three years. One of the participants from Ilongero said that *"In this year (2019) we sold almost all of our pigeon peas, we sell them to wholesalers; we sold one tin for up to fifteen thousand shillings which had 17 liters compared to the two previous years in which pigeon peas were not bought at all we only ate them".*

Another person from Mtinko said, *"We produced pigeon peas and sold it to wholesalers who sell pigeon peas in the market, the buyers are from within Singida region and they sell it in the market".*

4.1.2 Home consumption

Consumption was another use of which was mentioned by 35 out of 48 participants from all the six groups. They said that they usually cook different foods with pigeon peas such as stew and it is usually eaten with stiff porridge and rice as well as "makande" a mixture of pigeon peas and maize. A participant from Mtinko said that *"When we use pigeon peas for consumption at our houses, we usually use the green peas for cooking "makande" as well as stew which is eaten with other foods like rice".* However, it was observed from the focus group discussions that only a small amount that remained after selling the pigeon peas is used for consumption. Participant from Ilongero said that *"We rarely eat pigeon peas at home, because we usually sell them. The last time I ate*

pigeon peas was in September 2019 after harvesting pigeon peas, sold them and left some for home consumption".

4.1.3 Medicinal and fodder

Pigeon peas are also used as medicine by the people from the study areas to treat different kinds of diseases such as heart disease, malaria and treating snake bites. Twenty participants in all the six group discussions from both divisions Ilongero and Mtinko said that, they usually use pigeon pea roots and fresh leaves to treat these kinds of diseases. In the case of Malaria and snake bites, pigeon pea leaves and roots are used for the treatment of this disease In Ilongero a participant said "The *roots of pigeon peas can be used to treat heart diseases, people suffering from heart disease are given its roots to chew for some period of time until they get better"*

In Mtinko, one participant said "*The fresh leaves of pigeon peas can be ground to a fine powder and mixed with lep*

mon juice and given to a person suffering from malaria. My child was suffering from malaria, I gave her this mixture and after 6 days she got well".

After harvesting, leaves are used as feeds for cows and goats, one of the participant from Mtinko said that "*after harvesting, the leaves which remain in the fields are eaten by our own livestock as well as the livestock from our neighborhood*'.

4.1.4 Firewood and building woods

After harvesting of pigeon peas 22/48 participants from all the focus groups said they take the stems and use them as firewood in their houses. From both the two

divisions, 19 participants said they use them in repairing their house roofs and for construction of huts. One person in Ilongero said *"I use the stem after harvesting of pigeon peas for constructing our new hut which will be used by our elder child, and I gave firewood to our neighbour".*

The code book for these results is indicated in appendix 4

4.2 Nutrient content of pigeon peas-based products

4.2.1 Proximate composition of Raw Samples and the formulated Products

The proximate composition of the products produced and raw materials used are presented in Table 5. For the raw materials, Protein content ranged between 7.0 and 18.6g/100g; the highest protein was observed in pigeon peas flour while the lowest was observed in orange fleshed sweet potato. Carbohydrate content varied between 35.6 and 76.9g/100g; carbohydrate was highest in orange fleshed potato and lowest in amaranth flour. The fat content ranged between 0.6 and 3.7g/100g and fiber content ranged from 3.5- 12.9.

For the formulated products;

Biscuits

The protein content of the biscuits ranged between 18.9 and 9.9g/100g; the carbohydrate composition ranged between 66.9 and 44.2 g/100g, fat ranged between 15g/100g and 18g/100g the moisture content varied between 4.4 and 6.6g/100g and fiber ranged 7- and 8g/100g.

African doughnuts

The protein content of the African doughnuts ranged between 10 and 11g/100g; the carbohydrate content ranged between 44 and 56 g/100g, fat ranged between

10g/100g and 14g/100g the moisture content varied between 18 and 19g/100g and fiber ranged 4 and 10g/100g.

Pigeon buns

The protein content of the Pigeon buns ranged 10 and 11g/100g; the carbohydrate composition ranged between 44 and 56 g/100g, fat ranged between 10g/100g and 14g/100g the moisture content varied between 18 and 19g/100g and fiber ranged 4 and 10g/100g.

~~Table 8~~Table 9: Proximate Composition of the Raw Samples and the formulated Products in (g/100g)

Sample Name	Moisture	Fat	Protein	Carbohydrate	Ash	Fiber
Pigeon Peas	5.3	2.4	18.6	65.8	3.8	4.0
Amaranth	14.7	3.7	12.8	35.6	15.0	12.9
Orange Fleshed Sweet Potato	7.8	0.6	7.0	76.9	4.2	3.5
Wheat	7.9	1.5	13.3	73.2	0.7	3.5
Biscuits 1	6.9	15.5	18.9	49.8	1.8	8.8
Biscuits 2	3.6	17.0	9.9	58.7	2.2	8.0
Biscuits 3	4.4	18.3	10.7	66.9	2.2	7.2
African doughnuts (*maandazi*) 1	19.0	10.3	10.5	44.2	1.6	10.4
African doughnuts (*maandazi*) 2	18.7	12.3	10.9	46.3	2.0	7.8
African doughnuts (*maandazi*) 3	19.4	14.2	11.0	56.7	2.0	4.7
Pigeon Pea Buns 1	1.5	13.7	12.3	39.1	4.3	7.1
Pigeon Pea Buns 2	15.5	14.3	13.1	42.1	5.7	5.4
Pigeon Pea Buns 3	12.0	15.0	10.2	30.2	3.6	6.0

4.2.2 β-carotene and vitamin C in raw and formulated food products

Beta-carotene and vitamin C content of the products produced and raw materials used are presented in Table 6. For the raw materials Beta-carotene composition ranged between 4.7 and 48.5mg/100g and Vitamin C ranged between 0 and 32mg/100g.

Beta-carotene content ranged between 7.1 and 13.1 mg/100g and vitamin C ranged between 2.2 and 7.0mg/100g; In African doughnuts Beta-carotene ranged between 3.5 and 4.7mg/100g and Vitamin C 0 and 1.2mg/100g. Pigeon pea buns contains Beta-carotene content in the range of between 0.9 and 7.5mg/ 100g and Vitamin C from 0 and 5.4 mg/100g.

~~Table 10~~Table 11: β-carotene and vitamin C of the Raw Samples and the formulated Products (mg/100g)

Sample Name	Beta-carotene	Vitamin C
Pigeon Peas	4.7	0.4
Amaranth	48.5	32.0
Orange Fleshed Sweet Potato	35.5	14.9
Wheat	0	0
Biscuits 1	8.8	2.2
Biscuits 2	13.1	3.3
Biscuits 3	7.1	7.0
African doughnuts (*maandazi*) 1	4.7	0
African doughnuts (*maandazi*) 2	4.4	1.2
African doughnuts (*maandazi*) 3	3.5	0
Pigeon Pea Buns 1	7.5	5.4

Pigeon Pea Buns 2	**5.6**	**2.1**
Pigeon Pea Buns 3	**0.9**	**0**

4.2.3 Mineral composition in raw and formulated food products

The vitamin composition of the products produced and raw materials used are presented in Table 7. For the raw materials Zinc composition ranged between 4.7- 48.5mg/100g and Vitamin C ranged between 0-32mg/100g.

For the formulated products, the biscuits Vitamin A content ranged between 0.61-4.56 mg/100g and Iron ranged between 1.91- 8mg/100g; For African doughnuts Zinc 2.3-2.5mg/100g and Iron 0.7-1.4mg/100g, and Pigeon pea buns Zinc ranged between 2-4.8mg/100g and Iron from 0.7-2.8 mg/100g.

~~Table 12~~Table 13: Mineral Composition of the Raw Samples and the formulated Products (mg/100g)

Sample name	Zinc	Iron
Pigeon Peas	4.56	5.33
Amaranth	3.39	8.46
Orange Fleshed Sweet Potato	0.61	2.54
Wheat	3.22	1.91
Biscuits 1	2.74	1.83
Biscuits 2	2.87	1.33
Biscuits 3	3.0	1.91
African doughnuts (*maandazi*) 1	2.54	1.62
African doughnuts (*maandazi*) 2	2.35	0.75
African doughnuts (*maandazi*) 3	2.42	1.43
Pigeon Pea Buns 1	2.0	0.75
Pigeon Pea Buns 2	4.31	1.55
Pigeon Pea Buns 3	4.8	2.87

4.3 Nutritional status of school-age children

4.3.1 Mean Height and Weight

A total of 405 school age- children were from two divisions were recruited in this study. Among 405 selected pupils, 12 refused to provide consent of participation after explaining the details of the study, and thus we remained with 393 pupils. After data collection, through data cleaning and entry 5 questionnaires had no height measuments and 3 had no weight measurements (partial non response) and thus; only 384 questionnaires were accurately filled and hence used in analysis.

A total of 384 school-aged children from two divisions were involved in the analysis of this study in which 192 participants were obtained from each division. Among these 192 were girls and 192 were boys from different classes in primary schools.

The numbers of boys and girls in their respective age and their mean height and weight with standard deviation is given in Table 8. Results showed that among both boys and girls height and wight increased with increase in age. At the age group of 8 years and above both showed a sharp increase of weight and height. However, males were seen to be heavier and taller than girls in almost all age groups.

~~Table 14~~Table 15: Height and weight of School going children by sex and age

Age in Years	Sex	Height (cm)		Weight (kg)	
n		Mean	SD	Mean	SD
5-7	Male	114.2	6.05	18.6	2.27
34	Female		5.02	19.3	2.62
36		116.0			
8-10	Male	142.2	8.92	23.1	4.45
67	Female		6.69	23.1	3.66
61		124.1			
11-12	Male	159.0	2.10	31.6	5.32
91	Female		9.60	29.9	7.58
95		139.7			

4.3.2 Prevalence of Wasting according to area of residence, sex and age of respondents.

Wasting were defined as having a BMI for age z score (BAM) below –2 SD of the WHO standards

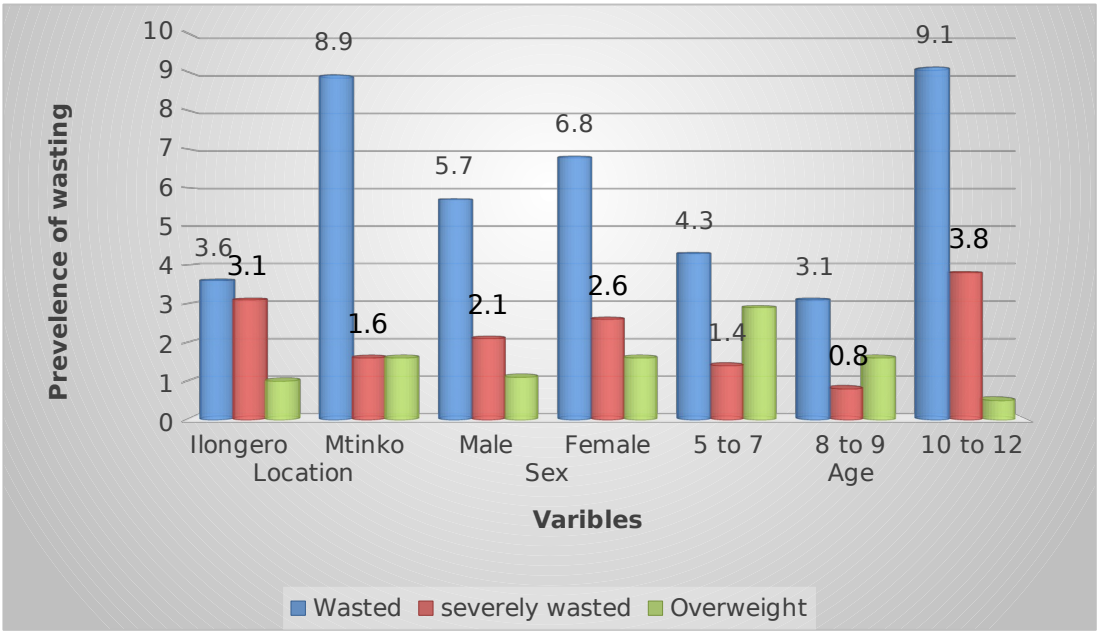
4.3.2.1 Wasting according to Area of residence

Among the 384 pupils, the overall prevalence of Wasting was 8.9% and 2.3% were severely wasted (Figure 2). The prevalence of Wasting in Ilongero and Mtinko was 3.6% and 8.9% respectively while 3.1% and 1.6% respectively were severely wasted. Ilongero showed higher prevalence of wasting than Mtinko.

4.3.2.2 Wasting according to sex and age of the pupils

Among the participating males and females, 5.7% and 6.8% respectively were wasted; 2.1% males and 2.6% females were severely wasted while 1.1% males and 1.6% female were overweight.

The prevalence of wasting was high in the age group 10-12 years, 9.1% were wasted and 3.8% being severely wasted followed by the age group of 8-10 y,ears; 3.1% were wasted and 0.8% were severely wasted compared to the age group of 6-7 years, 4.3% were wasted and 1.4% were severely wasted (Figure 2).



~~Figure 3~~Figure 4: Prevalence of Wasting in school age children

4.3.3 Prevalence of stunting according to area of residence, sex and age of respondents.

Stunting were defined as having a Height for age (HAZ) z score below –2 SD of the WHO standards

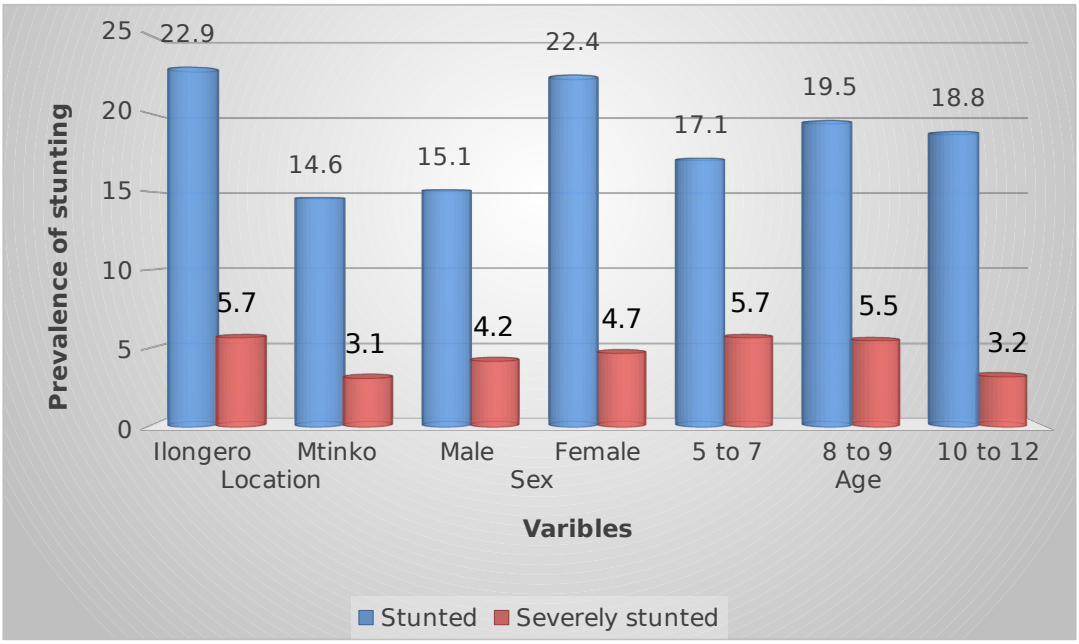
4.3.3.1 Stunting according to area of residence

Among the 384 pupils, the total prevalence of stunting between the two Divisions was 18.8% while 4.4% were severely stunted (Figure 3). The prevalence of stunting in Ilongero and Mtinko was 22.9% and 14.6% respectively while 5.7% and 3.1% respectively were severely stunted.

4.3.3.2 Stunting according to sex and age of the pupils

The overall results showed that 18.8% were stunted and 4.4% were severely stunted, among them 15.1% males and 22.4% females were stunted while 4.2% males and 4.7% females were severely stunted.

The prevalence of stunting is seen to be highest in 8-9 years age group with stunting being 19.5% and severely stunted 5.5%, followed by age group 10-12 years, with 18.8% of stunting and 3.2% severely stunted, age group 5-7 years show 17.1% stunted and 5.7% severely stunted (Figure 3).



~~Figure 5~~Figure 6: Prevalence of Stunting in school age children

4.4 Acceptability and preference of products

4.4.1 Sensory evaluation by school-age children

The sensory evaluation of school-age children which involved 76 participants from four different schools gave the following results;

The Table 9 shows age and sex of school-age respondents who participated in sensory evaluation. The majority of the participants were in the age group 10 – 12 years (73.7%) and only 26.3% were in the age group off 8-9 years. In terms of sex of the pupils, 59.2% were females and 40.8% were males.

~~Table 16~~Table 17: Characteristics of the school-age consumer panel

	Category	N	%
Age	8 – 9	20	26.3
	10 – 12	56	73.7
Total		76	100
Sex	Male	31	40.8
	Female	45	59.2
Total		76	100

~~Table 18~~Table 19: Sensory attributes of the formulated food products for the school-age children

Food Products	Aroma		Colour		Taste		Overall Acceptability	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Biscuits F1	6.18	1.411[a]	6.43	0.884[a]	6.62	0.879[a]	6.45	1.321[a]
Biscuits F2	6.55	0.737[a]	6.58	0.638[a]	6.42	1.145[a]	6.18	1.695[a]
Biscuits F3	6.66	0.623[a]	6.80	0.566[a]	6.71	0.921[a]	6.28	1.597[a]
African doughnuts (maandazi) F4	3.14	2.153[ab]	4.08	2.153[ab]	4.72	2.139[ab]	3.29	2.153[ab]
African doughnuts (maandazi) F5	3.51	2.414[ac]	3.95	2.460[ac]	4.50	2.527[ac]	4.38	2.026[ac]
African doughnuts (maandazi) F6	4.54	2.490[ad]	3.83	2.495[ad]	4.87	2.457[ad]	4.95	2.039[ad]
Pigeon Buns F7	4.67	2.532[ae]	4.41	2.644[ae]	3.83	2.413[ae]	3.51	2.386[ae]
Pigeon Buns F8	5.54	2.132[a]	4.51	2.641[af]	4.41	2.629[af]	4.59	2.246[af]
Pigeon Buns F9	6.36	1.174[a]	6.72	0.793[a]	6.53	1.227[a]	6.33	1.380[a]

The values denoted by different letters in the same column are significantly different (p<0.5). It was observed that all the attribute aroma, colour, taste and overall acceptability of the products were significantly different in all varieties.

Mean scores of male and female for sensory evaluation

Table 11 shows the mean scores of both male and female was almost similar in the formulated biscuits, In all sex all the formulated biscuits shows high mean of 6; Significant difference (P≤ 5) between gender was detected for aroma and overall acceptability of Biscuits F2.

~~Table 20~~Table 21: Sensory attributes mean score and standard deviation of formulated biscuits separated by gender

Food Products/ sensory attributes	Male		Female		P- value
	Mean	SD	Mean	SD	
Biscuits F1					
Aroma	6.06	1.41	6.27	1.42	0.543
Colour	6.45	0.85	6.42	0.91	0.888
Taste	6.48	1.06	6.71	0.72	0.271
Overall Acceptability	6.74	0.77	6.2-u4	1.57	0.107
Biscuits F2					
Aroma	6.58	0.72	6.53	0.75	0.005
Colour	6.61	0.67	6.56	0.62	0.703
Taste	6.48	0.96	6.38	1.27	0.694
Overall Acceptability	6.48	1.12	5.98	1.98	0.005
Biscuits F3					
Aroma	6.71	0.59	6.62	0.65	0.950
Colour	6.68	0.70	6.89	0.70	0.620
Taste	6.77	0.56	6.67	1.11	0.110
Overall Acceptability	6.29	1.53	6.27	1.66	0.950

Table 12 shows the mean score of both male and female was almost similar in the formulated African doughnuts, In all sex the formulated African doughnut shows mean of score of 3-5; Significant difference (P≤ 5) between gender was detected for aroma and overall acceptability of African doughnuts F6.

~~Table 22~~Table 23: Sensory attributes mean score and standard deviation of formulated African doughnuts separated by gender

Food Products/ sensory attributes	Male		Female		P- value
	Mean	SD	Mean	SD	
African doughnuts F4					
Aroma	3.48	2.43	2.91	2.04	0.270
Colour	4.32	2.15	3.91	2.16	0.416
Taste	4.52	2.25	4.87	2.07	0.486
Overall Acceptability	3.23	2.15	3.33	2.17	0.832
African doughnuts F5					
Aroma	3.42	2.54	3.42	2.54	0.781
Colour	4.06	2.39	3.87	2.53	0.733
Taste	4.45	2.61	4.53	2.49	0.891
Overall Acceptability	4.87	1.88	4.04	2.08	0.080
African doughnuts F6					
Aroma	4.45	2.45	4.60	2.54	0.004
Colour	3.32	2.54	4.18	2.43	0.143
Taste	4.74	2.59	4.96	2.38	0.712
Overall Acceptability	5.81	1.58	4.36	2.12	0.002

Table 13 shows the mean score of both male and female ranged between 4-6 in Pigeon pea buns, Significant difference (P≤ 5) between gender was detected in aroma in Pigeon buns F8 and taste in Pigeon buns F9.

~~Table 24~~Table 25: Sensory attributes mean score and standard deviation of formulated Pigeon buns separated by gender

Food Products/ sensory attributes	Male		Female		P-value
	Mean	SD	Mean	SD	
Pigeon buns F7					
Aroma	4.74	2.52	4.62	2.52	0.841
Colour	4.03	2.51	4.68	2.73	0.307
Taste	3.55	2.42	4.02	2.42	0.404

Overall Acceptability	**4.13**	**2.35**	**3.09**	**2.34**	**0.061**
Pigeon buns F8					
Aroma	**5.23**	**2.25**	**5.23**	**2.24**	**0.001**
Colour	**4.84**	**2.56**	**4.29**	**2.70**	**0.376**
Taste	**4.52**	**2.59**	**4.33**	**2.68**	**0.768**
Overall Acceptability	**4.58**	**2.51**	**4.60**	**2.07**	**0.971**
Pigeon buns F9					
Aroma	**6.48**	**1.03**	**6.27**	**1.27**	**0.432**
Colour	**6.61**	**0.80**	**6.80**	**0.79**	**0.415**
Taste	**6.39**	**1.41**	**6.62**	**1.09**	**0.003**
Overall Acceptability	**6.68**	**0.95**	**6.09**	**1.58**	**0.067**

Mean of age group for sensory evaluation

Table 14 shows the mean score of age which is grouped into young (8-9) and older age (10-12) was almost similar in the all the formulated biscuits, In all the age groups biscuits showed high mean score of 6, Significant difference (P≤ 5) between age group was detected for colour in biscuits F2, aroma and taste in biscuits F3.

~~Table 26~~Table 27: Sensory attributes mean score and standard deviation of formulated biscuits separated by Age

Food Products/ sensory attributes	**Young**		**Older**		**P- value**
	Mean	**SD**	**Mean**	**SD**	
Biscuits F1					
Aroma	**6.25**	**1.29**	**6.17**	**1.45**	**0.835**
Colour	**6.50**	**0.97**	**6.42**	**0.87**	**0.740**
Taste	**6.63**	**1.45**	**6.62**	**0.90**	**0.973**
Overall Acceptability	**6.81**	**0.54**	**6.35**	**1.45**	**0.215**

Biscuits F2					
Aroma	**6.38**	**0.86**	**6.60**	**0.69**	**0.405**
Colour	**6.31**	**0.55**	**6.65**	**0.57**	**0.002**
Taste	**5.81**	**1.83**	**6.58**	**0.83**	**0.060**
Overall Acceptability	**6.50**	**1.51**	**6.10**	**1.50**	**0.281**
Biscuits F3					
Aroma	**7.00**	**0.00**	**6.57**	**0.67**	**0.001**
Colour	**6.69**	**0.70**	**6.69**	**0.70**	**0.363**
Taste	**6.20**	**1.73**	**6.73**	**0.95**	**0.005**
Overall Acceptability	**6.56**	**0.89**	**6.20**	**1.74**	**0.423**

Table 15 shows the mean score of age which is grouped into young (8-9) and older age (10-12) ranged between (3-4) , there were no significant difference (P≤ 5) between age and the formulated African doughnuts

~~Table 28~~Table 29: Sensory attributes mean score and standard deviation of formulated biscuits separated by Age

Food Products/ sensory attributes	Young		Older		P-value
African doughnuts F4					
	Mean	**SD**	**Mean**	**SD**	
Aroma	**3.25**	**2.20**	**3.12**	**2.23**	**0.832**
Colour	**3.94**	**2.35**	**4.12**	**2.12**	**0.770**
Taste	**5.06**	**1.91**	**4.63**	**2.20**	**0.480**
Overall Acceptability	**3.69**	**2.41**	**3.18**	**2.09**	**0.409**
African doughnuts F5					
Aroma	**3.19**	**2.23**	**3.60**	**2.47**	**0.547**
Colour	**3.63**	**2.66**	**4.03**	**2.42**	**0.559**
Taste	**4.63**	**2.66**	**4.47**	**2.51**	**0.826**
Overall Acceptability	**3.94**	**2.21**	**4.50**	**1.98**	**0.327**
African doughnuts F6					
Aroma	**4.06**	**2.38**	**4.67**	**2.52**	**0.392**
Colour	**3.81**	**2.64**	**3.83**	**2.48**	**0.977**
Taste	**4.69**	**2.39**	**4.92**	**2.49**	**0.743**
Overall Acceptability	**4.69**	**2.33**	**5.02**	**1.97**	**0.570**

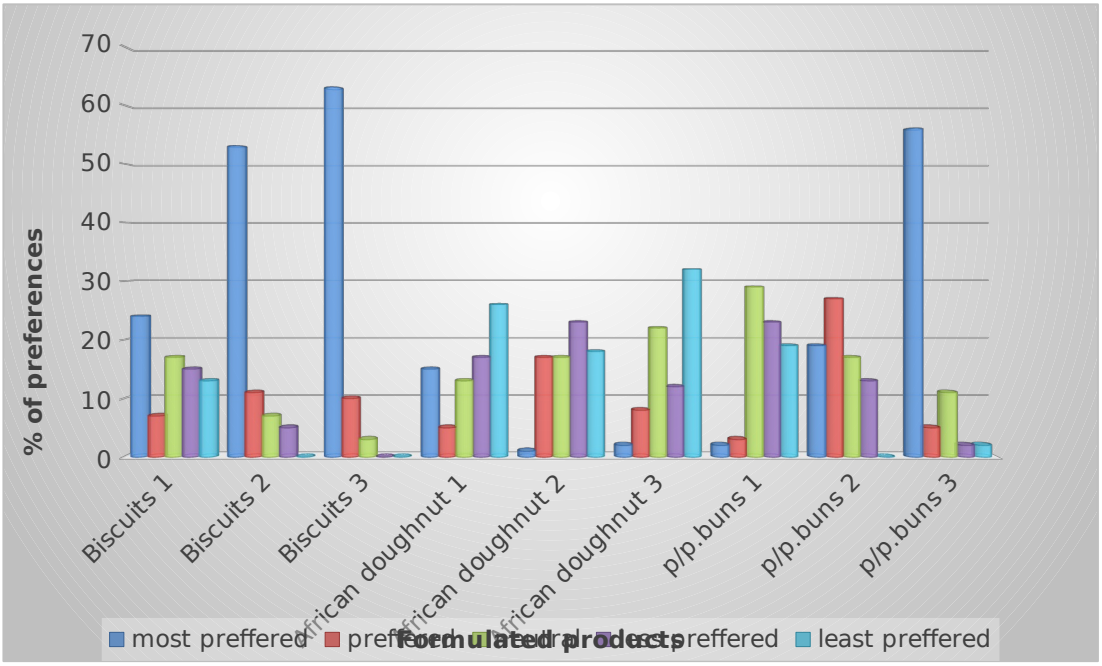
Table 16 shows the mean score of age which is grouped into young (8-9) and older age (10-12) ranged between (4-6) in Pigeon buns formulated, Significant difference (P≤ 5) between age group was detected in colour in Pigeon buns F8.

~~Table 30~~Table 31: Sensory attributes mean score and standard deviation of formulated biscuits separated by Age

Food Products/ sensory attributes	Young		Older		P-value
Pigeon buns F7	**Mean**	**SD**	**Mea**	**SD**	
Aroma	**4.81**	**2.64**	**n**	**2.52**	**0.803**
Colour	**4.76**	**2.79**	**4.63**	**2.62**	**0.564**
Taste	**3.94**	**2.57**	**4.32**	**2.39**	**0.841**
Overall Acceptability	**3.56**	**2.16**	**3.80**	**2.46**	**0.927**
			3.50		
Pigeon buns F8					
Aroma	**5.31**	**2.02**	**5.60**	**2.17**	**0.953**
Colour	**4.38**	**2.83**	**4.55**	**2.61**	**0.004**
Taste	**4.69**	**2.79**	**4.33**	**2.60**	**0.816**
Overall Acceptability	**4.58**	**2.13**	**4.60**	**2.29**	**0.003**
Pigeon buns F9					
Aroma	**6.31**	**1.45**	**6.37**	**1.10**	**0.388**
Colour	**6.69**	**0.70**	**6.73**	**0.82**	**0.839**
Taste	**6.75**	**0.68**	**6.47**	**1.33**	**0.416**
Overall Acceptability	**6.06**	**1.69**	**6.40**	**1.29**	**0.871**

4.4.2 Frequency of different attributes as perceived by school children

Figure 4 Presents the sensory preference of the formulated food products (biscuits, African doughnuts (*maandazi*) and pigeon peas bun by school-age children. The figure shows the most preferred formulated product was Biscuits 3 with the highest consumer acceptability score of 83%, followed by pigeon buns 3 with a score of 74% and then biscuits 2 with a score of 70%; with the least preferred products being African doughnuts (*maandazi)* 1 and African doughnuts (*maandazi*) 3 with a score of 35% and 43% respectively.



~~Figure 7~~Figure 8: Preference of formulated food products as perceived by School children

4.5 Promotional materials and participatory cooking demonstration

Table 15 shows age, sex and education level of parents/ caregivers who participated in cooking demonstrations. Among the participants, 34.4 % ranged from 20 – 30 years of age and 9.4% ranged from 51- 60 years of age; there were 84.4% females and 15.6% males most of them had primary education 87.5%.

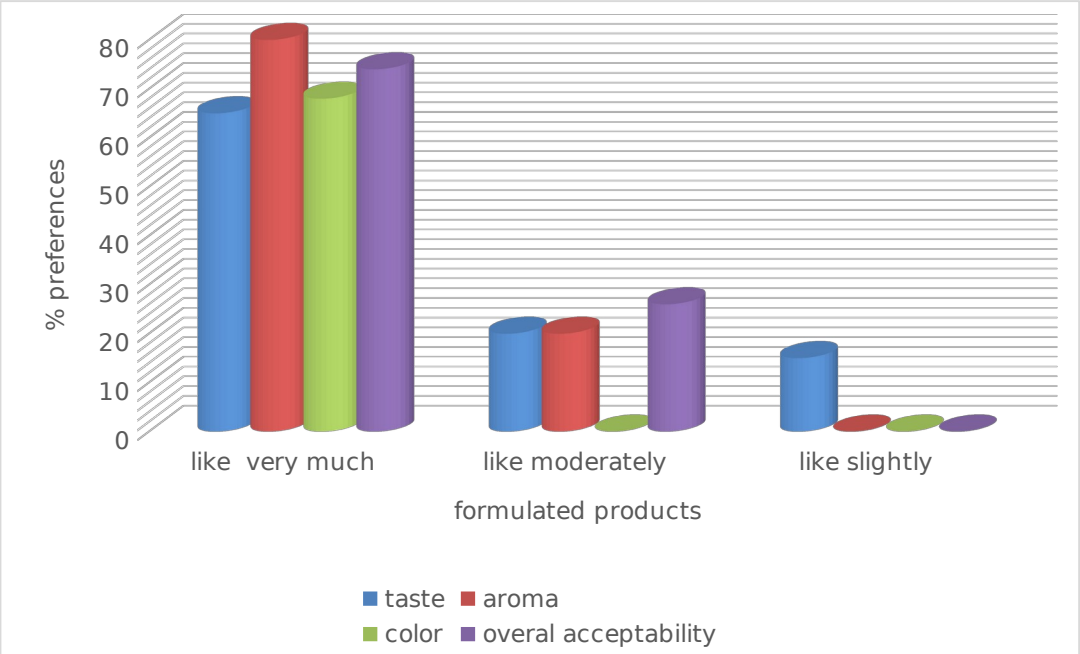
~~Table 32~~Table 33: Socio-demographic characteristics of caregivers

Variable	Category	Percent
Age	20-30	34.4
	31-40	31.3
	41-50	25.0
	51-60	9.4
Sex	Male	15.6
	Female	84.4

Education level	**Primary level**	**87.5**
	Secondary level	**6.3**
	Informal	**6.3**
Total		**32**

After the cooking demonstrations of the biscuits, participants tasted the acceptability of the biscuits and gave the following results;

Figure 5 shows that aroma received 80% high acceptability score than other attributes followed by overall acceptability with 74%, then colour and taste with acceptability score of 68% and 65% respectively, none of the attributes got a score of dislikes.



~~Figure 9~~Figure 10: Acceptability of pigeon peas biscuits as perceived by parents after cooking demonstration

CHAPTER FIVE

5.0 DISCUSSION

5.1 Utilization of pigeon peas

The purpose of this study was to promote the utilization of pigeon peas for improving nutritional status of school children in Tanzania. A total of forty-eight mothers from Singida rural region participated in the focus group discussions. The results indicated that pigeon peas are used in various ways.

Selling was seen as the main use of pigeon peas, the participants grew pigeon peas to obtain income which would help them attain their basic needs and wants; also, they sold their harvested pigeon peas since they believe pigeon peas have a short life span and so they sold after harvesting. Also, there was limited awareness on the nutritional importance of pigeon peas as well as a lack of knowledge on how to make different recipes from pigeon peas. This finding correlates with the one done by Silim *et al.*, (2005), he found that in the Northern Highlands of Tanzania, pigeon peas are considered a cash crop and a large proportion of the production is sold.

Besides Selling home consumption was the second major purpose for growing pigeon peas in all the surveyed villages. Pigeon peas as stew was the main form of consumption, most of the participants in the discussion boiled the pigeon peas for a long time, and then added some ingredients such as onions and tomatoes and oil to obtain pigeon pea stew which they eat together with rice or stiff

porridge, this was because they did not know how to prepare other recipes out of pigeon peas. Similar results were obtained in a study which was done in Nigeria by Odeny (2007), which found that dry seeds of pigeon peas were cooked whole until tender and mixed with maize, yams or sweet potatoes. The study reported that in many parts of Eastern Africa, dhal (pigeon pea stew) is becoming a popular meal.

The use of leaves and roots in the treatment of some diseases such as malaria and heart diseases and in first aid of snake bite was seen in all the surveyed areas in which leaves were used in treating snake bites and malaria and roots are used to treat heart diseases. This finding showed that the participants do not have similar knowledge on the use of pigeon pea and specific knowledge related to the plant uses might be kept and transmitted within communities in some areas as a result of vertical knowledge transmission (transmission from parent or grandparent to a child) (Ayenan *et al.*, 2017).

5.2 Nutrient content of the products

The moisture content of the formulated products was higher than the acceptable limit of 10% except for the biscuits which were below 10% which is an acceptable limit for long time storage. This suggests reduced chances of spoilage by microorganisms and consequently increasing shelf life. The moisture content of the flour used to prepare the products was within the acceptable limit of 10%. The low moisture content of the flour would enhance its storage

stability by avoiding mould growth, biochemical reactions and extend the shelf life of the final product Akubor (2017). Therefore, the biscuits produced in this study can stay for a long period of time without spoilage and hence people of Singida can prepare adequate of them and use them for a long time so long as they are in dry storage area and well-sealed to avoid the entry of air and reduce the crispness.

The findings of this study revealed that most of the formulated products are within the protein RDA of 10-30 percent of daily calories; however, biscuits F2 showed a lower protein content compared to the recommended allowance of protein. The high protein observed in biscuits may be due to the addition of eggs which are also high in protein. Protein is very important in general body growth and maintenance of body tissues. It assists the action of the enzyme in the body which catalyzes different metabolic reactions (Mahenge, 2018). The results of this study showed a high prevalence of wasting and stunting, the consumption of the formulated products which has a recommended amount of protein may help reduce the problem of malnutrition in this area. Also, according to TNNS, (2018) the prevalence of wasting for unde-five children exceeded the 5% threshold in Singida, therefore, the utilization of the formulated products may help reduce the burden of malnutrition.

Carbohydrate content of the majority of the formulated products was within the recommended daily allowance of 45-65% in a day, only two of them had a carbohydrate lower than the recommended amount. The high carbohydrate content was contributed by the availability of wheat flour, pigeon peas flour and

orange fleshed sweet potato flour. Carbohydrate is important since it provides a major source of energy and is stored as reserve energy for quick needs (Hailu, 2018). Since the prevalence of wasting was high in this study, the formulated products may help reduce the problem of wasting in school children in Singida region since energy will be reserved for quick needs and energy from protein reserve will not be used and hence reduce the burden of malnutrition.

Fat was revealed in the formulated products to be lower than the recommended daily allowance of 25%- 35% per day, however this amount can also be obtained by eating two to three of the formulated products i.e (two biscuits, African doughnuts or pigeon buns) since eating one biscuits, African doughnuts or pigeon buns will not meet the required amount of fat in a day. Moreover, adittional fat in a day can be meet by eating other food sources such as beans. Furthermore, the variations observed in the fat content of the formulated products, despite the same quantity of fat used in the recipe, may be due to variations in their moisture contents. In this study, the amount of fat in formulated products increased with an increase in pigeon peas flour in formulated products.

Diets high in fat predispose consumers to different illnesses such as obesity and coronary heart disease (Mahenge, 2018); therefore, the relatively low-fat content observed in the formulated products may be desirable to both the processor and health-conscious individuals. Essential fatty acids are needed to support the growth of children. Triglycerides serve as reserved energy of the

body. They also serve as a source for fat-soluble vitamins A, D, E and K (Alozie and Okoronkwo,2018).

Minerals are essential for the maintenance of the overall mental physical wellbeing and are important constituents for the development and maintenance of bones, teeth, tissues, muscles, blood, and nerve cells. They aid acid base balance, response of the nerves to physiological stimulation and blood clotting (Ohizua, 2017). The findings of this study revealed the presence of zinc in the formulated products; The amount of zinc in the formulated products increased with an increase in the amount of pigeon peas flour.

zinc is needed by over 300 enzymes, some of which are involved with metabolism of blood sugars. Lack of zinc may undermine cognitive development in children through alteration in attention, activity and other aspects of neuropsychological function (Mahenge, 2018).

The RDA for iron is 10-15 mg per day. The levels of iron make the pigeon pea-based products good sources of iron. The iron content in this study increased with an increase in pigeon pea flour. Iron is important in blood building. Deficiency of iron is the most common nutritional disorder in the world, causing anaemia that affects more than 3.5 million people in the developing world and impairments of learning ability (Akubor, 2017).

Vitamins is an organic substance essential for growth and tissue repair, as for wound healing and maintenance of cartilage, healthy gum, bone and teeth. The increased and decreased vitamin A contents in the formulated products from the flour blends could be attributed to the increased inclusion of pigeon pea, amaranth and orange fleshed potato.

The absence of vitamin C in most of formulated products signifies that the processing method adopted did not retain amount of this nutrient. Vitamin C is soluble in water, much of it is lost when food materials are washed, soaked or boiled and the cooking water discarded, oxidized especially in an alkaline medium, hence the formulated products had less vitamin C. The results of this study are similar to the one done by Adeola and Ohizua which had a low vitamin C content in the produced biscuits ranged from 0.12 to 0.21 mg/100g done by (Adeola and Ohizua, 2018).

5.3 Nutritional status of school-age children

The finding of this study indicated that the children in Singida rural settings suffer from undernutrition, especially stunting, followed by wasting. Overweight was rare and obesity was absent. The pattern of undernutrition is consistent with the global pattern for children under-five, as stunting shows a higher prevalence than underweight and wasting worldwide (UNICEF; WHO and World Bank, 2016).

The findings of this study revealed that undernutrition was more prevalent among girls than boys. However, for both sexes, the prevalence of undernutrition increased with age. One of the leading contributing factors to the positive correlation between age and prevalence of undernutrition is reported to be the delay in the start of the growth spurt. The delay in the start of the growth spurt is multifactorial and can be affected by many factors such as micronutrient deficiency, and energy intake deficiency (Srivastava *et al.*, 2012). The growth spurt in boys is slightly delayed compared with that of girls, which may explain the higher rates of stunting in older age groups as well as the sexual differences (Teblick,2017). Another contributing factor that leads to a higher prevalence of stunting in older children is that stunting, a chronic type of undernutrition, is maintained by prolonged exposure and is difficult to reverse in late childhood.

Girls of older years were regularly being engaged in different types of hard work with their parents like fetching firewoods, going to the farm with their mothers as well as fetching water compared to boys. As the girls remain outside, they can get food only for three times but the boys take some light food one or two times in a day in addition to the three times of heavy foods. All these are directly related to malnutrition. Less physical labour and extra light food are the causes of less percentage of malnutrition among boys (Veghari *et al.*, 2012).

Furthermore, a very early or delayed transition from exclusive breastfeeding to complementary food is thought to be harmful to children and can lead to undernutrition (Mc Donald *et al.*, 2013). On the other hand, this study findings indicated that stunting varied significantly from division to division indicating the importance of geographical variations from one village to the next. Also,

Singida rural children probably have less access to junk foods, so they have fewer problems of over nutrition. Singida rural children showed better nutritional conditions than children under-five from the rest of Tanzania (stunting 31.8%, overweight 2.8%) TNNS, (2018) with exception of wasting which showed a higher prevalence in this study (6.3%).

In this study, children showed a high prevalence of undernutrition possibly due to protein and micronutrient deficiencies, and therefore undernutrition can be a public health issue in school-aged children just like in younger ones. The consumption of the formulated products will help reduce the problem of malnutrition in Singida due to the presence of recommended amount of protein required in School-age children.

5.4 Sensory evaluation

The formulated samples varied significantly ($p < 0.05$) in terms of aroma, colour, taste and overall acceptability. All attributes were strongly influenced by the change in pigeon pea flour and amaranth flour levels. Samples with a higher level of pigeon pea and less amaranth had high scores in all attributes. This may be due to the bitter after taste of amaranth flour which reduced the acceptability of the panelists to products blended with amaranth flour. These findings revealed that pigeon peas products that were not blended with amaranth could be baked with satisfactory acceptance. This may be due to the reason that pigeon peas add natural colour and taste to processed foods. This finding confirms the report by Alozie and Okoronkwo (2018), that pigeon pea adds natural taste, colour, and aroma to processed foods. The acceptability of

pigeon peas biscuits with pigeon pea proportion of 55:30: 8:7 (30% wheat Flour, 57% Pigeon Flour, 0% Amaranth Flour and 13% Orange Fleshed sweet potato flour) which have the recommended amout of protein can be consumed and promoted to reduce the prevalence of malnutrition which is seen to be high in school children in this study seting as the findings of this study revealed.

5.5 Cooking demonstration

The participatory cooking demonstration showed that the biscuits received a higher acceptability score in terms of aroma due to the presence of cardamom which reduced the smell of pigeon peas which is not preferred by many individuals. Overall acceptability of the biscuits was due to that most of the participants liked the biscuits in all aspects including the size , shape, colour, aroma and taste. This may be due to the ingredients which were added in the biscuits hence increasing its palatability and appearance. Taste was also acceptable due to the availability of different ingredients such as sugar and margarine which increased the palatability of the products. Colour was influenced by the pigeon peas flour, because dehulled pigeon pea flour help add natural colour of the formulated products. Promotional materials and cooking demonstration will help increase the consumption of pigeon peas in the study area and help reduce the prevalence of malnutrition in school children.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

High prevalence of wasting and stunting was observed in school age children in the current study. Moreover, the formulated biscuits with high amount of pigeon peas in the formulation was mostly preffered by school age children then all other formulated products; the biscuits had a reasonably acceptable protein content which when provided to the school age children will help reduce the burden of malnutrition in school age children.

This study also provided parents with awareness on the nutritional importance of pigeon peas and how to prepare pigeon peas biscuits for their children to reduce the burden of malnutrition as well as increase their income and reduce food insecurity.

6.2 Recommendation

Based on the findings of this study, the following are recommended;

i. **Increasing awareness to people in the community on the health benefits of pigeon peas as well as introducing various foods and snacks of pigeon peas to increase its consumption.**

ii. **In assessing nutrition status by future researchers' other factors such as dietary assessment, family size, maternal nutrition knowledge and parental education should also be considered in order to capture possible causes that lead to malnutrition and further provide insight into the types of interventions to be implemented in this population.**

iii. **The government and relevant stakeholders directly involved in public health should be more proactive in creating awareness and tackling**

issues such as poverty which contributes to the problem of malnutrition in the country.

iv. **A longitudinal design should be used in future studies to establish a causal relationship between formulated pigeon peas products and nutritional status.**

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APPENDICES

Appendix 1: Consents for parents of the pupils~~Appendix 1~~

C~~onsents for parents of the pupils~~

My name is _____ I work on behalf of Agro ecology hub project. The objective of the project is to reduce the problem of malnutrition as well as food insecurity. Your children have been selected to participate in this study. I would like to ask your children some questions about there acceptability of different formulated products and measure there weight and height to assess their nutritional status. The information collected will help us to know which product were highly acceptable than the other and know the nutritional status of children in this area.

The formulated food products are safe to eat and the researcher and the teachers will taste the products before the pupils to ensure that the food is safe, and before distributing the food to the pupils we will make sure that each child has wash his/ her hands with running water and soap to avoid contamination of the food.

All the information obtained will be kept confidential. Neither their name nor any of the details we obtained will be shared with anyone outside our team in a way that can identify you. Your childrens participation is completely your choice. You do not have to allow your child to participate if you do not want him/her to. There is no penalty to you if you choose not to allow your child

participate. Also, you are free to stop your child at any time of the study. Your cooperation is greatly appreciated. If you decide to participate, I would expect this interview to take about half an hour.

Would you agree to allow your child to participate in this study? YES, NO

Appendix 2: Assent of the pupils participation~~Appendix 2~~

A~~ssent of the pupils participation~~

My name is _____ I work on behalf of Agro ecology hub project. The objective of the project is to reduce the problem of malnutrition as well as food insecurity. You have been selected to participate in this study. I would like to ask you some questions about acceptability of different formulated products and measure your weight and height to assess their nutritional status. The information collected will help us to know which product were highly acceptable than the other and know the nutritional status of children in this area.

The formulated food products are safe to eat and the researcher and the teachers will taste the products before you are given the products to taste to ensure you that the food is safe, and before distributing the food to you we want each one of to wash his/ her hands with running water and soap to avoid contamination of the food.

All the information obtained will be kept confidential. Neither your name nor any of the details we obtained will be shared with anyone outside our team in a way that can identify you. Your participation is completely your choice. You do not have to participate if you don't want to. There is no penalty to you if you not to participate. Also, you are free to stop at any time of the study. Your cooperation is greatly appreciated. If you decide to participate, I would expect this to take about half an hour.

Would you agree to allow your child to participate in this study? YES, NO

Appendix 3: Checklist for focus group discussions~~Appendix 3~~

C~~hecklist for focus group discussions~~

My name is _____ I work on behalf of Agro ecology hub project. The objective of the project is to reduce the problem of malnutrition as well as food insecurity. You have been selected to participate in this study. I would like to ask you some questions about some food crops including their processing, preservation, consumption and preferences. The information collected will help us to know the utilization of food crops.

I will be taking notes but I would also like to record this discussion so I don't miss anything. All the information you give will be kept confidential. Neither your name nor any of the things you tell us will be shared with anyone outside our team in a way that can identify you. Your participation is completely your choice. You do not have to participate if you do not want to. There is no penalty to you if you choose not to participate. Also, you are free to not answer questions you do not wish to answer and you may stop at any time. Your cooperation is greatly appreciated. If you decide to participate, I would expect this interview to take about an hour.

Would you agree to participate in this study? YES, NO

Appendix 4: Focus group discussion code book

~~Appendix 4~~

~~Focus group discussion code book~~

Name	Description	Files	References
Home consumption	Comments on the use of pigeon peas for their own foods.	6	78
Commercialisation	Comments on the use of pigeon peas as a source of income	6	94
Medicinal	Comments on the use of pigeon peas and its leaves/ stems as a source of medicine	6	43
Fire wood and building wood	Comments on the use of pigeon peas stems as a source of energy or building materials	5	50
Fodder	Use of pigeon peas leaves for feeding cattle's	5	6
Believes and taboos	Any cultural understanding on the consumption of pigeon	4	27

	peas		
Number of consumptions of pigeon peas in week	Number of times people consume pigeon peas in their households	5	15
Pigeon peas varieties	Number of pigeon peas varieties being cultivated in study area	6	7
Storage of pigeon peas	The place where pigeon peas and the time being stored after harvesting	5	13

Appendix 5: Checklist for parents

A: Checklist for parents

1. **Which kind of food crops do you usually consume?**
2. **How do you use pigeon peas?**
3. **In what different ways do you prepare pigeon peas for consumption?**
4. **Are there any taboos/believes towards consumption of pigeon peas? What are they?**
5. **On average, how many times do you consume pigeon peas in a week?**
6. **Is there only one kind of pigeon peas variety?**
7. **Are there any factors that influence you to prefer a certain type of variety?**
8. **Where and to whom do you sell your pigeon peas and at what price?**
9. **Where do you store your pigeon peas after harvest, for how long does it stay?**
10. **How do you store cooked pigeon peas product for a long shelf life?**

THANK YOU FOR YOUR PARTICIPATION.

B: Sensory Evaluation (Acceptability Test) of Pigeon Peas-Based Biscuits/ Pigeon Peas African doughnut/ Pigeon Pea Buns (Bagia). Using A Seven-Point Hedonic Scale.

Name; …… Grade…….

Sex…….

Taste and identify your acceptability towards the sample. Please take a sip of water and rinse before starting, you may rinse again with water after every sample test. Please taste the samples according to the number on each page. If you have any questions, please ask the server now.

Dislike very much

Dislike moderate

Dislike slightly

-Neither like nor dislike

-Like slightly

–Like moderately

—Like very much

C: Sensory Evaluation (Preference Test) of Pigeon Peas-Based Biscuits/ Pigeon Pea African doughnuts/ Pigeon Peas Buns (Bagia). Using A Five-Point Ranking Scale.

Name; …… Grade…….

Sex…….

Taste and identify your preference towards the sample. Please take a sip of water and rinse before starting, you may risen again with water after every sample test. Please taste the samples according to the number on each page. If you have any questions, please ask the server now.

1 Most preferred

2 Preferred

3 neutral

4 less preferred ☐ 

5 least preferred ☐ 

D: Assessing Nutrition Status (Anthropometric Measurement)

Age of pupils …….

WEIGHT (kg)	HEIGHT(m^2)	BMI FOR AGE ($kg/m^{2)}$

THANK YOU FOR YOUR PARTICIPATION.