DEVELOPMENT AND EVALUATION OF THE PHYSICAL, CHEMICAL AND SENSORY PROPERTIES OF TWO WEANING FOODS TO IMPROVE THE NUTRITIONAL INTAKE OF MALAWIAN CHILDREN

By

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ABSTRACT

DEVELOPMENT AND EVALUATION OF THE PHYSICAL, CHEMICAL AND SENSORY PROPERTIES OF TWO WEANING FOODS TO IMPROVE THE NUTRITIONAL INTAKE OF MALAWIAN CHILDREN

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There is high prevalence of protein energy malnutrition (PEM) and Vitamin A deficiency (VAD) in young children of weaning age in Malawi, a Sub Saharan Africa country. The aim of this study was to formulate and evaluate the physical and chemical properties and acceptability of porridge and a snack biscuit made from locally available foods that can be used for weaning or by people of other ages in Malawi. Weaning foods were formulated from ingredients produced locally in Malawi to maximize the protein and vitamin A for young children of weaning age. Cowpeas (C), maize (M), Orange Fleshed Sweet Potatoes (OFSP) and wheat (W) were formulated into a porridge and biscuit, and these were evaluated for protein, vitamin A and fat. The physical properties evaluated for biscuits only were height, diameter and spread ratio. Both products were also evaluated for their acceptability by mothers with children 6 months to 3 years. The study showed that for the porridge and biscuit formulations, formula 1 (50M: 30C:20 OFSP) had the highest protein content, Vitamin A compared to the others and to the control. Both Sensory tests with 110 mothers showed that both products were well accepted.

To my lovely parents—Ackim John Lungu and Littah Lungu—who instilled in me the value of education and truly believed I could attain any education goal I set.

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Chapter I. Rationale and Aims

There is a very high prevalence of protein-energy malnutrition (PEM) and vitamin A deficiency in young children of weaning age in Malawi, a Sub Saharan Africa (SSA) country, due, in part, to the poor nutritional quality of weaning foods (Malawi Demographic survey, 2010; Gibson et al., 2003). This is true, despite the availability of common local foods in Malawi that could be used to address both PEM and vitamin needs for this age group.

In Malawi, children under 5 years of age are most affected by PEM (Müller et al., 2003). In Malawi, 47 percent of under five children are stunted; 13 percent, underweight; and 3 percent, severely underweight (Malawi Demographic and Health Survey, 2010). In SSA close to 500 million preschool children have PEM (Steyn & Walker, 2000). PEM in SSA is complicated with other micronutrient deficiencies and several endemic, communicable diseases like malaria, diarrhea and tuberculosis

The weaning period is especially important for young children, because the transition from breast milk to foods is often not adequate in nutrients when food resources are scarce (WHO, 1998). The weaning period is also a critical time in terms of child growth and development. Poor nutrition during this time increases the risk of morbidity and mortality, lower attained size, and of compromised cognitive function (Verwimp, 2011; Allen, 1993). The nutrients most limited in weaning foods in developing countries are protein and vitamin A, along with total energy (Hoppe, Mølgaard, et al., 2004; Nuss et al., 2012; Hotz & Gibson, 2001). Proteins are essential for body growth (Hoppe, Rovenna Udam, et al., 2004) and Vitamin A, necessary for the child's growth, enhancing iron status, helping to decrease infectious morbidity, and reducing childhood mortality (Labadarios, 1994).

Vitamin A is also important for ocular health. Deficiencies can lead to visual impairment and blindness (WHO, 1996). In Malawi, complementary food given to children during weaning is usually a very thin porridge of refined maize, with low energy and low nutrient density, thus contributing to PEM and other vitamin and mineral deficiencies.

Use of this nutritionally inadequate porridge for weaning is unfortunate, because there are several types of legumes like cowpeas locally available in Malawi and rich in protein (Oneh Abu et al., 2005). Cowpeas are rich in glutamic acid, aspartic acid and lysine, but low in sulfur containing amino acids (Hallén et al., 2004). This makes cowpeas an excellent choice to enhance protein quality when combined with cereal grains that have proteins low in lysine but rich in sulfur containing amino acids (Hallén et al., 2004). Despite the fact that cowpeas are an inexpensive protein source, their use for protein complementarity in weaning foods is minimal (Adebooye and Singh, 2007). Because, Malawi is one of the leading countries in cowpea production in Africa (Uzogara and Ofuya, 1992), this food crop could and should be an important ingredient in various food applications such as baked foods, extruded products and weaning foods (Prinyawiwatkul et al., 1996).

Another food, widely grown in Malawi, is the orange fleshed sweet potato (OFSP), a good source of vitamins A and C (Burri, 2011; USDA, 2012). Sweet potatoes are widely grown in Malawi and the OFSP are now being promoted as a rich source of beta carotene (Chipungu et al., 2008). If dried sweet potato could be added to cowpea-enriched maize porridge as a weaning food and be adopted by mothers of weaning infants, this could help to prevent or at least reduce and ameliorate PEM and vitamin A in Malawi.

This study will be conducted to help address PEM and vitamin A deficiency in Malawi. The WHO and UNICEF recommends production of low cost, weaning foods from locally available materials (UNICEF and WHO, 2008) as was done successfully with Incaparina[a] in Latin America (Scrimshaw, 2007). Specifically, this study will aim to formulate and evaluate the physical and chemical properties and acceptability of porridge and a snack biscuit[b] made from locally available foods that can be used for weaning or by people of other ages. The weaning products will be formulated to increase the protein and vitamin A content.

Specific aims

1. To formulate a weaning porridge and snack biscuit[c] high in protein and vitamin A for children up to 3 years of age from local foods and materials.
2. To evaluate some the physical and chemical properties of a weaning foods from flours comprised of maize or wheat and cowpeas and OFSP.
3. To assess the acceptability of the weaning foods by mothers for their children in terms of:
    a. Appearance, taste, consistency/texture, flavor, and overall acceptability; and
    b. Access to ingredients for the weaning foods.

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[a] Incaparina is a grain-legume blend of corn and soy and other ingredients.

[b] A biscuit in Malawi is like a cookie in the U.S.

[c] The snack biscuit would be only for children over two years of age, due to concerns about younger children choking on a hard, dry food.

Hypotheses

Ho1 The various formulations will be no different or better than the 100 percent maize porridge or wheat biscuit in terms of protein and Vitamin a content.

Ho2 The various formulations will be no different or better than the 100 percent maize porridge or wheat biscuit in terms of the physical and chemical properties assessed.

Ho3 The various formulations will be no different or better than the 100 percent maize porridge or wheat biscuit in terms of appearance, taste, consistency/texture, flavor, and overall acceptability, or in access to ingredients.

Chapter II. Literature Review

In this section, literature is reviewed that is pertinent to all three research aims. First, the nutritional and weaning issues in Malawi are discussed. Then, the recommended protein, vitamin A and energy intakes of children 6 months to 3 years are presented in terms of the content in weaning foods available to mothers with limited resources. A brief review of the typical foods available in Malawi follows this with a section on the functional properties of weaning foods. Finally, consideration of the maternal acceptance of the weaning foods will include sensory assessment of taste, texture, color, appearance and overall acceptability.

Under nutrition in Malawi

Under-nutrition is prevalent in Malawi affecting half of the children (Malawi Demographic and Health Survey, 2010). In a 2009 report by the World Bank, Malawi ranked the 5th highest out of 136 countries in the prevalence of growth stunting. Furthermore, Malawi has higher rates of stunting compared to its neighbors and income peers in Africa (World Bank, 2009) and this situation has remained stagnant over the last decade. Compare this rate to that of Zimbabwe, a neighboring country, where about one-third of under five children are stunted, 9 percent are underweight and 2 percent, wasted (Zimbabwe Nutrition Survey, 2010). The under-nutrition in Malawi is associated with poverty and poor nutritional knowledge which results in early weaning, delayed introduction of complementary foods, a low protein diet and severe or frequent infections (Ijarotimi & Olopade, 2009).

Mothers in Malawi typically use white refined maize as a weaning food. Cereal porridges made from maize have low energy and nutrient content (Hotz & Gibson, 2001). Highly refined and unfortified weaning cereals can contribute to the high prevalence of under-nutrition (Hotz & Gibson 2001), because at ages six months to three years children have high energy and protein needs to meet their metabolic demands for rapid growth and development (Ijalotimi and Olapade, 2009).

Protein Energy Malnutrition (PEM) is a form of under-nutrition and it increases risk of infection (Stepheson et al., 2000). Malnourished children have severe breakouts of diarrhea and higher risk of pneumonia than do well-nourished children. This is a serious problem, because any nutrient deficiency impairs the body's resistance to infection (Scrimshaw & SanGiovanni, 1997). PEM increases the vulnerability to pathogens of the oral tissues.

Vitamin A deficiency is another major public health concern in Malawi and other developing countries (Babu, 2000). In Malawi 59 percent of preschool children and 38 percent of school children, 57 percent of women of child bearing age and 37 percent of men are affected (Chilima et al, 2005). WHO and UNICEF have prioritized the prevention and control of Vitamin A in their nutrition programs. Extreme Vitamin A deficiency manifests as xeropthalmia or the opportunistic infections and irreversible blindness that occur when the eyes fail to produce tears. Xeropthalmia is prevalent in the southern and eastern regions of Malawi (Babu, 2000), where 3.9 percent of children have xeropthalmia (Tielsch et al, 1986). Efforts by the Malawi government, like promoting consumption of indigenous plant food through home gardens to reduce vitamin A deficiency related blindness, have made little progress (Babu, 2000). Other government agencies, such as the Department of Nutrition and HIV and AIDS in the Office of the President and Cabinet, however, have recognized the importance of using indigenous plant foods to address nutritional disorders such as Vitamin A deficiency. Such agencies stress the importance of whole grains and vegetables in food and nutrition policies (Government of Malawi, 1990).

In addition to mortality and morbidity, childhood under-nutrition has long term effects on health, well-being and productivity (Kravdal & Kodzi, 2011). Chronic under-nutrition in childhood impairs cognitive and physical development putting children at health risk for the remainder of their lives. Undernourished children perform poorly in school and as adults are less productive than those well fed (WHO, 2010). For girls, malnourishment during early life can later result low birth weight babies (WHO 2010). This low birth weight compounded by lack of nutrient dense weaning foods can lead to further under-nutrition as the babies grow, creating a vicious cycle (WHO, 2010). This proposed research will help to enhance the protein and vitamin A content of weaning foods by increasing their nutrient-density to help prevent undernutrition.

Weaning in Malawi

In Malawi, there is a high prevalence of stunting, 47 percent, and wasting, 16 percent, (MDHS, 2010). This is true in part because during the weaning period, children grow rapidly and require high amounts of high quality proteins, micronutrients and energy in their diet to meet increased metabolic demands (Ijarotimi & Olopade, 2009) For example a child between 6 to 12 months needs 1050Kcal energy and 1.0g per Kg body weight of protein and 500mcg RAE of Vitamin A (Food and Nutrition Board, 2013). At about six months, the typical start of weaning, the supply of some nutrients and energy from breast milk are no longer adequate to meet the infant's needs (Gibson et al., 2001, Lin et al, 2008). During weaning in Malawi, inadequate intakes of several nutrients are widespread, because the staple weaning foods are predominately refined maize, a food with protein of low biological value, and intake of animal food sources are low (Gibson et al., 2003). It is therefore important that complementary foods provided be nutrient-dense as well as adequate in energy.

A study in Malawi by Hotz and Gibson (2001) found that mothers often gave non-nutritive liquids, such as water, to their children. These investigators also found that children consumed predominantly refined maize flour porridges which are bulky and low in energy and key nutrients for growth. For example refined maize flour porridges contain about 10gram of protein per 100g. (see table 4 formula 5). Other complementary foods Malawian mothers gave weaning children were the same as those prepared for the older family members like the starchy side dish of Nsima (Hotz & Gibson, 2001). That is children at six months of age were consuming foods that did not meet at least 80 percent of their estimated nutrient needs (Hotz & Gibson, 2001). Such complementary foods were deficient in essential macronutrients and micronutrients (Ijarotimi & Olopade, 2009) and often also led to nutritional deficiencies in iron, zinc, calcium, vitamin A and riboflavin (Gibson, 1998).

Protein complementarity

To prevent PEM during weaning blended flours such as corn and legumes are common supplementary foods for malnourished children in some other African countries (LaGrone et al., 2010). This parallels the use of grain and legume, corn, and soy blends in

Latin America to develop Incaparina (Schrimshaw, 2007). These blended flours are made from locally available, low cost ingredients, like cassava and soy, which are culturally and organoleptically acceptable by mothers and consumers in African countries (Siebel, 2007). Sensory testing of products from these blended flours has been done to establish product acceptability in different African countries like Nigeria and Ghana (Olapade et al, 2012). In countries where maize is the staple food, to raise energy density and protein quality of weaning foods cereal- legume complementation strategies have been implemented (Kannan et al., 2001; Egounlety, 2002). Weaning foods of high protein quality can be prepared from maize and locally available legumes. Legume fortified weaning foods provide good nutritive value and have been proven to prevent PEM in Nigeria (Osandahunsi and Awarh 2002). This is true in part, because there are not significant changes in the organoleptic qualities of the products (Annapure et al., 1998).

All proteins are not of equal biological value nutritionally. The BV for maize cereal is but that of cereal- legume mix is. RDA Biological value of milk and meat is 100 and is the best. The BV of cereals like maize is because of lysine an amino acid necessary for growth. The biological value of cereal-legume mixtures is because legumes have high lysine, the missing amino acid.

Formulated weaning foods currently available are not accessible to many low income mothers, because they contain a large proportion of milk which makes these foods too expensive for less privileged populations (Obatolu, 2003). The inaccessibility is due to both the high cost of production and to limited availability of culturally acceptable food materials used in the formulations (Agbede & Aletor, 2003). Mothers with children, who have moderate acute undernutrition, cannot afford the costly, but highly effective Ready-to-Use-Therapeutic Foods in Malawi (LaGrone et al, 2012). To increase the affordability of weaning foods, it is important to explore the nutritional strength of alternative low cost protein sources such as cowpeas. This research is unique in that it will use locally available foods in Malawi to make nutritious, affordable and culturally acceptable weaning foods for young children.

Protein, vitamin A and energy recommendations for young children

The most deficient nutrients in weaning foods in developing countries such as Malawi are protein, vitamin A and energy (Mosha et al., 2000). It is important for a child to have the recommended amounts of protein, vitamin A and energy for good growth and development. Energy is needed to support maintenance of physiological functions, to spare body protein, and for development of new tissue (Walker, 1990). In infants and young children, adequate energy intake is important due to meet needs for the high rate of growth (Dewey, 2001). In developing countries, the energy needs from complementary food for infants and toddlers who are still breastfed vary from 200 kilocalories per day at 6-8 months of age to 700 kilocalories per day at 9-11 months and 550 kilocalories at 12-23 months (Dewey, 2001).

Children and adults need protein for: 1) the maintenance of the normal physiological functions like production of enzymes, antibodies and hormones, and 2) normal growth or development of new cells and tissues. According to FAO/WHO/UNU (2001), the safe and adequate protein intakes for young children are shown in **Table 1** along with recommend energy needs and Vitamin A.

Table 1. **Recommended energy, protein and Vitamin A intake for young children by age.**

Child age mo, yr	Energy[1] Kcal/BW/da	Reference BW[2] in Kg	Kcal/da[3] from weaning foods	Protein[1] g/kg/da	Vitamin A[1] mcg RAE
0-6 m	116	7.4	0	1.47	400
6-8 m	101	9.2	200	1.15	500
9-11 m	101	9.2	700	1.15	500
1-2 y	106	11.4	500	1.09	300
2-3 y	106	13.8	500	1.09	300

Mcg=Micrograms; RAE= Retinol Activity Equivalent (1IU=0.3mcg RAE), BW= body weight

[1] FAO/WHO/UNU (2001)

[2] Food and Nutrition Board, National Research Council, (2008). Because the reference weight is from young children in the US, the energy estimates will be in excess of actual needs. [3] Dewey (2001)

Vitamin A is important for immune function, vision, reproduction and cellular communication (National Institutes of Health, 2012). Because it is a fat soluble vitamin and is stored in the liver, children and others should consume Vitamin A several times a week to meet their needs. The daily recommended intake of Vitamin A for young children in microgram retinol activity equivalent (mcg RAE) according to the National Institutes of Health (2012) is shown in Table 1. According to the World Health Organization guidelines for feeding a non-breastfed young child (2004), infants should eat 4-5 times a day (~1/2 cup each time) with additional nutritious snacks such as pieces of fruit or bread offered 1-2 times per day. WHO also recommends that the daily diet of children should include vitamin A-rich foods such as dark colored fruits and vegetables. This proposed research will formulate a porridge and a biscuit snack that will have increased levels of protein and Vitamin A, hence improving the intake of these nutrients.

Suitable weaning foods for children

Weaning foods should be thick and creamy and made of basic foods available within the community (Igah, 2008). A weaning food could consist of cereal mixed with a legume. However other foods must still be added for optimal nutrition. According to WHO (2008), the following are the basic four ingredients of weaning food.

- A staple as a main ingredient such as cereal
- A protein source from plant or animal foods
- Vitamins and minerals from vegetables and fruits
- An energy source to increase the energy density of the mixed porridge such as fat, oil or sugar.

When these four ingredients are used together in suitable proportions, they form a balanced diet (Igah, 2008). This research will use all four ingredients in developing the weaning porridge and biscuit to help provide a nutritionally balanced supplement for children in Malawi. Such a weaning food it is especially important in Malawi because children are typically breastfed until three years of age (MDHS, 2010).

Foods available in Malawi

Despite the nutrient deficiencies in weaning children, nutritious foods do exist that are locally available and culturally acceptable in Malawi. However, low utilization and inadequate knowledge about crop alternatives to maize is prevalent (Malawi Government of Malawi, 2007). Malawi is one of the most food insecure countries in the world and is unable to fulfill its growing national food need through its own food production (FAO, 2011). Malawi is a maize growing nation of farmers with small land holdings of less than one hectare. Three-quarters of the cultivated land is planted with maize each cropping season (Smale, 1995).

Malawi has rich diversity of pulses like beans, cowpeas and pigeon peas. Production of these has increased recently due to their nutritional benefits promoted by the government (Malawi Government, 2007). Besides maize, farmers also grow rice, sorghum, pulses, cassava and sweet potatoes on a small scale. These foods are usually sold in public markets and the money used to buy maize. Malawians use the phrase 'Maize is life' signifying the importance of maize in their diets (Sahley, 2005). In Malawi, lack of maize is generally interpreted as "lack of food" (Sahley, 2005) and close 52 percent of households in Malawi live below the poverty line are unable to afford a minimum basket of food (Malawi government and The World Bank, 2006). Inadequate food consumption and perhaps the dominance of bulky maize in the weaning diet contribute to high proportions of stunted children (Sahley, 2005) because maize alone is inadequate in high quality protein and other nutrients needed for growth. This proposed research will promote the use of other local foods such as cowpeas and sweet potatoes for better nutrition of children.

Composite flours

Nutritionally enhanced weaning foods can use composite flours because they are readily available in local communities. Composite flours are a mixture of flours from grains, legumes and tubers that are rich in starch and /or protein (Seibel, 2007). Types of tubers often used include cassava, sweet potatoes and yams in countries like Nigeria and Ghana (Olaoye et al. 2006) and other countries also encourage the use of these flours. Protein-rich flours from legumes like cowpeas and soy beans are mixed with cereals like, maize, rice and sorghum. Such flours are well suited for nutritionally enhanced biscuits and porridge for weaning children in Malawi, because of local availability. That is rural families grow these foods and mothers and care givers can easily prepare them.

In regards to baked products, biscuits may be an optimum food for the best use of composite flours compared to breads or other bakery products, due to their ready-to-eat form, wide consumption, and good eating quality (McWatters et al., 2003). Biscuits have a longer shelf life than bread (Seibel, 2007), because the high moisture content in bread encourages mold.

Following the recommendations from WHO and UNICEF (2008) to develop more low cost foods that incorporate locally grown crops to enhance nutritional quality, a number of researchers in Africa have developed many nutritionally enhanced foods without artificial fortification. When a search for terms like ‘cowpeas’, ‘chemical and physical food properties’ and protein complementarity’ was entered on the Web of Science for the last 20 years, 161 research articles were found. Twenty eight were on use of cowpeas to improve the protein value of food. About fifty were conducted in Africa, especially Nigeria, but only three studies were conducted in Malawi. Hotz and Gibson (2001) conducted an observation study while Legrone et al. (2012) and Lin et al. (2008) used soy- corn blends but soy is not extensively grown in the south eastern portion of Malawi where this researcher works. Fifty-six of articles were on use of cowpeas in developing weaning foods for children: the rest examined incorporating cowpeas into snack foods. No studies were identified that used OFSP in weaning foods. Therefore, the study is unique in combining cowpeas and OFSP, both traditionally grown foods and incorporating these into weaning foods.

Products such as weaning porridge and biscuits made from composite flours are well accepted by consumers in other parts of Africa (Aboaba and Obakpolor 2009). Such product acceptability is desirable, because it supports local agriculture and reduces imports. In an effort to help overcome undernutrition, this research will promote the use of composite flours from selected local Malawian crops that improve nutritional composition and the diest for Malawian children. Based on current eating choices of Malawian mothers and caregivers of weaning children, porridge and biscuits were the food products selected for study.

Physical and chemical properties of flours

Because composite flours are used in different food products, it is important to understand the physical and chemical properties of such flour mixtures. Understanding the physical properties of flours helps to determine how the flour can be used in various products. For example, the **water absorption** of composite flours is of practical importance because, it governs subsequent operations and quality of the final product (Sobukola and Abayomi, 2011). The moisture content of food and ingredients determines, in part, the food's texture, taste, appearance and stability. Moisture content knowledge is necessary to predict the behavior of foods during processing such as mixing, drying and packaging (Nielsen, 2003).

The **fat content** of foods is also important, because fat contributes over twice as many calories as does an equal weight of carbohydrate or protein (Uauy & Castillo, 2003). Young children, when not malnourished, tolerate fat well and fat is often used to increase calories (Georgilf & Innis, 2005). Fats supply essential fatty acids and aids in the absorption of fat soluble vitamins such as A,D,E and K (Milner & Allison, 1999). Fats also enhance the taste and acceptability of foods and determine the texture, flavor and aroma of foods (Molnar, 2004). The fat analyses of the weaning food formulations will contribute to understanding the products' quality and functionality. Fat analysis will also help to interpret the sensory data.

The **protein content** of foods is another property important for nutrient content, as well as, for its contribution to the functional properties of the product. The maximum nutritional benefits can be achieved by complementing cereals with cowpeas at the ratio of 45 to 15 which yields amino acid score closer to the FAO/WHO/UNU standards (Hallén et al., 2004). When cereals are complemented with legumes they increase the quality of the protein because cereals are limited in lysine, but legumes are not (Adebooye & Singh, 2007). Based on a study by Kerr et al., (2000), when cereals are mixed with legumes, functionality of the cereal changed due to the increased protein content. Several functional properties of a flour made from cowpeas should prove critical for the production of a high quality weaning porridge and snack food (Kerr et al., 2000). These properties include the flour's ability to absorb water and fat, its viscosity and the solubility of its proteins which affect the processing as well as the texture and appearance of a formulated food product.

Vitamin A in sweet potatoes is found in carotenoid form. These carotenoids are well retained in most cooking methods, this means that losses are very minimal of between 0-12 percent (Fouseca et al; 2008). But sweet potatoes retain their carotenoids thus cooking and storage effects are minimal which only causes losses of about 0-20 percent. This means that the developed products will not be affected much interms of their vitamin A content since the losses are minimal.

Pasting is the phenomenon following gelatinization of starch which involves granular swelling and exudation of molecular components from granules followed by total disruption of the granules (Aishat 2007). **Pasting properties** depend on physical and chemical characteristics such as the flour's granule size, granule size distribution, amylose/ amylopectin ratio and mineral content (Aishat, 2007). This research used one granule size, although the flours were expected to have different amylose and amylopectin ratios. This means that the weaning porridge and biscuit will be affected as different ratios of flours were combined. Paste viscosity affects the textural and sensory properties of food and is important in food processing operations (Beta &Corke, 2001). In a study conducted in Nigeria by Obatolu et al (2000), when cowpea flour was blended with maize, the **peak viscosity** was lower than that for the whole maize alone, but the temperature at peak viscosity was similar to maize flour alone. The researchers also found that the water absorption capacity of cowpea-maize blend was significantly lower than for maize flour alone. This difference was attributed to changes in the nutritional quality or BV of protein upon blending. In other words, the additional lysine in the legume-cereal blends affected the pasting viscosity.

In another study Oladunmoye et al. (2010), found that the pasting temperatures of maize, wheat and cowpea flours ranged from 50^{o}C to 70^{o}C. Cowpea flour alone had the highest Brabender units or the highest pasting viscosity compared to the other flours. Maize flour alone also had high consistency.

Type of starch in addition to protein affects the pasting viscosity. Differences in pasting viscosity of the wheat, cowpea or maize flours are also due to the chemical composition of amylose to amylopectin ratio and the nature of bonding within the starch structure.

In this study most of these physical and chemical properties of a weaning porridge and biscuit from blended flours were defined. That is moisture, crude fat, protein content, vitamin A and pasting properties. The findings were interpreted in terms of the products as well as the sensory analysis.

Sensory properties of weaning foods

Sensory evaluation is defined as a scientific method used to evoke, measure, analyze and interpret responses to products as perceived through the senses of sight, smell, touch, taste and hearing (Dzung et al, 2004). People might buy a food product for nutrition, convenience, and image, but most importantly, they buy the sensory properties or performance and sensory consistency (Dzung et al, 2004). It is therefore of key importance to include sensory evaluation as integral to defining and controlling product quality.

When composite flours that include cowpea and OFSP substituted at different proportions, these ingredients substituted for flour or added tend also change the sensory attributes of foods (Anyango et al, 2011). The sensory attributes of a new food product can be used to predict consumer perception of the composite flour products. When cowpea flour was substituted for wheat flour at low rates in another study the functional quality of cowpea fortified traditional African sorghum foods, the acceptability of the composite flour products did not differ from those from whole wheat using instrumental and descriptive sensory analysis (Olaoye et al, 2006). However with increases in proportional substitutions in composite , the acceptability of the traditional foods declined. This was attributed to the higher proportions of substitutions negatively influencing color and texture (Ndife et al, 2011).

When cowpeas are used in food products, they usually have a high score of 4 on a 5 point hedonic scale for color, where, 5=golden brown, 4= brown, 3= neither brown nor dark, 2= slightly brown, 1= dark brown, but low acceptability scores for texture, flavor and overall acceptability (Barimalaa & Okoroji, 2009). The low acceptability scores of between 2 and 3 are attributed to the beany flavor of cowpeas.

A study by Olapade et al (2012) on the acceptance of instant cowpea powder for complementary foods, found that complementary foods containing 20% cowpea by weight were comparable to traditional weaning foods in Nigeria. However, complementary foods containing 30% cowpeas got poorer scores for flavor, although this level was not significantly different. (Olapade et al, 2012).

Acceptability of OFSP in weaning foods has been conducted in Peru with mothers and in some cases children (Espinola et al, 1998). When mothers were involved, they nearly always reported that they would feed the new foods to their children. In a study by Espinola et al. (1998) in Peru on the acceptability of OFSP as a weaning food, about 90 percent of mothers found the weaning food acceptable, while only a small percentage did not. The acceptability of the weaning food declined only when the level of OFSP used exceeded 20 percent by weight.

In this study, five different flour levels were used. These formulations were selected based on previous research of levels used and on the acceptance of the developed products at these levels in preliminary testing at MSU. These levels or formulations were also selected due to the nutrient levels of the end products, especially for protein and Vitamin A. Mothers of young children evaluated the sensory characteristics of two weaning products made from cowpea, OFSP, maize and wheat flours. The results should help determine the products that the mothers can and will feed their children without difficulty.

Chapter III. Methods

This research study was composed of three parts. First was the production of two products from four types of flour and blends: sweet potatoes, cowpeas and maize or wheat (Part A). This preliminary step was done in the foods labs at Michigan State University prior to the return to Malawi. Next, was the assessment evaluation of the physical, chemical and nutritional properties of the flours when substituted at different levels in porridge and biscuits (Part B). The last part was having rural mothers in Malawi evaluate the sensory characteristics of the products made from the different types and proportions of flour (Part C). A timeline for the entire study is found in **Figure 1.**

Year	2012					2013						
	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Collecting project materials												
Laboratory work at Bunda college												
Recruiting mothers for sensory evaluation												
Dr Hoerr's arrival in Malawi												
Sensory evaluation												
Thesis write up												
Thesis defence												

Figure 1. **Timeline for all three parts of the thesis.**

Production of flours and weaning food products

1. Production of flours

First, the flours were milled in Malawi for use in the formulated weaning foods. Maize, cowpeas and orange fleshed sweet potatoes (OFSP) were procured from local markets, and then prepared and milled into flour, just as mothers in Malawi typically do. To make the flours, the researcher took the product to a local commercial mill for milling and sieving with a mesh size of 0.5mm. This is similar to the Malawi practice of women taking their home grown maize to commercial millers for milling. After milling, each flour was sealed in plastic freezer and bags with a zipper lock and kept in a refrigerator with temperature ranging from 9 to 15 degrees Celsius until further analysis until further analysis. This protected the flours from moisture and heat.

Dried white **maize**, of the SC 625 variety all harvested within 2011 year, was procured from SEEDCO Malawi, a seed company in Lilongwe, the capitol of Malawi. Dried **cowpeas**, (variety IT 82E-18) harvested within the same growing season, were procured from a local market in Lilongwe and processed according to the dry milling method by Dovlo et al. (1995). In this method, cowpeas are first cleaned by removing stones, dead insects and other debris and then broken roughly into small pieces using a mortar and pestle to loosen the seed coats. Next, the cowpeas are winnowed to remove the seed coats before washing and drying the dehulled cowpeas. The investigator purchased **OFSP** of the Zondeni variety from the Department of Agricultural Research Services, Bvumbwe Research Station in Thyolo, Malawi. OFSP were processed according to the procedure described by The ACP-EU Technical Center for Agricultural and Rural Cooperative (2007). Sweet potatoes were washed in clean water, changing the water until clean, then grated into small pieces of about 2cm thickness and sun-dried for two days on a raised platform on a clean black plastic sheet till all pieces were dry. All-purpose **wheat flour** was procured from local commercial shops. This wheat flour, high in gluten, was used only in the biscuit recipes.

2. Product preparation

Eight nutritionists from the Machinga Agriculture Development Division of southern Malawi, Department of Agricultural Extension Services, Food and Nutrition Branch developed a recipe book for Malawian families in 2011 (to be published). Edda Lungu, the primary researcher for this study, was the team leader for the group of six baccalaureate nutritionists and two with undergraduate diplomas (two year degrees). The recipes were developed to provide Malawian farmers and mothers with local and easy to use foods--especially cowpeas, OSFP, cassava and pigeon peas. The recipes in the booklet include culturally acceptable main dishes, infant foods and snacks which support the primary goal of this study of enhancing nutritional quality. A porridge and biscuit recipe was modified for the current research. As a result of several test trials in the food laboratory in the Department of Food Science and Human Nutrition at MSU about ¼ cup of water was added to the recipe for porridge (the original recipe will be likewise adjusted prior to publishing recipe booklet in Malawi to meet the required consistency for the porridge and the biscuit doughs).

For the various products, maize (M) or wheat (W), cowpea (C) and OFSP (O) flour were mixed in different proportions as shown in **Table 2**. These four flour formulas were used in the weaning food recipes shown in **Figure 2**. After preparation there was moisture loss in the biscuit due to the baking process as described later in this section. These experimental proportions were generated from the work of other investigators in Africa who had explored use of local crops in breads, porridge and cookies (Oladunmoye et al., 2010, Hallen et al., 2004, McWatters et al., 2001). One hundred percent maize flour was the control for the porridge and 100% wheat flour, for the biscuit.

Table 2. **Experimental flour formulas, percentage by weight, for weaning porridge and biscuit from flour blends of locally available foods in Malawi.**

	Formula Number				
Product/ Flour Type	**1**	**2**	**3**	**4**	**Control**
Porridge	**50M :30C: 20O**	**60M: 20C: 20O**	**70M: 20C: 10O**	**80M: 10C: 10O**	**100M**
Maize	50	60	70	80	100
Cowpea	30	20	20	10	0
OFSP	20	20	10	10	0
Biscuit	**50W: 30C: 10O**	**60W: 20C: 20O**	**70W: 20C: 10O**	**80W: 10C: 10O**	**100W**
Wheat	50	60	70	80	100
Cowpea	30	20	20	10	0
OFSP	20	20	10	10	0

OFSP=Orange fleshed sweet potato

Porridge Recipe

Makes ~1 cup

Ingredients

100g (11 ½ Tbsp) flour *

250ml water

dash salt (1.6 g)

20 g (1 tsp) Sugar

Procedures

1. Warm water in a medium size pot.
2. Sift flours and salt together.
3. Add the flour and salt to the warm water and stir.
4. Simmer the porridge for 45 minutes on low boil, stirring every few minutes.
5. Sweeten with sugar and stir.
6. Remove from pot from the heat and serve.

Biscuit recipe Makes 5-7 biscuits

Ingredients

100g (11 ½ Tbsp) flour *

25g (5.5 tsp) margarine

5 g (1 tsp) baking powder

dash (1.6 g)salt

25g (4 tsp) sugar

Procedures

1. Preheat oven to 175 degrees Celsius.
2. Sift dry ingredients together in a bowl and mix thoroughly.
3. *Rub in* margarine into the dry mixture (this is done by hand in Malawi but is similar to "cutting in" shortening into flour for pie crust and baking powder biscuits in the United States).
4. Add water slowly to make soft dough, which does not stick to the mixing bowl.
5. Roll out the dough on a floured board to an even thickness of 7mm.
6. Cut into shapes of uniform sizes with a biscuit cutter.
7. Bake biscuits in an oven till brown at 175 degree Celsius (347 ^{o}F) for 30 minutes.

Figure 2. Recipes for weaning porridge and biscuit for Malawian children of weaning age.

*= flour proportions from Table 2.

Assessment of physical, chemical and nutritional properties

The researcher prepared seven variations of each product both at Michigan State University, Department of Food Science and Human Nutrition and then at the Lilongwe University of Agriculture and Natural Resources. The **nutritional values** were calculated using Release 24 of the USDA National Nutrient Database for Standard Reference for 7,906 foods (http://ndb.nal.usda.gov) and that of the International foods database (FAO, 2012 http://www.fao.org/infoods/tables_int_en.stm), with special attention to protein, Vitamin A and energy in the products from the various flour formulations. Only the porridges that increase protein content by 25 to 50% were considered for further development. The protein content generated from the nutrient databases was verified by the Kjeldahl method (AOAC, 2000). The nutrient values for the product formulations are shown in **Tables 3 and 4**. From the nutrient calculations, one can see that if a child consumes at least 1.5 cups porridge of Formula #1 versus the control, this will increase protein and vitamin A intake by over 50 percent and by 100 percent, respectively. When a child consumes at least three biscuits in a day made from Formula #1 versus the control, the protein and vitamin A intake will be increased by 25 percent and a 100 percent, respectively.

Table 3. **Nutrient content in six biscuits for biscuit formulas, using various nutrient databases.**

Formula	Food Item	Amount	Gram	Kcal	CHO	Pro	Total Fat (g)	Na (mg)	Vit A (mg) RAE
1									
50W: 30C: 10O	Salt[1]	1 Dash	1.6	0	0.0	0.0	0.0	155.0	0.0
	Sugar[1]	4 tsp	16.8	65	16.8	0.0	0.0	0.0	0.0
	Baking powder[1]	1 tsp	4.2	2	1.3	0.0	0.0	488.0	0.0
	Margarine[1]	1.7 Tbsp	25	180	0.2	0.2	20.1	236.0	205.0
	Wheat flour[1]	3.3 Tbsp	50	182	38.2	5.2	0.5	1.0	0.0

Table 3 (cont'd)

Formula	Food Item	Amount	Gram	Kcal	CHO	Pro	Total Fat (g)	Na (mg)	Vit A (mg) RAE
	cowpea flour[2]	2.0 Tbsp	30	102	17.6	7.7	0.5	5.0	1.0
	OFSP[2]	1.33 Tbsp	20	15.2	3.5	0.3	trace	5.4	157.4
		# 1TOTAL	**147.6**	**546.2**	**77.6**	**13.3**	**21.1**	**890.4**	**363.4**
2	Salt	1 Dash	1.6	0	0.0	0.0	0.0	155.0	0.0
60W: 20C: 20O	Sugar	4 tsp	16.8	65	16.8	0.0	0.0	0.0	0.0
	Baking powder	1 tsp	4.2	2	1.3	0.0	0.0	488.0	0.0
	Margarine	1.7 Tbsp	25	180	0.2	0.2	20.1	236.0	205.0
	Wheat flour	4 Tbsp	60	218	45.8	6.2	0.6	1.0	

Table 3 (cont'd)

Formula	Food Item	Amount	Gram	Kcal	CHO	Pro	Total Fat (g)	Na (mg)	Vit A (mg) RAE
	cowpea flour	1.33 Tbsp	20	68	11.8	5.1	0.3	3.0	1.0
	OFSP	1.33 Tbsp	20	15.2	3.5	0.3	trace	5.4	157.4
		#2 TOTAL	**147.6**	**548.2**	**79.4**	**11.8**	**21.0**	**888.4**	**363.4**
3	Salt	1 Dash	1.6	0	0.0	0.0	0.0	155.0	0.0
70W: 20C: 10O	Sugar	4 tsp	16.8	65	16.8	0.0	0.0	0.0	0.0
	Baking powder	1 tsp	4.2	2	1.3	0.0	0.0	488.0	0.0
	Margarine	1.7 Tbsp	25	180	0.2	0.2	20.1	236.0	205.0
	Wheat flour	4.6 Tbsp	70	255	53.4	7.2	0.7	1.0	0.0
	cowpea flour		20	68	11.8	5.1	0.3	3.0	1.0
	OFSP		10	7.6	1.8	0.1	trace	2.7	78.7
		# 3 TOTAL	**147.6**	**577.6**	**85.2**	**12.7**	**21.1**	**885.7**	**284.7**

Table 3 (cont'd)

Formula	Food Item	Amount	Gram	Kcal	CHO	Pro	Total Fat (g)	Na (mg)	Vit A (mg) RAE
4	Salt	1 Dash	1.6	0	0.0	0.0	0.0	155.0	0.0
80W:1 0C:10O	Sugar	4 tsp	16.8	65	16.8	0.0	0.0	0.0	0.0
	Baking powder	1 tsp	4.2	2	1.3	0.0	0.0	488.0	0.0
	Margarine	1.7 Tbsp	25	180	0.2	0.2	20.1	236.0	205.0
	Wheat flour	5.3 Tbsp	80	291	61.1	8.3	0.8	2.0	0.0
	cowpea flour	0.6 Tbsp	10	34	5.9	2.6	0.2	2.0	0.0
	OFSP	0.6 Tbsp	10	7.6	1.8	0.1	trace		78.7
		# 4 TOTAL	**147.6**	**579.6**	**87.0**	**11.2**	**21.1**	**883.0**	**283.7**

Table 3 (cont'd)

Formula	Food Item	Amount	Gram	Kcal	CHO	Pro	Total Fat (g)	Na (mg)	Vit A (mg) RAE
5	Salt	1 Dash	1.6	0	0.0	0.0	0.0	155.0	0.0
Control	Sugar	4 tsp	16.8	65	16.8	0.0	0.0	0.0	0.0
100W	Baking powder	1 tsp	4.2	2	1.3	0.0	0.0	488.0	0.0
	Margarine	1.7 Tbsp	25	180	0.2	0.2	20.1	236.0	205.0
	Wheat flour	6.7 Tbsp	100	364	76.3	10.3	1.0	2.0	0.0
	cowpea flour	0	0	0	0.0	0.0	0.0	0.0	0.0
	OFSP	0	0	0	0.0	0.0	0.0	0.0	0.0
		# 5 TOTAL	**147.6**	**611.0**	**94.4**	**10.3**	**21.0**	**645.0**	**205.0**

Table 4. Nutrient calculations for 1.5 cups of porridge formulations using various nutrient databases.

Formula	Food Item	Amount	Grams	Kcal	CHO (g)	Pro (g)	Total Fat (g)	Na (mg)	Vit A (g) RAE
1	Salt[1]	1 Dash	1.6	0	0.0	0.0	0.0	155.0	0.0
50M :30C: 20O	Sugar[1]	4 tsp	16.8	65	16.8	0.0	0.0	0.0	0.0
	Maize flour[1]	3.3 Tbsp	50	188	41.4	2.8	2.5	2.0	6.0
	cowpea flour[2]	2.0 Tbsp	30	102	17.6	7.7	0.5	5.0	1.0
	OFSP[2]	1.3 Tbsp	20	15	3.5	0.3	trace	5.4	157.4
		# 1 TOTAL		**370**	**79.4**	**10.7**	**3.0**	**167.4**	**164.4**
2	Salt	1 Dash	1.6	0	0.0	0.0	0.0	155.0	0.0
60M :20C: 20O	Sugar	4 tsp	16.8	65	16.8	0.0	0.0	0.0	0.0
	Maize flour	4 Tbsp	60	226	49.7	3.4	3.1	3.0	7.2
	cowpea flour	1.3 Tbsp	20	68	11.8	5.1	0.3	3.0	1.0
	OFSP	1.3 Tbsp	20	15	3.5	0.3	trace	5.4	157.4
		#2 TOTAL		**374**	**81.8**	**8.8**	**3.4**	**166.4**	**165.6**

Table 4 (cont'd)

Formula	Food Item	Amount	Grams	Kcal	CHO (g)	Pro (g)	Total Fat (g)	Na (mg)	Vit A (g) RAE
3	Salt	1 Dash	1.6	0	0.0	0.0	0.0	155.0	0.0
70M :20C: 10O	Sugar	4 tsp	16.8	65	16.8	0.0	0.0	0.0	0.0
	Maize flour	4.6 Tbsp	70	263	58.0	3.9	3.6	4.0	8.4
	cowpea flour	1.3 Tbsp	20	68	11.8	5.1	0.3	3.0	1.0
	OFSP	0.6 Tbsp	10	8	1.8	0.1	trace	2.7	78.7
		# 3 TOTAL		**404**	**88.3**	**9.1**	**3.9**	**164.7**	**88.1**
4	Salt	1 Dash	1.6	0	0.0	0.0	0.0	155.0	0.0
80M :10C: 10O	Sugar	4 tsp	16.8	65	16.8	0.0	0.0	0.0	0.0
	Maize flour	5.3 Tbsp	80	301	66.2	4.5	4.1	4.0	9.6
	cowpea flour	0.6 Tbsp	10	34	5.9	2.6	0.2	2.0	0.0
	OFSP	0.6 Tbsp	10	8	1.8	0.1	trace	2.7	78.7
		# 4 TOTAL		**407**	**90.7**	**7.2**	**4.3**	**163.7**	**88.3**

Table 4 (cont'd)

Formula	Food Item	Amount	Grams	Kcal	CHO (g)	Pro (g)	Total Fat (g)	Na (mg)	Vit A (g) RAE
5 Control	Salt	1 Dash	1.6	0	0.0	0.0	0.0	155.0	0.0
100M	Sugar	4 tsp	16.8	65	16.8	0.0	0.0	0.0	0.0
	Maize flour	6.7 Tbsp	100	376	82.8	5.6	5.1	5.0	12.0
	cowpea flour	0	0	0	0.0	0.0	0.0	0.0	0.0
	OFSP	0	0	0	0.0	0.0	0.0	0.0	0.0
		# 5 TOTAL		**441**	**99.6**	**5.6**	**5.1**	**160.0**	**12.0**

[1] Calculated from the USDA NAL website

[2] Calculated from FAO website for international foods

[3] OFSP=Orange Fleshed Sweet Potato

RAE=Retinol Activity Equivalents

Selected physical and chemical properties were evaluated for the flours used in the weaning porridge and biscuit products. For most of these tests there were 14 samples: the five formulations for the two products (n=10) differing in content with cowpeas, OFSP, maize or wheat, plus the four flours of cowpeas, maize, OFSP and wheat (n=4). Procedures for testing each property are described in this section along with which samples were tested. Each test listed was run in triplicate.

Protein content analysis. The 14 just described samples were tested for protein content analysis using the Association of Analytical Chemists method 955.04 (AOAC 2000) also known as the Kjeldahl method (AOAC, 2000). Food samples were ground to pass through a 20 mesh screen. The samples were then digested by putting them to a flask where an acid and a catalyst completely broke down all organic matter to liberate the protein nitrogen. The digest was then diluted with water and borate anions titrated with standardized hydrochloric acid. A conversion factor of 5.7 was used to convert percent nitrogen to percent protein for legumes and 6.25 for maize and 5.83 for wheat (FAO, 2002. To calculate percent nitrogen the following formula was used: Percent protein= percent nitrogen X conversion factor. The expected result from this analysis was an increase in protein content of the weaning porridge and biscuit with increased levels of cowpea flour.

Vitamin A analysis. Vitamin A analysis of the four flours and 10 developed products (14 samples) was determined using the AOAC (2000) method 974.29. The samples were extracted in methanol, water and dichloromethane and then centrifuged, the aqueous phase was discarded and then the organic phase as read at 625nm UV spectrophotometer. For this study, the researcher anticipated that: a) the vitamin A content of the flours and of the 10 developed products would differ; and b) the products with the highest OFSP flour would have the highest vitamin A content.

Crude fat Analysis. Crude fat of the four flours and the 10 developed products (14 samples) was determined using the AACC method 30-10 (2000). Acid hydrolysis with Hydrochloric acid (HCl) was followed by the extraction of hydrolyzed lipid materials with mixed ethers. Ethers were evaporated and the lipid residue heated to a constant weight at 100 degree Celsius; the residue expressed as crude fat in grams. The following calculation was used for percent fat: Percent fat = weight of fat in the sample (g)/ Weight of the sample (g) X 100. For this research it was expected that OFSP would have the lowest fat content than the other flours and blends.

Moisture content. Moisture content was determined only for the four flours (cowpea, OFSP, wheat, maize) using a method described by Oladunmoye et al. (2010). Five grams of each flour sample were dried for 15 minutes in an oven set at 155 degree Celsius. The dried samples were then weighed and the difference in weight before and after drying was the moisture loss. The percent moisture was calculated as follows: Percent moisture = loss in moisture (g)/wet of weight of sample X 100. Each flour formulation was expected to have different moisture content as the products after cooking.

Thickness, diameter and spread ratio. The thickness and diameter of the five biscuit formulations were measured using a Vernier caliper (Palmer Instrument Co. Vernon Hills, IL, USA). The spread ratio of the biscuits was expressed as the ratio of diameter to thickness as described by Zaker et al. 2012. It was expected that the biscuits formulated at different levels of cowpea and OFSP would differ in thickness, diameter and spread ratio.

Line spread test for flours only. The line spread was conducted as described by Nicosia and Robbins (2007). This was done using a piece of glass with a template of premeasured concentric circles spaced 0.25 inches apart placed beneath it. The counter was level. A PVC pipe of inner diameter 2 inches was positioned in the middle of the template and filled with a 50ml liquid. The tube was then lifted and liquid was allowed to spread for 1 minute. Measurements were taken at 90 degrees increments and averaged to give a line spread reading for each trial. It was performed three times to obtain an average line spread reading.

Statistical analysis

Three replicates of all the assessments were conducted and means and standard deviations reported for the averages. Analysis of variance for differences between samples was run using SPSS, version 20, (International Business Machine Corp, Armonk, New York, 2011) to determine if there were significant differences between the flours, weaning porridge and biscuit for the mean values in terms of moisture content, protein, fat, Vitamin A, height, diameter, line spread test and spread ratio. For the porridge formulation, 100% maize was the control, while for the biscuit, 100% wheat was the control.

Sensory evaluation of formulated foods

Consumer acceptance sensory tests were conducted in Zomba district, Southern Malawi (see **Figure 3** for map of Malawi and **Figure 4** for) Zomba district. Zomba district, southern Malawi, is located in the southern eastern Malawi that is a very rich agriculture area with maize being the predominant food crop. Approximately 80 percent of the population in the area lives on subsistence farming. Women averaged five children per family. In addition to child rearing and food preparation, a mother's day begins at 4:00am to work in the fields until about noon. Afternoons are spent predominately indoors with household work. Flour mills are available in the communities at about 2 Km and walking is the major mode of transport for rural families.

Figure 3. **Map of Malawi in south eastern Africa.**

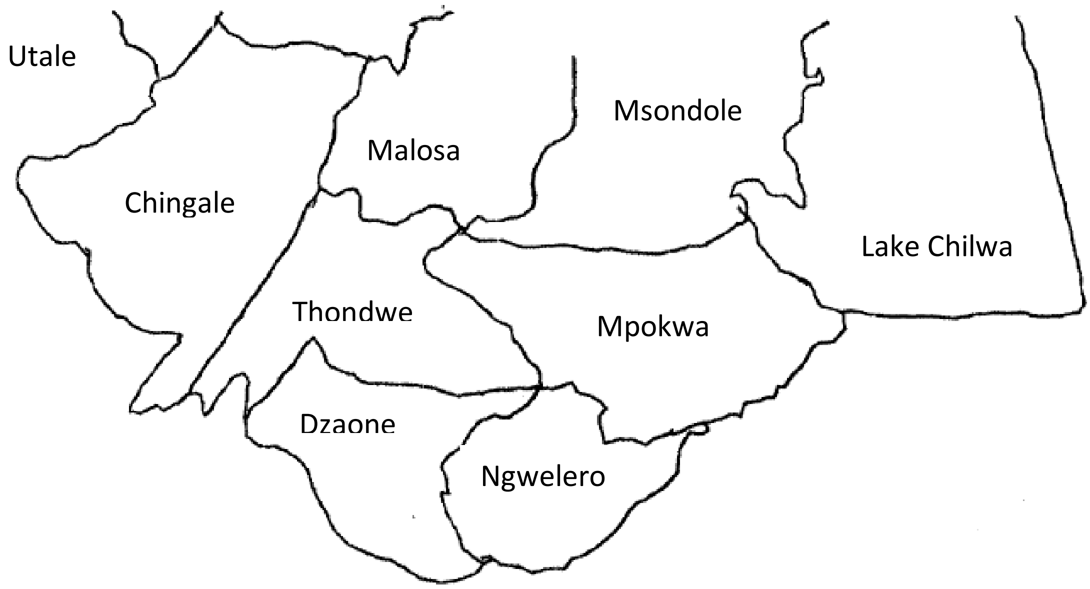

Figure 4. Map of Zomba district and Extension Planning areas (EPAs)

First, there was a sensory evaluation of the 10 biscuit and porridge formulations (see sensory questions in Appendix). Secondly, there was a purposive sampling of community leaders to answer questions on the degree of undernutrition they perceived and their own interest in promoting nutritionally enhanced foods in their sections (see questionnaire in Appendix).

Participants. The researcher, with help of local Extension agents, recruited 109 mothers of young children from rural communities to participate in the sensory panel. These untrained panelists were 18 or older, had at least one child between 6 and 36 months and were not allergic to any ingredients in the porridge or biscuit. (See recruiting flyer and consent form in Appendix).Opinion leaders also participated in the sensory testing and these included one village chief, one village women committee member, one church group committee member, one nutritionist from Save the children, one nutritionist from World Vision Malawi (WVM), one Community and Nutrition Coordinator from Support for Service Delivery Integration (SSDI), one nutritionist from Millennium Villages Project (MVP), one Food and Nutrition Officer and one Agriculture Extension Development Coordinator from the Ministry of Agriculture and Food Security, one Nutrition Officer and one Health Surveillance Officer from the Ministry of Health and Population services. For those opinion leaders that could read and write English they completed the opinion leader's questionnaire in English while those that could not completed the questionnaire in Chichewa.

Procedures. Preliminary sensory testing with 10 tasters was done at Michigan State University to see if the developed products were acceptable looking at the scores of the products which were above 6.0 scale. A questionnaire was used where panelists tested and filled the questionnaire with a 7-point Hedonic scale. The participants were random students and faculty within the department of Food Science and Human Nutrition Trout Building. Both products made from the flour of either cowpea formulas were acceptable. Before the field testing, Michigan State University institutional Review Board reviewed the procedures and instruments and granted an exempt status to the study (see Appendix for consent form). The 109 untrained panelists completed a consent form in their local language. The sensory evaluations were conducted in rural community classroom setting at the six Zomba district Extension Planning Areas. These Extension Planning Areas were Mpokwa, Nsondole, Thondwe, Likangala, Chingale and Malosa. These were rustic classrooms open to the outside without electricity or running water, with a steel roof and concrete floor. Tables and benches were available for community meetings and were also available for sensory testing.

Hired research aides helped to prepare and serve the formulated porridge and biscuit samples, identified only by codes of two digit numbers, to the panelists in small plates. The porridge was served warm and the biscuits, at room temperature of about 25 degrees Celsius. Each panelist was given porridge samples then after approximately 20 minutes they were given the biscuit samples which also took approximately 20 minutes to complete the test. The tests in the six different Extension Planning Areas were done on each separate day. It took close to seven hours to finish testing at each Extension Planning Area. This meant that one day was set aside for the Extension Planning Area. The porridge and biscuits were prepared at the Zomba District Agriculture Office and was then transported to the testing centers.

Research aides presented coded samples on a tray to each panelist to evaluate product's sensory attributes using a 7- point hedonic scale. The hedonic scale was developed by David Peryam and is a standardized tool in food research (Chambers, 1998). The researcher replaced the 9-point hedonic scale with a 7-point scale to avoid confusing the panelists and to aid translation of the scale into the local language. The scale categories were as follows: 7=Like very much; 6=Like moderately; 5=Like slightly; 4=Neither like nor dislike; 3=Dislike slightly; 2=Dislike moderately; and 1=Dislike very much. Panelists used this hedonic scale to answer questions about the acceptability of the products' flavor, taste, smell, mouth feel (texture), and overall acceptability. Paired t-test (ANOVA with Turkeys to see differences among the means) for unequal variances was used to analyze the sensory characteristics to see which formulation was better, worse or not different from the Control products of 100 percent maize or 100 percent wheat.

At the end of the product testing, the mothers were asked about their demographics and consumption frequency of the ingredients in the samples. Mothers were also asked about *their intent to*: 1) feed the porridge and biscuit formulations to their child, if preparation time were not considered; and 2) purchase the product, if it was on the market.

Community leaders both non-professional and professional answered a separate survey about use of the food ingredients and products in their communities. This was done to see whether the community leaders might be able to influence their communities to use the nutritionally enhanced products. The data from the community leaders' survey were tabulated and summarized.

Chapter IV. Results

Similar to Methods, the findings are presented according to their respective parts. That is Part B. Assessment of physical, chemical and nutritional properties; and Part C. Sensory evaluation of formulated foods.

Assessment of physical, chemical and nutritional properties

For the flours, the moisture content ranged from 0.83 to 2.49 with cowpea flour having the highest and wheat flour, the least, as shown in **Table 5**. For the biscuits, the height of Formulas 1, 2 and 3 significantly differed from that for the Control Formula 5. Formula 5 had the greatest height compared to the other formulas. Only Formula 1 had a greater diameter than the Control. Formulas 1 and 2 had larger spread ratios than the Control. Formulas 1 and 2 were sticky in the sense that when touched they would stick in the hands as compared to Formula 3, 4 and 5, reflecting the higher water content in Formulas 1 and 2. This could be due to the addition of cowpea and OFSP flours which needed less water than the wheat only. Formulas 1 and 2 had less of cowpea and OFSP flours. The addition of cowpea and OFSP flours decreased the amount of water needed to make dough. In terms of color, Formula 1 and 2 were dark orange whilst Formula 3 and 4 not as dark orange. Formula 5 was white in color. The dark orange color was due to the addition of OFSP flour which was on a higher side in Formula 1. In terms of crispness, Formula 5 was very crispy as compared to Formulas 1, 2, 3, 4.

Table 5. Physical properties of five biscuit formulations for one biscuit plus four flours, mean ± SD (ANOVA for difference from control). (See Table 2 for the formulas and Figure 2 for the recipes.)

Formulas or Flours	Percent moisture/2g	Height (mm)	Diameter (mm)	Spread ratio	Line spread (cm)
Biscuit formulas					
1 50W:30C:10O	-	8.26 ± 0.08**	57.37 ± 0.11*	6.94 ± 0.08**	0
2 60W:20C:20O	-	9.51 ± 0.56**	56.62 ± 0.76	5.96 ± 0.44**	0
3 70W:20C:10O	-	12.46 ± 0.39*	53.77 ± 0.69	4.31 ± 0.14	0
4 80W:10C:10O	-	13.23 ± 0.39	55.54 ± 0.47	4.19 ± 0.11	0
5 100W	-	14.60 ± 0.3	56.06 ± 0.55	3.84 ± 0.10	0

Table 5 (cont'd)

Formulas or Flours	**Percent moisture/ 2g**	**Height (mm)**	**Diameter (mm)**	**Spread ratio**	**Line spread (cm)**
Porridge formulas					
1 50W:30C:10O	-	-	-	-	1.8
2 60W:20C:20O	-	-	-	-	1.5
3 70W:20C:10O	-	-	-	-	1.5
4 80W:10C:10O	-	-	-	-	1.5
5 100W	-	-	-	-	1.5

Table 5 (cont'd)

Formulas or Flours	Percent moisture/2 g	Height (mm)	Diameter (mm)	Spread ratio	Line spread (cm)
Flours					
Wheat	0.83 ± 0.75	-	-	-	
Cowpeas	2.49 ± 0	-	-	-	
OFSP	2.16 ± 0.28	-	-	-	
Maize	1.99 ± 0.5	-	-	-	

*= Significantly different from control at p< 0.05

**= significantly different from control at p<0.01

All the formulas for porridge had higher protein content, as analyzed by the Kjelhdal method, than the Control with the content in Formula 1 nearly double that of the Control a shown in **Table 6.** For the biscuits, however, only Formula 1 had significantly more protein than the Control**.** For the flours, cowpea flour had the highest protein content (11.21 ± 0.46) compare to OFSP with the lowest (3.34±2.21). For the porridge, all four formulas had lower crude fat content than the control, but for the biscuits there were no differences. For the flours, OFSP had the lowest fat content (4.67 ± 1.36 g) compared to wheat with the highest fat (12.01 ± 3.05 g). For vitamin A, all the porridge and biscuit formulas had more than the controls, p>0.01). For the flours, the wheat formulation had the lowest vitamin A content compared to OFSP with the highest level. For the line spread, the biscuit formulations did not spread, but stayed on the same spot forming a heap. This could be due to the fact that the biscuit dough was thick which could be rolled on a rolling board to cut into biscuits. However for the porridge, the line spread was computed and Formula 1 had the highest line spread of 1.8cm than the rest and there were no significant differences between the formulations.

Table 6. **Chemical analysis for protein, fat and Vitamin A for the five formulations for porridge and biscuit plus the four flours, mean ± SD (ANOVA for difference from control.) (See Table 2 for the formulas and Figure 2 for the recipes.)**

Formulas or Flours	Protein (g/2g)	Crude fat (g/1g)	Vitamin A (µg/1g)
Porridge formulas			
1 50:M:30C:20O	10.00 ± 0.46**	3.06 ± 0.15*	157.4 ± 5.60**
2 60M:20C:20O	8.46 ± 0.51*	3.43 ± 0.25**	168.43 ± 2.89**
3 70M:20C:10O	9.30 ± 0.60*	3.30 ± 0.40*	71.53 ± 13.32*
4 80M:10C:10O	7.26 ± 0.35**	4.00 ± 0.10*	81.10 ± 5.46**
5 100M	5.46 ± 0.51	4.57 ± 0.20	8.36 ± 3.39
Biscuit			
1 50W:30C:10O	13.96 ± 0.90**	21.03 ± 1.20	363.06 ± 7.77**
2 60W:20C:20O	11.43 ± 1.20	20.80 ± 0.40	361.46 ± 6.75**
3 70W:20C:10O	12.36 ± 0.55	21.50 ± 0.36	300.83 ± 14.20**
4 80W:10C:10O	11.36 ± 1.00	22.30 ± 0.87	271.36 ± 5.84**
5 100W	10.50 ± 0.52	22.40 ± 0.36	204.43 ± 5.71

Table 6 (cont'd)

Formulas or Flours			
	Protein (g/2g)	Crude fat (g/1g)	Vitamin A (µg/1g)
Flours			
Wheat	6.32 ± 0.91	12.01 ± 3.05	2.06 ± 0.21
Cowpeas	11.21 ± 0.46	8.46 ± 0.61	2.83 ± 0.30
OFSP	3.20 ± 1.35	4.67 ± 1.36	784.46 ± 3.00
Maize	3.34 ± 2.21	5.43 ± 0.75	11.40 ± 1.50

*= Significantly different from control at $p < 0.05$

**= significantly different from control at $p<0.01$

Comparison with nutrient calculations. For the porridge Formula 1, there was less energy compared to the Control Formula 5 as shown earlier in Table 4 and the vitamin A increased by 150mg as well. Similar patterns for the biscuits were seen in Table 3 as the percentage of cowpea and OFSP flours were increased.

Table 7. Line spread determination of maximum viscosity of four flours used in porridge and biscuit formulations, means ±SD

Flours	Time held at 95^{o}C to reach maximum viscosity (minutes)	Maximum viscosity Temperature ^{o}C	Line spread (Cm)
Wheat	4±2	35±4^{a}	15±4^{a}
Cowpeas	9±3	91±5^{b}	12±2^{a}
OFSP	8±2	82±5^{b}	13±3^{a}
Maize	6±4	38±3	8±2

Values followed by different superscript number in a column are significantly ($P \leq 0.01$) different from each other.

The distribution of the flours from **Table 7** ranged from 8±2 to 15±4cm. the time to reach maximum viscosity ranged from 35±4 to 91±5 ^{o}C with maize having the lowest line spread reading (highest viscosity) and wheat having the highest line spread (lowest viscosity) but the values were not significantly different from each other. The temperature to reach maximum viscosity ranged from 35±4 to 91±5^{o}C with wheat having the lowest temperature and cowpea having the highest. The temperature to reach maximum viscosity for wheat flour was significantly lower ($p \leq 0.01$) than the other flours.

Sensory Evaluation of formulated foods.

For the mothers participating in the consumer acceptance sensory evaluation, the mean age was 31.28 years and ranged from 17 to 53 years as shown in **Table 8.** Children averaged 23.36 months and ranged from 7 to 48 months in age. The mean education level attained by mothers was primary school and one mother had 1-2 years of college, but one mother also had no education. The mean number of children within the households was four, but ranged from one to eight.

Table 8. Demographic data for 110 mother-child dyads involved in sensory testing from six rural sites in Zomba district, Malawi.

	Mean	SD	Range
Age[1]			
Mother (Yr)	31.28	9.19	17-53
Child (Mo)	23.36	12.22	7-48
Education[2]	2.37	1.35	0-5
Number child in household	4	2	1-8

[1] only year of birth was asked, so these are estimates

[2] 0= none, 1= primary school 1-4, 2= Primary school 5-8, 3= secondary school 1-2, 4= Secondary school 3-4, 5=College 1-2 years, 6= College 3-4 years.

Table 9. Access to ingredients for the weaning products in percentage yes, n=110 mothers

Access	Yes	
	Number	Percent
Have difficulty in getting:		
Margarine	13	12.6
Baking powder	31	31.6
Wheat flour	45	40.9
Cowpeas	23	20.9
Orange fleshed sweet potatoes	18	16.4
Maize flour	18	16.4
Flour mill	16	14.5
Grow on my farm:		
Cowpeas	48	57.1
Sweet potatoes	55	50
Orange fleshed sweet potatoes	43	57.3
Maize	80	85.1
Have difficulty in getting sweet potatoes, cowpeas and maize for weaning foods	50	62.5

Some mothers reported having difficulties in getting the ingredients used in the weaning products when asked, as shown in **Table 9**. The percentages reporting difficulty were 12.6 percent for margarine, 31.6 percent for baking powder, 40.9 percent for wheat flour, 20.9 percent for cowpeas, 16.4 percent for OFSP, 16.4 percent for maize flour and 14.5 percent for finding a flour mill. Higher percentages, however, reported <u>not</u> growing certain crops. Most did not grow cowpeas (57.1%), orange fleshed sweet potatoes (57.3%). Nearly all

85.1% grew maize. About 62.5 percent of the mothers reported difficulty in getting sweet potatoes, cowpeas, wheat flour and maize to use in preparing these weaning foods for their children. This was close to the 66.4 percent or 73/110 mothers shown in **Table 10**.

Table 10. Mothers (n=110) description of food problems relating to preparation of porridge and biscuit formulations.

Problems with food ingredients		**Frequency**	**Percent**
Lack of money to buy		19	17
Difficult access to seed		25	23
	Cowpeas	10	9.1
	Sweet potatoes	8	7.3
	Maize	7	6.4
Scarcity of ingredients		3	2.7
Run out of food by end of dry season		3	2.7
No food when no rain		3	2.7
Cowpeas eaten by pests		1	0.9
Not enough food to feed the family		4	3.6

For the 17 percent of the mothers who expressed that they had problems in getting ingredients, it was due to lack of money, for 23 percent, due to difficulty in access to seed--either cowpeas, sweet potatoes or maize.

Table 11 shows that Formula 1 for the porridge was the most liked in terms of appearance, taste, consistency, flavor and overall acceptability, with Formula 3 running a close second in appearance and taste. Although Formula 1 was the least liked of the biscuit formulas, Formula 2 did not differ significantly from the Control Formula 5 and the other formulas except on consistency where formula 1 was significantly different from the control formula 5.

Table 11. Results of sensory acceptance testing by mothers (n=110) for five formulations of weaning porridge and biscuit at six locations, mean ± SD.

	Appearance	Taste	Consistency	Flavor	Overall acceptability
Porridge					
1 50:M:30C:20O	6.38 ± 1.2[a]	6.4 ± 1.2[a]	6.2 ± 1.3	6.1 ± 1.7	6.3 ± 1.4[a]
2 60M:20C:20O	6.0 ± 1.7[bc]	6.0 ± 1.8[bc]	6.0 ± 2.0	6.0 ± 2.0	5.9 ± 1.7[bc]
3 70M:20C:10O	6.15 ± 1.6[bc]	6.0 ± 1.5[bc]	5.8 ± 1.7	5.7 ± 1.8	5.8 ± 1.9[bc]
4 80M:10C:10O	5.7 ± 1.8[bc]	5.9 ± 1.7[bc]	5.8 ± 1.8	5.6 ± 1.8	5.3 ± 2.1[bc]
5 100M	5.6 ± 1.8[b]	5.5 ± 1.8[b]	5.7 ± 1.8	5.3 ± 1.9	5.38 ± 1.9[c]

Table 11 (cont'd)

	Appearance	Taste	Consistency	Flavor	Overall acceptability
Biscuit					
1 50W:30C:10O	5.6 ± 2.0	5.5 ± 2.0	5.2 ± 2.1^{a}	5.4 ± 2.1	5.3 ± 2.0
2 60W:20C:20O	6.2 ± 1.5	6.1 ± 1.4	5.8 ± 1.6^{bc}	5.7 ± 1.9	5.8 ± 1.7
3 70W:20C:10O	6.0 ± 1.9	5.7 ± 1.7	5.6 ± 1.8^{bc}	5.3 ± 2.0	5.4 ± 2.2
4 80W:10C:10O	5.9 ± 1.5	6.0 ± 1.4	5.8 ± 1.6^{bc}	5.7 ± 1.8	5.7 ± 1.8
5 100W	6.3 ± 1.3	6.2 ± 1.7	6.1 ± 1.6	6.0 ± 1.6	5.7 ± 2.2

Values followed by different superscript number in a column are significantly (P≤0.01) different from each other.

Table 12. Intent of mothers/ caregivers to feed their children and purchase, if products were on the market.

	YES	
	Frequency	**Percent**
Feed their children		
Mothers	109	100
Opinion leaders	11	100
Purchase if on market		
Mothers/ caregivers	69	63
Opinion leaders	6	54

All the mothers/ caregivers and caregivers indicated that they were ready to feed their children the developed weaning foods **(Table 12).** However, about whether they would purchase the products if they were on the market, only 63 percent of the mothers and 54 percent of the opinion leaders indicated that they would buy if it was on the market. The main reason why some mothers and opinion leaders would not buy the products was lack of money.

Eleven opinion leaders participated in assessing the need for and access to more nutritious weaning foods and the typical maize porridge **(Table 13**). These opinion leaders included one village chief, one member of women's groups, one church group member, and seven nutritionists from various ministries and NGO's. These leaders had been in these positions for two to fourteen years. Ten of 11 of these reported that undernutrition was indeed a big challenge in their communities and in their work areas.

Table 13. Descriptive data of opinion leaders (n=11).

Name of Organization	Position	No of years in position	Undernutrition a problem in their area
Village women's committee	Treasure	2	Yes
Church group committee	Member	2	No
World Vision Malawi	Nutritionist	4	Yes
Millenium Villages Project	Nutrition coordinator	3	Yes
Save the Children	Community and Nutrition Coordinator	5	Yes
Support for Service Delivery Integration	Health and Nutrition coordinator	1	Yes
Ministry of Agriculture and Food Security	Food and Nutrition Officer	7	Yes
	Agriculture and Extension Development Coordinator	3	Yes
Ministry of Health	Nutrition officer	4	Yes
	Health Surveillance Assistant	2	Yes
Village leadership	Village chief	14	yes

Table 14. Causes of undernutrition and challenges to access to food and roles of leaders in keeping children well nourished, as reported by 11 opinion leaders in Malawi.

Cause	**Number**[1]
Inadequate intake of nutritious food	8
Low educational levels of mother	2
Frequent illness	3
Challenges	
Prioritizing modern foods from shops	3
Inadequate food until next growing season	7
Prioritizing maize only	2
Role of leaders in keeping children well nourished	
Educate women, mothers and caregivers about nutrition	8
Frequent monitoring of children's nutritional status	1
Frequent home visits	2

[1]Note that leaders could report more than one for each category, so the numbers could be more than 11.

Opinion leaders most frequently reported lack for food as the cause of under nutrition, although mothers' low education level and frequent illness by children was also reported **(Table 14).** Likewise, food inadequacy was frequently reported as the most challenging problem. Less frequently mentioned were prioritizing modern, processed packaged foods sold in shops over home prepared foods and growing primarily maize instead of more diverse crops. By far the most frequently mentioned role of opinion leaders was to educate the women, mothers and caregivers about child nutrition. Most leaders also stressed that the education should be directed to mothers and caregivers in rural communities. Various organizations were specifically addressing child nutrition feeding in these communities—Support for Service Delivery Integration (SSDI), The Clinton Foundation, World Vision Malawi, Millennium Villages Project, government hospitals, Department of Agriculture Extension. The interventions included the following: optimal complementary feeding, exclusive breastfeeding, dietary diversification, community therapeutic care, community management of acute under nutrition, supplementary feeding, and "scaling up nutrition". Scaling Up Nutrition is a global movement to improve maternal and child nutrition focusing on the first 1000 Days of a child's life (Malawi Government, 2012). It encourages multi-regional and multi-stakeholder collaboration to support and implement national or regional plans. It also promotes implementation and integration of evidence-based nutrition interventions through multi-regional programs and strategic plans such as in health, social protection, community development, agriculture, information, local structures and Non-Governmental Organizations (NGOs).

To encourage families to choose more nutritious food, a nutritionist from Ministry of Health, indicated that there is need to educate the mothers and give them practical examples of foods that they can use and give them examples where these have worked. The nutritionist from the Department of Agriculture Extension pointed out that families need to be encouraged to practice crop diversification so that families have a diversified diet. Eighty percent of the opinion leaders also highlighted that frequent awareness meetings, enhancing nutrition education and visits to families is important to see whether families are following the recommended child feeding practices. This helps monitor if mothers are indeed feeding nutritious food to their children.

Table 15. Opinion leaders (n=10) evaluation about community access to ingredients used in the developed weaning foods.

Ingredient	Number				
	Very easy	Slightly easy	Neutral	Slightly difficult	Very difficult
Cowpeas	5	2	2	1	0
OFSP	6	2	2	0	0
Wheat flour	0	0	0	6	4
Maize	10	0	0	0	0
Margarine	0	0	0	6	4
Milling services	10	0	0	0	0
Baking powder	0	0	10	7	2

Most of the opinion leaders, reported that cowpeas were very easy or slightly easy to acquire **(Table 15),** and reported similar findings for OFSP. All reported access to milling services. All leaders reported that it was slightly or very difficult to access wheat flour and margarine, while nearly all said the same about baking powder. This means that communities would find it fairly easy to make the porridge, but not the weaning biscuit.

Chapter V. Discussion

The most striking finding from this study is that the nutritional value in terms of both protein and Vitamin A content were improved for the two fortified weaning foods. Furthermore, rural mothers for infants and toddlers in rural Malawi found at least one of the nutritionally enhanced formulas for both the porridge and biscuit to have both good organoleptic properties and to be acceptable, Formulas 1 50M:30C:20O and 2 60W:20C:20O, respectively. Not only did the OFSP and cowpeas improve the nutrient content but also the acceptance was good for all of them. The major barrier for preparing the biscuit, however, was the lack of access to wheat flour, margarine and baking powder ingredients. For margarine, oil can be used instead of margarine, even though accessing this could also be difficult. The remainder of this discussion section will pertain to the specific parts of the study.

Nutritional properties

The nutritional properties of the different formulations for weaning porridge and biscuit using the FAO and USDA food tables indicated that both the protein and Vitamin A content increased. This was due to the addition of cowpea and OFSP flours, respectively. The findings generated from the nutrient tabulations using various databases were close to those from the chemical analyses reported in Part B. Of some concern for the weaning porridge, however, was that the energy values declined slightly with increasing amounts of cowpea flour. The protein content for the porridge Formula 1 was double that of the traditional maze porridge, a substantial increase. Vitamin A increased by about 150 mcg and the OFSP provided an attractive golden orange color to the traditional white porridge.

According to FAO/WHO/UNU (2001), a child between 6-11 months and weighs 9.2kg needs 200 Kcal/day energy, 1.15g/kg BW/ day protein and 500mcg RAE Vitamin A. This means that if an infant ate 1.5 cups of porridge Formula 1, he or she would get adequate energy and protein, but still be low in Vitamin A, even though 157 mcg per day is better than the 5 mcg in the traditional maize porridge. A child who is 1-3 years and weighs between 11.4 to 13.8 kg would need larger amounts of the porridge. It should be kept in mind that many of these children would be supplemented with breast milk and other foods as available. In Malawi, 72 percent of children under 6 months are exclusively breast fed and at 6 months, 87 percent of children are given complementary foods (MDHS 2010). The children are breastfed typically on average for 24 months and by feeding the children these weaning foods it would supplement their nutrient intake as the child has increased demand for nutrients for which breastmilk at this time may not be adequate.

Physical and chemical properties

The moisture content found in this study, from 6.4 to 13.8 percent with cowpea flour having the highest and sweet potato flour the lowest, were in line with the recommended values for storage especially for the cereals (Salma and Zaidah, 2006). Moisture content of 12-15.5 percent has been specified for cereal flour storage (Oladunmoye et al., 2010).

For the biscuits, Formula 5, the control, had the greatest height and proportionate increases in cowpea and OFSP flour supplementation showed decreases in height. This trend was also observed in a study by Younas et al. (2011) where they examined the effect of rice bran supplementation on cookie baking quality. Their mean values for height of cookies declined with increases in rice bran supplementation.

Results demonstrated that the addition of composite flours such as cowpeas and OFSP influenced the height and diameter, respectively. The higher the proportion of composite flours, the lower the height and the greater was the product diameter. This could be due to the gluten in flour which is present in wheat flour and enables the dough to expand unlike the other flours (Younas et al, 2011). This means that adding composite flours to wheat flour reduced the amount of gluten, therefore biscuits made with the composite flours could not be higher than the wheat only dough. So instead of increasing in height, the biscuits spread sideways there by increasing the diameter.

Okpala and Chinyelu (2011) also found that an increase in pigeon pea flour resulted in an increase in spread ratio as we found with increasing the proportion of cowpea flour. This increased spread occurs because hydrophilic starches granules absorb moisture during baking to become swollen and gelatinized (Okpala & Chinyelu 2011). The gelatinization increases dough viscosity and thereby reducing cookie spread. This increased spread also occurred with the higher proportions of cowpea and OFSP flours.

The protein concentration of the formulations improved compared with the control formulas for both the biscuit and porridge. This is advantageous because legumes are relatively low cost and good sources of limiting amino acids to mix with maize and improve the protein quality, as well as increase the B vitamins and carbohydrates (Abebe et al, 2006). For the porridge, Formula 1 50M:30C:20O and the most preferred had twice the protein of Formula 5 100M, the control, a positive result. These findings were also true for a study in Nigeria of a tempe-based formula as a weaning diet where it was found that for the cowpea prepared tempe, the protein content increased more than the maize only weaning food

(Osundahunsi & Aworh 2002). This reinforces how the addition of legumes to cereal-based weaning foods increases the protein content.

From the chemical analysis it was demonstrated that the protein values were below the minimum recommendations of FAO/WHO patterns for weaning foods which is 16.6 percent by weight (FAO/WHO 2001). However this analysis was for only 1.5 cups of porridge which might be one serving. This means that a child could eat more of the porridge and still get the recommended FAO/WHO value for protein. Additionally, mothers in rural Malawi typically continue breastfeeding up to two years of age. This means that the child would get protein from milk as well. Although some rural families do raise goats, the goats are raised for meat or a cash crop and not for goat milk. At this time goat milk is not culturally acceptable in some areas, although there are efforts by the Ministry of Agriculture to expand dairying.

Traditionally, development of complementary foods aims at improving or increasing protein quality and energy density (Burri 2011). The use of cowpea flour improved the protein quality, but not energy density. The crude fat in the control porridge was higher than the fat in the other formulas. This could be due to the additions of cowpea and OFSP which are generally low in fat. The fat in the biscuits was similar in all formulations because the biscuits used margarine which contributed to the increase in fat. Mothers could increase the energy density of the porridge by adding 1-2 teaspoons of cooking oil, although cooking oil must be purchased with cash. For families that grow ground nuts or sunflowers, they could use these for oil and add it to the porridge. However in Malawi families do not extract oil from the groundnuts and sunflowers at household level. Some farmer groups typically extract the oil and offer it for sale (Chitete 2011). In other parts of Africa, like Nigeria, families can extract their own oil from ground nuts or sunflowers at household level and then use the oil in the porridge. Hence, it is also important to promote extraction of oil from ground nuts and sunflowers at household level in Malawi so that families have a good source of energy.   Regardless, making a floor of the ground nuts or sunflowers would make it possible to add this directly to the porridge to increase the fat content.

The fat content of the biscuits was high and the about same for each formula, because it was a constant amount from the margarine. This was also true in a study by Zaker et al. (2012) where they found that the total fat content of biscuits was mainly a function of the externally added fat during biscuit preparation. But such fats or oils are not easy to access in rural villages.

The crude fat in the control porridge was higher than the fat in the other formulas; this could be due to the additions of cowpea and OFSP which are generally low in fat. The fat in the biscuits was similar in all formulations since the biscuits used margarine which contributed to the increase in fat. Fat content decreased with increases in cowpea and OFSP flours. This is due to the fact that cowpeas and OFSP are not oil crops hence reduced the fat content. A study by Nnam (1999) during a chemical evaluation of multi-mixes formulated from some local staples for use as complementary foods in Nigeria found that the fat content of the mixes were influenced by the type of legume used. Soy blends had higher fat content than cowpea blends which was three times higher and it was due to the fact that soybeans are oil seeds with higher oil content than cowpeas. Fat helps to make the biscuits have a softer texture since they don’t evaporate. If the margarine is not available, mothers can add ordinary cooking vegetable oil to the biscuits and this could help make the biscuits softer.

For the line spread, maize had the lowest line spread (8±2cm) meaning that it thickened much more compared to the other flours. The flours attained their maximum viscosity at the point where the porridges were very thick. For the sweet potato, the porridge was left for a longer time. The same also happened with wheat flour. The granular size of the flour may have contributed to the swelling of the flour hence different. Since the flours have different swelling properties, their use in product formulation may be different because they function differently. The difference in viscosities can be due to differences in ratio of amylose to amylopectin which are different for the flours. This would affect consistency of the biscuit and porridge. The type of milling that used would also determine the paste properties and the end product quality (Singh, 2003). This is because dry milling leads to flours of varying particle size and hence the end products made from these flours differ in quality too. Protein content and functionality is also associated with viscosity (Kethireddipalli et al, 2002). In this study cowpeas was found to have the lower viscosity (12±2cm), this means that the protein in cowpeas played a role in the viscosity. In a study by Kethireddipalli et al, (2002), found that cowpea paste flour had the least viscosity and that viscosity also depended on the moisture content of the flours. This was also true for wheat. The low viscosity in OFSP could be due to amylose content. According to a study by Brabet et al , (1998) found that when a flour is heated above the critical temperature granules swell irreversibly and amylose leaches out into the aqueous phase resulting in increased viscosity. The amylose content of OFSP was low and hence contributed to the decreased viscosity. The concept of viscosity is important for determining starch behavior in various food applications (Brabet et al, 1998) since they affect starch- based product quality such as texture, stability and digestibility. Though from the sensory test conducted there were no significantly differences, however, for the biscuit there were significant differences on consistency. The maize started to thicken at a maximum temperature of 38±2^{o}C. With an increase in temperature the maize slurry could not spread as it had thickened. Viscosity is a property of flour to resist in their flow, it can be seen that in wheat the viscosity was reduced and the slurry was free flowing. This might be due to the enzyme activity and the initial period of cooking (Moulishwar et al, 1993). This knowledge is beneficial since it lets scientists know the concentration of flour and time needed to cook for various porridges.

Traditionally, development of complementary foods aims at improving or increasing protein and energy density (Gibson et al; 2003). The use of OFSP in this study improved Vitamin A density in both the biscuits and porridges. Because these ingredients are fairly easy for families to access, these additions should be promoted weaning foods.

Sensory evaluation

There was a very good turnout and interest in the sensory testing that could be due the Extension workers from the areas doing a good job recruiting. Alternatively, the women might have been especially interested in the incentives provided, a plastic feeding plate and cup. At each site, there were about 25% more participants than anticipated and the investigator ran out of the incentives for the last six participants at the last site. Cash was given instead.

On education, the overall level of for all Malawian households is generally low (Malawi Government & World Bank 2006). Most mothers reported at least a primary school education up to year 5 to 8, a finding supported by the most recent demographic survey in Malawi (MDHS, 2010). While most women have had some education, only about 20 percent have had a secondary education compared to 30 percent of the men. In Malawi, 15 percent of women are uneducated compared to 7 percent of men. Education of women is vitally important to child health because the higher the education level the better care a child receives from the mother (MICS 2008). This means that these mothers cannot work for salaried jobs. The occupation of such households is characterized by a large reliance on household farming, implying a heavy reliance on agriculture for employment and subsistence farming. When a mother is educated, she is able to practice some of the nutrition education she gets from extension workers compared with the uneducated mothers. According to the MDHS (2010), stunting decreases as the level of mother's education increases for example 53 percent of children of uneducated mothers were stunted compared to 39 percent of children of mothers with a secondary education.

Also according to the MDHS (2010), on average a Malawian woman gives birth to 5.7 children and in Malawi, rural women will give birth to two more children during their reproductive years than urban women. The average number of children is highest in rural areas and poor households (Malawi Government and World Bank, 2006). The number of children in poor households is four times that of rich households and children alone make up to 49.9 percent of the total population. In this study, the households had 4±2 children in the households. These were larger number of children as compared to the number of children that urban households have and the study did not ask about other dependents in the households this means that they could be more people living in the households. Poor Malawian households are generally larger than the non-poor households with an average of 5.4 members compared to an average of 3.8 members in non-poor households (Malawi Government and World Bank, 2006) and these poor households are found in rural areas.

On the acceptance of the weaning foods, formula 1 50M:30C:20O of the porridge was more acceptable in terms of appearance compared to other formulas, though there were no significant differences among the formulas. Taste for formula 1 was more acceptable compared to the other formulas and so was consistency, flavor, and overall acceptability. The appearance of the porridge formula 1 became darker due to high concentration of cowpea and OFSP while the other formulas were lighter in color. The change in color of formula 1 to slightly orange was a positive and gave the porridge more eye appeal than the traditional all white porridge. As the cowpea and OFSP increased the acceptability in terms of appearance, taste, flavor and overall acceptability was greater than for the traditional refined maize porridge which has no flavor. Furthermore, the OFSP gave a slight sweetness as well.

The trend was not true for biscuits where the appearance for formula 5 was more acceptable than the other formulas. Incorporating cowpea flour resulted in slightly darker biscuits, like less well by the panelists, although there were no significant differences among the formulas. Formula 5 (control) was more preferred than formula 1 50W:30C:10O. This could be attributed to the fact that most people were not used to seeing biscuits as dark.

The overall acceptability of the biscuits was similar for formulas 5(control), 4, 3, and 2 indicating that at 20 percent of cowpea and OFSP flours the product was found acceptable. This was also true for a study by Zaker et al.,(2012) where the overall acceptability of biscuits from a composite soy wheat flour was limited to 20 percent soy flour. This therefore indicates that incorporation of cowpea and OFSP flours at the 20 percent level could be considered optimum with respect to sensory quality characteristics of the biscuits.

For some of the ingredients that are difficult for the households to have access to, use of locally available un refined maize flour which is called ‘mgaiwa’ in the local language and hence they can be making local biscuits with the cowpea and OFSP flours. Rural households can also use bicarbonate of soda as an alternative to baking powder which is slightly inexpensive. For margarine rural households can also use cooking oil as the fat source.

The department of agricultural research and the department of crop development and the department of Nutrition, HIV and AIDS are promoting the growing and consumption of OFSP currently. However the adoption rate is not very much as such still more households are not growing the OFSP. The departments can embark on a sensitization mission to sensitize the communities on the benefits of growing and consuming OFSP. The departments can there after distribute the vines either at a subsidized price or for free for planting in the villages so as to multiply the crop and then at least every household will have OFSP and can grow on their own. The rural families will then shift from looking at maize as life but rather they can utilize any other crop and equally benefit from it nutritionally.

It would therefore be recommended that government leaders should take part in the deliberate promotion of OFSP and cowpeas at household level. There are various organizations that are looking at means of providing nutritious food to rural malnourished children and these organizations include FAO, WFP, and other numerous local nutrition organizations. The international potato center is one organization that can promote growing of OFSP and the Bean/Cowpea Collaborative Research Support Program which promotes the legumes and deliberate efforts can be made so as to promote the consumption of these at household level. Once these are promoted at household level, then the local nutrition organization together with the ministry of Agriculture should work hand in hand in promoting the utilization of these foods at household level. If there is a unified effort in the promotion of utilization rural households will be able to prepare nutritious foods from the locally available crops.

Chapter VI. Strengths, Limitations, Future Research

This chapter concludes the thesis with strengths and limitations of the study. Implications for future research are presented as well.

Limitations

Several of the pieces of equipment needed to conduct the chemical and physical properties for the products were unavailable at the University in Malawi. For example, it was not possible to do pasting viscosity due to the absence of equipment. The researcher was not able to improvise cardboard privacy partitions between each taste station to avoid other panelists' facial expressions influencing the results. However, the participants were spaced widely apart with at least six feet between them. Sometimes the porridge could not be kept warm. Although this would affect the consistency and aroma, nevertheless, the women rated all formulations with good sensory scores overall.

Strengths

The use of locally available crops within the villages was a major strength, because the mothers and community leaders could see how they could use their own locally produced foods within their households to make tasty and nutritious foods for weaning infants. The high rate of attendance exceeded that anticipated, which implied that mothers and the community at large were interested in the study and strongly desired to improve their children's health. The community leaders, especially the village chiefs, also actively took part by informing mothers about the sensory testing. A major strength was that the primary researcher was from Malawi, spoke Chichewa, and familiar with both the food products and rural environment via her position within the Ministry of Agriculture. The fact that some mothers waited for hours with small children in their arms until after the sensory testing to request that the extension educator return to their village to show them how to make the porridge and biscuit demonstrates how effective both she and this study were. These things together should enhance the likelihood of community adoption of a nutritionally improved weaning food to help address under nutrition in Malawi.

Implications for Future Research

Future research should address the chemical analysis on the other equally important nutrients of the weaning foods. There is also need to assess the amino acid complementarity of the formulas. The bioavailability of the protein and vitamin A once the child consumes it could also be addressed. Finally, it is important to determine if and how the child's growth and nutritional status might change once fed these weaning foods.

APPENDIX

APPENDIX

Study poster- English

STUDY ON WEANING FOODS FOR CHILDREN

Weaning Foods Made From Cowpeas, Maize, Orange Fleshed Sweet Potatoes, or Wheat

on <u>28th February 2013 at Zomba Agriculture office starting at 9:00am</u>

Figure 5. Pictures of children eating porridge

<u>Study description</u>

The purpose of this research study is to evaluate the sensory quality of weaning foods made from cowpeas, orange fleshed sweet potatoes, maize or wheat by mothers

<u>Details</u>

- Recruiting 100 mothers or caregivers who are willing to try two weaning foods- a porridge and biscuit
- For participating, each person will receive a child sized feeding bowl, spoon and cup

Requirements

- Mother, caregiver 18 years and older with a 6 month to 3 year old weaning child
- Can at least read Chichewa, the local language

Contact

If interested, contact the study coordinator:

Edda Lungu, Food and Nutrition Officer, Ministry of Agriculture and Food Security

Cell: +265 999 326 289

Email: lunguedd@msu.edu

Principal investigator: Sharon Hoerr, PhD, RD (011 517-355-8474 x 110; hoerrs@msu.edu

Study poster- Chichewa

KAFUKUFUKU WA ZAKUDYA ZA ANA

Zakudya za ana oyambira miyezi isanu ndi umodzi kuchokera ku khobwe, mbatata yofiira ndi ufa wa tiligu pa 28 Febuluwale ku ofesi ya zamalimidwe ya Zomba nthawi ya 9:00 m'mawa

Figure 6. Pictures of children eating porridge

Cholinga cha kafukufuku

Kuti tione ngati zakudya zopangidwa kuchokera ku khobwe, mbatata yofiira ndi ufa wa tiligu zili zovomelezedwa ndi amai amene ali ndi ana oyambira miyezi isanu mpaka zaka zitatu.

Zofunika

- Tikufuna azimai 100 amena akufuna kutengapo mbali polawa zakudya za ana
- Amene atengepo mbali alandira mbale, kapu ndi sipuni yodyera mwana.

Zofunikila amai

- Amai oti alindi mwana kapena akusunga mwana oti ali ndi miyezi isanu ndi umodzi kufikila zaka zitatu
- Angathe kuwerenga Chichewa

Olumikazana nawo

Ngati mukufuna kutengapo mbali chonde adziwitseni a **Edda Lungu**, alangizi a zakudya mu unduna wa zamlimidwe ndi kuonetsetsa kuti kuli zakudya zokwanira, foni: +265 999 326 389, email: lunguedd@msu.edu

Principal investigator: Sharon Hoerr, PhD, RD (011 517-355-8474 x 110; hoerrs@msu.edu

Consent forms-English

Sensory Evaluation Consent Form for Weaning Porridge and Biscuit

Dear Participant:

We are investigating the sensory qualities of porridge and biscuits made from cowpeas, sweet potatoes, maize or wheat. These products were specially made from foods grown locally to improve the nutrition and growth of children during weaning. We would like you to take about 20 minutes to help us to evaluate these foods after tasting each one.

Please read the list of ingredients in the cooked porridge and biscuits before tasting:

- Cowpeas
- Maize
- Orange fleshed sweet potatoes
- Wheat flour (Biscuits)
- Margarine
- Baking powder
- Salt
- Sugar

If you have a known food allergy to any of the above ingredients, do not volunteer for this study.

If you agree to taste these products please sign the consent form below. You will be given a questionnaire to fill out and 5 samples of each product to evaluate. The purpose of this survey is to assess the sensory qualities of the products made from cowpeas, orange fleshed sweet potatoes and maize or wheat and their acceptability to mothers feeding young children.

Your response to the questionnaire is anonymous. We have no way to connect you, as an individual, to the completed survey form. You are free to not answer any question you choose, but please try to answer every question. Your time and feedback is greatly appreciated. Your consent form will be kept in a locked file cabinet at the Ministry of Agriculture and Food Security, in Liwonde, Machinga District.

Your participation in this study is voluntary. If you decide to refuse or discontinue participation during this study, we will honor it promptly and unconditionally.
If you complete the survey, you will receive a child-sized feeding bowl, spoon and cup as a thank you for your time and participation.

If you have any questions regarding this study, please contact Edda Lungu at Machinga Agricultural Development Division, Liwonde, on mobile: 0999 326 289.

Sincerely,

Dr. Sharon L. Hoerr, Professor
Department of Food Science & Human Nutrition
Michigan State University, 469 Wilson Rd
East Lansing, MI, USA 48823
Ph: 011 517-355-8474x110

Edda Lungu, MSU Graduate Student
Food and Nutrition Officer
Machinga Agricultural Development
Division
Private Bag 3, Liwonde, Malawi
Mobile: +265 0999 326 289

I have read the information presented above and voluntarily agree to participate in this study.

___________________________ _____________________

Participant's signature Date

Consent form- Chichewa

KUVOMELEZA KUTENGA MBALI PA KAFUKUFUKU WOLAWA PHALA LA MWANA NDI BISIKETI

Okondedwa,

Ife tikupanga kafukufuku wa phala la ana ndi bisiketi kuti tione mmene anth angalikondele. Phala ndi mabisiketiwa apangidwa kuchokera ku khobwe, mbatata yofiila, chimanga ndi tiligu. Zakudyazu zimapezeka mumadera ambiri mu m'Malawi muno. Zakudyazi zapangidwa ndicholinga choti zithandize ana kuti akhale anthanzi ndiponso akule bwino makamaka pa nthawi yomwe ayamba kudya zakudya zina pakatha miyezi isanu ndi umodzi. Tikukupemphani ngati muli omasuka, mutenegeko mbali polawa zakudyazi ndi kuyankha mafunso amene alipo.

Chonde musayambe kulawa werengani mwatsatane tsatane zinthu zimene zagwiritsidwa ntchito pophika zakudyazi. Zinthu ndi izi:

Khobwe

Chimanga

Mbatata yofiila

Tiligu

Majalini

Baking'I pawudala

Mtchere

Suga

Ngati mumadwala kapena kutuluka ziwengo mukadya zimene zili apazi chonde musalawe nawo.

Ngati mwavomeleza kulawa zakudyazi chonde sayinani dzina lanu pansi pa tsambali. Mupatsidwa mafunso ndipo yankhani mmene inu mukumvera ndi kuonera.

Mayankho amene mupeleke apa akhala achinsinsi. Ife sitidzalumikiza dzina lanu ndi mayankho amene inu mupeleke. Muli ndi ufulu osayankha mayankho amene mukuona ngati ndibwino kuti musayankhe koma tikupemphani kuti muyankhe funso lirilonse.

Simukakamizidwa kuti mutengepo mbali pa kafukufuku ameneyu. Ngati mukufuna kusiya mutayamba kale mungathe kutero ndipo ife tivomereza.

Mukamaliza kuyankha mafunso mulandira mbale yodyesela mwana, sipuni ndi kapu ngati chithokozo pa nthawi yanu komanso kutengapo mbali.

Ngati muli ndi mafunso okhuzana ndi kafukufukuyu chonde ayimbileni a Edda Lungu aku Machinga Agriculture Development Division, Liwonde pa 0999326289

Zikomo.

Dr. Sharon L. Hoerr, Professor Edda Lungu, MSU Graduate Student

Department of Food Science & Human Nutrition Food and Nutrition Officer

Michigan State University, 469 Wilson Rd Machinga Agricultural Development Division

East Lansing, MI, USA 48823 Private Bag 3, Liwonde, Malawi

Ph: 011 517-355-8474x110 Mobile: +265 0999 326 289

Ndawerenga ndipo ndamvetsetsa zones zofunika kuti ndidziwe ndisayambe kulawa zakudyazi ndipo ndikuvomereza kutengapo mbali pa kafukufuku ameneyu.

Siginecha________________________________ Tsiku

____

Sensory acceptance questionnaire porridge- English

Participant Number_____

Sensory evaluation questionnaire

Date____________________

Sample Number ___________________________

Instructions

Check one rating for each of the following: appearance, taste/flavor, texture/consistency, aroma/smell and overall acceptability.

Rating scale	Appearance	Taste/flavor	Texture/consistency	Smell/aroma	Overall acceptability
7. Like very much					
6. Like moderately					
5-Like slightly					
4-Neither like or dislike					

3-Dislike slightly					
2-Dislike moderately					
1-Dislike very much					

Sample Number ___________________________

Check one rating for each of the following: appearance, taste/flavor, texture/consistency, aroma/smell and overall acceptability.

Rating scale	Appearance	Taste/flavor	Texture/consistency	Smell/aroma	Overall acceptability
7. Like very much					
6. Like moderately					
5-Like slightly					
4-Neither like or					

dislike					
3-Dislike slightly					
2-Dislike moderately					
1-Dislike very much					

Sample Number ___________________________

Check one rating for each of the following: appearance, taste/flavor, texture/consistency, aroma/smell and overall acceptability.

Rating scale	Appearance	Taste/flavor	Texture/consistency	Smell/aroma	Overall acceptability
7. Like very much					
6. Like moderately					
5-Like slightly					
4-Neither					

like or dislike					
3-Dislike slightly					
2-Dislike moderately					
1-Dislike very much					

Sample Number ___________________________

Check one rating for each of the following: appearance, taste/flavor, texture/consistency, aroma/smell and overall acceptability.

Rating scale	Appearance	Taste/flavor	Texture/consistency	Smell/aroma	Overall acceptability
7. Like very much					
6. Like moderately					
5-Like slightly					

4-Neither like or dislike					
3-Dislike slightly					
2-Dislike moderately					
1-Dislike very much					

Sample Number ____________________________

Check one rating for each of the following: appearance, taste/flavor, texture/consistency, aroma/smell and overall acceptability.

Rating scale	Appearance	Taste/flavor	Texture/consistency	Smell/aroma	Overall acceptability
7. Like very much					
6. Like moderately					
5-Like					

slightly					
4-Neither like or dislike					
3-Dislike slightly					
2-Dislike moderately					
1-Dislike very much					

Demographic information

1. Year you were born ______________________________
2. Year your child was born__________________________
3. Highest level of education _________________________
4. How many children are in your house? _________________
5. Do you have difficulty purchasing or accessing any of the following? Y=Yes and N=No
    a. Margarine Y N
    b. Baking powder Y N
    c. Wheat flour Y N
    d. Cowpeas Y N
    e. Sweet potatoes Y N

f. Maize flour Y N

g. Mill Y N

6. Do you grow any of the following on your farm?

    a. Cowpeas Y N

    b. Sweet potatoes Y N

        i. If yes what variety are they?

            1. White

            2. Orange/ yellow variety

    c. Maize flour Y N

7. Do you anticipate any problems obtaining the flour from maize, cowpeas or Orange/yellow sweet potatoes to use in these weaning foods?

    a. Yes

    b. No

If yes explain

why____

____

____

8. Are you a community leader from where you are coming from?

    a. Yes

    b. No

Sensory acceptance questionnaire porridge- Chichewa

Nambala yanu______________

KULAWA PHALA LA ANA OTI AYAMBA KUDYA PHALA

Nambala ya phala___________________________

Malangizo

Chongani malo amodzi pa zinthi izi: maonekedwe, makomedwe mkamwa, mmene zikumvekera mkamwa, kanunkhilidwe ndi mmene chakusangalatsilani.

Muyeso	Maoneked we	Makomedw e mkamwa	Kamvekedw e mkamwa	Kanunkhilidw e	Kusangalats a kwake
7. Ndakonda kwambiri					
6. Ndachikondabe					
5. Ndakonda pang'ono					
4. Sindinakonde kapena kukonda					
3. Sindinachikondese se					
2. Sindinakonde					
1.Sindinakonde konse					

Nambala ya phala___________________________

Chongani malo amodzi pa zinthi izi: maonekedwe, makomedwe mkamwa, mmene zikumvekera mkamwa, kanunkhilidwe ndi mmene chakusangalatsilani.

Muyeso	Maonekedwe	Makomedwe mkamwa	Kamvekedwe mkamwa	Kanunkhilidwe	Kusangalatsa kwake
7. Ndakonda kwambiri					
6. Ndachikondabe					
5. Ndakonda pang'ono					
4. Sindinakonde kapena kukonda					
3. Sindinachikondesese					
2. Sindinakonde					
1.Sindinakonde konse					

Nambala ya phala___________________________

Chongani malo amodzi pa zinthi izi: maonekedwe, makomedwe mkamwa, mmene zikumvekera mkamwa, kanunkhilidwe ndi mmene chakusangalatsilani.

Muyeso	Maonekedwe	Makomedwe mkamwa	Kamvekedwe mkamwa	Kanunkhilidwe	Kusangalatsa kwake
7. Ndakonda kwambiri					
6. Ndachikondabe					
5. Ndakonda pang'ono					
4. Sindinakonde kapena kukonda					
3. Sindinachikondesese					
2. Sindinakonde					
1.Sindinakonde konse					

Nambala ya phala___________________________

Chongani malo amodzi pa zinthi izi: maonekedwe, makomedwe mkamwa, mmene zikumvekera mkamwa, kanunkhilidwe ndi mmene chakusangalatsilani.

Muyeso	Maonekedwe	Makomedwe mkamwa	Kamvekedwe mkamwa	Kanunkhilidwe	Kusangalatsa kwake
7. Ndakonda kwambiri					
6. Ndachikondabe					
5. Ndakonda pang'ono					
4. Sindinakonde kapena kukonda					
3. Sindinachikondesese					
2. Sindinakonde					
1.Sindinakonde konse					

Nambala ya phala___________________________

Chongani malo amodzi pa zinthi izi: maonekedwe, makomedwe mkamwa, mmene zikumvekera mkamwa, kanunkhilidwe ndi mmene chakusangalatsilani.

Muyeso	Maonekedwe	Makomedwe mkamwa	Kamvekedwe mkamwa	Kanunkhilidwe	Kusangalatsa kwake
7. Ndakonda kwambiri					
6. Ndachikondabe					
5. Ndakonda pang'ono					
4. Sindinakonde kapena kukonda					
3. Sindinachikondesese					
2. Sindinakonde					
1.Sindinakonde konse					

Mafunso ena apadera

1. Chaka chomwe munabadwira______________________________________
2. Chaka chomwe mwana wanu anabadwira____________________________
3. Sukulu munapita nayo patali bwanji?_________________________________
4. Muli ndi ana angati amene mukukhala nawo m'nyumba mwanu?_________________
5. Muli ndi vuto lirilonse kugula kapena kupeza zinthu izi: chongani E ngati yankho liri Eya ndipo chongani A ngati yankho liri Ayi:
    a. Majalini Ayi Eya
    b. Baking'i powudala Ayi Eya
    c. Ufa wa tiligu Ayi Eya
    d. Khobwe Ayi Eya
    e. Mbatata yifiira Ayi Eya
    f. Ufa wa chimanga Ayi Eya
    g. Chigayo Ayi Eya
6. Kodi mumalima izi kunyumba kwanu?
    a. Khobwe Ayi Eya
    b. Mbatata Ayi Eya
    c. Chimanga Ayi Eya
7. Ngati yankho lanu linali eya pa funso lamwambali, ndi mtundu wanji wa mbatata imene inu mumalima?
    a. Yoyera
    b. Yofiira

8. Kodi mumapeza mavuto ena aliwonse kuti mupeze ufa wa chimanga, khobwe kapena mbatata yofiira kuti mugwiritse ntchito pophika phala la mwana?

   a. Eya

   b. Ayi

9. Ngati mukuyembekezera mavuto fotokozani kuti mavuto anji?

   ____

   ____

   ____

   ____

   ____

10. Kodi ndinu atsogoleri kudela kwanu kumene mukuchokera?

   a. Eya

   b. Ayi

Zikomo kwambiri

Opinion leaders questionnaire- English

Interview questionnaire for Opinion Leaders from rural communities.

Hello,

My name is ______________________________. I am working with the Department of Agricultural Extension Services in the Ministry of Agriculture and Food Security, Machinga Agriculture Development Division. We are conducting a study on acceptance of a weaning porridge and biscuit made from cowpeas, orange fleshed sweet potatoes and maize or wheat.

The aim of the survey is to determine the acceptability of a new weaning porridge and biscuit in your area. I would like to interview you as an opinion leader in your community and invite you to participate. The survey will take about 15 minutes. All information you give will be confidential. Be assured that the answers that you provide will be used in combination with others to get a true picture of the acceptance of these foods. You are free not to answer any question you choose not to answer. Your participation is voluntary and you can stop anytime. There is no penalty if you do not participate.

If you have any questions or concerns about the survey, or about participating in the study, please contact me on lunguedd@msu.edu or call on+265 999 326 289 or contact your local extension worker.

Interview questionnaire for opinion leaders.

1. What is your role or position in the community you live?

   ____

2. For how many years have you been in that role or position?

   ____

3. To what degree is child under-nutrition a problem in in your area?

   a. Not at all
   b. A little
   c. A moderate amount
   d. A lot

4. If yes what do you think is causing it?

   ____

   ____

   ____

   ____

5. What are some challenges that your community faces in terms of access to food?

   ____

   ____

____

____

6. As an opinion leader, what is your role in helping to keep children in your community well nourished?

____

____

____

____

7. What intervention projects in your area, if any, address child nutrition feeding?

____

____

____

____

8. Some of porridges and biscuits are much more nutritious than the traditional maize only porridge or wheat only biscuit. How would you go about encouraging families in your community to choose the more nutritious ones instead?

____

____

____

____

9. What is the best way to ensure that mothers are feeding their children these nutritionally enhanced foods?

____

____

____

10. How difficult would it be for mothers in your community to access any of the following food ingredients?

    a. Cowpeas

5=Very difficult	4=Slightly difficult	3=Neutral	2=Slightly easy	1=Very easy

    b. Orange fleshed sweet potato

5=Very difficult	4=Slightly difficult	3=Neutral	2=Slightly easy	1=Very easy

    c. Wheat

5=Very difficult	4=Slightly difficult	3=Neutral	2=Slightly easy	1=Very easy

d. Margarine

5=Very difficult	4=Slightly difficult	3=Neutral	2=Slightly easy	1=Very easy

e. Milling services

5=Very difficult	4=Slightly difficult	3=Neutral	2=Slightly easy	1=Very easy

f. Baking powder

5=Very difficult	4=Slightly difficult	3=Neutral	2=Slightly easy	1=Very easy

Thank you very much for participating.

Opinion leaders questionnaire- Chichewa

MAFUNSO A ATSOGOLERI A DERA

Moni,

Dizna langa ndine__________________________________. Ndamagwira ntchito ku unduna wa zamalimidwe ndi kuonetsetsa kuti kuli chakudya chokwanira, ku Machinga Agriculture Development Division. Tikupanga kafukufuku wa zakudya za ana kuti tione ngati zili zovomelezeka ndi anthu. Zakudyazi zakonzedwa kuchokera ku khobwe, mbatata yofiira, ufa wa chimanga ndi ufa wa tiligu.

Cholinga cha kafukufuku ameneyi ndi kuti tione ngati anthu makamaka azimai angavomereze ndi kukonda zakudyazi ndikudyesanso ana awo. Tikufuna kukufunsani mafunso inu ngati atsogoleri a dera lanu. Mafunso atenga phindi 15 kuti timalize, mayankho anu akhala achinsinsi ndipo mayankho amene muyankhe azaphatikizidwa ndi mayankho a anthu ena kuti tione ngati anthu azikonda zakudyazi. Dziwaninso kuti simuzakakamizidwa kuyankha mafunso amenewa.

Ngati muli ndi mafunso pa zakafukufuku ameneyi chonde alembeleni a Edda Lungu pa lunguedd@msu.edu olo kuwaimbila phone pa + 265 999 326 289 olo afunseni alangizi aza ulimi mudera mwanu.

MAFUNSO ATSOGOLERI AMU DERA

1. Kodi muli ndi undindo wanji ku dera kwanu?

____

____

____

2. Kodi undindo umenewu mwakhalapo nthawi yayitali bwanji?

____

____

____

____

3. Kodi mudera mwanu muli mavuto a kunyetchera kwa ana?

    a. Ayi
    b. Pang'ono
    c. Mochepera
    d. Kwambiri

4. Ngati mavuto a kunyetchera alipo chimene chikuchitisa ndi chani?

____

____

____

5. Ndi mavuto anji amene mumapezana nawo mudera lanu makamaka pakapezedwe ka chakudya?

____

____

____

____

____

6. Inu ngati atsogoleri, muli ndi udindo wanji powonetsetsa kuti ana amudera mwanu akukula ndi thanzi la bwino?

____

____

____

____

7. Kodi mudera mwanu muli ma pulojekiti amene akuyang’anira za thanzi la ana?

____

____

____

8. Pali ma phala la ana komanso ma bisiketi ena oti ali ndi zofunikira mu thupi zambiri kuposa phala la ufa woyera ndi ma bisiketi a ufa wa tiligu yekha. Kodi inu ngati atsogoleri amu dera mudzawalimbikitsa bwanji anthu mudera mwanu kuti azidyesa ana phala ndi mabisiketi omwe ali ndi zofunikila nthupi zambiri?

____

____

____

____

9. Kodi njira yabwino yowonetsetsa kuti amai akudyetsa ana awo zakudya zabwino ngati zimenezi ingakhale chani?

____

____

____

____

10. Kodi ndi zovuta bwanji kwa azimai amudera lanu kuti apeze zinthu izi:

a. Khobwe

5=zovuta kwambiri 4=zovutilapo 3=pakatikati 2=zophwekerapo 1=zosavuta

b. Mbatata yofiira

5=zovuta kwambiri 4=zovutilapo 3=pakatikati 2=zophwekerapo 1=zosavuta

c. Tiligu

5=zovuta kwambiri 4=zovutilapo 3=pakatikati 2=zophwekerapo 1=zosavuta

d. Majalini

5=zovuta kwambiri 4=zovutilapo 3=pakatikati 2=zophwekerapo 1=zosavuta

e. Chigayo

5=zovuta kwambiri 4=zovutilapo 3=pakatikati 2=zophwekerapo

1=zosavuta

f. Baking'I pawudala

5=zovuta kwambiri 4=zovutilapo 3=pakatikati 2=zophwekerapo

1=zosavuta

ZIKOMO KWAMBIRI

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