NUTRIENT COMPOSITION AND CONSUMER ACCEPTABILITY OF MAIZE/MUSHROOM COMPOSITE PORRIDGE FOR COMPLEMENTARY FEEDING IN SIAYA COUNTY, KENYA.

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H60/28766/2013

A RESEARCH THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE (FOOD, NUTRITION AND DIETETICS) IN THE SCHOOL OF PUBLIC HEALTH AND APPLIED HUMAN SCIENCES, KENYATTA UNIVERSITY

NOVEMBER, 2018
DECLARATION

This thesis is my original work and has not been presented for a degree in any other university.

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DEDICATION

This work is dedicated to God the Almighty, my beloved wife Caro, my wonderful daughters Joanne and Sarah and my dear mom Bennedetta.
ACKNOWLEDGEMENTS

To God the Almighty who supplies Grace and Means be all Glory and Gratitude. His unfailing love and providence gave the impetus.

My special appreciation goes to my supervisors, Dr. Ann Munyaka, and Dr. Peter Chege of Kenyatta University Foods Nutrition and Dietetics Department for their timeless support: guidance, advice and encouragement throughout the work. I also wish to acknowledge the entire staff at the Department of Food, Nutrition and Dietetics for their support and contribution during my research. Mr. John Gachoya deserves mention for vital help on certain logistical aspects during the research process. May God bless their hearts and efforts.

Special acknowledgement to my entire family which I consider a special gift and blessing from the Lord. Their prayers and moral support yielded the stamina I required to forge through and complete the programme. Special mention of my brothers Zach and Allan for unwavering financial support.
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# ABBREVIATIONS AND ACRONYMS

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<tr>
<td>AOAC</td>
<td>Association of Official Analytical Chemists</td>
</tr>
<tr>
<td>ARI</td>
<td>Acute Respiratory Infections</td>
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<tr>
<td>BV</td>
<td>Biological Value</td>
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<tr>
<td>FAO</td>
<td>Food and Agricultural Organization of the United Nations</td>
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<tr>
<td>FBP</td>
<td>Folate Binding Protein</td>
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<td>FCTs</td>
<td>Food Composition Tables</td>
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<tr>
<td>FPM</td>
<td>Food Processing and Manufacturing</td>
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<tr>
<td>FVC</td>
<td>Food Value Chain</td>
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<td>GoK</td>
<td>Government of Kenya</td>
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<td>KNFNSP</td>
<td>Kenya National Food and Nutrition Security Policy</td>
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<tr>
<td>LSD</td>
<td>Least Significant Difference</td>
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<tr>
<td>MF</td>
<td>Maize Flour</td>
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<tr>
<td>MMF</td>
<td>Maize-Mushroom Flour</td>
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<tr>
<td>OMF</td>
<td>Oyster Mushroom Flour</td>
</tr>
<tr>
<td>MND</td>
<td>Micronutrient Deficiencies</td>
</tr>
<tr>
<td>MNM</td>
<td>Micronutrient Malnutrition</td>
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<tr>
<td>PEM</td>
<td>Protein Energy Malnutrition</td>
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<tr>
<td>RDI</td>
<td>Recommended Daily Intake</td>
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<tr>
<td>RP</td>
<td>Reverse Phase</td>
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<tr>
<td>RUTF</td>
<td>Ready to Use Therapeutic Food</td>
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<tr>
<td>SCRH</td>
<td>Siaya County Referral Hospital</td>
</tr>
<tr>
<td>SDG</td>
<td>Sustainable Development Goals</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>SSA</td>
<td>Sub-Saharan Africa</td>
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<tr>
<td>TZFCTs</td>
<td>Tanzanian Food Composition Tables</td>
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<td>UN</td>
<td>United Nations</td>
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<td>UNICEF</td>
<td>United Nations Children’s Fund</td>
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<td>WAFCTs</td>
<td>West African Food Composition Tables</td>
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<td>WHO</td>
<td>World Health Organization</td>
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## DEFINITIONS OF TERMS

<table>
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<th>Term</th>
<th>Definition</th>
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<tr>
<td><strong>Anti-nutrients:</strong></td>
<td>Organic and inorganic components of foods that interact with and lower the availability of certain nutrients for absorption or utilization by the body</td>
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<td><strong>Complementary feeding:</strong></td>
<td>Giving a child/infant other food besides breastmilk</td>
</tr>
<tr>
<td><strong>Complementary food:</strong></td>
<td>Any food given a child/infant besides breast milk</td>
</tr>
<tr>
<td><strong>Food system:</strong></td>
<td>The entirety of processes related to production, processing/ preservation, distribution and utilization of foods</td>
</tr>
<tr>
<td><strong>Food value chain:</strong></td>
<td>The set of actors and the sequence of activities involved in bringing food products from production to the final consumer (i.e. farm to fork set of processes and flows)</td>
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<tr>
<td><strong>Standard solutions:</strong></td>
<td>Solutions with known concentrations of the stated compounds of interest</td>
</tr>
<tr>
<td><strong>Stock solutions:</strong></td>
<td>Highly concentrated bulk solutions for storage from which working standards are prepared for routine running of samples</td>
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**OPERATIONAL DEFINITIONS OF TERMS**

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td><strong>Control/Plain porridge</strong></td>
<td>Porridge prepared from plain maize flour</td>
</tr>
<tr>
<td><strong>Diet</strong></td>
<td>Amount and kinds of food and drink a person consumes</td>
</tr>
<tr>
<td><strong>Dietary diversity</strong></td>
<td>The number of different types of foods and different food groups consumed in specified period</td>
</tr>
<tr>
<td><strong>Enriched porridge</strong></td>
<td>Porridge prepared from Supplemented flour (80:20 maize flour to mushroom flour ratio)</td>
</tr>
<tr>
<td><strong>Nutrient density</strong></td>
<td>Proportion of other nutrients in a food substance against its calorie content</td>
</tr>
<tr>
<td><strong>Mobile phase</strong></td>
<td>The solvent that moves through the chromatographic column</td>
</tr>
<tr>
<td><strong>Plain maize flour</strong></td>
<td>Pure maize flour (without added mushroom flour)</td>
</tr>
<tr>
<td><strong>Supplemented flour</strong></td>
<td>Maize flour with added mushroom flour</td>
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ABSTRACT

Childhood undernutrition remains a key issue of concern to many countries, in the post 2015 global agenda for development with many developing countries particularly in Sub-Saharan Africa (SSA) being affected. Undernutrition is a leading contributor to child morbidity and mortality being culpable for half of global child mortalities. Nutrition sensitive approaches are being advocated for sustainable outcomes, in the fight against malnutrition in vulnerable populations. Food based strategies including postharvest technologies target specific points in the food value chain. Maize (Zea mays), a basic staple widely used in complementary feeding in SSA is low in micronutrients and proteins while Oyster mushrooms (Pleurotus ostreatus) are reported to be rich in micronutrients and proteins and could thus provide a good supplement to maize and other cereal staples for complementary feeding in vulnerable populations. However, mushroom consumption in Kenya has remained low owing to paucity of local research evidence to drive the promotion of their cultivation and use. This study investigated the nutritional and sensory implications of supplementation of maize flour with oyster mushroom flour as a strategy towards enhancing complementary feeding in Siaya County. The study assumed a single factor completely randomized experimental research design. Validated procedures were used for nutrients analysis of the samples while sensory evaluation was conducted using Larmond’s reverse 9-point hedonic scale questionnaire on mothers with 6-23 months children. All analytical determinations were done in triplicate and means computed and subjected to statistical independent t-test for comparison. Sensory data was subjected to analysis of variance and post-hoc, Least Significant Difference. Differences were tested at p value < 0.05 significance. The results show significant mean compositional differences (p< 0.05) between enriched porridge (80:20 maize to mushroom formulation) and control porridge, in favor of the former, for all the nutritional components analyzed except carbohydrates, fats and energy value. Key analytical results were 51.461 ± 2.00 and 49.183 ± 0.420 Kcal /100g energy value; 1.228 ± 0.165 and 2.249 ± 0.043 % proteins; 0.330 ± 0.0160 and 0.801 ± 0.0320 mg/100g iron; 0.262 ± 0.006 and 0.385 ± 0.012 mg/100g zinc; 0.053 ± .002 and 0.094 ± .001 mg/100g thiamine; 0.034 ± 0.002 and 0.095 ± 0.006 mg/100g riboflavin; 0.377 ± 0.015 and 1.150 ± 0.011 mg/100g niacin and 1.673 ± 0.395 and 9.310 ± 1.01µg/100g folates for the control and enriched porridge respectively. Sensory analysis showed no significant differences in acceptability between the two porridge samples for all the sensory attributes except for color and aroma (in favor and disfavor of the enriched porridge respectively). Independent t-test showed no significant difference in overall acceptability (p = 0.082) between the two porridge samples. Supplementation of maize flour with oyster mushroom flour increases the nutrient content of porridge flour for complementary feeding of children. The study provides evidence that will inform current efforts in both agri-nutritional promotion of mushrooms and the development of new nutritious food products based on mushrooms. With further research, it is recommended that mushroom be considered as a component in formulation of complementary porridge flours.
CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

Undernutrition affects more than half of the world population, with higher prevalence in developing countries and with long ranging effects on health, intellectual capacity and productivity of those affected. Ultimately, nutritional deficiencies impact on the socioeconomic development of communities and nations (Fanzo, 2012). In September 2015, the General Assembly of the UN adopted the Sustainable Development Goals (SDGs) resolution which among other things aims at eradicating or alleviating the world’s greatest health and poverty issues by 2030. Fighting malnutrition cuts across three of the seventeen SDGs namely: (1) ending poverty (2) ending hunger, achieving food security and improved nutrition as well as promoting sustainable agriculture and (3) ensuring healthy lives and promoting well-being for all at all ages (United Nations Development Programme [UNDP], 2015).

Tackling malnutrition and achieving good nutrition for the optimum health of all Kenyans is a key policy commitment of the Kenyan Government. The government acknowledges the fact that diets in Kenya are typically deficient in one or more micronutrients and cites the major causes of such deficiencies as being, among others, lack of dietary diversity and poor nutritional quality of foods consumed by majority of the population and some population groups particularly young children, pregnant and lactating mothers (Government of Kenya [GoK], 2011). Based on the need for tactical diversity, the policy outlines four food-based strategies for tackling micronutrient deficiencies in populations. These include supplementation, food fortification, biofortification and dietary modification.
or diversification (GoK, 2011). Optimal complementary feeding is highlighted as a priority area within the second strategic objective of the Kenya national Nutrition action Plan 2012-2017: improving the nutritional status of children under 5 years of age. This is because malnutrition, as noted in the document, remains a major threat to the survival, growth and development of Kenyan children and the greatest vulnerabilities occur within the period of complimentary feeding (Ministry of Public Health and Sanitation, 2012).

Since the concentrations and bio-availabilities of nutrients in human diets depend on several factors spread across the entire food production system, nutrition sensitive interventions are being advocated as the sustainable strategy in tackling malnutrition with the potential to achieve better and more permanent nutritional outcomes (Food and Agricultural Organization [FAO], 2014). Particular points in the food value chain (FVC) are being targeted which are critical to nutrition outcomes and which carry potential for wider impact (Miller & Welch, 2013).

Food processing and manufacturing (FPM) is one of the key steps in the food value chain that can be manipulated to achieve desired nutritional goals. Food processing and manufacturing can impact the entire spectrum of food security issues; it can reduce postharvest losses and increase food availability; reduce food hazards and enhance food safety; increase nutritional value through development of new and more nutritious food products. It carries a great potential to both increase dietary diversity and enhance concentrations of nutrients in commonly consumed foods (Miller & Welch, 2013). There is need to explore diverse processing solutions in order to enhance the nutritional value of
foods particularly those that would usually constitute the diets of children in their critical period of growth, i.e. the first 1000 days, during which nutritional defects and abnormalities sustained cannot be corrected in later stages of life (GoK, 2011).

1.2 Problem Statement

Maize is the main staple food in Kenya contributing up to 41% of total caloric intake. It is traditionally the bulk ingredient in complementary foods in many communities across the country (Kaloi, Teyebwa, & Bashaasha, 2005). However, maize has low micronutrient content and lacks many vitamins particularly the B vitamins as well as minerals including zinc and iron (ACDI/VOCA, n.d.). The amount and quality of maize protein is also poor due to lack lysine and tryptophan (Osundahunsi & Aworh, 2003). Overdependence on complimentary food preparations from maize alone, therefore, has exposed infants and young children from many parts of the country, more so where diets are not diversified, to the risk of malnutrition, particularly micronutrient deficiencies.

Mushrooms, on other hand, have been consumed in many African communities since time immemorial (Wandati, 2013) and are reported to have good nutritional value: high contents of proteins, minerals and vitamins (Afetsu, 2014). They could therefore, provide a good complement to cereal-based diets in helping improve infant and young child nutrition (IYCN) (Mleczek, Magdziak, Goliński, Siwulski, & Stuper-Szablewska, 2013; Valverde, Hernández-Pérez, & Paredes-López, 2015). Besides, mushrooms hold a great promise as an economic crop (Gateri, 2012). However, many people are still apprehensive about mushrooms as a food source. Ignorance makes many people skeptical about whether a food
of fungal origin can hold any great nutritional promise (Okhuoya, Akpaja, Osemwegie, Oghenekaro, & Ihayere, 2010).

In Kenya, despite their potential to mitigate micronutrient deficiency challenges bedeviling the under-five population, mushroom production and utilization has not been mainstreamed into local agricultural production and diets owing to paucity of local research evidence necessary to drive their public promotion (Okhuoya et al., 2010). This study was undertaken to develop a complementary porridge formulation, based on maize and mushroom flour that would improve infant and young child nutrition (IYCN) in Siaya County while enhancing the shelf life and utility of mushrooms. The latest demographic health survey indicates that 4.7% of under-five children in Siaya County are wasted which compares poorly against the national rate of 4.0%. Furthermore, 24.7% and 7.1% of under-five children in Siaya are stunted and severely stunted respectively. These rates are just below the national figures of 26.0% and 8.1% for stunting and severe stunting respectively (Kenya Demographic Health Survey [KDHS], 2014). There is need for scaling up of IYCN in the county through innovative strategies that promise sustainable impact.

1.3 Purpose of the Study

The purpose of the study was to formulate a nutrient-rich porridge flour based on maize and oyster mushrooms to be used for complementary feeding in Siaya County and to assess its sensory acceptability.
1.4 Objectives of the Study

1. To determine the nutrient content of maize flour, mushroom flour, plain maize flour (control) porridge and maize/mushroom composite flour (enriched) porridge
2. To formulate a maize-mushroom composite porridge flour
3. To evaluate the sensory acceptability of the enriched porridge among mother and child pairs of children 6 – 23 months old.
4. To compare the nutrient content and sensory acceptability of the control porridge and experimental porridge.

1.5 Study Hypotheses

H₀₁ Enrichment of maize flour with oyster mushroom flour does not significantly improve the nutritional value of its porridge for complementary feeding.

H₀₂ Enrichment of maize flour with oyster mushroom flour has no significant effect on the sensory acceptability of its porridge.

1.6 Significance of the Study

This study involved the development of a product i.e. an enriched flour based on maize and mushroom which may potentially be used to avert or reverse micronutrient deficiencies among infants and young children. It has also provided evidence that will drive agri-nutrition particularly the promotion of cultivation and consumption of mushrooms as a nutritional crop and food. The study has also provided useful evidence that will inform the efforts of the local food industry towards the development of new food products based on
mushrooms, which can meet the nutritional needs of specific segments of the population such as infant and young children. Furthermore, the study has provided information on the nutritive value of locally grown oyster mushrooms and maize and the data generated might be useful in developing, updating or appraising national and regional food composition tables. This study has also provided critical baseline data that could be used for interventional research.

1.7 Delimitations of the Study

The study entailed the nutrient analysis of raw maize flour and mushroom flour, the formulation of a composite (enriched) porridge flour and nutrient analysis as well as sensory assessment of the enriched flour porridge. Samples were analyzed for proximate contents, iron, zinc, thiamine, riboflavin, niacin and folates.

1.8 Limitations of the Study

The study did not look at the levels of anti-nutrients in the porridge samples which may impact on their nutritional value. Furthermore, the shelf life of the flours and their nutrient retention under different storage conditions were not investigated. Sensory acceptance with the children was assessed by single exposure. Documented literature indicates that repeated exposures enhance sensory acceptance and that liking of foods are greatly enhanced by repeated exposures to the food product (Maier, Chabanet, Schaal, Issanchou, & Leathwood, 2007; Nicklaus, 2016).
1.9 Study Assumptions

The study assumed that responses in the sensory evaluation sheet were honest opinions of the respondents without bias whatsoever.

1.10 Conceptual Framework

The research was premised on the fact that maize flour, which is the common complementary staple among many communities in Kenya, is low in micronutrients and proteins. Overreliance on maize flour as the bulk ingredient for complementary foods therefore exposes children to malnutrition i.e. both protein and micronutrient deficiencies. Enrichment of maize flour with mushroom flour would improve the micronutrient and protein content in the composite flour without significantly compromising the sensory acceptability of its porridge. Germination of maize prior to processing is a common treatment that has been proven to reduce the levels of antinutrients thus increasing the bioavailability of micronutrients in the product. Figure 1.1 is a diagrammatic representation of this framework.
**Figure 1.1: Conceptual framework on the development of enriched porridge flour**

Source: - Researcher, 2016
CHAPTER TWO: LITERATURE REVIEW

2.1 Nutritional Challenges in Infant and Young Child Feeding

Nutritional deficiencies are of great public health concern worldwide and are more prevalent in low income countries (World Health Organization [WHO] & FAO, 2005). Micronutrient deficiencies (MNDs), in particular, affect people of all genders and ages but certain population groups, including women of child bearing age and children, appear to be at greater risk (Tulchinsky, 2010). Micronutrient deficiencies not only cause specific diseases, but they act as exacerbating factors in infectious and chronic diseases particularly among young children, and greatly impact morbidity, mortality, and quality of life (Tulchinsky, 2010). Interest in micronutrient malnutrition (MNM) has increased greatly over the recent decade occasioned by the realization that it substantially contributes to the global disease burden (Pizzol & Di Gennaro, 2016). Besides the overt clinical manifestations, micronutrient malnutrition contributes to a wide range of non-specific physiological impairments, leading to compromised immunity, metabolic disorders, and delayed or impaired physical and intellectual development (GoK, 2015; WHO, 2006).

The most commonly reported micronutrient deficiencies affecting populations in both developed and developing countries and which have been addressed in the WHO Guidelines include Iron, Zinc, Iodine, Vitamin A, Folate, Thiamin, Riboflavin and Niacin (Ngala, 2015; Ochola & Masibo, 2014; WHO, 2006). The public health implications of these deficiencies are potentially huge, and have a bearing on the design of strategies for the prevention and control of diseases such as HIV/AIDS, tuberculosis, and diet-related chronic diseases (WHO, 2006).
The war against malnutrition is currently witnessing a paradigm shift with more emphasis being laid on solutions intrinsic to the local context of affected populations, as well as their sustainability (Raymond, Agaba, Mollay, Rose, & Kassim, 2017). In this regard, food based approaches are assuming a center stage. Although there exist a wide array of crops within the scope of addressing malnutrition in diverse local settings, their potential has not been adequately explored. Mushrooms represent a typical example of such crops that could tilt the scale in the war against malnutrition, but which largely remains underutilized and/or neglected (Durst & Bayasgalanbat, 2014).

2.2 Nutrition Sensitive Strategies in Addressing Nutrient Deficiencies

Agriculture is the foundation of all food production systems and the primary source of nutrients. Agricultural interventions are thus assuming greater importance in addressing malnutrition. If agriculture cannot supply all the essential nutrients in amounts adequate for good health and productive lives, other interventions at the subsequent stages in the food value chain become imperative to avert malnutrition (Global Panel on Agriculture & Food Systems for Nutrition [GPAFSN], 2014).

Food processing and manufacturing is an important component of the food value chain. Besides improving nutrient profiles, it can improve dietary intakes by enhancing the sensory appeal (palatability) of foods to consumers, reduce risk of food borne illness, and reduce the time and energy required for domestic food preparation (FAO, 2014). Processing techniques to improve the density and bioavailability of nutrients in cereals
Studies have been carried out to develop complementary food mixtures using domestic techniques of germination and fermentation, also referred to as Amylase-rich Food Technology (Amankwah, Barimah, Nuamah, Oldham, & Nnaji, 2009). Cereal grains are sprouted, dried and then milled into flour. The amylase enzyme is activated during germination and partially hydrolyses the starch thereby reducing its gelatinization capacity. Consequently, less water is required to regulate viscosity during the preparation of porridges. Interest in this technology has been driven by the need to manage viscosity with less compromise to nutrient density of complementary food preparations for infants who suffer limited gastric capacity (Alnwick, Moses, & Schmidt, 1988; Treche et al., 1999).

The development of appropriate processing technologies is critical to addressing the key issues of food security (availability, nutritional adequacy and safety): Processing prolongs shelf-life thus promoting year round food availability, enhances value addition thus improving market/economic returns and reduces hazards thus increasing safety in many food commodities (Augustin et al., 2016; Capone, El Bilali, Debs, Cardone, & Driouech, 2014; FAO, 2017).

2.3 Nutritional Adequacy of Complementary Foods

Breastfeeding provides the ideal food to the infant during the first 6 months of life after which breastmilk alone is no longer sufficient to support the child’s nutrition. From 6
months, a gap between a child’s nutritional requirements and supply from breastmilk develops and increases with age. Complementary feeding is introduced to bridge this gap, and targets the age interval of 6 to 23 months (Abeshu, Lelisa, & Geleta, 2016). Ensuring adequate nutrition during the period of complementary feeding is a major global health priority with appropriate complementary feeding being a key element in the global recommendations for Infant and Young Child Feeding. According to World Health Organization (2002), complementary feeding ought to be timely, nutritionally adequate, safe and properly fed. However, fulfilling nutritional needs during this age interval has proved challenging. While some challenges are context specific, many cut across different settings (Dewey, 2013; Du Plessis, Kruger, & Sweet, 2013). The Kenya Demographic Health Survey (2014) has revealed that only 21% of Kenyan children aged 6-23 months are consuming minimum acceptable diet (MAD).

Since the complimentary feeding stage is characterized by rapid growth and development which place high demand on the body for energy and nutrient supply to keep pace with rapid physiological processes (Solomons & Vossenaar, 2013), complementary foods should have relatively high energy and nutrient density: Infants need complementary foods with much higher nutrient density than is required for adult diets. For instance, per 100 kcal of food, a six to eight months old breast-fed infant would require 9 times as much iron and 4 times as much zinc as an adult male. Thus, infants ought to be fed the most nutritious foods available in the household, yet so often the opposite is the case in many low-income countries where cereals or starchy roots and tubers commonly constitute the basis for complementary foods and are usually prepared as thin gruels. Consequently, their energy
content and nutrient density are usually low. Such inadequacies are further exacerbated if infants receive very few feedings per day (Agbon, Onabanjo, & Akinyemi, 2011; Gibson, Ferguson, & Lehrfeld, 1998). In developing countries, iron and zinc are generally the most problematic nutrients during the period of complementary feeding, largely because their concentrations in human milk are low relative to the infant’s needs (Dewey, 2013; Raymond, Agaba, Mollay, Rose, & Kassim, 2017). Furthermore, other nutrients (e.g., riboflavin, niacin, thiamin, folate, vitamin B-6, vitamin B-12, calcium, vitamin A, vitamin C, and vitamin E) may also be low depending on the types of foods consumed (Dewey, 2013). Diets that are predominantly based on grains and legumes are of particular concern with regard to the amount of bioavailable iron and zinc provided. This is because these foods are usually high in phytate, which binds these minerals and limits their absorption by the child (Agbon et al., 2011; Dewey, 2013).

2.4 Formulation of Complementary Foods

Low-quality complementary foods combined with inappropriate feeding practices put children under the age of 2 years in developing countries at high risk for undernutrition and its associated outcomes (UNICEF, 2005). Complementary foods need to be far more nutrient-rich compared to family foods. Unfortunately, however, the foods are often known to be of poor nutritional value and are characterized by low protein content, low energy density, and high bulk. Bulk is a major challenge in homemade complementary foods, where the problem of high viscosity and/or low energy density may occur (Dewey, 2013; Kimiywe & Chege, 2015; WHO, 2001).
Research on formulation of complementary foods for improved nutrition appears to be gaining momentum (Akinola, Opreh, & Hammed, 2014; Gibson & Hotz, 2001; Muhimbula, Issa-Zacharia, & Kinabo, 2011; Shiriki, Igyor, & Gernah, 2015). Various combinations of food materials have been tried including the incorporation of dried leaf products such as drumstick and amaranth complementary foods (Chege, 2012; Shiriki et al., 2014). Fortification of flour with natural additives compensates for dietary diversification (Chege, 2012) which is the most important factor in providing a wide range of micronutrients especially for infants (Akinola et al., 2014; Gibson & Hotz, 2001).

The use of mushroom powder in carbohydrate based products to enhance nutrient composition without affecting sensory acceptance has been recommended (Aishah & Wan Rosli, 2013). A study conducted to assess the bioavailability of iron from cereal products enriched with dried shiitake mushrooms revealed that addition of the mushroom greatly increased the bioavailability of iron in the products (Regula, Krejpcio, & Staniek, 2010) In an Indian study, mushroom powder was successfully incorporated in a Ready to Use Therapeutic Feed (RUTF) formulation with a high degree of efficacy (Wasnik & Rathi, 2012).

Food processing and manufacturing thus has an enormous potential in creating diversity of high value products, including mushroom-based complementary food products, which could address pertinent food and nutrition security issues, including micronutrient deficiencies in affected populations. Unfortunately, the efforts of local food processing and manufacturing have traditionally focused on sensory appeal rather than on improving
nutritional value of food commodities. It is only now that the increasing consumer health and nutrition awareness is beginning to have significant influence on food choice and consumption patterns creating a serious gap in availability of new nutritious products that can meet those new demands.

2.5 Significance and Nutritional Value of Maize

Maize is an important source of food security for millions of people in the developing world especially in SSA (Ai & Jane, 2016). Maize is the primary source of daily caloric intake for many populations across Africa. In Kenya, over 85% of the population depends on maize as their main source of calories (Onono, Wawire, & Ombuki, 2013). Gruels prepared from maize flour still constitute the main complementary food for most families across the country (Modu, Laminu, & Sanda, 2010) but cannot however, sufficiently sustain a healthy body particularly in for young children in their active and rapid growth.

Most maize-based infant and young children preparations in Kenya and Africa at large lack the complementary foods necessary to meet the body’s protein and micronutrient needs when maize is consumed in large quantities (Faber, 2005). The quality of protein in maize is also low, lacking in essential amino acids lysine and tryptophan while excessive in sulfur amino acids, this negatively influences the body’s protein utilization. Furthermore anti-nutrients (phytates, oxalates and tannins) abound in maize, which bind and render minerals unavailable for absorption or metabolism in the body (Beta, 2003; Konstance et al., 1998; Nadeem et al., 2010). A number of these nutritional challenges with the commodity can be mitigated through appropriate processing and manufacturing procedures and technologies.
such as fermentation, milling, food combination and fortification (Soetan, Oyewole, & others, 2009).

Since maize and maize based products are still critical to smallholder farming livelihoods and the food security of both rural and urban households, there is need to integrate nutrition research in the food processing and manufacturing of maize based products in order to enhance the potential of the crop through development of nutritious, value added products.

2.6 Nutritional Value of Mushrooms

Edible mushrooms are an excellent source of high quality proteins, reportedly between 19 and 35 % dwb (Marshall & Nair, 2009b). The Pleurotus spp. are particularly, considered good source of superior quality protein, with well distributed essential amino acids (Ahmed, Abdullah, & Nuruddin, 2016; Okon, Okon, Udoakah, & Obongotdot, 2015). A number of studies have reported a relatively rich profile of amino acids in oyster mushroom proteins with nearly all the essential amino acids being present in good concentrations. It has thus been suggested that supplementation of cereal diets with the mushroom would help overcome lysine deficiency (Bano, Srinivasan, & Srivastava, 1963; Oyetayo, Akindahunsi, & Oyetayo, 2007). Mushrooms are also reported to be good sources of minerals including iron, zinc, potassium, magnesium and phosphorous as well as the trace elements copper and selenium (Regula & Siwulski, 2007). Furthermore, they are a good source of vitamins D and B complex including niacin, riboflavin, thiamine, and folate (Afetsu, 2014; Cheung, 2010). Although certain antinutrients are present in mushrooms, their levels are reported
to be low and unlikely to cause any significant effect to health or to the bioavailability of the nutrients in mushrooms (Ijioma, Ngozi, Ngozi, & Okafor, 2015; Okon et al., 2015).

Due to their good nutritional profile, oyster mushrooms could be used to improve the nutrient content of cereal-based foods for complementary feeding (Deepalakshmi & Sankaran, 2014). They have been recommended as protein supplements to populations preponderantly dependent on cereal diets (Mallikarjuna et al., 2013) or as a substitute to animal source proteins (Marshall & Nair, 2009). Suggestions have also been made for their use as food additives (Khan et al., 2008) and as functional foods (Wandati, Kenji, & Onguso, 2013).

Despite such a great nutritional promise of mushrooms and huge production potential in Siaya and the country at large, lack of availability of local data/information on mushrooms has engendered low interest on the crop leading to low production and consumption. Many African Food Composition Tables (FCTs) still lack the necessary data on mushrooms. There is need for increased research on mushrooms specifically nutrient profiling of mushrooms of different varieties grown from various geolocations across the country, coupled with diversification of post-harvest technologies as well as FPM that would offer more options for utilization of mushrooms. The incorporation of mushrooms into the local food formulations to improve their functional and nutritional value and assessing the acceptability of such formulations among various populations of interest would form part of this necessary research.
2.7 Opportunity for Mushrooms

Owing to their good nutritional and high digestibility values mushrooms are gaining importance in today’s healthy diet (Tolera & Abera, 2017). More governments in developing countries are encouraging cultivation and consumption of mushrooms for sustainable livelihoods and a means to address malnutrition (Ahmed et al., 2016; Marshall & Nair, 2009). Oyster mushrooms are particularly suited for this role as they are easy to grow and require minimal capital investment. They are thus considered a big opportunity for the developing countries (Mutukwa, 2014; Vostovsky & Jablonska, 2007).

The possibility to use a wide range of plant waste (straw, corn, bagasse, sawdust, crop stalk, forest waste etc.) as growth substrates coupled with insignificant demand on agricultural land for cultivation position mushrooms as a crop of economic importance and a tool to alleviate poverty and bring diversification to agricultural production. Cultivation of saprophytic edible mushrooms represents an economical biotechnology for organic waste recycling which combines the production of high protein food with the control of environmental pollution (Okoro, 2012).

However, mushroom production and consumption have failed to kick-start due to lack of adequate information on their nutritional value as well as lack of appropriate post-harvest processing technologies for overcoming shelf life constraints as well as for value addition to enhance markets (Afetsu, 2014; Bernas, Jaworska, & Kmiecick, 2006; Rai & Arumuganathan, 2008).
2.8 Sensory Acceptability of Complementary Foods

Food acceptance and the development of preferences are major determinants of food intake, and which, in children, are largely driven by sensory properties of the food products (McCluskey, 2015). Sensory evaluation is therefore critical to the development of food products as well as dietary interventions where children are the target (Singh-Ackbarali & Maharaj, 2014). Sensory appeal is particularly critical in infants and young children whose rejection or acceptance of food items is purely based on sensation since their cognitive functions are still undeveloped (Nicklaus, 2016). The greatest challenge in the successful design and development of nutritious food products for young children is therefore, their sensory acceptance (Maier et al, 2007; Schwartz, Scholtens, Lalanne, Weewen, & Nicklaus, 2011). Several other factors are reported to be involved in the acceptance of new foods at the complimentary feeding stage. These include timing of the introduction of the complimentary foods, repeated exposure to the foods, variety of foods offered and parental influences during feeding (Harris & Coulthard, 2016; Hetherington, Cecil, Jackson, & Schwartz, 2011; Nicklaus, 2016). In particular, however, the sensory properties of the foods are important determinants of the initial acceptance of the foods by infants. Texture (mouth feel), taste and aromatic properties particularly play a role in their initial acceptance. Since research indicates that sensory preferences are developed early in life (Nicklaus, 2016; Ventura & Worobey, 2013), it is important for young children to accustom to the properties of nutritious foods so that they cultivate healthy eating habits as they grow (Nicklaus, Boggio, Chabanet, & Issanchou, 2005; Schwartz et al., 2011).
2.9 Summary of Literature Review

Malnutrition, particularly micronutrient deficiencies continue to haunt many parts of the developing world with certain population groups including infant and young children being at greater risk. Research focus is now shifting towards nutrition sensitive strategies in providing long-term solutions to the problem with agronomical and processing interventions, which impact on wider populations, taking a centre stage (FAO, 2017). The development of new, nutritionally improved crops and food products constitutes a significant outcome of this new shift. Non-conventional food sources, such as indigenous leafy vegetables (ILVs), insects and fungal foods, which have been part of the diet of various communities are now attracting research attention in this new onslaught on malnutrition.

Mushrooms have both nutritional and agricultural advantages that make them a crop with significant potential in addressing food and economic security challenges facing many communities across Kenya. Food Processing and manufacturing particularly the development of appropriate post-harvest technologies and processing options for mushrooms towards value addition will play a key role in translating this potential to actual gains in improving food and economic security. It has the ability to alter shelf life; deliver new food products e.g. complementary foods with enhanced nutritional value; control exposure to hazards and contamination thus enhancing safety of the consumers as well as improve sensory appeal thereby increasing food acceptance and actual consumption.
The development of new food formulations using mushrooms is a strategy that would impact the entire spectrum of food security issues including availability and access, nutritional adequacy and food safety besides boosting incomes for those who choose mushroom farming. Unfortunately, production and utilization of mushrooms, remains low due to little research on the crop. This study represents the efforts to fill the existing gap in nutritional research to provide evidence required to drive agri-nutritional advocacy that would see the cultivation and consumption of mushrooms scaled up across the country with the resultant benefits on nutrition and livelihoods.
CHAPTER THREE: METHODOLOGY

3.1 Research Design
The design of this study was a single factor completely randomized experimental design with three replicates, adopted from Ndung`u, Otieno, Onyango, and Musieba (2015).

3.2 Study Variables
Independent Variables of this study were the different flour samples (maize flour and mushroom flour) and porridge formulations under investigation while the dependent variables consisted of the nutrient content and the sensory acceptability of the samples.

3.3 Study Location
The study was conducted in Siaya County with Siaya County Referral Hospital serving as the catchment point for the study respondents. Siaya is one of the counties whose typical complementary diets consist mainly of food preparations from maize. The latest multiple cluster indicator survey for the county reveals that just about two thirds (65 per cent) of children in the 6-23 months age group are appropriately fed (Kenya National Bureau of Statistics [KNBS], 2013). Further, low household food security occasioned by high poverty rates as indicated by the high percentage of households (42%) that have reported lacking food or money to purchase food, as well as lower percentage of those in the acceptable range of food consumption score group in the region militate against children’s dietary diversity leading to poor IYCN (KDHS, 2014).
3.4 Research Respondents

A sensory evaluation panel was purposively selected from among mothers/caregivers with children 6-23 months old attending MCH clinic at Siaya County Referral Hospital. Mothers who had at least post primary education were selected because of their higher literacy and thus a better understanding of the descriptions detailed in the sensory evaluation form. The mothers were taken through a partial training to enable them to better understand what was expected of them so that they give better quality responses. Sick children were not included in this study since appetite and food intakes are known to be altered during sickness (Kerzner et al., 2015).

3.5 Sampling Techniques

The study area, Siaya County, as purposively sampled for the reasons outlined in section 3.3. Siaya County Referral Hospital was purposively chosen as the catchment point for the mothers for the sensory assessment. It is the largest and best equipped health facility in the County. Pre-study site survey conducted revealed that the facility’s MCH Clinic attracts mothers from all over the county probably because of the availability of better and diverse array of services in the hospital. Sampling frame of mothers (93) with children in the age range of 6 – 24 months was obtained from the hospital’s MCH clinic record. Thirty mothers were then randomly selected to participate using random number generator software.

3.6 Sample Size for Sensory Evaluation

The recommended sample size for affective consumer tests is 50-100. However, a minimum of 20 panelists is recommended for pilot testing. Recommended panel size for
descriptive sensory tests rages between 8 and 12 semi-trained panelists (Bureau of Indian Standards, 1972; Civille, Stone, Derthmer, & Eggert, 1981; Gacula, 1997). This being a pilot sensory evaluation a panel size of 30 caregiver/child pair was adopted. This sample size fell within the range that has been successfully applied in related studies by other researchers (Kebebu, Whiting, Dahl, & Henry, 2013; Ndife, Obiegbunna, & Ajayi, 2013; Ojinnaka, Ebiyensi, Ihemeje, & Okorie, 2013; Okafor, Okafor, Ozumba, & Elemo, 2012).

3.7 Research Instruments

Nutrient data sheets (appendix C) were used to record laboratory data. Structured questionnaires, based on the 9-point hedonic scale, (Appendix D) was used for sensory evaluation to gauge the sensory acceptance of the product while Observation sheets (Appendix E) were used to study the responses of the children, the targeted consumers, of the product.

3.8. Pre-Testing

The questionnaire that was used to record the observed feeding responses by the sampled children was tested on a group of 6 children from Ambira Sub-County Hospital which was situated 10 Km away from the study venue and did not fall within the normal catchment area of the SCRH MCH Clinic. The weaknesses were identified, and the questionnaire edited accordingly, without significant alteration of the substance of the content.
3.9 Materials and Procedures

The process of the product formulation and experiment was conducted as summarized in Figure 3.1

*Figure 3.1: Flow chart of the product formulation and experiment Process*
3.9.1 Acquisition and Processing of Raw Materials

One batch of fresh oyster mushrooms (30 Kgs) was sourced from the Jomo Kenyatta University of Agriculture and Technology Enterprises Section (JKUATES), quality sorted according to East African Standards Specification for Fresh mushrooms EAS56:2000 (East African Community [EAC], 2000) and cleaned to remove any soil particles, then blanched by placing mushroom samples in a square piece of cotton cloth and tying well before suspending them in hot steam at 88 °C for 1 min. This was to inactivate the enzymes which have been found to influence content and native profile of some vitamins. (Munyaka, Verlinde, et al., 2010a; Munyaka, Makule, Oey, Van Loey, & Hendrix, 2010b). The blanched mushrooms were then solar-dried for two days before milling into flour.

One batch of dry shelled maize (30 Kgs) was purchased from the local markets in Siaya and ferried to Nairobi. The maize was quality sorted according to East African Standards Specification for Maize grains EAS 2:2013 (EAC, 2013), then washed and soaked for two days before sun-drying to a stable moisture content of 10.74% as determined by oven drying followed by whole milling into flour. Portions of flour samples (500 g each) was weighed and packed in airtight polythene bags, using a plastic sealing machine, and stored away from light at -20 °C for use as required.

3.9.2 Preparation of Composite Flours

Three different trial formulations of composite flours were prepared according to a procedure described by (Gibson-Umeh & Okoli, (2017)’ Dada, Barber, Ngoma, & Mwanza,
(2018) and Toan & Anh, (2018): maize flour and mushroom flours were blended in the ratios of 90:10, 80:20 and 70:30 maize to mushroom flour

3.9.3 Preparation of Porridge Samples

Porridge was prepared from the composite flour samples and evaluated for sensory and/or nutrient content against a control porridge sample which was prepared from plain maize flour (100:0 maize to mushroom formulation).

A standard recipe was followed during the preparation of all the porridge samples: 100 g of flour was weighed into a sufuria (sauce pan) followed by addition of 1000 ml of clean water and stirring to form a homogenous slurry. The slurry was cooked in medium heat with continuous stirring for 10 minutes into a thick gruel and kept in thermo-flasks ready for serving to sensory respondents. Coded samples of the porridges were cooled to 40 °C prior to each sensory evaluation exercise. Samples for laboratory analysis were allowed to cool to room temperature and then stored under deep freezing at -20 °C. Nutrient analysis of the porridge samples was conducted in a span of three weeks from the date of preparation.

3.9.4 Nutrient Analysis

Nutrient analysis was conducted in two phases: The first phase entailed the determination of the nutrient composition of raw maize ad mushroom flour samples while in the second phase, two porridge sample prepared from control (100:0 maize flour to mushroom flour) flour and enriched (80:20, maize flour to mushroom flour) flour were analyzed for the same
nutrients as determined in the first phase. Table 3.1 gives a summary of methods employed for determinations of various nutritional components.

Table 3.1: Summary of methods

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Method</th>
<th>Principle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>AOAC (2005) method number 925.10</td>
<td>Gravimetry</td>
</tr>
<tr>
<td>Ash</td>
<td>AOAC (2005) method number 923.03</td>
<td>Gravimetry</td>
</tr>
<tr>
<td>Crude protein</td>
<td>AOAC (2005) method number 920.87</td>
<td>Titrimetry, Kjeldahl Digestion</td>
</tr>
<tr>
<td>Total fat</td>
<td>AOAC (2005) method number 920.39</td>
<td>Gravimetry, ether extraction</td>
</tr>
<tr>
<td>Total carbohydrates</td>
<td>(Atwater, 1910)- Difference</td>
<td>Calculation</td>
</tr>
<tr>
<td>Energy value</td>
<td>(Atwater, 1910)</td>
<td>Calculation</td>
</tr>
<tr>
<td>Mineral elements</td>
<td>AOAC (2005b) method number 975.03</td>
<td>Atomic Absorption Spectrophotometry</td>
</tr>
<tr>
<td>Thiamin</td>
<td>Modified Ekinci and Kadakal (2005)</td>
<td>HPLC with dual detection (UV- fluorescence)</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>Modified Ekinci and Kadakal (2005)</td>
<td>HPLC with dual detection (UV- fluorescence)</td>
</tr>
<tr>
<td>Niacin</td>
<td>Modified Ekinci and Kadakal (2005)</td>
<td>HPLC with dual detection (UV- fluorescence)</td>
</tr>
<tr>
<td>Folate</td>
<td>Modified Ekinci and Kadakal (2005)</td>
<td>HPLC with dual detection (UV- fluorescence)</td>
</tr>
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</table>

3.9.4.1 Determination of Moisture

Moisture content was determined using the oven drying method number 925.10 as described by AOAC methods (Association of Official Analytical Chemists [AOAC], 2005). Five grams of samples were weighed into pre-weighed dry crucibles and heated in hot air oven (Gellenkamp, UK) at 105 °C for 3 hours. Cooling and weighing of dried samples were done at intervals of 30 minutes until there was no weight change after three
successive weight measurements. The electronic balance (NBY323/64: Avery East Africa) was used in taking weight measurements. The final weight of dried samples was noted and the moisture content calculated as:

\[
\% \text{MC} = \frac{(\text{Wt of crucible + Fresh sample}) - (\text{Wt of crucible + dry sample}) \times 100}{\text{Weight of fresh sample}}
\]

3.9.4.2 Determination of Crude Protein:

The amount of protein was determined by total-Kjeldahl Nitrogen method (number 920.87) according to AOAC (2005). Samples were weighed (1 g) and digested in concentrated sulphuric acid with one Kjeldahl tablet followed by neutralization using 40% sodium hydroxide and distillation. The resulting solution was titrated with 0.1N hydrochloric acid using a mixed indicator (methyl red and bromocresol green). The Percent nitrogen (N) concentration was calculated using the following equation:

\[
\% \text{nitrogen} = (S - B) \times N \times 0.014 \times D \times \frac{100}{W} \times V
\]

Where:

\[D\] = dilution factor,

\[T\] = titre value = \((S-B)\),

\[W\] = weight of sample,

0.014 = constant value.
Crude protein was obtained by multiplying the corresponding total nitrogen (N) content by a conventional factor of 6.25 (maize flour) or 4.38 (mushroom flour) (Wandati 2013). Thus: \[
\text{Crude protein (\(\%\))} = \%N \times 6.25 \text{ or } 4.38
\]

3.9.4.3 Determination of Crude Fat:

Crude fat was determined by the soxhlet extraction method number 920.39 as outlined by AOAC (2005). Five grams of dried samples were weighed into preconditioned and weighed \((W_0)\) extraction thimble and placed in the soxhlet extraction apparatus. Fat content of the samples was extracted using organic solvent (petroleum ether) and boiled under reflux for 6 hours. The extraction thimbles were then removed and dried in an oven at 105\(^0\)C for 30 minutes, then cooled and weighed \((W_1)\). Percentage of fat content was calculated using the following formula:

\[
\text{Crude fat (\(\%\))} = \frac{\text{weight of fat in sample}}{\text{weight of dry sample}} \times 100
\]

\[
= \frac{w_0 - w_1}{\text{weight of dry sample}} \times 100
\]

3.9.4.4 Determination of Total Ash

Total ash content was determined by dry ashing according to AOAC (2005) method number 923.03. Five grams of samples was weighed in dry crucibles, carbonized on a hot plate and heated on a muffle furnace (Nerberthem: model; L9/11/C6, Germany) at 600\(^0\)C for 8 hours after which they were cooled in a dessicator and weighed. Ash content was
determined by the difference in weight after cooling the samples in desiccators to ambient temperatures.

\[
\% \text{ ash content} = \frac{\text{wt. of incinerated sample}}{\text{wt. of fresh sample}} \times 100
\]

3.9.4.5 Determination of Total Carbohydrates

The total carbohydrate content was estimated by the difference method, as described by Schakel, Buzzard, & Gebhardt, (1997) according to the following equation:

\[
\text{Carbohydrate(\%)} = 100 - (\text{moisture} + \text{fat} + \text{protein} + \text{ash})\%
\]

3.9.4.6 Determination of Total Energy:

The total energy value was calculated using the Atwater general factor system as described Food and Agriculture Organization of the United Nations (2003) as shown in the formula described by the following equation:

\[
\text{Total Energy (Kcal/100 g)} = [\text{(% carbohydrates} \times 4) + (\text{% proteins} \times 4) + (\text{% fat} \times 9)]
\]

3.9.4.7 Determination of Iron and Zinc Content.

Mineral content was analyzed using an atomic absorption spectrophotometer (Shimadzu AA-6200 Series, Japan) as described by AOAC (2005). Two grams of the ash residue of each sample was dissolved with concentrated nitric acid and hydrogen peroxide. Iron (Fe) and zinc (Zn), was determined at 259.9 nm and 213.9 nm, respectively, using an air-acetylene flame. Standard solution of ferrous ammonium sulphate (Fe (NH₄)₂(SO₄)₂) was used for determining concentration of iron. Zinc stock solution was prepared by dissolving
0.500g of pure zinc in 6N HCl before diluting to 1 L. Standard zinc solutions were then prepared by making appropriate dilutions.

A working solution of 10 mls of 1000 ppm (stock solution) was put into 100 mls flask and topped up to 100 mls mark with distilled water. Standard solutions for iron were prepared by adding 0, 2, 4, 6 and 8 mls of the working standard solution into 100 mls volumetric flask and topping up to 100 mls using distilled water. Both the samples and the standards were aspirated for analysis in atomic absorption spectrophotometer. A standard curve was prepared by plotting the concentration (ppm) of the minerals against the absorbance. From the standard curve the absorbance of the samples was extrapolated to determine the content of iron in the samples. This procedure was repeated for zinc analysis. All these assays were performed at Kenyatta University nutrition Laboratory.

3.9.4.8 Determination of Vitamins: Thiamine, Riboflavin, Niacin and Folates.

A modified RP-HPLC with dual (UV and Fluorescence) detection as described by Ekinci and Kadakal (2005) was used in the determination of the vitamins. An HPLC column conditioned as described in Table 3.2 was used.
Table 3.2: Chromatographic conditions for vitamin analysis

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Condition</th>
</tr>
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<tbody>
<tr>
<td>column</td>
<td>reversed-phase Discovery C₁₈ (150 mm × 4.6 mm); 30°C; ID 5µm particles</td>
</tr>
<tr>
<td>Mobile phase</td>
<td>A: - 0.1 mol L⁻¹ KH₂PO₄ (pH 7)</td>
</tr>
<tr>
<td>Flow rate</td>
<td>0.7 mL min⁻¹</td>
</tr>
<tr>
<td>Total run time</td>
<td>40 min</td>
</tr>
<tr>
<td>UV Detector (For Vit. B1, B2, B3)</td>
<td>UV detector, λ = 285nm; 460nm; 254nm</td>
</tr>
<tr>
<td>Fluorescent detector (For folates)</td>
<td>Excitation λ = 300 nm</td>
</tr>
<tr>
<td></td>
<td>Emission λ = 360 nm</td>
</tr>
<tr>
<td>Injection volume</td>
<td>20 µL</td>
</tr>
</tbody>
</table>

3.9.4.8.1 Sample Preparation (Solid-Phase Extraction) and HPLC Analysis

Test samples were subjected to SPE with Sep-Pak C₁₈ (500 mg) cartridges that enabled separation of water-soluble vitamins and remove most of the interfering components. Four parts of deionised water (20 g) were added into one part of test sample (5 g) (dilution factor, F, = 5). The mixture was homogenized using a homogenizer at medium speed for 1 min. The homogenized samples were centrifuged for 10 min at 14 × 10³ g.

The SPE method described by Cho, Ko, & Cheong, (2000) was used for the extraction of water-soluble vitamins. The stationary phase was flushed with 10 mL methanol and 10 mL water adjusted to pH 4.2 to activate the stationary phase. Homogenized and centrifuged test sample (10 mL) was then the loaded. Acidified water was prepared by adding a 0.005
M HCl solution drop by drop with stirring until the pH reached a predetermined value. The sample was eluted with 5 mL water (pH 4.2) then 10 mL methanol at a flow rate of 1 mL min⁻¹. The eluent was collected in a bottle and evaporated to dryness. The residue was dissolved in mobile phase. Before HPLC analysis, all samples were filtered through 0.45 μm pore size FP 30/45 CA-S filters at 7 bar max. Samples (20 μL) of solutions of the water-soluble vitamins were then be injected into the HPLC column. The column eluate was monitored with a UV/Vis detector at 285 nm for thiamine, 460 nm for riboflavin and 254 nm for niacin. Identification of compounds was achieved by comparing their retention times and UV spectra with those of standards stored in a data bank. Concentrations of the analyte vitamins were calculated from integrated areas of the sample and the corresponding standards.

The folate compounds most likely to be found in foods are 5-methyl tetrahydrofolate (5MeH₄folate), 5-formyl tetrahydrofolate (5CHOH₄folate) and tetrahydrofolate (H₄folate). Other folates may be found but are not generally significant in relation to overall folate activity. The analysis focused on these folates. Samples were extracted in phosphate buffer by means of tri-enzyme hydrolysis with α-amylase, protease and rat plasma deconjugase in the presence of ascorbate and 2-mecaptoethanol antioxidants. Extracts were then cleaned and concentrated using the immobilized FBP cartridges before analysis by HPLC. Fluorescence detection at excitation wavelength 300 nm and emission wavelength of 360 nm was used to determine the natural folates.
3.9.4.8.2 Preparation of Standards

Dipotassium hydrogen phosphate (0.1 mol L$^{-1}$; pH 7; extra pure) and methanol (HPLC grade), 90:10 was used as the mobile phase. Water used in all the experiments was double distilled and deionized. The vitamin standards (thiamine, riboflavin, niacin and folate) were of analytical-reagent grade from Sigma (Sigma–Aldrich, Deisenhofen-Germany) and thus were not further purified. Stock and standard solutions of thiamine, riboflavin, niacin and the three folate vitamers were prepared in mobile phase. Five different concentrations of each standard were used to prepare the standard curve. These solutions were sonicated and stored in dark glass flasks, to protect them from light, and kept under refrigeration (at -20 °C) in borate buffer containing 1% ascorbic acid. A standard curve was prepared for each vitamin. Correlation coefficients for thiamine ($R^2 = 0.9951$), riboflavin ($R^2 = 9945$), niacin ($R^2 = 0.9944$) and folate vitamers ($R^2 = 0.9944$), based on plots of concentration ($μg mL^{-1}$) against peak area (mAU) were determined.

3.9.5 Sensory Acceptability Evaluation

Sensory evaluation was conducted, on porridge samples from each of the four different formulations by a 30- member semi- trained panelists consisting of caregivers/ mothers (in the reproductive age 15-49 years) attending MCH clinic at Siaya County Referral hospital. The objectives of the study and the procedure for sensory evaluation were clearly explained to the participants and they were impressed on the need to give honest opinions after sampling the porridges. The method of Larmond (1977) was used, for the sensory evaluation. Each panelist was given coded porridge samples and required to rate each attribute on a 9-point scale score card (appendix D).
The sensory evaluation process was conducted in two phases on separate days at SCRH during morning hours. In the first phase, the participating mothers were invited to act as panellists for the sensory evaluation of the samples. Each of the panellists was provided with four coded samples of the porridge products in own table in a large, well ventilated and well-lit room. The tables were placed far apart such that communication between panellists was impossible for the purposes of independent opinions of the panellists. Four sensory questionnaires were given to each panellist, one questionnaire for each coded sample. The exercise was conducted in the morning hours between 9.00am and 12.00 noon. Samples served at a uniform temperature (45°C) and equal quantities (30 mls) were provided for each coded sample and for all the panellists. A glass of lukewarm water was provided for each panellist to rinse mouth in between sample. They were instructed to pause for 1 minute after tasting and scoring one sample before moving to the next. Scores were averaged to obtain overall rating for each attribute including overall acceptability.

In the second phase, the participating mothers were asked to come with their children to the venue which acted as a feeding centre. The mothers had been asked to observe a one-hour non-feeding period prior to the exercise. This was confirmed prior to commencement of the feeding exercise and delay done accordingly where child had fed within one-hour period. One measured portion of the porridge sample (according to the age recommended portion size) was given to each mother to give to her child in a private quiet place. Some of the samples were slightly sweetened with addition of small quantities of sugar while some were not depending on what the child is accustomed to as reported by the mother. Each mother was required to fill an observation sheet provided during the feeding session.
The maximum duration for each feeding session was 30 minutes with the mother encouraging the child but no force feeding was allowed during the exercise.

3.10 Statistical Analysis
Data was analyzed using SPSS statistical computer software version 17.0 and presented in form of tables and charts. All analytical determinations were carried out in triplicate and the mean values calculated. Descriptive statistics: means and percentages were used to describe nutrient content and sensory evaluation scores: The independent t-test, was used to compare mean nutrient values between samples while analysis of variance (ANOVA) and Least Significant Difference (LSD) were used to make comparisons for mean sensory scores. Differences were tested at 95% confidence levels (p<0.05), in the dependent variable, between the control and enriched flour porridge samples.

3.11 Ethical and Logistical Considerations
Research authorization was sought from the Graduate School of Kenyatta University. Ethical clearance was obtained from Kenyatta University Ethical Review Committee (KU/R/COMM/51/748) while a research permit was obtained from the National Council for Science, Technology and Innovation (NACOSTI/P/16/19913/13273). Permission was granted by the local Hospital administration of Siaya County Referral Hospital to provide venue for conducting acceptability tests. Only care givers who gave their informed consent were enrolled for the study.
The study objectives, procedures, benefits, possible risks and schedules were explained to
the caregivers before their informed consent was sought. They were then asked to sign (or
thumb print) an informed consent form (appendix B). Confidentiality was assured by use
of code names besides conducting the test feeding in private observation room. Each
mother child pair was interviewed separately. The outcomes of this research will be shared
with the County Nutrition Office for the greater benefit of the local communities.
CHAPTER FOUR: FINDINGS

4.1 Introduction

This chapter presents the study findings. Nutrient analysis was conducted on raw flour samples. Sensory evaluation was carried out on porridge prepared from four different flour samples: three sample from maize/mushroom composite flour at different ratios and one plain maize flour (control porridge). The porridge formulation giving acceptable overall acceptability score and highest supplementation rate of mushroom flour was taken for the second phase of nutrient analysis where it was compared against the control porridge. The results are organized as per specific objectives of the study namely: Nutrient composition of raw flour samples; formulations of composite flours from maize and mushroom flours; sensory evaluation of porridge from four different formulation, nutritional value of selected porridge samples. The results on comparison between composite flour porridge (enriched porridge) and plain maize flour porridge (control porridge) are also reported.

4.2 Nutrient Composition of Raw Flour Samples

Nutrient analyses were conducted for maize flour and mushroom flour at a moisture content of 10.74% and 10.65%, respectively and the results are presented on as-is basis.

4.2.1 Proximate Analyses

Maize flour was found to be significantly superior in total carbohydrates and energy value (P ≤ 0.001) to mushroom flour. However, although maize flour had higher fat content than mushroom flour, the difference was not significant (p value = 0.989). As shown in Figure 4.1, the total carbohydrates and energy value for maize flour were 75.305 ± 0.569 mg/100
g and 367.561 ± 0.827 Kcal/100 g, respectively while mushroom flour yielded carbohydrate content of 50.13 ± 1.689% and an energy value of 341.917 ± 4.893 Kcal/100 g (table 4.1). Determination of crude fat content yielded 2.967 ± 0.125% and 2.959 ± 0.897% for maize flour and mushroom flour, respectively.

The findings on protein determination by the current study indicate that mushroom flour had significantly higher content of crude protein than maize flour (P < 0.001). The mushroom flour yielded a protein content of 28.69 ± 0.961 mg/100 g while that of maize flour was 9.909 ± 0.218 g/100 g. Likewise, mushroom flour was significantly higher in crude ash content than maize flour (p value < 0.001). Crude ash contents of 1.078 ± 0.225% and 7.579 ± 0.257% for maize flour and mushroom flour, respectively were obtained. Determinations for both flours were conducted at a relatively similar moisture content as
shown in Table 4.1 which gives a summary of the results for proximate analysis of raw flour samples.

**Table 4.1 Proximate content of raw flour samples (g/100 g) as-is basis**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Maize flour</th>
<th>Mushroom flour</th>
<th>P value (t-test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture content</td>
<td>10.740 ± 0.373</td>
<td>10.647 ± 0.365</td>
<td>0.772</td>
</tr>
<tr>
<td>Energy value*</td>
<td>367.561 ± 0.827</td>
<td>341.917 ± 4.893</td>
<td>0.001</td>
</tr>
<tr>
<td>Total carbohydrates</td>
<td>75.305 ± 0.569</td>
<td>50.130 ± 1.689</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Crude proteins</td>
<td>9.909 ± 0.218</td>
<td>28.690 ± 0.961</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Crude fat</td>
<td>2.967 ± 0.125</td>
<td>2.959 ± 0.897</td>
<td>0.989</td>
</tr>
<tr>
<td>Crude ash</td>
<td>1.078 ± 0.225</td>
<td>7.579 ± 0.257</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

**NB:**
1. Values are means ± standard deviation of triplicate measurements
2. * Values are presented in Kcal

**4.2.2 Mineral Content**

Mushroom flour had significantly higher contents of both iron and zinc as compared to maize flour (p < 0.05) as shown in Table 4.2.

**Table 4.2: Mineral content of raw flour samples (mg/100 g) as-is basis**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Maize flour</th>
<th>Mushroom flour</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe</td>
<td>2.762 ± 0.184</td>
<td>6.347 ± 0.225</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Zn</td>
<td>1.554 ± 0.061</td>
<td>4.731 ± 0.398</td>
<td>0.004</td>
</tr>
</tbody>
</table>

**NB:**
1. Values are means ± standard deviation of triplicate measurements
2. Mushroom flour had significantly higher content of both iron and zinc the maize flour
The values obtained for iron and zinc contents in the current study are $6.347 \pm 0.225$ and $4.731 \pm 0.398 \text{ mg/100 g}$, respectively for mushroom flour and $2.764 \pm 0.184$ and $1.554 \pm 0.061 \text{ mg/100 g}$, respectively for maize flour.

### 4.2.5 Vitamin Content

As shown in Table 4.3 and Figure 4.2, significantly higher contents of all the four water-soluble vitamins analysed, thiamine, riboflavin, niacin and total folates were obtained in mushroom flour as compared to maize (p value for all the vitamins $\leq 0.01$).

#### Table 4.3: Vitamin content of raw flour samples (mg/100 g) as-is basis

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Maize flour</th>
<th>Mushroom flour</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thiamine</td>
<td>$0.442 \pm 0.005$</td>
<td>$1.730 \pm 0.479$</td>
<td>$0.010$</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>$0.182 \pm 0.018$</td>
<td>$1.137 \pm 0.049$</td>
<td>$&lt; 0.001$</td>
</tr>
<tr>
<td>Niacin</td>
<td>$3.544 \pm 0.134$</td>
<td>$15.804 \pm 1.895$</td>
<td>$&lt; 0.001$</td>
</tr>
<tr>
<td>Folates*</td>
<td>$20.119 \pm 0.524^*$</td>
<td>$244.955 \pm 10.850^*$</td>
<td>$0.001$</td>
</tr>
</tbody>
</table>

NB

1. - Values are means $\pm$ standard deviation of triplicate measurements
2. - values with superscript * are reported in $\mu$g/100 mg

Mean composition per 100 g of mushroom flour sample was $1.730 \pm 0.479 \text{ mg}$, $1.137 \pm 0.049 \text{ mg}$, $15.804 \pm 1.895 \text{ mg}$, and $244.955 \pm 10.850 \mu\text{g}$ for thiamine, riboflavin, niacin and total folates, respectively while those for maize flour are $0.442 \pm 0.05$, $0.182 \pm 0.018$, $3.544 \pm 0.134$ and $20.119 \pm 0.524 \text{ mg/100 g}$ for thiamine, riboflavin, niacin and total folates, respectively.
Figure 4.2: Vitamin content of raw flour samples (mg/100g)

4.3 Sensory Evaluation

Table 4.4 shows the results for sensory assessment of the formulated porridge samples. It is to be noted that in this study, “inverse” hedonic scale was used as per Larmond’s sample questionnaire Larmond (1977). This implies that higher scores represent less sensory acceptance/ greater dislike of the specified parameter/attribute under assessment and vice versa.
Table 4.4: Mean scores for sensory evaluation of porridge samples by mothers

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Mean scores for each sampled porridge formulation</th>
<th>df</th>
<th>F-value</th>
<th>p-value (Anova test)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100:0</td>
<td>90:10</td>
<td>80:20</td>
<td>70:30</td>
</tr>
<tr>
<td>Colour</td>
<td>2.867 ± 0.213^a</td>
<td>2.167 ± 0.179^b</td>
<td>2.033 ± 0.200^b</td>
<td>2.233 ± 0.171^b</td>
</tr>
<tr>
<td>Taste</td>
<td>2.933 ± 0.303^a</td>
<td>2.933 ± 0.244^a</td>
<td>3.367 ± 0.443^a</td>
<td>5.367 ± 0.354^b</td>
</tr>
<tr>
<td>Aroma</td>
<td>2.933 ± 0.289^a</td>
<td>3.700 ± 0.293^ab</td>
<td>4.267 ± 0.409^b</td>
<td>6.733 ± 0.328^c</td>
</tr>
<tr>
<td>Mouthfeel</td>
<td>2.633 ± 0.217^a</td>
<td>2.233 ± 0.171^a</td>
<td>2.133 ± 0.184^a</td>
<td>2.167 ± 0.180^a</td>
</tr>
<tr>
<td>Overall Acceptability</td>
<td>2.500 ± 0.178^a</td>
<td>2.533 ± 0.202^a</td>
<td>3.100 ± 0.293^a</td>
<td>6.467 ± 0.274^b</td>
</tr>
</tbody>
</table>

N/B:
1. Values are means ± standard deviation of all measurements (N=30)
2. Superscripts with different letters in the same row indicate significantly different values at p ≤ 0.05
3. Higher mean scores represent poorer sensory rating (less acceptability) of the assessed attribute
Scores ranged from 1 (like extremely) to 9 (dislike extremely) according to the 9-point hedonic scale score card. Mean scores for each attribute was computed per sample using SPSS-ANOVA.

Analysis of variance results showed that there were significant differences among the four porridge samples assessed (100:0, 90:10, 80:20 and 70:30 formulations) with regard to colour [F(3,116) = 3.419; p = 0.02], taste [F(3,116) = 11.425; p < 0.001], aroma [F(3,116) = 25.675; p < 0.001] and overall acceptability [F(3,116) = 61.706; p < 0.001]. However, the samples did not show significant differences in mouthfeel [F (3,116) = 1.505; p = 0.217].

Post hoc tests revealed that the control porridge differed significantly with all the composite porridge formulations while no significant differences existed among the composite formulations in colour. With regard to taste, the 70:30 maize to mushroom formulated porridge had significantly poorer sensory rating than all the other three formulations (100:0, 90:10 and 80:20): No significant differences existed in taste among the three formulations. Almost all the samples differed significantly from each other in mean scores for aroma with the 70:30 formulation recording the highest aroma mean scores (poorest rating and the control porridge being best rated for aroma (lowest mean score). In overall acceptability, the 70:30 formulated porridge had significantly higher mean scores (less acceptable) than all the rest of the formulations among which no significant differences existed in the mean scores. The best rated in overall acceptability was the control porridge followed by 90:10, 80:20 and 70:30 in the order.
Figure 4.3 shows effect of mushroom supplementation at different rates on the rating of various sensory attributes of the porridge samples. Higher levels of supplementation resulted into higher scores (poorer rating) on aroma and taste and thus overall acceptability while it resulted in lower scores (better rating) on color and mouthfeel.

![Figure 4.3: Effect of different supplementation rates on sensory mean scores](image)

Figure 4.3: Effect of different supplementation rates on sensory mean scores

The 80:20 (maize to mushroom flour) porridge formulation was the highest possible supplementation rate with the mushroom flour (the enriching flour) that did not significantly ($p = 0.082$) compromise the overall acceptability of the porridge. Consequently, it was selected for the subsequent phase of the study.
4.4 Nutrient Content of Porridge Samples

The enriched porridge and the control porridge samples were analysed for proximate composition, iron, zinc, thiamine, riboflavin, niacin and folate in the second phase of nutrient analysis and the results were obtained as presented in tables 4.5, 4.6 and 4.7. The enriched porridge had significantly higher content of all the nutrients, except crude fat and energy value, than the control porridge (p <0.05). Although the control porridge had higher fat content and energy value, the differences were not significant (p values were 0.637 and 0.182 for fat and energy value respectively).

4.4.1 Proximate Composition

As shown in table 4.5, Percentage proximate composition of control porridge and the enriched porridge, respectively were 51.461 ± 2.00 and 49.183 ± 0.420 Kcal/100g for energy value, 11.988 ± 0.648 and 9.563 ± 0.097 g/100g for total carbohydrates and 0.233 ± 0.055 and 0.215 ± 0.024 g/100 g for crude fat. The mean % crude protein for the porridge sample were found to be 1.228 ± .165 and 2.249 ± 0.043 g/100 g for control porridge and enriched porridge, respectively. The protein content of the enriched porridge was significantly improved (p value < 0.001). Crude ash content for plain porridge and the enriched porridge were found to be 0.092 ± 0.014 and 0.973 ± 0.077 g/100 g, respectively.

4.4.3 Mineral Content

Differences in mineral content between the two porridge samples were highly significant (P-value < 0.001 for both the two elements with the enriched porridge posting higher figures). The results are given in Table 4.6.
Table 4.5: Proximate composition of porridge samples (g/100 g) as-is basis

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Control porridge (100:0)</th>
<th>Enriched porridge (80:20)</th>
<th>P value (t-test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture content</td>
<td>87.123 ± 0.351</td>
<td>87.170 ± 0.173</td>
<td>0.134</td>
</tr>
<tr>
<td>Energy value</td>
<td>51.461 ± 2.00*</td>
<td>49.183 ± 0.420*</td>
<td>0.182</td>
</tr>
<tr>
<td>Total Carbohydrate</td>
<td>11.988 ± 0.648</td>
<td>9.563 ± 0.097</td>
<td>0.021</td>
</tr>
<tr>
<td>Crude protein</td>
<td>1.228 ± 0.165</td>
<td>2.249 ± 0.043</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Crude fat</td>
<td>0.233 ± 0.055</td>
<td>0.215 ± 0.024</td>
<td>0.637</td>
</tr>
<tr>
<td>Crude ash</td>
<td>0.092 ± 0.014</td>
<td>0.973 ± 0.077</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

NB:
1. Values are means ± standard deviation
2. Values with superscript * are presented in Kcal

Table 4.6: Mineral content of porridge samples (mg/100 g) as-is basis

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Control porridge</th>
<th>Enriched porridge</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe</td>
<td>0.33 ± 0.016</td>
<td>0.801 ± 0.032</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Zn</td>
<td>0.262 ± 0.006</td>
<td>0.385 ± 0.012</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

NB:
1. Values are means ± standard deviation
2. Enriched porridge significantly higher in both iron and zinc than the control porridge

Iron contents were 0.33 ± 0.016 and 0.801 ± 0.032 mg/100 g for the plain and enriched porridge, respectively while those of Zinc were 0.262 ± 0.006 and 0.385 ± 0.012 mg/100 g for the plain and enriched porridge, respectively.
4.4.4 Vitamin Content

Determination of vitamins showed highly significant differences (p-value < 0.001) in contents between the two porridge samples for all the four vitamins analysed as displayed in Table 4.7. Mean contents were found to be 0.053 ± 0.002 and 0.094 ± 0.001 mg/100 g for thiamine, 0.034 ± 0.002 and 0.095 ± 0.006 mg/100 g for riboflavin, 0.377 ± 0.015 and 1.150 ± 0.011 mg/100 g for niacin, 1.673 ± 0.395 and 9.310 ± 1.01 µg/100 g for total folates in the plain porridge and the enriched porridge, respectively.

Table 4.7: Vitamin content of porridge samples (mg/100 g) as-is basis

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Control porridge</th>
<th>Enriched porridge</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thiamine</td>
<td>0.053 ± 0.002</td>
<td>0.094 ± 0.001</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>0.034 ± 0.002</td>
<td>0.095 ± 0.006</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Niacin</td>
<td>0.377 ± 0.015</td>
<td>1.150 ± 0.011</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Folate</td>
<td>1.673 ± 0.395*</td>
<td>9.310 ± 1.01*</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

NB:
1. Values are means ± standard deviation
2. Values with superscript * are reported in µg/100 g

4.5 Test feeding

The enriched porridge was test-fed to infants between the ages of 6 to 23 months who were the targeted consumers of the product and observations made of their intakes and feeding responses which were recorded and summarised as reported in Table 4.8.

Half (50%) of the sampled children (N=30) finished their serving portion while only 10% of them refused the porridge. Forty percent of the children took the porridge albeit in
quantities below the recommended serving for their age. Further observations during test-feeding indicate that 66.7% of the children were positively disposed (cheerful, eager) during feeding while the rest (33.3%) had negative responses (indifferent, reluctant).
### Table 4.8: Feeding responses of the target population to the enriched porridge

<table>
<thead>
<tr>
<th>Age/months</th>
<th>Those who consumed stated amounts</th>
<th>Those who showed stated feeding responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full serving</td>
<td>Partial serving</td>
</tr>
<tr>
<td>6 (N=3)</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>7-8 (N=6)</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>9-11 (N=7)</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>12-23 (N=14)</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Total (N=30)</td>
<td>15 (50)</td>
<td>12 (40)</td>
</tr>
</tbody>
</table>
CHAPTER FIVE: DISCUSSION OF FINDINGS

5.1 Introduction

This chapter gives the interpretation and explanation of the findings presented in chapter four. It also shows how the findings of the present study relate with those of other studies.

5.2 Composition of Raw Flour Samples

5.2.1 Proximate Composition

5.2.1.1 Protein Content

In the current study, the protein content of oyster mushroom flour was found to be 28.69 ± 0.961 mg/100 g. These results for mushrooms agree with those reported by Bhattacharjya, Paul, Miah, and Ahmed (2015), Ahmed et al (2016) and Stamets (2005) who reported 27.30, 28.40 and 27.25 mg/100 g, respectively at a more or less similar moisture content. Regula and Siwulski (2007) and Okon et al (2015) however, obtained lower values for proteins in mushrooms namely 15.7 and 10.21 mg/100 g, respectively at a similar moisture content of 10.6%. The protein content of mushrooms is reportedly affected by factors such as mushroom variety, stage of development, the part sampled, level of nitrogen available in the substrate and geographical location, i.e. where the mushroom are obtained (Ikechukwuka et al., 2008). This could explain the differences between current study values and those previously reported by some researches (Okon et al., 2015; Regula & Siwulski, 2007).

The current values of 9.909 ± 0.218% protein content in maize four fall within the range of values reported by Rana and Khan (1985) and Begum, Uddin, Rahman, and Islam, (2014)
who reported 10.4 and 9.08%, respectively. Furthermore the current values are also close to that of 9.7% reported in the West African Food Composition Tables which was determined at 11.5% MC (FAO, 2012). The USDA (2015) has reported lower value of 6.90% for maize proteins. This could be due variation in the moisture content of determination.

According to these findings, oyster mushrooms are significantly superior to maize flour in protein composition (p value < 0.001) and is thus viable for protein enrichment in formulations involving maize flour as the basic ingredient. The findings also confirm mushrooms as a rich source of proteins as previously reported (Regula & Siwulski, 2007). Mushrooms outcompetes many of non-animal sources of protein such as grains and vegetables. The protein content of mushrooms reportedly falls between that of vegetables and animal sources (Kakon, Choudhury, & Saha, 2012). This means that other factors assumed, mushrooms generally make a good consideration for the supplementation of protein deficient diets and products which constituted the essence of this study. Poor general nutritional status, in particular, PEM is cited as a risk factor for micro-nutrient deficiencies (WHO, 2006).

**5.2.1.2 Crude Ash Content**

Crude ash content which represents the total inorganic component is an indicator of the total mineral content of foods (Lister, 2015). The results (7.579 ± 0.257% ) obtained for mushroom flour are consistent with those reported by Regula and Siwulski (2007), Okafor et al (2012) and Li, Zhang, Li, Li, and Sun (2017) who obtained 7.04, 7.6 and 7.9%,
respectively. Ahmed et al (2016) reported slightly higher value of 11.4% for crude ash content in mushrooms. The values of 1.078 ± 0.225% for maize flour, obtained in the current study fall within the range of 1.15 to 5.7% reported by other researchers and those posted in a number of FCTs (Begum et al., 2014; FAO, 2012; Ndukwe, Edeoga, & Omosun, 2015; Rouf Shah, Prasad, & Kumar, 2016). Slight variations in results are attributable to variations in sub-cultivars of maize analysed.

According to the current study findings, mushroom flour is significantly higher in crude ash content than maize flour (p value < 0.001 for both minerals in favour of mushroom flour). This points to the fact that mushrooms are generally superior in mineral composition to maize (cereals). This is attested by the results of the actual determination of the two minerals (iron and zinc) investigated by the study as presented in section 4.2.2.

5.2.1.3 Crude Fat Content

Analysis of crude fat yielded 2.967 ± 0.125% and 2.96 ± 0.90% for maize flour and mushroom flour, respectively and thus were not significantly different (p = 0.989). The crude fat values for oyster mushrooms currently obtained are within the range reported in literature (1.9 to 4.65%) (Ahmed et al., 2013; Alam et al., 2008; Dundar et al., 2008; Okafor et al., 2012; Regula and Siwulski, 2007). The findings have further confirmed mushrooms as low calorie food (Kakon et al., 2012) which would make the suitable as a component in calorie-controlled diets as argued by Bano (1993). The Crude fat content obtained for maize flour was within the range reported in literature (Begum et al., 2014; FAO, 2012; Lukmanji et al., 2008; Rana & Khan, 1985).
5.2.1.4 Carbohydrate Content and Energy Value

The current findings reveal that maize flour yields significantly higher amounts of total carbohydrates than the same quantity of mushroom flour (p < 0.001). The values obtained for total carbohydrates in mushrooms flour (50.130 ± 1.689%) fall within the range of those reported by many other researchers ranging from 29.60% (Ahmed et al., 2016) to 70% (Okon et al., 2015). The current value for carbohydrate content in maize flour (75.305 ± 0.569%) also corroborates the value of 76.9% previously reported by Gwirtz and Garcia-Casal (2014).

Energy values of 341.917 ± 4.893 Kcal/100 g and 367.561 ± 0.827 Kcal/100 g for mushroom flour and maize flour, respectively were found by the current study. The values for mushroom flour agree with those reported by Regula and Siwulski (2007) and Okon et al (2015) who reported 345 and 342.5 Kcal/100 g, respectively at a moisture content of 10.6%. Dundar, Acay, and Yildiz (2008) however, reported 243 Kcal/100 g while Okafor et al (2012) reported 313 Kcal/100 g at moisture content of 7.4 and 8.6%, respectively.

5.2.2 Mineral Content

The current study has yielded iron and zinc contents of 6.347 ± 0.225 and 4.731 ± 0.398 mg/100 g, respectively for mushroom flour while 2.762 ± 0.184 and 1.554 ± 0.061 mg/100 g iron and zinc, respectively were obtained for maize flour. These results further confirm the superior mineral content of mushrooms compared to maize flour already as indicated by the crude ash results in the proximate analysis.
Similar findings for iron in mushrooms have been reported by Regula & Siwulski (2007) (6.86 mg/100 g), Mallikarjuna et al (2013) (6.27 mg/100 g) and Li et al (2017) (7.1 mg/100 g). A good number of studies have also reported higher contents of iron in mushroom flour in the range of 15-65 mg/100 g (Ahmed et al., 2016; Alam et al., 2008; Deepalakshmi & Sankaran, 2014; Mattila et al., 2001; Poongkodi, HarithralkPriya, & HarithralkPriya, 2015). Roy, Azad, Sultana, Anisuzzaman, & Khondkar, (2015) however reported lower iron content of 2.19 mg/100 g in mushroom flour. The result for content of zinc in mushroom flour agree with those reported by Li et al (2017), Mallikarjuna et al (2013) and Poongkodi et al (2015) who reported 4.2-5.5 mg/100 g, 5.06 mg/100 g and 4.89-6.51 mg/100 g, respectively. Other authors have however, reported higher zinc contents ranging between 9 and 27.6 mg/100 g (Alam et al., 2008; Bhattacharjya et al., 2015; Deepalakshmi & Sankaran, 2014). The composition of mineral elements in mushrooms has been shown to be strongly affected by the chemical composition of the substrate or compost on which they are grown as well the species and size of samples (Bellettini et al., 2016; Ikechukwu et al., 2008; Ziarati & Rabizadeh, 2013). The findings for both minerals in maize flour fall within the range, albeit slightly less, of the figures reported in both the food composition tables for Tanzania (3.5 and 1.8 mg/100 g iron and zinc, respectively) and West African (3.8 and 1.7 mg/100 g iron and zinc respectively) (FAO, 2012; Lukmanji et al., 2008).

This study therefore, confirms that mushrooms are nutritionally viable for addressing widespread mineral deficiencies across populations as reported in other work (Mleczek et al., 2013; Stein, 2010; White & Broadely, 2009), particularly the essential minerals including Iron and Zinc whose deficiencies are common in developing countries (Muyanja,
Kyambadde, & Namugumya, 2014). Mineral deficiencies (especially Fe, Zn) in the diet affects the health and the development of children and results in potentially life threatening complications (FAO/WHO, 2001). Zinc is important for tissue/cell growth, cell replication, bone formation, skin integrity and cell mediated immunity. It plays an essential role in protein and nucleic acid synthesis, carbohydrate metabolism and is critical for successful pregnancy. Lack of zinc leads to stunted growth and retarded mental development (FAO/WHO, 2004). Iron, on the other hand, has several vital functions in the body: It is a component of haemoglobin in the red blood cells where it binds and transports oxygen from the lungs to other tissues via the blood stream. It also serves as an intra-cell electron transport medium, and as an integrated part of important enzyme systems in various tissues (Gupta, 2014). Iron deficiency is the most prevalent nutrition problem in the developing countries. Consequences of iron deficiencies include microcytic anaemia, reduced learning and work capacity and impaired human function at all stages of life (Bhandari & Banjara, 2015). The impaired mental development of 40 to 60% of children in the developing countries is attributed to iron deficiency (Fanzo, 2012).

5.2.3 Vitamin Content

Mean vitamin content per 100 g of mushroom flour sample was found to be 1.730 ± 0.479 mg, 1.137 ± 0.049 mg, 15.804 ± 1.895 mg, and 244.955 ± 10.850 µg for thiamine, riboflavin, niacin and folates, respectively. Results for thiamine fall within the range of those (1.9 to 2.0 mg/100g) previously reported by Deepalakshmi and Sankaran (2014), Mattila et al (2001) and Wang and Ng (2006). Crisan and Sands (1978) however, reported slightly higher values (4.8-8.9 mg/100g) while Stamets (2005) reported much lower
content of thiamine in mushroom flour (0.16 mg/100 g). Riboflavin content of mushroom flour obtained in the current study fall slightly below those reported by Deepalakshmi and Sankaran (2014) and Stamets (2005) whose values range between 1.9 and 2.4 mg/100 g. Findings of Niacin content for mushroom flour for this study (15.804 ± 1.895 mg/100g) fall outside the range reported by most studies i.e. 30 – 108 mg/100 g. Only two studies were identified that adequately reported the content of folate for mushroom flour i.e. Waang and Ng (2006) and Mattila et al (2006). Their values ranging between 300 – 700 µg/100 g fall above the findings (244.955 ± 10.850 µg/100g)) of the current study.

In this study, maize flour was found to contain 0.442 ± 0.005, 0.182 ± 0.018, 3.544 ± 0.134 and 20.119 ± 0.524 mg/100 g of thiamine, riboflavin, niacin and folates, respectively. These figures are within the range reported in a number of Food Composition Tables (FAO, 2012; Lukmanji et al., 2008; USDA, 2015).

The study thus confirmed that mushrooms are rich in vitamins particularly the water-soluble B vitamins. Vitamins constitute an essential part of human nutrition and their adequate supply is especially important in foods for infant and young children whose metabolic and immune systems are still very delicate and prone to deficiencies (Tomkins, 2000). Thiamine serves as a cofactor for key enzymes involved in carbohydrate metabolism. Mild thiamine deficiency is a significant public health problem across the world (Whitfield et al., 2018). Severe deficiency causes beriberi, a disease that has been associated with high consumption of refined rice and cereals and low intakes of animal and dairy products (de Benoist, 2008).
Riboflavin plays a central role in catabolism of carbohydrates. It provides the reactive moieties of the flavin coenzymes (FMN and FAD) which serve as electron carriers in redox reactions (FAO/WHO, 2004). Deficiency causes impaired growth, impaired vision, dermatitis, cracked and red lips and inflammation of the lining of mouth and tongue (WHO, 2006). Studies among school children have revealed mild riboflavin deficiency to be very common with nearly two thirds of children affected (Rohner, Zimmermann, Wegmueller, Tschannen, & Hurrell, 2007).

Niacin is a precursor for key coenzymes (NAD$^+$ and NADP$^+$) involved in the metabolism of macronutrients. It is vital for oxidation in all living cells. Tissues with a high respiration rate, such as the central nervous system, are the most extensively affected by deficiency (WHO, 2000). Niacin deficiency leads to Pellagra which clinically manifests in dermatitis, diarrhea and dementia. It can consequently lead to death. Populations preponderantly dependent on cereal diets are at risk of pellagra due to the low content of the vitamin in cereals. Many poor people in southern and eastern Africa might thus be at risk (Nuss & Tanumihardjo, 2011; WHO, 2000).

Folate (vitamin B$_9$) plays a central role in the synthesis and methylation of nucleotides that intervene in cell multiplication and tissue growth. Its role in protein synthesis and metabolism is closely interrelated to that of vitamin B12. Folate deficiency is associated with megaloblastic anemia and impaired cognitive function in children (Bhandari & Banjara, 2015; de Benoist, 2008).
5.3 Sensory Evaluation

Generally, all the composite porridge samples scored well for colour with poorest mean score at 2.867 ± 1.670 (like moderately). Poorest score for taste was recorded for 70:30 formulation at 5.367 ± 1.938 (dislike slightly). Most panellists who gave a negative score for taste felt that the taste for the 70:30 formulation was “a bit too strong”. The same sentiments were expressed for aroma which had the poorest score still being given for 70:30 at 6.733 ± 1.199 (dislike moderately). Aroma score was inversely related to the proportion of the mushroom component in the composite flour. The same relationship was noted for taste. Conversely, supplementation with mushroom flour appeared to improve the texture (mouthfeel) of the porridge with the best score being given for the 80:20 formulation. Best score for overall acceptability was given the 90:10 formulation and poorest score (highest mean score) given for the 70:30 formulation. As illustrated in figure 4.3, taste and aroma seemed to militate against the overall acceptability of the composite porridge samples while mouthfeel and colour appeared to have the opposite effect. Taste and aroma are sensory components that have been closely associated by a cross modal relationship and are the two primary sensory modalities influencing flavor perception (Yin et al., 2017). No significant difference in overall acceptability was however, found amongst the three formulations 80:20, 90:10 and plain porridge. Significant difference in overall acceptability was found to exist between 70:30 formulation and the rest of the formulations. The overall acceptability of the porridge samples from the composite flour were 2.500 ± 0.178, 2.533 ± 0.202), 3.100 ± 0.293 and 6.467 ± 0.274 for 100:0, 90:10, 80:20 and 70:30 porridge formulations respectively. This shows that mushroom supplementation of maize
flour of up to 20% rates will give organoleptically acceptable porridge [mean score 3.10 (like moderately)].

5.4 Nutrient Content of Porridge Samples
Nutritional analysis of porridge samples was conducted for plain maize flour (control) porridge and porridge made from the 80:20 maize: mushroom formulation (enriched porridge).

5.4.1 Protein Content
The mean % crude protein for the porridge sample were found to be 1.228 ± 0.165 and 2.249 ± 0.043 for control porridge and enriched porridge, respectively. The protein content of the enriched porridge was significantly improved (p value < 0.001). The protein values obtained for the plain porridge seemed to agree with those (1.2%) posted in the West African Food Composition Tables (FAO, 2012). The Tanzanian Food Composition Tables has posted slightly lower value of 0.8% (Lukmanji et al., 2008).

Proteins constitute an important nutritional component of complementary foods supplying essential amino acids (EAAs) as well as energy during times of energy deprivation. Adequate supply of dietary proteins is vital for maintaining cellular function and integrity as well as ensuring normal health and growth. Combined protein deficiency and low energy intake leads to PEM which is the most prevalent form of malnutrition worldwide (Abeshu, Lelisa, & Geleta, 2016; Schuftan, Ramalingaswami, & Levinson, 1998). Severe forms of PEM are also associated with micronutrient deficiencies, weakened immunity and
increased susceptibility to life threatening diseases such as gastroenteritis and acute respiratory infections (ARIs) (Anil, 2015; FAO, 1997; Latheef, 2015).

5.4.2 Crude Fat, Carbohydrates and Energy Value
The plain porridge and the enriched porridge, respectively contained 51.461 ± 2.00 and 49.183 ± 0.420 Kcal/100 g of energy value, 11.988 ± 0.648 and 9.563 ± 0.097% of total carbohydrates and 0.233 ± .055 and 0.215 ± 0.024% of crude fat. Current values for energy, carbohydrate and fat content are close to those reported in the WAFTs (51.461 kcal/100 g, 11.988% and 0.1%, respectively) which were also determined at about the same moisture content (87.6%). Although the enriched porridge is lower in carbohydrate and fat content, this is compensated by its higher values in protein content so that the two porridge samples are not significantly different in energy value (p= 0.182). Supplementation of maize flour with mushroom flour at 20% rate therefore, does not significantly compromise the energy value of the porridge. Energy density is a key consideration in foods meant for complementary feeding since children at this stage are in their critical growth period and are most vulnerable to PEM (Abeshu et al., 2016). Protein energy malnutrition occurring in the critical growth period could have lifetime implications on a child’s health and capabilities (Michaelsen, Weaver, Branca, & Robertson, 2000).

5.4.3 Crude Ash, Iron and Zinc content
Crude ash contents for plain porridge and the enriched porridge were found to be 0.092 ± 0.014 and 0.973 ± 0.077 g/100 g respectively. The WAFCTs has posted 0.1 g/100 g content of crude ash for maize porridge which agree with present results. Results for mineral
analysis confirm that mushroom supplementation actually improves the mineral content of the enriched porridge. Differences in both iron and zinc contents between the two porridge samples were found to be highly significant (p value < 0.001 for both the elements) with the enriched porridge yielding higher values. The findings for iron and zinc determination (0.33 ± 0.016 and 0.262 ± 0.006 mg/100 g respectively) in control porridge are close to those reported in the TZFCTs (0.33 and 0.2 mg/100 g). The WAFCTs has however, reported lower values (0.04 and 0.06 mg/100 g for iron and zinc, respectively).

5.4.4 Vitamin Content
Mean vitamin contents found in current study were: 0.053 ± .002 and 0.094 ± .001 mg/100 g of thiamine, 0.034 ± .002 and 0.095 ± .006 mg/100 g of riboflavin, 0.377 ± .015 and 1.150 ± .011 mg/100 g of niacin, 1.673 ± .395 and 9.310 ± 1.01 µg/100 g of total folates in the control porridge and the enriched porridge respectively. This study has obtained higher thiamine content for maize porridge than reported in both the TZFCTs and the WAFCTs (0.0 and 0.01 mg/100 g respectively). However, findings for riboflavin and niacin agree with those reported in WAFCTs (0.02) and TZFCTs (0.4) respectively. Current findings on folate content for maize porridge fall between the values reported by the two composition tables (1.0 and 3.0 µg/100 g).

5.5 Nutrient/Energy Density
Dilution effect, comes into play during porridge preparation as indicated by the reduced nutrient concentrations in porridge samples vis a vis the raw flour samples. This might pose a setback in feeding small children who still suffer limited gastric capacities and cannot
accommodate large volumes of intake. Thicker gruels in preparations for infants and young children are thus emphasized to enhance energy and nutrient density (Abeshu et al., 2016; Aleke, 2004). Thinner consistencies of preparations would require larger quantities of feed intake or more number of feedings per day to meet the recommended daily allowances (RDAs). Processing strategies such germination not only improve nutrient availability by reducing the levels of antinutritional factors, but also reduces water bulking in porridge preparations for small children through partial enzymatic hydrolysis of the starch component in cereals (Treche et al., 1999; Alnwick et al., 1988).

5.6 Test feeding

The findings from the observations made during test feeding show that the enriched porridge flour can be successfully launched as a nutritional product for the target population. This is because a good proportion (50%) of the sample size (N = 30) finished their serving portion while only 10% refused the porridge. Furthermore, majority (66.7%) of the children were positively disposed (cheerful or eager) during the feeding to suggest that they liked or enjoyed the porridge. Further inquiries revealed that some of the children who refused the porridge or took less than the recommended serving either had a general difficult feeding or distaste for porridge rather than specific non-acceptance of the porridge under trial; no force-feeding was entertained during the exercise. Notwithstanding, slight modifications to ameliorate taste and aroma might be necessary for optimum outcomes.
CHAPTER SIX: SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary

This study has found that at about similar moisture content of determination, Oyster mushroom flour has significantly higher content of key nutrients investigated in this study as compared to maize flour. Oyster mushrooms flour has higher contents of proteins, iron, zinc, thiamine, riboflavin, niacin and folates. Likewise, enriched porridge also has a corresponding and significantly higher nutrient content as compared to the control porridge. While maize flour has significantly higher energy value than mushroom flour, there is however no significant difference in energy value between the enriched porridge and the control porridge (p= 0.182).

The sensory evaluation has revealed that there are no significant differences in sensory acceptance between the enriched porridge and the control porridge except in color and aroma. The enriched porridge has better sensory appeal for color and a poorer appeal in aroma. Notably, although the enriched porridge also has less appeal in taste, the difference is not significant. The overall acceptability of the porridge samples is not significantly different.
6.2 Conclusions

From the results presented in chapter four, this study concludes that oyster mushroom flour has a high nutritional value: they are higher in proteins, minerals particularly iron and zinc, as well as group B vitamins: thiamine, riboflavin, niacin and folates as compared to maize flour. They thus pass as a nutrient dense food. Secondly, the findings of this study show that enrichment of maize flour with oyster mushroom flour significantly improved the nutrient content of the composite (enriched) flour and consequently the nutritional value of the enriched porridge. This is because the enriched porridge had a significantly superior nutrient content than control porridge: particularly with respect to key nutrients including protein content, crude ash (total minerals), iron, zinc, thiamine, riboflavin, niacin and total folates. The first hypothesis of this study is consequently rejected. Furthermore, at a rate not exceeding 20%, enrichment of maize flour with mushroom flour does not significantly compromise the overall sensory acceptability of its porridge: the mean score for overall acceptability of the enriched porridge was not significantly different from that of the control porridge. Moreover, feeding trials indicate that majority of the sampled children showed positive responses during feeding while at least half finished their serving portion. The second hypothesis is therefore accepted, albeit at enrichment rates of 20% or below.

This study has shed light on the nutritional and sensory viability of the use of mushrooms to enhance cereal-based complementary porridge formulations as a strategy towards mitigating undernutrition among children in the complementary feeding stage in Siaya County and other affected populations.
6.3 Recommendations

6.3.1 Recommendations for further research

➢ Further nutrient analysis to include the determination of other nutrients that were not subject of this study in order to establish the complete nutrient profile of locally grown oyster mushrooms.

➢ Investigation of the antinutrient content of both the raw flour and porridge samples to estimate bioavailability.

➢ The nutritional and keeping quality of the maize/mushroom composite flour be investigated during storage at different time, temperature and oxygen combinations.

➢ Interventional studies be conducted to investigate the efficacy of formulated porridge to mitigate actual nutritional deficiencies and address malnutrition.

6.3.2 Recommendations for policy/practice

➢ Mushrooms be incorporated in complementary porridge formulations as a strategy for addressing malnutrition including micronutrient deficiencies.

➢ Frontline nutrition workers should encourage the use/consumption of mushrooms as part of nutritional counselling.

➢ Production and consumption of mushrooms be promoted through intensive agri-nutrition campaigns and by deliberate incentives on mushroom farming. This is because of the potential mushrooms hold for enhancing complementary diets and thus mitigating malnutrition.
REFERENCES


workshop held in Nairobi, Kenya. Ottawa Ont. Canada: Canadian International Development Research Centre.


Regula, J., Krejpcio, Z., & Staniek, H. (2010). Bioavailability of Iron from Cereal Products Enriched with Dried Shittake Mushrooms (Lentinula edodes) as


Singh-Ackbarali, D., & Maharaj, R. (2014). Sensory Evaluation as a Tool in Determining Acceptability of Innovative Products Developed by Undergraduate Students in Food Science and Technology at The University of Trinidad and Tobago. *Journal of Curriculum and Teaching, 3*(1).


Vostrovsky, V., & Jablonska, E. (2007). Mushroom growing with information support as opportunity for the developing countries. *Agricultura Tropica et Subtropica, 40*, 120.


APPENDICES

APPENDIX A: LETTER OF INTRODUCTION

RESEARCH STUDY: REQUEST FOR PARTICIPATION

Dear respondent,
My name is Felix Ondiek, a Master’s student from Kenyatta University. I am undertaking a study on the “Nutrient content and sensory attributes of maize/mushroom based porridge for use in complementary feeding in Kenya”.

I am writing to seek your consent to participate in this study whose finding may be beneficial to you either directly or indirectly.

Please read the information relating to the study in attached form for more clarification about the study before giving your consent.

You may forward any concerns or complaints relating to the study through the contacts below.

Your participation will be highly appreciated.

My contacts
Cell-phone: 0720393235
Email: felix.ondiek@gmail.com

Supervisors
Dr. Ann Munyaka
Cellphone: 0712108087
Email: munyaka.ann@ku.ac.ke

Dr. Peter Chege
Cell-phone: 0722642356
Email: chege.peter@ku.ac.ke

Kenyatta University
Kenyatta University Ethics Review Committee
PO Box 43844 – 00100, Nairobi
Tel: 87120901
Email: secretary.kuerc@ku.ac.ke

Thank you

PTO
APPENDIX B: CONSENT FORM

YOUR CONSENT

Dear respondent,

Before agreeing to participate in the research, it is important that you read and understand the information below. Then you can indicate your willingness to participate in the research. You should feel free to ask any questions that you may have.

**Title of Research Study**: Nutrient Content and Sensory attributes of Maize/Mushroom based Porridge for use in Complementary Feeding in Kenya.

**Principal Investigator**: Felix O. Ondiek

**A. Purpose of the Research Study**: To formulate a nutrient-rich local complementary food product based on oyster mushrooms and maize and test its sensory acceptance.

**B. Procedures Description**:

1. You will be given measured portions of porridge prepared by the researcher to feed your child and asked to rate your opinion on specific sensory attributes indicated in a form provided for the purpose.

2. You will also be given a measured portion of porridge prepared by the researcher to feed your child and asked to observe as the child takes the porridge and record those observations in an observation form which will be given.

3. A researcher will help in filling the form for those who cannot write.

**C. Benefits of participation**: The direct benefit of your child participating in this study will consist of the porridge portions that will be given to the child. You may also be given nutrition counselling depending on the need.

**D. Risks or Discomforts of this study**: The risks of you and your child participating in this study is expected to be minimal, if any, and may include possible allergies to the new food product under study.

**E. Protection against the risks**: Appropriate arrangements will be made in liaison with the County Referral Hospital to have you or your child receive medical attention for any reported allergies that may arise from taking part in the study.

**F. Confidentiality**: To secure the confidentiality of your responses, your name and other identifying information will never be attached to your answers. Interviews will be conducted in a separate and private room and the information will not be used for any other purposes other than this research.
**G. Complaints:** Any complaints or concerns you may have relating to the study during its course may be forwarded to the relevant stakeholders through the contacts given in the introduction/consent form.

PTO

**H.** Please note that your participation is voluntary, and you have right to withdraw from the study at any time.

Thank you,

Felix Ondiek.
Principal researcher.

**Respondent**
I have understood the purpose of this study and hereby willingly give my consent to participate.

Code_________________(optional) Sign _____________________Date_________

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APPENDIX C: DATA SHEETS FOR NUTRIENT CONTENT

Date ___________________________ Time ______________________

Sample Material. ____________________________________________

**Proximate Analysis**

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**Mineral Analysis**

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**Vitamin Analysis**

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APPENDIX D: SENSORY EVALUATION FORM FOR CARE-GIVERS

Date ----------------------------------- place ---------------------------------------- time ---------

Code number of panelist -------------------------------

Product code ----------------------------------------

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<td>Dislike slightly</td>
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<tr>
<td>7</td>
<td>Dislike moderately</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Dislike very much</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Dislike extremely</td>
<td></td>
</tr>
</tbody>
</table>

NB: Kindly tick your honest ratings for each attribute
**APPENDIX E: OBSERVATION SHEET FOR TEST FEEDING**

Date of evaluation ________________ Place ________________ - Time _____ -
Product code ____________________ -
Child number ________________ Age ________________
Is the child well ________________ Sick ________________?

**Total consumption**
How much of the porridge did the child consume? (Tick as apply)

1. Whole portion ____________________
2. ≥ ¾ portion ____________________
3. ≥ ½ portion ____________________
4. ≥ ¼ portion ____________________
5. Refused/< ¼ portion ________________

**Feeding Responses**
Describe behavior or expressions of the child during feeding (tick as apply)

1. Positive (Cheerful / Eager) ____________________

2. Negative (Reluctant/indifferent) ____________________

**Note: Age-wise Recommended Serving portions**

- ≥ 12 months: 1 cup
- 9 – 11 months: ¾ cup
- 7 – 8 months: ½ cup
- 6 months: ¼ cup
## APPENDIX F: STATISTICAL RESULTS OF POST-HOC (LSD) FOR SENSORY DATA ANALYSIS

<table>
<thead>
<tr>
<th>Tested attribute for sample formulations</th>
<th>P values with different formulation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100:0</td>
</tr>
<tr>
<td>100:0</td>
<td></td>
</tr>
<tr>
<td>colour</td>
<td>-</td>
</tr>
<tr>
<td>taste</td>
<td>-</td>
</tr>
<tr>
<td>aroma</td>
<td>-</td>
</tr>
<tr>
<td>Mouth feel</td>
<td>-</td>
</tr>
<tr>
<td>Overall acceptability</td>
<td>-</td>
</tr>
<tr>
<td>90:10</td>
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</tr>
<tr>
<td>colour</td>
<td>0.011</td>
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<tr>
<td>taste</td>
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<tr>
<td>aroma</td>
<td>0.114</td>
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<tr>
<td>Mouth feel</td>
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<tr>
<td>Overall acceptability</td>
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<td>colour</td>
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<tr>
<td>taste</td>
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<td>aroma</td>
<td>0.004</td>
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<tr>
<td>Mouth feel</td>
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<tr>
<td>Overall acceptability</td>
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<td>70:30</td>
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<td>colour</td>
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<tr>
<td>taste</td>
<td>0.00</td>
</tr>
<tr>
<td>aroma</td>
<td>0.00</td>
</tr>
<tr>
<td>Mouth feel</td>
<td>0.083</td>
</tr>
<tr>
<td>Overall acceptability</td>
<td>0.00</td>
</tr>
</tbody>
</table>
APPENDIX G: RESEARCH APPROVAL BY GRADUATE SCHOOL BOARD

KENYATTA UNIVERSITY
GRADUATE SCHOOL

E-mail: dean-graduate@ku.ac.ke
Website: www.ku.ac.ke

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 020-8704150

FROM: Dean, Graduate School

TO: Ondiekh Felix Odhiambo
C/o Food, Nutrition & Dietetics Department.

DATE: 5th April, 2016

REF: H60/28766/13

SUBJECT: APPROVAL OF RESEARCH PROPOSAL

We acknowledge receipt of your revised Research Proposal as per our recommendations raised by the Graduate School Board of 30th March 2016 entitled “Nutrient Content and Sensory Attributes of Maize/Mushroom Based Forridge for Use in Complimentary Feeding in Siaya County, Kenya”.

You may now proceed with your data collection, subject to clearance with the Director General, National Commission for Science, Technology and Innovation.

As you embark on your data collection, please note that you will be required to submit to Graduate School completed Supervision Tracking Forms per semester. The form has been developed to replace the Progress Report Forms. The Supervision Tracking Forms are available at the University’s Website under Graduate School webpage downloads.

Thank you

TO: DEAN, GRADUATE SCHOOL

CC: Chairman, Food, Nutrition & Dietetics Department

Supervisors:

1. Dr. Ann Mutyaka
C/o Food Nutrition & Dietetics Department
Kenyatta University

2. Dr. Peter Chege
C/o Food Nutrition & Dietetics Department
Kenyatta University
**APPENDIX H: ETHICAL APPROVAL**

KENYATTA UNIVERSITY
ETHICS REVIEW COMMITTEE

Email: chairman_kuerc@ku.ac.ke
secretary_kuerc@ku.ac.ke
erckud08@gmail.com
Website: www.ku.ac.ke

Our Ref: KU/R/COMM/51/748

Date: 20th June, 2016

Ondieke Felix Odhiambo
Kenyatta University,
P.O Box 43844,
Nairobi

Dear Ondieke,

APPLICATION NUMBER FKU/S02/1598- "NUTRIENT CONTENT AND SENSORY ATTRIBUTES OF MAIZE MUSHROOM BASED PORRIDGE FOR USE IN COMPLIMENTARY FEEDING IN SIAYA COUNTY, KENYA." - VERSION 2

1. **IDENTIFICATION OF PROTOCOL**
The application before the committee is with a research topic, "Nutrient content and sensory attributes of maize mushroom based porridge for use in complimentary feeding in Siaya County, Kenya." - Version 2.

2. **APPLICANT**
Ondieke Felix Odhiambo, Department of Food Nutrition & Dietetics

3. **SITE**
Siaya County, Kenya

4. **DECISION**
The committee has considered the research protocol in accordance with the Kenyatta University Research Policy (section 7.2.1.3) and the Kenyatta University Ethics Review Committee Guidelines AND APPROVED that the research may proceed for a period of ONE year from 20th June, 2016.

5. **ADVICE/CONDITIONS**
   i. Progress reports are submitted to the KU-ERC every six months and a full report is submitted at the end of the study.
   ii. Serious and unexpected adverse events related to the conduct of the study are reported to this board immediately they occur.
   iii. Notify the Kenyatta University Ethics Committee of any amendments to the protocol.
   iv. Submit an electronic copy of the protocol to KU-ERC.

When replying, kindly quote the application number above.

If you accept the decision reached and advice and conditions given, please sign in the space provided below and return to KU-ERC a copy of the letter.

**DR. TITUS KAHIGA**
CHAIRMAN ETHICS REVIEW COMMITTEE

I, [Signature], accept the advice given and will fulfill the conditions therein.

Signature: ___________________________ Dated this day of ___________________________ 2016.

cc: Vice-Chancellor
    DVC-Research Innovation and Outreach
APPENDIX 1: RESEARCH PERMIT

THIS IS TO CERTIFY THAT:
MR. FELIX ODHIAMBO ONDIEK
of KENYATTA UNIVERSITY, 5505-100
Nairobi, has been permitted to conduct research in Siaya County on the topic: NUTRIENT CONTENT AND SENSORY ATTRIBUTES OF MAIZE/MUSHROOM BASED PORRIDGE FOR USE IN COMPLIMENTARY FEEDING IN SIAYA COUNTY, KENYA.

for the period ending: 26th August, 2017

Permit No. : NACOSTI/P/16/19913/13273
Date Of Issue : 29th August, 2016
Fee Received: ksh 1000

Applicant’s Signature:

Director General
National Commission for Science, Technology & Innovation

CONSIDERATIONS
1. You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit.
2. Government Officer will not be interviewed without prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two (2) hard copies and one (1) soft copy of your final report.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice.

RESEARCH CLEARANCE PERMIT

Serial No.: 11827

CONDITIONS: see back page
APPENDIX J: LOCAL ADMINISTRATION PERMIT

REPUBLIC OF KENYA
MINISTRY OF EDUCATION, SCIENCE & TECHNOLOGY
State Department of Education

Telephone: COUNTY DIRECTOR OF EDUCATION
Fax: SIAYA COUNTY
COUNTY DIRECTOR OF EDUCATION
SIAYA COUNTY
P.O. BOX 564
SIAYA

When replying please quote
Ref. SCA/10/VOL I Monday, November 28, 2016

TO WHOM IT MAY CONCERN

RE: RESEARCH AUTHORIZATION: FELIX ODHIAMBO ONDIEK

The above mentioned has been mandated to carry out research in Siaya County vide an authorization letter from National Commission for Science, Technology and Innovation Ref. No.NACOSTI/P/16/19913/13273 dated 29th August, 2016

The research title is “Nutrient content and sensory attributes of maize/mushroom based porridge for use in complimentary feeding in Siaya County, Kenya”

Kindly accord him the necessary assistance.

Thank you

FOR:
COUNTY DIRECTOR OF EDUCATION
SIAYA COUNTY
P. O. Box 564 • 40600, SIAYA

SAMPLUEL C. ONDIEKI
FOR: COUNTY DIRECTOR OF EDUCATION
SIAYA COUNTY

Our Vision: To have a globally competitive quality education, training and research for Kenya’s sustainable development
APPENDIX K: LOCAL RESEARCH PERMIT

REPUBLIC OF KENYA

THE PRESIDENCY
MINISTRY OF INTERIOR & CO-ORDINATION OF NATIONAL GOVERNMENT

Office of the
County Commissioner
SIAYA COUNTY
P O Box 83
SIAYA

E-Mail cc.siaya@yahoo.com
When replying please quote

CC/SC/A.31/(103)

28th November, 2016

Deputy County Commissioners
SIAYA COUNTY

RE: RESEARCH AUTHORIZATION – FELIX ODHIAMBO ONDIEK

The person referred to above from Kenyatta University has been authorized by the Director-General/CEO, National Commission for Science, Technology and Innovation to carry out research on "Nutrient content and sensory attributes of maize/mushroom based porridge for use in complimentary feeding in Siaya County," for the period ending 26th August, 2017.

The purpose of this letter therefore is to ask that you accord him the necessary support as he carries out the research in your Sub Counties.

FAITH N. NJANG'I
For: COUNTY COMMISSIONER
SIAYA COUNTY

Copy to: Felix Odhiambo Ondiek
APPENDIX L: PHOTO GALLERY

1. Solar-dried mushroom samples ready for milling

2. Sample extraction for HPLC analysis
3. HPLC analysis – Injecting samples into the HPLC Column

3. HPLC Analysis – Placing samples into the auto-sampler
4. HPLC Analysis: Preparation of standard curves

5. Sample extraction in the fumehood
6. AAS Analysis – Replacing the hollow cathode lamp