DEVELOPMENT OF EXTRUDED INSTANT MIXED MUSHROOM SOUP

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EXTENDED ABSTRACT

A study was conducted to develop extruded instant mixed mushroom soup supplemented with banana, soybean and orange fleshed sweet potatoes. The nutritional qualities, physical properties, sensory acceptability and the shelf life of the developed product were evaluated. Proximate compositions were determined to evaluate the potential of the product to supply energy and required nutrients. Moisture, ash, protein, fiber, ether extract, carbohydrate and energy content ranged from 4.41% to 9.61%, 2.91% to 3.81%, and 34.46% to 35.45%, 2.10% to 2.35%, 18.14% to 19.16%, 30.02% to 36.46%, and 432.72 to 444.31 kcal/100 g, respectively. The colour values were significantly different between all samples, angle of repose was 41.39 to 50.19º and viscosity was 15-29mPa.s. Results indicated that as the amount of soybean flour increased, the appearance of the instant mixed mushroom soup changed favorably in terms of colour, angle of repose and viscosity. The formulations were good in sensory quality and were highly acceptable with sample C being the most acceptable, followed by sample A. Sample B was the least acceptable by consumers. Formulation C composed of Mushroom (8%), Banana (17%), Soybean (70%) and OFSP (5%), provide 444.31kcal/100g energy and 34.46% protein was nutritionally superior and sufficient to meet day-to-day nutritional requirements as a food supplement. The study indicated that instant mixed mushroom soup can be safely stored for less than one month after being opened. Preparation of this instant mixed mushroom soup is so easy that it can be termed as convenient healthy mixed soup.

DECLARATION

I, AFRAIDAY RICHARD KAKIGWA, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my original work done within registration period and that it has neither been submitted nor been concurrently submitted in any other institution.

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Prof. Bendantunguka P. Tiisekwa Date

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DEDICATION

This work is dedicated to my Kakigwa's Family who made the foundation of my education and to all orphans children.

TABLE OF CONTENTS

LIST OF TABLES

TABLES IN MANUSCRIPT I

TABLES IN MANUSCRIPT II

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS AND ACRONYMS

ADF	Acid Detergent Fiber
ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
BRAT	Bananas Rice Applesauce Toast
CF	Crude Fat
CP	Crude Protein
DM	Dry Matter
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
g	gram
HTST	High Temperature Short Time
ISO	International Organization for Standardization,
KCAL	Kilo calories
MT	Metric tons
NBS	National Bureau of Statistics
NDF	Neutral Detergent Fiber
OFSP	Orange Fleshed Sweet Potatoes
PC	Principal Component
QDA	Quantitative Descriptive Analysis
RPM	Revolution per Minute
SUA	Sokoine University of Agriculture
TBS	Tanzania Bureau of Standards
TZS	Tanzania Shillings
UNU	United Nations University
WHO	World Health Organization

WSI	Water Solubility index

CHAPTER ONE

1.0 INTRODUCTION

1.1 Importance of Mushroom

Mushrooms are regarded as a macro-fungus with a distinctive fruiting body which is large enough to be seen with the naked eyes and to be picked by hand (Chang and Miles, 1992). Mushrooms are important constituents of minor forest produce; they offer tremendous applications and can be used as food or medicines (Bilal *et al*., 2010). Mushrooms represent one of the world's greatest untapped resources of nutrition and palatable food.

More than 3000 mushrooms are said to be "the main edible species", of which only 100 are cultivated commercially and only ten of those on an industrial scale (Reis *et al*., 2012). Their global economic value is blooming due to rise in consumption as a food, medicinal and nutraceutical values (Chang and Miles, 2004). Production of mushrooms continuously increases over time, China is the largest producer of edible mushrooms. Global mushroom productions were over 10 million tons in 2017 (FAOSTAT, 2017).

The most cultivated mushroom varieties are *Agaricus bisporus, Lentinula edodes, Pleurotus* spp. and *Flammulina velutipes* (Reis *et al*., 2012). These species grow very fast and require little space and environmental control (Bonatti *et al*., 2004). Mushrooms have been found to be effective against cancer, cholesterol reduction, stress, insomnia, asthma, allergies and diabetes (Bilal *et al*., 2010). Due to high amount of proteins, they can be used to bridge the protein malnutrition gap. Also can be used as nutrient supplements, and suitable for diabetic and heart patients (Bilal *et al*., 2010). Mushrooms also, have wider biological properties such as antibacterial, antimutagenic, anticancer and antiviral activities (Garcia-Lafuentea *et al*., 2010; Schillaci *et al*., 2013).

1.1.1 Nutritional composition of mushroom

Mushroom (*Pleurotus ostreatus*), oyster mushrooms are healthy foods, low in calories and fat, rich in protein, chitin, vitamins and minerals, also contain significant amounts of γ-amino butyric acid (GABA) and ornithine (Genenu *et al*., 2017). Due to high nutrient dense, mushrooms can used as substitute of meat, fish, fruits and vegetables (Kakon *et al*., 2012). It represents an excellent source of protein, vitamins (B1, B2, niacin, C, folic acid, and provitamin D ergosterol), dietary fibers, minerals (P, K, Na, Ca and Fe) and low in fat (Moharram *et al.*, 2008). On dry matter basis, mushrooms contain about 39.9 % carbohydrate, 17.5 % protein, 2.9 % fats, the rest being fiber and minerals (Demirbaş, 2001). According to Yasmin *et al*. (2015) dried mushrooms contains about 13.25% moisture content 35.67%, protein 3.28% fat, 7.80%, ash 53.20% carbohydrates and about 3.87 mg/100g of vitamin C. and in powder form, mushroom contains moisture content of 11.5±0.1%, ash 7.6±0.06%, protein 31.3±0.6%, fat 2.2±0.1%, fiber 9.76±0.04%, carbohydrate 37.98±0.61%, and energy 296.93±0.81kcal (Genenu *et al*., 2017). It is a unique plant food in that it is very low in carbohydrates making them ideal for diabetic patients. Therefore, mushrooms can be a good supplement to cereals (Chang and Buswell, 1996) and are used in various sausages, vegetables, health drinks, soups, cake and bakery products.

1.2 Banana and its Nutritional Composition

Banana (*Musa paradisiaca*) is the fourth most important staple crop in the world. The current global production of bananas grew at annual rate of about 3.2% percent, reaching a record of 114 million tonnes in 2017 (FAO, 2018). Tanzania is one among the biggest producer in Africa. In Tanzania, banana production is predominant in the Eastern zone (Mkuranga and Morogoro districts), Northern zone (Moshi rural and Arusha districts), Southern Highlands (Rungwe and Ileje districts) and Lake Zone (Kagera Region) (Anon, 2002; Nkuba and Mgenzi, 2003). In 2014, Tanzania produced 3.2 MT of banana (FAOSTAT, 2017), which is the main staple food for 20 to 30% of the population and play a key role in food security (Ndunguru, 2009).

Bananas are an excellent source of potassium (Sampath *et al*., 2012). Potassium benefits the muscles as it helps maintain their proper working and prevents muscle spasms. Bananas are the best food to infants because are easy to digest and have a little allergic reactions. Also are excellent source of vitamins, including vitamin A that aids in healthy teeth, bones, and soft tissue. It also contain vitamin B6 that boost body's immune system, promotes brain and heart health. While vitamin C helps in healing, growth of tissue, and ligaments and vitamin D helps body to absorb calcium.

Bananas are part of the BRAT (Bananas Rice (or other starchy food) Applesauce Toast) diet, a diet many physicians recommend for children recovering from gastrointestinal problems, particularly diarrhea (Sampath *et al*., 2012). Bananas vary in composition, however, the average chemical composition (% dry matter) of the flours are: protein, 44.14±0.07, lipids 0.453±0.009, ash, 1.084±0.06, carbohydrate 86.92±0.08 and total fiber 8.49±0.67 (Bezerra *et al*., 2013).

1.3 Soybean and Its Nutritional Composition

Soybean (*Glycine max* L.) is a species of legume native to East Asia, is recognized as an oil seed containing several useful nutrients including protein, carbohydrate, vitamins, and minerals (Hassan, 2013). Soybean protein is one of the least expensive sources of dietary protein (Hassan, 2013) and a good substituent for animal protein (Sacks *et al*., 2006) and their nutritional profile except sulfur amino acids (methionine and cysteine) is almost similar to that of animal protein because soybean proteins contain most of the essential amino acids required for animal and human nutrition. The soybean flour contains 13.3% protein, 1.6% fat and 33% crude fiber (Hassan, 2013). These remarkable properties of soybean make it an ideal choice of supplementary foods. Generally, on a dry matter basis, soybean seeds content 5.6-11.5% of water, 32 to 43.6%, crude protein 15.5 to 24.7%, fat 4.5 to 6.4%, crude ash 10 14.9%, neutral detergent fiber (NDF), 9 to 11.1%acid detergent fiber (ADF) and 31.7 to 31.85% carbohydrates (Poultry Feeding Standards, 2005).

1.4 Orange Fleshed Sweet Potatoes and its Nutritional Composition

Orange -Fleshed Sweet Potatoes (OFSP) (*Ipomoea batatas* Lam) is an important tuber crop grown in the tropics, sub-tropics and warm temperate regions of the world (Honi *et al*., 2016). Sweet potato ranked seventh most important food crop of the world after wheat, rice, maize, potato, barely and cassava (CIP, 2017). More than 105 million metric tons were produced globally each year 95% of which are grown in developing countries (CIP, 2019). The sweet potato is grown in all East Africa countries. Sweet potato production was reported to be 112.8 million tons (in 115 countries) in 2017 and China is the leading producer, followed by Nigeria and Tanzania, Indonesia and Uganda (FAOSTAT, 2019).

Sweet potatoes are rich source of starch, sugars, minerals and vitamins (Mitra *et al*., 2012). Beta-carotene is the major pro-vitamin A carotenoid and the dominant carotenoid in Orange-Fleshed Sweet Potatoes (OFSP) (Low *et al*., 2007). Being rich in β-carotene, the orange fleshed sweet potato is gaining importance as the cheapest source of antioxidant having several physiological attributes like anti-oxidation, anti-cancer and protection against liver injury and is most suiting as biofortified crop to combat malnutrition in small and marginal farming community (Mitra *et al*., 2012). Orange fleshed sweet potato has considerable potential to contribute to a food based approach to tackle the problem of vitamin A deficiency. Pro-vitamin A is largely retained when boiled, steamed, or roasted is highly encouraged for consumption as an alternative source of Vitamin A (Low *et al*., 2007). On dry basis, it contains moisture (10.97±0.95%), ash (2.11 ±012%), protein (4.80 ± 0.24%), fats (0.39 ± 0.03%), starch (33.66 ± 3.76%), crude fiber (2.57 ± 0.14%) and total carbohydrates (90.13%) (Rodrigues *et al*., 2016).

1.5 Extrusion and Extrusion Cooking

Extrusion is a process which combines several unit operations including mixing, cooking, kneading, shearing, shaping and forming. Extrusion is the most common method of preparing snacks, pasta and ready-to-eat foods as a means of improving the nutrient profile for example increasing levels of dietary fiber, increase digestibility and enriching foods with nutrients such as lycopene (Honi *et al*., 2016; Dehghan-Shoar *et al*., 2010).

Extrusion cooking is defined as a high-temperature-short-time (HTST) cooking process, which involves the cooking of ingredients in the extruder barrel, by a combination of high pressure, heat and friction to produce highly expanded, low-density products with unique characteristics (Pansawat *et al.,* 2008). The main advantages of extrusion are environmentally friendly (produces little process effluents) and can be operated continuously with high throughput (Guy, 2011).

In addition, extrusion process denatures undesirable enzymes and proteins, inactivates some anti-nutritional factors, sterilizes the finished product, gelatinization of starch, partial dextrinization of starch; and retains natural colours and flavours of foods (Anounye *et al*., 2012; Pathania *et al*., 2013).

1.6 Characteristics of a Good Soup Powder

A good soup powder should be re-hydratable and cookable within minimum time, retaining nutrients and palatability almost similar to the freshly cooked product (Abeysinghe and Illeperuma, 2006). Also, it should be cost effective, storage stable; show no sign of caking, the presence of which decreases the consumer acceptability (Prasad and Singh, 2014). Higher water activity accelerates caking phenomena and leads to increase in lipid oxidation, enzymatic activity, microbial growth and thus deteriorates faster. Intrinsic as well as extrinsic factors largely affects the caking phenomenon (Prasad and Singh, 2014). Higher temperature and water activity also affect the optical characteristics and decides the sensory acceptability of powdered mix.

1.7 Characteristics of the Formulated Soup Mix

According to Niththiya *et al*. (2014), the optimum condition for the reconstitution of formulated soup mix powder using uncooked palmyrah (*Borassus abellifer*) tuber flour and locally available vegetable was evaluated by conducting preliminary trials. Initially, known weights of soup mix samples (40g) were taken and mixed with different amounts of water (400, 500 and 600ml) separately and heated for 5 minutes in a hot plate. The appearance and consistency of soup were observed by a panel. Among the different ratio of reconstitution soup mix to water (1:10, 1:12.5. 1:15) the ratio of 1:12.5 was widely accepted by the panel of judges as the optimum level of reconstitution for both vegetable and prawn added soup mixes.

According to Krishna (2015) on development and shelf life evaluation of soup powder prepared by incorporation of white button mushroom (*Agaricus bisporus* L.), for reconstitution 100 g of soup powder was mixed with 650 ml of cold water and this mixture was brought to boil and simmered for 10-15 min, found that the reconstituted mushroom soup was acceptable, with an overall acceptability score of 7.1 on a nine-point hedonic scale.

1.8 Problem Statement and Justification

Nutrient intake directly affects the nutritional status of a person, that mean if the amount of intake of nutrients increased, then the nutritional status will also increase. Children is the most important part of the society which is vulnerable and needs very careful nurturance (Gulati, 2010). Age in physiologically normal human beings also affects the increase in food consumption, so the amount of nutrient intake also increases (Ambarsari, *et al.*, 2009) which means breast milk is adequate to meet the energy and nutrient requirements of an infant up to six months of age; thereafter, it is insufficient to sustain normal growth because the baby's energy requirement increase by 24-30% compared with energy at 3-5 months of age (Andarwulan and Hariyadi, 2014) thus, baby require complementary foods to meet its energy and growth requirement (Baxter, 2005). An ideal complementary food must be nutrient dense, easily digestible, of suitable consistency and affordable to the consumers. Therefore, there is a need to apply other processing technologies other than traditional methods to prepare complementary foods that are nutrient dense, relatively safe, ready-to-feed "instant" thereby reducing maternal workload in preparing meals several times in a day.

According to the Food and Agriculture Organization (FAO, 2012) an estimated 12 million children below the age of 5 (five) years die annually over 50% of all these cases attributed to malnutrition. Development of nutritious supplementary foods is among the method to combat malnutrition among children. The balanced status of protein, fat, carbohydrate, minerals, vitamins, amino acids and active ingredients in mushroom makes it an ideal choice for food supplementation. Considering to their high nutritional quality and local availability, banana, soybean and orange fleshed sweet potatoes would be good choice of nutrient sources for enriching mushroom. Several studies have been conducted on development of instant soup. A study on development and shelf life evaluation of soup powder prepared by incorporation of white button mushroom (*Agaricus bisporus* L.) whereby wheat flour and skimmed milk powder were mixed and fat was melted and mixed (Krishan, 2015). Formulation and nutritional evaluation of a healthy vegetable soup powder supplemented with soy flour, mushroom and moringa leaf has also been reported by Tasnim *et al.* (2017). There is limited reported work on formulation of instant soup that incorporates locally foods with high nutrient content. This study aiming to overcome the available challenge through development of instant mushroom soup supplemented with banana, soybean and orange fleshed sweet potatoes, and evaluates nutritional contents, consumer acceptability (sensorial properties), physical properties and shelf life of the developed product. Furthermore, it will facilitate to increase the availability of nutritious food in the market hence enable wider choice by consumer.

1.9 Objectives

1.9.1 Overall objective

The main objective of this study was to develop extruded instant mixed mushroom soup supplemented with banana, soybean and orange fleshed sweet potatoes.

1.9.2 Specific objectives

i. To formulate three samples of instant mushroom soup for nutritional qualities.
ii. To compare sensory acceptability of the developed products.
iii. To determine physical properties of developed products.
iv. To assess the shelf life of the developed products.

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CHAPTER TWO

MANUSCRIPT I

2.0 Nutritional Qualities and Storage Stability of Formulated Instant Mixed Mushroom Soup

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2.1 Abstract

Instant food products are convenience foods which are hygienic, free from microbial contamination and also convenient to prepare. This study involved formulation of three sample of extruded instant mixed mushroom soup supplemented with banana, soybean and orange fleshed sweet potatoes. Formulation was done to provide the highest possible amino acid score (>65%) according to the recommendation by WHO/FAO/UNU (2007). Proximate compositions were determined to evaluate the potential of the product to supply energy and nutrients required. Moisture, ash, protein, fiber, ether extract, carbohydrate and energy content ranged from 4.41% to 9.61%, 2.91% to 3.81%, and 34.46% to35.45%, 2.10% to 2.35%, 18.14% to 19.16%, 30.02% to 36.46%, and 432.72 to 444.31 kcal/100 g, respectively. Samples were stored in low density polyethylene bags under at a room temperature 25±3^{0}C and evaluated for storage stability using moisture, colour change and mould growth parameters. The results showed that after 1 month there were overgrowing of mould to all samples which cause those parameter fails to be analysed for shelf life determination. The products were physically and chemically acceptable for a period of one months. When compared to locally available soup powders

the developed mushroom-banana-soybean-orange fleshed sweet potato instant soup powder was nutritionally superior and sufficient to meet day-to-day nutritional requirements as a food supplement.

2.2 Introduction

After the period of exclusive breastfeeding (six months), children have a high demand for nutrient, usually provided as complementary foods (Dewey, 2001). Complementary foods need to be rich in calories and nutrients and must be highly digestible and bioavailable. Traditional complementary foods in Tanzania are based on starchy staples, usually cereals such as maize, rice, sorghum and finger millet and non-cereals such as cassava, sweet potatoes, yams, bananas and plantains (Mosha *et al*., 2000). Such foods are usually low in high quality protein and micronutrients (Kikafunda *et al*., 2006). Over dependence on low quality protein diet is the main cause of protein-energy under-nutrition n hidden hunger in both developing and developed countries. Major food-related causes of malnutrition include inadequate feeding, foods with low energy and nutrient density, low bioavailability of nutrients, poor access to food, use of poor processing methods and microbial contamination (Ijarotimi and Ashipa, 2005).

Legumes is one among important nutritious diet in developing countries due to its availability and a rich source of high quality protein, especially lysine (Ofuya and Akhidue, 2006). The use of such inexpensive, high quality protein diet is highly recommended for combating protein-energy deficiency and improving nutritional status of general public in developing countries (Shiriki *et al*., 2015). This work aimed to formulate a nutritious and acceptable mushroom-banana-soybean-orange fleshed sweet potato instant soup and evaluating its nutritional composition and storage stability.

2.3 Materials and Methods

2.3.1 Samples

Oyster mushrooms were purchased from farmer in Morogoro, soy bean (yellow bean), green banana (Genomic group AAA), orange fleshed sweet potatoes (garnet yam) and packing bags were purchased from the local market in Morogoro Municipal Tanzania.

2.4 Sample Preparation

2.4.1 Preparation of ingredients for the formulation of the mushroom-banana-soybean-orange fleshed sweet potato instant soup.

2.4.1.1 Preparation of mushroom flour

Mushroom flour was prepared according to Genenu *et al*. (2017). Clean and fresh mushrooms were chopped to about 2 cm and blanched in hot water (100°C) for 3 minutes. Then water was drained and mushroom dried in air conventional dryer 65°C for 48 hours. After drying, the pieces were allowed to cool and blending by using a duty heavy blender into fine powder (pass through 0.5 mm sieve size) and stored in polythene packet at a room temperature.

2.4.1.2 Banana flour preparation

Banana flour was prepared according to Tribess *et al*. (2009). Bananas (Genomic group AAA) were peeled, washed in water (which contain salt to reduce browning) and cut into 5 mm slices using stainless steel knives. Then banana slices were placed in trays and dried in air conventional dryer at a temperature of 60°C for 24 hours. Dried banana chips were milled by milling machine into flour to pass through1 mm mesh sieve and stored in polythene packet at room temperature.

2.4.1.3 Preparation of orange fleshed sweet potato (OFSP) flour

OFSP tubers were washed with clean water to remove soil and dirt and then peeled using a kitchen knife, then chopped to about 0.2-0.4 cm width, 2-5 cm length and 0.1-0.3 cm thick and dried in air conventional dryer at 65˚C for 48 h. The dried chips were milled into flour to pass through 0.8 mm mesh screen then stored in polythene packet at room temperature (Rodrigues *et al.*, 2016).

2.4.1.4 Preparation of soybean flour

Soybean grains were treated to inactivate lipoxygenase, by immersing them in boiling water for two minutes followed by cooling with tap water. Then, they were dehulled by using dehulling machine and dried in air conventional dryer (65°C for 72 h) and then milled using milling machine into fine flour and pass at 1 mm sieve then stored in polythene packet at room temperature

2.4.1.5 Product formulation

The samples were combined in proportions that provided the highest possible amino acid score>65%) according to the recommendation by WHO/FAO/UNU (2007). Initially three samples of mushroom instant soups were formulated, as indicated in Table 2.1.

Table 2.1 Proportions (g/100g) of ingredients in the tested formulations for mushroom banana-soybean-orange fleshed sweet potato instant soup samples

Ingredient	**Sample A (%)**	**Sample B (%)**	**Sample C (%)**
Mushroom	5	11	8
Banana	10	5	17
Soybean	80	75	70
OFSP	5	9	5
Total	**100**	**100**	**100**

Sample A= mushroom 5%, banana 10%, soybean 80% and OFSP 5%, sample B= mushroom 11%, banana 5%, soybean 75% and OFSP 9%, sample C= mushroom 8%, banana 17%, soybean 70% and OFSP 5%

2.4.1.6 Extrusion of mixed ingredients

Extrusion of the composite product was carried out in a commercial twin-screw extruder (Model JS 60 D, Qitong Chemical Industry Equipment Co. Ltd, Yantai, China). Prior to extrusion, mixed flour samples were conditioned with water to moisture content of 21%. The mixed flour sample was extruded at temperatures of 134^{o}C for zone 1 and 103^{o}C for zone 2, motor speed was 24.76 rpm and feeder speed rate of 10.76 rpm. After extrusion, the extrudates were allowed to cool at room temperature and thereafter milled using milling machine (sieve size- 1mm) to obtain extruded flour. Extruded flour was packaged in polyethylene packets and kept at a room temperature 25±3^{0}C until the analysis were completely especial shelf life analysis.

2.5 Proximate Composition

The proximate composition including dry matter, ash content, crude protein, crude fiber, crude fat and carbohydrates of the extruded product were determined according to Association of Official Analytical Chemists (AOAC) (2005). The results were presented as an average of duplicate determinations.

2.5.1 Dry matter

Dry matter was determined by oven drying method 925.10 (AOAC, 2005). One gram of each sample was dried for 24 hours in a conventional oven set at 105^{o}C to constant weight. The samples were dried in pre-dried and pre-weighed crucibles. Dry matter was obtained by taking the difference between weight of the samples before and after drying. The difference obtained was expressed as percent dry matter with respect to original amount of the samples taken.

$$\%Dry\ matter = \frac{(C-B)}{A} x\ 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

Where: A = Weight of the sample taken (g)

B = Weight of crucible (g)

C = Weight of crucible and dry sample (g)

(C-B) = Weight of dry sample (g)

2.5.2 Ash content

Determination of ash content of extruded flour was done according to AOAC (2005) method 923.03. One gram of dry sample were placed into a pre-heated and pre-weighed crucible and incinerated in a muffle furnace set at 550^{o}C for 24 hours until grey ash was obtained. Percent ash content was calculated by expressing in percentage the ratio of weight of ash (g) and weight of dry sample (g); whereby weight of ash was the difference between the weights of samples before and after incineration.

$$Ash(\%DM) = \frac{weight\ of\ ash\ (g)}{weight\ of\ dry\ sample(g)} x\ 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(ii)}$$

2.5.3 Crude protein

Crude protein content of the samples was determined using the micro-Kjeldahl method 920.87 (AOAC, 2005). The dried sample 0.5 g were weighed and transferred into 250 mL digestion tubes; 0.6g of catalyst (mixture of 10g K_2SO_4, 0.5g $CuSO_4$), 6 mL of concentrated H_2SO_4 were added to each tube. Samples were digested using Tecator digestion system 40 (Model 1016 digester, Sweden) for 1 hr to obtain a clear greenish solution. The digest was cooled and mounted in the distillation unit (Foss Tecator, Model 2200 Kjeltec auto distilling unit, Sweden). The distilled water, 75 mL was added to the digest followed by 70 mL of 40% NaOH and steam distilled for 4min. The distillate, 50 mL was collected in conical Erlenmeyer flask containing 25 mL of 4% boric acid. The distillate was thereafter titrated with 0.105g/100 mL hydrochloric acid. The blank volume was also determined.

$$\%Nitrogen = \frac{14.01x(titre-blank\ )mL\ xconcentration\ of\ acid\ in\ n/mol}{weight\ of\ sample(g)x1000} x100 \ldots\ldots\ldots\ldots\ldots (iii)$$

$$\%\ CP = \%Nitrogen\ x\ 6.25 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (iv)$$

2.5.4 Crude fiber

Crude fiber was determined by using AOAC (2005) official method 920.86. Ankom fiber analyzer (Model ANKOM 220, USA) was used to determine crude fiber. One (1.0) g of sample was digested in the fiber analyzer by dilute sulphuric acid (0.125M H_2SO_4) for 30 min and washed with hot distilled water. The residues were then digested by dilute alkali (0.125 M KOH) for 30 min and washed with distilled hot water. Digested residues were dried in an oven set at 105^0C for 4 hours, then cooled in a desiccator and weighed. The residues were then placed in muffle furnace and incinerated at 550^oC for 3h, cooled and weighed again. Total fiber content was taken as the difference between the residues before and after Incineration.

$$\%C.F. = \frac{(\text{Weight of sample residues before incineration} - \text{Weight after})g}{\text{Weight of dry sample taken for determination}(g)}\ x\ 100 \ldots\ldots\ldots\ldots\ldots (v)$$

2.5.5 Crude fat

Determination of crude fat was done by using Soxhlet ether extraction AOAC method 945.87 (AOAC, 2005). The dry sample (3 g) was placed into the extraction thimble and assembled to the soxhlet apparatus. The petroleum ether 60 mL of was used for continuous reflux for 55min in three phases, the boiling phase for 15min, the fat extraction phase for 30 min and petroleum ether recovery phase for 10 min. Petroleum ether was then recovered by evaporation. Pre-weighed cups containing fat were dried in an oven at 105^oC for 30 min to evaporate any remaining petroleum ether, cooled in a desiccator for 20 min and weighed.

Percentage fat was calculated by using the formula:

$$\% \, Crude\ fat = \frac{Weight\ of\ crude\ fat(g}{Weight\ of\ dry\ sample\ (g)}\ x\ 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.... \text{(vi)}$$

2.5.6 Carbohydrate

Carbohydrate was calculated as a percentage difference using the formula:

% Carbohydrate = 100 % – (% protein + % crude fiber + % crude fat + % Ash)…..... (vii)

2.5.7 Energy

The energy content was calculated using the Atwater's conversion factors. Thus energy values were obtained by multiplying % fat by factor 9 and % protein and % carbohydrate by factor 4 each (AOAC, 2005).

Energy content = [(%Carbohydrate x 4) + (%Fat x 9) + (%protein x 4)] ……….......(viii)

2.6 Storage Studies

Instant mixed soup mixes were packed in polythene bags. Samples were stored at room temperature (25±3^{0}C) for shelf life estimation over a period of 4 months and the product was evaluated for moisture content as per standard methods of AOAC (2005), colour change and mould growth using ISO 21527-1 (2008).

2.7 Results and Discussions

Chemical composition of developed extruded instant mixed mushroom soup supplemented with banana, soybean and orange fleshed sweet potatoes (g/100g dry weight) is summarized in Table 2.2. The composition was compared with the guidelines on formulated complementary foods for older infants and young children (CAC/GL 8-1991) indicated in (Table 2.2).

Table 2.2: Guidelines on formulated complementary foods for older infants and young children

Characteristics	Requirements
Energy	At least 4 kcal
Protein	6-15% of the total energy
Fat	At least 10g
Dietaryfiber	Not exceeding 5g
Vitamin A	400µg
Vitamin D18	5µg
Vitamin E	5 mg
Vitamin C	30 mg
Thiamine	0.5 mg
Riboflavin	0.5 mg
Niacin NE	6 mg
Vitamin B_6	0.5 mg
Folate DFE	150µg
Vitamin B_{12}	0.9µg
Biotin	8 µg
Pantothenic	8 µg
Vitamin	2 mg
Calcium	15 µg
Iron	11.6, 5.8, 3.9
Zinc	8.2, 4.1, 2.4
Iodine	90µg
Copper	0.34 mg
Selenium	17µg
Magnesium	60 mg
Manganese	1.2 mg
Phosphorus	460 mg

Source: CAC/GL 8-1991

2.7.1 Proximate compositions of the developed extruded instant mixed mushroom soup supplemented with banana, soybean and orange fleshed sweet potatoes

The moisture, ash, protein, fiber, fat, carbohydrate and energy content for the three formulations ranged from 4.41% to 9.61%, 2.91% to 3.81%, 34.46% to 35.45%, 2.10% to 2.35%, 18.14% to 19.16%, 30.02% to 36.46% and 432.72 to 444.31 kcal/100 g, respectively (Table 2.3). The protein and energy contents were found slightly higher than the results of Tasnim *et al.* (2017).

Table 2.3: Proximate composition (g/100 g DM) and energy content (kcal/ 100 g) of extruded instant mixed mushroom soup

Nutrients	Instant soup mix		
	Sample A	Sample B	Sample C
Moisture	4.41	9.61	7.73
Ash	3.29	3.81	2.91
Crude protein	35.45	35.05	34.46
Crude fiber	2.25	2.35	2.10
Crude fat	18.14	19.16	18.95
Carbohydrates	36.46	30.02	33.98
Energy	438.9	432.72	444.31

Sample A= mushroom 5%, banana 10%, soybean 80% and OFSP 5%, sample B= mushroom 11%, banana 5%, soybean 75% and OFSP 9%, sample C= mushroom 8%, banana 17%, soybean 70% and OFSP 5%

2.7.2 Moisture

The moisture content of the three sample (A, B and C) were 4.41%, 9.61% and 7.73% respectively. The lowest moisture content was found in sample A (4.41%) and highest was found in sample B (9.61%). Moisture content is an important factor in maintaining food quality because increase in moisture facilitates the growth of microbes and reduce quality. When moisture is above 18%, some microorganisms may be reproduced gradually. However, in case of dried materials, moisture content less than 10% is considered as more proper for keeping quality of soup ingredients (El Wakeel, 2007). The results obtained in this study shows to be less than 10% which is a good indication for storage stability. Moreover, the moisture content of the developed soup was higher compares to the report study of Tasnim *et al.* (2017) which ranged from 2.83% to 5.46%.

2.7.3 Ash

The ash content of the three sample (A, B and C) were 3.29%, 3.81% and 2.91% respectively. The level of ash in food is an important nutritional indicator for mineral density but also a quality parameter for contamination, especially with foreign matter

(Fennema, 1996). The ash content of the developed instant mixed mushroom soup formulations were found to be higher than that of the results of other studies (Krishna, 2015; Singh, 2014). Higher values obtained in our formulations may be due to the incorporation of soy flour and mushroom that are good sources of minerals. This reasoning is supported by other studies (Ayo *et al.*, 2014; Farzana and Mohajan, 2015; Tasnim *et al.,* 2017). The obtained higher ash content of the developed soup product suggests that it may contain higher minerals contents.

2.7.4 Crude protein

The protein content of the three sample (A, B and C) were 35.45%, 35.05% and 34.46% respectively. According to the CAC/GL 8–1991, protein should be range from 6-15% of the total energy. The results shows that all the formulated samples had meet the recommended protein of which is not less than 6% but not higher than 15% of the total energy. Protein is an essential macronutrient for the growth and maintenance of the body (FAO/WHO/UNU, 1985). The protein content of the developed soup shows higher values than that of the results of other studies (Carvalho *et al.,* 2013; Kaur and Das, 2015; Neeraj *et al*., 2017; Niththiya *et al.,* 2014; Tasnim *et al.,* 2017). This result is supported by the finding of other studies where incorporation of soy flour, mushroom was found to increase the protein content (Ayo *et al*., 2014; Farzana and Mohajan, 2015). Soybean is a good source of protein and an excellent complement to lysine-limited cereal protein (Garg *et al.,* 2014). Mushroom is also a good source of high-quality protein (Singh *et al*., 1995).

2.7.5 Crude fiber

The fiber content of the three sample (A, B and C) were 2.25%, 2.35% and 2.10% respectively. For children, dietary fiber is recommended to be low so as to increase energy density. According to Codex Almentarious Comission (CAC/GL 8–1991) recommendation, fiber intake for children should not exceed 5g per 100 g of food on dry weight basis. The results show that all the formulated samples were within the recommended level set by CAC/GL 8 – 1991. The highest fiber content was found in the developed instant mixed mushroom soup than the results reported by other researchers (Krishan, 2015; Singh, 2014; Tasnim *et al.*, 2017). The highest fiber content in the developed soup may be due to inclusion of soy flour and mushroom as supported by other studies (Farzana and Mohajan, 2015; Ndife *et al.*, 2011). Moreover, an extraordinarily high or appreciable level of total fiber was reported for mushroom (Manzi *et al.*, 2004). Dietary fiber plays an important role in the prevention of several diseases such as cardiovascular diseases, diverticulosis, constipation, irritable colon, cancer and diabetes (Elleuch *et al.*, 2011). However, too much of it for older infants and young children may increase dietary bulkiness, hence limiting adequate food intake by infants and young children so as to increase energy density (FAO, 1985).

2.7.6 Crude fat

The crude fat content of the three sample (A, B and C) were 18.14%, 19.16% and 18.95% respectively. According to the CAC/GL 8-1991, fat should be at least 10g in this study, fat content were higher than the recommended fat but is still acceptable. The crude fat content of the developed soup shows higher than other studies (Abdel- Haleem and Omran, 2014; Kaur and Das, 2015; Niththiya *et al.*, 2014; Tasnim *et al.*, 2017). Soy flour contains 18% of fat (Kundu *et al.*, 2011). The two polyunsaturated fats that are found in soy flour, including the two essential fatty acids, linoleic and linolenic, assist in the absorption of vital nutrients that are required for human health (Hegstad, 2008). Fats also increase the energy density of food. However, too much fat is not recommended as it dilutes the density of protein and micronutrients per 100 kcal (Innis, 1991). Children with moderate malnutrition, especially those who are moderately wasted, have increased needs for energy for catch-up growth. They thus require a diet with high energy density. Therefore a diet with high fat content is likely to be beneficial for acute malnourished children.

2.7.7 Carbohydrate

The carbohydrate of the three sample (A, B and C) were 36.46%, 30.02% and 33.98% respectively. A carbohydrate is an important source of energy in diet. It includes sugars or polymers of sugar such as starch that can be hydrolyzed into simple sugars. The carbohydrate of the developed product were lower than the results of other researchers (Abeysinghe and Illeperuma, 2006; Kaur and Das, 2015; Neeraj *et al*., 2017; Niththiya *et al.,* 2014). Extrusion has been associated with increased carbohydrate content due to starch degradation into dextrin and simple sugars like free glucose (Yusuf *et al.,* 2018). A decrease was observed as the proportions of soya bean were added. This agrees with Sefah-dedeh *et al*. (2001) who reported that legumes addition reduces carbohydrate content of cereal based formulation.

2.7.8 Energy value

The energy value of the three sample (A, B and C) were 438.9, 432.72 and 444.31 (kcal/100 g) respectively. The recommended energy value by CAC/GL 8–1991 should be at least 4 kcal in which the results shows that all the formulated samples were higher than the recommended energy value. Energy density is most important for children with wasting, as they have an increased energy need for catch-up growth. The most important factor influencing energy density is the fat content, as the energy density of fat (9 kcal per g) is more than double that of protein and carbohydrate (4 kcal/g) (Michaelsen *et al*., 2009). High energy density has been pointed out as a major cause of fast growth and well nourishment among undernourished children (Dewey and Brown, 2003).

2.8 Storage Studies

2.8.1 Moisture content

Moisture content of the product is the predominant parameter defining the stability of products during storage. Higher moisture content usually is associated with the detrimental changes in physico-chemical properties of the food product. However, in case of dried materials, moisture content less than 10% is considered as more proper for keeping quality of soup ingredients (El Wakeel, 2007). The results of moisture content obtained (Table 3) show that at 0 month all formulations had the moisture content less than 10%. After 1 month, however there were overgrowth of mould in all formulation which made shelf life study to be terminated.

Table 2.4: Effect of storage time on moisture content (%) of Instant Mixed Mushroom Soup

Sample code	**Storage period (months)**	
	0	**1**
A	4.41	ND
B	9.61	ND
C	7.73	ND

Sample A= mushroom 5%, banana 10%, soybean 80% and OFSP 5%, sample B= mushroom 11%, banana 5%, soybean 75% and OFSP 9%, sample C= mushroom 8%, banana 17%, soybean 70% and OFSP 5%
ND = Not determined, because the study was discontinued after the sample having been overgrown by mold

2.8.2 Colour

The result of storage assessment shows that due to the overgrowing of mould after 1 month, colour failed to be detected in all samples hence only results at 0 month are shown.

Table 2.5: Effect of storage time on color (E) of Instant Mixed Mushroom Soup

Sample code	Storage period (months)			
	0		1	
	a*	b*	a*	b*
A	331.5	402.5	ND	ND
B	150.5	180.5	ND	ND
C	125.0	163.0	ND	ND

a*=redness and b*=yellowness
Sample A= mushroom 5%, banana 10%, soybean 80% and OFSP 5%, sample B= mushroom 11%, banana 5%, soybean 75% and OFSP 9%, sample C= mushroom 8%, banana 17%, soybean 70% and OFSP 5%
ND = Not determined, because the study was discontinued after the sample having been overgrown by mold

2.8.3 Microbial analysis of mushroom-banana-soybean-orange fleshed sweet potato instant soup

The changes in mold count of mixed mushroom soup powder during storage are presented in Table 5. The data revealed that during storage, after 1 month there were overgrowth of mould which was considered as Too Numerous To Count (TNTC) because it was impossible to tell whether colonies are separated.

Table 2.6: Effect of storage time on mold count of Instant Mixed Mushroom Soup

Sample	Storage period (months)	
	0	1
A	2×10^2	TNTC
B	Absent	TNTC
C	1×10^2	TNTC

Sample A= mushroom 5%, banana 10%, soybean 80% and OFSP 5%, sample B= mushroom 11%, banana 5%, soybean 75% and OFSP 9%, sample C= mushroom 8%, banana 17%, soybean 70% and OFSP 5%

2.9 Conclusion and Recommendation

This study shows high nutrient density, specifically high in protein and some nutrient such as carbohydrates and energy in the tested formulations. It can be concluded that the product would be able to support optimal growth of undernourished children and other people and this could play a great role in alleviating the protein energy malnutrition in Tanzania. On the shelf life the soup powder was acceptable only for just less than 1 month which makes it an appropriate choice for the fulfillment of nutritional demand of the country. However, due it's very short shelf life it is recommended that future research be directed towards prolonging the shelf life of product. By considering the nutrients content all formulation A, B and C can be used as a complementary food for infants and young children but for the case of storage stability all formulations is acceptable only for 1 month after being opened.

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CHAPTER THREE

MANUSCRIPT II

3.0 Physical properties and sensory acceptability of instant mixed mushroom soup

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3.1 Abstract

The physical and sensory parameters of formulated instant mixed mushroom soup were evaluated. The formulations involved a combination of various proportions of mushroom, banana, soya beans and orange fleshed sweet potatoes. The mixture of each sample was extruded, milled and used to prepare mixed soup by formulation of three sample (A, B and C). Colour redness (a*) and yellowness (b*) values were significantly different between all samples. Angle of repose was 41.39 to 50.19º and viscosity was 15-29mPa.s. Results indicated that as the amount of soybean flour increased, the appearance of the instant mixed mushroom soup changed in terms of colour, angle of repose and viscosity. The sensory intensity attributes including whiteness, colour, aroma, saltiness, mouth feel and viscosity ranged from 2.5-3.4, 4.2-5.8, 4.4-5.7, 2.5-2.8, 2.9-4.2 and 3.1-5.7 respectively. Intensity attribute 9 was the most highly rated while the intensity 1was the least rated. The most acceptable formulation was sample C which consisted of Mushroom (8%), Banana (17%), Soybean (70%) and OFSP (5%) with overall acceptability of liked very much on a hedonic scale. Multivariate analysis of the sensory data indicated that consumers had highest preference for sample C associated with aroma, mouth feel and colour attributes. From these results it was concluded that formulation C was most acceptable and recommended for validation and scale up.

3.2 Introduction

Physical properties of food are attributes that lend themselves to description and quantification by physical rather than chemical means. The physical characteristics of extrudates reflect the degree of modifications achieved during the extrusion cooking. Some of the physical properties, which express the effectiveness of extrusion, are: expansion, solubility, color, particle size or void size and mass flow rate. These properties are used for evaluating the working of extruder as well as the suitability of the end product for its end use (Patil *et al*., 2005). Physical properties may also have an influence on the sensory characteristics of food.

In product development sensory tests are very useful in accurate measurement of human responses to foods and minimize the potentially biasing effects of brand identity and other information influences on consumer perception (Lawless and Heymann, 2013). The results of the tests may help to differentiate between the desirable and undesirable formulations or products.

Difference tests attempts to answer whether any perceptible difference exists between two types of foods (Adinsi *et al*., 2014). Those that quantify perceived intensities of the sensory characteristics of a food product are known as descriptive sensory which is performed by using trained judges (Murray *et al*., 2001). According to Mohajan *et al*., (2018) supplementation of soy flour has an effect on functional, nutritional, and sensory properties of soup powders and suitable for ready-to- eat soup formulation. Tasnim *et al.*, (2017) found that the developed soy–mushroom–moringa soup powder was nutritionally superior to locally available soup powders and sufficient to meet day-to-day nutritional requirements as a supplement. Therefore, this study aimed at developing instant mushroom soup supplemented with banana, soybean and orange fleshed sweet potatoes, considered physical properties and evaluated sensory acceptability of the formulated products.

3.3 Materials and Methods

3.3.1 Samples

Oyster mushrooms were purchased from farmer in Morogoro, soy bean (yellow bean), green banana (Genomic group AAA), orange fleshed sweet potatoes (garnet yam) and packing bags were purchased from the local market in Morogoro Municipal Tanzania.

3.4 Sample preparation

3.4.1 Preparation of ingredients for the formulation of the mushroom-banana-soybean-orange fleshed sweet potato instant soup

3.4.1.1 Preparation of mushroom flour

Mushroom flour was prepared according to Genenu *et al*. (2017). Clean and fresh mushrooms were chopped to about 2 cm and blanched in hot water (100°C) for 3 minutes. Then water was drained and mushroom dried in air conventional dryer 65°C for 48hours. After drying, the pieces were allowed to cool and blending by using a duty heavy blender into fine powder (pass through 0.5mm sieve size) and stored in polythene packet at a room temperature.

3.4.1.2 Banana flour preparation

Banana flour was prepared according to Tribess *et al*. (2009). Bananas (Genomic group AAA) were peeled, washed in water (which contain salt to reduce browning) and cut into 5 mm slices using stainless steel knives. Then banana slices were placed in trays and dried in air conventional dryer at a temperature of 60°C for 24 hours. Dried banana chips were milled into flour to pass through1 mm mesh sieve and stored in polythene packet at room temperature.

3.4.1.3 Preparation of orange fleshed sweet potato (OFSP) flour

OFSP tubers were washed with clean water to remove soil and dirt and then peeled using a kitchen knife, then chopped to about 0.2-0.4 cm width, 2-5cm length and 0.1-0.3 cm thick and dried in air conventional dryer at 65˚C for 48 h. The dried chips were milled into flour to pass through 0.8 mm mesh screen then stored in polythene packet at room temperature (Rodrigues *et al*., 2016).

3.4.1.4 Preparation of soybean flour

Soybean grains were treated to inactivate lipoxygenase, by immersing them in boiling water for two minutes followed by cooling with tap water. Then, they were dehulled by using dehulling machine and dried in air conventional dryer (65°C for 72 h) and then milled using milling machine into fine flour and pass at 1mm sieve then stored in polythene packet at room temperature

3.4.1.5 Product formulation

The samples were combined in proportions that provided the highest possible amino acid score>65%) according to the recommendation by WHO/FAO/UNU (2007). Initially three samples of mushroom instant soups were formulated, as indicated in Table 3.1.

Table 3.1: Proportions (g/100g) of ingredients in the tested formulations for mushroom-banana-soybean-orange fleshed sweet potato instant soup samples

Ingredient	Sample A (%)	Sample B (%)	Sample C (%)
Mushroom	5	11	8
Banana	10	5	17
Soybean	80	75	70
OFSP	5	9	5
Total	**100**	**100**	**100**

Sample A= mushroom 5%, banana 10%, soybean 80% and OFSP 5%, sample B= mushroom 11%, banana 5%, soybean 75% and OFSP 9%, sample C= mushroom 8%, banana 17%, soybean 70% and OFSP 5%

3.4.1.6 Extrusion of mixed ingredients

Extrusion of the composite product was carried out in a commercial twin-screw extruder (Model JS 60 D, Qitong Chemical Industry Equipment Co. Ltd, Yantai, China). Prior to extrusion, mixed flour samples were conditioned with water to moisture content of 21%. The mixed flour sample was extruded at temperatures of 134^{o}C for zone 1 and 103^{o}C for zone 2, motor speed was 24.76 rpm and feeder speed rate of 10.76 rpm. After extrusion, the extrudates were allowed to cool at room temperature and thereafter milled using milling machine (sieve size- 1mm) to obtain extruded flour. Extruded flour was packaged in polyethylene packets and kept at a room temperature 25±3^{0}C until the analysis were completely especial shelf life analysis.

3.5 Analyses

3.5.1 Colour

X-ma 3000 Spectrophotometer (made in Korea) was used to measure the colour of the instant soup samples. Approximately 1g of each instant soup sample was dispensed in a small glass bowl each then diluted with 50ml of chloroform. The colour parameters measured were redness (a*) and yellowness (b*). A white tile of known L, a, and b values were used as standard.

3.5.2 Angle of repose

The angle of repose was determined by using a fixed funnel that was filled with the flour sample at desired moisture content, then flour were free fallen and form a natural heap. Then pictures were taken and the angle of repose was calculated by using Image J software (version, 1.49p, 2015).

3.5.3 Viscosity

Myr Rotational Viscometer (Viscotech HISPANIA S.I) was used to determine the viscosity. About 24g of each soup sample were filled into the separate beaker 200 mL and was boiled up to a temperature of 95^0C followed by cooling. Viscosity was measured at 19-13.3% rpm rotor speed under temperature conditions of 55.6–65°C and expressed as mPa.s.

3.6 Preparation for Sensory Evaluation

3.6.1 Cooking procedures of soup powders

The gruel was prepared using 200 gram of instant mixed mushroom soup powder and salt (2g) then added into 1500 ml hot water and boiled for 5 min (to pasteurize) ready for evaluation.

To conduct quantitative descriptive test, ten panelists were trained for three days, the attributes and intensities to be used were discussed and agreed. The pre-test was conducted to assess the trainees understanding before the actual test. The assessors were selected and trained according to ISO Standard (1993). The sensory evaluation test was categorized in quantitative descriptive test and consumer test (Meilgaard *et al.*, 2006). In quantitative descriptive test ten trained panelists (three males and seven females) were served with soup samples prepared to assess the intensity of attributes whiteness, colour, viscosity, salty, aroma and mouth feel, uniformity using a 9-point hedonic scale with rates: 9 (like extremely) and 1 (dislike extremely) was used according to Lawless and Heymann (2010).

Forty panelists were served the soup samples prepared to assess and give scores for the attributes; colour, aroma, taste and overall acceptability. Panelists were asked to test one product at a time and express their degree of preference in relation to the following sensory attributes: whiteness, colour, viscosity, salty, aroma, taste and general acceptability. The degree of preference was converted into numerical scores ranging from 1 to 5, whereby 1 was most preferred and 5 was least preferred. After testing a product, the panelist rinsed his palate before testing the next product. Sensory evaluation procedure was carried out at between 10:30 am to 12:30 pm.

3.6.2 Statistical analysis

The results were presented as an average of two replicates. Sensory evaluation data were analyzed by using two way ANOVA using R COMMANDER software program, Duncan's Multiple Range Test method was used to assess the difference between means at 95% confidence interval.

3.7 Results and Discussion

3.7.1 Color of the instant mixed mushroom soup

The results of soup colours are shown in Table 3.2. The results indicated that as the amount of soybean flour increased, the appearance of the instant mixed mushroom soup also increase and the vice versa. The redness (a*) and yellowness (b*) values were also differ significantly between all samples. The redness (a*) values of the instant mixed mushroom soup sample A was found to be the highest value (331.5) followed with sample B then C. Regarding yellowness (b*) values, where sample A recorded the maximal b* value, in contrast, and sample C recorded the minimal b value. Moreover, sample A found to have highest colour value (402.5) probably due to higher amount of soya flour. According to the study by Abdel-Haleem and Omran (2014) indicated that supplementation with legumes significantly increased the lightness (L) and yellowness (b) values of the dried vegetarian soup mixtures. Color is a key quality trait because of the visual impact at the point of sale (Mares and Campbell, 2001). It provides some indication of the quality of the starting materials and, in some cases, the age of the product. Although it does not necessarily reflect nutritional, flavor, or functional values, it determines the acceptability of a product by consumers. Factors controlling colour stability, which include alkaline formulation, flour refinement and enzymatic browning associated with polyphenol oxidase, have been extensively investigated (Hatcher *et al*., 2008).

Table 3.2: Color of the instant mixed mushroom soup

Sample	**(a*)**	**(b*)**
A	331.5	402.5
B	150.5	180.5
C	125.0	163.0

a*=redness, b*=yellowness
Sample A= mushroom 5%, banana 10%, soybean 80% and OFSP 5%, sample B= mushroom 11%, banana 5%, soybean 75% and OFSP 9%, sample C= mushroom 8%, banana 17%, soybean 70% and OSP 5%

3.7.2 Angle of repose

The angle of repose for extruded instant mixed mushroom soup increased as the moisture content increased. The results indicated that the increase in angle of repose was 41.39 to 50.19^o as moisture content was from 4.41 to 9.61% as presented in Table 3.3. The angle of repose is widely used in the field of agriculture in the design and dimensioning of silos, tanks, hoppers and bunkers to determine the capacity and required volume of the stored and transported seeds, wheat, rice, flour etc (Al-Hashemi and Al-Amoudi, 2018).

Table 3.3: Moisture content and angle of repose value for test samples

Sample	Moisture content (g/100g DM)	Angle of repose
A	4.41	41.39º
B	9.61	50.19º
C	7.73	47.14º

Sample A= mushroom 5%, banana 10%, soybean 80% and OFSP 5%, sample B= mushroom 11%, banana 5%, soybean 75% and OFSP 9%, sample C= mushroom 8%, banana 17%, soybean 70% and OFSP 5%.

3.7.3 Viscosity

Viscosity is an important characteristic of liquid foods for food processing, quality control, sensory evaluation, and structural analysis (Antonio *et al*., 2009). The viscosity of extruded instant mixed mushroom soup using presented in Table 3.4. It was indicated that sample B had higher temperature but less viscous compared to sample A which is more viscous followed by sample B. The highest values of viscosity in the extrudates were associated with a high proportion of ungelatinized starch, whereas the lowest values of viscosity might reflect greater degradation and gelatinization of starch that is attributed to depolymerization and molecular entanglement resulting from the processing conditions (Hagenimana *et al*., 2006). Also at high temperature the extruded mass became plastic and less viscous allowing the molecules to become more susceptible to compression during extrusion. Thus, greater thermal and mechanical action was produced, resulting in degradation of the starch granules and, consequently, lower viscosity value was obtained. Carvalho *et al*. (2002) reported that high barrel temperature resulted in increased mechanical effort during the extrusion process, hence greater starch degradation and low viscosity. When starch is heated with water, it goes through some physical and chemical changes such as swelling, granule rupture, crystallinity loss and amylose leaching (Zeng *et al.,* 2011). Viscosity is dependent on the rigidity of starch granules, which in turn affect the granule swelling potential (Sandhyarani and Bhattacharya, 1989) and the amount of amylose leaching out in the solution. The maximum viscosity at a given concentration reflects the ability of the granules to swell freely prior to their physical breakdown.

Table 3.4: Viscosity values of the instant mixed mushroom soup

Sample	Temperature	Viscosity (mPa.s)
A	55.60º	29
B	58.70º	15
C	47.14º	20

Sample A= mushroom 5%, banana 10%, soybean 80% and OFSP 5%, sample B= mushroom 11%, banana 5%, soybean 75% and OFSP 9%, sample C= mushroom 8%, banana 17%, soybean 70% and OFSP 5%

3.8 Sensory Results

3.8.1 Consumer characteristics

Consumer characteristics for analyses of developed instant mixed mushroom soup were presented in (Table 3.5). Panelist (42.5%) were male and remaining (57.5%) were female. 96.7% of the panelists fall on the age group of 19-30 years while the remaining percent was in age group of 31- 42 years.

Table 3.5: Characteristics of consumer panel (n=40)

Characteristics	Category	Frequency (N)	Percent (%)
Age	19-30	39	96.7
	31-42	1	3.3
	Total	**40**	**100**
Sex	Male	17	42.5
	Female	23	57.5
	Total	**40**	**100**

3.8.2 Quantitative Descriptive Analysis

Table 3.6 shows the mean intensity scores of formulated three samples of instant mixed mushroom soup. Sample A and C differed significantly ($p<0.05$) with sample B in all attribute intensities except for whiteness intensity score. Sample C had higher scores in all attributes in which it contained lower percentage of soya bean which is similar to the work reported by Olatunji *et al*. (2012) who found that there were constrains or factors which have discouraged many families from consumption and the utilization of soybeans. In case of aroma of the instant mixed soup, the highest score (5.7) was obtained for sample C and the lowest score was for sample A (4.8) and sample B (4.4), which may be due to beany odour of soybean. At higher concentration, it imparted its characteristics odour and resulted in low score for flavour (Akubor and Ukwuru, 2003). These observations are also supported by Mohajan *et al*. (2018) who reported soup powders with lowest level of soy flour incorporation having highest scores for all the sensory attributes evaluated. Based on these results, it can be concluded that soy flour has effect on sensory properties of instant mixed soup powders and hence recommend formulation C with 70% soybean.

Table 3.6: Mean hedonic score of samples

Sample	Whiteness	Colour	Aroma	Saltiness	Mouth feel	Viscosity
A	2.7±1.72a	5.2±1.61a	4.8±1.45a	2.77±1.19a	3.6±1.59a	4.9±1.63a
B	3.4±1.89b	4.2±1.64b	4.4±1.59a	2.5±0.94b	2.9±1.42b	3.1±1.25b
C	2.5±1.78a	5.8±1.60a	5.7±1.57b	2.8±1.22a	4.2±1.89a	5.7±1.98a

Sample A= mushroom 5%, banana 10%, soybean 80% and OFSP 5%, sample B= mushroom 11%, banana 5%, soybean 75% and OFSP 9%, sample C= mushroom 8%, banana 17%, soybean 70% and OFSP 5%

3.8.3 Consumer test

3.7.3.1 Consumer acceptability

Figure 3.1 shows the mean hedonic values of consumer acceptability of the three formulated samples. There was significant difference in consumer acceptability between samples with Sample C was most acceptable by consumer followed by sample A and sample B as shown in Figure 3.1.

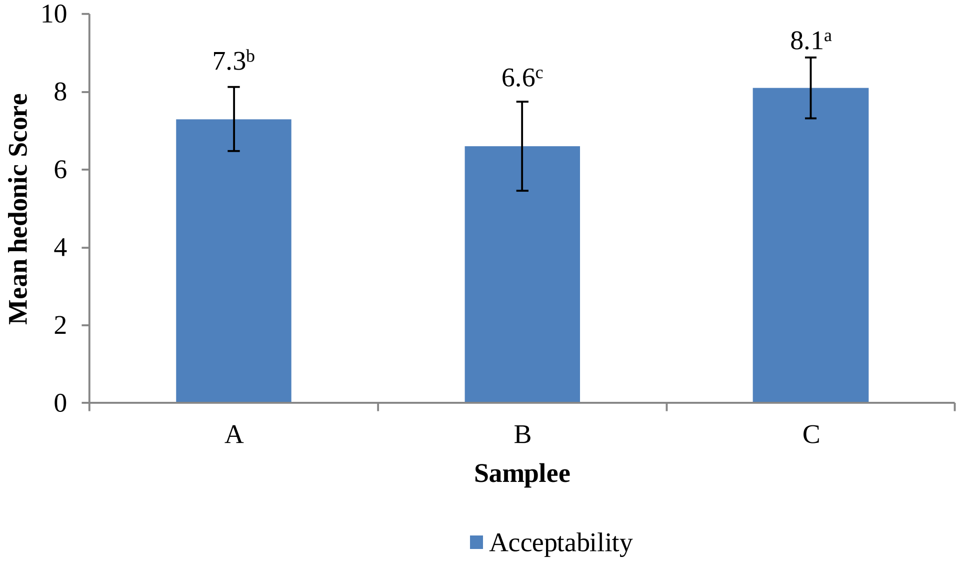

Figure 3.1: Mean hedonic values of consumer acceptability

Sample A= mushroom 5%, banana 10%, soybean 80% and OFSP 5%, sample B= mushroom 11%, banana 5%, soybean 75% and OFSP 9%, sample C= mushroom 8%, banana 17%, soybean 70% and OFSP 5%

3.8.3.2 Consumer preference

Sensory evaluation of food products is important for determining consumer acceptability (Samuel *et al*., 2006). In this study the consumer preference results (Table 3.7) agreed with acceptability results, whereby sample B was the most preferred sample in respect to whiteness, colour, salty and aroma in which it appeared to be satisfactory to the panelist. The remaining other attributes appears to be equally to all samples.

Table 3.7: Consumer preference results

Sample	Median	Rank sum
A	3	109[a]
B	3	126[b]
C	2	78[c]

Friedman chi-squared =28.362, df =2, P=0.0000007, Least Significant Rank Difference (LSRD) =30.4
Sample A= mushroom 5%, banana 10%, soybean 80% and OFSP 5%, sample B= mushroom 11%, banana 5%, soybean 75% and OFSP 9%, sample C= mushroom 8%, banana 17%, soybean 70% and OFSP 5%.

3.8.4 Multivariate approach

i Principal component of descriptive sensory data

Figure 3.2 shows bi-plot with the two first significant principal components from principal component analysis (PCA) on average sensory attributes. PC 1 accounted for 94.43% of the systematic variation in the data between sample B associated with whiteness attribute on one side and sample A and sample C associated with the remaining attributes. PC 2 accounted for 5.56% of variation between samples A and C. Sample C had higher association with aroma, mouth feel attributes whereas sample A was more salty.

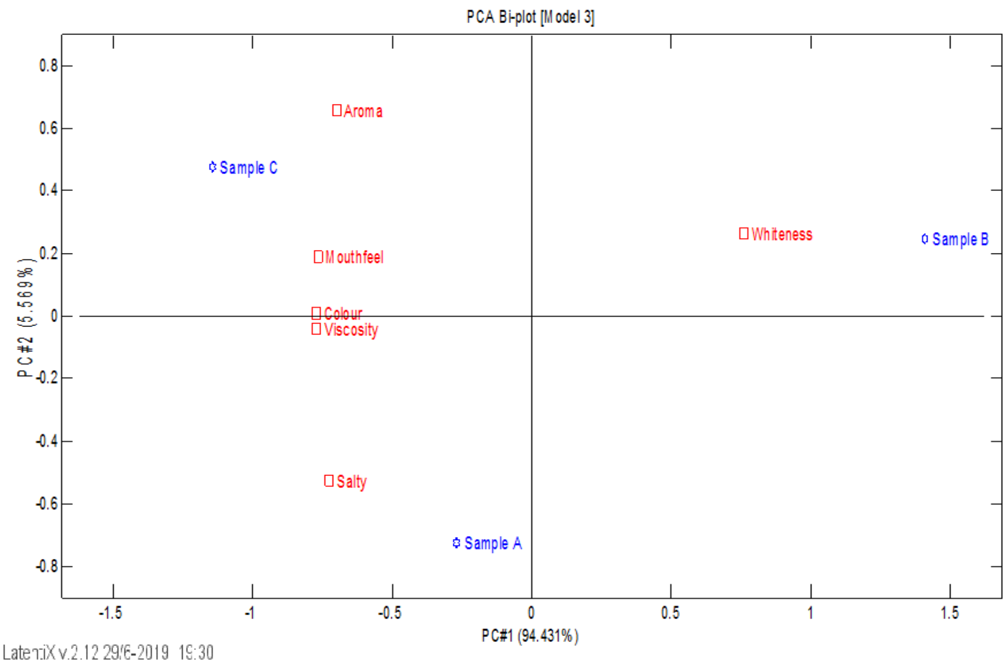

Figure 3.2: A biplot of PCA showing systematic variation of samples and their associated attributes in intensity values

ii. Relationship between descriptive data and hedonic liking by Partial Least Square Regression (PLSR)

Figure 3.3 shows the results from a PLSR using descriptive data as X-variables and liking rated by the consumers as *Y*-variables. It shows that, the two first significant components described 100% of the variation in *Y*. Most consumers fall to the right of the vertical Y-axis which means that consumer had highest preference for sample C associated with aroma, mouth feel and colour attributes. Very few consumers preferred sample B associated with whiteness. Interestingly, apart from showing the association between descriptive and hedonic data, PLSR managed to detect the variation in sample liking which could not be detected by hedonic results.

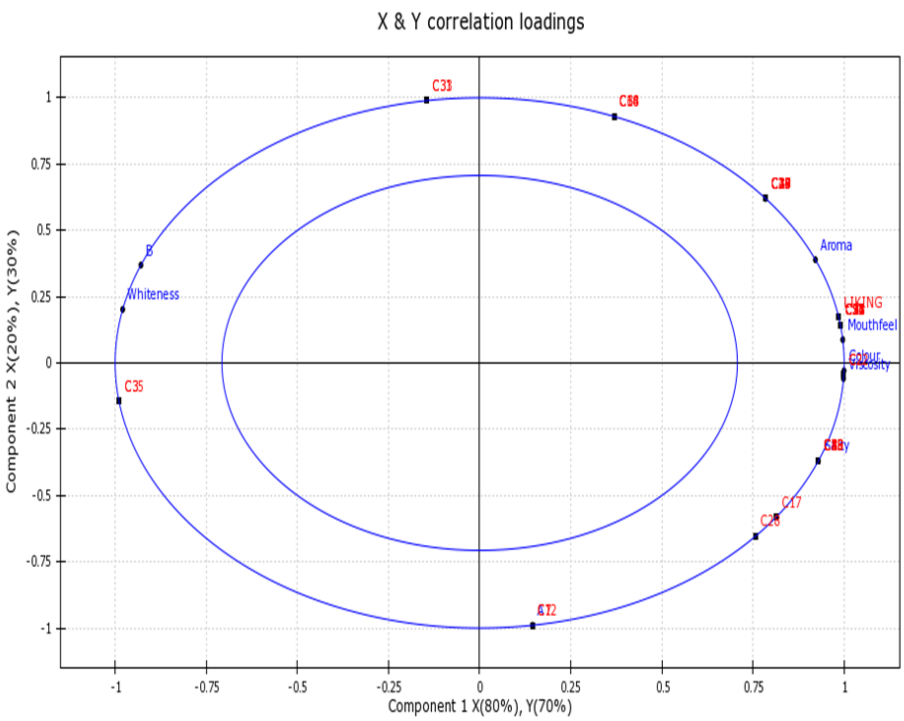

Figure 3.3: Correlation loadings from a partial least squares regression of sample with descriptive data as X variables and hedonic rating as Y variables

3.9 Conclusion and Recommendation

The study showed that the general quality of the product is dependent on both physical and sensory qualities. Composition, viscosity and different sensory attributes including whiteness, colour, saltiness and aroma affected acceptability and preference to varying degrees. Overall, formulation C was the most acceptable and is recommended for further development. The proportion of soy bean content, aroma, colour and mouth feel were most important attributes affecting acceptability of the formulation.

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CHAPTER FOUR

4.0 GENERAL CONCLUSIONS AND RECOMMENDATIONS

4.1 General Conclusions

Development of instant mixed mushroom soup supplemented with banana, soybean and orange fleshed sweet potatoes that aimed to increase availability of nutritious food in the market for wider choice by consumer was accomplished.

This study has shown that the developed instant mixed mushroom soup supplemented with banana, soybean and orange fleshed sweet potatoes had better nutritional composition to meet the recommended nutritional requirements of complementary food for infants and young children.

Addition of soybean lead to favorable change in the appearance of the instant mixed mushroom soup in term of colour, angle of repose and viscosity, however, it resulted into viscous and drinkable product suitable for young children. The most preferred and acceptable formulation was C with composition of Mushroom (8%), Banana (17%), Soybean (70%) and OFSP (5%) with overall acceptability of liked very much on a hedonic scale.

4.2 Recommendations

i. Based on the nutritional composition, physical and sensory attributes formulation C is recommended for further development such as an attempt to lower moisture content which showed it to be inferior to formulation A in terms of shelf life.

ii. The study of the shelf life of the product under various weather conditions and more time than four month it is recommended because more studies shows the shelf life of instant soup range from six month to a year. In this study due to limited time shelf life studies were limited to only 4 months, therefore a longer period study is also recommended.

iii. Also it is recommended that extrusion cooking technology should be used to prepare children foods because, the extrudates produced are easy to prepare and takes short time; therefore will reduce the women work load and time and the extrusion process is environmentally friendly.

iv. Since the study aimed to develop nutritious product with higher protein content, it is recommended that some spices should be added to the sample so as to improve aroma and taste.

v. It is recommended to determine the levels of vitamins, minerals and ant-nutritional factors of the developed products.

vi. Further study is also needed to determine the functional properties such as bulk density, water absorption index, water solubility index, degree of gelatinization and starch digestibility.

APPENDICES

Appendix 1: Quantitative descriptive sensory evaluation form

Sensory Evaluation Form

Quantitative descriptive Analysis (QDA) of Extruded Instant Mixed Mushroom Soup

Sex…………………..……………………………Age……………………………Time……

Please evaluate each coded sample in the order they are listed. Choose appropriate number in a scale from 1 to 9, where 1 is low intensity and 9 is high intensity. How do you find the following characteristics for different extruded instant mixed mushroom soup. Put the appropriate number against each characteristic.

Sample number

Whiteness ____

Grey 1 2 3 4 5 6 7 8 9 Very white

Colour ____

Faint 1 2 3 4 5 6 7 8 9 Very concentrated

Viscosity ____

Not viscous 1 2 3 4 5 6 7 8 9 Very viscous

Salty ____

Not salty 1 2 3 4 5 6 7 8 9 Very salty

Aroma ____

Not aromatic 1 2 3 4 5 6 7 8 9 Very aromatic

Appendix 2: Questionnaire for Preference Test

NUMBER______________________________ DATE ____________________________

AGE___________________GENDER_____________

You are provided with three samples of Extruded Instant Mixed Mushroom Soup. Please assess each sample and determine which one you prefer based on the scale that is provided below by writing the particular number on the space provided.

Mostly preferred	Average			least preferred
1	**2**	**3**	**4**	**5**

Record your result below

Attributes	251	315	897
Whiteness			
Colour			
Viscosity			
Salty			
Aroma			
General acceptability			

Comments………………………………………………………………………………

…………………………………………………………………………………………