OPTIMISING TRADITIONAL NUTRI-DIETS WITH FINGER MILLET, SESAME, MORINGA AND BAMBARA GROUNDNUTS INCLUSION FOR UNDER FIVE CHILDREN

A dissertation submitted in partial fulfilment of the requirements for the Master of Science Degree in Food Security and Sustainable Agriculture

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DECLARATION

I hereby declare that the research project entitled "**Optimising traditional nutri-diets with finger millet, sesame, moringa and bambara groundnuts inclusion for under five children** " submitted to Bindura University of Science Education, Department of Agricultural Economics, Education and Extension is a record of an original work done by me under the guidance and supervision of **Professor C. Gadzirai** and this work is submitted in partial fulfilment of the requirements for the award of aMaster of Science Degree in Food Security and Sustainable Agriculture. The results embodied in this thesis have not been submitted to any University or Institute for the award of any degree or diploma.

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DEDICATION

I dedicate this thesis to my late brother Charles Chibandamabwe, you will always be loved my brother and may your soul rest in peace.

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ABSTRACT

A study on optimising traditional nutri-diets with finger millet, sesame, moringa and Bambara groundnuts inclusion for under 5 children was done at Heather Chimoga Orphan care in Murehwa to formulate a less cost complementary traditional porridge that reduce malnutrition for under 5 children. The experiment was laid out in a completely randomised design (CRD). It had 4 processed flours (finger millet, sesame, Bambara groundnut and moringa blended at different ratios with 100% finger millet being as a control. The validated procedures were used for sample nutrient analysis and sensory evaluation was done using a 9 –point hedonic scale questionnaire for 50 caregivers with under 5 children using purposive sampling procedure at Mashoko High School in Bikita District of Masvingo Province. A simple random sampling method was used for the nutritional analysis. The data was subjected to an analysis of variance (ANOVA) procedure of the Statistical Package for Social Science statistical software program (IBM SPSS version 20.0) and post hoc analysis. The results reported as (mean ± SD) and the difference between the treatments was determined by Fisher's Least Significance Difference (LSD) at 0.05 significance level. The results show significant mean difference ($p< 0.05$) in all the nutrients for the raw flours analysed. The raw flours were formulated to 7 porridges with different blending ratios, analysed and subjected to organoleptic evaluations. The analysis of variance showed significant differences in energy, proteins and vitamins ($p<0.000$). All porridge samples had energy values below the infants' complementary foods recommendations. Key analytical results were 329.2±0.20; 348±1.00 ; 343.5±0.447 ; 353.3±0.47; 362.4± 0.10; 371.5±0.10 ; 355.5±0.10 Kcal/100g energy for Mi, MiBa, $MiSBaMO_1$, $MiSBaMO_2$, $MiSBaMO_3$, $MiSBaMO_4$ and $MiSBaMO_5$ respectively . The porridge samples had 6.7±0.20; 11.21±0.02; 13.07±0.02; 12.9± 0.02; 12.4± 0.01; 12.6± 0.02; 12.4± 0.02 g/100g protein for Mi, MiBa, $MiSBaMO_1$, $MiSBaMO_2$, $MiSBaMO_3$, $MiSBaMO_4$ and $MiSBaMO_5$ respectively. $MiSBaMO_1$ protein amount was within the recommended infants' dietary needs. All the porridge samples had fair vitamin amounts. MiBa had least amount of thiamine 0.29±0.20 mg/100 which is below the recommended. There were significant differences in the amount of micronutrients ($p<0.000$) in all the porridges. All the porridge samples had vast amount of micronutrients which were within the infants recommended dietary range. Mi had low Fe amount (4.0± 0.212 mg/100g). Zinc amounts were below the dietary recommendations in all the samples, MiBa having the least 1.02±0.021 mg/100g. Analysis of variance showed significance difference in colour, aroma, appearance and overall acceptability ($p<0.05$) whilst there were no significant differences in taste and texture ($p>0.05$). A porridge sample $MiSBaMO_1$ showed highest score with mean value of 7.56 in taste, 7.36 in aroma, 7.48 mean value in texture, 7.42 mean appearance, 8.24 in overall acceptability with 96% total acceptability by caregivers .The results of the sensory evaluation showed that blending at 60% millet, 25% Bambara nut, 5% sesame and 10% moringa increased the organoleptic properties of the porridge and also improved the nutritional composition of the traditional complementary porridge for under 5. The formulated porridge ratio can ensure healthy lives, compact child malnutrition for poor people and therefore with further research it is recommended for under 5 children as a complementary porridge.

Keywords: Complementary; malnutrition; organoleptic; stunting; wasted

LIST OF ACRONYMS AND ABBREVIATIONS

AOAC	Association of Official Analytical Chemists International
Ba	Bambara groundnut
DW	Dry weight
DRV	Dietary Reference Value
FAO	Food and Agriculture Organisation
HCOC	Heather Chimoga Orphan Care
HIV	Human Immune Virus
Mo	Moringa
Mi	Finger millet
PEM	Protein Energy Malnutrition
RDA	Recommended Dietary Allowance
UNICEF	United Nations Children’s Fund
WHO	World Health Organisation
ZimVac	Zimbabwe Vulnerability and Assessment Committee

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CHAPTER 1

INTRODUCTION

1.1 Background of the study

Malnutrition among children is unacceptable in the world with large numbers in the developing countries (Muhimbula et al., , 2011). According to Shankar *et al.*, (2018) malnutrition causes irreversible damage to the infants. Protein energy malnutrition (PEM) in children is prevalent where maize is used as a staple food and is prone in developing countries (Awoyale *et al.*, 2011) and is caused by protein and calorie deficiency (Wakil and Alao, 2013). Protein energy malnutrition could be reduced through use of nutritious and available food staffs (Awoyale *et al.*, 2011). Protein energy malnutrition includes marasmus and kwashiorkor and is associated with cognitive effect in children. It leads to physical retardation, increased death rate, and also leads to chronic mental problems (Kumari, 2018). According to Kumari, (2018), 65% of children in developing countries are underweight, 50% die of protein energy malnutrition and 32.5% are stunted. In 2019 stunting in Zimbabwe was 26.8% which is high for WHO standards and is the leading form of malnutrition in under 5 years children in Zimbabwe (ZimVac, 2019). Protein energy malnutrition is as a result inadequate food supply that is caused by political, socio-economic and natural disasters (Grover and Ee, 2009) and Zimbabwe is among the countries affected. According to Disseka *et al.,* (2018), the World Health Organisation (WHO) recommend breast feeding for up to 6 months and from there complementary feeding is required to meet the child's nutrition needs (WHO Complementary Feeding 1998).

Cereals are used as complementary feeding for children in Zimbabwean households although they have low protein content (9.4%) and also micronutrients (Julien *et al.*, 2016). Cereals also lack some amino acids such as lysine, methionine and tryptophan which are essential. Blending cereals, legumes, moringa leaf powder which is rich in bio-available nutrients and addition of sesame with high levels of oleic and linoleic acids which are unsaturated fatty acids can be used as a strategy to reduce malnutrition in children (Disseka *et al.*, 2018). Cereal based supplementary food can also be improved by complementing it with Bambara groundnuts (*Vigna subterranean*) which is protein-rich grain (Arise *et al.*, 2018). Bambara groundnut can be used in complementary porridge with cereals, sesame and fortified with moringa as a strategic measure to combat PEM among 6-59 months aged children in Zimbabwe. Due to high cost of protein rich food, there is a need to utilise the traditional locally available small grains and legumes to cater for the PEM in children as is being practiced by Heather Chimoga Orphan Care (HCOC) in Zimbabwe.

Heather Chimoga Orphan Care (HCOC) is an orphanage mission started in 2001 by the Renewed Hope Charitable Foundation (www.hcoc.org.zw) and is located Marozva Village in Nyamashato Ward 1 in Murewa District of Mashonaland East Province of Zimbabwe. It feeds almost 900 orphans and vulnerable children on daily basis using traditional porridge of small grains and the ingredients are rapoko, sorghum, millet, peanuts, soybeans, maize, and cowpeas and addition of moringa after cooking. The mixtures are done in proportions which vary from time to time. The HCOC have HIV programs that feeds vulnerable children with that porridge and it was found to be highly nutritious. However there is knowledge gap on the nutritional content of the traditional porridge visa viz dietary requirements of children and also the appropriateness of ratios that are being used to make the porridge. From literature (DENHERE, 2016), it was found that soybean is highly nutritious as compared to other legumes however it is not locally available to many smallholder farmers. There is a need to find out if there are other locally available cereals and legumes that can be substituted to provide the ideal nutritional content using cheap available cereals and legumes.

Many studies focused on blending cereals with other legumes (Wakil and Alao, 2014), neglecting Bambara groundnut. Bambara groundnut as a legume has the ability to supply 20-45% of the protein required for complementary feeding across all the ages (Dewey and Brown, 2003 WHO Complementary Feeding 1998). The potential of formulating a nutri-diet with Bambara groundnut, sesame millet and moringa as way of combating PEM in children has not been studied very often. This study aims at optimising traditional nutri-diets with finger millet, sesame, moringa and Bambara groundnuts inclusion for under five children to reverse the challenges of children malnutrition.

1.2 Statement of the Problem

Protein-energy malnutrition is a serious problem in children of 6-59 month in developing countries (Disseka *et al*., 2018) including Zimbabwe with 26.8% stunting rate in 2019 which is high for WHO standards and is the leading form of malnutrition in under 5 years children in Zimbabwe (ZimVac, 2019). Due to increases in food prices, many people are incapacitated to purchase food to diversify the diets for their children especially after weaning stage hence they resort to traditional porridge for small grains which include finger millet and maize porridge but have low protein content (Oghe et al., 2002). The situation of heavy dependency on cereal for children of 6-59 month especially in rural areas pose a continuous threat toward stunting and wasting of under 5 children which can result in death of children. Some organisations like Heather Chimoga Orphan Care are blending cereals and legumes to reduce malnutrition but it is to a lesser extent in reducing malnutrition because they do not have the specified standard ratios in mixing the small grains and the legumes for making up the porridge because the nutritional content of the ingredients is not known. This needs attention by finding ways to formulate the nutri-packs by blending the small grains which are locally available with legumes through blending and fortification with moringa to avert malnutrition in children. The traditional nutri-diets cannot be sold commercially since they have not been analysed for their nutrition reference values versus the dietary needs of children according to the Standard Association of Zimbabwe (SAZ).

1.3 Objectives of the study

1.3.1 Main objective

To produce a low cost nutritious porridge that reduces malnutrition in children at age of 6-59 months using finger millet, sesame, Bambara groundnuts and moringa.

1.3.2 Specific objectives

The study seeks to;

1 Determine the nutrient content of finger millet, sesame, Bambara groundnuts flours and moringa leaf powder

2 Formulate a complementary porridge for children of 6-59 month using finger millet, sesame, moringa and addition of Bambara groundnut at different levels.

3 Determine the nutritional composition of the formulated porridges

4 Assess the consumer acceptability of the formulated porridge to caregivers

1.4 Research Questions

Which flour has the highest amount of nutrients?

What is the best combination of flours that can meet the dietary needs of 6-59 month old children?

Which is the most acceptable porridge by caregivers?

1.5 Significance of the study /Justification

This study focuses on optimising traditional nutri-diets with finger millet, sesame, moringa and Bambara groundnuts inclusion as a way to produce a low cost traditional complementary porridge and to avert protein energy malnutrition for under five children. Many studies focused on blending cereals with legumes such as beans, groundnuts, cowpeas and soyabeans neglecting the potential of Bambara groundnuts. Formulation of this nutri-pack from finger millet, sesame, moringa and Bambara groundnuts nuts construct concrete steps towards the achievement of SDG 3 which is to ensure healthy lives and promote wellbeing for all the ages

(United Nations, 2015). It also increases the opportunity to augment the utilisation of Bambara groundnut in different traditional food products with the rural areas to reduce protein-energy in 6-59 month children. This study also provides information to the local food processors to make efforts in the formulation of different food products with cereal-legume blending and addition of sesame and moringa to meet the nutrition requirements of under 5.

1.6 Scope/Delimitations and Limitation of the study

The study entailed the nutrient analysis of raw finger millet, Bambara groundnut, sesame and moringa flours, the formulation of a composite (enriched) porridge, sensory evaluation of the porridge and nutrient analysis of protein, vitamin, and mineral content of the overall accepted porridge. Due to financial constraints the amino acid profile of the samples were not analysed. The sensory evaluation was done using caregivers with fewer than five children around Mashoko High School. The anti-nutritional factors were not analysed due to financial problems.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews protein-energy malnutrition (PEM) in children and other causes of malnutrition in children. It also covers the complementary foods from blending of cereals and legumes and some nutritional benefits of complementary feeding to children. The strategies to compact PEM and the challenges associated with the formulation of complementary foods for children in Zimbabwe are also reviewed and also the potential of using Bambara groundnut to combat PEM and also its utilisation is reviewed. Complementary foods from cereal-legume formulation is also covered and their nutritional benefits. The nutritional composition of Bambara groundnut, millet, moringa, sesame and also nutritional problems of cereal-legume blending in traditional complementary foods formulation is covered. The consumer behaviour on the traditional nutri-diets is also covered in this section.

2.1.1 Malnutrition in Sub-Saharan Africa and Zimbabwe with special focus in children

According to World Health Organisation (WHO), malnutrition is the cellular imbalance between nutrients and the energy supply and the demands of the body for them to ensure specific functions, maintenance and growth (Grover and Ee, 2009). It is a broad term to refer to stunting, wasting and micronutrient deficiency but also technically refers over nutrition (Hovel *et al.*, 2001). According to UNICEF, malnutrition is problem globally since nearly 50% of child death are a results of under nutrition and in 2011, 45% of children's death was attributed to under nutrition (Schultink, 2015). Although one out of four children globally are stunted, the highest prevalence rates of stunting are in sub-Saharan African and South Asia (Schultink, 2015).

Malnutrition is dominant in developing countries to infants and pre-school children (Osundahunsi and Aworh, 2003), 33% under 5 suffers from stunting and also 29% suffer from underweight in developing countries (LE, 2001). According to (Nations and Unicef, 2013) in 2011, 26% of children under the age of 5 were stunted that is roughly 165 million people and Sub-Saharan had 40% of under 5 who were stunted. There was a prevalence of 9% wasting of children under 5 and also 30 million which 21% of children under 5 who were underweight in Sub-Saharan by 2011 (Nations and Unicef, 2013)

According to ('Nutrition dashboard for Zimbabwe', 2019), the stunting prevalence for under 5 children in Zimbabwe was 29.9% and for 2017 it was 30.4% ('Nutrition dashboard for Zimbabwe', 2018). The national stunting rate was 26.2% in 2018 and was highest in Murehwa District with 36.2% which showed an increase from 30.9% in 2010 (Zimbabwe National Nutrition Survey, 2018). Although people can use their domestic animals for meat to reduce protein energy malnutrition because of its vast amount of complete proteins and also micronutrients which include zinc, iron and vitamin B12 as recommended by World Health Organisation, Murehwa district remain highest in stunting rate because of the lowest people who own goats which was 65% people with 0 goats (ZimVac, 2019) and also they recorded the highest cattle mortality rate of 29% which left them with limited options for protein diversification for their children exposing them to high risk of protein energy malnutrition. The stunting rate increases from 26.2% in 2018 to 26.8% in 2019 and it is the leading form of malnutrition in Zimbabwe and is high above the WHO threshold of 20% (ZimVac, 2019). Stunting is affecting 1 in 3 children who are less than 5 years in Zimbabwe and also underweight and wasting increased between the years 2018 and 2019 (ZimVac, 2019).

2.1.2 Protein-energy malnutrition

Protein energy malnutrition (PEM) remains a major nutritional disorder in under 5 children in developing countries and is also accompanied by infection illness (Temesgen, 2017). PEM occurs during transitional phase from breast feeding to semi-solid or adult foods (Temesgen, 2017). PEM is a severe health problem of under 5 years children not only affecting the present population but can extent to the next generations (LE, 2001). PEM results from inadequate balanced diet supply which is caused by political, socioeconomic and natural disasters and is much pronounced in developing countries. PEM is attributable to 60.7% of death in children with diarrhoea (Grover and Ee, 2009). PEM is a group of associated disorders which includes marasmus, kwashiorkor and associated with cognitive effect in young children and infants. It affects young children and infants because of high protein and energy requirements in relation to their body weight and can result in physical retardation, increased death and long term mental disorders (Kumari, 2018).

According to Aguayo, (2017), about 155 million of 0-59 month children globally are stunted as a result of PEM, 36% in sub-Saharan and is estimated by WHO child growth standards that stunting cause 1 million death of children annually. According to Grover and Ee, (2009), 50% of children's death is caused by under nutrition, 8.4% severe malnutrition and 4.6% by moderate malnutrition. In 2017, the global stunting rate for under 5 was 155 million with 75% of the children are in Sub Saharan or Asia and is a result of PEM (Batiro *et al.*, 2017).

2.1.3 Causes of malnutrition in children

Child malnutrition is caused by interlinked factors as illustrated by the UNICEF child malnutrition conceptual framework (Figure 2.1). The UNICEF conceptual Framework shows that inadequate dietary intake and diseases are the primary determinants of malnutrition and they determine the growth, survival and development of children (Kenneth *et al*., 1998). The conceptual framework shows how different factors affect the nutrition of children at different levels (UNICEF, 2013).

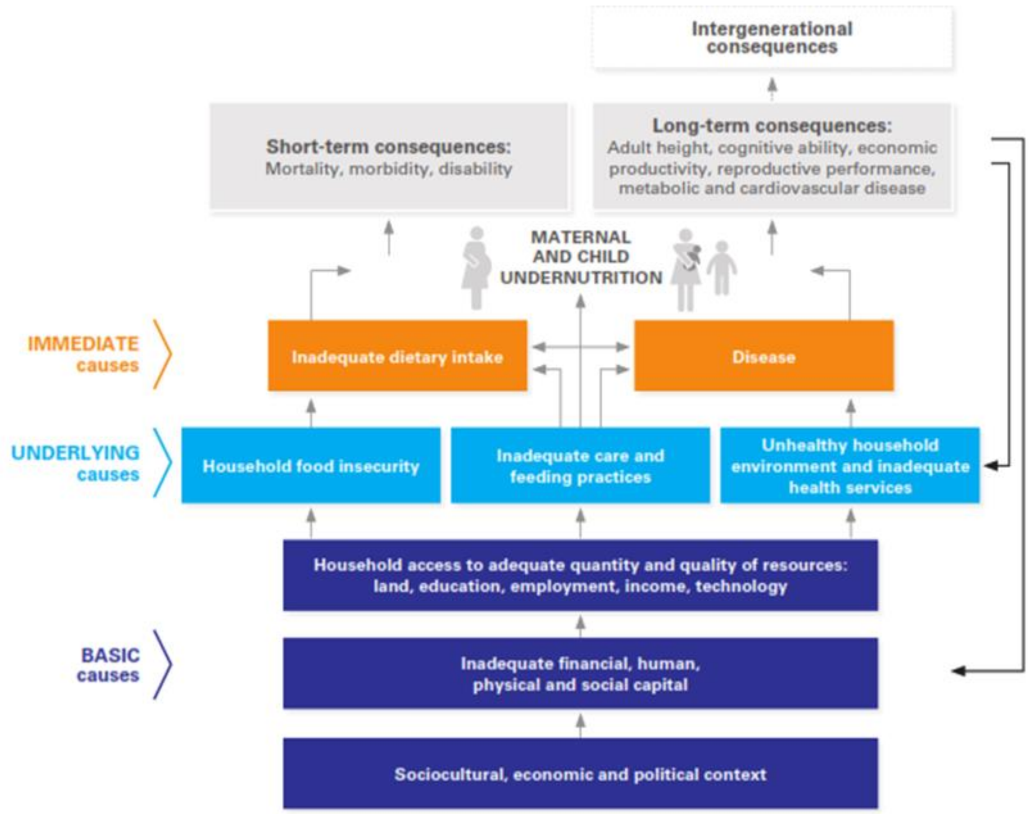

Figure 2.1 UNICEF Conceptual framework for children malnutrition(UNICEF,2013)

2.1.3.1 Immediate causes of child malnutrition

Inadequate dietary intake and diseases are the immediate causes of malnutrition and are directly interlinked to PEM (Kenneth *et al*., , 1998), (Nations and Unicef, 2013), (Schultink, 2015). According to Tette *et al*., , (2015), malnutrition is associated with not deworming children at regular intervals hence cause diseases like diarrhoea. The infectious diseases in children lead to inadequate dietary intake which makes children susceptible to malnutrition (Turner *et al*., 2009). The interaction between inadequate dietary intake and infectious diseases forms an interrelationship creating a vicious cycle. As a result of diseases infection and inadequate dietary intake, child suffers from weight loss and alters the growth rate (Turner *et al*., 2009).

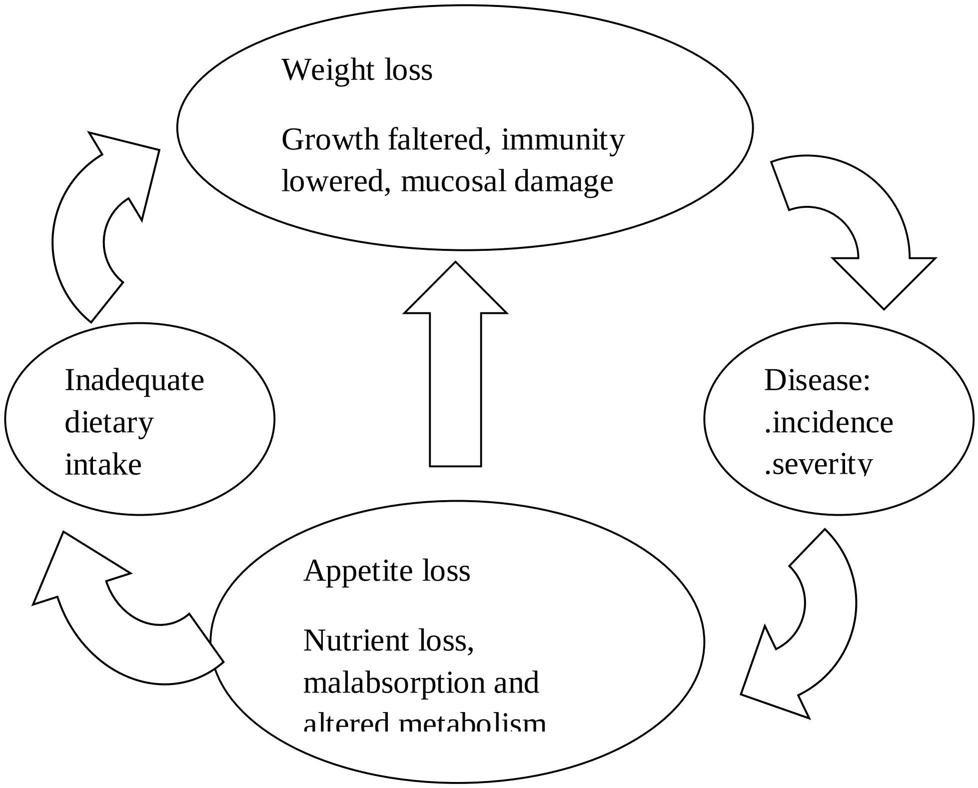

Figure2.2 Malnutrition infection cycle(Turner, Nielsen and Madsen, 2009)

2.1.3.2 Underlying causes of child malnutrition

The underlying causes of child malnutrition are household food insecurity, inadequate care and feeding practices, unhealthy household environment and inadequate health services (Schultink, 2015). Children with inadequate health services and poor access to improved water sanitation are at risk of malnutrition (Extended Analysis of Multiple Indicator Cluster Survey (MICS) 2014:, 2016). Unemployment and income poverty are interrelated which increases the household food insecurity thereby causing an increase in children malnutrition. Increase in household income increases food and health accesses to households and reduces malnutrition prevalence (Turner, Nielsen and Madsen .,2009). Household should have enough food at all times, have sufficient resources of acquiring food, utilise it and also it should be available for their active and healthy life and hence reduces child malnutrition (Turner, Nielsen and Madsen .,2009). Health services should be available in rural areas in order to reach children in need and public healthy interventions for instance vitamin A supplementation and immunisation since diseases causes children malnutrition (Turner, Nielsen and Madsen, 2009)

2.1.3.3 Basic causes of child malnutrition

Malnutrition is also affected by the basic causes which include inadequate human, financial, physical and social capital as argued by UNICEF (Schultink, 2015). It also encompass societal structures and also limiting the access of poor people to the essential resources (Schultink, 2015). According to (Turner, Nielsen and

Madsen .,2009), the basic causes of child under nutrition are the economic, social and political contexts that creates structural under nutrition causes and are found at national as well as international level.

2.1.4 Complementary foods from cereal legume formulations

Breast milk is required as recommended by WHO for the first four months of children's feeding due to large amounts of essential nutrients (Wakil and Alao, 2014). The reduction of breast feeding by slowly introducing complementary foods to children is called weaning and it must be done since beyond six months breast milk alone cannot meet the nutritional requirements of the developing child (Wakil and Alao, 2014). Complementary feeding is done by provision of fluids and foods in addition to breast feeding and some are designed to specifically meet specific physiological or nutritional needs of children (Achidi *et al.*, 2016). Malnutrition starts when infants are given complementary feeding and it contributes to high prevalence of malnutrition to under 5 years infants worldwide (Muhimbula *et al.*, 2011). In developed countries, complementary foods are made on staple cereal and they are of insufficient and low nutrition (Muhimbula *et al.*, 2011). Fortified complementary foods from cereal-legume blends can reduce malnutrition since infants require highly nutritious foods with high energy to cater for their high growth velocity (Shankar *et al.*, 2018). According to (Shankar *et al.*, 2018), grains and legumes should be precooked to denature anti-nutritional factors and to increase its digestibility.

The WHO and UNICEF complementary foods estimated energy requirements are 300kcal/day for 9-11months aged infants and 550 kcal/day for 12-23 months aged children with an assumption of average breast intake ('Complementary feeding', 2001). In developed countries, complementary food are made from blends of cereals and legumes to reduce protein malnutrition for instance maize and horse eye beans (Olatidoye, 2015), pearl millet with groundnuts; cowpea and moringa (Wakil and Alao, 2014), rice and soyabean (Achidi*et al.*, 2016), maize and Bambara nut (Arise *et al.*, 2018), blends of finger millet; kidney beans and mango (Oghe *et al.*,, 2002) and also maize and Bambara groundnut (Mbata *et al.*, 2005). Cereal products are used as complementary feeding of children in many developing countries but they have low protein content (9.4%) and also micronutrients (Julien *et al.*, 2016). Cereals also lacks some amino acids such as lysine, tryptophan and threonine (Wakil and Alao, 2014) which are essential hence supplementation of cereals with legumes such as Bambara groundnut with high lysine levels up to 6.8% and 1.8g/ 100g of methionine increases protein content of cereal-legume complementary foods (Arise *et al.*, 2018).

2. 1.5 Nutritional requirements of 6-59 months old infants from complementary foods

2.1.5.1 Energy requirements

The recommended energy intake from complementary foods differs according to how much milk is ingested by the infant, fat content of the milk, age of the infant and also frequent of feeding with the complementary food (Monte and Giugliani, 2004). The total energy requirements for health infants is 615 kcal/day for 6-8 months and 686 kcal/day for 9-11 months old children (Monte and Giugliani, 2004). According to (Benbouzid *et al.*, 1995) the recommended energy intake for 6-8 months old infants is 70-470 kcal/day, 230-670 kcal/day for 9-11 and 490-1000 kcal/day for 12-23 months old infants. The recommended energy intake for infants with an average breast milk feeding and three meal complementary food intake per day ranges from 0.6kcal/g at 6-8 months to 1 kcal/g at 1 year to 23 month and energy intake should increase to 1.2 kcal/g if breast milk intake is low (Monte and Giugliani, 2004). The weaning food should also provide 4kcal/g on dry weight basis (Temesgen, 2017). According to (Disseka *et al.*, 2018) the recommended FAO energy requirement for complementary feeding should be 400-425 kcal/100 g.

Table 2.1 Estimated Energy requirements for infants and young children from 6-59 months by sex

Age (months)	Reference weight in kg		Estimated Energy Requirement (EER)kJ/d		
	Boys	girls	Boys	girls	Source of nutrient
6	7.9	7.2	2.700	2.500	Breast milk at 8 times a day
7	8.4	7.7	2.800	2.500	Infant formulas
8	8.9	8.1	3.000	2.700	Soy based infant formulas & breast
9	9.3	8.5	3.100	2.800	Thick porridge of maize, millet or soya
10	9.7	8.9	3.300	3.000	Rice mixed with beans and vegetables
11	10.0	9.2	3.400	3.100	Thick porridge at 5 meals a day
12	10.3	9.5	3.500	3.200	complementary foods
15	11.1	10.3	3.800	3.500	maize porridge
18	11.7	11.0	4.000	3.800	cereal-legume porridge
21	12.2	11.6	4.200	4.000	3 meals a day complementary foods
24	12.7	12.1	4.400	4.200	mixtures of mashed foods, rice
36	14.3	13.9	3.400	3.200	thick porridge
48	16.2	15.8	3.600	3.400	sadza and meat and vegetables
59	18.4	17.9	3.800	3.600	family foods 3 meals a day, plus snacks between meals eg bananas

Source ('DIETARY ENERGY', 2006) and ('Complementary feeding', 2001)

2.1.5.2 Protein requirement

Proteins are required in infants because they are the major sources of the essential amino acids and its deficiency together with energy leads to protein-energy malnutrition in children (Temesgen, 2017). According to Mbithi-mwikya *et al.* (2000), the WHO requirements for protein in 2-5 year old children is 33.9%. The protein requirement varies according to the age, 1.12 g/kg/day for 6 months aged children (Millward, 1989) and 1-3 years requires 0.87g/kg/day (Patil *et al.*, 2016). The complementary food should provide a recommended protein requirement of 16% for the infants (James *et al.*, 2018). Disseka *et al.*, 2018 also argued that weaning foods should provide the recommended standard of 11-21% for proteins.

2.1.5.3 Mineral requirement

A diversity of mineral-rich complementary weaning food should be consumed by infants since traditional porridge have relatively small amounts of minerals (Achidi *et al.*, 2016). The complementary weaning food formulated should also target the micronutrient deficiency for calcium, iron and zinc since they are deficiency in many children's diets (Oghe *et al.*, 2002). For infants aged 9 to 11 months, complementary feeding should provide 86% zinc, 97% iron, 76% magnesium and 72% calcium and also the recommended iron intake for 6 to 8 month is 4 mg/100 kcal, 2.4 mg/100 kcal for 9 to 11 month and 0.8 mg/ 100 kcal (Achidi *et al.*, 2016) and most of the minerals are found in cereals (P. Singh, 2016).

2.1.5.4 Vitamin requirements

The supply of vitamins like niacin, thiamine, riboflavin, and folate need further evidence before recommendations are made available (Monte and Giugliani, 2004). According to (Monte and Giugliani, 2004) complementary feeding and breast milk contribute very low vitamin D requirements but exposure of a baby's face and hands only for 17 minutes a day or 4 minutes a day for baby wearing nothing but diapers is enough to avoid vitamin D deficiency. If complementary food does not provide enough Vitamin A, it can be administered in capsules of 100,000 IU for 6 to 11 month old infants and 200,000 IU for children between 12 and 59 month old at 4 to 6 month intervals (Monte and Giugliani, 2004).

Table 2.2 The recommended vitamin intake by age

	Recommended vitamin intake						
	6-8 month		9-11 month		12-23 month		Source of vitamin
	WHO/UNICEF 1998	WHO 2002	WHO/UNICEF 1998	WHO 2002	WHO/UNICEF 1998	WHO 2002	
Folate mg/day	32	80	32	80	50	160	Fortified bread, peas &broccoli
Niacin mg/day	4	4	5	4	8	6	Cereals
Pantothenic acid mg/day	1.7	1.8	1.7	1.8	1.7	1.8	Sweet potatoes, whole grains
Riboflavin mg/day	0.4	0.4	0.4	0.4	0.6	0.5	Eggs, milk, fortified grains
Thiamin mg/day	0.2	0.3	0.3	0.3	0.5	0.5	Infant formulas, pork
Vitamin B_6 mg/day	0.3	0.3	0.4	0.3	0.7	0.5	Fish, fortified cereals
Vitamin C mg/day	25	30	25	30	30	30	Citrus fruits, plums
Vitamin D µg/day	7	5	7	5	7	5	Fortified soy milk, sun

Source (Dewey and Brown, 2003)

2.1.6 Nutritional benefits of cereal-legume complementary foods

PEM is one of the children health problems in developing countries (Steve, 2008) which is caused by poor feeding practices using traditional cereal complementary foods with very low nutritional composition. However blending cereals with legumes increases the nutritional composition of the complementary foods (Wakil and Alao, 2014) for children reducing PEM. According to (Arise *et al.*, 2018), there was a significant increase in protein from 13.0% to 32.3% and a decrease in carbohydrate from 73.12% to 51.27% by addition of Bambara groundnut in maize snacks. Fortification of fermented maize dough with Bambara groundnut also increases protein content from 10.1% to 16.4% and from 10.1% to 16.2% protein from boiled Bambara groundnut (Mbata *et al*., 2005).

Supplementation of tradition cereal complementary foods with locally available legumes with high levels of proteins and lysine increases protein content of cereal-legume blends and reduce PEM in children although the legumes are limited in sulphur, amino acids (Muhimbula *et al*., 2011). Blending of cereals and legumes increases nutritional composition of complementary foods through mutual complementation of the amino acids (Muhimbula *et al*., 2011). The proximate analysis of fortified Ogi from maize and sorghum with Bambara groundnut showed 100% protein composition improvement, increased ash content of maize and sorghum Ogi by 15.33% and 23.89% respectively (Afolabi *et al*., 2018). According to Osundahunsi and Aworh, 2003) legumes improves the protein content of cereal-legume complementary foods.

According to Temba *et al.* (2016) blending of sorghum with cowpea, pigeon pea, groundnut and sesame seed in weaning foods in Sudan increased protein between 16.5-19.4%, blending sorghum with sugar beans porridge in Botswana increased protein up to 13.32% and also blending of sorghum with Marama bean to produce a porridge in South Africa increased protein content between 62-95% against 33.9% protein requirement for under 5 years.

2.2.1 Nutritional composition of Bambara groundnut

Bambara groundnut (*Vigna subterranean L. Verdc*) is a legume which originated in African (Arise *et al*., 2015). Bambara groundnut grain protein varies from 15.1% to 25% and an approximation of 56% carbohydrate and the availability of higher protein content can be utilised as low cost protein supplements in food (Arise *et al*.,2015). Bambara groundnut is rich in threonine, leucine, lysine and protein ranges from 16.5-25% (Mune *et al.*, 2011). However the legume's use in dishes is limited due to presence of some antinutritional factors such as chymotrypsin inhibitors, cyanogens and trypsin inhibitors (Mune *et al.*, 2011). According to (Arise *et al.*, 2018). Bambara groundnut contain 15-27% protein and is also rich in carbohydrates which ranges from 56-68% and 1.8g/100g of methionine which is a limiting factor in other legumes and it can be used in fortifying complementary foods to combat PEM in children. Bambara groundnut can be used in complementary foods since the seeds contain 14-24% protein which is higher in methionine which an essential amino acid, 6-12% oil and contain up to 60% carbohydrates (Steve, 2008). Bambara groundnut has also been reported to be a source of potassium, calcium, also contains 5-8% fats and 366-415 kcal/100g of calories (Adegunwa et al., 2014).

Table 2.3 Comparison of nutritional composition of different legumes

Legume	Carbohydrate (%)	Protein (%)	Ash (%)	Crude fibre (%)
Bambara groundnut	55.62	22.05	3.96	2.30
Cowpea	55.92	23.85	3.81	3.92
Groundnut	13.75	27.00	5.81	3.02
Lima bean	50.43	24.18	5.64	2.06
Pigeon pea	48.30	25.97	4.05	4.60
Soybean	25.19	37.26	4.85	5.05

Source (OYEYINKA, 2016)

2.2.2 Nutrition of millets used in complementary foods

Millet refers to different species of all which are small grained annual cereals in the grass family (Mckevith, 2004). Millet is a cereal in the Graminae family and is a major source of food in Africa grown in marginal areas which are hot and dry. Millet is a major source of protein and energy in underdeveloped countries (Amadou and Le, 2013). Millets contains 7-11% proteins, 60-70% carbohydrates, 2-7% crude fibre and contains manganese, iron and phosphorus (Singh, 2016). It also contains essential fatty acids such as oleic and linoleic acids as well as essential amino acids such as methionine and cysteine but lacks lysine and threonine (Singh, 2016) and also contains vitamin B which is folacin, thymine and riboflavin.

Finger millet contains minerals such as calcium which ranges from 160-358 mg/100g and plays an important role in the growth and development of children. Finger millet also contain phosphorus which ranges from 130-284 mg/g and also contain up to 20% of iron (Ramashia *et al.*, 2019). Finger millet contains 44.6% of essential amino acids and also 81-85% of starch in finger millet is amylopectin, contains up to 20% amylose and 1.5% reducing sugar. Finger millet have high levels of total antioxidant capacity and contain 79-367 mg/100g total carotenoids (Kandlakunta and Golla, 2017). Finger millet also contain nutraceuticals, the phytates, tannins and polyphenols are antioxidants which helps in metabolic processes and aging

(Kandlakunta and Golla, 2017). Millets also have magnesium which helps in reducing the effects of migraine and heart attacks (Amadou and Le, 2013).

Table 2.4 Nutritional composition of millets (per 100g of cereal)

Millets	Protein (g)	Fibre (g)	Mineral (g)	Iron (mg)	Calcium (mg)
Pearl millet	10.6	1.3	2.3	16.8	38
Finger millet	7.3	3.6	2.7	3.9	343
Foxtail millet	12.2	8.0	3.2	2.8	31
Proso millet	12.4	2.2	1.9	0.8	14

Adapted from (E. Singh, 2016)

2.2.3 Nutritional composition of moringa (Moringa oleifera)

Moringa oleifera Lam is a nutritious and multipurpose vegetable tree and also known by different names such as mooringai, nebeday, benzolive drumstick tree and marango (Mishra et al., 2014). Moringa leaves contain β-carotene, proteins, pyridoxine, nicotinic acid, minerals, folic acid and phenolic compounds. Moringa leaf powder at 25g daily given to children gives a recommended daily allowance of 125% calcium, 42% protein, 60.5% magnesium, 42% potassium, 70% iron, 272% vitamin A and 22% vitamin C (Jideani, 2014). According to (Iwara *et al.*, 2014) moringa leaves have high protein content (27%) and also rich in potassium, calcium, phosphorus, Vitamin A and C and it acts as natural antioxidants such as flavonoids and phenolics which increases the shelf life of fat containing foods (Iwara *et al.*, 2014).

Table 2.5 Nutritional comparison of moringa and other foods

Nutrient	Moringa (mg/g)	Other foods
Vitamin A	6.781 mg	carrot 1.891 mg
Vitamin C	220 mg	orange 30 mg
Calcium	441 mg	cow milk 121 mg
Potassium	260 mg	banana 89 mg

Adapted from (Tahir, Tahira and Haq, 2010)

2.2.4 Nutritional composition of sesame

Sesame (*Sesamum indicum L*) belongs to the Pedaliacea family (Animashaun *et al.*, 2017) and has been cultivated for centuries in Africa because of its high protein and oil content (State, 2013). Sesame contain approximately 50% oil, 20-25% protein, rich in tryptophan and methionine (3.2%) which lacks in legume based complementary diets (State, 2013). It contains sulphur containing amino acids but limited in lysine (Pal, 2010) but its use in food is limited because of the anti-metabolites like phytate (State, 2013). Sesame is rich in methionine (3.1%) which is a limiting amino acid in traditional legume diets. It contains tryptophan and also manganese, copper, vitamin B1 and E. The lignans and lignin glycosides have been isolated in sesame seeds and also oil which has shown anti-oxidative and hypo-cholesterolemia effects to liver of rats (State, 2013). According to Temba *et al.*, (2016) wheat-sesame blending in formulation of porridge in Sudan increased protein content between 18.43- 20.84% and also lysine which increases between 0.22-0.50% .

2.3 Nutritional problems of cereal-legume blending in traditional complementary foods

The presence of some anti-nutritional factors is one of the nutritional challenges in cereal-legume blending in the formulation of traditional complementary foods. According to Gemede and Ratta (2016), anti-nutritional factors are chemical compounds synthesised naturally in plants responsible for reduction nutrient utilisation of plant food. Anti-nutritional factors have negative effects which are related to the absorption of plant nutrients and micronutrients. The traditional complementary foods have low nutrients due high concentrations of fibre and also some anti-nutritional factors which reduce their nutritional benefits (Haile and Shufa, 2019). To increase nutritional benefit, traditional complementary foods should be added with animal source food which has high biological value so as to enhance growth and development of infants (Haile and Shufa, 2019). Cereals and legumes naturally contain chemical compounds which reduce the bioavailability and inhibit the digestibility of nutrients and such chemical compounds are antivitamins, enzyme inhibitors and mineral binding agents (Temba *et al*., 2016).

According to Temba et al. (2016) phytic acid, tannins, lectins, saponins, protease inhibitors and amylase inhibitors are responsible for growth inhibition and also reduce the availability of nutrients. Legumes have high quantities of proteases whilst cereals have large amounts of phytic acid. However besides reducing nutrient availability in traditional complementary foods, anti-nutritional factors have beneficial health effects in low concentrations for example lectins, tannins, saponins and amylase inhibitors reduce blood glucose, plasma cholesterol and triglycerides (Gemede and Ratta, 2016).

Cereals and legumes are also vulnerable to contamination by mycotoxins which reduce the nutritional content and also unsafe for consumption in the formulation of traditional complementary foods. Cereals and legumes contain mycotoxins and compositing them will increase the levels of mycotoxins in the complementary food (Temba *et al*., 2016). Mycotoxins are stable compounds which are difficult to eradicate in the food systems along the food chain and pose risks to health hence strategies to prevent their formation is vital for example to breed crops which are resistant to mycotoxigenic fungal infection (Temba *et al*., 2016).

2.4 Consumer acceptability of traditional complementary nutri-blends

Legumes play an important role in the formulation of traditional nutri-diets for children as they are highly nutritious. However they need to be processed and also blended in suitable proportions for them to be accepted by the consumers and acceptance is affected by taste, colour and consistency, beliefs of food taboos, cultures, family dietary pattern, previous feeding patterns and also nutritional knowledge (Temesgen, 2017). According to Denhere, (2016) the acceptability in terms aroma of the composite porridge increased with the increase in the concentration of brown Bambara groundnut. There was a decrease in overall acceptance by consumers in soybean, banana and cowpea formulation as there was an increase in proportion of soybeans (Martin *et al*., 2010). The taste of the traditional porridge was also interfered with the fermented and untreated soybean (Martin *et al*., 2010). Complementary foods for the infants should be blended with legumes and cereals to increase the energy, protein and micro-nutrients but they should be guided by the principles of high acceptability, low cost and high nutritional value (Walle and Moges, 2017).

According to Chiweshe et al. (2012), traditional complementary porridges should be added sugar and salt so as to increase its flavour, colour appeal, palatability and overall acceptance of the porridge. Addition of oil and sugar is also important in increasing the acceptability of the porridge to the target groups. Sugar is also an important component to be included in complementary foods to increase flavour and encourage children to eat as alluded by (Muhimbula *et al*., 2011). Roasting of legumes also increases the acceptability of the cereal-legume complementary foods (Muhimbula *et al*., 2011). According to the studies by (Mbata *et al*., 2005), traditional foods fortified with bambara nut is a viable option in increasing the nutritional quality of African nutri-diets through their organoleptic evaluation studies of the fermented maize fortified with bambara nut.

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CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter elaborates on the materials in which it gives how and where the materials where collected. The methods employed in order to achieve the stated objectives of the study are outlined which include the processes involved in making the flours. It also gives the description of the study sites in which the study was done and also the research design that was used. It also outlines the sampling procedure that was used during the sensory evaluation of the traditional complementary porridge that was formulated. This chapter includes the data collection and data analysis procedure used in the study. The ethical considerations are also outlined in this chapter and it ends with a brief summary of the whole chapter.

3.2 Description of study site/s

The project was carried out at Heather Chimoga Orphan Care (HCOC) which is an orphanage mission started in 2001 by the Renewed Hope Charitable Foundation. The organisation is located in Marozva Village in Nyamashato Ward 1 in Murewa District of Mashonaland East Province of Zimbabwe and is 75 kilometres northeast from the capital city of Harare. Sensory evaluation was done at Mashoko High school in Bikita District (ward 1) of Masvingo Province and is located 106 km from Chiredzi town. It is a Church of Christ boarding school in Mashoko Mission and the mission is highly populated. Mashoko High is between the township and Mashoko Mission Hospital.

3.3 Research design

The experiment was laid out in a completely randomised design (CRD) with 7 treatments replicated 3 times since it was analysed in triplicates and 100% finger millet was used as a control. It had 4 processed flours (finger millet, sesame, Bambara groundnut and moringa) and 2 blending ratios of finger millet which is 70% and 60%.

3.3.1 Materials and Methods

3.3.1.1 Collection of samples

The white Bambara groundnut (*Vigna subterranea*) landrace variety was used in this research and was purchased from local farmers in Bikita District of Masvingo Province, Zimbabwe and finger millet (*Eleusine coracana*) was purchased at a local market in Bikita. Moringa (*Moringa oleifera*) leaves were obtained in Masvingo and were harvested at about 0900 hours. The trees were 3 months old and about 2.0 m high and the leaves were stored in a polythene bag in a room for further processing. Sesame was obtained in Chiremwaremwa rural farmers in Bikita District of Masvingo Province.

3.3.1.2 Processing of finger millet

The finger millet was manually sorted by winnowing to remove foreign material and washed with tape water. It was soaked overnight to enable germination. It was drained by spreading on a clean sack at room temperature and also to enable germination. The process of germination was done to increase bioavailability of vitamins, proteins, increase digestibility , minerals and also decrease the anti-nutrients (Muhimbula *et al.*, 2011). The germinated finger millet was then washed and dried for 2 days as argued by (Shobana *et al.*, 2013). The dried finger millet was then ground into flour using a Changfar grinding mill to produce flour. The flour was stored in an air tight polyethylene bag at room temperature ready for formulation of porridge and analysis.

3.3.1.3 Processing of Bambara groundnut

The Bambara was sorted by removal of foreign material through winnowing and cleaned with tape water. The Bambara groundnut was soaked in water for 24 hours as done by (OYEYINKA, 2016). It was dehulled manually by hands so as to remove the seed coat (Arise *et al.*, 2018). The dehulled Bambara were dried by sunlight for 5 days. The dried Bambara was milled into flour on a 0.50 mm sieve wire and stored in a polyethylene bag for analysis.

3.3.1.4 Processing of moringa

The moringa leaves were removed dust particles and extraneous material through washing on tape water which contain 1% Sodium chlorate 1 (NaCIO) and stored for 7 days at room temperature. The dried moringa leaves were ground into powder with a grinding stone. The powder was sieved with a 0.25 mm sieve to remove the remaining material. The powder was lastly packaged in well labelled Zip-lock bags as argued by (Wakil and Alao, 2014) and stored in an air tight plastic container in a dark room (Disseka *et al*., 2018) ready for analysis and formulation.

3.3.1.5 Processing of Sesame

The sesame seeds were sorted to remove extraneous material and washed with clean tape water and drained at room temperature. The seeds were boiled in water in a kango pot for 5 minutes for dehulling (Disseka *et al.*, 2018). The sesame seeds were roasted in an oven at 160^{o}C for 25 minutes (Animashaun *et al.*, 2017) and cooled at room temperature. The roasted sesame seeds were pounded in a mortar and grounded using a grinding stone. The flour was stored in an air tight polyethylene bag and stored at room temperature for analysis and formulation.

Figure 1: Showing processed sesame, Bambara nuts and finger millet respectively

3.3.1.6 Formulation of composite blends

The blends were formulated using the modified (Malleshi *et al*., 1989) and (Wakil and Alao, 2013) and they were blended in % as sown in table 3.1 below.

Table 3.1 Composition of the designed formulations (%)

Product	Code	Millet	Bambara groundnut	Sesame	Moringa
1	Mi	100	0	0	0
2	MiBa	70	30	0	0
3	$MiSBaMo_1$	60	25	5	10
4	$MiSBaMo_2$	60	20	10	10
5	$MiSBaMo_3$	60	15	15	10
6	$MiSBaMo_4$	60	10	20	10
7	$MiSBaMo_5$	60	5	25	10

Mi-Millet, Ba- Bambara groundnut, S-Sesame, Mo- Moringa powder

3.3.2 Determination of moisture content

Moisture was determined using the AOAC (2003) method 934.01 as done by Denhere, (2016). An empty petri dish with a lid was oven dried at 105°C for 3 h, cooled on a desiccator and weighed. A sample of 3 g was weighed into a dish and uniformly spread. A petri dish with a sample oven dried at 105°C for 3 h, cooled in a desiccator and a dish with a sample reweighed. The moisture content was calculated as follows:

% moisture content = $\frac{(W1-W2)}{W1}$ X 100

Where W1 = weight of sample (g) before drying

W2 = weight of sample (g) after drying

3.3.3 Crude Fibre determination

Crude fibre was determined using the method as done by (Solomon, 2005). A sample of 4g was weighed into a 250ml beaker, 50 ml of 4% H_2SO_4 was added and 200ml of distilled water added into the beaker. The contents were heated to a boiling point for 30 minutes whilst constantly stirring using a stirring rod. To ensure a constant volume, distilled water was added and after boiling, the mixture was poured into a funnel with a filter paper connected to a vacuum pump. The beaker was then washed with hot distilled water and transferred with a jet of hot water and washing was also continued on the funnel until the filtrate was free of acid as it was indicated by a litmus paper. The acid- free residue was then transferred quantitatively from the filter paper into the beaker and removing some traces with 5% NaOH and 200ml by volume of hot water. The mixture was again brought to boil for 30 minutes whilst stirring and keeping the volume constant with hot water. The mixture was later filtered and washed until alkaline free.

The resultant residue was finally washed with 2 parts of 2ml of 95% alcohol and residues on filter paper was transferred to weighed crucible and dried in an oven at 110 ^{o}C to a constant weight after it has been cooled in a desiccator. According to Solomon, (2005) the crucible contents were ignited at 550^{o}C for 8 hours in muffle furnace, cooled and the weighed. The crude fibre was later calculated as weight loss after ignition (Solomon, 2005).

3.3.4 Protein analysis

A porridge sample was passed through a 20 mesh screen for the sample to be homogenous as argued by (Nielsen, 2010). The sample was weighed to 1.0 g and placed into a Kjeldahl flask and 5 g of Kjeldahl catalyst was added together with 200 ml of concentrated H_2SO_4 (AOAC 2000). A blank solution was prepared in a tube. The flask was placed in inclined position and heat until frothing ceases and boiled bristly until solution clears and this was done for digestion to breakdown all organic matter. The sample was cooled and 60 ml of distilled water was added. The flask was immediately connected to the digestion bulb on condenser and with the tip of the condenser immersed in standard acid and 6 drops of mix indicator in receiver. The flask was rotated to mix the contents and later heated until NH_3 was distilled. The receiver was removed, condenser washed and titrate excess standard acid with standard NaOH and the protein content was calculated as

$$\text{Protein \%} = \frac{(A-B) \times N \times 14.007 \times 6.25}{W}$$

Where A = volume (ml) of 0.2 N HCl used in the titration

B= volume (ml) of 0.2 N HCL that was used in blank titration

N= normality of HCL

W= weight of the sample in g

14.007 = atomic weight of nitrogen

6.25= protein- nitrogen conversation factor of the prepared porridge samples

3.3.5 Determination of Fat content

The fat content was determined using the Soxhlet method according to (Nielsen, 2010) and AOAC (2000). A bottle and a lid were placed in an incubator at 105^{o}C overnight to get a constant weight of the bottle. A sample of 5g was weighed, put into extraction thimble and transferred into Soxhlet. A prepared bottle was filled with 250 ml of petroleum ether extract and taken to the heating mantle. The Soxhlet apparatus was connected, water turned on to cool and the heating mantle switched on. The sample was heated for 14 h at a heat rate of 150 drops/ min. The solvent was evaporated using a vacuum condenser. The bottle was incubated at 85^{o}C and the solvent had completely evaporated and the bottle was dry. The bottle partially covered with a lid was transferred to a desiccator to be cooled. The bottle was reweighed and its dried content and the fat content was calculated as

$$\text{Fat \%} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times 100$$

3.3.6 Mineral Analysis

The mineral elements that were analysed were calcium, zinc, magnesium, iron, potassium and phosphorus. According to Gitau, (2018) samples of 0.5g was each weighed into 100 ml beakers and labelled. A digestion mixture of concentrated HNO3 and H2O2 (5:3) was added into the beaker with samples and left in a fume chamber overnight (Gitau, 2018). The mixture was digested at 100 ^{O}C for 3 hours until a clear solution was obtained. The resultant clear digest was topped up with 50ml deionized water for the respective different mineral elements. The atomic Absorption Spectrophotometer was then used for the mineral analysis and the results obtained were converted to mg/100g.

3.3.8 Carbohydrate and Energy Determination

The total carbohydrate analysis of the porridge samples was calculated by method of difference as follows : Total carbohydrate (%) = 100 - [% moisture + % crude fibre + % crude protein + % crude fat] as argued by (Julien *et al.*, 2016).

According to (Solomon, 2005), the maximum amount of energy the samples of carbohydrates, protein and fats after completely burnt in a bomb calorimeter is 4.1 Kcal/g for carbohydrates, 5.65 Kcal/g for protein and 9.45 Kcal for fats but the net heat of combustion in the human body differs from bomb calorimeter since in the calorimeter heat energy comes from oxidation of carbon to carbon dioxide, hydrogen to water and nitrogen from the proteins to nitrous oxide but the body is not capable of using the energy from nitrogen and this amounts to 1.3 Kcal so the body is only capable of using 4.3 Kcal/g of the protein (Solomon, 2005). The factors 4, 9 and 4 approximately represent the amount of energy available to the body per gram of protein, fat and carbohydrate. Therefore the energy content in the porridge samples was calculated by multiplying the grams of carbohydrates, protein and fats by the factor as indicated by the formula below:

Energy Calculations (kcals) = (protein x 4 + fat x 9 + carbohydrates x 4)

3.3.9 Vitamin Analysis

The vitamins that were analysed were thiamine (Vitamin B_1), riboflavin (Vitamin B_2), and niacin. For Riboflavin (Vitamin B_2) analysis, the AOAC (2005) Method 970.65 using the Fluorescence approach was used. The AOAC (2005) Method 944.13 using the Microbiological approach was used for Niacin. For Thiamine, the method used was according to (Solomon, 2005) as described below

To a sample of porridge, 5 g was weighed and 5 ml of 0.02 M HCl was added. The mixture was transferred into a 100 ml volumetric flask and more 0.02 M of HCl was added up to 70 ml mark and the mixture were warmed at 50^{o}C for 1 hour on a water bath whilst periodically shaking the mixture. The flask was cooled at room temperature and the flask was made up to 100 ml mark by adding distilled water. The flask was shaken vigorously and left for 15 minutes and the suspensions were filtered using a filter paper. For spectrophotometric measurement, 5 ml of the sample was pipetted into the test tubes which were well labelled and 5 ml of potassium ferricynanide :NaOH mixture 1:9 v/v (oxidation solution) was added. The mixture was shaken; left to stand for 2 minutes and 3 drops of H_2O_2 was added into the test tube and shaken. The absorbance of the preparation was determined at 369 nm against the blank prepared in the same manner but instead, 5 ml of water was added instead of the porridge sample extract and the calculations were as follows:

Thiamine contents (mg)/100g sample

$$\text{Mg Vit. B1} = \frac{\text{Abs.} \times 100^{*} \times 110 \times 1000}{5}$$

Where 100* = volume to which the extract was made

110 = conversion factor

5 = weight of the sample taken for the extraction of Vit. B1

3.4 Sampling procedure

According to Odhiambo, (2018) for effective sensory evaluation tests for porridges, the sample size should be 50-100 caregivers. The sampling size was 50 mother-child pair with 6-59 months old children at and around Mashoko High School in Bikita District ward 1 of Masvingo Province. Purposive sampling technique with a closed ended structured questionnaire was used for literacy mothers who can understand the details of the 9-point hedonic scale score evaluation form. Sensory evaluation was given to the mothers who give their informed consent written in English and also the translated in Shona which is the local language. The objectives of the study were explained to the participants for sensory evaluation.

3.5 Data collection procedure

Nutrient data sheets were used to record laboratory data and were recorded triplicate to find the mean. Structured questionnaires based on the 9-point hedonic scale (Amagloh *et al.*, 2013) were used for sensory evaluation to gauge the sensory acceptance of the formulated porridge. The 9-point hedonic scale questionnaire consisted of the colour, taste, texture, aroma, appearance and overall acceptability of the porridge which was rated from dislike extremely to like extremely (Odhiambo, 2018).

3.6 Data analysis procedure

Data was done in triplicate and the proximate and mineral analysis were analysed using an analysis of variance (ANOVA) procedure of the Statistical Package for Social Science statistical software program (IBM SPSS version 20.0). The results reported as (mean ± SD) and the difference between the treatments was determined by Fisher's Least Significance Difference (LSD) at 0.05 significance level. Descriptive statistics of means, percentages and graphs were used to describe the nutrient content and sensory evaluation scores.

3.7 Ethical considerations

Research authorization was sought from the Bindura University of Science Education. The study objectives, procedures, benefits, possible risks and schedules were explained to the CEO of the Heather Chimoga Orphan care. Confidentiality was assured by use of code of names through questionnaires for consumer acceptability of the porridge. Participants signed the informed consent form before taking part and they were written in both Shona and English. The data was reported as it is without falsification.

3.8 Summary

This chapter covers the description of study sites as well as the research design. It uncovers the materials used in the study and also the methodologies employed during the study. It also gives a detail on the sampling procedures, data collection and data analysis procedures in order to meet the stated objectives of the study. The ethical considerations of confidentiality and informed consent were also looked into detail.

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CHAPTER 4

RESULTS

RAW FLOURS FROM FINGER MILLET, BAMBARA GROUNDNUTS, SESAME AND MORINGA LEAF POWDWER NUTRITIONAL ANALYSIS

Abstract

Energy was analysed in Kcal/100g and proteins were analysed in mg/100g whilst vitamins, thiamine, riboflavin and niacin in mg/100g were analysed, whilst the mineral elements analysed were calcium, phosphorus, magnesium, zinc, iron and potassium in mg/100g with the help of food composition tables. The raw sesame flour had highest amount of energy with mean value of 573 Kcal /100g followed by Bambara groundnut with 388.33 Kcal whilst finger millet had 329.33 Kcal and the least energy was found in moringa with 205.6 Kcal. Analysis of variance on proteins showed that there were significant differences in the amount of proteins in all the raw flours ($p<0.05$). The highest amounts of proteins were obtained in moringa leaf powder with a mean value of 27.066 ±0.251 /100g whilst least was obtained in finger millet with 6.700±0.556g /100g. Bambara groundnut had a mean value of 21.73±1.474 and sesame had 18.300±0.600 /100g. Analysis of variance showed that there were significant differences in thiamine, riboflavin and niacin in finger millet, Bambara groundnut, sesame raw flours and moringa leaf powder ($p>0.001$). Finger millet had 0.32± 0.9165, 0.14±0.44, 0.90±0.17mg/100g for thiamine, riboflavin, niacin respectively and Bambara nut 0.23±0.1154, 0.23±0.5774, 1.13±0.21 mg/100g for thiamine, riboflavin and niacin respectively. Sesame had 0.62±0.3175 thiamine, 0.24±0.6028 riboflavin and 3.83±1,15mg/100 niacin. Moringa had highest amount of vitamins with 2.73 ±0.115, 20.87±0.55, and 8.37±0.15mg/100g for thiamine, riboflavin and niacin respectively. For micronutrient moringa had highest mean value for calcium 2004.3±1.15, potassium 1326.3 ±3.21mg , magnesium 355.3±52.25 and28.2±0.06 mg/100g iron whilst Bambara groundnut had least value of 0.33±0.49 mg/100g calcium 0.19±0.11, 1.33±0.22, 0.17±0.25mg/100 for phosphorus, potassium and magnesium respectively. Finger millet had highest amount of phosphorus (259.7±40.41 mg/100g) whilst sesame had highest zinc amount with a value of 7.66 ±0.23 mg/100g. The different values of different micronutrients showed a greater potential of producing a traditional complementary weaning porridge which is rich in nutrients through blending the raw flours in different ratios.

Keywords

Energy, Proteins, Vitamins, Minerals, Recommended

4.1 Introduction

This chapter uncovers the analysis of nutrient composition in the raw Bambara groundnut, sesame, finger millet flours and moringa leaf powder. The chapter also covers a summary of the materials and methods used in this study and also a description of the study area for the analysis of the raw flours. The chapter also covers the research design used and the sampling procedure of the raw flours and also the data collection procedure and analysis used. This chapter also present the results and also the discussion of the findings for the analysis of the raw flours. The chapter covers the challenges faced during the analyses of the raw flours as well as the recommendations and also the conclusion for this chapter.

4.2 Material and Methods

The samples were collected and processed as described in Chapter 3 section 3.3.1.2 for finger millet, section 3.3.1.3 for Bambara groundnut, section 3.3.1.4 for moringa and section 3.3.1.4 for sesame. The porridges were formulated in different ratios as shown in Chapter 3 table 3.1. Different components were analysed as described in chapter 3.

4.2.1 Description of study area

The project was done at Heather Chimoga Orphan Care (HCOC) which is an orphanage mission started in 2001 by the Renewed Hope Charitable Foundation. The organisation is located in Marozva Village in Nyamashato Ward 1 in Murewa District of Mashonaland East Province of Zimbabwe and is 75 kilometres northeast from Harare and it is located at geographical coordinates Latitude 17°39′S 31°47′E Longitude 17.650°S 31.783°E.

4.2.2 Research Design

The experiment was laid out in a completely randomised design (CRD) with 7 treatments replicated 3 times since it was analysed in triplicates and 100% finger millet was used as a control. It had 4 processed flours (finger millet, sesame, Bambara groundnut and moringa) and 2 blending ratios of finger millet which is 70% and 60%.

4.2.3 Sample analysis.

Simple random sampling method was used for sampling the raw flours since it is cost effective and less time consuming and the flours were analysed to determine their nutritional composition before blending according to the different ratios. The components that were analysed include the total energy using the calculation method and proteins. The micronutrients analysed were calcium, magnesium, phosphorus, potassium, zinc and iron for all the raw flours. The vitamins analysed were thiamine, riboflavin and niacin since some of the vitamins are readily available in breast milk in large quantities.

4.2.4 Data collection procedure and analysis

The nutrients analysed for each raw flour were recorded on a nutrient data sheet as shown on appendix D. Nutritional composition analysis were done in triplicate and mean was determined. The data were analysed using an analysis of variance (ANOVA) procedure of the Statistical Package for Social Science statistical software program (IBM SPSS version 20.0). The results reported as (mean ± SD) and the difference between the treatments was determined by Fisher's Least Significance Difference (LSD) at $p<0.05$ significance level.

4.2.5 Challenges encountered during data collection

Electricity power cuts was one of the major challenge encountered during the nutritional analysis as it affected the boiling and weighing processes using an electronic balance. Financial problems were also encountered in giving the remuneration to the technicians who helped and also to purchase the reagents for the analysis. Of the most problem encountered was corona virus which delayed the analysis.

4.3 Results and Discussion

4.3.1 Energy of raw flours

Statistical analysis showed that there were significant differences ($p> 0.05$) in energy in Kcal for all the raw flours which are finger millet, Bambara groundnut, and sesame and moringa leaf powder. Post hoc tests show that there were significant differences in energy among all the raw flours at 0.05 least significant differences. The raw sesame flour had highest amount of energy with mean value of 573 Kcal /100g which is also argued by ('Tanzania Food Composition Tables', 2008). The large amount of energy in sesame is a result of oil which is a component of energy as argued by(Pal, 2010). The least of all the raw flours in terms of energy content was moringa leaf powder with a mean value of 205.6 Kcal as also argued by (Nozipho, 2017) but also differs with results obtained by (Isingoma *et al.*, 2015) who found 332 Kcal. Finger millet had mean value of 329.33 Kcal as also alluded by ('Tanzania Food Composition Tables', 2008), (Chitsiku, 1989)and (Shobana *et al.*, 2013). According to (Isingoma *et al.*, 2015) finger millet porridge has least allergenic and non-acid forming and is recommended for weaning complementary food but has low energy densities as also revealed by the results from this study. Bambara groundnut had a mean energy value of 388.33 Kcal which is higher than finger millet hence complementary weaning foods can be improved by blending of finger millet and Bambara groundnut as argued by (Arise *et al.*, 2018).

4.3.2 Protein of raw flours

Analysis of variance on proteins shows that there were significant differences in the amount of protein in all the raw flours ($p<0.05$). The post hoc analysis showed that there is significant difference between finger millet, Bambara groundnut, sesame flours and moringa leaf powder at 0.05 least significant differences. The highest amount of protein was obtained in moringa leaf powder with a mean value of 27.066 ±0.251 /100g and this is also argued by (Nozipho, 2017). According to (Isingoma *et al.*, 2015) due to large amount of proteins in moringa, it is used to bridge the low nutritional value of finger millet complementary foods and is also considered as the most nutrient rich plant as argued by (Ijarotimi *et al*.,2013). Bambara groundnut had a mean value of 21.73±1.474g /100g, sesame had 18.300±0.600 /100g whilst finger millet had 6.700±0.556g /100g also as argued by ('Tanzania Food Composition Tables', 2008). The amount of proteins in Bambara groundnut was also alluded by (Denhere , 2016) who stated that it has a mean value of 20.1g/100g amount of proteins and also argued by (Mune *et al.*, 2011). According to (Arise *et al.*, 2018), Bambara groundnut contain 15-27% protein which is within the range of this study results and it can also be used as protein supplement and complementary weaning foods for children. The amount of proteins in sesame was also argued by (Chitsiku, 1989). However blending of finger millet, Bambara groundnut, sesame and moringa can give the WHO recommended protein amounts in weaning food which is between 11-21% as stated by (Disseka *et al.*, 2018).

4.3.3 Vitamin Analysis

Analysis of variance showed that there were significant differences in thiamine, riboflavin and niacin in finger millet, Bambara groundnut, sesame raw flours and moringa leaf powder ($p>0.001$). However post hoc tests showed no significant differences in thiamine between finger millet and Bambara groundnut ($p>0.05$) and between sesame and finger millet.Moringa had highest amount of thiamine (2.73 ±0.115 g/100g) and niacin (8.37± 0.15 g/100) as also argued by (Nozipho, 2017) as shown on table 5.1. Bambara groundnut recorded lowest levels of thiamine (0.23±0.1154 g/100g) and this is in range for fresh Bambara groundnut as stated by ('Tanzania Food Composition Tables', 2008). The mean values for thiamine in finger millet, Bambara groundnut and sesame were slightly different.

Table 4.1 Mean value for each vitamin

Vitamin	Mean value for each vitamin				F value	P value
	Finger millet	Bambara nut	Sesame	Moringa		
Thiamine	0.32± 0.9165	0.23±0.1154	0.62± 0.3175	2.73 ±0.115	123.598	0.000
Riboflavin	0.14±0.44	0.23±0.5774	0.24±0.6028	20.87±0.55	4102.084	0.000
Niacin	0.90±0.17	1.13±0.21	3.83 ±1,15	8.37± 0.15	101.099	0.000

N/B Values are the means ±standard deviations of triplicate measurements

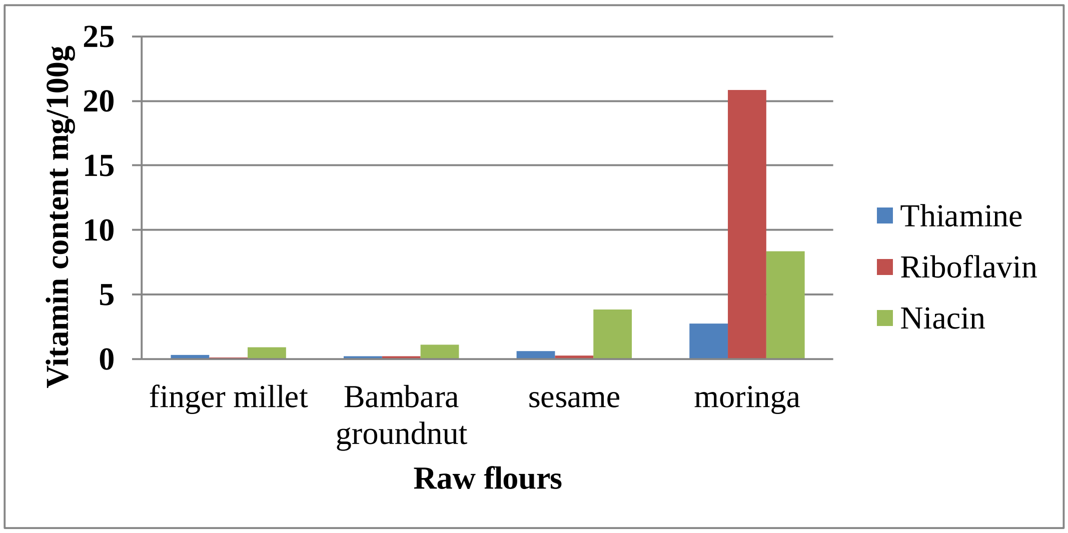

Figure4. 1 Mean values of vitamins for raw flours (mg/100g)

Moringa had highest mean value for riboflavin (20.87±0.55 g/100g) as shown on fig 1 above and this was also argued by (Nozipho, 2017). Post hoc analysis also showed no significant differences in riboflavin between finger millet, Bambara groundnut and sesame ($p>0.05$). The results also showed that there were significant difference in niacin between finger millet, moringa and sesame (p<0, 05) and no significant differences between finger millet and Bambara groundnut at 0.05 least significant difference. The results showed that moringa had highest levels of vitamins also as argued by (Wakil and Alao, 2013), (Anjorin, Ikokoh and Okolo, 2010) and (Nozipho, 2017)

4.3.4 Mineral Composition Analysis

Analysis of variance shows that there were significant differences among all the micronutrients in all the raw flours tested ($p>0.05$). The results showed that Bambara groundnut had lower mineral content as compared to other raw flours. Moringa leaf powder had the highest amount of nutrients among all the raw flours which makes it a potential plant to combat malnutrition in children when incorporated into the weaning foods as argued by (Arise *et al.*, 2015).

Table 4.2 Mineral analyses of the raw flours

Sample	Mean value for each nutrient component					
	Ca	P	Zn	K	Fe	Mg
Finger Millet	315.7± 36.12^{d}	259.7±40.41^{a}	1.30± 0.10^{b}	408.0 ±0.00^{c}	4.06±1.45^{d}	63.7±63.5^{b}
Bambara	0.33±0.49^{c}	0.19±0.11^{c}	6.32±0.79^{c}	1.33±0.22^{d}	22.5±4.73^{b}	0.17±0.25^{b}
Sesame	1027.3±78.83^{b}	632.3 ±4.93^{b}	7.66 ±0.23^{b}	477.0± 10.14^{b}	12.9 ±2.91^{c}	353.0 ±2.64^{a}
Moringa	2004.3±1.15^{a}	201.3±3.05^{a}	0.15±0.10^{a}	1326.3 ±3.21^{a}	28.2±0.06^{a}	355.3±52.25^{a}

N/B Means± standard error is based on three replications. The means with different superscript in the same column are different using Least Significant Difference multiple comparisons at $p<0.05$

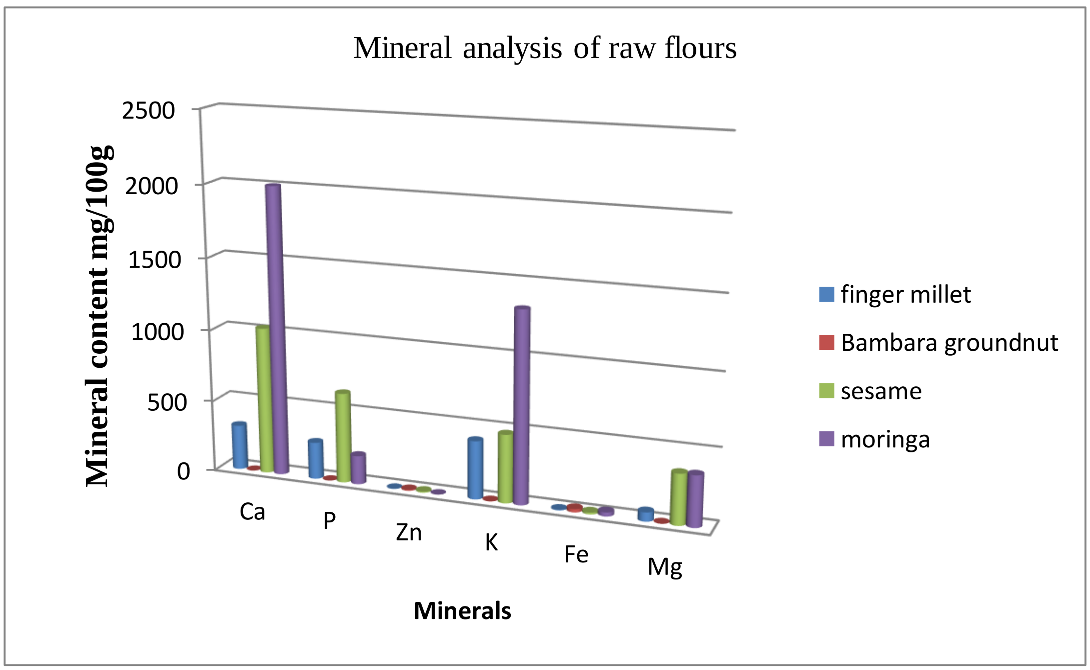

Figure4. 2 Mean values of minerals for raw flours

Calcium levels (mg/100g) shows significant differences ($p<0.05$) for all the ingredient samples used. The highest amount of calcium was obtained in moringa (2004.3±1.15 mg/100g) as also argued by (Nozipho, 2017) and this is the reason for using it in complementary weaning foods (Wakil and Alao, 2014). Lowest levels of calcium were obtained in Bambara groundnut (0.33±0.49mg/100g) whilst appreciable levels were obtained in finger millet (315.7± 36.12mg/100g) and sesame (1027.3±78.83mg/100g). There were significant differences ($p<0.05$) in phosphorus and sesame had highest levels of phosphorus (632.3

±4.93mg/100g) and this was in agreement with ('Tanzania Food Composition Tables', 2008) whilst lowest levels was obtained in Bambara groundnut (0.19±0.11mg/100g). There were significant difference (p<0.05) in zinc levels for all the flours. Sesame had highest level of sodium (7.66 ±0.23 mg /100g), 6.32±0.79, 1.30± 0.10 mg/100 for Bambara groundnut and finger millet respectively whilst moringa had least amount of zinc (0.15±0.10mg/100g).

Although significantly different (P<0.05) all the ingredients had high levels of potassium, 1326.3 ±3.21mg/100g, 477.0± 10.14mg/100g and 408.0 ±0.00/100g for moringa, sesame and finger millet respectively. Bambara groundnut had lowest levels of potassium (1.33±0.22mg/100g) as also argued by ('Tanzania Food Composition Tables', 2008). There were significant differences in iron levels for all the ingredients used in the formulation. Moringa had highest levels of iron (28.2±0.06mg/100g) and this was also stated by (Nozipho, 2017). Bambara groundnut and sesame had fair levels of iron which are 22.5±4.73and 12.9 ±2.91mg/100g respectively and they are within the range for WHO/FAO requirements for complementary foods (Kenneth, Kathryn and Lindsay, 1998). Finger millet had lowest levels of iron (4.06±1.45 mg/100g) also argued by (Chitsiku, 1989) and this is below the amount of iron WHO/FAO requirement in complementary food (WALKER, 2019). There were no significant differences (p>0.05) in magnesium levels between finger millet: Bambara groundnut and also between sesame and moringa. Highest levels of magnesium were obtained in moringa (355.3±52.25mg/100g) and sesame (353.0 ±2.64 mg/100g), fair magnesium in finger millet (63.7±63.5mg/100) whilst low levels in Bambara groundnut (0.17±0.25mg) as also argued by ('Tanzania Food Composition Tables', 2008).

4.4 Conclusion

From the results in this chapter, it shows that moringa leaf powder had high nutritional value in terms of proteins, vitamins and minerals especially potassium, calcium and iron. Moringa had also highest levels of thiamine, riboflavin and niacin. However the energy values for all the flours were below the WHO/FAO recommended energy values for infants formulations. The results in this chapter also showed that sesame had highest amount of energy as compared to other raw flours as a result of high fat content and it shows greater potential of producing high energy dense complementary traditional porridge. Finger millet had average nutritional composition whilst Bambara nut shows fair nutritional value and this shows that formulation of the Bambara groundnut, finger millet, sesame and moringa can produce a traditional complementary weaning porridge with high nutritional value which can combat malnutrition in children.

4.5 Recommendations

i) Formulation of a traditional complementary porridge from finger millet, Bambara groundnut, sesame and moringa inclusion.

ii) Further nutritional analysis of the nutrients not analysed in this chapter

iii) Determination of the anti- nutritional factors of the raw flours

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CHAPTER 5

RESULTS

NUTRITIONAL ANALYISIS OF PORRIDGE SAMPLES AND SENSORY EVALUATION OF THE FORMULATED PORRIDGES

Abstract

A study on optimising traditional nutri-diets with finger millet, sesame, moringa and Bambara groundnuts inclusion for under five children was carried out with a special focus on formulating a low cost traditional complementary porridge using local resources to reduce malnutrition. Nutritional analyses were done for all the porridges. The analysis of variance showed significant differences in energy, proteins and vitamins ($p<0.000$). A porridge sample $MiSBaMO_4$ had the highest amount of energy of 371.5±0.10 Kcal/100g whilst Mi had least energy value 329.2±0.20 Kcal/100g. The entire porridge samples had energy values below the infants' complementary foods recommendations. $MiSBaMO_1$ had the highest amount of proteins 13.07±0.02 g/100g and was within the recommended infants' dietary needs. All the porridge samples had fair vitamin amounts. MiBa had least amount of thiamine 0.29±0.20 mg/100 which is below the recommended. There were significant differences in the amount of micronutrients ($p<0.000$) in all the porridges All the porridge samples had vast amount of micronutrients which were within the recommended dietary range. Mi had low Fe amount (4.0± 0.212 mg/100g). Zinc amounts were below the dietary recommendations in all the samples MiBa having the least 1.02±0.021g.100g. Sensory evaluations were done focusing on taste, colour, aroma, texture, appearance and overall acceptability at Mashoko High School in Bikita District of Masvingo Province in Zimbabwe. A purposive sampling method was adopted to select 50 child-mother pairs (caregivers) with infants between 6-69 months. A 9-point hedonic scale questionnaire was used for data collection and the data was subjected to analysis of variance using SPSS version 20 and mean differences tested at 0.05 least significance differences. The results showed that there were significant differences in colour, texture, appearance and overall acceptability ($p<0.05$) and no significant differences in texture and colour. A porridge sample $MiSBaMO_1$ showed highest score with mean value of 7.56 in taste, 7.36 in aroma, 7.48 mean value in texture, 7.42 mean appearance, 8.24 in overall acceptability with 96% total acceptability by caregivers. MiBa with 70% finger millet and 30% Bambara nut had the highest mean value for colour and the lowest mean of all the attributes was 5.82 which were recorded in the aroma for $MiSBaMO_4$. Porridge $MiSBaMO_1$ had highest organoleptic attributes accepted by the caregivers

Keywords

Organoleptic, Sensory evaluations, hedonic scale, taste, colour, aroma, texture, appearance, overall acceptability

5.1 Introduction

Nutritional analysis was done on all the formulated porridges. Sensory attributes plays a significant role in the overall acceptability of a particular food as alluded by OYEYINKA, (2016). According to Temesgen, (2017), traditional complementary porridge should be blended in suitable proportions to increase their acceptance by the consumers. The acceptance of traditional complementary porridges is affected by taste, colour and consistency, beliefs of food taboos, cultures, family dietary pattern, previous feeding patterns and also nutritional knowledge (Temesgen, 2017). There was a decrease in overall acceptance by consumers in soybean, banana and cowpea formulation as there was an increase in proportion of soybeans (Martin *et al.*, 2010). The taste of the traditional porridge was also interfered with the fermented and untreated soybean (Martin *et al.*, 2010). This chapter gives the sensory evaluation results from the 9-point hedonic scale from a sampled group of 50 people.

5.2 Materials and Methods

5.2.1 Preparation and cooking

The sample of the porridges for sensory evaluation was formulated as outlined in Chapter 3 method 3.3.1.6. The sample porridges were cooked on a Defy gas stove. Half Kango pot water was boiled whilst blending cold water with the porridge. To boiling water, the blended porridge was added whilst stirring using a wooden rod to prevent lamps. A half table spoon of d'lite pure cooking oil was added to Mi and MiBa samples since they had no sesame whilst stirring and is optional when cooking the porridges. The porridges were cooked to for 10 minutes and grand fine salt and brown sugar was added to taste and later removed to be served to the participant whilst still hot.

5.2.1.1 Pilot Study

A pilot study was done before the actual sensory evaluation was done. According to Denhere, 2016) pilot study determines whether the approach to be used is feasible and also is used to diagnose the methodological challenges and find the solutions. A total of five female teachers and five ancillary female staff at Mashoko High School were used for pilot study in order to check the feasibility of the data collection tools and also to refine the informed consent form and it was done a week before the actual survey. From the pilot study it was shown that the participants prefer the informed consent form in Shona and also explanation of the sensory evaluation questionnaire.

5.2 Description of study area

The project was done at Heather Chimoga Orphan Care (HCOC) which is an orphanage mission started in 2001 by the Renewed Hope Charitable Foundation. The organisation is located in Marozva Village in Nyamashato Ward 1 in Murewa District of Mashonaland East Province of Zimbabwe and is 75 kilometres northeast from Harare. Sensory evaluation was done at Mashoko High school in Bikita District (ward 1) of Masvingo Province and is located 106 km from Chiredzi town. It is a Church of Christ boarding school in Mashoko Mission and the mission is highly populated. Mashoko High is between the township and Mashoko Mission Hospital. Mashoko high school comprised of approximately 700 learners and 66 both teaching and non-teaching staff. It is also located 400m from the township and approximately 900m from Mashoko Dam.

5.3.1 Sampling procedure

Simple random sampling was used for analysis of the porridge samples. Each nutrient for each porridge sample was analysed in triplicate and mean determined. For the effective sensory evaluation tests for porridges, the sample size should be 50-100 caregivers as argued by Odhiambo, (2018). According to Muhimbula *et al*.(2011) caregivers are used in the sensory evaluations of food instead of the target recipients which are children because adults are able to objectively evaluate the organoleptic properties of the food using the 9-point hedonic scale questionnaire. A sample of 50 caregivers with infants between the ages of 6-59 months in Mashoko mission was used for the sensory evaluations of the porridge. A purposive sampling technique with a closed ended structured questionnaire was used for literacy caregivers who can understand the details of the 9-point hedonic scale score evaluation. Sensory evaluation was given to the mothers who gave their informed consent written in English and also some in Shona.

5.3.2 Data collection procedure

A nutrient data sheet was used for recording the data after analysis and mean determined. Structured questionnaires based on the 9-point hedonic scale (Amagloh *et al.*, 2013) were used for sensory evaluation to evaluate the taste, colour, aroma, texture, appearance and overall acceptability of the 7 sample porridges. The sensory evaluation questionnaire had a rating which ranges from 1 which is dislike extremely, 2 dislike very much, 3 dislike moderately, 4 dislike extremely, 5 neither like or dislike 6 like slightly, 7 like moderately, 8 like very much. Participants give a rating on the colour, taste, aroma, texture, appearance and overall acceptability on the 9-point hedonic scale for all the seven porridges after signing the informed consent form.

5.3.3 Data analysis procedure

One way analysis of variance (ANOVA) using the Statistical Package for Social Science statistical software program (IBM SPSS version 20.0) was used for the analysis of the sensory evaluation attributes. The results reported as (mean ± SD) and the difference between the treatments was determined by Fisher's Least Significance Difference (LSD) at $p<0.05$ significance level. Post Hoc Test was used to determine which mean treatments are different.

5.3.4 Challenges encountered during data collect

Several problems were encountered during the project and the main was the Corona virus diseases (Covid-19) which prevent the researcher to perform the sensory evaluation at Heather Chimoga Orphan Care as planned before. Electricity was also a problem since electricity power cuts were encountered when the mineral analyses were being done and also for milling of the flours. Financial constraints were also encountered which limit the proximate analysis. Gathering of the participants for sensory evaluation was also a problem since some of the caregivers were not available on time. The mothers' illiteracy and the challenges associated with some of them was also a challenge in the sensory evaluation as also argued by (Muhimbula et al., 2011).

5.4 Results and Discussion

5.4.0 Nutritional analysis of the porridge samples

The nutritional analyses were done for all the porridges formulated and the results were presented in form of mean ± standard deviation

5.4.1 Energy and Protein content

There were significant differences in terms of energy and for all the traditional complementary porridges formulated ($P<0.000$).A porridge sample $MiSBaMO_4$ had the highest mean energy value (371.5±0.10 Kcal/100g). According to (Monte and Giugliani, 2004) in developing countries, complementary food provide 200kcal for 6-8 month old infants, 300 kcal for 9-11 and 550 kcal for 12-23 month infants with average breast milk intake. According to (Wakil and Alao, 2014), complementary weaning foods should be of low dietary bulky and have a balanced calorie density. The amount of energy required in infants from complementary foods depends on the quantity of breast milk consumed and age of the child (Kenneth, Kathryn and Lindsay, 1998). All the formulated porridge was within the range of the required energy requirements for 6-8 and 9-11 months old infants. The recommended infants and children foods should be energy dense since low energy food limit the utilization of other nutrients and also total energy intake as argued by (Walle and Moges, 2017). According to (Walle and Moges, 2017) and (Disseka *et al.*, 2018), the recommended energy from complementary food for infants should be between 400-425 Kcal to meet the WHO and FAO requirements. However all the formulated porridge were slightly below the recommended infants energy needs as argued by (Disseka *et al.*, 2018).

Table 5. 1 Energy, Protein and Vitamin content of the porridge samples

Nutrient	Mean ± SD for each porridge sample							P value
	Mi	MiBa	$MiSBaMO_1$	$MiSBaMO_2$	$MiSBaMO_3$	$MiSBaMO_4$	$MiSBaMO_5$	
Energy	329.2±0.20	348±1.00	343.5±0.447	353.3±0.47	362.4± 0.10	371.5±0.10	355.5±0.10	0.001
Protein	6.7±0.20	11.21±0.02	13.07±0.02	12.9± 0.02	12.4± 0.01	12.6± 0.02	12.4± 0.02	0.000
Thiamine	0.62±0.02	0.29±0.20	0.55±0.02	0.57±0.02	0.59±0.02	0.61±0.02	0.63±0.02	0.004
Riboflavin	0.14±0.02	0.17±0.02	2.23±0.02	2.24±0.20	2.24±0.00	2.24± 0.00	2.24±0.00	0.000
Niacin	0.90± 0.20	0.96±0.02	1.86±0.02	1.97±0.02	2.17±0.02	2.26±0.02	2.39±0.02	0.000

There were significant differences in protein content among all the formulated porridge ($p<0.05$). A porridge sample $MiSBaMO_1$ had the highest amount of proteins with a mean value of 13.07±0.02 g/ 100g whilst the control had the least amount of 6.7±0.20 g/ 100g. According to (Disseka *et al.*, 2018) protein plays a significant role in infants body by being involved in enzyme and hormone synthesis during infants growth and development. The recommended protein standard for weaning foods is between 11-21% as argued by (Disseka *et al.*, 2018), so the formulated porridge was with the range of protein requirements for weaning foods. The protein requirement for infants should be between 13-15g/100g for complementary weaning foods as argued by (WALKER, 2019) and high protein content in the formulated porridge might be a contribution of moringa as argued by (Nozipho, 2017). A porridge sample $MiSBaMO_1$ had protein content within the range for the Recommended Daily Dietary Intakes for infants as stated by (Gebhard and Thomas, 2002).

5.4.2 Vitamin content

The results for the vitamins showed significant differences among all the formulated porridges ($p<0.05$). All the porridges had the recommended thiamine needs for infants as argued by (Millward, 1989) except MiBa with mean value of 0.29±0.20 mg/100g. The results showed that blending of the flours enrich the porridge in terms of the vitamins. According to (Gebhard and Thomas, 2002) the recommended niacin Dietary Reference Intakes is between 2-8mg , 0.2-0.6mg thiamine and 0.3-0.6mg riboflavin for children up to 8 years old. The formulated porridge samples from $MiSBaMO_1$ – $MiSBaMO_5$ were within the recommended range for thiamine and riboflavin. The formulated porridge flours had vitamins that were within the range of the recommended nutrient composition for third world complementary weaning food as argued by (Walker , 2019).

5.4.3 Mineral composition

Analysis of variance showed significance differences ($p<0.05$) in all the porridge for all the nutrients. The results showed that blending of small grains, legumes and moringa improves the mineral content of the traditional complementary porridge. According to (Aguayo, 2017) complementary foods should have high nutrient density and should be fed frequently to the infants to ensure physical growth as well as brain development. The formulated porridges showed improved nutritional composition for all the elements as compared to the control porridge which is 100% finger millet.

Table 5. 2 Mineral content of the formulated porridge samples

Micronutrient	Mean ± SD for each porridge sample							P value
	Mi	MiBa	$MiSBaMO_1$	$MiSBaMO_2$	$MiSBaMO_3$	$MiSBaMO_4$	$MiSBaMO_5$	
Ca	315±0.070	221±0.070	441.2±0.070	492.5±0.070	595.1± 0.070	595.1±0.070	646.6 ±0.070	0.000
P	259.6±0.070	181.7±0.14	207.5±0.141	239.3± 0.141	270± 0.141	302± 0.141	334.1± 0.070	0.002
Zn	1.35±0.070	1.02±0.021	1.25±0.014	1.6±0.021	1.97±0.021	2.36±0.021	2.74±0.014	0.000
K	408.2±0.282	286.8±0.141	401.7±0.014	425.5±0.000	449.1±0.070	472.5± 0.707	496.5±0.707	0.001
Fe	4.0± 0.212	9.6±0.148	8.6±0.084	11.25±0.21	10.7±0.141	10.3±0.282	9.6±0.070	0.000
Mg	63.7± 0.070	285.5±0.70	305±1.414	328.5±0.707	352.±0.707	376±2.121	401±1.414	0.000

According to (Gebhard and Thomas, 2002), the 2000 Dietary Reference Value (DRV) for calcium ranges from 210-500mg for 6- 36 months old infants and up to 800 mg for less than 8 years old children. This was in agreement with the results obtained from this study for all the porridge samples formulated. According to (Odhiambo, 2018) iron and zinc deficiency affects the health, growth and development of infants. Zinc is an important element in children's diet for skin integrity, bone formation, tissue and cell growth and also for cell replication and its deficiency leads to retarded mental development and also stunted growth in infants (Odhiambo, 2018). All formulated porridge samples did not meet the zinc recommended value of 3.6 mg/100g of complementary infant's foods. However the formulated porridge was fair and close to FAO/WHO 1991 infant formulas requirements.

Iron is also an important element in infants body since it is a component of haemoglobin which transport oxygen in the red blood cells and its deficiency causes anaemia in infants as argued by (Monte and Giugliani, 2004) and (Odhiambo, 2018). According to (Gebhard and Thomas, 2002), the Recommended Dietary

Allowance (RDA) for iron ranges from 6-10mg for infants and the formulated porridges had the recommended iron content which is 10.03±0.955mg/100g. All the formulated porridge flours had iron value that is recommended of complementary foods as argued by (WALKER, 2019) whilst the control (Mi) had iron content below the recommended 4.0± 0.212 mg/100g . These results showed the significance of blending cereals with legumes in efforts to increase the mineral elements to reduce malnutrition in infants since all the mineral elements were increased with blending as compared to the control.

5.5 Sensory evaluation

The organoleptic evaluations of the porridge samples were rated according to taste, colour, aroma, texture, appearance and overall acceptability using a 9-point hedonic scale as argued by (DENHERE, 2016). For all the attributes on a 9-point hedonic scale, like moderately to like extremely with an average mean score of 6 and above was considered liked or positive and mean score of 5 with score which ranges from like moderately to like extremely was considered neutral and mean score below 4 which ranges from dislike moderately to dislike extremely was considered disliked or negative as argued by (Chiweshe, Edziwa and Chikoore, 2012). Analysis of variance showed significance difference in colour, aroma, appearance and overall acceptability ($p<0.05$) whilst there were no significant differences in taste and texture ($p>0.05$).

Table 5. 3 Mean sensory evaluation scores of the porridge for all attributes evaluated

Attribute	Mean scores for each porridge sample							F value	P value
	Mi	MiBa	$MiSBaMO_1$	$MiSBaMO_2$	$MiSBaMO_3$	$MiSBaMO_4$	$MiSBaMO_5$		
Taste	7.44± 1.358[a]	7.34±1.944[a]	7.56± 1.451[a]	6.92 ±1.627[a]	6.92±2.248[a]	7.04±2.020[a]	6.90±1.898[a]	1.180	0.316
Colour	6.46±1.876[a]	7.64±1.467[b]	6.98±1.558[a]	6.54±1.740[a]	7.36±1.626[c]	6.84±1.683[a]	6.90±1.717[a]	3.184	0.005
Aroma	6.50±1.764[a]	7.28 ±1.896[b]	7.36 ±1.575[c]	6.64± 1.977[a]	7.16 ±1.822[a]	5.82 ±2.219[a]	6.28± 1.819[a]	4.674	0.000
Texture	7.10±2.003[a]	7.32±1.731[a]	7.48±1.810[a]	6.88 ±1.662[a]	6.52±2.063[a]	6.66±1.836[a]	6.84± 2.103[a]	1.681	0.125
Appearance	6.72± 1.949[a]	7.34±1.722[a]	7.42 ±1.667[a]	6.60± 1.818[a]	6.28± 2.295[b]	6.08 ±2.059[a]	6.28± 2.167[a]	3.604	0.002
Overall Acceptibility	6.62±1.701[a]	7.86±1.125[b]	8.24±1.117[c]	6.76±1.611[a]	6.68±1.812[a]	6.44 ±1.971[a]	6.54 ±1.693[a]	10.040	0.000

N/B Values are the means ±standard deviations of all the measurements (N=50)

Higher mean values show higher acceptability of the assessed sensory attribute

Values with superscripts of different letters in the same row shows significant differences with the control (Mi) at $p \leq 0.05$

5.5.1 Sensory evaluation of taste

There were no significant differences in taste for all the porridge samples ($p > 0.05$). $MiSBaMO_1$ with 60% finger millet25% Bambara groundnut, 5% and 10% moringa had the highest mean value of 7.56± 1.451 which mean it is positive or it was liked and the least taste was recorded $MiSBaMO_5$ with 60% finger millet. 5% Bambara groundnut, 35% sesame and 10% moringa maybe because it had much of sesame and less of Bambara groundnuts. The mean for taste which ranges from 6.90 to 7.44 were in line the results for effects of processed Bambara nut in finger millet based infants feeds as argued by (James *et al.*, 2018). According to (Muhimbula, Issa-zacharia and Kinabo, 2011) taste is an important attribute in infants complementary feeds since the feed might have high nutritional value but not acceptable. There was no clear cut trend in changes of mean values with increases or decrease of the blending ratios with different flours.

5.5.2 Sensory evaluation of Colour

Analysis of variance showed that there was a significant difference in colour for all the porridge samples with $p<0.05$ and this was not in line with (Arise *et al.*, 2018). Post Hoc Tests showed that there is a significant different in colour between control (Mi) with 100% finger millet and MiBa (70% finger millet: 30% Bambara nut) with a p value of 0.000 ($p<0.05$) and also a significance difference between control and MiSBaMO3 $p<0.05$ whilst MiSBaMO1, MiSBaM04 and MiSBaMO5 had no significant difference to the control. MiBa sample had the highest mean value of 7.64±1.467 because it had a lot of Bambara groundnut which is white and makes a blended colour which is more appealing and Mi with 100% millet had least acceptable colour. However there was no clear trend about the colour as also argued by (DENHERE, 2016).

5.5.3 Sensory evaluation of aroma

Analysis of variance showed that there was a significant differences in aroma between the porridge samples with $p<0.000$. Post Hoc Test shows that there was a significant difference in aroma between the control and MiBa ($p<0.05$) and between Mi and MiSBaMO1 ($p<0.05$). The highest mean value in aroma was in $MiSBaMO_1$ (7.36 ±1.575)whilst the least was in $MiSBaMO_4$ which was 5.82 ±2.219 and the results was also found by (Arise *et al.*, 2018) in fortification of snack with Bambara groundnut. According to (Muhimbula, Issa-zacharia and Kinabo, 2011) aroma is an important parameter in sensory evaluation since it is an integral part between the taste and overall acceptability of food.

5.5.4 Sensory evaluation of Texture and Appearance

There was no significant difference in texture among all the porridges assessed ($p > 0.05$). There was a significant difference in appearance ($p<0.05$) among Mi, MiBa, $MiSBaMO_1$ (60% millet: 25% Bambara nut :5% sesame: 10% moringa), $MiSBaMO_2$,(60% millet: 20% Bambara nut :10% sesame: 10% moringa) $MiSBaMO_3$,(60% millet: 15% Bambara nut :15% sesame: 10% moringa) $MiSBaMO_4$(60% millet: 10% Bambara nut :20% sesame: 10% moringa) and $MiSBaMO_5$(60% millet: 25% Bambara nut :5% sesame: 10% moringa). The analysis also showed that there is a significant difference in appearance between a control ($p<0.05$) and $MiSBaMO_3$. The mean values for texture between 6.52 to 7.42 was also argued by (Achidi *et al.*, 2016). The highest score for texture and appearance was obtained in $MiSBaMO_1$ which were 7.48±1.810 and 7.42 ±1.667 respectively. The mean for texture and appearance decreased with decrease in Bambara groundnut ratio as shown on figures 3 and 4 respectively and the results were also argued by(DENHERE, 2016) for brown Bambara groundnut. The results for texture and appearance showed that the entire porridge samples had mean values above 6.0 which show that they were positive or liked by the caregivers.

5.5.5 Sensory evaluation of overall acceptability of the porridge

Analysis of variance showed that there were significant difference in overall acceptability among all the treatments ($p<0.05$). Post Hoc Tests showed that there were significant differences between the control (Mi), MiBa and $MiSBaMO_1$ ($p<0.05$) whilst there were no significant differences between the control Mi, $MiSBaMO_2$, $MiSBaMO_3$ ($p>0.852$) $MiSBaMO_4$ and $MiSBaMO_5$ ($p>0.05$). $MiSBaMO_1$ had the highest mean value of 8.24±1.117 as opposed to James *et al.*, (2018) in which (Mi) finger millet had the highest acceptability. $MiSBaMO_4$ with 6.44 ±1.971 was least overall accepted by the consumers and is not considered suitable for the infants.

Table 5.4 The percentage of caregivers who rated overall acceptability of the traditional complementary porridge

Score	Mi	MiBa	$MiSBaMO_1$	$MiSBaMO_2$	$MiSBaMO_3$	$MiSBaMO_4$	$MiSBaMO_5$
Like extremely	22%	36%	58%	8%	18%	10%	8%
Like very much	10%	30%	22%	32%	20%	20%	26%
Like moderately	16%	22%	10%	22%	16%	30%	26%
Like slightly	24%	8%	6%	18%	24%	18%	10%
Neither like nor dislike	18%	4%	4%	14%	12%	8%	18%
Dislike slightly	8%	0%	0%	2%	4%	6%	10%
Dislike moderately	2%	0%	0%	2%	2%	2%	0%
Dislike very much	0%	0%	0%	4%	0%	0%	0%
Dislike extremely	0%	0%	0%	2%	0%	6%	2 %
Total acceptability	**72%**	**96%**	**96%**	**80%**	**78%**	**78%**	**70 %**

From table 5.4 it clearly shows that the highest percentages of the consumers showed increased acceptance of the porridge with increase in Bambara groundnuts. The highest overall acceptability was obtained in MiBa and $MiSBaMO_{1.}$ Increase in sesame was not significant on the overall acceptability of the porridge to the consumers. It also shows that the best ratio is 60% finger millet and 25% Bambara nut in all the sensory attributes evaluated. The results showed that there were significant differences in colour, aroma, appearance and overall acceptability which contradict with Mbata, Ikenebomeh and Ahonkhai, (2005) and argued with Odhiambo, (2018).

5.6 Conclusion

The recommended energy from complementary food for infants should be between 400-425 Kcal to meet the WHO and FAO requirements, however all the formulated porridge samples were slightly below the recommended infants energy needs but were within the range for 6-11 months old children. A porridge sample $MiSBaMO_1$ met the protein requirement for infants should be between 13-15g/100g for complementary weaning. The formulated porridge samples from $MiSBaMO_1$ – $MiSBaMO_5$ were within the recommended range for thiamine and riboflavin. All the porridges had the recommended thiamine needs for infants except MiBa. All the porridges met the recommended micronutrient dietary requirements for complementary weaning foods. However all the porridge samples did not met the zinc recommendations.

The results of the sensory evaluation showed that blending of millet, Bambara nut, sesame and moringa with ratio in $MiSBaMO_1$ increased the organoleptic properties of the porridge. The porridge sample 3 was liked as compared to the control in all the attributes but MiBa also showed highest mean score for colour. All the traditional complementary porridges were positive or acceptable but with clear preference for porridge with Bambara nut over the control. The undesirable sensory dark colour of finger millet was masked by Bambara groundnut and the study showed that 5% sesame in porridge had the best aroma. The study shed light on the importance of blending traditional porridge to increase the sensory acceptability in terms of taste, aroma, colour, texture, appearance and overall acceptability of the porridge. A porridge ($MiSBaMO_1$) was analysed after overall accepted and the formulated porridge showed improvement in the nutritional composition as compared to the control porridge.

5.7 Recommendations

- $MiSBaMO_1$ to $MiSBaMO_5$ should be selected based on organoleptic evaluations because they meet all dietary needs for infants except for zinc and slightly below the recommended energy needs for above 11 months old infants
- A porridge $MiSBaMO_1$ is recommended in terms of sensory attributes to be given to the infants since it has high acceptability by the caregivers to their children.
- MiBa nutritional composition to be improved through bio-fortification since it was highly accepted by caregivers
- The organoleptic evaluations using the infants below five noting their facial expression and observation is also recommended since caregivers have bias.

5.8 Reference

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CHAPTER 6

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

Optimising the traditional locally available crops to produce low cost complementary foods is the way to go to meet the dietary needs of infants, to meet the demands of the poor and to meet SDG 3. This chapter summaries the study, give conclusions, policy implementation and recommendation and also areas for further research. The aim of this study was to produce a low cost nutritious porridge that reduces malnutrition in children at age of 6-59 months using finger millet, sesame, Bambara groundnuts and moringa. The study sought to; (i) determine the nutrient content of finger millet, sesame, Bambara groundnuts flours and moringa leaf powder (ii) formulate a complementary porridge for children of 6-59 month using finger millet, sesame, moringa and addition of Bambara groundnut at different levels (iii) determine the nutritional composition of the formulated porridges, (iv) Assess the consumer acceptability of the formulated porridge to caregivers.

6.2 Research summary

Statistical analysis showed that there were significant differences ($p > 0.05$) in energy in Kcal for all the raw flours which are finger millet, Bambara groundnut, and sesame and moringa leaf powder. The results for this analysis of raw flours show that sesame flour had highest level of energy and moringa leaf powder had highest amount of proteins and vitamins as compared to all the flours. Analysis of variance on proteins shows that there were significant differences in the amount of protein in all the raw flours ($p<0.05$). The results also showed that there were significant differences in thiamine, riboflavin and niacin in finger millet, Bambara groundnut, sesame raw flours and moringa leaf powder ($p>0.001$). There were significant differences in micronutrients with moringa leaf powder having highest amounts of calcium, potassium, iron and magnesium whilst sesame had highest amounts of phosphorus and zinc. A total of seven complementary porridge flours were formulated at different flour levels following WHO cereal legume blending requirements. Analysis of variance showed significant differences in all the nutrients analysed for all the porridges ($p<0.05$). All the porridge samples were slightly below the recommended energy requirements for complementary weaning foods. They have recommended vitamins except MiBa porridge sample in thiamine. All the porridge samples had the recommended micronutrients except for zinc. Analysis of variance showed significance difference in colour, aroma, appearance and overall acceptability ($p<0.05$) whilst there were no significant differences in taste and texture ($p>0.05$). The formulated porridges were accepted by caregivers but with clear overall acceptability for $MiSBAMO_1$ with 60% finger millet, 25% Bambara groundnut, 5% sesame and 10%

moringa. The overall accepted porridge was analysed for nutrition composition and it compared against the control which was 100% finger millet and the control was outweighed in all the nutrients analysed.

6.3 Conclusions

In conclusion, findings from this study showed that there is a potential of value addition of locally available small grains, legumes and moringa leaf powder to produce low cost nutritious complementary porridge to reduce malnutrition in children. This study also shed light on the nutritional composition of Bambara groundnuts, finger millet, and sesame and moringa leaf powder and the results showed that there is highest amount of nutrients in moringa leaf powder as compared to other flours. Moringa leaf being highly nutritious should be added to the traditional complementary porridge in attempts to address malnutrition in poor resource population groups. Since the porridges ($MiSBaMO_1$ to $MiSBaMO_5$) had variations in the amount of nutrients which were within the recommended dietary needs for infants, recommendation is based on sensory evaluation of the porridge samples. The traditional complementary porridges were overall accepted by the caregivers but porridge with 60% finger millet, 25% Bambara groundnut, 5% sesame and 10% moringa leaf powder was the most acceptable porridge by the caregivers. It can also be concluded that formulation of a traditional complementary porridge by blending the small grains, legumes and moringa leaf powder improved the nutritional content of the porridge and this can be a way to produce low cost complementary porridge for the infants to reduce malnutrition.

6.4 Policy implication and recommendations

- Moringa leaf powder should be incorporated into traditional complementary porridge formulations for infants to combat malnutrition.
- Blending of finger millet, Bambara groundnut, sesame and moringa at the caregiver recommended rate of 60%:25%:5%:10% should be encouraged during formulations of the porridge.
- Production of small grains and legumes should be encouraged by the government through contract farming, giving incentives on their production and through awareness campaigns on social media on their nutrition.
- Government and non-governmental organisations to train small holder communal farmers in value addition of small grains and legumes and also processing.
- The recommended porridge sample $MiSBaMO_1$ should be fortified to increase zinc and energy concentration to meet the dietary recommendations for under 5

6.5 Areas for further research

- Analysis of the anti-nutrients of the raw flours and the formulated porridges.

- Further analysis of nutrients not analysed in this project and also the amino acid profile.
- Organoleptic evaluations using the same formulated porridge to be conducted in other parts of Zimbabwe.
- The keeping quality and storage time of the formulated porridge flour to be determined at different temperatures.
- Bioavailability studies since presence of a nutrient does not necessarily imply the nutrients are available when consumed.

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6.7 Appendices

APPENDIX A: NUTRIENT ANALYSIS DATA SHEET

DATE________________________________ TIME_______________________________

SAMPLE CODE_______________________

PROXIMATE ANALYSIS: SAMPLE NUMBER___________________

Analyte	Amount per 100g				
	Units	Analysis 1	Analysis 2	Analysis 3	Mean
Crude protein					
moisture					
Ash					
Total Carbohydrates					
Crude Fat					
Energy					

MINERAL ANALYSIS: SAMPLE NUMBER___________________

Analyte	Amount per 100g				
	Units	Analysis 1	Analysis 2	Analysis 3	Mean
Iron					
Calcium					
Zinc					
Potassium					
Magnesium					
Phosphorus					

VITAMIN ANALYSIS: SAMPLE NUMBER___________________

Analyte	Composition per 100g				
	Units	Analysis 1	Analysis 2	Analysis 3	Mean
Riboflavin					
Thiamine					
Niacin					

APPENDIX B: SENSORY EVALUATION QUESTIONNAIRE

OPTIMISING TRADITIONAL NUTRI-DIETS WITH FINGER MILLET, SESAME, MORINGA AND BAMBARA GROUNDNUTS INCLUSION FOR UNDER FIVE CHILDREN

Sample number

Participant number

INSTRUCTIONS

1 Please read and sign the consent form before participation on the sensory evaluation

2 Do not communicate with other caregivers whilst tasting the porridge

3 You should answer the questionnaire honestly and faithfully

4 Taste the porridge in order presented from left to right

5 Rinse your mouth with water before tasting the porridge and after tasting each porridge.

6 Please rate the colour, taste, texture, aroma, appearance and overall acceptability of the porridge according to 9 point hedonic scale given below. Kindly note that you may re-test any sample if you wish to do so.

Table 1: 9-point hedonic scale

9	Like extremely
8	Like very much
7	Like moderately
6	Like slightly
5	Neither like or dislike
4	Dislike slightly
3	Dislike moderately
2	Dislike very much
1	Dislike extremely

Sample Code	Taste	Colour	Aroma	Texture	Appearance	Overall Acceptability
Mi	Score:	Score:	Score:	Score:	Score:	Score:
MiBa	Score:	Score:	Score:	Score:	Score:	Score:
$MiSBaMO_1$	Score:	Score:	Score:	Score:	Score:	Score:
$MiSBaMO_2$	Score:	Score:	Score:	Score:	Score:	Score:
$MiSBaMO_3$	Score:	Score:	Score:	Score:	Score:	Score:
$MiSBaMO_4$	Score:	Score:	Score:	Score:	Score:	Score:
$MiSBaMO_5$	Score:	Score:	Score:	Score:	Score:	Score:

Thank you so much for taking part

APPENDIX C: CONSENT FORM IN ENGLISH

I am Chibandamabwe Lawrence a student at Bindura University of Science Education studying towards a Master of Science in Food Security and Sustainable Agriculture. I am doing a thesis entitles "Optimising traditional nutri-diets with finger millet, sesame, moringa and Bambara groundnuts inclusion for under children. This project is done in order to reduce protein energy malnutrition in under five children using low costs complementary traditional porridge and to increase the consumption of underutilised local cereals and legumes. I would like to find the acceptability of the made traditional complementary porridges from the caregivers. The caregivers with under five children are required to taste 7 samples of the infant porridges and rate the samples using 9 point hedonic scale. There will be no hazards for caregivers who agree to participate in the study.

My contact details are 0779689943 or lawrechibanda@gmail.com. All the data that is collected from this study remain confidential and is only used for the purpose of this study only and all the participants remain anonymous. Participation in this study is done voluntarily and the participants are free to leave without any negative consequence at any time of the sensory evaluation.

Participation in this sensory evaluation will not attract any potential benefits and is not in collaboration with any NGO in the area. The participants will not receive any payments in any form and all the data collected will be destroyed after use.

Declaration:

I___________________________________ (full name and surname) hereby confirm that the sensory evaluation form has been clearly explained and I understand the purpose of the study and how the information collected from me will be collected and used. I consent to take part in the research project. I understand that the participation is voluntary.

________________________________ ____________________

Signature Date

APPENDIX D: CONSENT FORM IN SHONA

CONSENT FORM FOR SENSORY EVALUATION OF THE PORRIDGE IN SHONA

Zita rangu ndinonzi Chibandamabwe Lawrence ndiripa chokoro chedzidzo yepamusoro paBindura Yunivhesiti ndichiita Master of Science in Food Security and Sustainable Agriculture. Ndirikuita tsvakurudzo pamusoro pekugadzirwa kwebota revanava nemakore asipasi pemashanu ndichishandisa rukweza, runinga moringa uyenyimo. Tsvakurudzo iyi irikuitirwa kudzivirira kushaikwa kwezvekudya kwakakwa namumuviri mevana ndichishandisa upfu hwezvirimwa zvisingadhurii zvichirimwa munharaunda dzedu uye kuwedzera kushandiswa kwezvirimwa zvisinganyanyi kushandiswa nevanhu.Ndirikuita tsvakurudzo yekudiwana kana kusandiwa kwebota irikubva kunevanhu vanochengeta vana varipasi pemakore mashanu. Pane mhandonomwe dzakasiyana dzebota iri dzinoda kuravirwa uye hapana kusagadzikana kwehutano kunowanika kubva mubotairi.

Ndinobatika panharembozha dzinoti +263779689943 kana kuti lawrechibanda@gmail.com. Ruzivo rwose rwunoramba rwakavanzika uye hunoshandiswa patsvakurudzo inochete uye mazita evanhu haazotaurwe zvachose. Kuva mutsvakurudzo iyi hakumanikidzwi uye munhu anogona kusiya panguva yaanoda pasina zvakashata zvinoitika.

Pakutora basa mutsvakurudzo iyi hakuwanise cheuviri uye hausimubatanidzwa hwemabazi akazvimirira oga anopa chikafu munharaundaino. Hapana mubhadharo uchaitwa pakuva nhengo yetsvakurudzo ino uye ruzivo rwose huchaparadzwa tapedza.

Kupika

Ini______________________________(zita rakazara neredzinza) ndinobvuma kuti zvese zvirimaererano netsvakurudzo iyi zvatsanangurwa uye ndanzwisisa donzvo retsvakurudzo iyi nekunzwisisa kutsvakwa kweruzivo kunobva kwandiri. Ndinobvuma kubata basa mutsvakurudzo idzi. Ndinonzwisisa kuti kubata basa mutsvakurudzo iyi hakumanikidzwe munhu kuzvidira.

___________________________ ___________________________

Kusayina Zuva

APPENDIX E : PREPARATION OF THE PORRIDGE FOR SENSORY EVALUATION

APPENDIX F: PART OF THE CAREGIVERS DURING SENSORY EVALUATION