ADDIS ABABA UNIVERITY

Addis Ababa Institute of Technology

School of Chemical and Bio Engineering

Development of weaning food from a blend of Oat, Rice and Cowpea flour

A Thesis Submitted to The School of Chemical and Bio-Enginerring, Addis Ababa Institute of Technology in Partial Fulfillment of the Requirements for the Degree of Master of Science in ChemicalEngineering (Food Engineering)

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December, 2021

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I declare that this thesis is presented for the degree of Master of Science in Chemical Engineering (Food Engineering). The thesis is my original work and has never been presented in part or in whole to any other university, and that all the source materials used for this thesis have been duly acknowledged.

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Acknowledgments

First of all, I would like to thank the almighty God .I would like to express my special gratitude to my advisor, Ato Adamu Zegeye (Assoc.Professor) for the research idea, professional comments, and guidance in the process of this thesis work.

I would also like to appreciate Mr Debebe Hailu and Ms Aregash Behed of the center for Food science and nutrition laboratory for their technical and psychological support in the overall laboratory analysis work.Many thanks go to Holleta Agricultural Research Center, Fogera Agricultural Research Center and Awash Melkasa Agricultural Research Center for helping in identifying the required variety and provision of the sample.

I thank also Addis Ababa Institute of Technology (AAiT), microbiology laboratory assistants for guiding me during analysis. I thank my family for support from starting to finishing this thesis.I would like to extend my gratitude to my friends and all people who have supported me complete this work.

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List of Abbreviations

AOAC	Association of Official Analytical Chemists
ANOVA	Analysis of Variance
APC	Aerobic bacteria Plate Count
CFU	Colony Forming Unit
FAO	Food and Agriculture Organization
NNS	National Nutrition Strategy
OAC	Oil Absorption Capacity
PEM	Protein Energy Malnutrition
SPSS	Statistical Package for the Social Sciences
TPC	Total Plate Count
WAC	Water Absorption Capacity
WFP	World Food Program
WHO	World Health Organization

Abstract

Cereals and legumes are highly cultivated plants in Ethiopia.They contain high macro and micronutrients, but they have anti-nutritional factors by nature which limit the bioavailability of food nutrients.This study focused on development of weaning food from Oat, Rice, and Cowpea flour for the age group of 6 to 24 months babies. This age is a critical period of mental, physical, and intellectual development.Raw materials were selected based on nutritional availability. Roasting method was used at 100,120, and 140 ^{o}c, Blending ratio refers 60 to 70% cereals and 30 to 40% legumes.Ratio1(50% Oat,10% Rice,40%Cowpea) contained higher protein content than Ratio2 and Ratio3 this is because of the avalibilty of high amount of Cowpea. Optimization using Minitab 17 software was used in order to formulate the nutrient and to compare the product from commercial product which is FAFFA flour.The roasting process and blending ratio had a significant (P<0.05) effect on proximate composition, functional properties, anti-nutritional factor, mineral content, and microbial analysis.According to optimized result P2,P3&P9 labled weaning products have been found good nutrietious especially P3(ratio1with140^{o}c roasting temperature) was selected of having optimum protein and energy containing 18.1%protein, 4.9%fat, 70.8%carbohydrate and 400.2kcal energy.As roasting temperature incresed the same ratio of protein,fat, ash and mineral contents were significantly (P<0.05) increased but moisture and fiber contents were decreased. WaterAbsorption Capacity(WAC) and Oil Absorption Capacity(OAC) of the formulated products ranged between 2.01 to 2.85 and 1.57 to 1.94ml/g,respectively,which were higher than the raw material values.Bulk density of the formulated products were lower than the raw material values due to roasting.After processing both phytate and tannin content of formulated products were decreased due to roasting so increased bioavalablity of products.

***Key words**: Cowpea,Development,Oat,Rice,Weaning food*

1.INTRODUCTION

1.1 Background

Malnutrition is the main health problem in developing countries and contributes to mortality, poor physical and intellectual development of infants, as well as lowered resistance to disease and consequently smothers development. Malnutrition refers to lack, excesses, or imbalances in a person's intake of nutrients. There are two types of malnutritions; the first one is protein-energy malnutrition and the second is micronutrient malnutrition.Protein-energy malnutrition occurs during the critical transitional stage when children are starts semi-solid food. During this period, children need nutritionally balanced, calorie-dense supplementary foods in addition to mother's milk because of the increased nutritional demands of the growing body(Amankwah *et al*., 2009). Nutrition in early life has the highest impact on child growth, development,and survival.

WHO and UNICEF recommend that all mothers must breastfeed their children exclusively for the first six months and thereafter they should continue to breastfeed for as long as the mother and child wish, and both suitable and adequate weaning food should be added after six months of life.Infants are especially vulnerable to malnutrition because they have a high growth velocity and also high energy and nutrient requirements(Shankar *et al*., 2018). Weaning foods are widely used during the transition from consuming exclusively breastfeeding or infant formulas to the introduction of a family diet.

The major criteria for a good-quality weaning food are high balanced-protein content, high caloric value per unit of food volume, soft roughness with low fiber content, acceptable vitamin and mineral contents, and lack of anti-nutritional factors. Weaning foods are usually formulated using a mixture of cereals and legumes which guarantee a proper balance of amino acids to provide a complete protein. Cereals and legumes are highly cultivated plants in Ethiopia.They contain high macro and micronutrients and important source of foods direct for human consumption and indirectly life stock feed. Weaning foods are commonly formulated using a mixture of cereals and legumes which assurance a good balance of amino acids to provide a complete protein. Legumes are a good source of nutrients (protein, starch, minerals, and vitamins) and essential health-keeping compounds (phenolic, inositol phosphates, and oligo-saccharides). Legumes are richer in protein content than cereal grains. When legumes and cereals are eaten together, they provide complete protein requirements (Ahmed & Hasan, 2014). All grains have different purposes due to varieties, nutritional compositions, actions, and bioactive compounds.Oat intake in the human diet has been enhanced because of health benefits related to dietary fibers such as beta-glucan, functional protein, lipid and starch components, and phytochemicals existing in the Oat grain. Oat is important for human consumption in a variety of forms such as Oat porridge, Oat flour for babies, Oatcake, and also used food industries. It is a high-calorie food and a high biological value of proteins. It is important to human feeding to make traditional foods consumed as breakfast and other various products.

Cowpea is an important source of protein.Most of the cowpea produced is used for direct consumption in both urban and rural areas.Cereals and legumes contains anti-nutritional factors.Anti-nutritional factors are mostly linked with compounds or substances of natural or synthetic origin, which affect the absorption of nutrients and act to decrease nutrient intake, digestion, and utilization may yield other adverse effects(Popova & Mihaylova, 2019).Different processing methods such as soaking, dehulling, germination and roasting are important to eliminate anti-nutritional factors and increase the nutritional quality of final products.Some study on infant foods has obtains that the germination process is used to activate enzymes; decrease the level of anti-nutritional factors, increase the digestibility of macronutrients, bioavailability of minerals, increase the content of amino acids and other nutrients.

The roasting process of infant food preparation must be kept at optimal temperature, otherwise the risk impact of nutritional quality of products such as high temperatures will cause protein denature.Roasting is important to improve color, prolong shelf life, improve flavor, and reduce the anti-nutrient factors of cereals and legumes(Kavitha & Parimalavalli, 2014). This study focused on optimizing the nutrition availability of weaning flour products using locally obtained cereals and legumes by using different processing methods and increasing awareness and identify which types of cereals and legumes are good sources of nutrients.

1.2 Statement of problems

As the infant age nutrient intake must be increased due to the need of adequate protein and energy supplement.By the age of six months, they need complementary or additional foods to meet their needs for proper growth and development.In developing countries including Ethiopia, children are attacked by malnutrition due to feed lack of nutrient products. Eventhough, there are some imported and local products found in market with high energy content, fortified with minerals and vitamins,but the cost of product is very high, and difficult to purchase for families with lower income so the majority of families prepare infant foods by traditional processes utilizing cereals and legumes.That process are nutritional problems such as raw materials contain of anti-nutrition factors by nature which reduce the nutreint bioavailability due to traditional process is not used good process method, during blending the traditional method has aproblem of select raw materials according to nutrient availability, the traditional roasting method has a problem of protein denaturing, bulky, bad flavor, taste and color effects and reduces nutrients such as protein, vitamin A, zinc and iron.

This research focused on produce nutritional weaning food ,substitute traditional process by good technological processing method and optimization both bleaning ratio of rawmaterials and roasting method.Furthermore, market products cost is high the reason of use additives and preservatives are imported so in this work produce weaning food by using local access of cereals and legumes, increases accessibility of products.

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1.3 Objectives

1.3.1 General objective

The general objective of the study was to investigate the development of Weaning food from a blend of Oat, Rice, and Cowpea flour.

1.3.2 Specific objectives

The specific objectives of the research were:

- To analyze the proximate composition of each raw material and the product
- To formulate the blend and manufacture the product
- To optimize nutrients by processing (roasting temperature with blending ratio) methods.
- Conduct physicochemical /Functional analyses of the product
- Conduct anti-nutritional factors determination
- Conduct microbiological examination of the product
- Determine the sensory quality of the product

1.4 Research questions

This study aimed to answer the research question

- Does the roasting process of Oat, Rice and Cowpea and blending of weaning food affect nutritional, functional properties, and sensory values?
- Does the processing method eliminate anti-nutritional factors and microbial load of the formulated product?
- Which blending ratio and roasting temperature can produce a good nutritional value of weaning foods?
- Does the nutritional value of formulated weaning food meet international standards; WHO/FAO and WFP?

1.5 Significance of the study

In Ethiopia Oat, Cowpea, and Rice grains are high harvested and simply accessed in the local area. It is widely used in the purpose of directly and indirectly traditional methods but does not have adequate nutrients due to lack of awareness of process methods. This study focused on replacing traditional process methods of prepared weaning food with technological processes, increasing awareness of people about overall advantages nutrition and how to find the good processing methods. During production good technology process must be selected, and method by using optimization of essential nutrients that fulfill the optimal requirements, enhance the bioavailability of minerals, produce a product which is free from microbial contamination.This advantage prevents overall infant age malnutrition problems.In the future, I hope enhanced different weaning food industries will be used from locally available of raw materials such as cereals, legumes, and other sources of food. This is used to improve the country's economy by preventing foreign currency and assured international quality standard products in our country. Furthermore, enhanced utilization of locally accessible agricultural resources can provide employment job opportunities and distributes knowledge,increasing accessibility and availability of infant products overall urban and rural areas of our country.

1.6 Scope of the study

The thesis work generally focused on the production of weaning food by applied nutrition optimization. The analysis of the study was proximate composition, functional properties, and mineral contents, anti-nutritional factors, microbial load analysis, and sensory attributes of weaning food. This work covers optimization of blending ratio and roasting temperatures, with dependant varables such as proximate compositions of formulated waning food compared to FAFFA flour product by applied Minitab 17 software applications.

2. LITERATURE REVIEW

2.1 Overview of Oat, Rice and Cowpea production in the World, Africa, and Ethiopia

Rice is a dietary main food and one of the most important cereal crops in the world.The exceptional taste of Rice gives an easy way to combine Rice with other food to attain better taste and nutritional balance(Rohman *et al*., 2014). The Main Rice manufacturing countries in the world are China, India, Indonesia, Bangladesh, Vietnam, and Thailand. Also, the main Rice manufacturing countries in Africa are Cote d'Ivoire, Guinea, Madagascar, Mali, Nigeria, and Tanzania. the first areas of Rice production in Ethiopia were Gambella (1973–1982), Pawe (1985–1988), and Fogera Plain (early 1980s). However, among these areas, Fogera is now becoming the leading rice producing area*(*Alemu *et al*., 2018).Currently, Fogera, Gambella, Metema, and Pawe plains located in the northern, northwestern, and western regions of Ethiopia are becoming major Rice-producing areas in Ethiopia.

Rice (Oryza sativa L.) accounts for 27% of the world's cereal production second to wheat with 30%(Birhane, 2013). In Ethiopia Rice, research centers are found in Fogera, Pawi, Abobo, Gurafereda, Maytsebri, Goda, and Chewake.Oat originated from the western part of the Mediterranean region. World Oat producing countries are Europe, North America, Canada, and China. The Main Oat manufacturing countries in Africa are Morocco, South Africa, Algeria, Egypt, Tunisia, Kenya, and South Africa(Supervisor *et al*., 2020). Oat (*Avena sativa* L.) is one of the most important well-adapted fodder crops grown in the highlands of Ethiopia mainly under rain-fed conditions(Beyene *et al*., 2015).

Common Oats are richly grown-up in the central highlands especially at Selale highlands in north Shewa and some parts of west Shewa like Meta-Robi and Galessa areas of Dendi woreda. It is also developed to a major scale in other parts of the country like Arsi, Bale, and Gojjam (Kebede *et al*., 2016).Oats can explain to a wide range of climate and soil types.They can be range in the spring where winter is severe as in Canada, the northern United States, Russia, and Scandinavia, as well as higher-altitude regions in the tropics or subtropics(Huang *et al*., 2020).

The Cowpea is extremely used in the world such as Latin America, southern United States of America, and Asia. In Africa, Nigeria is the main producer and user of Cowpeas, accounting for about 45% of the world's Cowpea production (Etana *et al.*, 2013).In Ethiopia, the highest production regions are Amhara, Gambella, Oromia, Tigray, and SNNPR region. The Cowpea has been highest normally cultured and consumed in Asia, Tropical Africa, South America, parts of Southern Europe, and the United States(Zerihun, 2020).

Table 2.1: Global Cowpea production in 2012

Country name	Production (tone)	Area(hectare)
Nigeria	2137900	3701500
Niger	1593166	5325168
Burkina faso	573048	1205162
United republic of Tanzania	190500	197323
Cameroon	174251	209019
Mali	149248	353382
Kenya	138673	28877
Myanmar	115200	132000
Mozambique	103839	377900
Sudan	80000	260000

Source: Kebede *et al*., (2020)

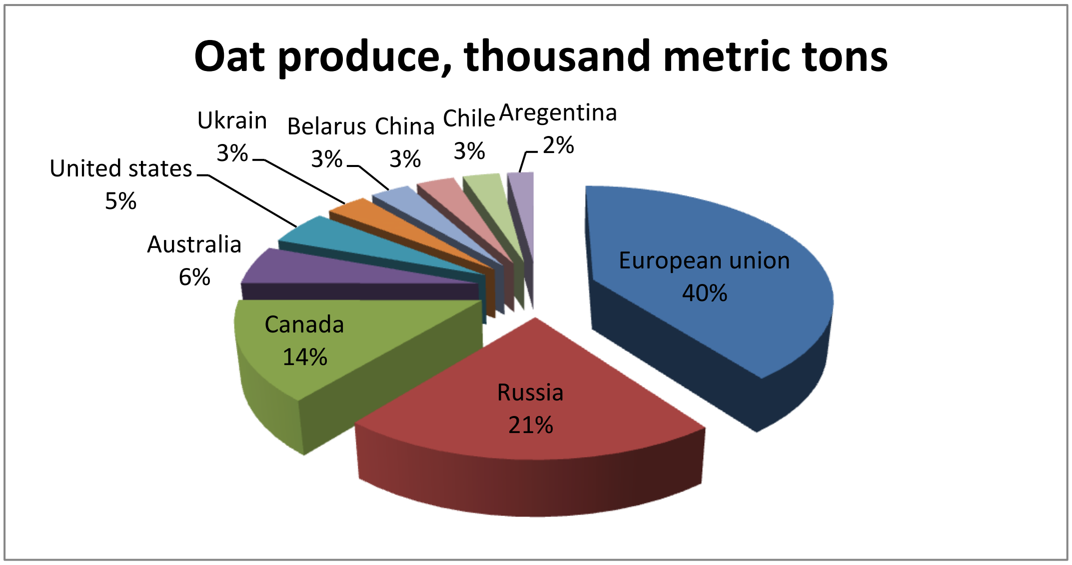


Figure 2.1: World Oat productions in 2013

Source:Mushtaq *et al*., (2014)

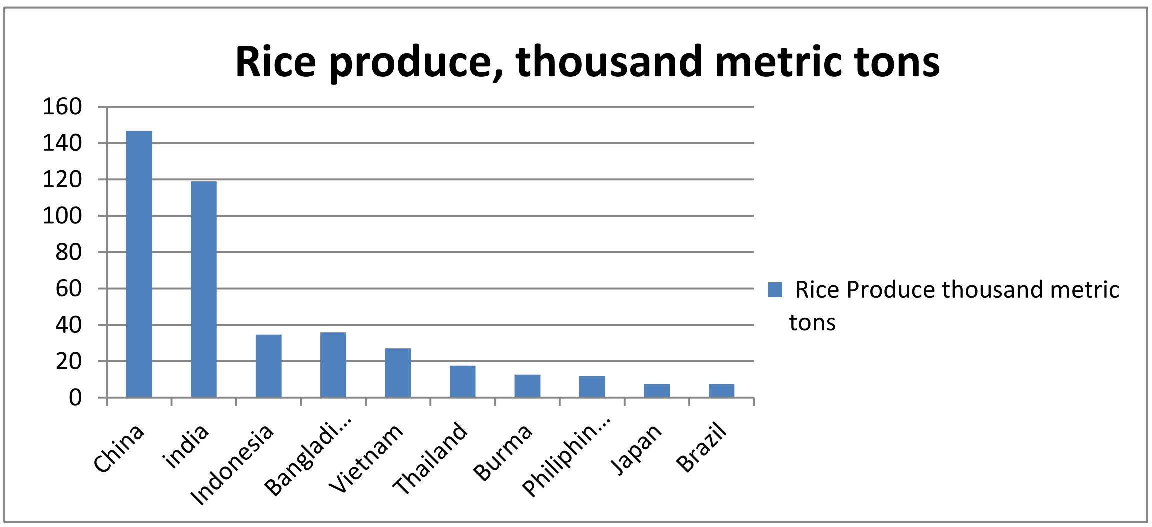


Figure 2.2: World Rice productions

Table 2.2: Production of Oat, Rice and Cowpea 2019/2020 in Ethiopia

Types of grain	Production(Kuntal)	Area(hectare)	Source
Oat	457,543.61	21,281.80	(CSA, 2014)
Rice	1,706,301.01	57,575.72	
White Cowpea	1,727,398.97	94,789.97	

2.1.1 Economic importance of Oat, Rice, and Cowpea in Ethiopia

Cereals and legumes are the main food sources in Ethiopia. Rice is important for food safety; it is becoming a good source of income and employment opportunity. It can be prepared for different types of foodstuffs. The flour can be used to make ‘Enjera, bread, porridge, and ‘Tela(Birhane, 2013).Rice commonly used in Ethiopia as breakfast in form of kinchie and shorba.Rice utilization in Ethiopia is low due to lack of technology and lack of awareness about the nutrient value and health benefits of Rice.Legume protein is having double or triple protein content in cereals. Cowpea is a legume, which is measured to be one of the main high-quality plant protein sources in the tropics.It is produced in Ethiopia mainly for its edible seeds, pods, and the leaves that are used as human food and animal feed, and income provided to households.

Legumes are known as poor people’s meat because the protein content is around equal to certain meat types.Cowpea is used in Ethiopia as boiled, roasted, or as a stew-like dish known as ‘Wot’ that attends the locally made bread called ‘Injera’(Kebede *et al*., 2020).Cowpea is a good base of nutrients; protein, essential minerals, vitamins, and folate so important to reduce malnutrition and use health benefits.In Ethiopia, Oat is used to mix other cereals and legumes to make traditional infant flour, consume made breakfast, and is also used for important to sustenance health conditions such as strength bone, increase weight. Oat also used consumes a form of atmit and genfo and input of industrial manufacturing like flack form to use breakfast. Generally, Rice, Cowpea and Oat are important for daily household consumption for different purposes and economic benefits for our country.

2.2 Malnutrition

Malnutrition refers to deficiency of all essential nutrients. In the world each country is affected by different forms of malnutrition's, especially in developing countries due to poverty and lack of sufficient knowledge about nutrition, malnutrition is the key cause of morbidity and mortality of children in the world such as 149 million under five years children are attacked by stunned, 45 million wasted, 38.9 million overweight,45% death (WHO, 2021).There are two types of malnutritions, the first one is protein-energy malnutrition which includes lack of protein, fat, and carbohydrate, the second one is micronutrients such as deficiency of essential minerals and vitamins.Malnutrition affects up to two years of age infants because of this age is high nutritional requirements for growth and development (Blossner *et al*., 2005), high brain growth velocity, this age is a transition period of family food trained so it must be fulfilled required quality and quantity of nutrients. Undernutrition included underweight (low weight for age), wasting (low weight for height), and stunting (low height for age).

2.2.1 Malnutrition in Ethiopia

Malnutrition is a common public health problem and the main cause of death of children in developing countries. In Ethiopia there are different forms of malnutrition such as low weight for height (Wasting), low height for age (Stunning), low weight for age (underweight) and the second form is micronutrient malnutrition like vitamin A deficiency, Iron deficiency, and Zinc deficiency which includes overweight and obesity which is too heavy or excessive fat for height. In Ethiopia, the main causes of malnutrition are determined food insecurity, poor guiding and child feeding practices, high incidence of infectious diseases, and limited access to quality nutrition services. Household capital, education, and family planning are also key drivers of children's nutrition.

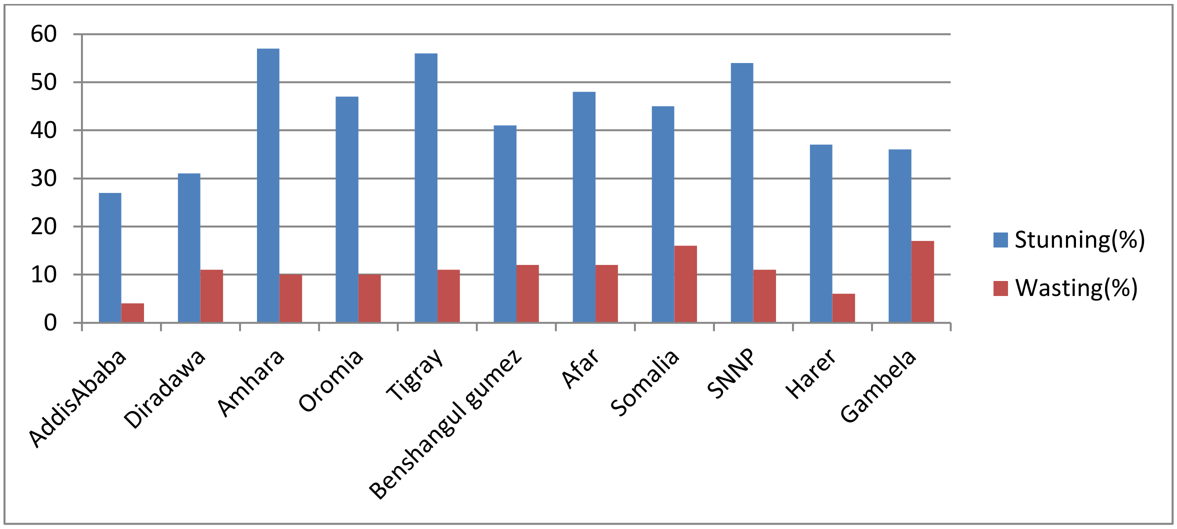


Figure 2.3: Stunning and wasting malnutrition in Ethiopia

Source: ORC Macro, (2000)

2.2.2 Preventive strategies of malnutrition in Ethiopia

Optimal income breastfeed is important to keep the health of both infant and mother (Alemayehu *et al*., 2009).In developing country including Ethiopia, breastfeeding is a common practice, but a great number of mothers do not train optimal breastfeeding. Exclusive breastfeeding practices in developing countries are still low.Approximately 56 million infants less than six months of age in developing countries, around 22 million are exclusively breastfed, while over 34 million children (60.7%) are not(Mamo *et al*., 2020).

Conditions of the feeding system in the early years have a major effect on the supportable health of children because nutrition is the high effect of good growth of organ formation and immune structure of children.Variety of food and optimum essential nutrient contents of food consumption is the key good health of children. In rural and unlearned families, children are more attack protein-energy malnutrition and micronutrient shortage, so during the weaning period give awareness about uncontaminated breastfeeding practices and a good exercise of stable diet include good processing technique and reduce nutrition problems.Preventing malnutrition in Ethiopia must be applied and priority concerns WHO and FAO policy this helps the growth of sustainable development of nutritional value.

Inorder to prevent malnutrition and improve the nutritional status of the population, the government together with partners, organized National Nutrition Strategy (NNS) (Federal minstry of Health, 2008). One of the problems of malnutrition in Ethiopia is failure economy status with population growth and lack of nutrition knowledge, so in the recent and future time; create continues awareness of nutrition of the infants' requirement from during pregnancy period, better assist to mother initiate and sustain breastfeeding and supplementary feeding system for all populations, increase infant food industry and accessibility of products in our country. Malnutrition, poverty, and disease problem are inhibited related to each other.

2.3 Importance of nutrition for infants

Appropriate complementary feeding helps growth and prevents stunting among children between 6 and 24 months of age. Infants are most vulnerable to malnutrition and infection during the transition period when complementary feeding begins.Infants are inadequate to consume adequate quality and quantity of nutrients; they will suffer from famine or malnutrition. Inadequate knowledge about proper foods and feeding practices is often a greater determinant of malnutrition than the lack of food.Optimal complementary feeding depends on accurate information and skilled support from the family, community, and health system.In developing country trained breast milk energy intake K.cal per day is decrease through the baby’s age increase. However, at the age of six months and above when the child’s birth weight is estimated to have doubled, breast milk is no longer adequate to meet the nutritional needs of the growing infant.

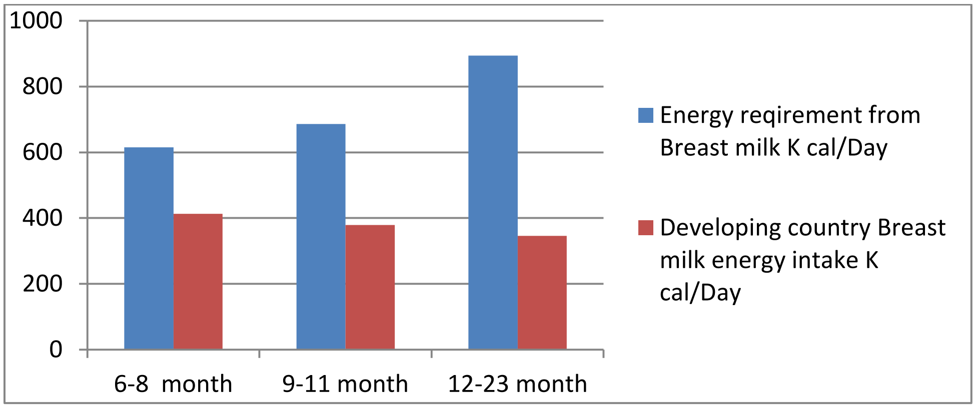


Figure 2.4: Energy gap of breast milk in developing country

Source: Geneva, (2000)

2.3.1 Weaning food

The advantage of weaning food production is an introduction of a modified family food to an infant(Nabi *et al*., 2019). The introduction of weaning food supplementation prepared from easily accessible and low-cost ingredients have importance to meet the requirements for child growth. Cereals and legumes are good sources of nutrients to prepare weaning food. Weaning food recommended that 30 to 40% of legumes and others portion is cereals and other raw materials.Weaning food must contain all essential nutrients like protein, carbohydrates, fat, minerals, vitamins for optimal growth and development.Infant's development is affected by consumption of nutrient food at an early age to the addition of mother breast milk feeding. Children's malnutrition is the significance of a range of factors, which are often related to poor food quality, insufficient food intake, severe and repeated infectious diseases(Abdullah, 2013).

2.3.2 Weaning food development in Ethiopia

Ethiopia is among countries suffering with children malutration. In Ethiopia, there is a high birth rates per year, but there is not enough weaning food industry.FAFFA food Share Company is first established in Ethiopia in 1962. This industry produces various baby foods such as famix flour, cerefam flour, FAFFA flour, corn flakes, soya milk, Oat flack, flips, and other infant foods.Recently starting some infant food product industry's but not meet the gap of requirements. Moreover, infancy is a period of rapid physical growth as well as physiological, immunological, and mental development when nutritional necessities are at their highest(Melese, 2013).Children in Ethiopia are introduced directly to the regular household diet made of cereal or starchy root crops. Introducing directly into the family meal; option creates a problem, as the child may not be able to eat enough adult diet to meet his or her nutritional needs.In Ethiopia there is poor feeding practice this results in some baby's importance stay mental development, limited intellectual ability,decrease immunity system (resisting disease).Good nutrition availability is a result of the quality and quantity of food.

FAAFA flour is weaning food and recommend feed from six month babies.This product prepared from cereals and legumes such as Wheat, Soya and Checkpea.

Table 2.3: Local and imported weaning food products

No	Types of weaning food	Local /Imported	Manufacturing country
1	Cerifam	Local	Ethiopia(FAFFA Food Share Company)
2	Ayu porridge	Local	Ethiopia
3	Mamas choice	Local	Ethiopia(Agro industry PLC)
4	FAFFA	Local	Ethiopia(FAFFA Food Share Company)
5	Barley mix	Local	Ethiopia(FAFFA Food Share Company)
6	Bulla flour	Local	Ethiopia
7	Cerelac	Imported	Kenya
8	Corn flour	Imported	Dubai
9	White Oat	Imported	United kingdom
10	RIRI baby foods	Imported	China

2.4 Nutritional composition and health benefit of Oat, Cowpea, and Rice

Oat

Oat has a significant amount of appreciated nutrients such as proteins, starch, unsaturated fatty acids, and dietary fiber as soluble and insoluble fractions. Water-soluble fibers can form sticky solutions, this results in fighting the digestibility of the intestine. β-Glucan is a soluble fiber readily available from Oat grains that have been gaining interest due to its multiple functions, bioactive properties,importance to control blood glucose and cardiovascular disease and considered to increase the production of immune system cells for babies.Oat contains micronutrients such as vitamin E, folates, zinc, iron, selenium, copper, manganese, carotenoids, betaine, choline, sulfur-containing amino acids, phytic acid, lignins, lignans, and alkylresorcinols (Rasane *et al*., 2015).

Rice

Rice gives the major dietary energy for the body. Rice is a good source of thiamine (vitamin B1), riboflvin (vitamin B2) and niacin (vitamin B3).The Rice endosperm is rich in carbohydrates and holds a fair amount of digestible protein, composed of an amino acid profile that links positively with those of other grains. As a consequence, Rice has been fortified with some minerals such as iron (Fe) and zinc (Zn), inorder to prevent diseases associated with mineral deficiencies.The Health benefit of Rice includes stabilizing blood sugar label and resist to high blood pressure, reducing heart diseases, cholesterol-free means low-fat contents, protecting types of cancer, and also important skincare(Rasane *et al*., 2015).

Cowpea

Cowpea is considered a nutrient-dense food with low energy density. An average Cowpea grain has 23-32% of protein 50-60% carbohydrate and around 1% fat on a dry basis. The total protein content of Cowpea is about two to four times greater than cereal and tuber crops. Cowpea is contained many other health-promoting components, such as soluble and insoluble dietary fiber, phenolic compounds, minerals, and many other functional compounds including B group vitamins. Thus, Cowpea contributes a lot to improving the quality of human health by offering several health benefits.The main limiting factors of consumption of Cowpea include poor digestibility of acids and the presence of anti-nutritional factors.Nevertheless, sufficient processing methods can be used to destroy those anti-nutritional factors, and increase the bioavailability levels particularly when it is used as a food(Jayathilake *et al*., 2018). Cowpea help to protect gastro intestine disorder, cardiovascular disease, obesity, diabetes, and several types of cancer.

2.4.1 Macro nutrition benefit of weaning food

Macronutrients such as protein, fat, carbohydrate, and energy are important for children. Proteins are the main source of essential amino acids and source of energy during times of energy deprivation, although fat and carbohydrate are utilized preferentially by the body.Protein plays important role in creating and maintaining every cell in our body.Protein, an amino acid is used for bone growth activities. Protein makes antibodies mean to support the immune system and is also used highly effective control blood sugar concentrations. Enzymes are proteins, this is important to reduce the activation energy of a chemical reaction in our body and digest dietary fat in our body.Protein must be balanced intake for infants; if high protein taken is over a recommended range, a problem of overweight and diabetes diseases appears. Dietary fats provide the infant and young child with energy, essential fatty acids, and the fat-soluble vitamins A, D, E, and K. Fat not only provides energy in the diet but also has a significant role in encouraging good health in children. Fat is a high portion of energy provided than protein and carbohydrates. Fat has an important role in taste perception and optimal functioning of the human body. Carbohydrate such as glucose, lactose, sucrose is metabolic important for infants (Kalhan & Kilic, 1999).

2.4.2 Micronutrition benefit of weaning food

Acceptable intakes of micronutrients such as iron, zinc, and calcium are important for confirming optimal health, growth, and development of infants and young children.Calcium is one of the macro minerals which is important for infants to help develop bone and skeleton parts of the body. Iron advantage of the increased immune system. Zinc is important to metabolism and tissue formation activities. Zinc plays an important role in the promotion of normal growth and development and is an element in the enzymes that work with red blood cells, which move CO_2 from tissues to the lungs. It also helps to maintain an effective immune system(Ekweagwu *et al*., 2008). Iron is important to prevent parasitic infections like malaria and iron deficiency malaria.

Table 2.4: Nutritional composition and health benefits of Oat, Rice and Cowpea

Types of Grain	Nutritional composition (%)	Health Benefits
Oat	-Protein = 12.62 % -Fat = 6.19% -Ash =1.97% -Moisture = 4.2% -Fiber =13.65 -Carbohydrate = 55.75% (Krishi Vidyapeeth *et al*., 2020)	-Heart dieses; reduce risk of blood pressure -Diabetes; help to prevent blood sugar -Weight control; -Intestinal digestive
Cowpea	-Protein = 28 % -Fat =4.75 % -Ash =4.12% -Moisture =4.66% -Fiber =1.87% -Carbohydrate = 56.05% (Aletan, 2018)	-prevent cancer and anemia -support a healthy metabolism -helps maintain strong bone -encourages mental well-being -help repair muscle tissue -supports a healthy cardiovascular system -supports immune system -prevent depression and diabetes
Rice	-Protein = 8.41 to 11.77% -Fat = 1.14 to 2.57% -Ash =0.62% to 1.63% -Moisture = 9.78 to 11.93% -Fiber = 1.58-1.38 -Carbohydrate = 74.96%-78.03% (Cherie & Dagnaw, 2019)	-diabetes control -control heart health -prevent heart disease -help digestive health -prevent obesity

2.5 Anti-nutrient factors in cereals and legumes

Legumes and cereals contain high amounts of macronutrients and micronutrients but also anti-nutritional factors. Cereals and legumes usually have a significant amount of anti-nutrients which have negative impact digestive enzymes activity, binding minerals ultimately making them unavailable to participate in the physiological functioning of the body.Anti-nutritional factors are associated with nutrients and act as the major concern because of reduced nutrient bioavailablity. The anti-nutritional factors, which reduce the nutritional value of foods, can be decreased by the use of food preparation methods such as fermentation, cooking, soaking, and roasting. These food processing methods decrease anti-nutritional factors, increase protein digestibility and improve the biological value of cereal and legume crops(Samtiya *et al*., 2020). The major anti-nutrient factors that originate in plant-based foods are phytates, tannins, lectins, oxalates,etc.

Phytic acid

Phytate needs a high concentration of cereals and legumes.It is found in the outer parts of cereals and with endosperm parts of legumes (Petroski & Minich, 2020).Phytic acid is commonly a negatively-charged structure, which mostly binds with positively-charged metal ions such as zinc, iron, magnesium, and calcium to create complexes and decrease the bioavailability of these ions through lower absorption rates(Samtiya *et al*., 2020).This compound consequence of lower metabolism and contribute animea problem.

Tannins

Tannins exhibit anti-nutritional properties by impairing the digestion of various nutrients and preventing the body from absorbing beneficial bioavailable substances.Tannin-protein complexes may reason digestive enzymes inactivation and protein digestibility decrease caused by protein substrate and iron interaction(Popova & Mihaylova, 2019).

2.6 Processing methods used to reduce anti-nutritional factor

Grains contain complex carbohydrates, dietary fiber, vitamins, and minerals, reduced by some processing methods such as dehulling, soaking, roasting, and germination.This processing method is important to reduce anti-nutrient factors and help to easily digestible.

Soaking

Soaking is removing the anti-nutrient content of foods and it reduces the cooking time.Soaking generally raises the hydration level of legumes and cereals,which make them soft and also activate an endogenous enzyme-like phytase to enhance ease of further processing. Soaking of grains and beans was found much effective to enhance the minerals concentration, protein availability, and the advantage of easy digestibility.

Roasting

Roasting is dry heat treatment, helps to extend shelf life, reason for precooked enhance flavor, color, taste and overall sensory acceptance, improving their digestibility and eliminating the anti-nutrient factors of cereals and legumes.During the roasting process, smelling and volatile substances like hekanal will be removed.

Dehulling

Dehulling is used to improve the digestibility of grain and the nutritional quality of products due to dehulling, the soluble and insoluble dietary fiber, phytic acid, and tannin decreased significantly(Oghbaei & Prakash, 2016).

Germination

Germination has been described to encourage an increase in free limiting amino acids and accessible vitamins with improved functional properties of seed components.It has also been presented to decrease anti-nutritional factors and also increase the protein digestibility, crude fiber and protein contents and peptides are synthesized the new protein, increase total mineral content, significantly decrease fat and carbohydrate content(Kavitha & Parimalavalli, 2014). Germination is important to activate phytase enzyme to reduce phytic acid (Samtiya *et al.*, 2020). This process is advantageous of calorie-dense as a result it reduces the viscosity for weaning food through a breakdown of starch.

2.7 Physicochemical and functional properties of Oat, Cowpea, and Rice

Functional properties are the major physicochemical properties that replicate the complex interface between the composition, structure, molecular conformation, and Physico-chemical properties of food components composed with the nature of the environment in which these are associated and measured (Chandra, 2013). The functional properties of foods are influenced by the components of the food material, particularly the carbohydrates, proteins, fats and oils, moisture, fiber, ash, and other ingredients or food additives added to the food other ingredient also designate the components of food material.

pH of flour

pH is an important measure that imitates the chemical conditions of a solution.The pH can control the availability of nutrients, biological functions, microbial activity, and the behavior of chemicals.

Water Absorption Capacity and Oil Absorption Capacity

Water absorption capacity is referring to the capacity of the flour or starch to hold water by gravity that can contain bound water, hydrodynamic water, capillary water, and physically entrapped water(Hasmadi *et al*., 2020). Oil absorption capacity is definite that the ability of flour to bind with oil.Oil absorption capacity has regulated the physical entrapment of oil. The amount of WAC and OAC has affected the quality of products.

Dispersibility: Dispersiblity is a uniform dispersal of the solution.This property is determined nature and molecular structure of solvent and solution.

Bulk density: Bulk density is defined as the mass of many particles of flour material divided by the total volume they occupy.It is a functional property of flours, powders, fine particles, granules, and other divided solids of foods. The total volume includes particle volume, internal pore volume, and antiparticle void volume. The variation in bulk density of foods could be due to the variation in the starch content of the foods. The higher the starch content the more likely the increase in bulk density. Also, bulk density depends on factors such as geometry, method of measurement, particle size, surface properties, and solid density of the materials and can be improved when the particles are smaller, properly tapped/vibrated, compactible, and with suitable packaging material(Godswill *et al*., 2019). Low bulk density is useful in the design of complementary foods.

Viscosity: Viscosity is the resistance of food flow that is determined to infant food acceptability by both babies and mothers. High amounts of viscosity of infant food are not accepted by infants because it is difficult to feed. The viscosity of roasted grain of weaning food has ranged between 411.67 to 1,065.61 mpa.s (Makori *et al*., 2017).

3. MATERIALS AND METHODS

3.1 Material collection

Oat (*Sorataf*) was collected from the Holetta Agricultural Research Center, Rice(fogera1) was collected from Fogera Agricultural Research Center in the west-central highlands of Amhara region and Cowpea(Bola) was collected from Awash Melkasa Agricultural Research Center.

Figure 3.1: Raw Oat, Rice and Cowpea

3.2 Sample preparation

Sample preparation include good processing methods such as cleaning, washing, soaking, drying, germination ,roasting and milling. In this study soaked and dried time was refer from recommended different previous studies.And also samples are roasted by electrical oven (model: Leicester,LE675FT,England), roasted temperature and time range was refere from pre-taste of traditional weaning food preparation.Roasted oven carred out one killo gram of sample by material of steelness still plate and uniformly distributed.

3.2.1 Oat flour preparation

Defectes such as small grain size, un-similar type of grain, broken grain, stone, dust, and other foreign materials were removed from Oat, then Oat was washed with pure water and soaked in distilled water (1:3w/v) for 8 hours. The water was drained from soaked Oat by using a nylon sieve. The soaked Oat was dried by air drier unit it reaches a moisture content of 12%, the dried Oat was roasted by electrical oven by three labels of temperatures at 100^{o}c, 120^{o}c and 140^{o}c for

10min.The roasted Oat was milled by using miller (ZN-08 model miller, made in china). Finally, the flour was sifted using 250µm stainless sieve.

3.2.2 Rice flour preparation

Defectes such as small grain size, un-similar type of grain, broken grain, stone, dust, and other foreign materials were removed from Rice, then Rice was washed with pure water and soaked in distilled water (1:3w/v) for 6 hours. The water was drained from soaked Rice by using a nylon sieve. The soaked Rice was dried by air drier unit it reaches a moisture content of 12%, the dried Rice was roasted by electrical oven by three labels of temperatures at 100^{o}c, 120^{o}c and 140^{o}c for 10min. The roasted Rice was milled by using miller (ZN-08 model miller, made in china). Finally, the flour was sifted using 250µm stainless sieve.

3.2.3 Cowpea flour preparation

Defectes such as small grain size, un-similar type of grain, broken grain, stone, dust, and other foreign materials were removed from Cowpea, then Cowpea was repeated washing with pure water and soaked in distilled water (1:2w/v) for 9 hours.The water was drained from soaked Cowpea by using a nylon sieve, the soaked Cowpea was covered by aluminum foil and set in a dark environment. After 24 hours all Cowpea seeds were fully germinated. Separate hull and root from germinated Cowpea easily by manually. The germinated Cowpea was dried by air drier unit it reaches a moisture content of 12%, the dried Cowpea at was roasted by electrical oven by three labels of temperatures at 100^{o}c, 120^{o}c and 140 ^{o}c.The roasted Cowpea was milled by using miller (ZN-08 model miller, made in china). Finally, the flour was sifted using 250µm stainless sieve.

3.2.4 Flow diagram for the production of Cowpea, Oat and Cowpea flour

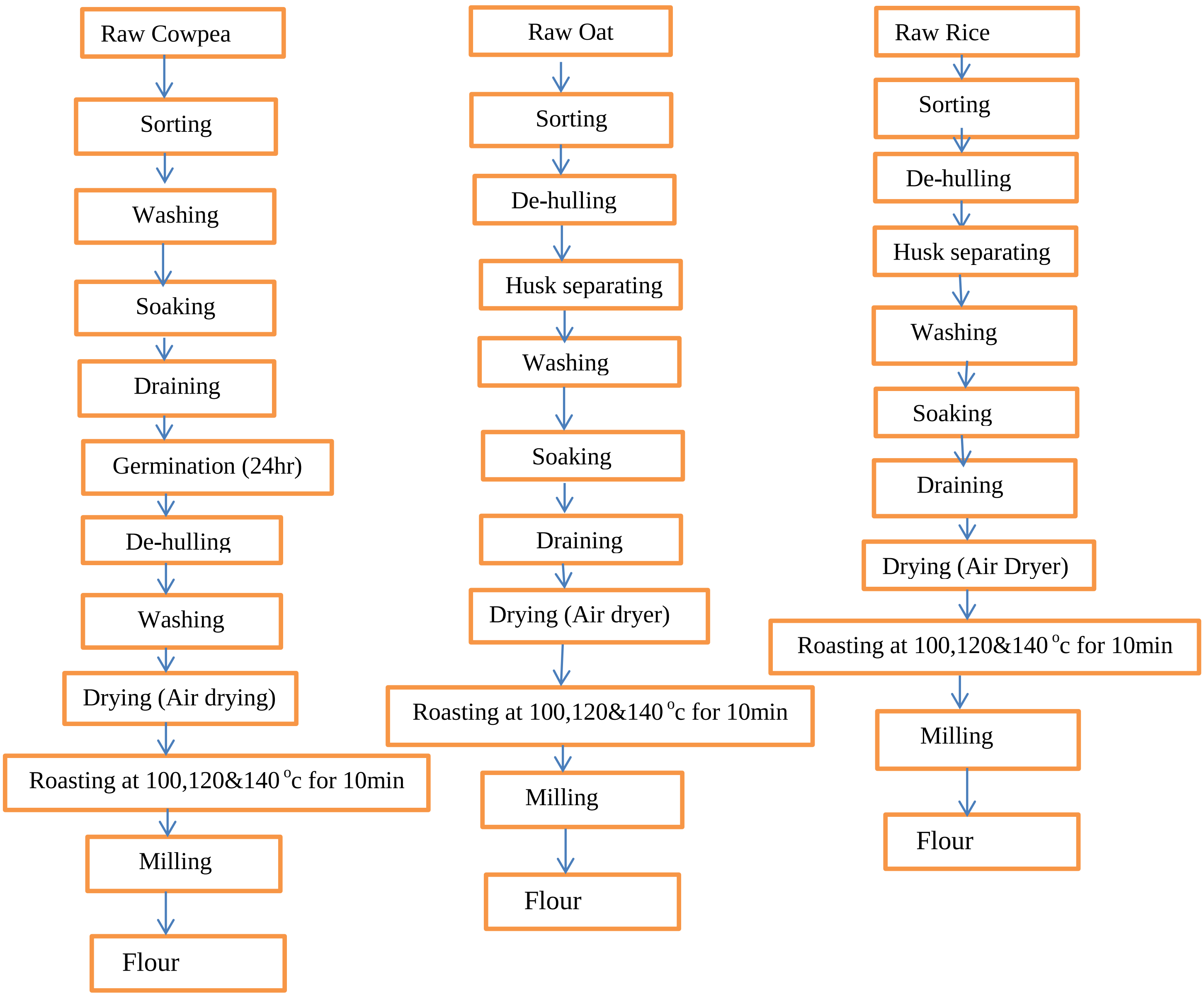


Figure 3.2: Flow diagram for the production of Cowpea, Oat and Rice flour

3.3 Experimental framework of the study

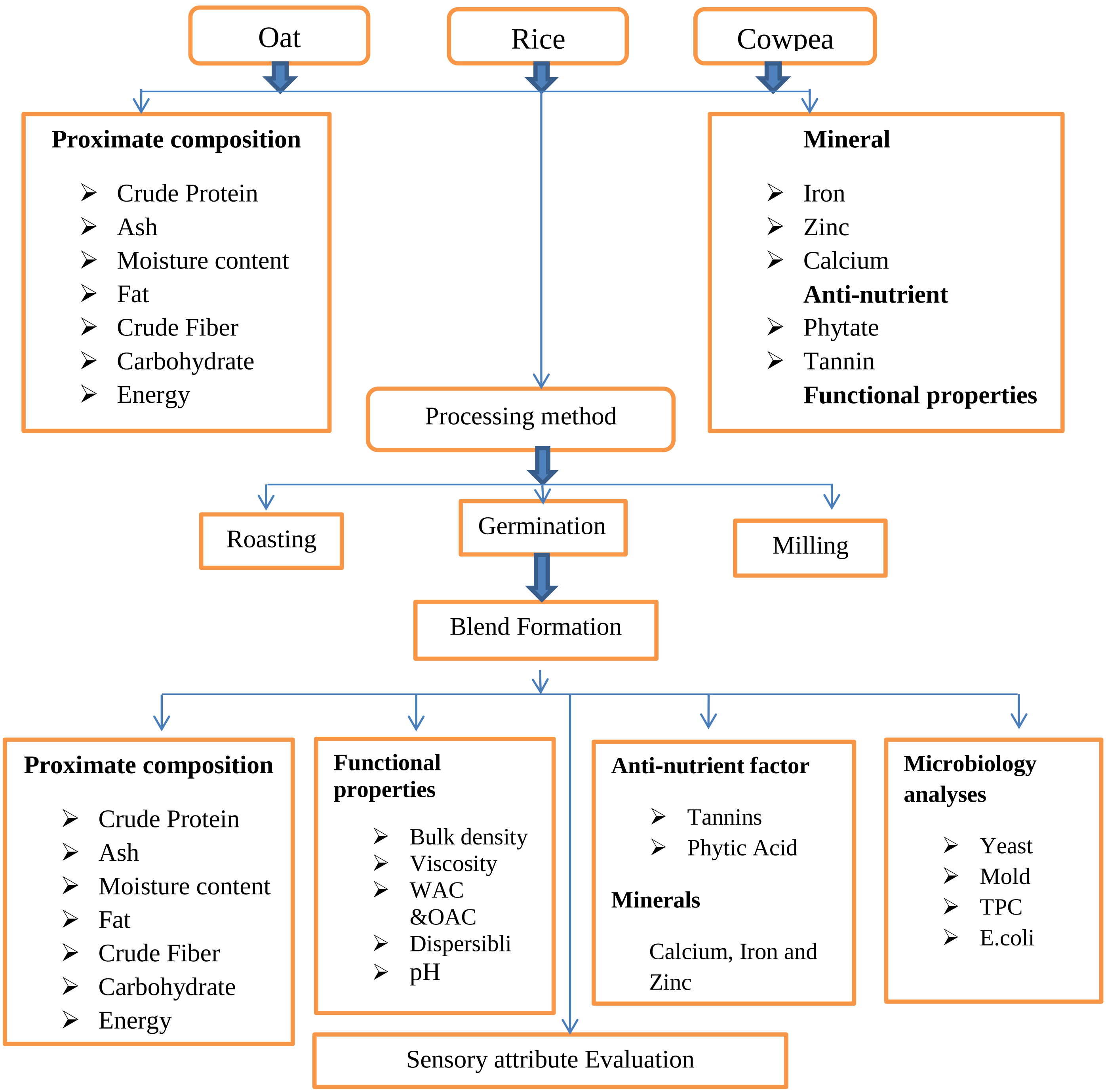


Figure 3.3: Experimental framework of the study

3.4 Processing method of flour production

Soaking: After removing foreign materials the grains were properly washed and soaked in distilled water.This process helps to release important vitamins, break down the difficult-to-digest component (anti-nutrient factors) like phytic acid and tannins, easily remove hull , generally soaking is important to the grain become easily digested and improve mineral and protein bioavailability.

Germination: After being properly sorted and washed, Cowpea was soaked by distilled water 1:3w/v for 9 hours at room temperature.The steeping water was removed and cowpea was drained by using a nylon sieve and the cowpea was set in a dark place and a temperature of 25^{o}c for 24 hours. After that Cowpea was easily hulled manually and washes repeated by distilled water then dried by using air dryer for 12 hours.In this study cowpea was germinated due to contain high amount of antinutreints.Germination is important to improve the nutritional value of the product, as it increases the digestibility of protein and carbohydrates, increases vitamins, and eliminates anti-nutritional factors.

Roasting: Raw materials was roasted by an electrical oven at 100^{o}c, 120 ^{o}c, and 140 ^{o}c for 10min. Roasting is the preheated process it helped to extend shelf life, improve flavor, color, odor, and overall acceptance of the product and also helps undesirable microorganisms, remove toxin, allergies, and food contaminants.

3.5 Blend formulation

Weaning food formulation's first criteria were selected and ensure proximate composition especially protein and fat contents of raw materials.The weaning product must be fulfilled protein-energy requirements and also blend of raw materials is considered to reach the target of WHO or FAO standard in infant’s age.Blends of cereals 60-70% and legumes 30-40% ranges are recommended for weaning food(Griffith *et al*.,1998),ratio of cereals(Oat and Rice), legume(Cowpea) as indicated in Table 3.2.Each ratio was roasted by three labels of roasting temperatures such as 100^{o}c, 120^{o}c and 140^{o}c.This temperature refer from pretest condition of traditional roasting temperature.Finally nine formulated weaning food sample products was prepared showed in Table 3.3.

Table 3.1: Mixture value of Oat, Rice and Cowpea

Types of raw material	Ratio 1	Ratio 2	Ratio 3
Oat	50	45	60
Rice	10	19	10
Cowpea	40	36	30

Table 3.2: Weaning product samples

Sample code	Formulated weaning products
Product 1 (P1)	Ratio 1 roasted at 100^{o}c
Product 2 (P2)	Ratio 1 roasted at 120^{o}c
Product 3 (P3)	Ratio 1 roasted at 140^{o}c
Product 4 (P4)	Ratio 2 roasted at 100^{o}c
Product 5 (P5)	Ratio 2 roasted at 120^{o}c
Product 6 (P6)	Ratio 2 roasted at 140^{o}c
Product 7 (P7)	Ratio 3 roasted at 100^{o}c
Product 8 (P8)	Ratio 3 roasted at 120^{o}c
Product 9 (P9)	Ratio 3 roasted at 140 ^{o}c

3.6 Analytical methods

3.6.1 Proximate composition analysis

1. Determination of moisture content

The moisture content was determined according to AOAC,(2000) method. The dish was properly cleaned and dried at 130^{o}c by the electrical oven and cooled by desiccator for 25-30 min, then the weight of the dish by analytical balance mass of dish(M_1), weight 5gram sample in the dish(M_2), the sample was dried at 105^{o}c for 3hours finally measure the weight of dried sample with a dish(M_3).

$$\text{Moisture content (\%)} = \frac{(M_2 - M_3)}{M_2 - M_1} \times 100 \qquad \text{Equ (1)}$$

Where:- M_1 = mass of crucible

M_2 = mass of crucible and sample

M_3= mass of crucible and sample after dried

2. Determination of total ash

Ash content was determined according to AOAC,(2000) method.The cleaned crucible dish is dry by oven at 130 ^{o}c and cooling by desiccator then the mass of crucible dish (M_1) by analytical balance, weight 2.5 gram of sample with a crucible dish (M_2), burns still completely remove smoke from burning sample, then put in a furnace at 550 ^{o}c for four hours, then the sample was removed from the furnace and cooled by desiccators and weight of sample with ash (M_3).Finally calculated Ash content of the sample.

$$\text{Ash content (\%)} = \frac{(M_3 - M_1)}{M_2 - M_1} \times 100 \qquad \text{Equ (2)}$$

Where:- M_1 = Mass of the crucible

M_2 = Mass of the crucible and sample

M_3 = Mass of the crucible and sample after drying

3. Determination of crude protein

Protein content was determined according to AOAC,(2000) method used Kjeldahl.There are three stages of crude protein determination such as digestion, distillation, and titration.0.5 grams of flour sample added to the digestive tube and 6ml of concentrated sulfuric acid were added then add 3.5ml of hydrogen peroxide and shake a few minutes, add 3 grams of catalyst mixture (Potassium sulfate and Copper sulfate) were added and digested the temperature reached 370^{o}c. Then in distillation add 25ml of 40% NaOH and 25ml of boric acid with 10 drops of indicator solution. After that, the distillate was titrated by using 0.1N of HCL to reddish color. Calculate the amount of nitrogen and finally need the percentage of protein.

$$\%N = \frac{(V_2 - V_1) \times V\ Hcl \times 14 \times 100}{W \times 1000} \text{……………………………………………………Equ (3)}$$

Where:- V1=Volume in ml of the standard Hcl read before titration

V2=Volume in ml of the standard Hcl read after titration

W = Weight of sample in gram

VHcl= Volume of Hydro Chloric Acid

Used conversion factor is 6.25 finally

Crude Protein content(%) = total N(%)× 6.25…………………………………Equ (4)

4. Determination crude fat

Fat content was determined according to AOAC,(2000). First clean and dry thimble and weighted 2 gram dried sample, then sample put to the thimble and covered by fat-free cotton at the top and bottom parts of thimble were placed in the extraction chamber, 50ml of petroleum adds to cleaned and dried extraction flask, then the extractions took place for 4 hours, then after extraction, the flask was removed from the extraction and dried by electric oven at 100 ^{o}c for 30 minutes then it was removed from the oven and cooled by desiccator finally, calculate the amount of fat by using measure weight of before the extraction flask and weight of after extraction flask by analytical balance.

$$\text{Crude fat content(\%)} = \frac{(M_2-M_1)\times 100}{M} \quad \text{……Equ (5)}$$

Where:- M_1= Mass of dried flask

M_2=Mass of dried flask and extracted oil

M=Mass of the sample

5. Determination of crude fiber

Crude fiber analysis was determined according to AOAC,(2000) method.1.6 gram of the weighted sample was transferred to the beaker and mixed 200ml of 1.25% sulfuric acid, and left to boil for 30 minutes. Record was done by placing the watch glass in the mouth of the beaker. After 30 minutes of heating gently keeping the level constant with distilled water, 20 ml of 28% KOH was added and gently boil again for 30 minutes. Subsequently, it was washed with 1% sulfuric acid and NaOH solution. After that, it was filtered and then dried in an electric oven for 2 hours. After cooling to room temperature in a desiccator for 30 minutes and weighing, the crucible was transferred to a muffle furnace and incinerated at 550°C for 30 minutes. Finally, it was cooled again in a desiccator and weighed again. The crude fiber content was determined by the following formula

$$\text{Crude Fiber content(\%)} = \frac{(W_1 - W_2) \times 100}{W_s} \quad \text{……Equ (6)}$$

Where:- W_1= Weight of crucible with fiber after drying

W_2 = Weight of crucible with ash

W_s= Sample dry weight

6. Determination of carbohydrate

Carbohydrate content was calculated by using the method of different

% Carbohydrate = 100 - (%Crude protein+%Crude fiber+%Fat+%Moisture+%Ash) …Equ (7)

7. Determination of energy

The gross energy content in each sample was determined by the following formula

Gross Energy (Kcal) = (9*Crude Fat) + (4*Crude protein) + (4*Carbohydrate) ………Equ (8)

3.6.2 Mineral analysis

A mineral content such as Calcium, Iron, and Zinc was determined according to the Association of Official Analytical Chemists AOAC,(2000) method.This analysis was used atomic absorption Spectrometer (AAS). About 2.5 grams of the sample were weighed and ash by using a hot plate up to completely remove smoke organic matter then put furnace at 550 ^{o}c at 5 hours. The ash was treated with 7ml of 6N HCL and dry by hot plate and treated again 10ml of 3N HCL was added to the dish and heated just boiled then cooled and filtered by using add distilled water to remove completely from filter paper add to 100 ml graduated flask. Finally, concentration amounts of samples was read by using an atomic absorption spectrometer (AAS) used air acetylene flame. Finally, calculate using sample absorption or emission value and blank reading. Mineral content calculated by mg/100 gram.

Mineral content (mg/100gram) = S-B *V / 10W…………………………………………Equ (9)

Where:- S = Concentration of sample solution

B = Concentration of Blank solution

V = Volume of extract

W =Weight of sample

3.6.3 Functional properties of the weaning food

WAC and OAC were determined according to Adebowale *et al*., (2005) procedures.

1. Determination of Water Absorption Capacity (WAC)

About weighted one gram of sample and transferred to clean and dried test tube, add 10 ml of distilled water, then tolerable standing for 30 minutes the sample was centrifuged at 4000rpm for 30 minutes. Finally removing the supernatant and measure the weight of the test tube with the sample and calculated by the formula

$$WAC(ml/g) = \frac{(W_2 - W_1)}{W_0} \quad \text{...Equ (10)}$$

Where:- W_0= Weight of dry sample

W_1= Weight of test tube

W_2= Weight of test tube with sediment

2. Determination of Oil Absorption Capacity (OAC)

1 gram of sample was transferred to cleaned and dried test tube, add 10 ml of sunflower oil, then allowed standing for 30 minutes then the sample was centrifuged at 4000rpm for 30 minutes. Finally removing the supernatant and measure the weight of the test tube and calculated OAC by formula

$$WAC(ml/g) = \frac{(W_2 - W_1)}{W_0} \quad \text{...................... ....Equ (11)}$$

Where:- W_0= Weight of dry sample

W_1= Weight of tube with dry sample

W_2= Weight of tube with sediment

3. Determination of Dispersibility of flour

Dispersibility was determined according to EA *et al*., (2018). 10 grams of each flour sample transfer into 100ml cleaned and dried measuring cylinder. Distilled water added up to 100ml volume then stirred and allowed to settle for 3 hours.Finally settled particle was recorded and subtracted from 100 to give difference is determined percentage of dispensability.Dispersibility is important indicates the rate of reconstitution of flour sample in water.

4. Determination of Bulk Density

Bulk density was determined according to Ijarotimi & Keshinro, (2019). About weighted 5 gram of flour sample and transfer to 20ml graduated cylinder. The sample was tapped continuously up to need constant volume, then determined bulk density by formula

$$\text{Bulk Density} = \frac{\text{Weight of sample}}{\text{Volume of sample}} \quad \text{……………………………………………………Equ (12)}$$

3.6.4 Phisico-chemical properties of the weaning food

1. Determination of viscosity

Viscosity was determined according to Kanensi *et al*., (2013). This study was determined 10% dry matter base of each flour was prepared with 200ml of distilled water and the porridge sample was heated up to 95^{o}c, uniformly mixed held for 15minutes and cooled to 50^{o}c. Finally determine read by a viscometer VT550(Rheo,Champlan,France).

2. Determination of pH value

pH value was determined according to AOAC,(2000) used an official method 981.12. About weighted 10-gram flour sample transfer to beaker then add to 50ml of distilled water, mixed with 50ml distilled water and stirred 10 minutes. pH meter was calibrated by using buffers such as pH 4.0 and pH 7.0.Finally, pH value determines by calibrated electrode PH meter.

3.6.5 Anti-nutrient factor analysis

1. Analysis of phytate

Phytate analysis was determined according to Oa *et al*., (2017). About 0.1 gram of dried sample was extracted with 10ml of 0.2% of HCL for one hour an ambient temperature ,then centrifuged at 4000rpm(model 800-1) for 30 min after centrifuge clear supernatant used for phytate determination,the clear supernatant was employed.the supernatant sample solution was then homogenized and centrifuged after 2ml of wada reagent (0.03% of $Fecl_3.6H_2O$ containing 0.3% sulfosalcilic acid in water) was added to 3ml of the supernatant sample solution(4000rpm for 10min).UV spectrometer (LAMBDA 950) was used to detect the absorbance at 500nm.the amount of phytic acid was calculated using phytic acid standared curve and result was expressed as phytic acid in µg/g.

$$\text{Phytic acid}(\mu g/g) = \frac{(A_s - A_B) - \text{Intercept} * 10}{\text{Slop} * W * 3} \quad \ldots\ldots \text{Equ (13)}$$

Where: - AS = Sample absorption

AB = Blank absorption

W = Weight of sample

2.Analysis of Tannin

Tannin was determined according to Oa *et al*., (2017). 2 grams of dried sample was added in a screw cap test tube and 10ml 1% HCL in methanol was mixed to the sample containing tube, the tube was closed with lid and allowed to shake on mechanical shaker for 24hour at ambient temperature.It was centrifuged at 1000 gravity for 5 min using centrifuge(model 800-1) and 1ml supernant was taken and mixed again with 5ml of vanillin-HCL reagent in other test tube and left for 20min until the reaction is completed and then the reaction is completed and then the absorbance was read at 500nm using UV-spectrometer(LAMBDA 950).

standard solution preparation:D-Catechin/gram of sample.40mg of D-Catechin was taken 0,0.2,0.4,0.6,0.8 and 1ml of stock solution in a test tube and adjusted volume of each tube to 1ml with 1%HCL in methanol.In each tube 5ml of vanillin –HCL reagent was added and allowed for 20min to complete the reaction.The absorbance was read at 500nm.Reference curve was prepared from the series of standard solution.The amount of tannin was calculated using tannin standard curve and result was expressed as tannin in mg/g.

$$\text{Tannin (mg/g)} = \frac{((A_s - A_b) - \text{Intercept}) * 10}{\text{Slope} * D * W} \qquad \text{Equ (14)}$$

Where: - AS = Sample absorption

AB = Blank absorption

W = Weight of sample and

D = Density of solution (0.791g/ml)

3.6.6 Microbiological analysis

Microbiological analysis of weaning food: Total Plate Count (TPC), Yeast, Mold, and E.coli, determine according to Ware *et al*., (2018). First all equipments were sterilized by autoclave 121^{o}c for 15min. Plate count agar media was used for the detection Total Plate Count (TPC) by the multiple tube technique.One up to ten series dilution of sample was prepared and from every series dilution, 0.1ml was poured into labled petridish and spread over the agar surface.Incubation was done at 35^{o}c form 1 up to 3 days.

Yeast and mold determination was prepared 10ml of liquid sample transfer to 90ml of diluting flask, to make the first dilution.First properly shake, mix and take 1ml into a tube of 9ml of normal saline. From the first dilution 1ml transfer to the second dilution repeat this dilution up to made required dilution, then shake all dilutions. From each dilution transfer into duplicate marked petri dish, Potato Dextrose Agar(PDA) to each petri dish finally incubate at 22 and 37^{o}c for 5days, counting the colony of each dilution.

E Coli was determined by using the dilution method, prepared different petri dishes and dilution first dilution10^{-1}, second dilution 10^{-2} and third dilution 10^{-3}, take 10 ml from each dilution, then incubated at 37^{o}c for 48hours and after two-days count and the results was putted in dilution factor and test total coliform used LSTB (Lauryl sulfate broth) after that if get positive coliform to analysis further test using EC broth, but the sample result was negative so that the step is not proceeding, prepare LSTB in 3 test tube and put 1 ml of each dilution based on dilution factor and incubate at 37^{o}c for 48 hours finally observed the sample and there was no gas formation and turbidity in the test tube, so cannot required further testing.

3.6.7 Sensory evaluation of the weaning food

Sensory analysis attribute of weaning food was done in Addis Ababa University, Addis Ababa University Institute of Technology (AAiT), selected 20 mothers' panelists: master students and work in university staff.The panelists were given orientation overall sensory evaluation procedures. Weaning porridge products were prepared. Weighted 20 grams of weaning flour and mixed with 200ml of pure water, then heated up to 95^{o}c for 10 minutes and cooled at 40^{o}c, then transfer to the plastic dish in different code samples. This evaluation was included color, Aroma, flavor, taste, texture, and overall acceptability using seven hedonic scales was panelist follows; (7)like extremely,(6) like very much, (5)like slightly, (4)neither like nor dislike, (3)dislike slightly, (2)dislike very much,(1)dislike extremely.Panelists used mouth rinsed with bottled water an interval of evaluation for each sample.

3.7 Experimental design and statistical analysis

Experimental analysis of results was given as mean and standard deviation (SD) using one-way analyses of variance (ANOVA) by using SPSS version 20 Duncan's multiple range test software application. Except for sensory attribute analysis, all analysis was measured in triplicate of each sample, differences considered to be significant at $P<0.05$ (95% confidence level). In this study optimization of proximate composition analysis were by using Minitab 17 software design the effect of two variables(Factors) such as blending ratio(R1, R2 and R3) and roasting temperature(100^{o}c,120^{o}c and140^{o}c) of weaning flour compared with commercial FAFFA flour.Because, FAFFA flour product is recomend for the age of six month to two year babies.

4. RESULTS AND DISCUSSION

4.1 Proximate composition of raw Oat, Rice, and Cowpea

The result for formulated weaning food from blended Oat, Rice and Cowpea is discussed below. The blended formulation of weaning food was based on 60 to 70% cereals and 30 to 40% legumes as recommended by FAO/WHO standards (Griffith *et al*., 1998).In this study,processing methods such as, soaking, germination (Cowpea) and roasting were applied and those processes influenced the proximate composition,functional properties, physicochemical properties, anti-nutrient factors, mineral contents, microbiological load and sensory quality of the products.

Table 4.1: Proximate Composition of raw Oat, Rice and Cowpea

Grain	Crude protein (%)	Crude fat (%)	Crude fiber (%)	Ash (%)	Moisture (%)	Carbohydrate (%)	Energy (Kcal/100g)
Oat	16.9 ± 0.02^{b}	9.0± 0.026^{c}	1.1±0.02^{a}	2.6 ± 0.01^{b}	4.0±0.03^{a}	66.4±0.09^{b}	414.2±0.14^{c}
Rice	9.6 ± 0.03^{a}	2.0±0.04^{a}	1.2±0.02^{a}	2.0 ± 0.01^{a}	4.5±0.01^{b}	80.7±0.12^{c}	379.2±0.06^{b}
Cowpea	21.5 ± 0.02^{c}	2.4±0.02^{b}	1.36±0.16^{b}	3.6 ± 0.03^{c}	5.3±0.03^{c}	65.8±0.18^{a}	371±0.65^{a}

i^{a-c} shows that all values within the same column having the same superscript are not significantly different.

All values are means of triplicate ± standard deviation.

The proximate compositions such as protein, fat, fiber, ash, moisture, carbohydrate and energy contents of raw Oat, Rice and Cowpea are presented in Table 4.1. All results are expressed in dry matter base.The protein content of raw Oat, Rice and Cowpea were 16.9%, 9.6% and 21.5%, respectively.The protein content of Cowpea (21.5%) was higher than the protein content of Oat (16.9%) and Rice(9.6%).The protein content of Oat(16.9%) was higher than the protein content reported by Krishi Vidyapeeth *et al* (2020) which is (12.62%).The protein content of rice (9.6%) agrees with the result reported by Cherie & Dagnaw(2019) which ranges between 8.41 to 11.77%.

The protein content of Cowpea (21.5%) was lower than the result reported by Aletan (2018) which is (28%).The result variation can be due to soil type or specific variety selected.The moisture content of raw Oat, Cowpea and Rice were 4.0%,5.3% and 4.5%, respectively.The moisture content of Oat(4.0%) was lower than the moisture content reported by Krishi Vidyapeeth *et al* (2020) which is (4.2%) where as the moisture content of Cowpea (5.3%) was higher than the result reported by Aletan (2018) which is (4.66%). The moisture content of Rice (4.5%) was lower than the result reported by Cherie & Dagnaw(2019) which ranges between 9.78 to 11.93%. The fat content of raw Oat, Rice and Cowpea were 9.0%, 2.0% and 2.4%, respectively.The fat content of Oat (9.0%) was higher than Rice (2.0%) and Cowpea (2.4%).The fat content of Oat (9.0%) was higher than the result reported by Krishi Vidyapeeth *et al* (2020) which is (6.19%). Fat content of Rice (2.0%) agrees with the result reported by Cherie & Dagnaw(2019) which ranges between 1.14% to 2.57% and Cowpea fat content (2.41%) was lower than the result reported by Aletan (2018) which is (4.75%).

The ash content of Oat, Rice and Cowpea were 2.6%, 2.0% and 3.6%, respectively. The ash content of Cowpea (3.6%) was higher than Oat (2.6%) and Rice (2.0%). The ash content of Cowpea(3.6%) was found to have lowest content than the result reported by Aletan (2018) which is (4.12%).The ash content of Oat(2.6%) was higher ash content than the result reported by Krishi Vidyapeeth *et al* (2020) which is (1.97%).

The fiber content of raw Oat, Rice and Cowpea were 1.1%, 1.2% and 1.36%, respectively. The fiber content of Oat(1.1%) and Rice(1.2%) were found to have lower value than the result reported by Krishi Vidyapeeth *et al* (2020) which is (13.65%) and Cherie & Dagnaw(2019) which ranges between 1.58 to 1.38%, respectively.The fiber content of cowpea (1.46%) was higher than the result reported by Aletan (2018) which is (1.87%).

The carbohydrate content of raw Oat, Rice and Cowpea were 66.4%, 80.7% and 65.8%, respectively.All results of carbohydrate were higher than the results reported by Krishi Vidyapeeth *et al* (2020) which is (55.75%) , Cherie & Dagnaw (2019) which is (56.05%) and Aletan (2018) which ranges 74.96 to 78.03%, respectively.The energy value of raw Oat, Rice and Cowpea were 414.2 kcal/100 g, 379.2kcal/100g and 371 kcal /100g ,respectively.

4.2 Minerals and anti-nutritional factors of raw Oat, Rice and Cowpea

Table 4.2: Minerals and anti-nutritional factors content of raw Oat. Rice and Cowpea

Raw Grain	Minerals			Anti-nutritional factors	
	Iron (mg/100g)	Zinc (mg/100g)	Calcium (mg/100g)	Phytate (mg /100g)	Tannin (mg /100g)
Oat	6.8±0.02[a]	3.7±0.02[a]	152±0.01[a]	195.3±0.01[a]	214±0.016[a]
Rice	2.4±0.01[c]	3.5±0.01[b]	8.6±0.02[b]	106.6±0.006[b]	BDL
Cowpea	5.9±0.02[b]	2.6±0.02[c]	83±0.01[b]	172±0.015[b]	263±0.014[b]

i[a-c] shows all values within the same column having the same superscript are not significantly different

All values are means of triplicate ± standard deviation

BDL= Below Detect in Limit

In this study mineral contents of raw materials are indicated in Table 4.2. As shown in the table, the iron contents of raw Oat, Rice and Cowpea were 6.8mg/100g, 2.4mg/100g and 2.6mg/100g, respectively.The iron content of Oat(6.8mg/100g) was higher than Rice(2.4 mg/100g) and Cowpea(2.6mg/100g).The zinc contents of raw Oat, Rice and Cowpea were 3.7mg/100g, 3.5mg/100g and 2.6mg/100g, respectively.The calcium contents of raw Oat, Rice and Cowpea were 152mg/100g, 8.6mg/100g and 83mg/100g, respectively.

In this study, calcium content of Rice (8.6mg/100g) was lower than Oat(152mg/100g) and Cowpea (83mg/100g). The iron content of Cowpea(5.9mg/100g) agrees with the result reported by (Famata *et al*., 2013) which is (6mg/100g) and calcium content of Cowpea(83mg/100g) was higher than the result reported by Famata *et al* (2013) which is (54.43mg/100g).The zinc content of Cowpea(2.6mg/100g) was lower than the result reported by Famata *et al* (2013)which is (5.72mg/100g).

In this study phytate content of raw materials are indicated in Table 4.2.As shown in the table, the phytate contents of raw Oat, Rice and Cowpea were 195.3mg/100g, 106.6mg/100g and

172mg/100g, respectively and also tannin content of raw Oat, Rice and Cowpea were 214 mg/100g, BDL and 263 mg/100g, respectively.The phytate content of Rice(106.6mg/100g) was higher than the result reported by Samtiya *et al* (2020) which is (93.7mg/100g).The phytate content of Cowpea(172mg/100g) was lower than the result reported by Diouf *et al* (2019) which is (836mg/100g).The tannin content of Cowpea(260mg/100g) agrees with the result reported by Samtiya *et al* (2020) which is (263mg/100g).

4.3 Functional properties of raw Oat, Rice and Cowpea

Table 4.3: Functional properties of raw Oat, Rice and Cowpea

Raw Grain	WAC(ml/g)	OAC(ml/g)	Bulk Density(g/ml)	Dispersibility(%)
Oat	2.04 ± 0.02^{c}	1.45 ± 0.02^{b}	0.80 ± 0.02^{a}	62 ± 0.03^{b}
Rice	1.77 ± 0.017^{a}	1.51 ± 0.02^{c}	0.85 ± 0.01^{b}	65 ± 0.02^{c}
Cowpea	1.85 ± 0.01^{b}	1.37 ± 0.01^{a}	0.84 ± 0.016^{b}	57 ± 0.017^{a}

$i^{a\text{-}c}$ shows all values within the same column having the same superscript are not significantly different

All values are means of triplicate ± standard deviation

The functional properties of raw material values obtained are presented in Table 4.3.As observed from the table, WAC of raw Oat, Rice and Cowpea were 2.04ml/g, 1.77ml/g and 1.85ml/g, respectively.WAC of Oat(2.04ml/g) was higher than Rice(1.77ml/g) and Cowpea(1.85ml/g). This result indicates Oat had high ablity of water binding capacity than Rice and Cowpea.WAC of Cowpea(1.85ml/g) was found to be lower than the result reported by Appiah *et al*(2011) which ranges between 1.89 to 2.15ml/g.OAC of raw Oat, Rice and Cowpea were 1.45ml/g, 1.51ml/g and 1.37ml/g, respectively.

Bulk density of raw Oat, Rice and Cowpea were 0.80g/ml, 0.85g/ml and 0.84g/ml, respectively. Bulk density of Rice(0.85g/ml) was higher than bulk density of Oat(0.80g/ml) and Cowpea (0.84g/ml).Dispersibility of raw Oat, Rice and Cowpea were 62%, 65% and57%, respectively.

Dispersiblity of Cowpea(57%) was lower than Rice(65%) and Oat (62%). Dispersibility of Rice (65%) highly agrees with the result reported by Joy (2016) which is (58.0% to 67.5%).

4.4 Proximate composition of the formulated weaning food

This study focused on formulated weaning foods from a blend of Oat, Rice and Cowpea by using three blending ratios Ratio1, Ratio2 and Ratio3 with three roasting temperatures 100^{o}c, 120^{o}c and 140^{o}c.Proximate composition of formulated products were affected by the nutrient composition of raw materials used and roasting methods.The proximate compositions of formulated weaning foods were compared to WHO/FAO standards, World Food Program(WFP) standards and commercial FAFFA infant flour product.

WFP recommends nutritional content of weaning food to be 16% protein, 10% fat , 420 kcal carbohydrate, less than 5% ash content and 5 to 10% moisture content reported by WFP (2018).According to FAO/WHO, proximate composition of weaning food is recommended to be 15% protein , 8% fat , 3.8% fiber , 2.9% ash, 5% moisture content, 68% carbohydrate and 400 kcal energy as reported by Nkeudem *et al* (2018) whereas FAFFA recommends infant flour proximate compositions to be 17% protein, 6% fat, 3.15% fiber, 6.5% moisture, 2.6% ash content, 70% carbohydrate and 381.3kcal energy.

Good energy contents are the main criteria of weaning foods and energy is provided from protein ,fat and carbohydrate.As indicated in Table 4.1,higher protein content was obtained from Cowpea, higher fat content from Oat and higher carbohydrate content from Rice.Proximate composition of formulated weaning food are presented in Table 4.4.

Table 4.4: Proximate composition of formulated weaning food

Formulated Product	Crude protein (%)	Crude fat (%)	Crude fiber (%)	Ash (%)	Moisture (%)	Carbohydrate (%)	Energy Kcal/100g
P1	15.9±0.026[e]	4.5±0.02[c]	2.3±0.02[e]	1.1±0.03[a]	3.5±0.02[g]	72.6±0.07[c]	395.1±0.3[c]
P2	**16.8±0.016[g]**	**4.6±0.01[d]**	**1.5±0.01[b]**	**1.2±0.03[b]**	**3.2±0.03[d]**	**72.7±0.08[c]**	**399.5±0.3[e]**
P3	**18.1±0.015[i]**	**4.9±0.01[e]**	**1.1±0.01[a]**	**2.2±0.01[g]**	**2.8±0.01[b]**	**70.8±0.04[a]**	**400.2±0.2[f]**
P4	13.2±0.026[a]	4.2±0.03[a]	2.8±0.01[g]	2.0±0.03[f]	3.4±0.02[f]	74.4±0.1[g]	388.2±0.2[a]
P5	14.9±0.01[b]	4.3±0.01[b]	2.4±0.01[f]	1.5±0.01[d]	3.2±0.03[d]	73.7±0.09[f]	393.1±0.3[b]
P6	15.5±0.01[d]	4.6±0.02[d]	2.3±0.02[e]	1.6±0.03[e]	3.1±0.01[c]	72.9±0.04[d]	395.1±0.3[c]
P7	15.2±0.02[c]	4.6±0.02[d]	2.3±0.03[e]	1.2±0.02[b]	3.4±0.02[f]	73.3±0.1[e]	395.4±0.2[c]
P8	16 ±0.026[f]	4.9±0.01[e]	1.8±0.02[d]	1.4±0.05[c]	3.3±0.02[e]	72.6±0.09[c]	398.4±0.4[d]
P9	**17.2±0.01[h]**	**5.1±0.02[f]**	**1.6±0.02[c]**	**1.5±0.04[d]**	**2.6±0.02[a]**	**71.9±0.07[b]**	**402.9±0.3[g]**
FAFFA	17	6	3.15	2.6	6.5	70	381.3
WFP	>16	>10		< 5	5 to 10		420
FAO/WHO	15	8	3.8	2.9	5	68	400

i[a-i] shows all values within the same column having the same superscript are not significantly different

All values are means of triplicate ± standard deviation

Key: P1, P2 and P3 =R1 roasted at 100°c, 120 °c and 140 °c for 10 min, respectively

P4, P5 and P6 = R2 roasted at 100°c, 120 °c and 140 °c for 10 min, respectively

P7, P8 and P9 = R3 roasted at 100°c, 120 °c and 140 °c for 10 min, respectively

R1 (Ratio1) = 50% Oat +10% Rice+ 40% Cowpea

R2 (Ratio2) = 45% Oat +19%Rice + 36% Cowpea

R3 (Ratio3) = 60% Oat +10% Rice+ 30% Cowpea

Figure 4.1: Formulated weaning food

4.4.1 Moisture content

The moisture content of formulated weaning food was found to ranged between 2.6 to 3.5%.This result shows that roasting has reduced moisture content of the flours when compared to the raw samples.The moisture content of P9(2.6%) had the lowest moisture content than the other samples. The moisture content of all formulated weaning foods ranged between 2.6 to 3.5%. This results were higher than the moisture content reported by Satter (2013) which is (2.43%) but less than the standard of FAFFA(6.5%), WFP standards(5 to10%) and FAO/WHO standards(5%). The moisture content optimization of weaning food products as compared to FAFFA flour is indicated below in the figure 4.2.

4.4.2 Ash content

The ash content of formulated weaning food was indicated in Table 4.4. The results ranged between 2.1% to 2.2%. Jahan *et al* (2021) which is (2.33) and Satter (2013) which is (2.26%) reported have higher ash content than result obtained in this study. Ash content indicates the total mineral contents in the samples.Ash contents of all formulated weaning food were ranged between 1.1 to 2.2% which is lower than the ash content of FAFFA flour(2.6%).However, all ash value of formulated weaning food agrees with the result to WFP standards (<5%) and less than FAO/WHO standards (2.9%).The ash contents of formulated weaning food ranged between 1.1%

to 2.2% were less than ash content of raw materials (2.0% to 3.6%).This result indicated that some processes such as washing, soaking and roasting has affected the ash contents.Ash content optimization of weaning food products as compared to FAFFA flour is indicated below in the figure 4.3.

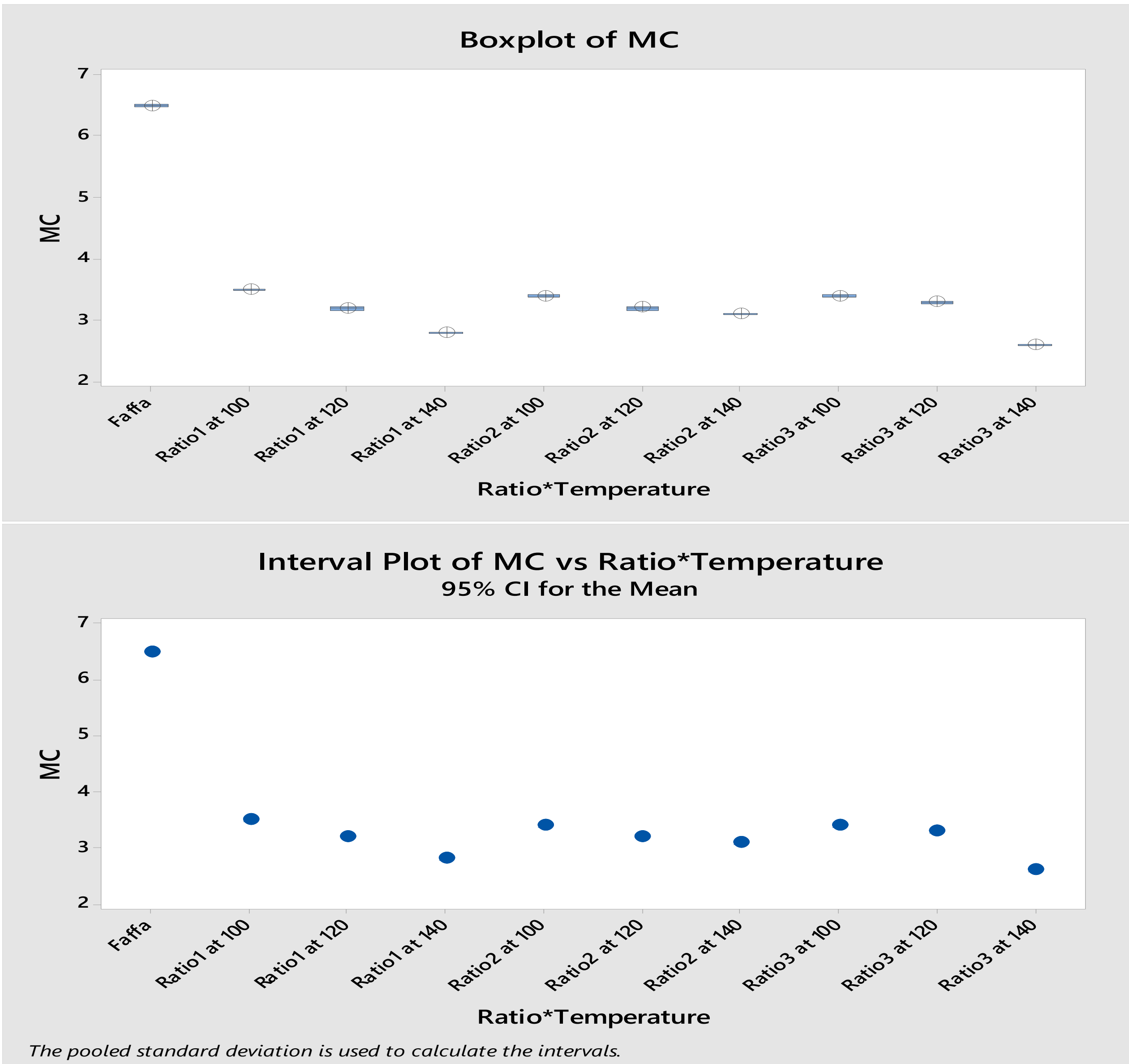


Figure 4.2: Relation of formulated product and FAFFA moisture content

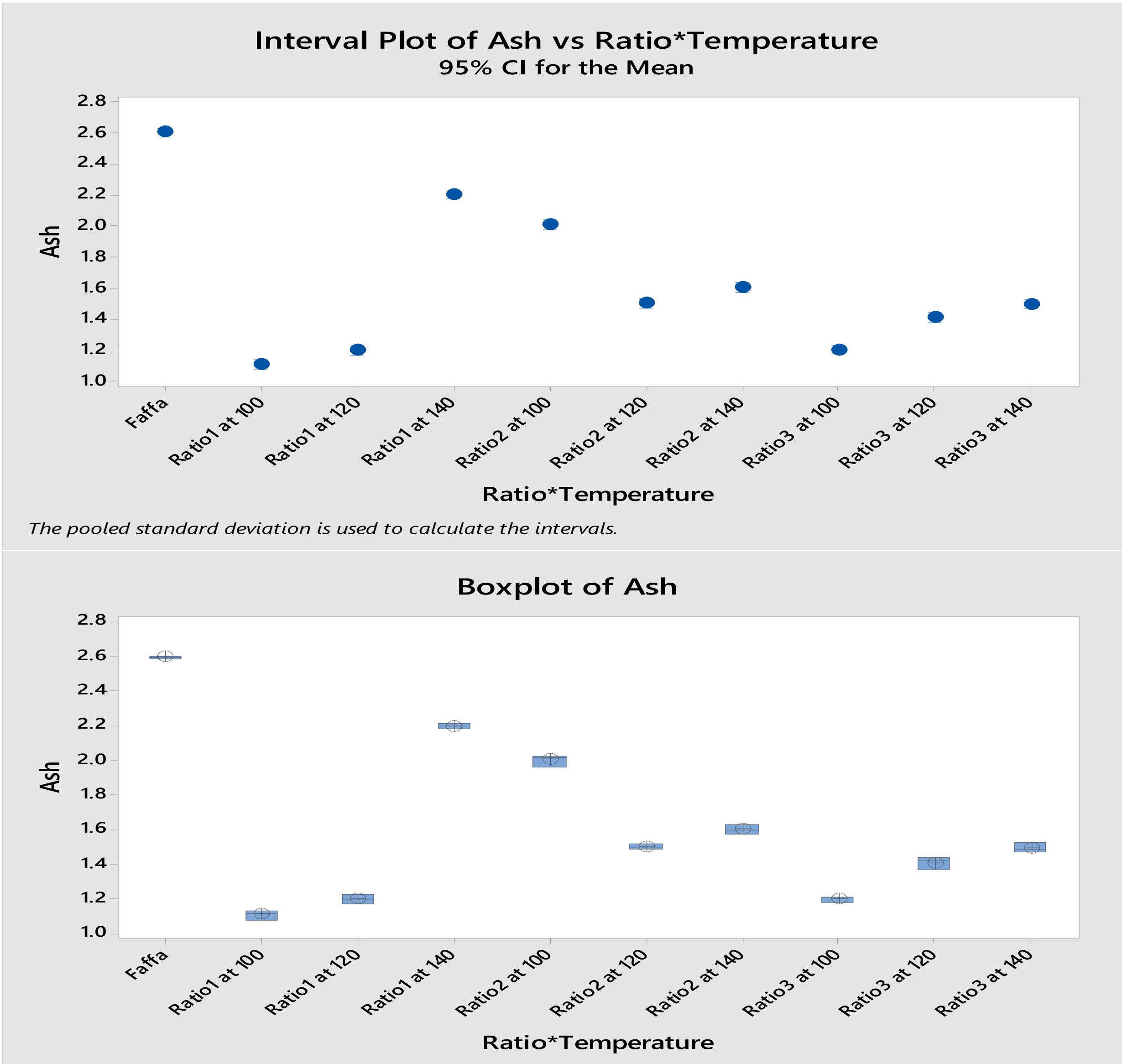


Figure 4.3: Relation of formulated product and FAFFA ash content

4.4.3 Protein content

As shown in Table 4.4, P3(18.1%) had the highest protein content than P1(15.9%) and P2 (16.8%).Similarly, P6(15.5%) had the highest protein content than P4(13.2%) and P5(14.9%). This indicated that protein contents of formulated weaning food products are significantly increased due to increased roasting temperature.Both roasting and germination processes are known to enhance alpha amylase activity and protein digestibility.Germination process enhances protein content of legumes due to metabolic activity such as releasing of amino acid and peptide (Hassan *et al*., 2021).

Optimizing the roasting temperature is important for weaning food because this parameter affects the qualities of protein, fat,color, flavor and overall acceptance of products.This study focused on optimization of roasting temperature with blending ratio, formulated food product of P2(16.8%), P3(18.1%) and P9(17.2%) had a good protein contents.The protein content of formulated weaning food P2, P3, P8 and P9 were 16.8%, 18.1%, 16% and 17.2%, respectively and the results were higher than the protein contents of weaning food reported by Satter (2013) which is (15.98%).However, protein content of P1(15.9 %) showed similar value with protein content repoted by Satter (2013).

When comparing with FAO/WHO standards(>15%), only P4(13.2%) and P5(14.9%) had the lowest protein content.The remaining products had higher protein content than FAO/WHO standards.The protein contents of P2(16.8%),P3(8.1%),P8(16%) and P9(17.2%) agreed with World Food Program(WFP) standards (>16%).The protein contents of P3(18.1%) and P9(17.2%) were higher than the protein content of FAFFA(17%) and protein contents of P1,P2,P4,P5,P6,P7 and P8 were lower than protein content of FAFFA.The protein content optimization of weaning food products as compared to FAFFA flour is indicated below in figure 4.4.

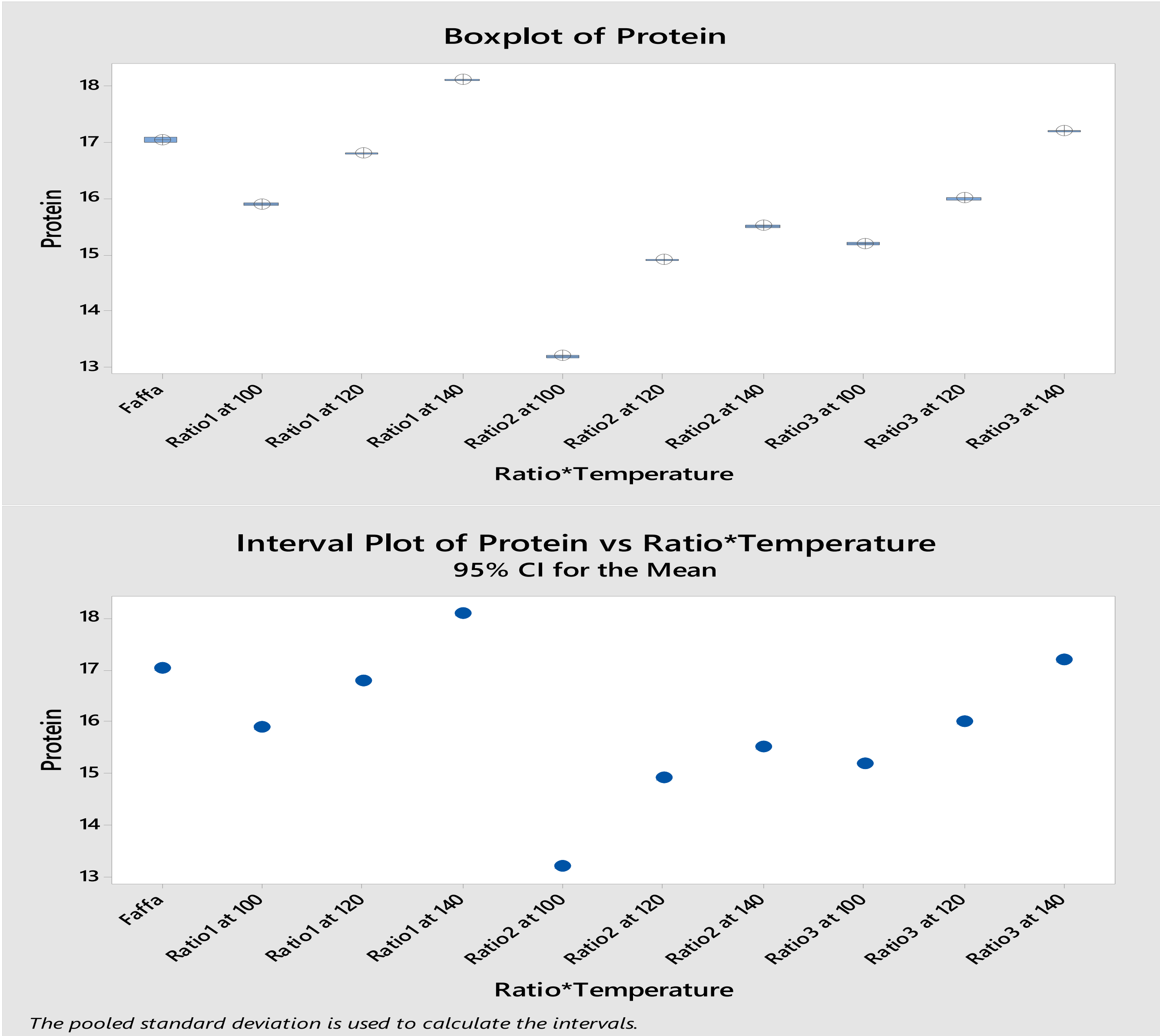


Figure 4.4: Relation of formulated product and FAFFA protein content

4.4.4 Fat content

As shown in Table 4.4, fat contents of formulated weaning food ranged between 4.2 to 5.1%. The difference in fat content among all blended products were significant (P<0.05). The highest value was observed for R3 (4.6 to5.1%) with high Oat proportion than R1 (4.5 to 4.9%) and R2 (4.2 to 4.6%). However, the obtained fat content of all formulated foods didn't agree with the WFP standards (>10%) and FAO/WHO standards (8%).The fat content of P3(R1 roasted at 140^{o}c) 4.9% was higher content than P1(roasted at 100^{o}c) 4.5% and P2(roasted at 120^{o}c) 4.6%.

In this study, it was observed that, as the roasting temperatures were increased, the fat content of formulated weaning foods increased simultaneously. The fat content of weaning foods reported by Srivastava *et al* (2015)which ranges between 5.89 to 6.42% were higher fat content than the results obtained from the formulated weaning foods. P9(5.1%) had the highest fat content among the formulated foods.However, the fat content of all formulated weaning food were lower than FAFFA flour standards(6.0%). High amount of fat indicates high energy contents of the product, on the other hand low fat content is important for long shelf life due to decreasing the chance of rancidity.Fat contents optimization of weaning food products as compared to FAFFA flour are indicated below in the figure 4.5.

4.4.5 Fiber content

The crude fiber content of formulated weaning foods are presented in Table 4.4. The results ranged between1.1% to 2.8%.The obtained results were lower fiber content than FAFFA flour(3.15%) and FAO/WHO standards(3.8%). The fiber content of all blends showed significant difference and the highest value was observed in R2(2.3 to 2.8%).The fibers have an advantage of preventing overweight, cardiovascular disease and diabetes.The fiber content of P3(1.1%) was lower than P1(2.3%) and P2(1.5%). P6(2.3%) had lower fiber value than P4(2.8%) and P5(2.4%).Similarily,P9(1.6%) scored lower fiber content than P7(2.3%) and P8(1.8%).This indicated that fiber content of formulated weaning food were decreased with increased roasting temperature.Fiber content optimization of formulated weaning food as compared to FAFFA flour is indicated below in the figure 4.6.

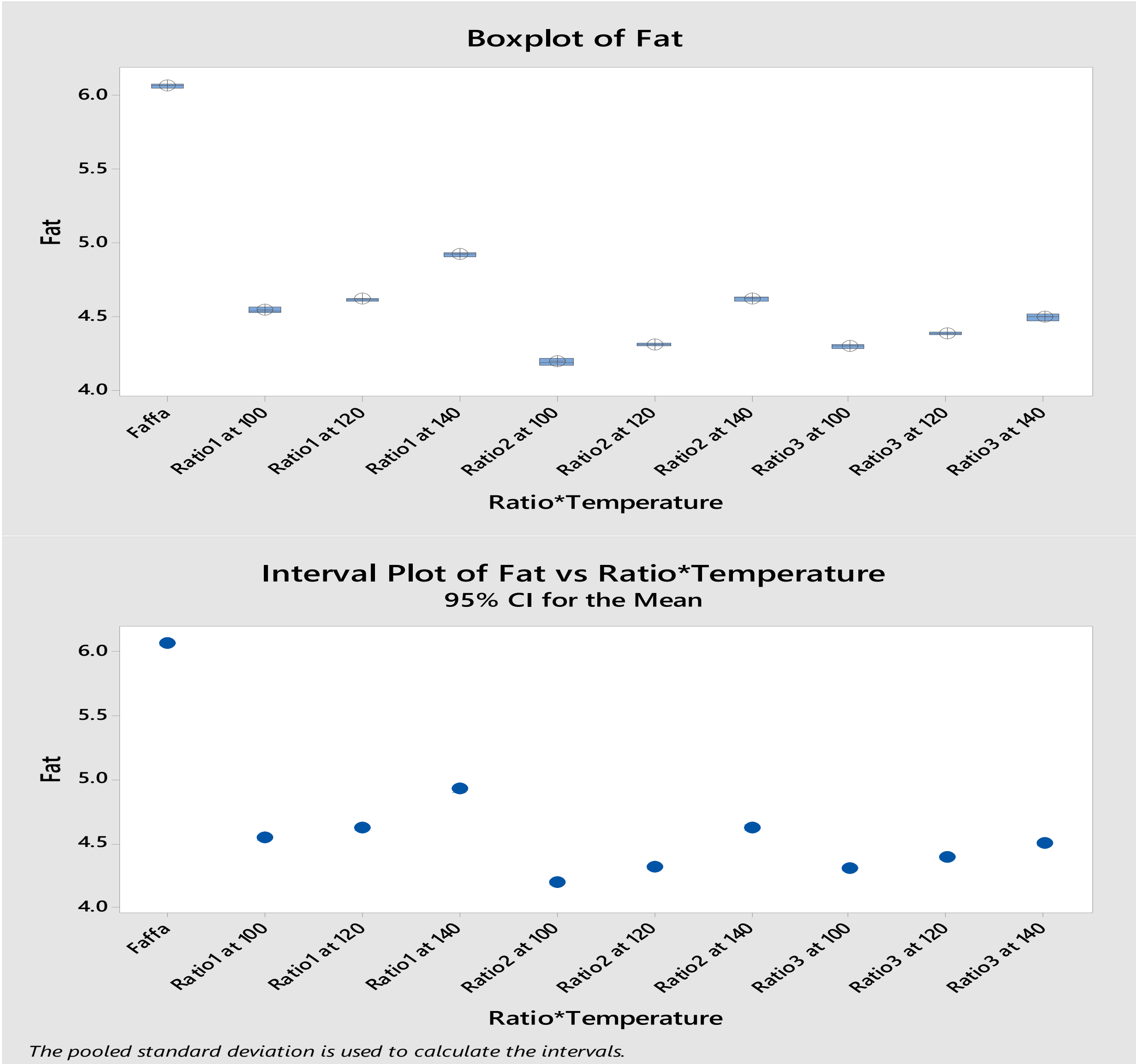


Figure 4.5: Relation of formulated product and FAFFA fat content

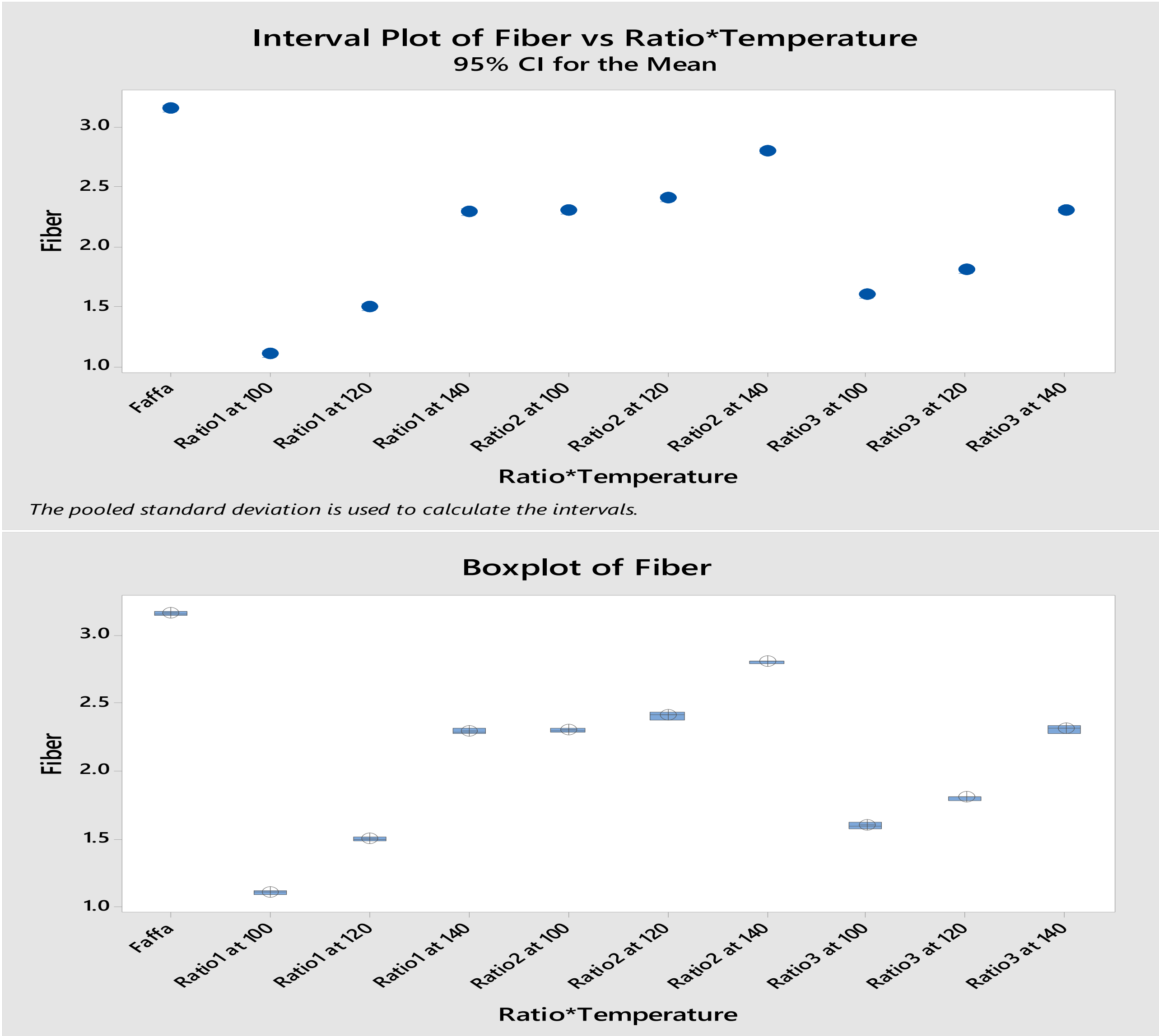


Figure 4.6: Relation of formulated product and FAFFA fiber content

4.4.6 Carbohydrate and energy content

The carbohydrate content of formulated weaning foods are shown in Table 4.4. The results ranged between 70 to 74.4%.The carbohydrate content of all blends showed significant difference(P<0.05).The highest value was P4(74.4%).All formulated foods had higher carbohydrate content than FAO/WHO standards(68%) and FAFFA flour(70%).The carbohydrate content of R2(72.9 to 74.4%) was higher than R1(70.8 to 72.7%) and R3(71.9 to 73.3%).The energy values of formulated weaning foods were ranged between 388.2.1 to 402.9 kcal.There was significant difference(P<0.05) in the energy content of all blended samples.R3(395.4 to

402.9kcal) scored higher energy content than R1(395.1 to 400.2) and R2(388.2 to 395.1kcal).In this study, energy content of all formulated weaning foods ranged between 395.4 to 402.9kcal were higher energy content than FAFFA flour(381.3kcal).When comparing energy values with FAO/WHO standards(400kcal), P3(400.2kcal) and P9(402.9kcal) scored higher energy content.This indicated that caloric value has increased as the roasting temperature increased. Carbohydrate and energy content optimized weaning food products as compared to FAFFA flour are shown below in figure 4.7 and 4.8 respectively.

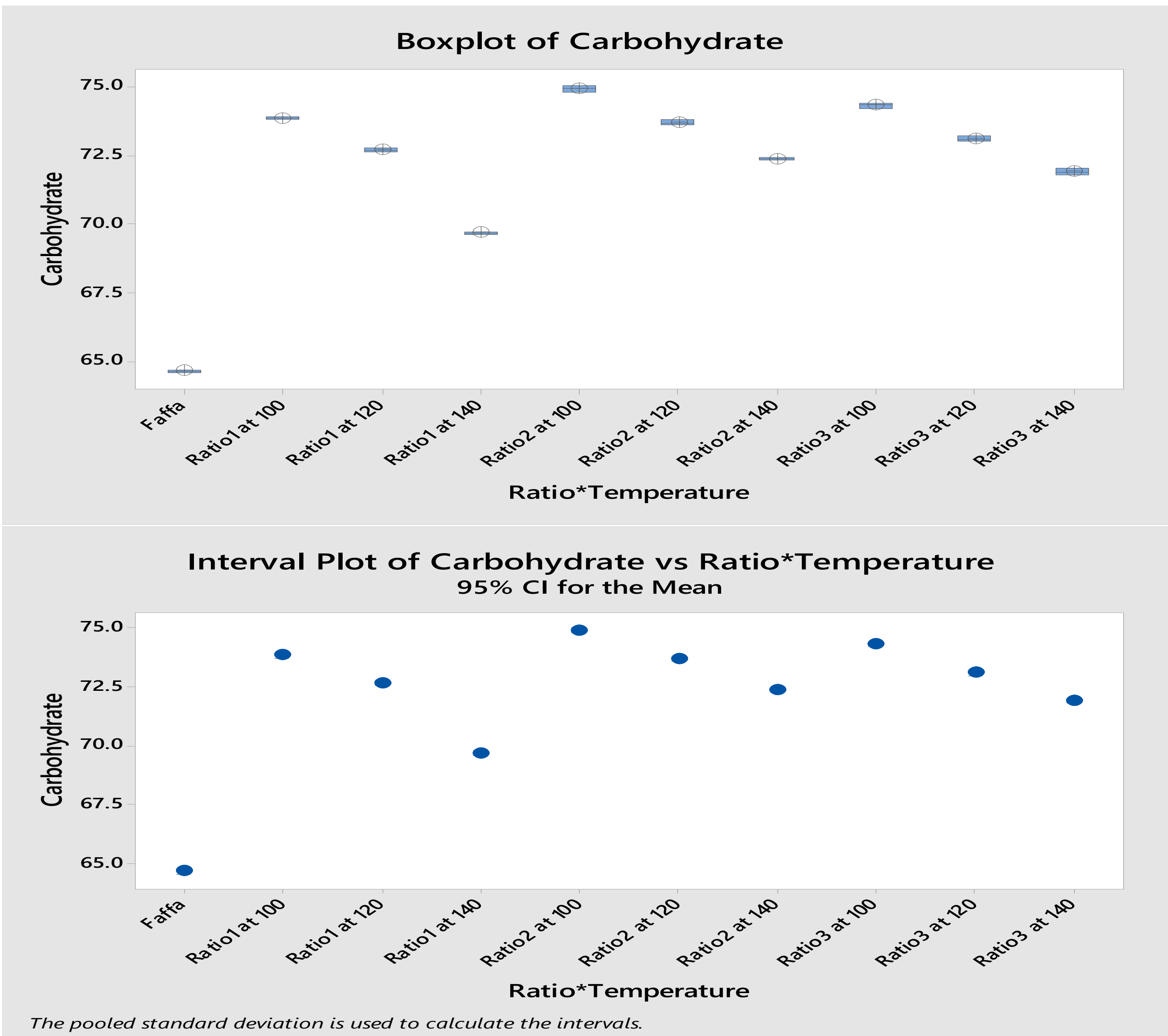
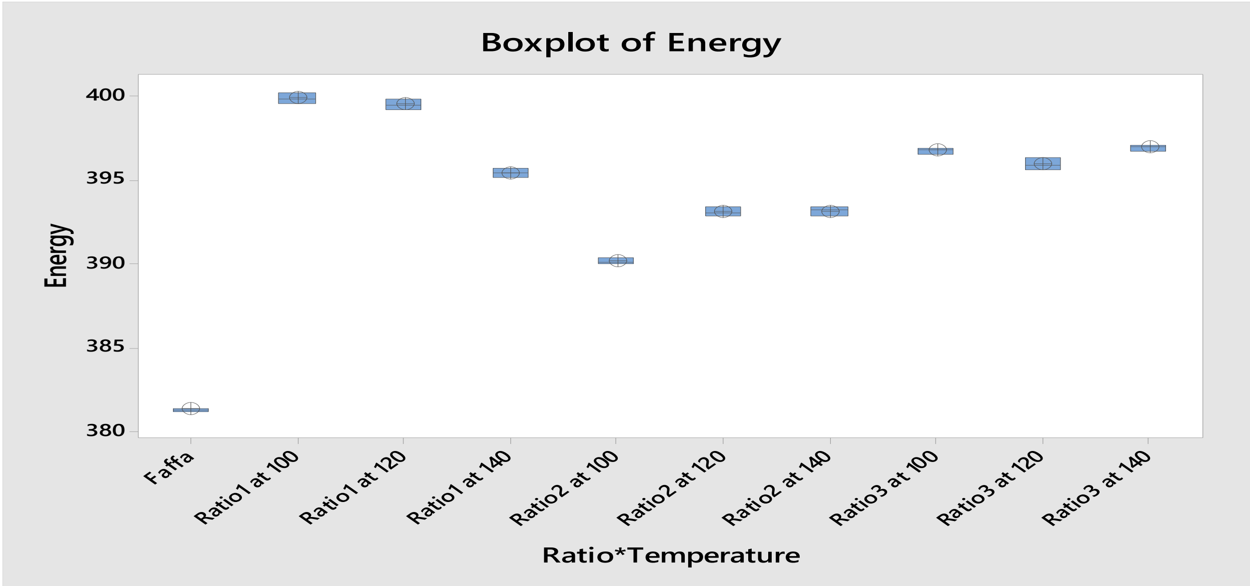


Figure 4.7: Relation of formulated product and FAFFA carbohydrate content



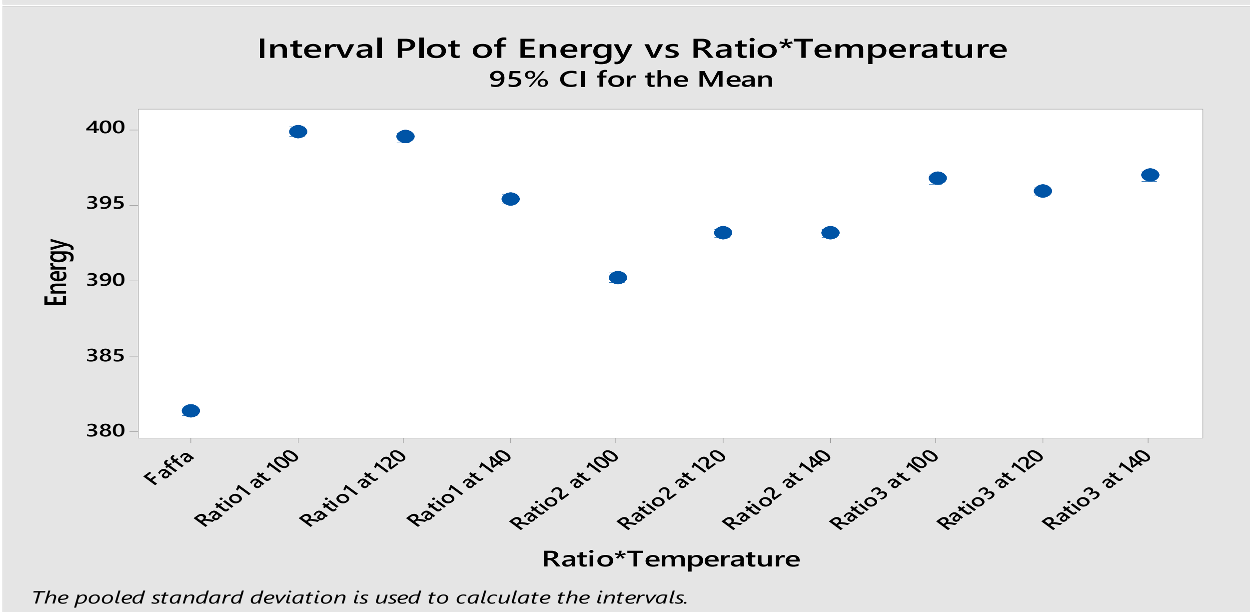


Figure 4.8: Relation of formulated product and FAFFA energy content

4.5 Mineral analysis result of the formulated weaning food

Table 4.5: Mineral analysis result of the formulated weaning food

Formulated flour	Fe(mg/100g)	Zn(mg/100g)	Ca(mg/100g)
P1	5.8±0.01[c]	3.05±0.02[b]	107.1±0.03[d]
P2	5.81±0.02[c]	3.09±0.02[c]	107.2±0.014[e]
P3	5.82±0.02[c]	3.12±0.016[c]	107.5±0.028[f]
P4	5.48±0.01[b]	3.09±0.02[c]	98.06±0.01[a]
P5	5.53±0.017[a]	3.05±0.02[b]	98.15±0.015[b]
P6	5.8±0.01[c]	2.85±0.02[a]	98.38±0.02[c]
P7	5.88±0.018[d]	3.2±0.01[d]	116.1±0.02[g]
P8	5.9±0.01[de]	3.21±0.015[de]	115.9±0.02[i]
P9	5.92±0.018[e]	3.23±0.02[e]	115.7±0.01[h]
FAFFA	8	5	100
WHO/FAO	>5.8	2.4 to 10	400 to 500mg/day

i[a-i] shows all values within the same column having the same superscript are not significantly different

All values are means of triplicate ± standard deviation

The mineral content of formulated weaning foods are presented in Table 4.5.The iron contents of formulated weaning foods ranged between 5.47 to 5.92mg/100g, zinc contents ranged between 3.05 to 3.23mg/100g and calcium contents ranged between 98.06 to 115.7mg/100g. All blended samples varied significantly ($P<0.05$) in calcium, iron and zinc content.The calcium content of the samples increased directly proportional to increased Cowpea addition.The iron content of formulated weaning foods(5.48 to 5.92mg/100g) were higher than the result reported by Srivastava *et al* (2015) which is (3mg/100g) and also calcium content of formulated weaning food (98.06 to 116.1mg/100g) were higher than the result reported by Bassey *et al*(2013) which is (55.9mg/100g).

World Health Organization(WHO) recommendes that the mineral content of weaning food to have iron concentration(>5.8mg/100g) and zinc concentration ranges between 2.4 to 10mg/100g. In this study, iron content of R1(5.8 to 5.82 mg/100g) and R3(5.88 to 5.92 mg/100g) weaning products agreed with WHO recommendations.But R2(5.48 to 5.8mg/100g) was below the WHO standards.The zinc content of formulated weaning food were ranged between 2.85 to 3.23mg/100g. This values agreed with WHO recommendations.The calcium content of formulated weaning foods ranged between 98.15 to 115.9mg/100g. The iron content of formulated weaning foods ranged between 5.48 to 5.92 mg/100g. The result was lower than the value of FAFFA flour (8mg/100g). The zinc content of formulated weaning foods were 2.85 to 3.23 mg/100g which is also lower than the values of FAFFA flour (5mg/100g), whereas calcium content of formulated weaning foods ranged between from 98.06 to 116.1mg/100g and the results were higher than FAFFA product(100mg/100g).

4.6 Functional properties

Table 4.6: Functional properties

	WAC(ml/g)	OAC(ml/g)	Bulk density(g/ml)	Dispersibility(%)
P1	2.4 ± 0.016^{c}	1.57 ± 0.037^{a}	0.71 ± 0.02^{f}	69 ± 0.01^{c}
P2	2.6 ± 0.026^{d}	1.60 ± 0.025^{a}	0.69 ± 0.03^{d}	64 ± 0.02^{b}
P3	2.85 ± 0.035^{e}	1.58 ± 0.015^{a}	0.68 ± 0.03^{c}	62 ± 0.03^{a}
P4	2.05 ± 0.02^{a}	1.94 ± 0.037^{d}	0.73 ± 0.04^{g}	79 ± 0.02^{i}
P5	2.13 ± 0.017^{b}	1.59 ± 0.028^{a}	0.71 ± 0.016^{f}	75 ± 0.036^{g}
P6	2.19 ± 0.04^{b}	1.84 ± 0.035^{b}	0.70 ± 0.02^{e}	73 ± 0.04^{e}
P7	2.01 ± 0.036^{a}	1.84 ± 0.037^{b}	0.69 ± 0.017^{d}	76 ± 0.02^{h}
P8	2.02 ± 0.045^{a}	1.89 ± 0.045^{c}	0.62 ± 0.025^{b}	74 ± 0.02^{f}
P9	2.14 ± 0.09^{b}	1.81 ± 0.02^{b}	0.61 ± 0.02^{a}	70 ± 0.04^{d}
FAFFA	2.8	1.87	0.72	75

$i^{a\text{-}i}$ shows all values within the same column having the same superscript are not significantly different

All values are means of triplicate ± standard deviation

4.6.1 Water Absorption Capacity (WAC) and Oil Absorption capacity (OAC)

WAC and OAC of formulated weaning food are shown in Table 4.6.WAC of formulated weaning foods ranged between 2.0 to 2.85ml/g and OAC of the samples ranged between 1.57 to 1.94ml/g.There was significant difference between each formulated product.The WAC of R1(2.4 to 2.85ml/g) was higher than R2(2.05 to 2.19ml/g) and R3(2.01 to 2.14ml/g) whereas, there was no significant difference between WAC values of P7(2.01ml/g) and P8 (2.02ml/g). Low WAC is necessary in complementary foods for making semi-solid porridge with high caloric density per unit volume.

WAC and OAC content of raw materials, as indicated in Table 4.3, ranged between 1.85 to 2.01ml/g and 1.38 to 1.5ml/g, respectively.This result shows that roasting has increased both WAC and OAC of the flours when compared to the formulated samples.P3(2.85ml/g) scored slightly greater WAC than P1(2.43ml/g) and P2(2.59ml/g).Similarly,P6(2.19ml/g) scored higher WAC than P4(2.05ml/g), P5 (2.13ml/g) and P9(2.14ml/g) scored higher WAC than P7(2.01ml/g) and P8(2.02 ml/g).In this study, it was found that WAC has increased as the roasting temperature was increased because of enhanced gelatinization of starch.This result agreed to the result reported by Beniwal *et al* (2019).

The WAC of formulated weaning food were ranged between 2.01 to 2.85ml/g and this values agreed to the results reported by Tiencheu *et al* (2016) which is (2.0 to 3.3ml/g).The WAC of FAFFA flour was 2.8ml/g and all weaning food samples scored less WAC than FAFFA flour except P3(2.85ml/g).The high amount of WAC indicated a high binding capacity of water.

The OAC is a property of the interaction nonpolar and lipid side chain of amino acid, which bind hydrocarbon side of flour and a property of provide good flavor of the product.OAC of formulated weaning foods were ranged between 1.57 to 1.94ml/g and this values were higher OAC scored than the result reported by Achidi *et al* (2016) which is (1.05 to 1.75ml/g). The OAC of FAFFA flour was1.87ml/g. Both P4(1.94ml/g) and P8(1.89ml/g) scored higher OAC than FAFFA flour.The OAC values were observed to slightly increased as thermal processes were increased.

4.6.2 Bulk density

The bulk density of formulated weaning food are presented in Table 4.6. The values ranged between 0.61 to 0.73g/ml.The bulk density of raw material are shown in Table 4.3 which ranged between 0.78 to 0.84g/ml.This indicates that bulk density value of formulated weaning foods were lower bulk density than raw materials value, reason of roasting process due to moisture loss.P3(0.68 g/ml) scored lower bulk density than P1(0.71 g/ml) and P2(0.69 g/ml).Similarly, bulk density of P6(0.70 g/ml) was lower than P4(0.73 g/ml) and P5(0.71 g/ml).

The bulk density of formulated weaning food P3,P8 and P9 were 0.68g/ml, 0.62g/ml and 0.61g/ml, respectively were lower than the result reported by NAEEM *et al* (2021) which is (0.69 to 0.76g/ml).The remaining samples agreed with the results NAEEM *et al* (2021).Except P4(0.73g/ml),all bulk density of formulated weaning foods were lower than FAFFA flour (0.72g/ml).Low bulk density flour is important for weaning foods (Godswill *et al*., 2019) and also bulk density of flour is important to indicate the required condition of packaging size meaning higher bulk density contains higher weight in a limited volume.

4.6.3 Dispersibility

Dispersibility of formulated weaning food are presented in Table 4.6. The values ranged between 62 to 79%.Dispersibility of P1(69%) was higher than P2(64%) and P3(62%).P4(79%) scored higher dispersibility value than P5(75%) and P6(73%).Similarly,P7(76%) scored higher dispersibility value than P8(74%) and P9(70%).This result clearly indicated that dispersibility was slightly decreased as the roasting temperature increased.Generally dispersibility in the water indicated the reconstitution ability of flour.Both P4(79%) and P7(76%) scored higher dispersiblity value than FAFFA(75%) and P5(75%) scored was equal dispersibility value as FAFFA flour.

4.7 Physico-chemical properties of the weaning food

4.7.1 Viscosity

Viscosity of formulated weaning foods are indicated in Table 4.7.The values are ranged between 794 to 1147mpa.s. Except P6(1,147mpa.s), all results of formulated weaning foods agreed with the results reported by EA *et al*(2018) which is (411.67 to 1,065.61 mpa.s).Viscosity content of P4(1,009 mpa.s) was lower viscosity value than P5(1,113 mpa.s) and P6(1,147 mpa.s). Generally the viscosity of formulated weaning foods can be expressed as P1<P2<P3, P4<P5<P6, P9<P8<P7.This result indicated that viscosity significantly (P<0.05) directly proportional to the increament of roasting temperature.R2,having higher carbohydrate content has shown significantly higher viscosity values ranged between (1,009 to 1,147mpa.s) than R1 and R3.Higher percentage of carbohydrate content of product results a high viscosity value. In this study, Rice contained higher amount of carbohydrate (80.7%) and R2 scored higher viscosity value due to higher Rice proportion.Amount of viscosity depends on flour composition, starch properties of flour, processing methods and particle size of four. Decreased particle size or flour product leads to high viscosity.

Table 4.7: Physico-chemical properties of formulated weaning food

	Viscosity(CP)	PH Meter
P1	821 ± 0.03^{b}	6.2 ± 0.01^{b}
P2	985 ± 0.01^{d}	6.2 ± 0.02^{b}
P3	980 ± 0.02^{c}	6.1 ± 0.038^{a}
P4	1009 ± 0.03^{f}	6.3 ± 0.01^{c}
P5	1113 ± 0.04^{h}	6.1 ± 0.01^{a}
P6	1147 ± 0.02^{i}	6.3 ± 0.04^{c}
P7	794 ± 0.02^{a}	6.2 ± 0.02^{b}
P8	950 ± 0.03^{e}	6.4 ± 0.02^{d}
P9	1030 ± 0.03^{g}	6.4 ± 0.01^{d}

i^{a-i} shows all values within the same column having the same superscript are not significantly different

All values are means of triplicate ± standard deviation

4.7.2 pH

The pH values of formulated weaning foods are shown in Table 4.7.The values ranged between 6.0 to 6.1.There was no significant difference between pH values of all formulated weaning foods.Nature of raw materials and processing methods have influenced pH value of products. The pH value affects flavor, microbial stability and keeping quality of food products.The pH value of formulated weaning foods were similar to pH values reported by Imtiaz (2007) which is (5.96 to 6.06).

4.8 Anti-nutritional properties

Weaning food must have adequate nutrients, macro-nutrients such as protein, fat, carbohydrate and micro-nutrients (minerals), but anti-nutritional factors are a problem of reducing this bioavailability of products so anti-nutrient analysis are very important for infant foods.

Table 4.8: Anti-nutritional properties of formulated weaning food

	Phytate (mg/100g)	Tannin(mg/100g)
P1	101.6 ± 0.017^{i}	140 ± 0.02^{d}
P2	99.6 ± 0.006^{h}	110 ± 0.01^{b}
P3	92 ± 0.016^{b}	93 ± 0.01^{a}
P4	92.7 ± 0.015^{d}	190 ± 0.02^{i}
P5	92.5 ± 0.013^{c}	180 ± 0.02^{h}
P6	90 ± 0.015^{a}	179 ± 0.015^{g}
P7	98.2 ± 0.015^{g}	149 ± 0.01^{f}
P8	95.3 ± 0.049^{f}	145 ± 0.02^{e}
P9	95 ± 0.02^{e}	134 ± 0.015^{c}

i^{a-i} shows all values within the same column having the same superscript are not significantly different

All values are means of triplicate ± standard deviation

4.8.1 Phytate

The phytate compositions of formulated weaning food are showed in Table 4.8.The results ranged between 90 to101.6 mg/100g. In this study, phytate content significantly($P<0.05$) decreased due to decreased roasting temperature. The phytate content of P3(92 mg/100g) scored lower than P1(101.6 mg/100g) and P2 (99.6 mg/100g).Anti-nutrient content of raw materials before processing is clearly presented in Table 4.2.When results are compared to the processed food samples, a decrement of anti-nutritional values were observed after processing. This result agreed with the report of Hendek Ertop & Bektas (2018). Processing methods such as soaking, germination, roasting and milling process are important to reduce anti-nutrient factors and to improve nutrient availability.The phytate content of formulated weaning food were ranged between 90 to 101.6mg/100g. This values agreed with the result reported by Nwogwugu *et al* (2013) which ranges between 59 to 120mg/100g.

4.8.2 Tannin

The tannin contents of formulated weaning foods are shown in Table 4.8. The values ranged between 93 to 190 mg/100g.The tannin content of raw materials are indicated in Table 4.2. Except Rice both raw Oat and Cowpea had high tannin contents 214 and 263 mg/100g ,respectively. When compared to the formulated weaning foods, there was significant difference ($P<0.05$).This indicated washing, soaking and roasting processes decreased tannin contents of sampels.The tannin content of P3(93mg/100g) scored lower value than P1(140mg/100g) and P2 (110 mg/100g). Similarly, P6 (179 mg/100g) scored lower value than P4(190 mg/100g) and P5 (180 mg/100g) and P9(134 mg/100g) scored lower value than P7(149 mg/100g) and P8(145 mg/100g).This result indicated that increased roasting temperature significantly decreased tannin contents in each ratio.Higher amount of tannin content of weaning food results digestion problem and palatability of protein due to a form of complex insolubility.

4.9 Microbiological quality

Table 4.9: Microbiological quality of formulated weaning food

Product	Yeast (Colony)	Mold(Colony)	Total Plate Count (Cfu/g)	E Coli
P1	8	4	3.2×10^2	Nill
P2	5	2	5.3×10	Nill
P3	4	1	5	Nill
P4	2	3	2.6×10^2	Nill
P5	2	3	1.71×10^2	Nill
P6	1	1	1.6×10^2	Nill
P7	2	3	4.3×10^2	Nill
P8	2	3	2.5×10	Nill

P9	Nill	2	1.4×10	Nill

i[a-i] shows all values within the same column having the same superscript are not significantly different.

All values are means of triplicate ± standard deviation different.

The microbiological result of formulated weaning food are shown in Table 4.9. Total Plate Count (TPC), E coli, Mold and Yeast were determined.Yeast count of P1, P2 and P3 was found to score 8, 5 and 4, respectively. P4, P5 and P6 scored 2, 2 and 1, respectively and P7, P8 and P9 were found to score 2, 2 and Nill, respectively.Total Plate Count (TPC) of formulated weaning foods ranged between 5 to 4.3×10^2 cfu/g.The values were lower than the values reported by Bekele (2011) which is (1.8×10^2 to 6.7×10^3 cfu/g). E.coli value of all formulated weaning food was nill, which agreed to the result of Bekele (2011) reported.

The mold content of weaning foods ranged between 1 to 4 colonies.The values were lower than the results reported by Amankwah *et al*(2009) which is (2.0×10^2 cfu/ml). The yeast content of formulated weaning foods were ranged between nill to 8 colony.The values were lower than the results reported by Amankwah *et al*(2009) which is (1.8×10^2 cfu/ml).

Microbial analysis of weaning foods are very critical because children are very sensitive to disease. Therefore, during infant products preparation, special care should be taken. The result of this study indicated that mold and yeast count significantly decreased as the roasting temperature increased.Total Plate Count of P1, P2 and P3 were 3.2×10^2 cfu/g, 5.3×10 cfu/g and 5 cfu/g, respectively whereas Total Plate Count of P4, P5 and P6 were 2.6×10^2 cfu/g, 1.71×10^2 cfu/g and 1.6 cfu/g, respectively.Total Plate count of P7, P8 and P9 were 4.3×10^2 cfu/g, 2.5×10 cfu/g and 1.4×10 cfu/g, respectively.This result indicated that total plate count decreased with increased roasting temperature.This indicated that precooking process can be used as preservation method as it has reduced total plate count of samples.

Total Plate Count is described as total number of bacteria which are able to grow in aerobic environment.Table 4.9 shows that the E coli was not detected on formulated weaning food products.E.coli indicated that direct and indirect fecal contamination.Generally roasting temperature was important to decrease microbial load and inactivate microorganisms.Standard of microbiological load for weaning food are Total Plate Count (TPC) <10^5cfu/g, E.coli<10, Yeast and molds <10^3 reported by ORC Macro (2000).

In this study, all microbial results are acceptable when compared with the recommended standard values.Amount of TPC ranged between 1.4×10 to 1.71×10^3cfu/g were lower than the recommended value (<10^5cfu/g), Yeast results ranged between 1.6 to 6.3×10^2 and mold results ranged between from 1 to 4 colonies.Both results were lower than the Standards (< 10^3). Weaning food products can have certain amount of microbial load.Therefore, processing techniques like preheating or roasting must be applied and also Good Manufacturing Practice(GMP) are important to keep products safe from contamination during processing, packaging, storage and transportation.

4.10 Sensory attributes

Table 4.10: Sensory attributes of weaning food

Product Code	Mouthfeel	Flavor(Aroma)	Color	Taste	Overall acceptance
P1	5.6±0.04	5.55±0.07	6.32±0.03	5.0±0.05	5.44±0.06
P2	6.1±0.56	5.64±0.06	6.3±0.14	5.45±0.3	5.78±0.1
P3	6.4±0.03	6.0±0.14	6.07±0.1	5.86±0.2	6.7±0.03
P4	5.8±0.15	5.6±0.16	6.9±0.02	5.45±0.2	5.8±0.14
P5	5.82±0.02	5.34±0.05	5.9±0.02	5.25±0.07	5.76±0.08
P6	5.85±0.07	5.4±0.03	5.45±0.22	5.4±0.01	5.43±0.05
P7	5.81±0.3	5.1±0.16	5.5±0.01	6.15±0.5	5.7±0.16
P8	5.8±0.01	5.5±0.01	5.75±0.07	5.65±0.22	5.76±0.09
P9	5.6±0.02	6.3±0.01	5.73±0.04	5.7±0.03	5.8±0.06

$i^{a\text{-}i}$ shows all values within the same column having the same superscript are not significantly different

Sensory quality attribute of formulated weaning porridge(semi solid) products (P1 to P9) was evaluated by 20 mother panelists because they are more close to baby's foods and understand the overall acceptance of infant food. Seven point hedonic scale was used (7-Like Extremely, 6-Like Very much, 5-Like slightly 4-Neither like nor dislike, 3-Dislike slightly 2-Dislike Very much and 1-Dislike Extremely). Sensory evaluations such as Mouth feel, Flavor (aroma), Color, Taste, Overall acceptability were considered. Average sensory results are indicated in Table 4.10. Mouth feel value of P3(6.4) was significantly higher than the remaining samples. This value implies that the product is liked very much. P1(5.6) and P9 (5.6) scored equal mouth feel value. Also mouth feel value of P4(5.8), P5(5.82), P6(5.85), P7(5.81)and P8(5.8) are not significantly different ($P<0.05$).

The flavor value of P9(6.3) was significantly higher than all other products. P1(5.55) and P3 (6.0) were not significantly different with each other ($P<0.05$). Flavor value of P7(5.1) was significantly lower than other samples. The color value of P4 (6.9) was significantly higher than the other product's color rating at ($P< 0.05$). This indicates it's color was liked extremely. P8(5.7) and P9(5.7) scored equal color value. Except P6(5.4), color of all samples are like extremely and like very much. This was because of the weaning flour color lightness and attractiveness during sensory evaluation. Flour color was dependent on roasting temperature and nature of raw material(grain).In this study, roasting temperature was optimized and color of raw materials was found to be good . P7(6.15) and P1(5) has scored the highest and lowest taste values respectively. Over all acceptability of P3(6.7) was significantly higher than the other products.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Infant malnutrition is the main health problem in Ethiopia.Optimization of nutrients are important for the proper growth and development of infants. The majority of the country's population is poor.Therefore it is impossible for the population to use imported infant supplementary foods. Infant foods are prepared by traditional processes utilizing cereals and legumes. Cereals and legumes have anti-nutritional factors by nature which limits their nutrient availability and the health benefits and risks of blending ratio is not well known during traditional processes.

This study was aimed to develop weaning food from cereals and legumes by applying processing methods such as dehulling, soaking, washing, germination(Cowpea), and roasting.Anti-nutrient factors such as phytate and tannin were decreased when roasting temperature was increased. Therefore, bioavailability of nutrients and some essential minerals were improved and digestibility of protein was inhibited. Additionally, roasting increases the shelf life of products, inactivate microbial growth, and improve the sensory acceptability of products like flavor, color, and taste because it is a precooking process. This study focused on the development of a weaning food from a blend of Oat, Rice, and Cowpea.During the study, blending ratio and roasting temperature affected proximate composition, functional properties, anti-nutritional factor, microbial load, and sensory evaluation of formulated weaning food.

Blending ratio has affected the nutritional value of products due to the composition of raw materials. As the roasting temperature increased, nutritional content of products such as protein, fat, ash, energy and mineral contents increased whereas moisture and fiber contents decreased. Functional properties such as WAC, OAC and viscosity slightly increased. Bulk density and dispersibility of product decreased. Microbial load such as Yeast, Mold, E coli and Total Plate Count (TPC) decreased when roasting temperature increased.Nutritional content of formulated weaning food and commercial FAFFA flour were compared considering blending ratio and roasting temperature by using Minitab 17 software design application.

According to the results found, P2, P3 and P9 were highly nutritious and scored better sensory evaluation, particularly P3 (roasted at 140^{o}c) contained the better nutrition among the three(18.1% protein ,4.9% fat and 400.2kcal energy).Except for fat contents, other proximate compositions meet with FAO/WHO and WFP standards.

5.2 Recommendations

This study focuses on the development of weaning food from a blend of Oat, Rice, and Cowpea flour. Based on the results found, the following points are recommended:

- Additional researches are required in this area, and fabricated weaning food products must include dairy products, vegetables, fruit, and other animal sources in addition to cereals and legumes.
- Further detailed research should be done on the effect of fermentation ,germination and roasting process of weaning food.
- A broad study on shelf life stability, preservatives and anti-micobial agents of weaning food should be carried out.
- Study on other aspects of functional ,physical properties withcooking temperature and time of porridge is reqired.
- Inspiring public awareness on the importance of cereals, legumes and other locally available resources by avoiding anti-nutritional factors through processing methods is important.

References

Abdullah, A. M. (2013). *Development of nutritionally enriched instant weaning food and its safety aspects*. *May 2015*. https://doi.org/10.5897/AJFS13.1009

Achidi, A. U., Tiencheu, B., Tenyang, N., Womeni, H. M., Moyeh, M. N., Ebini, L. T., & Tatsinkou, F. (2016). Quality Evaluation of Nine Instant Weaning Foods Formulated from Cereal, Legume, Tuber, Vegetable and Crayfish. *International Journal of Food Science and Nutrition Engineering*, *6*(2), 21–31. https://doi.org/10.5923/j.food.20160602.01

Adebowale, Y. A., Adeyemi, I. A., & Oshodi, A. A. (2005). Functional and physicochemical properties of flours of six Mucuna species. *African Journal of Biotechnology*, *4*(12), 1461–1468. https://doi.org/10.4314/ajb.v4i12.71409

Ahmed, S., & Hasan, M. M. (2014). *ISSN 2311-4673 Journl of Pharmacy and Pharmaceutical Sciences Legumes : An Overview*. *2*(1), 34–38.

Alemayehu, T., Haidar, J., & Habte, D. (2009). Determinants of exclusive breastfeeding practices in Ethiopia. *Ethiopian Journal of Health Development*, *23*(1). https://doi.org/10.4314/ejhd.v23i1.44832

Alemu, D., Tesfaye, A., Assaye, A., & Addis, D. (2018). a Historical Analysis of Rice Commercialisation in Ethiopia : the Case of the Fogera Plain. *APRA Working Paper 18*, *December*, 1–7.

Aletan, U. I. (2018). *Comparison of the Proximate and Mineral Composition of two Cowpea Varieties obtained from Mile 12 Market , Lagos*. *3*(1), 43–48.

Amankwah, E. A., Barimah, J., Nuamah, A. K. M., Oldham, J. H., & Nnaji, C. O. (2009). Formulation of weaning food from fermented maize, rice, soybean and fishmeal. *Pakistan Journal of Nutrition*, *8*(11), 1747–1752. https://doi.org/10.3923/pjn.2009.1747.1752

AOAC(2000).Official Methods of analysis associasion of Official Analytical Chemists.Fourth Edition,AOAC,International,Washington,DC,USA,Official methods 923.03.

AOAC(2000).Official Methods of analysis.17th Edition,The association of Official Analytical Chemists, USA.Methods 925.10,26.12,900.02,922.26 and 985.29.

Appiah, F., Asibuo, J. Y., & Kumah, P. (2011). Physicochemical and functional properties of bean flours of three cowpea (Vigna unguiculata L . Walp) varieties in Ghana. *African Journal of Food Science*, *5*(February), 100–104.

Bassey, F. I., Mcwatters, K. H., Edem, C. A., & Iwegbue, C. M. A. (2013). Formulation and nutritional evaluation of weaning food processed from cooking banana, supplemented with cowpea and peanut. *Food Science & Nutrition*, *1*(5), 384–391. https://doi.org/10.1002/fsn3.51

Bekele, M. (2011). *Institute of Technology (AAiT) School of Graduate Study Department of Chemical Engineering Effect of fermentation on Quality Protein Maize-soybean blends for the production of weaning food*.

Beniwal, S. K., Devi, A., & Sindhu, R. (2019). Effect of grain processing on nutritional and physico-chemical, functional and pasting properties of amaranth and quinoa flours. *Indian Journal of Traditional Knowledge*, *18*(3), 500–507.

Beyene, G., Araya, A., & Gebremedhn, H. (2015). *Evaluation of different oat varieties for fodder yield and yield related traits in Debre Berhan Area , Central Highlands of Ethiopia*. *September*.

Birhane, A. (2013). Effect Of Planting Methods On Yield And Yield Components Of Rice (Oryza Sativa L.) Varieties In Tahtay Koraro Wereda, Northern Ethiopia. *International Journal of Technology Enhancements and Emerging Engineering Research*, *1*(5), 1–5.

Blössner, M., Onis, M. De, & Organization, W. H. (2005). Malnutrition: quantifying the health impact at national and local levels. *Environmental Burden Disease Series*, *12*(12), 43.

Chandra, S. (2013). Assessment of functional properties of different flours. *African Journal of Agricultural Research*, *8*(38), 4849–4852. https://doi.org/10.5897/AJAR2013.6905

Cherie, D. A., & Dagnaw, L. A. (2019). Nutritional Composition Analysis of Improved and Released Rice Varieties in Ethiopia. *International Journal of Research and Review*, *6*(February), 69–73.

CSA, (Central Statistical Agency of Ethiopia). (2014). Agricultural sample survey. Report on area and production of major crops. Volume I, VII and VIII. *Statistical Bulletin*, *I*, 578.

Diouf, A., Sarr, F., Sene, B., Ndiaye, C., Momar Fall, S., & Cyrille Ayesso, N. (2019). Pathways for Reducing Anti-Nutritional Factors: Prospects for Vigna unguiculata. *Journal of Nutritional Health & Food Science*, *7*(2), 1–10. https://doi.org/10.15226/jnhfs.2019.001157

EA, M., JB, H., JOY, I., & I, N. (2018). Effect of Fermentation and Roasting on the Physicochemical Properties of Weaning Food Produced from Blends of Sorghum and Soybean. *Journal of Nutrition & Food Sciences*, *08*(02). https://doi.org/10.4172/2155-9600.1000681

Ekweagwu, E., Agwu, A. E., & Madukwe, E. (2008). The role of micronutrients in child health: A review of the literature. *African Journal of Biotechnology*, *7*(21), 3804–3810. https://doi.org/10.4314/ajb.v7i21.59444

Etana, A., Tadesse, E., Mengistu, A., & Hassen, A. (2013). *Advanced evaluation of cowpea (Vigna unguiculata) accessions for fodder production in the central rift valley of Ethiopia*. *5*(March), 55–61. https://doi.org/10.5897/JAERD12.128

Famata, A. S., Modu, S., Mida, H. M., Hajjagana, L., Shettima, A. Y., & Hadiza, A. (2013). Chemical composition and mineral element content of two cowpea (Igna unguiculata l . walp .) varieties as food supplement. *International Research Journal of Biochemistry and Bioinformatics*, *3*(4), 93–96.

Federal minstry of Health. (2008). *National nutrition strategy of Ethiopia*. *January*.

Geneva, W. H. O. (2000). WHO/PAHO. Guiding principles for complementary feeding of the breastfed child. *World Health Organization, UNICEF*, *0*(8), 0–22.

Godswill, C., Somtochukwu, V., & Kate, C. (2019). the Functional Properties of Foods and Flours. *International Journal of Advanced Academic Research | Sciences*, *5*(11), 2488–9849.

Griffith, L. D., Castell-Perez, M. E., & Griffith, M. E. (1998). Effects of blend and processing method on the nutritional quality of weaning foods made from select cereals and legumes. *Cereal Chemistry*, *75*(1), 105–112. https://doi.org/10.1094/CCHEM.1998.75.1.105

Hasmadi, M., Noorfarahzilah, M., Noraidah, H., Zainol, M. K., & Jahurul, M. H. A. (2020). Functional properties of composite flour: A review. *Food Research*, *4*(6), 1820–1831. https://doi.org/10.26656/fr.2017.4(6).419

Hassan, S., Hussain, M. B., Akram, M., & Egbuna, C. (2021). *Effect of Germination Processing on Bioactive Compounds of Cereals and Chapter 16 Effect of Germination Processing on Bioactive Compounds of Cereals and Legumes*. *April*. https://doi.org/10.1007/978-3-030-42319-3

Hendek Ertop, M., & Bektaş, M. (2018). Enhancement of Bioavailable Micronutrients and Reduction of Antinutrients in Foods With Some Processes. *Food and Health*, *2014*(March), 159–165. https://doi.org/10.3153/fh18016

Huang, C. W., Liang, W. H., Esvelt Klos, K., Chen, C. S., & Huang, Y. F. (2020). Evaluation of agronomic performance and exploratory genome-wide association study of a diverse oat panel for forage use in Taiwan. *Grassland Science*, *66*(4), 249–260. https://doi.org/10.1111/grs.12276

Ijarotimi, O. S., & Keshinro, O. O. (2019). Formulation and Nutritional Quality of Infant Formula Produced From Germinated Popcorn, Bambara Groundnut and African Locust Bean Flour. *Journal of Microbiology, Biotechnology and Food Sciences*, *2020*(vol. 10), 1358–1388.

Imtiaz, H. (2007). Evaluation of weaning foods formulated from germinated wheat and mungbean from Bangladesh. *African Journal of Food Science*, *5*(17), 897–903. https://doi.org/10.5897/ajfs11.180

Jahan, S., Bisrat, F., Faruque, M. O., Ferdaus, M. J., Khan, S. S., & Farzana, T. (2021). Formulation of nutrient enriched germinated wheat and mung-bean based weaning food compare to locally available similar products in Bangladesh. *Heliyon*, *7*(5), e06974. https://doi.org/10.1016/j.heliyon.2021.e06974

Jayathilake, C., Visvanathan, R., Deen, A., Bangamuwage, R., Jayawardana, B. C., Nammi, S., & Liyanage, R. (2018). Cowpea: an overview on its nutritional facts and health benefits. *Journal of the Science of Food and Agriculture*, *98*(13), 4793–4806.

https://doi.org/10.1002/jsfa.9074

Joy, E.-E. (2016). The Effect of Variety and Processing Methods on the Functional and Chemical Properties of Rice Flour. *International Journal of Nutrition and Food Sciences*, *5*(1), 80. https://doi.org/10.11648/j.ijnfs.20160501.22

Kalhan, S. C., & Kiliç. (1999). Carbohydrate as nutrient in the infant and child: Range of acceptable intake. *European Journal of Clinical Nutrition*, *53*, s94–s100. https://doi.org/10.1038/sj.ejcn.1600749

Kanensi, O. J., Ochola, S., Gikonyo, P. N. K., & Makokha, P. A. (2013). *Effect of Steeping and Germination on the Diastatic Activity and Sugar Content in Amaranth Grains and Viscosity of Porridge*. *3*(1), 1–7.

Kavitha, S., & Parimalavalli, R. (2014). Effect of processing methods on proximate composition of cereal and legume flours. *Journal of Human Nutrition and Food Science*, *2*(6), 1051–1055.

Kebede, E., Bekeko, Z., & Moral, M. T. (2020). Expounding the production and importance of cowpea (Vigna unguiculata (L .) Expounding the production and importance of cowpea (Vigna unguiculata (L .) Walp .) in Ethiopia. *Cogent Food & Agriculture*, *6*(1). https://doi.org/10.1080/23311932.2020.1769805

Kebede, G., Feyissa, F., Assefa, G., Mengistu, A., & Tekletsadik, T. (2016). *Study on current production and utilization status and further prospects of Oats (Avena sativa) in mixed farming systems of the central highland areas of Ethiopia*. *September*. https://doi.org/10.14662/ARJASR2016.021

Krishi Vidyapeeth, M., Gadhe, I. K., Katke, I. S., & Corresponding Author, I. (2020). Studies on physical, chemical and mineral evaluation of oats (Avena sativa). *~ 79 ~ Journal of Pharmacognosy and Phytochemistry*, *9*(5), 79–82. www.phytojournal.com

Makori, N., Kassim, N., Kinabo, J., & Matemu, A. (2017). Nutrient Composition of Cereals-based Complementary Flour and its Nutritional Adequacy in Infants Nutrition. *Journal of Food Research*, *6*(6), 45. https://doi.org/10.5539/jfr.v6n6p45

Mamo, K., Dengia, T., Abubeker, A., & Girmaye, E. (2020). Assessment of Exclusive Breastfeeding Practice and Associated Factors among Mothers in West Shoa Zone, Oromia, Ethiopia. *Obstetrics and Gynecology International*, *2020*. https://doi.org/10.1155/2020/3965873

Melese, T. (2013). Nutritional Status of Ethiopian Weaning and Complementary Foods: A Review. *Open Access Scientific Reports*, *2*(2), 1–9. https://doi.org/10.4172/scientificreports.621

Mushtaq, A., Gul-Zaffar, ., Z., A. D., & Mehfuza, H. (2014). A review on Oat (Avena sativa L.) as a dual-purpose crop. *Scientific Research and Essays*, *9*(4), 52–59. https://doi.org/10.5897/sre2014.5820

Nabi, A. G., Shah, F., Zeb, A., Bashir, S., & Khalil, A. A. (2019). *Effect of Roasting , Sprouting and Fermentation on the Sensory Attributes of Cereal-Legume Supplemented Weaning Food Abstract : Key words : Introduction : Objective : Methods : Results : Conclusions : July*.

NAEEM, M., UN-NISA, M., AHMAD, N., IMRAN, M., ANWAR, H., & MANZOOR, M. F. (2021). Preparation of weaning foods by replacing plant proteins with egg protein. *Food Science and Technology*, *2061*, 1–9. https://doi.org/10.1590/fst.44920

Nkeudem, A. G., Irene, S., Ngole, U., Judith, A., Ning, T. R., Metuge, S., & Giscard, K. K. (2018). Nutritional Evaluation of Commonly Used Local Weaning Food Processed and Sold in the Mount Cameroon Region. *International Journal of Food Science and Nutrition Engineering*, *8*(6), 131–141. https://doi.org/10.5923/j.food.20180806.01

Nwogwugu, M., Uchegbulem, A., Euro, C., & Bio, J. E. (2013). *Available online a t www.scholarsresearchlibrary.com Chemical and microbial qualities of weaning food produced from mungbean (Vigna radiata) and maize (Zea mays) Department of Nutrition and Dietetics Imo State Polytechnic , Umuagwo- Ohaji Department o*. *2*(3), 34–39.

Oa, A., Ao, A., So, A., Jimoh, Ko, E., Oo, A., & La. (2017). Influence of Processing Methods on the Nutrient, Anti- Nutrient, Mineral Compositions and Functional Properties of Akee Apple (Blighia Sapida Konig) Seed and Aril Flour. *Journal of Human Nutrition & Food*

Science, *5*(1), 1–7. https://www.jscimedcentral.com/Nutrition/nutrition-5-1101.pdf

Oghbaei, M., & Prakash, J. (2016). Effect of primary processing of cereals and legumes on its nutritional quality: A comprehensive review. *Cogent Food & Agriculture*, *2*(1). https://doi.org/10.1080/23311932.2015.1136015

ORC Macro. (2000). *Nutrion of young children and monthers in Ethiopia: Findings from the 2000 Ethiopia Demographic and health survey*.

Petroski, W., & Minich, D. M. (2020). Is there such a thing as "anti-nutrients"? A narrative review of perceived problematic plant compounds. *Nutrients*, *12*(10), 1–32. https://doi.org/10.3390/nu12102929

Popova, A., & Mihaylova, D. (2019). Antinutrients in Plant-based Foods: A Review. *The Open Biotechnology Journal*, *13*(1), 68–76. https://doi.org/10.2174/1874070701913010068

Rasane, P., Jha, A., Sabikhi, L., Kumar, A., & Unnikrishnan, V. S. (2015). Nutritional advantages of oats and opportunities for its processing as value added foods - a review. *Journal of Food Science and Technology*, *52*(2), 662–675. https://doi.org/10.1007/s13197-013-1072-1

Rohman, A., Helmiyati, S., Hapsari, M., & Setyaningrum, D. L. (2014). Rice in health and nutrition. *International Food Research Journal*, *21*(1), 13–24.

Samtiya, M., Aluko, R. E., & Dhewa, T. (2020). Plant food anti-nutritional factors and their reduction strategies: an overview. *Food Production, Processing and Nutrition*, *2*(1). https://doi.org/10.1186/s43014-020-0020-5

Satter, A. (2013). Development of nutritionally enriched instant weaning food and its safety aspects. *African Journal of Food Science*, *7*(8), 238–245. https://doi.org/10.5897/ajfs13.1009

Shankar, A. S., Satyanarayana, C. V. V., Alavi, S., Edukondalu, L., Joseph, M., & Lakshmipathy, R. (2018). Study on Cereal-Legume Based Complementary Foods for Infants. *International Journal of Current Microbiology and Applied Sciences*, *7*(08), 3310–3317. https://doi.org/10.20546/ijcmas.2018.708.354

Srivastava, S., Singh, S., & Zaki Shamim, M. (2015). Nutritional composition of weaning food using malted cereal and pulses flour for infants. *International Journal of Pure and Applied Bioscience*, *3*(1), 171–185. www.ijpab.com

Supervisor, T. G., Ketema, M., & Demilw, G. (2020). *University of Gondar College of Agriculture and Rural Transformation*. *April*.

Tiencheu, B., Achidi, A. U., Fossi, B. T., Tenyang, N., Ngongang, F. T., & Womeni, H. M. (2016). Formulation and Nutritional Evaluation of Instant Weaning Foods Processed from Maize (Zea mays), Pawpaw (Carica papaya), Red Beans (Phaseolus vulgaris) and Mackerel Fish Meal (Scomber scombrus). *American Journal of Food Science and Technology*, *4*(5), 149–159. https://doi.org/10.12691/ajfst-4-5-5

WHO. (2021). Who | 2021. In *Noncommunicable diseases* (p. https://www.who.int/news-room/fact-sheets/detail/n).

World Food Programme (WFP). (2018). *Nutritional Guidance for Complementary Food*. *February*, 1–4.

Y. Waré, L., P. Nikièma, A., C. Meile, J., Kaboré, S., Fontana, A., Durand, N., Montet, D., & Barro, N. (2018). Microbiological safety of flours used in follow up for infant formulas produced in Ouagadougou, Burkina Faso. *AIMS Microbiology*, *4*(2), 347–361. https://doi.org/10.3934/microbiol.2018.2.347

Zerihun, W. (2020). *Cowpea (Vigna unguiculata (L .) Walp ., Fabaceae) landrace (local farmers ' varieties) diversity and ethnobotany in Southwestern and Eastern parts of Ethiopia*. *June 2019*. https://doi.org/10.5897/AJAR2018.13641

Appendix

Appendix A: Sensory attribute evaluation form

MSc food engineering research project, department of chemical engineering

Name------------------------ Date--------------------------

Time--------------------------

Score	1	2	3	4	5	6	7
	Like Extremely	Like Very much	Like slightly	Neither like nor dislike	Dislike slightly	Dislike very much	Dislike Extremely

Sample code	**Sensory evaluation criteria**				
	Mouth feel	Flavor(Aroma)	Color	Taste	Over all acceptability
P1					
P2					
P3					
P4					
P5					

Appendix B: One way ANOVA (SPSS Version 20)

Oneway

[DataSet0]

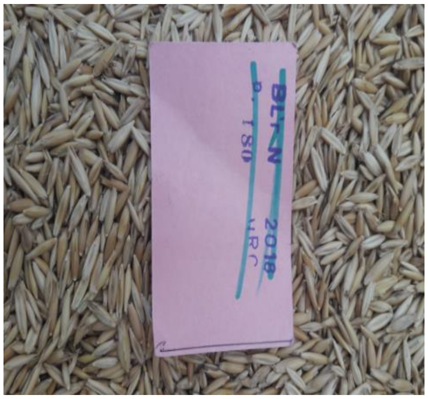
Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
protine	P1	3	15.8973	.02608	.01506	15.8325	15.9621	15.88	15.93
	P2	3	16.8003	.01650	.00953	16.7593	16.8413	16.78	16.81
	P3	3	18.0973	.01504	.00869	18.0600	18.1347	18.08	18.11
	P4	3	13.1980	.02600	.01501	13.1334	13.2626	13.17	13.22
	P5	3	14.9013	.01193	.00689	14.8717	14.9310	14.89	14.91
	P6	3	15.5047	.01380	.00797	15.4704	15.5389	15.49	15.52
	P7	3	15.1973	.02281	.01317	15.1407	15.2540	15.18	15.22
	P8	3	16.0033	.02663	.01538	15.9372	16.0695	15.97	16.03
	P9	3	17.2010	.01411	.00814	17.1660	17.2360	17.19	17.21
	Raw Oat	3	16.9130	.01744	.01007	16.8697	16.9563	16.89	16.93
	Raw Rice	3	9.5960	.03245	.01873	9.5154	9.6766	9.57	9.63
	Raw cowpea	3	21.5327	.02203	.01272	21.4779	21.5874	21.52	21.56
	Total	36	15.9035	2.75869	.45978	14.9701	16.8369	9.57	21.56

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
WAC	P1	3	2.4287	.01601	.00924	2.3889	2.4684	2.41	2.45
	P2	3	2.5953	.02639	.01524	2.5298	2.6609	2.57	2.61
	P3	3	2.8463	.03522	.02033	2.7588	2.9338	2.81	2.87
	P4	3	2.0497	.02155	.01244	1.9961	2.1032	2.03	2.07
	P5	3	2.1337	.01724	.00996	2.0908	2.1765	2.12	2.15
	P6	3	2.1870	.04351	.02512	2.0789	2.2951	2.14	2.23
	P7	3	2.0083	.03675	.02122	1.9170	2.0996	1.97	2.03
	P8	3	2.0177	.04574	.02641	1.9040	2.1313	1.97	2.05
	P9	3	2.1390	.09057	.05229	1.9140	2.3640	2.04	2.21
	Total	27	2.2673	.28368	.05459	2.1551	2.3795	1.97	2.87
OAC	P1	3	1.5693	.03755	.02168	1.4760	1.6626	1.53	1.61
	P2	3	1.6047	.02574	.01486	1.5407	1.6686	1.58	1.62
	P3	3	1.5770	.01539	.00889	1.5388	1.6152	1.56	1.59
	P4	3	1.9407	.03570	.02061	1.8520	2.0293	1.90	1.97
	P5	3	1.5977	.02845	.01642	1.5270	1.6683	1.57	1.62
	P6	3	1.8423	.03547	.02048	1.7542	1.9305	1.80	1.87
	P7	3	1.8470	.03764	.02173	1.7535	1.9405	1.80	1.87
	P8	3	1.8927	.04571	.02639	1.7791	2.0062	1.84	1.92
	P9	3	1.8147	.02409	.01391	1.7548	1.8745	1.79	1.83
	Total	27	1.7429	.14875	.02863	1.6840	1.8017	1.53	1.97

Appendix C: Picture of raw materials



Whole Oat

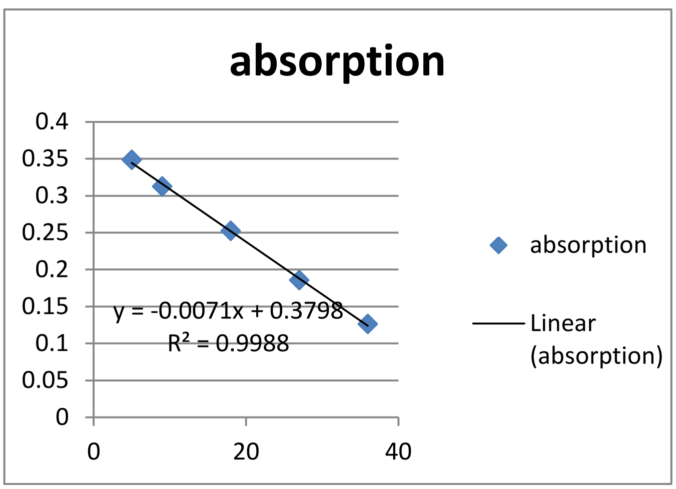
Whole Rice

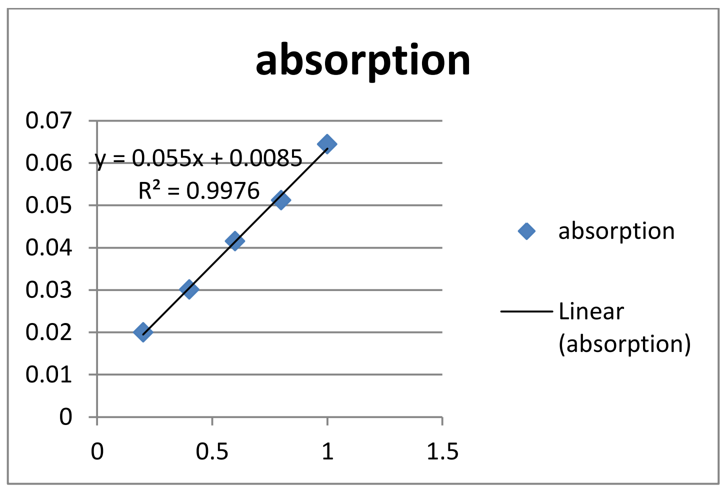
Whole Cowpea

Germinated Cowpea

Appendix D: Picture of anti-nutrient laboratory analysis

A. Phytate and Tannin analysis





B. Phytate and Tannin Standard graph

Key: standared solution preparation for calculation phytate and tannin:using Excel plot the calibration curve was prepared (absorption with concentration) and the slope and intercept was found out from the graph equation 13 and 14.

Appendix E: Picture of protein and fat analysis in laboratory

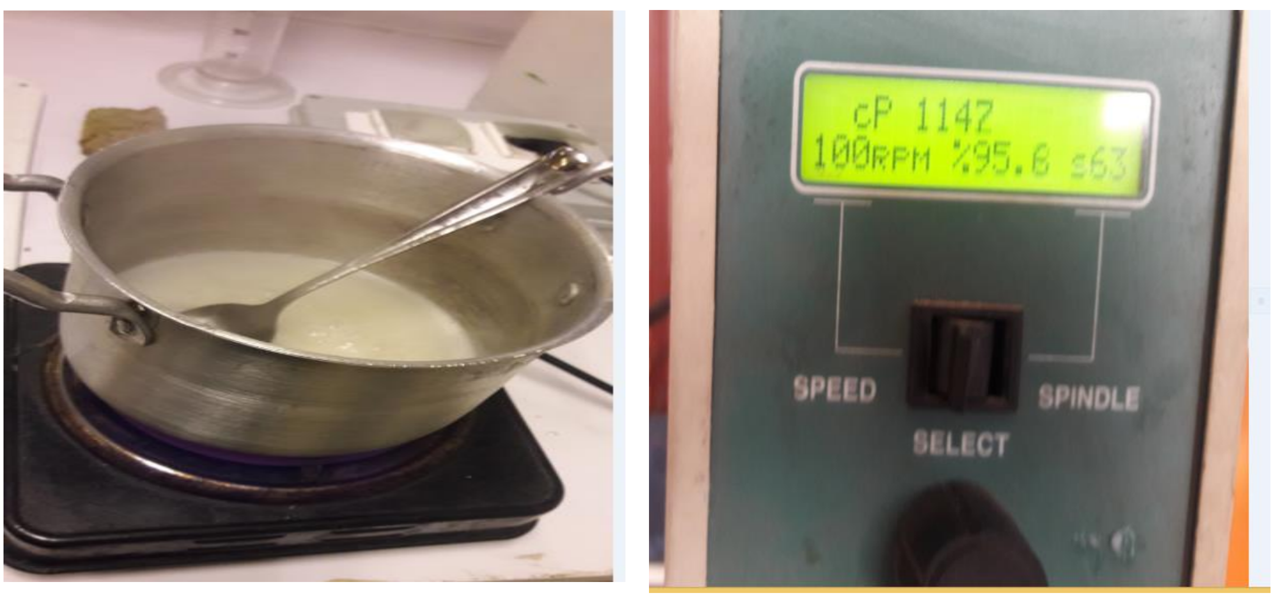
A. Protein analysis: Digestion, Distillation and Titration

B. Fat Extraction analysis

Appendix F: Sensory quality attributes evaluation by panelist

Appendix G: Picture of microbial and viscosity analysis in laboratory

A. Microbial analysis



B. Determine Viscosity of weaning flour