ADDIS ABABA INSTITUTION OF TECHNOLOGY

ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

DEPARTMENT OF CHEMICAL ENGINEERING

Development of supplementary food from blends of maize and soybean flour with moringa powder

Thesis submitted to the school of Graduate Studies of Addis Ababa University in partial fulfillment of the Masters Degree in Chemical Engineering (Food Engineering)

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LIST OF ABBREVIATIONS

AACC	American Association of Cereal Chemists
AOAC	Association of Analytical Chemists
APC	Aerobic bacteria plate count
Cfu	Colony forming unit
D. formula	Diet formula
EHNRI	Ethiopian Health and Nutrition Research Institute
FAO	Food and Agriculture Organization

GI	Gastrointestinal
HDPE	High Density Polyethylene
LDL	Low density lipoproteins
OAC	oil absorption capacity
PEM	Protein Energy Malnutrition
PAG	Protein Advisory Group
PUFA	Poly unsaturated fatty acid
RDA	Recommended dietary allowance
WHC	Water holding capacity
WHO	World Health Organization

ABSTRACT

The objectives of the study were to develop supplementary foods from moringa, maize and soybeans blend for infants. The sample diets were formulated with different proportion and Faffa was used as a control .Material balance method was used to predict the nutrient requirement in order to meet the standards of the final product. Analyses were made for different formulated diets and compared with the control and recommended daily allowance (RDA). The five supplementary blends (Diets 1,2,3,4 and 5) were formulated based on the protein and energy of the food commodities. Standard procedures were used to determine the basic principal in formulated diets. UV-spectrophotometer analyzer was used to detect tannin and phytate content of samples, Viscometer analyzer was used to detect and quantify the gruel concentration, and functional properties. The overall results *indicated that nutrient content of Diet 1 was 16.31%, protein, and 10.94% fat and 59.91% carbohydrate; Diet 2 had 20.58% protein, 12.48% fat and 53.06% carbohydrate. Diet 3 exhibited 20.77% protein, 10.79% fat and 52.95% carbohydrate. Diet 4 had 21.04% protein, 10.80% fat and 52.19% carbohydrate, whereas Diet 5 gave 33.27% protein, 18.05% fat and 33.62% carbohydrate and the process reduced the tannin and phytate groups by 87.46%and 87.44%, respectively. The difference was found between all means stastically significance ($P<0.05$). The protein and fat contents for diet 2, 3 and 4 were suitable for infants between the age groups of 6-12 months as compared to recommended dietary allowance for infants and children. They also had higher value than that of the control (FAFFA). The subject formula would meet the RDA for protein and fat based on an estimated daily intake of 65g of weaning foods by a normal six months old infant in Ethiopia. Whereas the subject diets do not meet the RDA for other nutrients based on the same estimation. Frequent feeding on these foods is also recommended to increase the daily nutrient intake. The microbial load count (Cfu/g) level fell below the allowable recommended range for bacterial count 10^4-10^5Cfu/g. Sensory evaluation showed that the formulated diets were most preferred by both semi trained and weaning babies with the help of their mothers. The suggested technology was feasible and also formulation with moringa powder can therefore be used as a weaning food to improve the nutritional status of Ethiopian children and also help solve problem associated with protein energy malnutrition among infant in Ethiopia particular, and developing countries in general.*

Key words: **Supplementary food based on protein and energy, moringa powder, maize and soybean flours.**

1. INTRODUCTION

1.1 Background

Malnutrition has become one of the major world health problems facing developing countries. Throughout the developing world, malnutrition affects almost 800 million people, or 20 percent of the world population *USAID (2000*). Clinically, malnutrition is characterized by inadequate or excess intake of protein, energy, and micronutrients such as vitamins, and the frequent infections and disorders that result *Dutra-de-Oliveira (1991*).

Protein energy malnutrition (PEM) generally occurs during the crucial transitional phase when infant are weaned from liquid to semi-solid or fully adult foods. During this period, because of their rapid growth, children need nutritionally balanced, calorie-dense supplementary foods in addition to mother's milk. In Sub-Saharan Africa, extreme poverty, inadequate caring practices for children, low levels of education and poor access to health services are among the major factors causing under nutrition *WHO (2000)*. Conflicts and natural disasters in many countries have further exacerbated the situation. Worldwide, the most common form of malnutrition is protein- energy deficiency, affecting up to 80 percent of the population, as many as four or five billion people Agyepong (1991).

Provision of adequate and appropriate supplements to young children prevents malnutrition. Foods that are regularly fed to the infant, in addition to breast-milk, providing sufficient nutrients are known as supplementary or complementary foods. These could be liquid like milk or semi-solids in case of infant or solid preparations like rice etc.; in the case of children over the age of one year *WHO (2002*). They attributed this to inadequate complementation to the breast milk. However, high price of proprietary weaning foods, vegetable, animal proteins and the non-availability of low priced nutritious foods, combined with bad feeding practices and late introduction of supplementary foods, are mostly responsible for aggravating the disorder among children *Dutra-de-Oliveira* (*1991*). Good nutrition, particularly during infancy and childhood can promote adequate physical and mental development. Certain nutrients such as protein, fats and oils in food maintain life; thus used for cells growth, repair, and regulation of function *Berggr (1998*).

Generally in many East African mothers usually breastfeed for 12 months. Many urban poor and rural women breast feed for up to 18 and 24 months *Armar (1989*). However in many East African countries, exclusive breastfeeding is usually adequate up to three to four months of age, but after this period it may become increasingly inadequate to support the nutritional demands of the growing infant. Thus, in a weaning process there is always the need to introduce soft, easily swallowed foods to supplement the infant’s feeding early in life. The weaning process may be gradual, lasting for months until the infant is finally introduced to the family diet. On the other hand, in abrupt weaning, the infant is introduced straight into the family menu with various foods like rice, cassava, corn and groundnuts *Eschleman (1991*). This latter option creates a problem, as the child may not be able to eat enough of the adult diet to meet his or her nutritional needs *Kazimi (1979*). These supplements are carbohydrate rich foods, which are actual portions of the adult diet and hence are not suitable for infants especially babies, because of its components, their bulky nature and consistency as well as their unbalance in the nutrient composition. This is the underlying cause of malnutrition in Africa *Armar-Klemesu and Wheeler (1991*).

Over 70% of dietary portion in the developing countries is supplied by cereals that are relatively poor sources of protein (*Glover, 1976*). Research showed that most of the weaning foods consumed in communities of developing nations are deficient in essential nutrients *FAO/WHO (1998*). Several strategies have been used to improve the nutritive value of weaning foods Gopaldas *et al* (1988).The traditional East - African weaning foods could be improved upon by combining locally available foods that complement each other in such a way that new pattern of amino - acids created by this combination is similar to that recommended for infants *Fashakin and Ogunsola (1982*). However, the high lysine content of legumes improves the nutritional quality of cereals by complementing their limiting amino acids sulphur containing amino acids are limiting in legumes and relatively high in cereals, whereas lysine is limiting in cereals and high in legumes *Bressani and Ellias (1966); Ekpenyong et al (1977*). Soya beans have recently become popular in the East African sub-region due to their high protein content and quality, and are being cultivated at an increasing stead rate. It is a grain legume, which holds many advantages over animal products. And introduction of moringa leaf powder in infant cereal to increase its protein, vitamin and mineral content. Hence, there will be improvement of the nutritional value of the food as well as the nutritional status of the consumer (the infant) if both cereals and legumes are blended with moringa during the preparation of the food. Soybeans, moringa and maize are locally produced and this may make the weaning product very affordable. This study was undertaken to developing supplementary food by blending of maize, soy bean flour with moringa powder and Characterized nutritional value and consumer acceptability of a formulated products moringa-based weaning using different formulation *Nambiar (2001*).

Ethiopia is among the most deplorable country in the world, in the area of weaning food and has the 6th highest infant mortality rate in the world. Available data shows that, 504,000 children under 5 years old die per year in Ethiopia, and second highest as a proportion of population. This is the equivalent of the famine in 1984-85 before 20 years. Apart from the large number of child deaths, 52% of Ethiopian children suffer from stunting and 11% wasting; resulting from the long term effects of malnutrition, because the child enters the family eating pattern and eats not only small amounts of food, but foods unsuitable for weaning purposes and also ignorance of mothers was the main reason for child malnutrition. The child nutrition remained fairly stable up until the age of 5 months, after that, the nutritional conditions deteriorated, with 40% of children malnourished before the age of 2 years *UNICEF (2004*). The static's clearly established the deplorable weaning food situation among the childhood population and its consequent malnutrition problems. This research was undertaken to help determine the most cost effective approach to reducing child malnutrition in Ethiopia.

It is in this light research seeks to development of supplementary food from blends of so moringa powder with maize and soybean flours which would have a high protein content to reduce malnutrition among the children of the Ethiopian population.

1.2 Statement of the Problem

The demand for protein with balance in essential amino acids is increasing in Ethiopia. However, due to low levels of standards of living, those people may not have an income to buy and eat proteinous foods of animal origin. As a result of this, looking for plant which can supplement a protein identical to animal origin is a crucial.

There is a lot of competition in the market which forces weaning industry to search for ingredients which impart a nutritional miracle moringa leaf powder to the weaning product. Moringa based supplementary food contains nutrients in concentrated forms for feeding programs at institutes such as schools or for emergency rations. However, the acceptances of moringa based supplementary food depend on their nutritional and organoleptic quality and cost of production. To address these issues, these supplementary foods can be prepared from composite flours such as maize, soybean and moringa powder blend. Since the available literature on moringa based blended products is rather scanty, the present investigation was

undertaken to study the nutritional, sensory and quality of moringa based blended supplementary food and optimize the incorporation level the flour blend. Processing of moringa products generates annually several tons of low-value products. The volume and diversity of agricultural products represent an enormous and underutilized renewable resource, which can create shortage of food and cost impacts on other cereal and legume. Know uses for these products are needed to increase value and create new market opportunities. Moringa meals may represent an important protein and mineral source for human nutrition increasing the value of moringa leaves.
The poorly fed women in Africans at best can produce approximately 500 to 600ml of milk daily. For ideal growth infant at a weight of 5kg or at age 3 to 4 months' require more than 850 ml of breast milk daily. Thus, the infant's nutrient need fail to be met by breast milk alone, resulting in dietary inadequacy *Whitehead (1996*).

Ethiopia is the 6th highest infant mortality rate in the world. Available data shows that, 504,000 children under 5 years old die per year in Ethiopia, Apart from the large number of child deaths, 52% of Ethiopian children suffer from stunting and 11% wasting; resulting from the long term effects of malnutrition. *UNICEF (2004*).

In Ethiopia, the decreasing of weaning food production among childhood population brought malnutrition problem, that is 94 death out of every 1000 live birth among infant from 0-2 years old *FAO (2006*).

For the infant, mother's milk alone is not adequate after 6- months, additional food (supplementary food) is necessary for proper growth of health. Most of commercially available weaning foods produced from animal sources, such as dairy products, meat and fish, also high cost, beyond the reach of most poor families *Badamosi* (1*995*).

1.3 General Objective

The general objective of the present work was to develop supplementary food for infants from blends maize, soy bean flour with moringa powder.

Whereas the specific objectives were to:

-Determine the best combination of the blend proportion for infant supplementary foods in terms of the major qualities (nutritional quality and sensory quality)
- Determine the functional properties of the formulate product (bulk density, water holding capacity and viscosity)
- Determine the chemical composition and antinutrtional factor of a formulated product.
- Examine the microbiological quality of the formulated product.
-Compare the nutritional value of the formulated products with RDA of the world and African standards for infant requirement (6-12 months).
-Study techno economic feasibility of the project.

1.4 Significance the study

The Significance of the study is to reveal the impact associated with the formulation blend, particle size of a sample , nutritional quality, high dietary bulk and efficiently used of natural resource of moringa plant for supplementary food. Therefore, production of moringa powder, with reduced antinutritional constituents for development of supplementary food contains nutrients in concentrated forms for feeding infants and also feeding programs at institutes such as schools or for emergency rations.

Therefore, the outcome of this research will be baseline information for consumers, policy makers, researchers and manufacturers.

2. LITERATURE REVIEW

2.1 Malnutrition

Malnutrition is a state of impaired health resulting from under nutrition a lack of nutrients or from over nutrition i.e. excessive intake of nutrients. Malnutrition also may result if the body cannot properly use the food it receives. For example, a child who has frequent bouts of diarrhea may be poorly nourished, because the nutrients in the food cannot be absorbed from the intestinal tract *Armar Klemesu and Wheele (1991*).

Under nutrition is widespread in the developing countries of the world. Throughout the world it is estimated that four hundred (400) million people suffer from serious nutritional deficiencies *Ojofeitimi (1992*). Asia, Africa and Latin America have about twenty five percent to thirty percent (25%-30%) of the population suffering from semi starvation *Armar Klemesu and Wheeler (1991*). Children are the hardest hit. The poorly nourished child is highly susceptible to infection, and infections are more severe and last longer in malnourished than in a well nourished child. The child is then more vulnerable to next infectious disease to which he or she is exposed. The annual death fifteen million children under the age of five year. This represents one fourth of the death throughout the world. The growth patterns of a child are useful means for judging nutritional well-being. When a child is poorly nourished, the growth rate diminishes particularly because of delay in bone development *Ojofeitimi (1992); Armar* (*1989*). Both the quality of the bone (the amount of calcium and phosphorus it contains) and its capability for growth is influenced by nutrition. Sexual maturity appears to occur late in populations that are malnourished than in developed countries *Armar Klemusu and Wheeler* (*1991*).

2.1.1 Nutritional concerns of Malnutrition

Every child admitted to the hospital for poor weight gain or malnutrition should be screened for the presence of illnesses and condition that could lead to protein-energy malnutrition. Children with higher-than average risk for malnutrition should be more closely assessed and evaluated often. Children who cannot or will not eat, or who are unable to absorb nutrients taken by mouth, may be fed by the use of tube feeding. Tube feeding is often used to provide nutrients to children who have burns, inflammatory bowel disease, or other long-term conditions, that case chronic malnutrition or malabsorption (e.g. cystic fibrosis or AIDS), and interfere with the ability to take in enough calories. This procedure involves inserting a thin tube through the nose and carefully guiding it along the throat until it reaches the stomach or small intestine *FAO/WHO (1998)*.

If long-term tube feeding is necessary, the tube may be placed directly into the stomach or small intestine through an incision in the abdomen Bennett and Fred Plum (1996). Tube feeding cannot always deliver adequate nutrients to children who:

• Are severely malnourished

• Require surgery

• have persistent diarrhea or vomiting

• Have a gastrointestinal tract that is not functional

Intravenous feeding can also supply some of the nutrients these children need. Doctors or registered dieticians can help parents monitor overweight or obese children. These professionals may suggest a weight loss program if the child is more than 40 percent overweight. Keeping weight gain under control is accomplished by changing eating habits, lowering fat intake, and increasing physical activity.

2.1.2 Prevention of Malnutrition

Proper nutrition is required to ensure optimal health. Consumption of a wide variety of food, with adequate vitamin and mineral intake, is the basis of a healthy diet. Researchers have stated that no single nutrient is the key to good health, but optimum nutrition is derived from eating a diverse diet, including a variety of fruits and vegetables. Because foods such as fruits and vegetables provide more nutrients than vitamin supplements, food is the best source for acquiring needed vitamins and minerals *FAO/WHO (1998); USAID (2002*). Breastfeeding a baby for at least six months is considered the best way to prevent early-childhood malnutrition. The United States Department of Agriculture, Health and human Service recommended that all Americans over the age of two should:

- Consume plenty of fruits, grains, and vegetables
- Eat a variety of foods that are low in fats and cholesterol, and contain only moderate amounts of salt, sugars, and sodium.
- Engage in moderate physical activity for at least 30 minutes, at least several times a week.
- Achieve or maintain their ideal weight
- Iron deficiency can be prevented by consuming red meat, egg yolks, and fortified breads, flour, and cereals (*Bennett and Fred Plum 1996*).

2.1.3 Malnutrition in Ethiopia

As shown above, the statistics on child nutrition in Ethiopia are appalling. The reasons for the high rate of stunting (52%) and wasting (11%) which reflects the poor state of child nutrition. The way how can malnutrition are reduced so that new generations of children don't start life with the huge physical and mental challenges of malnutrition are important. Understanding child malnutrition is essential for Save the Children to devise programmers' of support which can tackle this monumental problem. The commitment of the Government of Ethiopia to tackling child malnutrition is questionable. There are no major programmers' for tackling malnutrition, the departmental responsibility is unclear (Ministry of Health or Rural Development), and the agenda for child nutrition seems to be set by the World Bank rather than the government.

Determination of malnutrition in North Wollo, Ethiopia, by SC (UK) Ethiopia, June 2002 revealed that, for children under six months, the most important factor associated with malnutrition is breastfeeding pattern. The ability to exclusively breastfeed depends on whether or not a mother can spend sufficient time with her child as well as the knowledge that exclusive breastfeeding is best for children aged 0-6 months. Women who spend more than two hours away from their children aged less than six months are significantly less likely to exclusively breastfeed than other mothers are. Malnutrition increases very rapidly between 5-10 months in this population. This is partly explained by the introduction of inappropriate weaning foods. Up to 20% of women delay introducing weaning foods until the child is 10 months old. Diarrhea is highly associated with malnutrition at this age.

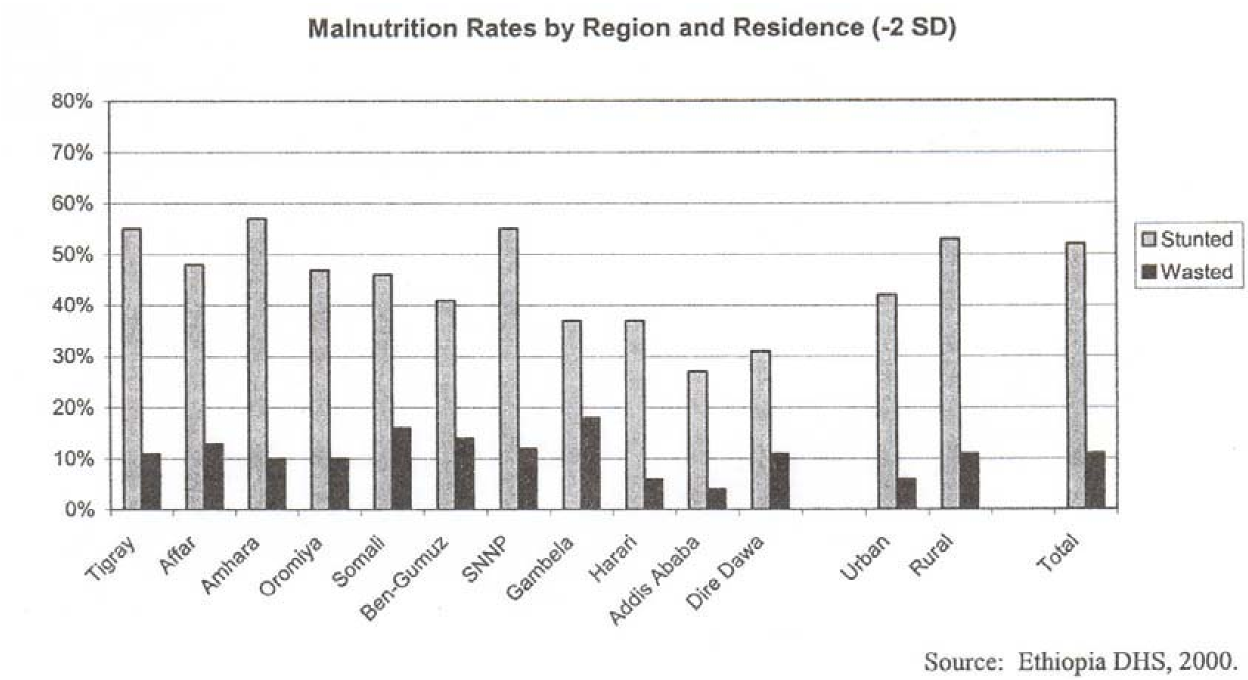

Fig- 2.1 Malnutrition rates by region and residence

As far as the beginning of malnutrition is concerned, it is suggested that it starts in the early stages of breast feeding. Despite the fact that virtually all mothers breastfeed their newborns, 11 % of infants less than six months of age are already stunted. Malnutrition rates continue to rise to 12-23 months of age, resulting in stunting in nearly 60% of children and wasting in about 20%. From that period onwards about 60% of children remain stunted and about 10% of children remain wasted.

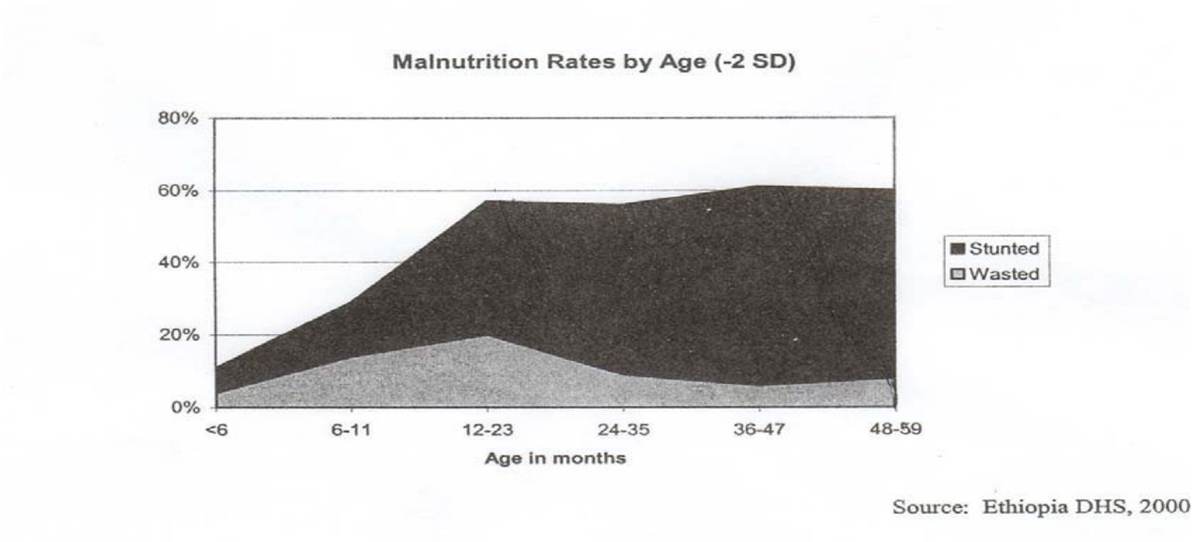

Figure 2.2 Malnutrition rates by age

2.1.4 The status of weaning food manufacturing in Ethiopia

FAFFA is an Ethiopian variety of protein rich infant food. Unfortunately tryptophan and methionine are limiting amino acids, and result indicates that FAFFA does not have the expected biological value for children. Although in Ethiopian village a marked improvement occurred in nutritional status of the children enrolled in an applied nutrition program which included to supplementary food distribution, health supervision and nutrition advice, protein rich weaning food, such as FAFFA, superamine and other should not be considered equal in nutritional value to milk based formula. Precaution should be taking to guarantee that such weaning foods are used as supplementary only and that the basic diet is mixed diet based not only on vegetables, but contains animal protein as well *Jelliffe (1998).*

Most Ethiopian infants suffer from malnutrition, particularly from a lack of adequate protein. Malnutrition and related disease account for about 4 million deaths per year of Africa children below the age five. With the increasing attention being given to the young, particularly infants baby foods and weaning foods to supplement their diet are likely to gain in importance.
In Ethiopia now a day most industry oriented towards basic needs and based on agricultural products with fast growth urbanization, due to a growing number of populations have gradually

lost the capacity to feed their people. Unproportional supplying of food creates same industry in Ethiopia *UNIDO (2005*).

Table 2.1 Leading Companies in the Ethiopian Food Sector local powder food production

Kaliti Food Share Company
Dire-Dawa Food Complex
Ada Food
Fafa Food
Misrak Powder
Yerer Powder
Kokeb Powder
Tigray Powder
Eshet Food Grain Factory
Sunlight Industry & Distribution Plc.
Nile Food Preparation Factory

(Source; UNIDO, 2000)

Table 2.2 Different supplementary foods soled in Addis Ababa.

Trade mark	Protein content (%)	Fat content (%)	Energy in Kcal
White oats	11	8	365
Riri	15	11.5	400
Cerifam	18	5	400
Cerelac	15	9	413
Faffa	18	5.1	400
Faviana	18	8	400
Nestle (Oats)	18	9	400
Beltishchew metine	16	6	400

Source different supermarket (2011)

2.2 Protein Energy Malnutrition (PEM)

PEM, "the silent emergency of the world" which may have hunted mankind since the dawn of history is by far the most lethal form of malnutrition. It is an imbalance between the supply of energy and protein, and the body's demand for them to ensure optimal growth and function. It is currently the most widespread and serious health problem of children in the world being the moderate or severe forms *USAID (2002*). This syndrome is one example of the various levels of inadequate protein and/or energy intake between starvation (no food intake) and adequate nourishment. Although infants and children of some developing nations dramatically exemplify this type of malnutrition, it can occur in persons of any age in any country. Inadequate intake of food essential nutrients leads to under nutrition, resulting in deterioration of physical growth and health. On the other hand, excess intake of high-energy food relative to the body's needs results in overweight and obesity. Children under 5 years of age are the most visible victims of PEM and most susceptible to PEM's characteristic growth impairment because of their high energy and protein need and their vulnerability to infection. PEM is self-perpetuating within the poor population of backwards and economically struggling nations. It must be clearly demarcated from generalized famine following massive disaster such as warfare, droughts, floods or earthquakes. Peak incidence is immediately after epidemics of infections, illness and diarrhea or in hungry months. In any country, the prevalence rates will be influenced by season, the availability of food, incidence of infection and the state of development of the health services *Armar (1989*).

2.2.1 Classification of PEM

PEM may be viewed as a consequence of chronic and cumulative failure to meet physiological and nutritional requirements *Barners (1989); Guiro et al (1987*).
Clinically PEM has three forms:

• Dry (thin, desiccated)

• Wet (edematous, swollen)

• Combined form between the two extreme

The form depends on the balance of non-protein sources of energy. Each of the three forms can be graded as mild, moderate or severe. The dry form, Marasmus, result from near starvation with deficiency of protein and non-protein nutrients. The marasmic child consumes very little food-often because his mother is unable to breastfeed making him very thin from loss of muscle and body fat. The wet form is called ‘Kwashiorkor,’ an African word meaning “first child-second child”. It refers to observation that the first child develops PEM when the second child replaces the first child at the breast. The weaned child is fed a thin gruel of poor nutritional quality (compared with the mother’s milk) and fails to thrive. The protein deficiency is usually identified than the energy deficiency and oedema results. Children with kwashiorkor tend to be older than those with marasmus and tend to develop the disease after they are weaned .The combined form of PEM is called Marasmus Kwashiorkor. Children with this form have some oedema and more body fat than those associated with marasmus. Marasmus is associated with the early abandonment or failure of breastfeeding and with consequent infections, most notably causing infantile gastroenteritis. These infections results from improper hygiene and inadequate knowledge of infant caring that are prevalent in the rapidly growing slums of developing countries. Kwashiorkor is less common and usually manifest as maramic- kwashiorkor. It tends to be confined to parts of the world (rural Africa, the Caribbean and Pacific islands) where staple and weaning foods such as yam, cassava, sweet potato and green banana are protein deficient and excessively starchy *Barners (1989*).

2.3 Nutrition in Infants

Nutrition plays an important role in life even before birth and an infant’s nutrition during the first year of life. This is for the growth, development and maturation of body tissues which occur rapidly during the first year of life. A healthy infant’s birth weight doubles by about five month of age and triples by one year and thus infants have a higher basal metabolic rate about twice that of adults, based on body weight *Whitney (1999).*

According to *Wardlaw and Insel (2000*), an infant typically increase in length by 50% in the first year. Such rapid growth requires both nourishment and sleep in abundance. They also need concentrated source of nutrient and energy to support their tremendous growth and development. When an infant is inadequately fed there is the risk of stunted growth and a range of biochemical changes that can impair development to the extent of permanently damaging the infant health. During the first four to six months of life, all nutrients required by an infant can be provided by breast milk and so there's no dietary need for the introduction of solid food before then *Trussel* (*2003*). By the age of 6 month, most infant need additional foods, the purpose of which is to complement the breast milk and make certain nutrient that the young child continues to have enough energy and nutrients to grow normally. This goal is only achieved when these foods are prepared and fed to the infants under hygienic conditions and given in adequate proportions. Cereals should be introduced differently a week at a time to identify allergies and for the infant to develop preference *Akaninwor (2004*).

2.3.1 Weaning Foods

Professionally literature on infant feeding is with references to "weaning period" –transition from breast-feeding to complete reliance on other foods *Eschleman (1991*). However, the word "wean" is to accustom *Eschleman (1991*). Other authors have used the word wean to mean a complete cessation of suckling. Others also indicate that weaning is the process of gradual introduction of food to an infant so he gets accustomed to food other than breast milk notwithstanding the fact that is normally referred to as a cessation of breast feeding *Armar (1989*).

During this time the feeding pattern of infants gradually changes from exclusive milk diet to diets similar to that of the rest of the family. It is also the time when the baby's feeding behavior will progress from sucking to biting and chewing. There is no precise age at which weaning should start, between four and six months of age. The low nutrient density and high bulk of the weaning foods, early introduction of solid foods, and unhygienic practices predispose infants to malnutrition, growth retardation, infection, and high mortality *Eschleman (1991*). Weaning foods with low fibre content is very important since it helps in the safety of children considering their stomach capacity since they have to consume more to get satisfied to meet their daily energy requirement *Eka (1972*). Multi-approach strategies, involving the development of improved recipes and processing, nutrition education, access to safe water and promotion of breastfeeding, are recommended solution to the problems. On other hand, in abrupt weaning the infant is introduced directly into the family meal. This latter option creates a problem, as the child may not be able to eat enough of the adult diet to meet his or her nutritional needs *Eschleman (1991*).

West African mothers usually breastfeed for 12 months. Most urban and rural poor women, breastfeed from 18 to 24 months and most Ghanaian moth weaning by the third month of life *Armar* (*1989*). A few mothers, however, start after one month. Based on interviews with breast-feeding Ghanaian mothers, *Armar and Wheeler (1991*) reported that the main weaning food for infants up to six month of age was a traditional fermented maize porridge. From six months onwards, the infants are given the family diet with complementary breastfeeding. The family foods on which the infant are weaned include dishes made from cereal, starchy tubers, legumes, and vegetables. These indicate that there is early supplementation with solid food or early weaning. Although the majority of women start weaning their infants at the age of three to four months, a few being within the first two months of life. The first solid food and the most popular weaning food is a thin cereal gruel, which is called by different names depending on the type of cereal or the West African country. For example, *koko* in Ghana, Ogi, prepared form maize or sorghum (couscous ogi), is a popular weaning food start in Sierra Leone *Jonsyn* (*1985*). Legumes are rarely used for weaning and are introduced much late (after six months of age) because of the problems of indigestibility, flatulence, and diarrhea associated with their use *King et al (1985*). The quality of weaning foods used to feed a baby has been found to be very crucial to mental development of that baby. The most rapid growth of the brain occurs from 5 months before birth to 10 months after birth. At the end of the first year of life, the brain, first organ to attain full development has achieved 70% of its adult weight *wardlaw (2000*). Poorly nourished babies have fewer and s nourished. Most authors have indicated that early and severe malnutrition is an important factor in deficiencies in late mental development apart from social and hereditary influences *Wardlaw (2000*). According to the Protein Advisory Group (*PAG, 1971*) guidelines for weaning foods, protein content should be 20%, fat levels up to 10%, moisture 5% to 10%, total ash not more than 5%. Weaning food inclusion of soy bean in the diet is found to improve nutrient density of food and improve nutrient intake, which results in the prevention of malnutrition problems *Badamosi et al (1995*).

Legumes are now largely replacing milk and other sources of animal protein, which are expensive and not readily available, as stable substitute for high-quality protein. This notwithstanding, however, soybean is used in weaning because the factors responsible for these undesirable factors are removed through roasting and soaking etc of the soybean. A large variety of oilseeds and pulses, including cowpeas, groundnuts, pigeon’s peas and melon seeds, forming

part of the traditional diets of many people. Traditional food uses of soybean are very limited; however, efforts are being made to promote their incorporation in diets *Badamosi et al (1995*). Extensive research into the process characteristics, nutritional quality and consumer acceptability of soybeans and soy-cereal blends is necessary if these items are to be used effectively to improve the nutrition status of the vulnerable group of the population. At the Food Research Institution flour produced on pilot scale is gaining popularity among middle-income mothers as a protein supplement of cereal-based weaning foods. First step in weaning involve the in tastes and textures. First weaning foods are suitable cereals usually mixed with the baby's usual milk or purred fruits and vegetables. Initially only small amounts of food of a smooth consistency are required to teach the baby to take food from a spoon and gets used to the texture of solids in the mouth. Later on, more solid foods can be introduced. First weaning foods are generally blend so that the taste is not too far removed from milk with more sophisticated tastes and textures being introduced, as the baby grow older. Commercial weaning foods are designed to help to provide a healthy mixed diet for babies. Products are developed using expert medical nutritional advice and follow current UK legislation (SI No 29472 1997, SI No 1999) and Department of Health recommendations for daily amounts of the major nutrients *Barners* (*1989*).
They must also comply with specific regulations on baby foods as well as general food legislation production of different. In addition, commercial baby foods should;

- Contain products those are consistent in composition and quality;
- Ensure that nutritional content and eating quality is maintained throughout processing and packing (commercial baby foods undergo more rigorous cooking than home-made foods);
- Be capable of being stored safely and maintaining quality throughout their shelf-life (unlike home-made baby foods which are usually eaten on the day of preparation)
- Be easy to prepare and appropriate for the recommended age group.

The weaning period represents a stage of rapid growth and development and the weaning diet must supply adequate energy in the form of carbohydrate and fat and also protein and essential vitamins and minerals. Thus when developing commercial weaning foods manufacturers take into account the following criteria:

Energy (Calories) – Growth of infants depends on the provision of adequate calories for tissue building and energy expenditure *Barners (1989*). The total energy content of the infant's diet must be maintained with controlled limits. An insufficient energy intake could lead to failure to thrive, whereas an energy intake in excess of requirements may lead to obesity. The "energy density" (amount of energy in a given quantity of food) is, therefore important. For example high fibre foods have a low energy density, whilst sugar and fat have a high energy density.

Carbohydrate — is the source of energy and its intake must be controlled. If given in excess it may be converted into fat and stores as such in the body. The type of carbohydrate that is included in the food is also important, as babies need carbohydrate that is easily digestible.

Protein —an adequate amount of protein must be provided in the diet, but too much protein should be avoided. Protein is the principal material of tissues and so is found in the body fluids and secretions as well. The protein ingested must contain specific amount of each of the essential amino acids. Example, lysine; 4.2 g /100g, and, Cystine 2.0 g /100g *Barners (1989*).

Fat — Infants must receive an adequate amount of fat, as it is the most important sources of energy and it represents a concentrated form of energy. Fat is also important to provide essential fatty acids and certain vitamins. Lack of these essential fatty acids causes the skin of the infants to be dry and thickened and become susceptible to inflammation in the folds of the groin or axilla *Barness (1979*). Example: Linoleic acid, 0.71 µg/100g.

Fibre — unlike adults, infants do not benefit from a high fibre intake and therefore fibre levels must be controlled. Fibre can interfere with the absorption of essential minerals and because babies have a small stomach capacity it is difficult to consume sufficient quantities of fibre-rich foods to meet energy requirements.

Vitamins and minerals— added vitamins and minerals may be needed to ensure an adequate intake or restore loses, which may occur during processing. Example Thiamine (vitamin B1;

40µg/100g, Riboflavin (vitamin B2); 60 µg/100g, Magnesium 6mg/100g, Calcium 50mg/100g are suppose to be added to compensate for the losses Barners (1989).

Salt – there is no added salt (sodium chloride) in commercial baby foods.

Additives – by law, artificial additives such as preservatives, colorings, antioxidants and artificial sweeteners are not permitted in commercial weaning foods. No artificial flavoring is used in commercial baby foods *Barners (1989*).

2.4 Nutritive value and nutritional problems of weaning foods in East Africa.

Traditional weaning foods in East Africa are known to be of low nutritive value *Guiro et al.* (*1987*) and are characterized by low protein, low energy density, and high bulk density. Maize pap has been implicated in the etiology of protein-energy malnutrition on children during the weaning period *Naismith (1973)*.
Cereal-based diets have lower nutritional value than animal-based ones. Cereals form the primary basis for most of the traditional weaning foods in East African. The protein content of maize and guinea corn is of poor quality, low in lysine and tryptophan. These two amino acids are indispensable to the growth of the young child Oyenugu (1968).

2.4.1 Strategies for solving weaning food problems in Africa

Ignorance and food taboos in East Africa can result in weaning foods of poor nutritional quality. Improving the nutritional value of the weaning foods by itself will not eliminate the problems. Training and nutritional education of the mothers is necessary to change feeding practices and provide correct information. Nutritional education can easily be incorporated into primary health care programmes. Health workers and nutritionists can educate rural mothers about the importance of adequate weaning foods and practices, infant health, host defense system, home-scale drying, processing, and so on. The importance of varying the baby's diet and practicing good hygiene when handling and storing the baby's food can be included as well. The teaching and training of rural mothers can have a long-term impact on weaning practices and nutritional

status of children. In the Philippines, a weaning education Programme led to a reduction in the prevalence of malnutrition from 64% to 42% *Nnanyelugo et al. (1990*).
Several strategies may be used to improve the nutritive value of weaning foods. The traditional East African weaning foods could be improved by combining locally available foods that complement each other in such a way that the new patters of amino acids created by this combination are similar to that recommended for infants. Cereals are deficient in lysine but have sufficient sulphur containing amino acids that are limiting in legumes. Therefore, the combination of cereals and legumes has been found to produce amino acid patterns that adequately promote growth *Uwaegbute (1989*).

2.5 Manufacturing weaning food

In recent years it has become clear that gifts of food from the<<have countries>> to the <<have nor countries>> may be associated with political strength and conditions. Milk is not simply a protein commodity in shipped in powder form, but is associated with definite political conditions. United state surplus foods have been sent overseas not out of purely altruistic motives, but to support and subsidize American farmers. A country may abruptly be cut off from supplies, not because of bad consequences of their milk distribution program, but out of other considerations. Clearly, developing countries must develop the capacity to locally produce their own weaning foods *Anderson (1996*).

The original weaning cereal product, Icaparina, was introduced in 1963 as a family food, first in Guatemala and later in Colombia and other Central America countries. After the first several years, the sale became profitable, thus insuring counting local production. Using cotton seed flour as protein concentrate, Incaparina has resulted in an improvement in nutrition status and has proved effective both in the prevention and even in the treatment of protein malnutrition *Bjornesjo (1997*).

2.6 Soybean

Soybean has become the 'gold nugget of Nutrition' because of the combination of nutrient it provides. Soybean (*Glycin max*.) is a widely used, inexpensive, and nutritional source of dietary protein *McArthur et al. (1988*). Its protein content (40%) is higher and more economical than that of beef (18%), chicken (20%), fish (18%) and groundnut (23%) *Iita (1990*). Soybean is also of particular interest as a vegetable protein source because of its cholesterol lowering abilities in patients with type II hyperlipoproteinaemia *Sirtori et al. (2000*).

Apart from proteins, Soybeans also contain carbohydrate (32%), fat (20%), minerals/vitamins (5%) and fiber (3%). A lot of work has been reported on the chemical composition, cultivation and processing of Soybean. However, more studies need to be carried out to elucidate its nutritional value. Soybean may hold many advantages over animal products above and beyond the fact that Soybean is low in saturated fatty acids and of course, cholesterol free. Soybean is a legume and cultivated in many areas of the world, from tropics to temperate regions. For centuries, Soybean has played a major role in the diet of the population of Eastern Asia particularly China where soybean was termed sacred "grain" The other four being rice, barley, wheat and millet. Now most countries have recognized the importance of soybean as a potential source of high quality protein and oil. Its high fibre and low carbohydrate content in diet generally improves the control of diabetes. However, varieties of low fibre content of less than 5% have corresponding higher protein levels *Kakad et al. (1983).*

Supplementation of soy fibre significantly enhanced return of serum glucose levels towards fasting levels during the later half of the test meal though soy fibre had no effect on plasma insulin levels. Lactose intolerance means the body cannot digest or absorb the sugar, lactose in milk, other dairy products, and foods to which milk has been added. Because of this, lactose free soy-protein based formula in the management of long-term lactose restriction, a number of studies have addressed the role of these formulas in the recovery of acute infantile diarrhea *American Academy of Pediatrics (1998*).

There is much evidence from studies on experimental animal and human subjects that substitute soy-protein for animal in the diets reduces the concentration of total and LDL cholesterol in the plasma or serum *American Academy of Pediatrics (1998*). The suggested importance for lowering cholesterol levels is as follows:

- It improves the catabolism of cholesterol rich in Low Density Lipoprotein fraction (LDL)
- Absorption of lipids from gastrointestinal (GI) tract may be slow with soy protein.
- It increases billiard cholesterol excretion

2.6.1 Uses of Soybeans

The uses of soybean are numerous. They are processed to give soy milk, soy sauce, tofu (soybean curd) yogurt, soybean sprout, Tempeh (soy steak), which is extensively used in the Far East as infant feeding. The seed yield edible, semi-drying oil which is extensively used in the Far East as food. The bulk of the oil is used for edible purposes particularly as a salad oil or in the manufacture of margarine, shortening and soy meal. The residues after the extraction of the oil is a very rich protein feeding stuff for livestock and for the manufacture of synthetic fibre, textile sizes and fire fighting foam. Soy flour prepared from whole soybeans is used in bakery and other food product extends to cereal flour, meat products and in health foods. Soybean flour is becoming increasingly important as an ingredient of food stuffs and bakery products such as bread, biscuits and cakes, *Iita (1990*).

2.6.2 Nutritional Composition of Soybeans

Protein, starch and vitamin content of the seed vary considerably according to the cultivar, origin of seed, climate and soil. Variations of 29.6%-50.3% in the crude protein content have been reported. There is also a considerable variation in amino acid content according to the cultivars and origin of the seed, but soybeans are relative in low sulphur containing amino acids that is cysteine and methionine. *Asiedu (1989*).

Table 2.3 Chemical Composition of Soybean per 100g Edible Portions

Constituent	Composition/ 100g	Amino acid profile (gram/ 100g protein)

Moisture	7g	Arg	46	Thr	41
Protein	38g	His	21	Trp	41
Fat/oil	17g	Iso	56	Val	37
Ash	4.6g	Leu	79		
Fiber	4.8g	Lys	62		
Carbohydrate	26g	Met	21		
Mineral	7g	Phen	87		

Source: (Asiedu, 1989)

2.6.3 Anti-Nutritive Properties of Soybean.

Raw soybeans contain anti-nutritional compounds, which has to be removed. Such chemicals include trypsin inhibitors; which prevent the action of the breakdown of protein by trypsin; haemaglutinins, which cause agglutination of red blood cells, phosphatidylcholine, which produces an objectionable flavour and bitterness and raffinose which cause flatulence. Some preprocessing treatment such as soaking the bean, removes the phosphatidylcholine, raffinose as well as the bitterness. Heat treatment inactivates the trypsin inhibitors and haemaglutinins. Other compounds such as urea which are undesirable are also removed during soaking process *Ologhobo (1984*).

Tannins

Food tannins are polyphenolic compounds, which are widely distributed in plants. They can be classified as condensed or hydrolyzable tannins. Most of the tannins in soybean and moringa are condensed tannins (figure 2.3), formed by polymerization of flavan-3-ols or flavan-3, 4-diols. The amount of tannins in plant depends on the variety, the degree of maturation and extraction method, and varies from 0.2 to 3% of defatted soybean meal Naczk et al. (1998).

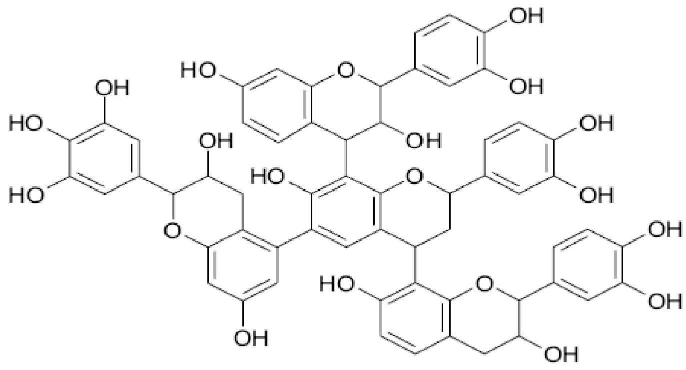

Fig.2.3 Structure of condensed tannin.

Some of the tannins in soybean exist in insoluble forms. Naczk et al. (2000) measured the content of insoluble-bound tannins in soy bean hulls and concluded that their insolubility may be due to polymerization as well as to the formation of insoluble complexes with the fiber and protein fractions of the seed.

2.7 Maize (*zea mays)*

Maize is a gigantic domestic grass [*Zea mays*] of tropical Mexican origin. The plant is used to produce grain and fodder that are the basis of a number of food, feed, pharmaceutical and industrial products. Cultivation of maize and the elaboration of its food products are inextricably bound with the rise of pre-Colombian Mesoamerican civilizations *Matz (1959*). Maize is composed mainly of carbohydrates but it also has an appreciable amount of minerals, vitamins and amino acid especially methionine. The nutritional compositions of maize are shown in Table2.4.

Table 2.4 Proximate Composition of Maize

Constituent	Composition (%)	Amino acid profile (gram/ 100g protein)			
Moisture	6	Arg	38	Thr	21
Protein	10	His	24	Trp	04
Fat/oil	4.4	Iso	29	Val	40
Ash	1.2	Leu	23	Phen	42
Fiber	2.2	Lys	11		

Carbohydrate	65	Met	20		

Source: (Matz, 1959)

2.7.1 Uses of maize

In East Africa maize is used in the preparation of corn dough, which is used for various foods such as porridge, kenkey, banku and atmet. The grains are fed to livestock and the husk is used for wrapping kenkey and other local food. The straw is used for making door mats.
In the United States and Canada, the primary use of maize is a feed for livestock, forage, silage or grain. Silage is made by fermentation of chopped green cornstalks. The grain also has many industrial uses, including transformation into plastics and fabrics. Some is hydrolyzed and enzymatic ally treated to produce syrup, particularly high fructose corn syrup, a sweetener, and some fermented and distilled to produce grain alcohol. Grain alcohol from maize is traditionally the source of bourbon whiskey *Watson (1987*). Increasingly, ethanol is being used at low concentrations (10% or less) as an additive in gasoline for motor fuels to increase the octane rating. Lower pollutants and reduce petroleum use *Watson* (*1994).*

Human consumption of corn and corn meal constitutes a staple food in many regions of the world. Corn meal is made into a thick porridge in many cultures; from the polenta of Italy and the mamaliga of Romania to mush in the U.S or sadza, nshima, ugali and mealie pap in Africa. Sweet corn is a genetic variation that is high in sugars and low in starch that is served like a vegetable. Popcorn is kernels of certain varieties that explode when heated forming fluffy pieces that are eaten as a snack. Another common food made from maize is corn flakes. The floury meal of maize (cornmeal or masa) is used to make cornbread and Mexican tortillas. Teosinte is used as fodder, and can also be popped as popcorn. Some forms of the plant are occasionally grown for ornamental use in the garden. Corncobs can be hollowed out and treated to make inexpensive smoking pipes, first manufactured in the United States in 1969. Corn cobs are also used as a biomass fuel source. In Canada and the U.S these are called “corn mazes” and are popular in many farming communities. Maize is sometimes used as biomass fuel, such as ethanol. Maize is also used as fish bait. It is particularly popular in Europe for coarse fishing.

Stigmas from female corn flowers, known popularly as corn silk, are sold as herbal supplements *Doebley (1994)*

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2.8 Moringa leaves

The tropical drought resistant tree *Moringa oleifera* is native to India but has been introduced to the African and South American continents. The leaves are consumed raw, cooked as other green leaves or as a dried, concentrated powder. The Moringa is suitable for home gardening, as it is easy to grow and its fresh leaves can be harvested continuously. It has been claimed to have an unusually high content of calcium, iron, and vitamin- A *Makkar (1997*).

High quality protein and a low content of antineutrinos such as tannins and oxalates *Barminas (1998*). Moringa leaves have therefore been promoted as a potential low cost high quality food. Published data on the nutrient content of Moringa leaves are, however, inconsistent (*Lockett, 2000*). Probably reflecting different pre- and post harvest procedures, varieties, leaf age, etc. There is limited information on the bioavailability of nutrients from Moringa leaves, although they were effective in improving vitamin A status in depleted rates. Systematic nutrient analyses and human intervention trials assessing the effects of consumption of Moringa leaves are needed before the potential effects of the Moringa tree can be estimated *Lockett (2000*). It's a deciduous tree or shrub, fast growing, drought resistant, average height of 12 meters at maturity. Now, using Moringa leaves, traditionally eaten in countries such as Niger, Nigeria, Senegal and Ethiopia. For these programs the leaves are generally dried and ground in to powder, facilitating conservation and consumption *Broin (2006).* The nutritional compositions of Moringa leaves are shown in Table 2.5

Table 2.5 Proximate Composition of Moringa leaves powder

Constituent	Composition (%)	Amino acid profile (gram /100 g protein)			
Moisture	7.5	Arg	49	Thr	44
Protein	27.1	His	23	Trp	16
Fat/oil	3.5	Iso	30	val	39

Ash	1.2	Leu	72	Phen	51
Fiber	19	Lys	49		
Carbohydrate	38.2	Met	13		

Source: ***(Dolcas, 2008)***

2.8.1 Using Moringa leaf powder to enrich baby food

In Africa, more often that not, the porridges given to babies are poor nutritional value usually cereal flour with sugar added, sometimes small fish and rarely powdered milk. These baby cereals do not cover children protein and lipid needs, introduction of moringa leaf powder in infant cereal to increase its protein, Vitamin and mineral content *Broin (2006*).

To calculate the formula of infant cereal, we took in to consideration the needs of children between the ages of six months and two years whose diet is mixed. The requirement was defined by the WHO. We also took in to consideration the nutritional value of ingredients widely available in Africa used for infant cereal. The formulation of various mixtures was made possible application developed *IRD (2006*). Moringa stenopetala leaves are a staple food for Konso people in Ethiopia, African Moringa tree (also known locally as aleko or shiferaw) is used for a variety of purposes in southern Ethiopia. In most households, the fresh leaves are cooked and eaten. The tree is particularly valued in the Konso region, where both its leaves and roots are used as medicine .Konso villagers eat the fresh leaves on a daily bases, mixing the leaves with maize and then cooking them in earthen pots *Mekonnen (1997*).

Table 2.6 Nutritional compared to moringa leaf powder and other diet

Fresh leaves	**Dried leaf powder**
4 time vitamin A of carrot	**10** time vitamin A of carrot
7 time vitamin C orange	**12** time vitamin C orange
4 time calcium of milk	**17** time calcium of milk
3 time potassium of banana	**15** time potassium of banana
¾ time iron of spinach	**25** time iron of spinach
2 time protein of yogurt	**9** time protein of yogurt

Sources *(Dolcas, 2008)*

2.9 Processing of weaning food

The reasons for processing food include preservation of foods for use in times of shortage; increases shelf life; removal of toxins; removal of ant nutrients, which will improve digestibility and availability of nutrients; and improvement of palatability. As part of food processing, it is also possible to fortify foods. Food preservation is done in order to reduce the content of microorganisms and enzymes, or to decrease their activity, which can be done by heating, by removal of water or by adding a preservative such as acid, sugar, or salt. Processing will typically decrease the content of vitamins and minerals, but some methods, like fermentation and germination can increase the content of some nutrients, e.g. vitamin B and C. As processing will also decrease the content of ant nutrients, it will have a positive effect on the availability of vitamins and minerals, different food processes can have different effects on a number of nutritional qualities.

Precooked products have other advantages in addition to avoidance of the loss of heat-sensitive micronutrients. They can be prepared instantly and, therefore, are highly convenient. Foods that need to be cooked may be more likely to be prepared once each day and stored for subsequent feedings, increasing the risk of bacterial contamination. However, if contaminated water or liquid is added to the precooked food, the risk of gastrointestinal illnesses increases. Use of precooked products in social programs and in conditions of poverty in different country has not resulted in increased prevalence of diarrhea, showing this to be a feasible option Hotz and Gibson (2001).

First weaning foods are generally blend so that the taste is not too far removed from milk with more sophisticated tastes and textures being introduced, as the baby grow older. Commercial weaning foods are designed to help to provide a healthy mixed diet for babies. Products are developed using expert medical nutritional advice and follow current UK legislation (SI No 29472 1997, SI No 1999) and Department of Health recommendations for daily amounts of the major nutrients *Barners* (*1989*).
They must also comply with specific regulations on baby foods as well as general food legislation production of different. In addition, commercial baby foods should;
Contain products those are consistent in composition and quality;

Ensure that nutritional content and eating quality is maintained throughout processing and packing (commercial baby foods undergo more rigorous cooking than home-made foods).
Be capable of being stored safely and maintaining quality throughout their shelf-life (unlike home-made baby foods which are usually eaten on the day of preparation)
Be easy to prepare and appropriate for the recommended age group.

The weaning period represents a stage of rapid growth and development and the weaning diet must supply adequate energy in the form of carbohydrate and fat and also protein.

3. MATERIALS AND METHODS

3.1 Source of material

The variety of stored soybean (Afgat), maize (*BH-540*) and Moringa (*Shiferaw*) were obtained from Awassa Agricultural Institute Ethiopia. Weaning food namely Faffa product in the experimental samples was used as a control, because it was plant based supplementary blend. Flours of soy bean and maize and moringa leave powder were obtained as per the process shown in Figures 3.1.

3.2 Sample preparations

3.2.1 Preparation of food commodities

Defective grains (with holes), stones, dried pods and other debris were removed from the soybeans. The beans were then washed and soaked in water for a day. This was done to remove some of the anti- nutritive factors such as trypsin inhibitors and haemaglutinins present in the beans. The soaked beans were then placed in a nylon sieve and allowed to drain. It was then lowered into a container containing already boiled water for about 20 minutes. This step is called "blanching". This was done to make dehulling easier, and to inactivate enzymes activity. The water was drained off and discarded. The dehulled beans were then solar dried after which it was roasted at 70 ^{0}C using an electric oven to further reduce anti- nutritive factors and improve upon the flavour of the final product. The roasted soybeans were milled into flour to obtain smooth and consistent particle sizes (*250μm*). The cereals maize was separately washed with tap water and air-dried for 12 hours. The cereals roasted at 70^{0}c for 30 minutes. Moringa leaf was separately washed with tap water and cooked the leaves in boiled water for 30 min .The leaves were dried at room temperature for 48 hours. Finally the dried grain and moringa leaves were milled (Retsch Gmbh,T-sk-1 made in Germany) into powder to obtain smooth and consistent particle sizes (*250μm*) (Vibrate sieves Fritsch, Volt 220 made in Germany), lastly the powder of soy bean, maize and moringa leave were analyzed for their chemical

proximate composition and blends formulated based on the protein contents. The procedure is as shown in Figure 3.1.

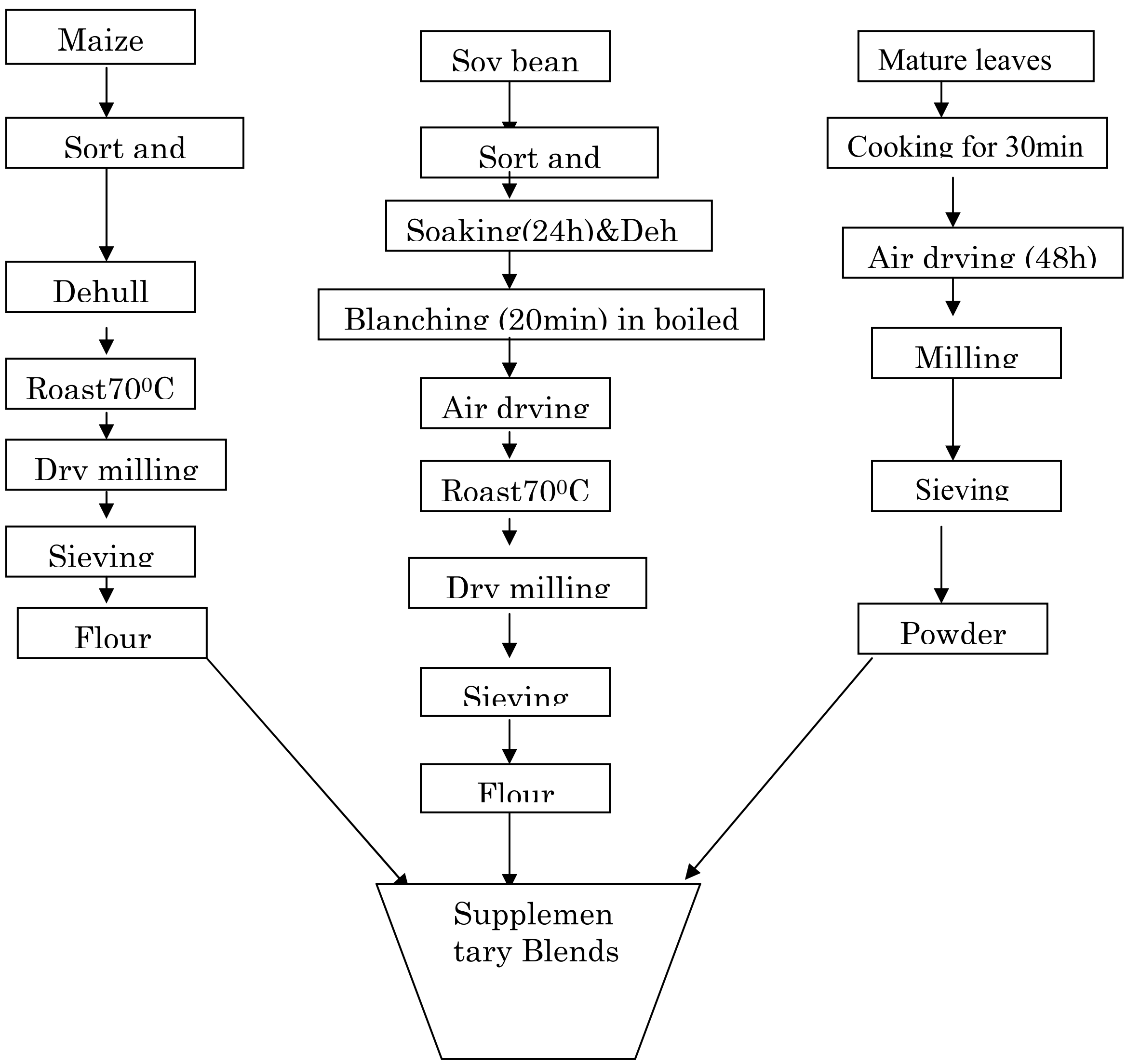


Fig. 3.1 Flow diagram for the preparation of flour of soybean, maize and moringa leave powder.

3.3 Blend formulation

3.3.1 Methodological approach to formulate maize, moringa and soybean blend supplementary food

Food formulation for infant and young children is undertaken using the following methodological approaches:

The first methodological approach is adapted from Cameron and Hofvander (1983). In this publication, a multi-mix infant formula is expected to include four basic ingredients:

(i) A staple as the main ingredient (i.e. preferably a cereal , maize selected)

(ii) A protein supplement from a plant or animal food source (e.g. beans, groundnut, olifeira leaf, meat, chicken, fish, eggs, etc),

(iii) A vitamin and mineral supplement (e.g. a vegetable and / or fruit),

(iv) An energy supplement to increase the energy density of the mix (e.g. fat, oil or sugar, etc).

According to Amankwah et al. (2009) the nutritional composition of the various flours were determined after which a composite flour was prepared by blending employing the material balance method (Annex 1) , such that the blended flour will meet the standard set by World Health Organization (WHO, 2001) guideline energy (kcal) and protein requirement for supplementary food. This states that protein should be 20-25 %, carbohydrate 45 -65% and energy = 88.75 kcal/kg/day for 7-12 months age having weight 8kg.

Table-3.1 RDA value for 7-12 months age

Nutrients	WHO	EQSA
Energy kcal/ day	710	400
Protein g/ day	20-25	20

Source- FAO/WHO Human energy and protein requirements (2001)and Ethiopia quality standard and authority ES-3354

Table -3.2. Proximate compositions of processed flour and powder sample

Component	Content of sample		
	Soy bean flour	Maize flour	Moringa leave powder
Energy (kcal)	441.22±0.07	382.01± 0.48	386.74 ±0.50
Protein %	39.99 ± 0.06	7.37 ±0.04	28.29 ± 0.05

Table -*3.3 Formulations of weaning food sample blends in different ratios*

Formula	Total mass	Maize	soybean	Moringa
Diet – 1	100g	70	25	5
Diet-2	100g	60	30	10
Diet-3	100g	50	35	15
Diet-4	100g	50	25	25
Diet-5	100g	40	30	30

A dry weight of 65g of the formulated weaning foods were calculated and compared to recommended dietary allowance (RDA) for the same age group for infant 6-12 month *Mariam (2005*).

Table-3.4 Estimated amount of nutrient / 65 g of the sample composite compared with RDA.

Nutrient(g)	RDA * to 1 year amount in 65g
Moisture	-
Ash	-
Crude protein	13-14
Crude fat	10-25
Crude fiber	-
Energy(kcal)	650

Source: Recommended dietary allowance adapted from *Guthrie (1990*)

3.4 Analysis method

3.4.1. Proximate analysis of moringa, soy bean and maize samples

Determination of moisture content (AOAC 2000, 925.05)

The moisture dish was dried at 130^0C for one hour and placed in desiccator for about 15-20 minutes. The mass of the dish was measured (M_1). About 2-3gram of the sample was weighed into the moisture dish (M_2). The sample was dried at 130^0C for one hour or at 100^0c for 6 hours. After drying is completed, it was measured as M_3.

$$Moisture\ (\%) = \frac{M_3 - M_1}{M_2 - M_1} x100\%$$

where :

M_1 = Weight of dish

M_2 = Weight of fresh sample and dish

M_3 = Weight of Sample after drying

- **Determination of dietary (crude) fiber in food samples (AOAC 2000, 920.169)**

About 2gram of the sample was weighed. If the sample contains fat>1%, the fat was extracted by hexane. The defatted sample was transferred in to 600ml beaker. Fiber contamination from paper or brush was avoided. 0.25-0.5g bumping granules, followed by 200ml of 1.25% sulfuric acid solution were added to the beaker near-boiling. The sample in the beaker was boiled for 30 minutes by rotating periodically. Near the end of refluxing, it was placed on Buchner funnel fitted with No.9 rubber stopper and filtered. At the end of filtration the solids were washed by warm water and 1.25% sodium hydroxide. The filtration was continued until dryness. The residue was placed on crucible, dried for two hours at 130^0c or overnight 110^0c, cooled in the desiccators and weighed (M_1). Then again it was ashed at 550^0c, cooled in desiccators and weighed (M_2). Finally the crude fiber percentage was calculated as

$$Crude\ fiber\ (\%) = \frac{M_1 - M_2}{Weight\ of\ sample} x\,100\%$$

$$Where, M_1 = Weight\ of\ crucible\ and\ residue$$
$$M_2 = Weight\ of\ crucible\ and\ ash$$


Figure 3.2 during crude fiber analyses

Kjeldahl method of crude protein analysis (AOAC 2000, 979.09)

Digestion

About 0.1-1g of the food sample was weighed on an analytical balance into the digestion flask (round- bottom flask with a long neck, similar in appearance to a volumetric flask except for the round bottom and the lack of a calibration line) or larger test tube. Then the sample was digested by addition of small volume (3-5ml) of concentrated H_2SO_4 (an oxidizing agents which digests the food), anhydrous Na_2SO_4 or K_2SO_4 that speed up the reaction by raising the boiling points of H_2SO_4 and a catalyst ($CuSO_4$, selenium, titanium or mercury) to speed the reaction. About 1 g of catalyst mixture was made of Na_2SO4 or K_2SO_4 with anhydrous $CuSO_4$ in the ratio of 10:1 used. Digestion was converted any nitrogen in the food (other than that which is in the form of nitrates or nitrites) into ammonia and other organic matter to CO_2 and H_2O. In acidic solution, ammonia was not liberated as gas because rather it exists as ammonium sulfate salt.

$$\text{N (in food)} \longrightarrow (NH_4)_2\,SO_4$$

Distillation

After digestion had completed, the content in the flask was diluted by water and a concentrated NaOH (40%) solution. It was added to make the solution slightly alkaline and to liberate ammonia gas.

$$(NH_4)_2\ SO_4 + 2NaOH \longrightarrow 2NH_3 + 2H_2O + NaS_2O_4$$

The ammonia was then distilled into receiving flask that consist a standardized strong acid such as solution of excess boric acid (4%) or sulfuric acid for reaction with ammonia or sulfuric acid.

Titration

If H_2SO_4 was used in the receiving flask, the excess acid was back titrated with NaOH.

$$NH_3 + H_2SO_4 \longrightarrow (NH_4)\ SO_4 + H_2SO_4 \text{ (that is excess)}$$

(Back titration reaction)

$$H_2SO_4 \text{ (the excess)} + NaOH \longrightarrow Na_2SO_4 + H_2O$$

But if boric acid was used, the borate ion was titrated with standard acid (0.1N HCI).

$$NH_3 + H_3BO_3 \text{ (boric acid)} \longrightarrow NH_4 + H_2BO_3 \text{ (borate ion)}$$

$$H_3BO_3 + H^+ \longrightarrow H_3BO_3$$

Calculation: Total nitrogen, percent by weight

$$= \frac{(T - B) * N * 14.007 * 100}{W}$$

Where: T: Volume in ml of the standard sulphuric acid solution used in the titration for the test material

B: Volume in ml of the standard sulphuric acid solution used in the titration for the blank determination

N: Normality of standard sulphuric acid

W: Weight in grams of the test material

Crude protein, percent per weight = 6.25 * total nitrogen

Fig.3.3 Protein analyzer unit

Crude Fat content determination (AOAC 2000, 4.5.01)

About 3-4 gram of sample was weighed and put into a thimble lined with a circle of filter paper. The thimble and contents was placed into a 50mL beaker and dried in an oven for 2 hours at 110^{0}C. Thimble and contents was transferred in to extraction apparatus. The beaker was rinsed for several times with the solvent hexane. The sample contained in the thimble was extracted with the solvent hexane in a Soxhlet extraction apparatus (2055 soxtec, swiden) for 6-8 hours at a condensation rate of at least 3-6 drops per second. At the completion of the extraction, the extracted was transferred from the extraction flask into a pre-weighted evaporating small beaker (150-250mL) with several rinsing with the solvent. The hexane was evaporated until no odor of its detected. The beaker and contents was dried in an oven for 30 minutes at 100^{0}C.Then it was removed from the oven and cooled in a desiccator. The beaker and contents was weighed.

$$Crude\ \ fat\ (\%) = \frac{M_1 - M_2}{Weight\ \ of\ \ sample}\ x\ 100\%$$

Fig 3.4 Crude fat extraction unit

- **Total ash determination (AOAC 2000, 941.12)**

The porcelain dish which was used for the analysis was cleaned by drying at 120^{0}C and igniting ay 550^{0}C in furnace for three hours. Then the dish was removed from the furnace and cooled in a desiccators .The mass of the dish was measured by analytical balance (M_1).About 5gram of the sample was weighed in to porcelain dish (M_2).The sample was dried at 120^{0}C for one hour in drying oven (memmert, 854schwabach, Germany). The sample was removed from the drying oven and carbonizes by blue flame of Bunsen burner by placing the sample dish on wire gauze. The sample was then placed in furnace (Carbolite, astonlane Hope, Sheffield S302RR, England) at about 550^{0}C until free from carbon and the residues appear grayish white (about 8 hours).The sample was removed from the furnace and if the ashing was incomplete it was moistened by the few drops of water and placed in an oven at 120^0C for one hour and re-ash at 550^0C until white ash color is obtained .It was removed from the furnace and placed in the desiccator. Finally the mass was weighed (M_3).

$$Ash\ (\%) = \frac{M_3 - M_1}{M_2 - M_1} x\ 100\%$$

Where :

M_1 = *Weight of the dish*

M_2 = *Weight of fresh sample and dish*

M_3 = *Weight of ash and dish*

The ash content ignition method. (Horsefall and Ayebaemi, 2004)

The crucibles used was thoroughly washed and dried in an air-circulating oven at 100°C for 15 minutes. They were removed into a dessicator to cool. The crucibles were later preheated in the carbolite furnace (Carbolite, astonlane Hope, Sheffield S302RR, England) at 550°C for 10 minutes. About 3 gram of the sample was placed in the pre-heated, cooled and weighed crucible and then reweighed. The temperature was allowed to rise to 550°C and the ashing was carried on for one hour at this temperature. The crucibles was removed from the furnace, allowed to cool in a dessicator and reweighed.

Water soluble and insoluble Ash. (Ranganna, 2002)

The total ash was boiled in silica dishes with 25ml water for 15 minutes. They were filtered through filter paper and thoroughly washed with hot water. Transferred the filter paper in to new crucible. The crucibles were later preheated in the carbolite furnace (Carbolite, astonlane Hope, Sheffield S302RR, England) at 550°C for 10 minutes. The sample was placed in the pre-heated, cooled and weighed crucible and then reweighed.

Water soluble ash = Total ash – (water insoluble ash – Blank)

Fig.3.5 Samples drying in furnace

- **Crude carbohydrate determination**

Total carbohydrate was calculated by difference with the exclusion of crude fiber.

3.4.2. Determination of functional properties

- **Water adsorption**

This was determined using the method of (*Sosulski, 1982*). Samples (3 g) were mixed with 25 ml of water and stirred six times for 1 min at 10 min intervals. The mixtures were centrifuged (Hettich Universal II Germany) at 3000 rpm for 25 min, and supernatants were removed. Pellets were dried at 50 °C for 25 min and weighed. Water adsorption capacity was expressed as the number of grams of water retained by 100 g of material.

$$Wateradsorpation\ (\%) = \frac{wetsample - drysample}{drysample}\ x\ 100\%$$

- **Fat adsorption**

For determination of fat adsorption the method of (Lin, Humbert, and Sosulski, 1974) was used. Samples (0.5 g) were mixed with 6 ml of soy oil. After 30 min the mixtures were centrifuged (Hettich Universal I I, Germany) at 300 rpm for 25 min and the volume of the supernatants was weighed. Oil adsorption capacity was expressed as the number of grams of oil retained by 100 g of material.

- **Bulk density**

This was determined using the method of (Sosulski, 1982).Samples (25g) was taken in to measuring cylinder and then packed. After that measured the volume and calculated the final result in g/ml.

- **Apparent Viscosity**

Apparent viscosity was determined by the method described by (*Quinn and Beuchat ,1976*).Cold water slurries contains 20% sample solids were heated in a boiling water bath constant stirring until boiling which was continued for three minutes. They were cooled to room temperature and their viscosity was measured with a Brookfield Synchroelectric Viscometer.

3.4.3. Determination of ant nutritional factors

3.4.3. 1. Condensed tannin determination

The procedure of Burns (1971) as modified by Maxson and Rooney (1972) was used for Condensed tannin estimation. About 1g of weighed sample was extracted with 10ml of 1% HCl in methanol for 24hrs at room temperature with mechanical shaking after centrifugation at 1000 rpm for 5min then 1ml of the supernatant was mixed with 5ml of vanillin HCl reagent which was prepared by combining equal volume of 8% concentrated HCl in Methanol and 4% vanillin in Methanol. Finally, absorbance was read at 500mm after 20 min using UV-Vis Spectrophotometer (DU-64 spectrophotometer, Beckman, USA).
A stock D.catechin solution was used as the standard and values of tannin was read in mg of D. catchin / gram of sample. To do this, 20mg D. catchin was weighed and dissolved in 100ml 1% HCl-l Methanol.Then,1.25, 6.25, 12.5, 18.25ml stock were taken and diluted with 25ml 1% HCl in Methanol.

$$Tannin\ in\ mg/g = \frac{Abso - Intercept}{Slop\ x\ Density\ x\ Weight\ of\ sample}$$

Figure 3.6 UV-Spectrophotometer for analyzing phytate and tannin

3.4.3. 2. Determination of phytate

The procedure of Latta and Eskin (1980) and later modified by Vaintraub and Lapteva (1988) was used for phytic acid estimation. About 5gm of dried sample was extracted with 100ml 2.4%HCl for 1hr at an ambient temperature and centrifuged at 3000rpm for 30 min.The clear supernatant was used for the phytate estimation then after,1ml of wade reagent(0.03% solution of $FeCl_3.6H_2O$ containing 0.3% sulfosalcilic acid in water) was added to 3ml of sample solution and the mixture was centrifuged. The absorbance at 500nm was measured using UV-Vis Spectrophotometer (DU-64 spectrophotometer, Beckman, USA).The phytate concentration was calculated from the difference between the absorbance of the controlled (3ml of water + 1ml of wade reagent) and that of assayed sample. The concentration was calculated using phytic acid standard curve and result was expressed as phytic acid in mg/100gm fresh weight.

$$Phytic\ acid\ in\ \mu g/g = \frac{Abso - Intercept}{Slope * Density * Weight\ of\ sample}$$

3.4.4. Sensory Evaluation of formulated Diets

- **Sensory evaluation of formulated diets using untrained panelist**

Ten (10) table spoonful of each sample was made into paste and poured into 1000 ml of boiling water. This was allowed to cook for 20 minutes. However, for samples diet-1, diet-2 diet-3 diet-4 diet-5 and FAFFA as control.

The cooked samples were presented for sensory evaluation by ten students between the ages of 1-7 years aided by their mothers from the SOS children village Addis Ababa. The panelists were babies familiar with weaning diets. The attributes that were looked out for were appearance, aroma, taste, mouth feel, after taste, colour and overall acceptability. The panelists were to assign score to their preference for the various attributes using a seven (7) point hedonic scale with 1 being like extremely and 7 dislike extremely. Mothers were to score based on the reaction, facial expression and general response by children.

3.4.5. Microbial analysis of samples.

- **Preparation of samples for microbial studies**

One sample of 20g each of formulated diets were packaged in a high density polyethylene (HDPE) and stored in refrigerator for microbial analysis.

- **Preparation of culture media**

The culture media was prepared by suspending 23g nutrient agar into one liter of distilled water. It was then boiled to dissolve completely and sterilized by autoclaving (Midas 36 Prior clave, U.K) at 121ºC for 15 min. It was allowed to cool to a temperature blew 45ºC.

- **Microbial load count**

The pour plate method was used to determine the total count. One gram of each of the two supplementary food formulations was suspended into 9ml of sterile distilled water in a Mac Carney bottles to give 10^1 dilutions. Serial dilutions were made up to 10^3. Each diluents of the samples was plated out in duplicate using the pour plating technique by transferring 1ml from each Mac Carney bottle into 2 different Petri dish and pouring 15ml of the nutrient agar media on each sample as described by Badau *et al*. (2001). Incubation of plates was done in an aerobic for 48 h at 37°C. After incubation period the colonies appearing on the agar plates were counted using a colony counter. The average colony obtained from the countable duplicate plates, were expressed as colony forming unit per gram (Cfu/g).

3.4.6. Experimental design and data analysis

The three food varieties including Faffa (control), namely maize flour, soybean flour, and moringa leave powder were produced in triplicate and evaluated under completely randomized design. The collected data were subjected to analysis of variance (ANOVA) by using SPSS statistical soft ware (SPSS version 15.0, 2006). The mean Values of the quality parameters of the three food varieties were determined using LSD test. Significant differences were defined at $p<0.05$. An ANOVA was performed to evaluate the main effects and interaction of functional properties (bulk density, water holding capacity, oil absorption capacity and viscosity) and proximate composition values (protein, fat and carbohydrates) on formulation type. Super pro designer version 5.1 was employed to draw the equipment layout of weaning food processing plant.

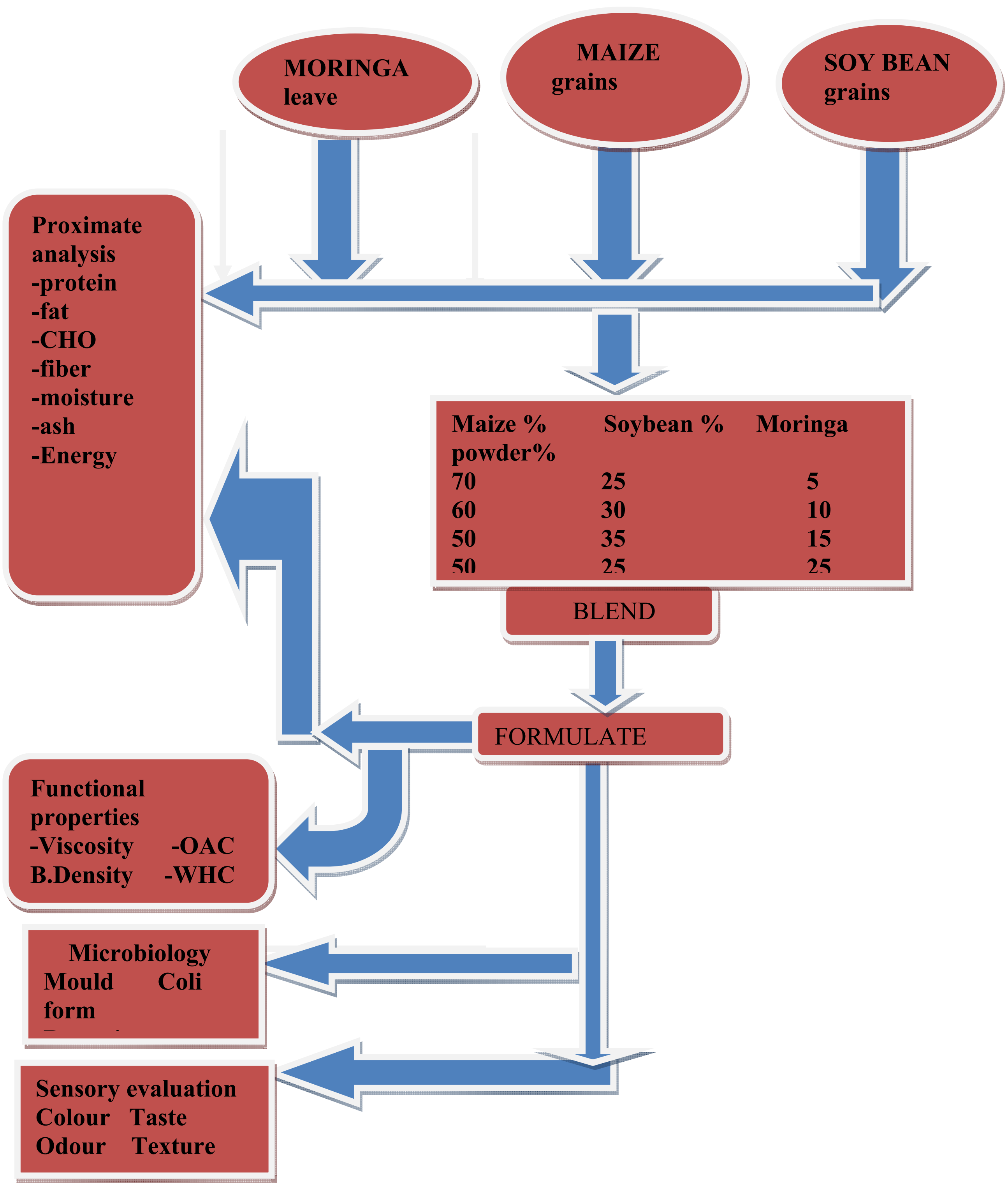

MORINGA leave
MAIZE grains
SOY BEAN grains
Proximate analysis
-protein
-fat
-CHO
-fiber
-moisture
-ash
-Energy
Maize % Soybean % Moringa powder%
70 25 5
60 30 10
50 35 15
50 25 25
BLEND
FORMULATE
Functional properties
-Viscosity -OAC
B.Density -WHC
Microbiology
Mould Coli form
Sensory evaluation
Colour Taste
Odour Texture

Figure 3.7 structure of over all the thesis

4. RESULTS AND DISCUSSION

4.1 Composition of Flour Sample

The supplementary food was developed from different blends of flour of maize and soy bean with moringa leaves powder. The maize flour, soybean flour and moringa leaves powder were analyzed for their proximate composition and mineral contents. The results are presented in Table 4.1.

Table 4.1 Proximate compositions of the raw flour samples

Component	Content of sample		
	Soy bean flour	maize flour	moringa powder
Moisture	6.57 ± 0.03	9.06± 0.04	7.77 ±0.16
Ash %	4.59 ± 0.05	1.40± 0.01	8.32 ±0.21
Fat %	17.46 ± 0.10	4.77 ± 0.01	10.22 ±0.03
C.protein %	39.99 ± 0.06	7.37 ±0.04	28.29 ± 0.05
C.fiber %	10.84 ±0.39	3.59 ±0.09	19.67 ±0.29
Carbohydrate%	31.01. ±0.07	77.41 ±0.48	45.40± 0.50
Iron (mg/100g)	8.72 ±0.26	2.82 0.27	58.64 ±0.68
Zinc(mg/100g)	5.24 ±0.01	2.03 ±0.01	3.12 ± 0.03

Calcium(mg/100g)	226.81 ±0.23	56.86 ± 0.04	1417.74 ± 1.66

Values are means ± SD of three analyses

It is clear from Table 4.1 that the percent protein content of soybean flour, maize and moringa leaves powder was 39.99± 0.06,7.37 ±0.04 and 28.29 ±0.05respectively.

The proximate nutrient compositions of the five processed flour samples were presented in Table 4.1. The results indicated the protein content of maize observed in this study was low compared to the literature value of 10 % Matz (1959). However, that of soybeans and moringa was significantly higher compared with literature value of 38 % and 27% Tindal (1983); Asiedu (1989). Also the slight increased in protein content from the raw sample to flour could be ascribed to the processing techniques such as roasting and milling etc which resulted in the breakdown of lipocytes in soybean to release protein and fat. Not only does the roasting increase these parameters but also inactivated anti nutritional factors in the haul of these crops Ologhobo and Fetuga (1984).Soybean and moringa exhibited higher value of fat/oil content as compared with literature value of 17 % and 5.34%, respectively Dolcas (2008). Amount of fibre was high in soybean compared to literature value of 5 % Kakad *et al. (*1972). Maize gave higher fibre content compared to literature value of 2.2 % Matz (1959); Tindall (1983). Values obtained for flour samples in soy bean showed that the high value ash content of compared to literature 4.49% Asiedu (1989) with maize recording significantly lower value of 1.4 % compared to 2 % reported by Tindal (1983) and Matz (1959).The value of carbohydrate for flour samples showed in tabel4.1was higher compared to literature (Moringa, Maize and Soybean, 38.2,65 and 26, respectively). The decrease in ash content of flour is attributable to the dehulling process and this is very important since some of the anti nutritive factors are deposited in the haul of these crops. Ash content of food samples is an indication of the mineral content in a particular sample.

4.2 Formulation of Supplemented Diets

Figure 4.1 Packed composite flours

4.3 Nutritional Composition of the Supplementary Diets

The proximate composition of the formulated product was determined to ascertain its overall nutritional content, as shown in Table 4.2.

Table 4.2: Proximate composition of supplementary diets on dry based

Component		Formula Diet				
	Diet-1	Diet-2	Diet-3	Diet4	Diet5	Faffa
Moisture%	8.59±0.08	8.29±0.01	8.59±0.06	8.74±0.06	7.03±0.07	6.5
Ash%	2.80±0.01	3.45±0.01	2.80±0.01	5.01±0.27	4.82±0.17	2.6
Fat%	10.94±0.03	12.48±0.07	10.79±0.27	10.8±0.05	18.1±0.05	5.1[a]
C. Protein%	16.31±0.02	20.58±0.11	20.77±0.05	21.04±0.13	33.27±0.05	18[a]
C. Fiber %	2.48±0.26	3.02±0.08	3.26±0.15	2.22±0.05	3.16±0.04	3.16
Carbohydrate %	59.91±0.01	53.06±0.01	52.95±0.01	52.19	33.62	70[a]
Total energy(kcal)	409.14±0.06	406.86±0.121	408.32±0.01	390.12±0.23	429.56±0.10	400[a]
Iron (mg/100g)	7.08	10.17	13,25	18.25	21.34	
Zinc (mg/100g)	2.89	3.10	3.32	3.98	3.32	
Calcium (mg/100g)	167.39	243.93	127.20	297.79	516.10	
Tannin mg/100gm	12.55±0.04	50.52±0.02	BDL	BLD	BLD	- -
Phytate mg/100g	3.10±0.13	7.52±0.01	9.73±0.07	BLD	BLD	-

NB BDL means below detection limit Values are means ±SD of three analyses a is the value of a manufacturer

To investigate that whether there exist a significant difference in these proximate analyses among the diet formulations a one – way ANOVA was conducted.

The proximate nutrient composition of the five formulated diets and proprietary formula (FAFFA food) was presented in Table 4.3. The results indicated that the protein, fiber, moisture and fat values were higher in all the five formulate (except diet-1 for protein) diets than FAFFA food. Energy contents were all comparable to values for FAFFA product. The protein and fat content to the blend were mainly provided by soybean and moringa while the main source of carbohydrate was maize. The results of this project had been shown that soybean in formulated diets is a good nutritional supplement because of its high protein and fat content for infant. In the processing of the soy flour, the beans were not defatted and hence full fat soybean flour was used in this study.

As per recommendation of Food Agricultural organization and World Health Organization FAO/WHO (1998) that vegetable oils be included in foods meant for infants and children, because it provide essential fatty acids like that of n-3 and n-6 Polyunsaturated Fatty Acids (PUF's) needed to ensure proper neural development.

Soybean was also of particular interested as a vegetable protein source because of its cholesterol lowering abilities in patients with type II hyperlipoproteinamia Lovati *et al. (*2000). The major components of the blends were protein; fat and carbohydrate were as minor components are minerals and vitamins as shown table 4.3.

There is a significant difference ($p<0.05$) in protein, fat, and carbohydrate among the three diet formulations. The probable reason for the significant variation in protein among the formulations could be due to the ratio blend of soy bean and moringa flours are higher in Diet5, 4, 3 and Diet-2 in comparison with Diet-1 showed higher protein contents. This could be explained by the inclusion of moringa and soy bean in these four diets. Both food commodities had been recommended for infant feeding Nnam (2002) due to their positive contribution to protein nutrition levels.

The result was an indication that during the processing stage that was where protein was does not denatured because of moderate use of heat and protein is stable at 70 ^{0}C Mensa-Wilmot

(2001).The inclusion of soy bean and moringa increased the level of protein in the formulate diet .The report of Kage et al (2003), Showed that soy bean and moringa contribute good quality protein in terms of essential amino acids. Legume and oil seeds were reported higher in protein of good quality amino acids Robellen (1998). The proximate nutrient composition of the five formulated diets and proprietary formula (FAFFA) were presented in Table 4.3. The results indicated that fat, protein and energy values were higher in the formulated diets than FAFFA. Protein is also higher in diet 5, 4, 3 and 2 than in FAFFA, but energy values in terms of Kcal are slightly higher in all formulated diet except diet 4 in comparison to FAFFA sample.

The comparison result is presented in Table 4.3. The amount of protein of diets 2, 3, 4 and 5 (20.58-20.77g) met the RDA value (20-25g), for infant 6-12 months of age. Diet 1 fell short of the RDA level and also diet 4 and 5 exceed the RDA value. The percentage fat which meet the requirement of RDA all the five formulated diets ranged from 10.79 to 18.1 which met the RDA (10-25g). However, the energy content of all the five diets are (390.12-429.58) blew the RDA. The fat content of a sample blends ranged from 10.79 to 18.1%, but the difference were found significant ($P<0.05$). It's also due to the different number of ratio flour blends of soy bean in the formulate diets. This could be attributed to the inclusion of oil-dense soy beans in the formulate diets. This attribute tends to agree with the recommendations of FAO/WHO (1998) that vegetable oils be included in food meant for infants and children, which will not only increase the energy density, but also be a transport vehicle for fat soluble vitamins. The fatty acid composition of the five formulate diet were not determined, but according to Fernandez (2002), the fatty acid composition of same supplementary food, revealed that the foods were devoid of arachidonic and decosahexanoic acids, but high in linolec and linolenic acids, however, food containing high fat is susceptible to both hydrolytic and oxidative/enzymatic and oxidative/enzymatic rancidity which is responsible for off flavor and this affect both the general acceptability and storage ability of the products. The moisture contents of the products were all below 10% these values are lower enough to allow for good storage if packaged properly. These results compared favorably with the commercial weaning food sold in Ethiopia.

Among the blend ratio of a flour maize, moringa and soy bean (10:3:7) was found most acceptable when compared to the other formulated for a specific age ranged 6 to 12 months. Dite-3 was most acceptable within approximate analysis and functional properties value when compared with the proprietary formula (FAFFA) sold in Ethiopia.

The nutritional composition of Diet-3 as given in table 4.3 exhibited some moderate differences with the FAFFA. The protein of Diet-3 (20.77%) was higher than the FAFFA (18%) the difference was significant (p < o.o5). The protein contents of the formulate diets were high because they used both soy bean and moringa in the production of the formulate diets and these ingredients are higher in protein content.

The results showed that most of the nutrient values were higher in Diet-3 blend than in FAFFA product; again, a dry weight of 65g of the Diet-3 supplementary food of the blend diet was calculated and compared to recommended dietary allowances (RDA) for the same age groups 6 to 12 months Mariam (2005).The comparison result is presented in table-4.3.

Table-4.3. Estimated amount of nutrient /65 g of the sample composite compared with RDA.

Nutrient(g)	RDA * to 1 year amount in 65						
	RDA	Diet-1	Diet-2	Diet-3	Diet-4	Diet-5	FAFFA
	-	-	-	-			
Protein	13-14g	10.6	13.37	13.5	13.67	21.61	11.7
Fat	10-25	7.11	8.12	7.01	7.02	11.76	3.25
	-						
Energy(kcal)	650	266	264	265	253	278	260

Source: Recommended dietary allowance adapted from (*Guthrie, 1990*).

The amount of protein provided by 65g of Diet-2, 3 and 4 ranged from 13.3 to 13.67 which meet the requirement as per RDA (13-14g), for infant up to 1 year age. The protein content in these five diets could be attributed to higher content of ingredients soy bean and moringa. The fat contents in 65g of the formulate diet-5 was 11.76g which is in between RDA (10-25g). The energy content of all the formulate diets ranged from 253-266 Kcal which was below than RDA (650-275kcal).

This short-falls could either be attributed to nutrient loss during processing or the processing method of the formulate diet. According to Sato (2003) it had been proved dehulled soy bean seed have higher fat content than not dehulled to increase the energy content.

FAO /WHO (1998) have also recommended that foods fed to infants and children should be energy-dense once. This, according to the recommendation, was necessary because low energy foods tend to limit total energy intake and the utilization other nutrients as mentioned above. However, the total calculated energy values in 65 g of the five formulated diets fell below the RDA requirement. This suggests that infants may have to consume more quantities of the diets to meet their energy needs, which was often an impossible task of considering the size of their stomach. Therefore, reformulation of the diets may be necessary to increase the carbohydrate content of the diets. In review of above, it is advised to increased energy value of the diet, the carbohydrate in the form of sugar may be incorporated in the formula diet priers to feeding.

Different supplementary food available in Addis Ababa market. It is apparent from the table that no one of the supplementary foods meets the requirement of RDA with respect to energy. In review the above the formulated diets may be used as substitute to replace more expensive proprietary formula products.

4.4 Functional properties

Functional property of weaning food was a very important factor for determination of its acceptability by infants. As a result, this property of the formulated diets was analyzed at laboratory and the results are presented in Table 4.4.

Table 4.4: Functional properties of supplementary diets (Mean ±SD)

Functional properties	Diet-1	Diet-2	Diet-3	Diet-4	Diet-5	Faffa
Bulk density (g/ml)	0.64 ± 0.02	0.57 ± 0.07	0.53 ± 0.01	0.54± 0.21	0.49± 0.08	0.63± 0.01
Water absorption capacity (%)	130.37 ± 0.01	114.37± 0.11	113.36± 0.04	113.4± 0.06	112.02± 0.04	128.77± 0.03
Oil absorption capacity (%)	144.14 ±0.03	136.63 ± 0.43	145.23± 0.03	145.34± 0.61	118.36± 0.80	153.0± 0. 14

Apparent viscosity (20 % W/W)	2612.65 ±0.34	2296.06± 0.27	2248.10±0.01	2239.72 ± 0.21	2190.3± 0.01	2557.07 ± 0.01

Values are means ± SD of three analyse

To investigate that whether there exist a significant difference in these functional properties among the diet formulations a one – way ANOVA was conducted.

There was a significant difference ($p<0.05$) in bulk density, water holding capacity, oil absorption capacity and viscosity among the three diet formulations. The probable reason for the significant variation in bulk density among the formulations attributed may be due to the percent carbohydrate variation in the formulate diets. That indication is high correlated with the high viscosity of a samples food because when the food absorbed more water, it will lead the food to have thick gel that gives the high viscosity of the food Nout and Ngoddy (1997), which was really not good for young babies who are consumers of the Diet -1 than Diet-2,3 ,4 and 5 because the four diets were low bulk density viscosity and water absorption as compared to Diet-1,but this again depends on several molecular properties such as size, shape, flexibility and hydration of the protein. Because solutions of randomly coiled polymers displays greater viscosity and this can be seen in food containing protein and carbohydrate Perez-Conesa (2002).

The probable reason for the significant variation in water absorption among the formulations could be due to carbohydrate contents. This trend was observed in the samples Diet 2 3, 4 and 5 which exhibited low water absorption capacity low carbohydrate content decreased the water absorption capacity of most food systems Dorosko and Rollins (2003).

The probable reason for the significant variation in oil absorption capacity among the formulations could be due to the different contents of crude fat among the formulation diets. The lowest content of crude oil absorbed high amount of oil than the higher content of crude fat product. This observation agreed with the report of Ikujenlola (2004).

Viscosity of the food is one of the most important functional properties of the food acceptability to both mothers and young children. Viscosity is the measure of the resistance to flow. Food is visco-elastic in nature. Weaning food of high viscosity is usually unacceptable to growing infants as it makes feeding difficult and causes suffocation. The probable reason for the significant variation in viscosity among the formulations could be due to carbohydrate content. The Diet-2, 3,4 and 5 gave a better viscosity (< 2250cps) than Diet-1 (2296 cps) (Table 4.5). The consistencies of the blended samples (Diet 2 and 3) were soft and free flowing compared to the high viscosity and thick consistence of Diet -1 and the low viscosity of Diet 2, 3,4and 5 samples was due to low contented of carbohydrate as comparison to Diet-1.FAFFAsample used as control had much higher viscosity (2557cps) comparison to formulated diet which ranged from2239 to 2248cps.

The apparent viscosity of Diet-1was also higher than Diet 2, 3, 4 and 5 and the difference were significant ($p<0.05$). The result of the functional properties of the Diet-1 was in accordance with the value reported by Kulkarni (1991) they studied sorghum malted-based weaning food formulation. The aspect of high viscosity could be corrected by changing the processing to fermenting the raw material or germinate the maize or add œ-amylase to help in the degradation of the carbohydrate to reduce the viscosity as these have been reported in many studies in cereals and legumes combination Simango (1997). The viscosity of a gruel concentration of 20% (W/W) was selected the best as comparison of the other gruel concentrations 10 and 15%, because of high nutritional density and the viscosity of the formulate diets shows good pasting properties as a result were with accepted range which will not stick along the throat of the child while eating it Fashakin (2005).

Some of the functional properties investigated in FAFFA revealed to be higher than of the formulated diet-2,3,4 and 5 but lower than diet-1 with those bulk density, water observation and viscosity and also high oil absorption capacity than the formulate diets because FAFFA product have low fat content. This observation agreed with the report of Ikujenlola (2004).

Consistency and particle size when reconstitutes according to label direction for weaning flour use, dry cereal and legume is a soft, smooth texture of lumps and chewable particle and is suitable for spoon feeding of infants and children (ES-3356, 2007).
Large food particle have a low surface –to-volume ratio and this must be reduce the enzymatic reaction and water absorption and responsible for high viscosity with long time rate of

absorption. The difference in particle size between the coarse and fine flour was analyzed using sieve analysis the particle size selected 250µm to be uniformly blends the sample diet and responsible for functional properties of food samples Farrell (2001)

The weight retained sieve of a give size particle (250µm) after sequential sieving showed in table 4.5.

Table 4.5 Particle size distribution by weight

Mesh size (µm)	Weight (g)
100	10
150	16
250	74

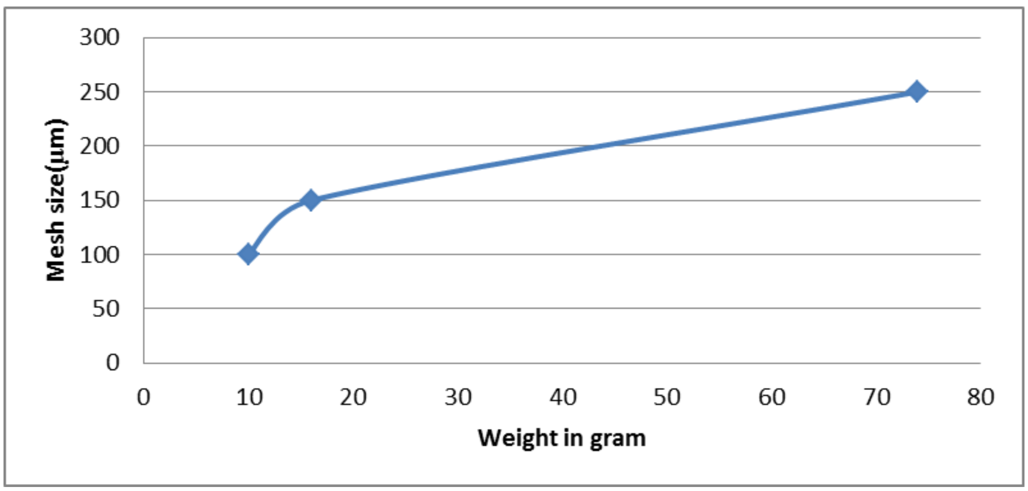


Figure-4.2 Particle size distribution by weight in 250µm particle size

4.5 Anti nutritional content

Plants contain anti nutritional compound such as tannin and phytate, which had been to be removed. Such chemical prevent the action of breakdown of protein objectionably flavor and bitterness. The processed raw material its anti nutritional content showed on table 4.10. The value of tannin and phytate content, on treated and untreated soybean, maize and moringa can be expressed. Tannin content of untreated raw material was found to be from the literature 20mg/g, 673 mg/g and 12.76mg/g for soybean maize and moringa respectively Wada (2002). Soaked dehulled boiled and milling processed were very important to deactivated or reduced the content of anti nutritional factor of soybean, maize and moringa reduced to 0.25mg/g, 0.06mg/g and 4.53 mg/g, respectively. Similar results were reported for soybean seeds soaked in water for 24h and boiled for 30min (Ahmed, 2005). Since most tannin located in the testa, its physical removal reduced tannin content and also tannin content in maize more reduced due to harvesting season was the main reason for this result.

The phytate content of untreated raw materials as predicted in the literature were found to be from the literature 16.70mg/g, 21.00mg/g, and 29.45mg/g for soybean, maize and moringa, respectively Kataria etal. (1989), the processing treatments were reduced phytate content in to 1.99mg/g, 1.48mg/g and 5.51mg/g for soybean maize and moringa respectively. The processing methods soaking, boiling, dehulling and roasting were significantly decreased tannin content by 98.70, 99.12 and 64.58% and phytate content by 88.08, 92.95 and 81.29% for soybean, maize and moringa, respectively. The phytate content of moringa increased during processed the reason it may be the season time harvesting had different concentration of phytate content Naczk et al. (1998).

Table 4.6 Anti nutritional content of un processed and processed flour

Ingredients	Tannin (mg m of D. catchin /g)	Phytate mg of D. catchin/g
Unprocessed soy bean	0.45 – 20	9.20 - 16.70
Processed soy bean	0.26± 0.01	1.99± 0.02
Unprocessed maize	4.73 - 6.73	9.8 - 21
Processed maize	0.6± 0.4	1.48± 0.07
Unprocessed moringa leave	5.19 -12.76	3.10 - 29.46
Processed moringa leave	4.52± 0.02	5.51± 0.03
Diet-1	0.12± 0.04	0.031± 0.13
Diet-2	0.50± 0.02	0.075± 0.01
Diet-3	BDL	0.097± 0.07

BDL means below detectable level **Values are means ± SD of three analyses**

4.6 Water solubility of ash

Ash content of a food stuff present inorganic residue remaining after destruction of organic matter. It may not necessarily be equivalent to the mineral matter as same changes may occur due to same interaction constituents. High ash may in some cases be suggestive of the presence of adulterants, Water insoluble ash is a measure of sand and
other siliceous matter present which should be absent in weaning food recommended for infant.

Table 4.7 Water soluble and insoluble ash (gram)

Formulated diet	Total ash	Blank	In soluble ash	Soluble ash
Diet 1	0.0837±0.08	0.00000903	0.00000888±0.56	0.08369±0.43
Diet 2	0.1023±0.03	0.00000776	0.00000780±1.34	0.10229±0.65
Diet 3	0.0840±0.00	0.00000968	0.00000969±0.32	0.08399±0.03
Diet 4	0.1512± 0.02	0.00000903	0.00000918±0.00	0.15119±0.56
Diet 5	0.1446±0.54	0.00000867	0.00000883±0.97	0.14459±0.08
Control	0.0804±0.43	0.00000827	0.00000834±0.65	0.08039±0.03

Water insolubles of ash in all formulated diets are absent presented in table 4.7. The result indicated the samples do not contaminated or adulterated with sand and siliceous matter, such supplementary food that contain insoluble ash are not allowed for infant feeding Ranganna, (2002).

4.7 Sensory evaluation of formulated diets

4.7.1 Sensory Evaluation using semi trained panelist

Samples Diet 1, 2, 3, 4 and 5 were formulated from maize and soybean flour with moringa powder. Cooked samples Diet 1, 2, 3, 4, 5 were presented for sensory evaluation to ten semi trained panels. The attributes that were looked out for were appearance, flavour, taste, mouth feel, after taste, colour and overall acceptability. The panelists were to assign scores to their preference for the various attributes using a seven (7) point hedonic scale with 1 being like extremely and 7 dislike extremely.

Table, 4.8: Organoleptic results of the formulated diets.

Sample	colour	Flavour	taste	Mouth feel	Acceptability
Diet-1	2 .0±0.02	2.4 ± 0.07	2.1 ± 0.03	2.4 ±0.01	2.28± 0.01
Diet-2	2.1 ± 0.01	2.4 ± 0.04	2.3 ±0.01	2.7 ±0.24	2.32± 0.06
Diet-3	2.3 ±0.01	2.1 ±0.01	2.0 ±0.11	2.6± 0.56	2.38± 0.01
Diet-4	4.5 ± 01	2.3 ±0.04	2.3 ±0.24	2.4 ±0.46	2.87 ± 0.11
Diet-5	5 ± 07	2 .0±0.06	2 .0±0.00	2.3 ±0.41	2.83 ± 0.33
FAFFA	2.0 ±0.01	2.5 ±0.01	2.0 ±0.07	2.3 ±0.8	2.29± 0.03

Values are means ± SD of three analyses

To investigate that whether there exist a significant difference in these sensory evaluations among the three formulated diet and FAFFA product a one – way ANOVA was conducted.

The mean scores from sensory evaluation showed that the formulated samples were like very much. There was no significant difference (p>0.05) between formulated the blends and a control (FAFFA). Sixty six percent of the nursing mothers preferred diet-1, 2, 3 to diet4, 5. The evaluation of the samples by babies, measured by observing their facial expressions to identify signs of like or dislike of the formulations, recorded that 43% of the infants showed high degree of acceptance for the products by delightfully taking the products whereas 14% showed signs of dislike for the product by its colour, 29% of the infants neither liked nor disliked the product by their show of indifference whereas 14% exhibited slight dislike for the products when fed. On the other hand, the 88% of mothers showed acceptance of the products and requested that the products should be made available on the market. They based their desire for the product on its convenience, affordability and nutrient content.

The expression of dislike for the products was because some of the babies were already accustomed to a particular kind of weaning food. It could also be that the time for the sensory evaluation was not favorable since most of the babies might have been fed to satisfaction.

4.8 Microbial Analysis

All the products were analyzed bacteriological for total viable bacterial count, coliform bacteria, yeast and mould. The overall bacteriological status of the product was observed to be satisfactory. A food product for consumption should have microbial count below 1×10^5 cfu/ml. The International Microbiological Standard recommended limit of bacteria contaminants for food of less than 10^6 cfu/g Anon, (1974) whereas Rombouts and Nouts (1995) revealed that bacterial counts obtained in plants food were in the order of 12×10^7 to 10^8 cfu/g. Total bacterial counts of the formulated diets 10^3cfu/g were which is below the acceptable range 10^4 to 10^5cfu/g (ES ISO 4833), however, yeast/mould and coliform counts were found to be absent in all the formulated diets low bacteria counts. In the formulation diets exhibited very high standard of sanitation during performing all the processing steps during processing of weaning foods.

Table 4.9 Microbiological result of the formulated diet

Parameters (Testes)	Method reference	Result
Mold count25^{o}c/5-7 days	NMKL,N0.98,1997	$<1x10^1$ cfu/g
Yeast count at 22^{o}c/5-7 days	NMKL,N0.98, 1997	$< 1x10^3$ cfu/g
APC at 30^{o}c/72hr	NMKL,N0.86, 2006	$<1x10^1$ cfu/g

Coliform count	NMKL,N0.44, 2004	$<1x10^1$ cfu/g
Fecal count	NMKL,N0.125, 2005	$<1x10^1$ cfu/g
E.coli count	NMKL,N0.125, 2005	$<1x10^1$ cfu/g
S. aureus count	NMKL,N0.66, 2003	$<1x10^1$ cfu/g

$< 1x10^1$ means has no coloni

5. Suggested technology for weaning food manufacturing plant

5.1. Weaning food-making procedure

Weaning food were prepared using maize, moringa and soybean flour and other ingredients like sugar, and salt. Weaning food prepared from Ethiopian moringa (Shiferaw), soy bean (Agfat) and maize (BH -540) with various blend ratio. The flour size of used in this study was maintained at 250µm and was obtained by using sieving screen. Individual mixing of the flour samples of weaning food was done and finally its nutritional, textural and sensory characteristics were evaluated. Weaning food produce from FAFA food complex were treated as control. The weaning prepared were powder form with particle size250 µm. Weaning food packaged in LDPE bags of thickness 0.1016 mm and stored in airtight containers for further studies.

5.2. Raw materials

The best formulated diet was diet-3 so it's used for weaning food manufacturing plant

Ingredient	Percentage
Maize ………………………	50%
Moringa…………………	15%
Soybean …………………	35%
Sugar……………………….	9%
Salt ………………………	…0.5%
Vitamins /min……………	0.5%

5.3. Material and energy balance of main unit operation for supplementary

5.3.1 Material and Energy Balance

Material and energy balances are very important in food industry. Material and energy balance are fundamental to the control of processing, particularly for the control of yields of products. The first material balance are determined in the exploratory stage of a new process, improved during pilot plant experiments when the process is being planned and tested , checked out when the plant is commissioned and the refined and maintained as a control instrument as production continues . When any changes occur in the process, the material balances need to be determined again. Material quantities, as they pass through food processing operations, can be described by material balances. Such balances are statements on the conservation of mass. The law of conservation of mass leads to what is called a mass or a material balance.

5.3.1.1 Material balance

It is estimated that, 2160 ton of supplementary food would be processed annually assuming that the factory operates for 300day/year and 24hour per day, Per hour of final product rate is 300 kg of supplementary food.

Preferred formulate for blended supplementary food product.

Maize ……………………….45%

Moringa…………………...13.5%

Soybean ……………………31.5%

Sugar……………………….9%

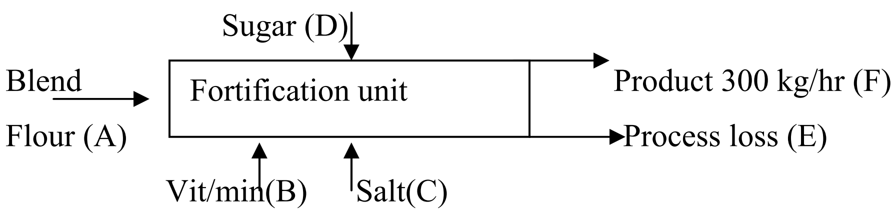
Salt …………………………0.5%

Vitamins ……………………0.5%

Blended flour (90%) = maize (45%) + soy bean (31.5) +moringa (13.5)

The material balance for individual unit operation curried out as follows.

1- Packing and fortification unit



Blended flour +vit /min premix+ salt+sugare= product+ process loss

Assume the process loss= 0.1% of feed material

A+B+C+D = 300kg+0.001(A+B+C+D)

(A+B+C+D)-0.001(A+B+C+D) =300 kg/hr

0.999(A+B+C+D) = 300 kg/hr

A+B+C+D= feed material=300.30/hr

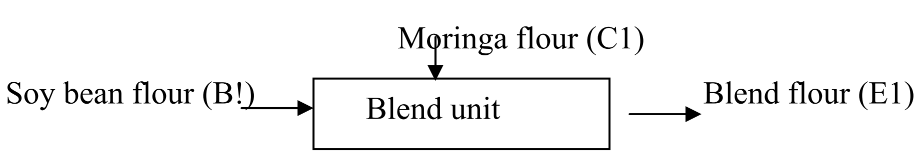
A=blend flours= 0.09(feed material) = 0.90x300.30=270.03kg/hr

B=vit/min= 0.005 (feed material) = 1.5015 kg/hr

C= salt=0.005(feed material) =0.1.5015 kg/hr

D= 0.09(feed material) =27.027kg/hr.

2- Blend units operation



Maize flour (A1) →

Process loss (D1)

The flour moisture 3.23% and also assume process lost 0.5% of feed.

The flour of maize, moringa and soy bean have 8% moisture contents.

Assume process loss = 0.5% of feed materials

Process loss = 0.005* (A1+ B1 +C1)

A1 +B1 +C1= D1 +E1

A1+ B1 +C1 =270.03 + 0.005* (A1 + B1 + C1)

(A1 +B1 + C1)_- 0.005 * (A1+ B1 + C1) =270.03

0.995 * (A1 + B1 + C1) =270.03

A1 + B1 + C1 =271.39

From the stated formulation ratio maize 45% moringa 13.5% and soy bean 31.5%.

The blend ratios are maize, moringa and soy bean 50, 15, and 35% respectively.

Maize flour =0.50* 271.39 =135.69

Moringa flour =0.15 *271.39= 40.72

Soy bean flour =0.35*271.39 =94.99

3- Milling unit

Rousted grain-→ Milling → flour of grain

Assume the process loss is negligible

Mass of roasted=mass of flour grain

Maize roasted= 135.69 kg

Soy bean roasted = 94.99kg

Dry Moringa= 40.72kg

4- Roast unit operations

Clean ingredient → Roasting unit → roasted ingredients

Moisture lose

For grain moisture loss 2.42% of feed

Moisture of feed materials 10.42% and moisture of roasted grain is (8%).

Maize = water lost +roasted maize

Maize grain =2.42 %(Maize grain) + 135.69 kg

Maize grain =0.0242 *(Maize grain) +135.69

0.9758 *(Maize grain) = 135.69

Maize grain = 139.06kg.

For soy bean the clean ingredient =94.99/0.9758kg.

5- Drying unit

Cooked moringa (78% m.c) → Drying → drying moringa

Drying ↓ Moisture loss

The feed material content 78% and its product 7% moisture content

The moisture loss during a process are 78-7% =71%of the feed material.

Cooked moringa = moisture loss +dry moringa

Cooked moringa = 71% (cooked moringa) + 40.72

(1-0.71) cooked moringa = 40.72

0.29(cooked moringa) = 40.72

Cooked moringa =40.72/0.29

Cooked moringa =140.41

Cooked soy bean (15%) → Drying → dry soy bean

Drying ↓ Moisture loss

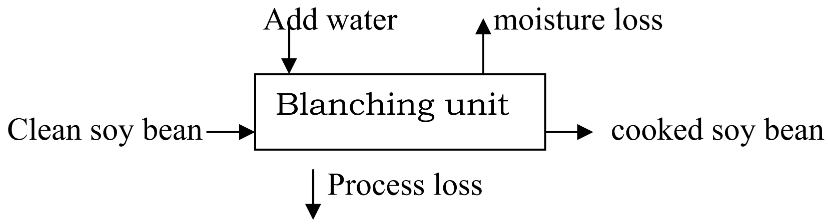
The feed material moisture content is 15% and the product 7%moisture content

Moisture loss= 8% of the feed material

Cooked soy bean= 8% (cooked soy bean) +dry soy bean

Cooked soy bean= 97.3/0.92 = 105.76kg

6 -Blanching unit



Assume process loss = 0.5% of the feed material

The feed moisture content =17.18%

The cooked moisture content = 15%

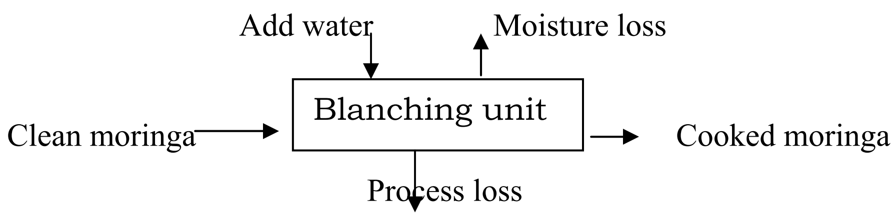
Add water = 20% of the feed material

Clean soy bean + add water = Cooked soy bean + process loss + moisture loss

Clean soy bean + 0.2*(clean soy bean) = 105.76 + 0.005* (clean soy bean) + (0.2+0.1718-0.15)* (clean soy bean)

0.9732 * (clean soy bean) = 105.76

Feed material = clean soy bean = 108.67kg



Assume process loss = 0.5% of the feed material

Moisture loss = add water + moisture feed – cooked moringa

The feed moisture content 80.19%

Cooked moisture content =78%

Add water = 20% of the feed material

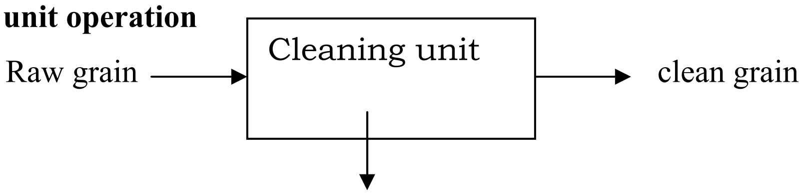
Clean moringa + add water = cooked moringa + process loss + moisture loss

Clean moringa + 0.2 *(clean moringa) = 140.41 + 0.005 *(clean moringa) + (0.2 + 0.8018 – 0.78) * (clean moringa)

0.9732 * (clean moringa) =140.41

Clean moringa = 144.28kg

7- Cleaning unit operation



Impurity

Impurity

Allowable impurity in the raw grain is 6% maximum (ES 419, 2000)

Feed material = impurity + clean grain

Clean grain = (feed material) – 0.06 * (feed material)

Feed material = clean grain/0.94

For maize grain = 139.06/0.94 = 147.94kg

For soy bean grain = 108.06/0.94 = 115.61kg

For moringa leave the impurity assumes 4% maximum

Clean moringa = (feed material) – 0.04 * (feed material)

Raw moringa leave = feed material = clean moringa/0.96 = 150.29kg

For an annual production of supplementary food from maize, moringa and soy bean blend the required quantities of the ingredients are calculated as follow:

Raw maize = 147.94kg/h * 300 days/year * 16h/day = 709.920 ton/year

Raw soy bean = 115.61kg/hr * 300 days/year * 16h/day = 554.928 ton/year

Raw moringa leave = 150.29kg/year * 300 days/year * 16h/day = 721.392 ton/year

5.3.1.2 Energy balance

The first law of thermodynamics (the energy of an isolated system is constant) is useful in conducting an energy balance, the approach is similar to the mass balance mentioned above. The technique of energy balance is useful in the design of processing system that are involved in the processing of heating and cooling so that to ensure the heat exchange is adequately provided.

5.3.1.2.1Electric heat consumption of the unit operation

Cooking, drying and roasting units operation.

Definitions of symbols in electricity house

CP = specific heat capacity, Hfg = latent heat of evaporation

Q = heat

Ms = mass of vapur, Mf = mass of feed, Mp = mass of product

Hfg at 280c = 2435.7KJ/kg, Hfg at 72, ^{0}c 70^{0}c and 60^{0}c are 2330, 2334 and 2358.6KJ/kg respectively.

CP of water 4.2KJ/kg.K

Energy balance on cooking moringa leaves and soy bean unit operation product of temperature for cooking moringa and soy bean are 60 ºC and 72 ºC respectively.

(Hfg) latent heat of evaporation at 72 and 60 ºC are 2330 and2358.6 KJ/kg

QL or assumed to be insignificant due to a well insulated chamber.

Calculating the heat capacity of solid matter of the product and raw materials

$$Cds = \sum cixi$$

Cp (protein) = 20062+1.2089X10-3(60)2= 2.0965

Cf (fat) 1.9842+1.4733X10-3(60) – 4.8008X10-6(60) 2=2.0713

Cc (carbohydrate) 1.5488+1.9625x10-3(60) 0.-5.9399x10-6(60) 2=1.6678

Cfi (fiber) = 1.8459+1.8306X10-3(60)-4.6509x10-6(60) 2=1.9656

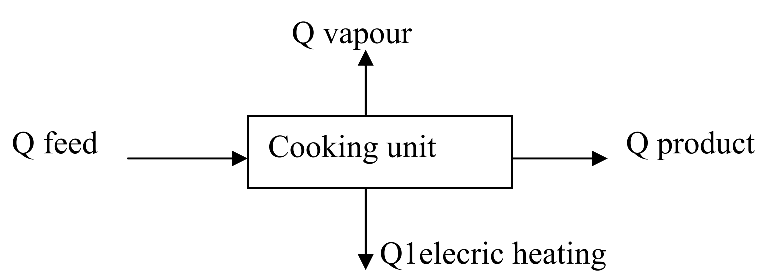
Cash (ash) = 1.0926+1.8896x10-3(60)-3.6817X10-6(60) 2=1.2202

CW (water) $=4.1762-9.0864\times10^{-5}(60)+5.4731\times10^{-6}(60)^{2}=4.2039$

CP moringa =0.27*2.097+0.02*2.0713+0.40*1.66+0.19*1.965+0.74*4.20

= 1.56KJ/kg.K

Total energy balance on cooking of moringa leaves



Mass of feed = 144.28 g /h

Mass of product =140kg/h

Mass of water vapour = 2.88kg/h

T1=28°C

T2 = 60°C

Cdp= 1.56KJ/Kg .k

<u>General</u>

$Q_{feed} + Q_{electric} = Q_{water\ vapor} + Q_{product}$

$Q_{feed} = {}^{m}{}_{feed}\, {}^{C}P_{feed}\,(T_{feed} - T_{ref)}$

$Q_{feed} + Q1 = Q$ water vapour + Q product

$Q_{feed} = M$ feed * CP feed * $(T_1 - T_2)$

= 144.28 * 1.56 * 32

=7202.46 KJ

Q product = Mp * Cp *$(T_p - T_{ref})$

= 140 * 1.5371 *180

= 8607.76KJ

Q of water vapour = Ms *Hfg

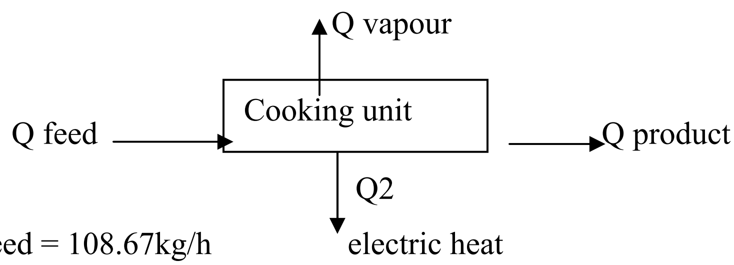
= 2.88 * 2358.6

= 6792.77KJ

Q1 = (Q water vapour + Q product) – Q feed

Q1 = 8198.07KJ

For soy bean cooking unit operation



Mass of feed = 108.67kg/h

Mass of product = 105.76kg/h

Mass of vapour =2.36kg/h

T1 = 28^0c and T2 =72^0c

Q feed + Q2 = Q water vapour + Q product

Q feed = M feed * CP feed * $(T_1 - T_2)$

= 108.67 * 1.78 * 44

=5811.03 KJ

Q product = Mp * Cp *$(T_p - T_{ref})$

= 105.76* 1.80 *148

= 2817.4KJ

Q of water vapour = Ms *Hfg

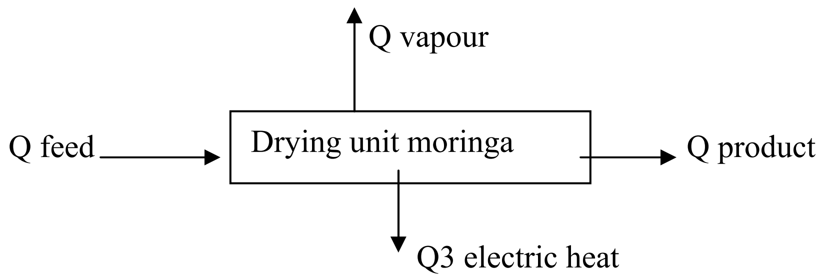
$= 2.88 * 2330$

$= 6719.72KJ$

Q2 = (Q water vapour + Q product) – Q feed

=1026.09KJ.

For soy bean and moringa drying unit operation



Mass of feed = 140.41kg/h

Mass of product = 40.72kg/h

Mass of vapour =99.69kg/hr

T1 = 28^0c and T2 =30^0c

Q feed + Q3= Q water vapour + Q product

Q feed = M feed * CP feed * $(T_1 – T_2)$

$= 140.41 * 1.76 * 2$

$=494.24KJ$

Q product = Mp * Cp *$(T_p – T_{ref})$

$= 40.72* 1.78 *70$

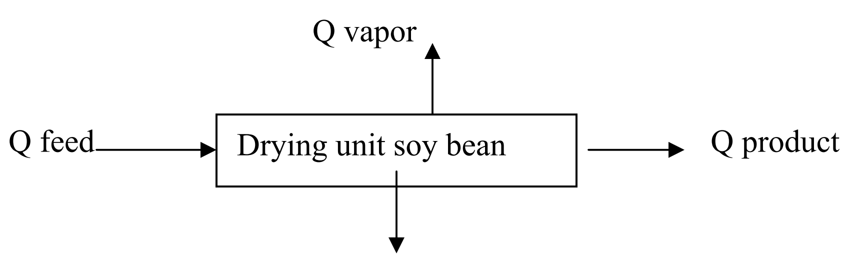
$= 5073.71KJ$

Q of water vapour = Ms *Hfg

$= 99.69*2435.7=24281.4$

Q3 = (Q water vapour + Q product) – Q feed

=28860.96KJ



Q4 electric heat

Mass of feed = 105.76kg/h

Mass of product = 97.3kg/h

Mass of vapour =8.46kg/h

T1 = 28^0c and T2 =60^0c

Q feed + Q4= Q water vapour + Q product

Q feed = M feed * CP feed * ($T_1 – T_2$)

= 105.76 * 1.80* 32

=6091.78KJ

Q product = Mp * Cp *($T_p – T_{ref}$)

= 97.3* 1.46 *40

= 5682.31KJ

Q of water vapour = Ms *Hfg

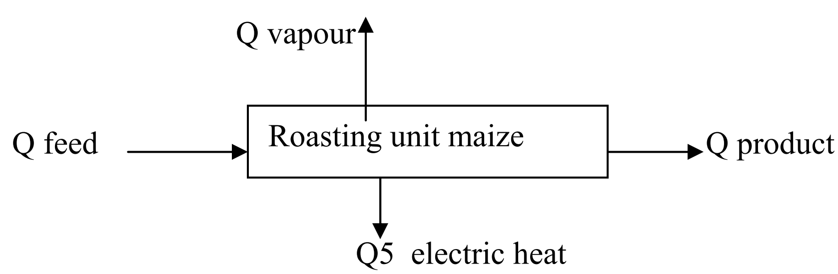
= 8.46*2358.6

=19953.76KJ

Q4 = (Q water vapour + Q product) – Q feed

=19544.3KJ

For soy bean and maize roasting unit operation



Mass of feed = 139.06kg/h

Mass of product = 135.69kg/h

Mass of vapour =3.37kg/h

T1 = 28^0c and T2 =70^0c

Q feed + Q5= Q water vapour + Q product

$Q\ feed = M\ feed * CP\ feed * (T_1 - T_2)$

$= 139.06 * 1.32 * 42$

$= 7709.49 KJ$

$Q\ product = Mp * Cp *(T_p - T_{ref})$

$= 135.69 * 1.33 * 30$

$= 5414.03 KJ$

Q of water vapour = Ms *Hfg

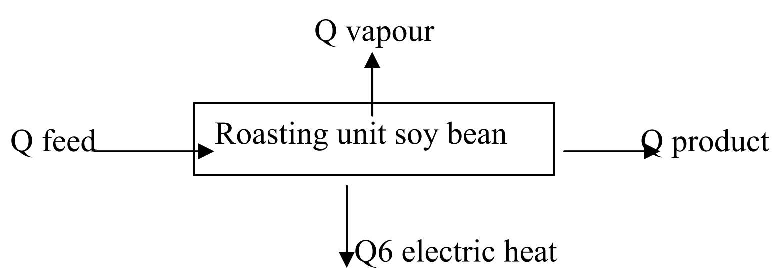
$= 3.37*2334$

$= 7865.58\ KJ$

Q5= (Q water vapour + Q product) – Q feed

=5570.12KJ.

Roasting unit operation for soy bean



Mass of feed = 97.33 kg/h

Mass of product = 94.99 kg/h

Mass of vapour =2.34kg/h

$T1 = 28^0c$ and $T2 = 70^0c$

Q feed + Q6= Q water vapour + Q product

$Q\ feed = M\ feed * CP\ feed * (T_1 - T_2)$

$= 97.33 * 1.80 * 42$

$= 7358.15 KJ$

$Q\ product = Mp * Cp *(T_p - T_{ref})$

$= 94.99 * 1.81 * 30$

= 5157.96KJ

Q of water vapors = Ms *Hfg

= 2.34*2334

=5461.56 KJ

Q6= (Q water vapor + Q product) – Q feed

=3261.37KJ.

- **Water consumption for supplementary food process**
- **Water consumption during washing of raw grain**

It was found that 31.950 L of water is required to make 300 kg of raw grain per hour.

1 hr ________ 300 kg of raw grain

24hr ________ X, where x = weight of raw grain per day

X = 4800kg of raw grain per day

1 day _____ 4400 kg of raw grain

300 day _____ Y, where Y weight of raw grain per annum

Y = 300 x 4800 = 1,440, 000kg of raw grain per annum

From the above material balance of water required during supplementary food production

31.950 L of water ____________ 300 kg

Z ____________ 1, 440, 000, kg

Where Z = the amount of water required for production of cleaned raw grain per .

annum

Z = 153,360 L of water per annum - - - - - - - - - - - - - - - - - - (1)

- **Water consumption during drying ,cooking and roasting in form of steam**

It was found that 120kg of water is vaporized per hour.

1 h________ 120 kg of water vapors

24h ________ X, where x = weight of water vapors per day

X = 2880kg of water per day

1 day _____2880 kg of water vapors

300 day _____ Y, where Y weight of water per annum

Y = 300 x 4800 = 864, 000kg of water per annum

From the above material balance of water required during heat exchange

120 L of water ____________ 120 kg

Z ____________ 864, 000, kg

Where Z = the amount of water required for production of supplementary food per .
annum

Z = 864,000kg water per annum - - - - - - - - - - - - - - - - - - (2)

- **Water required for workers**

According to the studies conducted on sanitary comfort condition in working sites of supplementary food manufacturing, 60 L is established as a minimal water value per day for day each worker however, this figure can be reduced when we consider the situation in developing countries it would not be far from the actual situation if we assumed 40 L per day/ person

40 L* 30 person = $\frac{1200 \text{ L}}{\text{Day}}$ = 360,000 L /annum - - - - - - - - - - - - - - - - (2)

- **Processing plant hygiene**

Water consumption was estimated according to the specification of high pressure water model HD 585 capacity 500 L/h. the water volume is designed for the processing plant washing and sanitization hence for 300 working days of the plant assuming one hour of cleaning per day so the quantity of water required for plant hygiene

300 hr per annum *500L /h = 150,000L /annum - - - - - - - - - - - - - - - - (3)

- Total plant water requirement is the sum of equation 1, 2 and 3

= 153360 + 360,000 + 150,000 L/annum

= 663360 L/annum -(4)

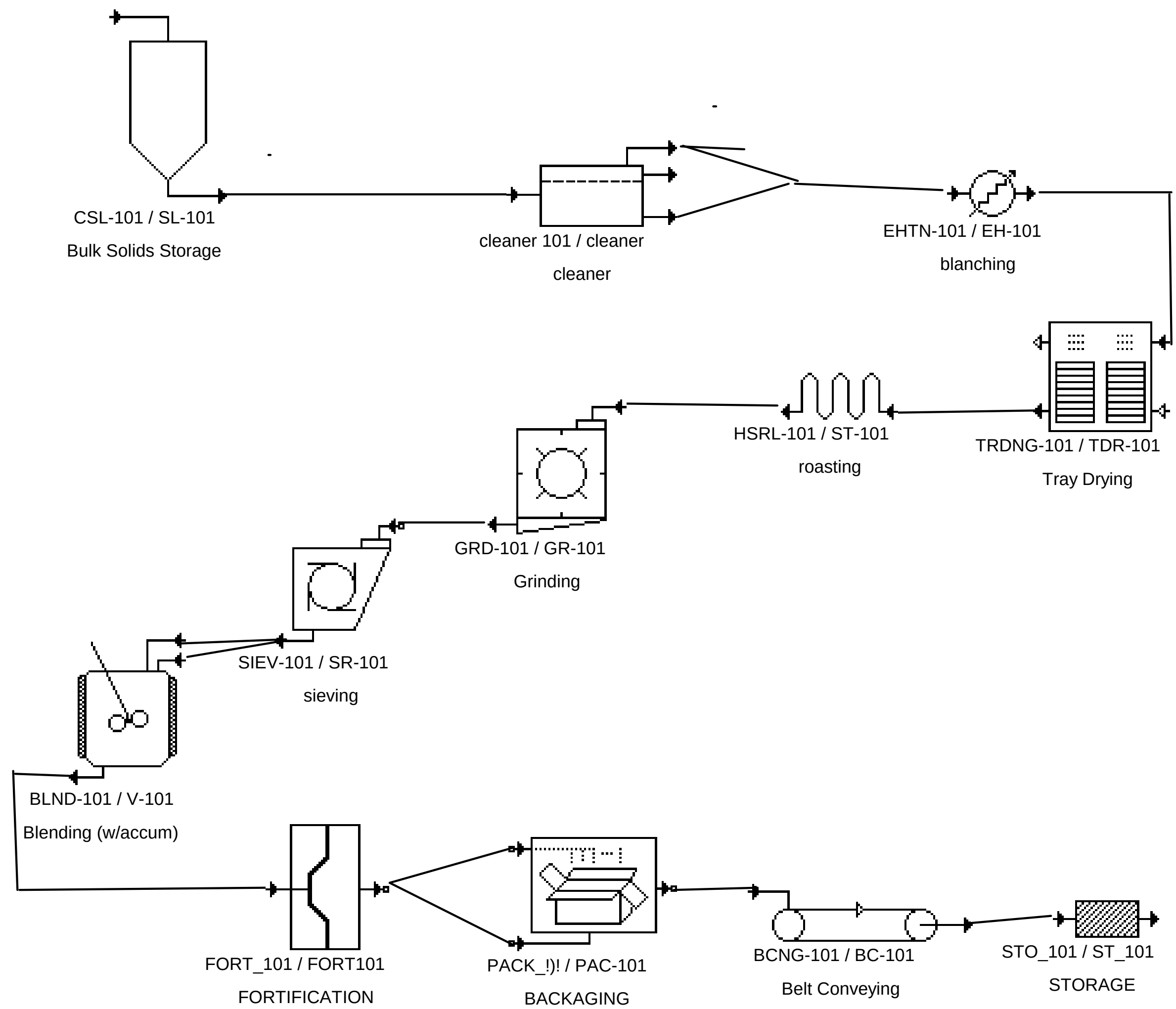


Figure 5.1 Process flow for the manufacturing of weaning food

5.4 Equipment design

Determination of density of the feed materials during milling at 25^{o}c

ρd=∑xi ρi

ρp (protein) = 1.3299x10-3- 5.1840x10-1(25) =1316.94

ρc (carbohydrate= 9.255x10-2-4.1757x10-1(25) =915.15

ρf(fat) = 1.5991x10-3-3.6589x10-1(25) =1591.34

ρfi(fiber) = 1.3115x10-3-3.6589x10-1(25) =1302.35

ρa(ash) = 2.4238x10-3-2.8063x10-1(25) =2416.78

ρm(moisture) = 9.9718x10-2+3.1439x10-3(25)-3.757x10-3(25)=994.91

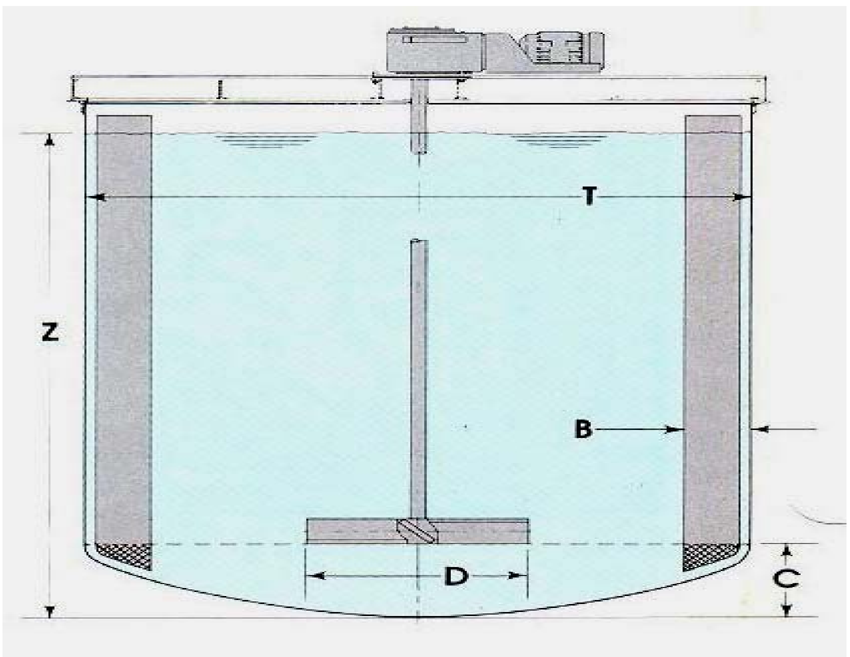
ρd Maize =0.067(ρp) +0.237(ρ)+0.675(ρc)+0.0158ρi)+0.00+(ρa)+0.21(ρw)

= 1387.51 kg/m^3

ρd Soy bean = 1419.67 kg/m^3

ρd Moringa = 675.81kg/m^3

Design of flour blender



Nomenclature

Where:

T = Vessel Diameter **N** = Impeller speed

Z = flour Depth A= Gear Box

D = Impeller Diameter **B**= Baffle width

C = Impeller off Bottom Clearance

✷ **Power theory**

Dimensional Analysis

The dimensionless equation for blender power was derived by the early investigators using dimensional analysis. Considered that impeller power should be a function of the geometry of the impeller and the tank, the properties of the flour (particle size and density) the rotational speed of the impeller and gravitational force. The Buckingham pi theorem gives the following general dimensionless equation for the relationship of the variables.

$$f\left(\frac{D^2 N\rho}{\mu}, \frac{DN^2}{g}, \frac{Pg_c}{\rho N^3 D^5}, \frac{D}{T}, \frac{D}{Z}, \frac{D}{C}, \frac{D}{P}, \frac{D}{W}, \frac{D}{L}, \frac{n^2}{NL}\right) = 0$$

Where D = impeller diameter; C = clearance of impeller off vessel bottom

T = tank diameter; Z = flour depth

W = blade width; N = impeller rotation speed

p = pitch of blades; P = power

N = number of blades; g = gravitational acceleration

l = blade length; g_c = Newton's law conversion factor

μ = particle size of flour

ρ = density

Physical significance of dimensionless groups

1. Reynolds number, N_{Re}

By definition $N_{Re} = \frac{\rho * u * L}{\mu}$ -(1)

For blending, the following are the one generally employed

L = D -(2)

V = ND - (3)

Substitution gives

$$N_{Re} = \frac{\rho * ND * D}{\mu} = \frac{D^2 N\rho}{\mu}$$ -(4)

2. Froude number, $N_{Fr} = V^2/Lg$ - (5)

Substitution of Equation (2&3)

$$N_{Fr} = \frac{(ND)^2}{Dg} = \frac{DN^2}{g}$$

3. power number, $N_p = \dfrac{\Delta\rho}{\rho V^2}$ -----------------------------------(6)

In practice the pressure distribution is not known, but in dynamically similar systems it can be shown that Δρ and power are related by

$$\frac{KP}{ND^3} = \Delta\rho \quad \text{------------------------------------- (7)}$$

Making this substitution into the pressure coefficient together with the reference velocity V=ND gives

$$N_p = \frac{\Delta\rho}{PV^2} = \frac{KP/ND^3}{g(ND)^2} = \frac{KP}{\rho N^3 D^5} = \frac{Pg_c}{\rho N^3 D^5} \quad \text{-------------------------(8)}$$

For geometric similarity, this reduces to

$Np = K (N_{Re})^a (N_{Fr})^b$

For a fully baffled tank the exponent b generally equals to zero

⇨ $Np = K (N_{Re})^a$

Table 5.a. Determination of the dimensionless group of impeller

Impeller type	Pitched-blades	turbine
Number of baffles	8	0
N_Q	0.87	0.34

N_P	2.8	0.72
Np/N_Q	3.2	2.3
$N_{Re} \times 10^{-5}$	1.3	1.0

According to works for pitched blade turbine k = 0.44 summary of test conditions heat transfer to jacketed walls with pitched-blade agitators

Table5.b. Determination of the size of impeller

Investigators	Determinations of size						
Impeller	Diam(D,in)		W/D	C/D		Speed N (rpm)	
	12		0.17	0.83		107-240	
Vessel	Diam T(in)		Z/T			Type of bottom	
	30		1			dished	
No of blades	D/T	B/D	Zi/T	Z_L/T	No of baffles	Nre* 10^{-5}	NQ
8	0.51	0.14	0.3	1	8	1.3	0.87

Where D/T = ratio of impeller diameter to vessel diameter

B/D = ratio of blade width to impeller diameter

Zi/T = ratio of axial distance from impeller center to bottom of vessel to vessel diameter

Z_L/T = ratio of flour depth to vessel diameter

$N_Q = 0.42\ ND^2\rho$

- **Design**

During designing of blender most important steps are gathering an information based on physical properties, rheological properties and thermal properties of an ingredient to be blend such as ρ,k, h etc.

The fundamental relations are important include size factors, impeller diameter (D) and tank (vessel diameter (T). it is possible to express the relative power intensity (II_2/II_1) as a function of scale D_2/D_1 or T_2/T_1.

From the geometric similarity, the following information are obtained

$$\frac{T_1}{D_1}=\frac{T_2}{D_2},\frac{W_1}{D_1}=\frac{W_2}{D_2},\frac{Z_1}{D_1}=\frac{Z_2}{D_2},\frac{C_1}{D_1}=\frac{C_2}{D_2},\frac{B_1}{D_1}=\frac{B_2}{D_2},etc$$

From dynamic and kinematics similarity

$N_{Re1} = N_{Re2}$, $N_{Fr1} = N_{Fr2}$, $N_{p1} = N_{p2}$, $Q_1 = Q_2$

Important data for designing

- blending time /retention time θ = 30 minutes
- weight of blend flour = 300.30 kg/hr
- density of blend flour = 143 kg/ m_3

Taking retention time θ = 30 minutes

Since $\theta=\frac{V}{Q}$

= <u>total volume of tank</u>

Flour flow rate

And $Q=\frac{m}{\rho}=\frac{300.30kg/hr}{143kg/m^3}=2.1m^3/hr$

$= 35000\ cm^3/min$

⇨ V = Q*θ

= 35000*30

$= 105 \times 10^4\ cm^3$

Since $V\cong\frac{\pi}{4}T^3$

$$T = \sqrt[3]{\frac{4}{\pi}*V} = \sqrt[3]{\frac{4}{\pi}*1050000}$$

$T = 110.65cm$

By Geometric similarity

$D = 0.51 * 110.65 = 56.43$ cm

$B = 0.14 * 110.65 = 15.49$cm

$W = 0.17 * 56.43 = 9.59$cm

$C = 0.83 * 56.43 = 46.84$ cm

$Z_d = T = 110.65$cm (flour height)

$Z_i = 0.5*110.65 = 55.33$ cm

Total tank height $= H = \frac{T}{0.6} = \frac{110.65}{0.6} = 184.42cm = 1.84m$

Speed $N = 74$rpm

$N_Q = 0.87$

$N_p = 2.8$

$N_{Re} = 1.3 \times 10^{-5}$

Type of bottom = dished

Baffles – flat baffles type

$$Bafflewidth = \frac{T}{12} = \frac{110.65}{12} = 9.22cm$$

- **Design of impeller**

Impeller blade design

$$T_Q = \frac{PE_d}{N} \qquad (1)$$

Where T_Q = Torque

P = horse power output of the drive motor

E_d = gear reducer efficiency

N = rotational speed in rpm

If the hub radius (R_h) is small compared to the impeller radius, then $\check{R} \approx 0.75R$

Where R is the effective point of application of the torque on the impeller

From elementary mechanics

$$S = \frac{MC}{I} \text{ -- (2)}$$

Where, S = allowable working stress for the blade metal in psi

M = bending moment in lb.r

$\frac{I}{C}$ = section modulus for the blade cross- section in in^3

Since the greatest bending moment occurs at the point where the blade is attached to the hub, the required section modulus at this point is

$$\frac{I}{C} = \frac{M}{S} = \frac{F(R - R_h)}{S} = \frac{PE_d}{nSN}\left(1 - \frac{4R_h}{3R}\right) \text{ ----------------- (3)}$$

Where, n is the number of blades on the impeller

If the blades are flat plates

$$\frac{I}{C} = \frac{D_w D_t^{\,2}}{6} \text{ ------------------------------------ (4)}$$

Where D_w = blade width in inch (vertical projected height for pitched turbines);

Dt = blade thickness,in

By substation

$$D_t = \sqrt{\frac{6PE_d}{nSND_w}}\left(1 - \frac{4R_h}{3R}\right) \text{ ---------- (5)}$$

Note: - S < endurance limit and S < yield point

For the impeller arrangement shown in above the maximum tension,

$$F_b = \frac{F * X}{Y} \text{ ---------------------------------- (6)}$$

$$F = \frac{T_o}{R} \text{ ---------------------------------- (7)}$$

For the above equation

P_{sh} (shaft + power) = Np* D^5 N^3 ρ*n

= 2.8* $(1.38)^5$ $(74/60)^3$ (143)*8

= 57401.34 w = 57.4 kW

Considering P_{sh} = Pmotor* E_d and substituting in equ (1)

$$T_Q = \frac{P_{sh}}{N} = \frac{57.4kw}{240/60} = 14.35KN/m$$

$$R = \frac{D}{2} = \frac{0.56}{2} = 0.28m$$

From equation (5)

$$D_t = \sqrt{\frac{6P_{sh}}{nSND_w}\left(1 - \frac{4R_h}{3R}\right)}$$, for $R_h << R$

$$D_t = \sqrt{\frac{6P_{sh}}{nSND_w}}$$

$$D_t = \sqrt{\frac{6*57.4*10^3}{8*(240/60)*130*10^6*Sin45*23.5*10^{-2}}}$$

D_t = 2.74 x 10^{-2} m = 17.86 mm

- **Shaft design**

The combined shear stress, S_s due to torque and bending in the shaft can be calculated from the formula.

$$S_s = \left(\frac{C}{J}\right)\sqrt{M^2 + T_Q^2}$$

By substituting $\frac{\pi D_s^3}{16}$ *for* $\frac{J}{C}$ and re-arranging

$$D_s = 1.72\sqrt[6]{\frac{M^2 + T_Q^2}{S_s^2}}$$

Where, M = combined total maximum bending moment at the lower .
support bearing for a cantilever shaft

J/C = shaft section modulus in torsion

D_s = shaft diameter, in

S_s = allowable shear stress, psi

For vertical shaft with symmetrical arrangement of impeller blades, baffles and vessel walls

M =0 and for design $S_s = \frac{S}{2} = \frac{130}{2} = 65N/mm^2$

$$D_s = 1.72\sqrt[6]{\frac{T_Q^{\ 2}}{S_s^{\ 2}}}$$

$$= 1.72\sqrt[3]{\frac{T_Q}{S_s}}$$

$$= 1.72\sqrt[3]{\frac{14.35KN/m}{65N/mm^2}}$$ = 0.11m (110mm)

- **Impeller Hub design**

The bending moment in the hub, due to the blades are greatest at the juncture of blade and hub, and reach as high as one–half of the bending moment in the blade it self. It is possible, therefore, to calculate one of the limiting values for hub thickness from equation 5 by using a stress concentration factor of 1.35 and adding the key way depth, R_x

$R_H – R_S = 0.68\ D_t + R_K$ -(8)

The minimum hub thickness, $(R_h – R_s)$, for torque transmission can be calculated from equation

$$\frac{J}{C} = \frac{T_Q}{S} = \frac{\pi\left(R_h^{\ 4} - R_s^{\ 4}\right)}{2R_h} \text{ - (9)}$$

By combining with Eq (1) and incorporating concentration factor f

$$R_h - R_s \cong \sqrt[3]{\frac{2fT_Q}{\pi S} + R_s^{\ 3}} - R_s = \sqrt[3]{\frac{2fPE_d}{\pi NS} + R_s^{\ 3}} - R_s$$

Taking $R_k = \frac{1}{5}\left(R_h - R_s\right)$

From equation (8)

$R_H – R_S = 0.68\ D_t + 0.2\ (R_H – R_S)$

⇨ $R_H - R_s = \frac{0.68}{0.8}D_t = 0.85 * 17.86 = 15.18mm$

Since $R_s = \frac{D_s}{2} = \frac{110}{2} = 55mm$

$R_H = R_s + 15.18$

=55 + 15.18

= 70.18 mm

And $R_k = \frac{1}{5}(R_H - R_s)$

= 0.2*(70.18 – 55)

= 3.04 mm

- **Mechanical design of vessel**

Vessel material stainless steel

From power number $N_p = \frac{\Delta P}{\rho V^2} = \frac{\Delta P}{\rho (ND)^2}$

⇨ $\Delta P = \rho (ND)^2 N_p$

$$= 143\left(\frac{240}{60} * 0.0564\right)^2 * 2.8$$

= 20.38 N/m^2

Volume occupied by the flour

$\frac{\pi}{4}T^3$ = 105 x 10^4 cm^3

Mass of flour in the tank at any time

= V* ρ = 105 x 10^4 cm^3* 143 kg/m^3

= 150.15 kg

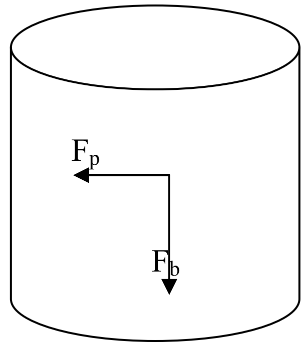
Force due to gravity on the bottom part of the tank

F_b = 150.15* 9.81

= 1471.47 N

Pressure due to mass on the bottom part

$$P_b = \frac{F_b}{A_b} = \frac{1471.47}{\frac{\pi}{4}T^2} = \frac{1471.47N}{\frac{\pi}{4} * 1.11^2} = 183.87 N/m^2$$



Primary stresses

1. The longitudinal and circumferential stresses due to pressure (internal ≅P) given by

$$\delta_h = \frac{PD_i}{2t}, \delta_L = \frac{PD_i}{4t}$$

2. The direct stress δ_w due to weight of the vessel,

$$\delta_w = \frac{W}{\pi(D_i + t)t}$$

Taking the critical point failure possibly be occurred and

$\delta_L = \delta_W$ = allowable stress

$\delta_W = S = 130\ N/mm^2 = \dfrac{1471.47N}{\pi(1012.47 + t)t}$

⇨ $t^2 + 1012.47t - 4.5 = 0$

$$t = \frac{-1012.47 \pm \sqrt{(1012.47)^2 - 4*1*(-4.5)}}{2}$$

⇨ t is very small

For any vessel diameter have a thickness mm (including corrosion allowance)

Taking minimum applicable wall thickness, hence: wall thickness t =6mm

Milling unit operation size selection

- for maize – feed mass = 135.69 kg/h

  Density =1387.51

  Volume= 0.097 m^3/h

For specific retention time (45min) = 0.456-> 0.5m^3 cab be selected

- for soy bean– feed mass 94.99 kg/h

  Density 1419.67 kg/m3

  Volume = 0.87m3/h

For specific retention (45 min) = 0.8 7-> 0.9m3 can be selected

- for moringa leave mass 40.72kg /h

  Density = 675.81 kg/m^3

  Volume = 0.60 m^3/h

For specific retention time (4min) 0.45=> 0.5m^3 can be selected

5.4.2 Financial analysis

5.4.2.1 Building, equipment and manpower requirements

Plant parameters

Capacity tons per year	2160
Number of shifts /day	2
Working days/year	300
Land area/ covered, m^2	1000

✷ **Machinery and equipment**

If the cost of a piece of equipment or plant of size or capacity q_1 is C_1, then the cost of a similar piece of equipment or plant of size or capacity q_2 can be calculated from

$$C_2 = C_1(q_2/q_1)^n$$

Where the value of the exponent *n* depends on the type of equipment or plant.

Table 5.1 Total plant and machinery cost costs

SN	Item	Quantity	Unit price (birr)	Total price (birr)
1	Mill machine	3	100,012.00	300,036.00
2	Universal,blender-300.350kg capacity	1	66,700	66,700.00
3	Silo	3	60,000	240,000.00
4	Cooling conveyor-size 10m	1	6947.58	6947.58
5	Oven	1	12,033	12,033.00
6	Water tank (10000 liter)	1	8,160	8,160.00
7	Water tank (15000 liter)	1	10,280	10,280.00
8	Water tank (6000 liter)	1	6,098	6,098.00
9	Weighing scale	1	27,589.49	27,589.49
10	Delivery vehicle	1	300,000	300,000.00
11	Contingencies on Equipment	10 %		97784.4
	Total			1,075,628.5

- **Building requirements**

Several structures are required for different purposes like production area, packaging area, laboratories, stores, etc. The total area required for these structures is 1000 m^2 and from the current construction costs in Addis Ababa an average of 2000 birr per m^2 of the area for the buildings.

SN	Building	Total area (m^2)	Unit price Birr/m^2	Total Price(Birr)
1	Raw material storage (5*25)	125	2,000	250,000.00
2	Working space(8*25)	500	2,000	1,000,000.00
3	Office(5*20)	100	2,000	200,000.00
4	Laboratory(15*5)	75	2,000	150,000.00
5	Final product storage (5*25)	125	2,000	250,000.00

6	Other common facilities like cafeteria, bath etc(15*5)	75	2,000	150,000.00
7	Contingencies on Building	10%		200,000.00
		1000		**2,200,000.00**

Table5.2 Building requirement

- **Manpower requirement**

Table 5.3 Human resource requirement

SN	Particulars	Required No	Gross monthly salary (birr)	Total monthly salary (birr)	Gross yearly salary (Birr)
1	Manager	1	4,000	4,000	48,000.00
2	Skilled worker	2	2,000	4,000	48,000.00
3	Weighing of ingredients	2	400	800	9,600.00
4	Semi – skilled worker	5	1,300	1300	15,600.00
5	Production supervisor	2	2500	5000	60,000.00
	Total	**12**			**181,200.00**

- **Cost of raw materials**

Table5.4. Cost of raw material

Particulars	Quantity per annum	Unit price	Total cost(birr)
Raw maize (Kg)	709,920	4	2,839,680
Soy bean (Kg)	554,428	7	3,880,996
Moringa leave	721,392	2	1,442,784

Sugar	12,969	14	181,566
Salt	7200	2.50	18,000
Water	663,360	0.00315birr/liter	2056.9
Total			8,052,689.9

- **Cost of utility**

Table 5.6.Cost of utilities

Particulars	**Quantity per annum**	**Unit price**	**Total cost (Birr)**
Electricity (Kwh)	467,469	0.4993	133,407.27
Water	864,000	0.00315birr/liter	2,678.4
Packaging materials	2,160,000	0.02/kg	55,039.19
Total			191,124.86

5.4.3 Cost estimation

- **Fixed capital cost estimation**

Table 5.4 Fixed capital cost estimation

Item		Description/factor	Total cost, birr
I. Direct cost	A. Material + labor	Estimated	8,052,689.9
	a. Equipment	,, ,,	1,075,628.5
	b.Installation	0.35*1,075,628.5	376469.99
	c. Instrumentation	0.10*1,075,628.5	1,075,62.85
	d. Piping	0.3*1,075,628.5	322,688.55
	e. Electrical	0.25*1,075,628.5	268,907.13
	B. Building + auxiliary	Direct estimated	2,200,000
	C. Service facilities	0.4*1,075,628.5	430,251.4
	D. Land	0.06*1,075,628.5	64,537.7
	Total direct cost	**A + B + C +D**	13,441,140.03
II Indirect cost	A. Engineering &supervision	0.1*13,441,140.03	1,344,114.00
	B. Construction + Contractor fee	0.1*1344144	1,344,114.00
	C. Contingency	0.06*1344144	672,057.4
	Total indirect cost	A + B + C	3,360,285
III. Fixed capital investment		**Direct + Indirect cost**	16,801,425.71
IV. Working capital		16,801,245.71*0.15	2,520,213.75
V. Total capital investment		**III + IV**	19,321,638.75

✷ **Estimation of total product cost**

Table 5.5 Estimation of total product cost

Item		Description/factor	Total cost, birr
	A. Fixed Charges		
	a. Depreciation	0.1*mach + 0.02 *buil.	151,562.85
	b. Local taxes	0.02*FCI	434,169.81
	c. Insurance	0.006*FCI	130,250.94

I.Manufacturing cost	**Total of A**		**715,983.61**
	B. Direct production cost		
	Total product cost (tpc)	Total fixed charg/0.15	107397.54
	a. Raw material	Already estimated	12,852,689.9
	b. Utilities	,, ,,	191,124.86
	c.Operating labor (ol)	0.1*tpc	477322.47
	d. Supervisory	0.1*ol	47732.25
	e. Maintenance	0.05*FCI	1,085,424.54
	f. Lab charges	0.12*ol	57,278.70
	Total of B		**14,818,970.27**
	C. Plant overheads	**0.1*tpc**	**477322.47**
	Total manufacturing cost	**A + B + C**	**16,012,276.38**
Π.General Expenses	a. Administrative cost	0.05*tpc	238,661.20
	b. Distribution	0.1*tpc	477322.47
	c. R & D	0.05*tpc	238,661.20
	d. Interest	0.05*tpc	238,661.20
	Total general expenses		**1,193306.07**
Total product cost		**I + Π**	**17,205,582.45**
Total product cost/kg of supplementary food		17,205,582.45/2160000=7.96Birr/cost	

- **Gross earnings**

Whole selling price of 1kg of product =18birr

Expecting all produced will be sold

Total income = 18*2160000= 38,880,000.

Gross income = total income – total product cost

= 38,880,000 – 17,205,582.46 = **21,674,417.51birr**

Let the tax rate be 35% (income tax of Ethiopia)

Taxes = 0.35*21,647,417.51birr = **7,586,046.13birr**

Net profit = gross income - tax

= 21,674,417.51 birr – 7,586,046.13 birr

= 14,088,371.38 birr

Rate of return

$$ROI = \frac{net\ \ profit}{total\ capital\ investment} x100 = \frac{14{,}088{,}371.38}{19{,}321{,}638.75} x100 = 70.91\%$$

$$payback\quad period\quad = \frac{FCI}{NP\ +\ Depre} = \frac{16{,}801{,}425.72}{14{,}239{,}934.29 + 151{,}562.85} = 2\,year$$

- **Break even analysis**

Break even point is the point when total annual production cost equals total annual sales. That is the point where profit equals zero. The break even point is determined from the relation:

$$BEP = \frac{TFC}{(Sup - Vcup)} = \frac{TPC - DPC}{(Sup - Vcup)}$$

Where, BEP = Break-even point (units of production)

Vcup = Variable costs per unit of production

Sup = Selling price per unit of production

TPC = Total production cost

DPC = Direct production cost

$$(A) \qquad Vcup = \frac{Direct\ \ production\ cost}{Amount\ of\ \ weaningfood}$$

$$= \frac{14{,}818{,}970.27\ birr/year}{2{,}160{,}000\, kg/year} = 6.86\, birr/kg$$

$$(B) \qquad BEP = \frac{TPC - DPC}{Sup - Vcup}$$

$$= \frac{17{,}205{,}582.45\ birr/year - 14{,}818{,}970.27\ birr/year}{18\ birr/kg - 7.9\ birr/kg} = 540{,}000\ kg/year$$

$$BEP\ (\%) = \frac{540{,}000\ kg/year}{2{,}160{,}000\ kg/year}\, x\, 100 \qquad where, \qquad capacity\ of\ \ the\ \ plant = 2160000\ kg/year$$

$$= 25.81\ \%$$

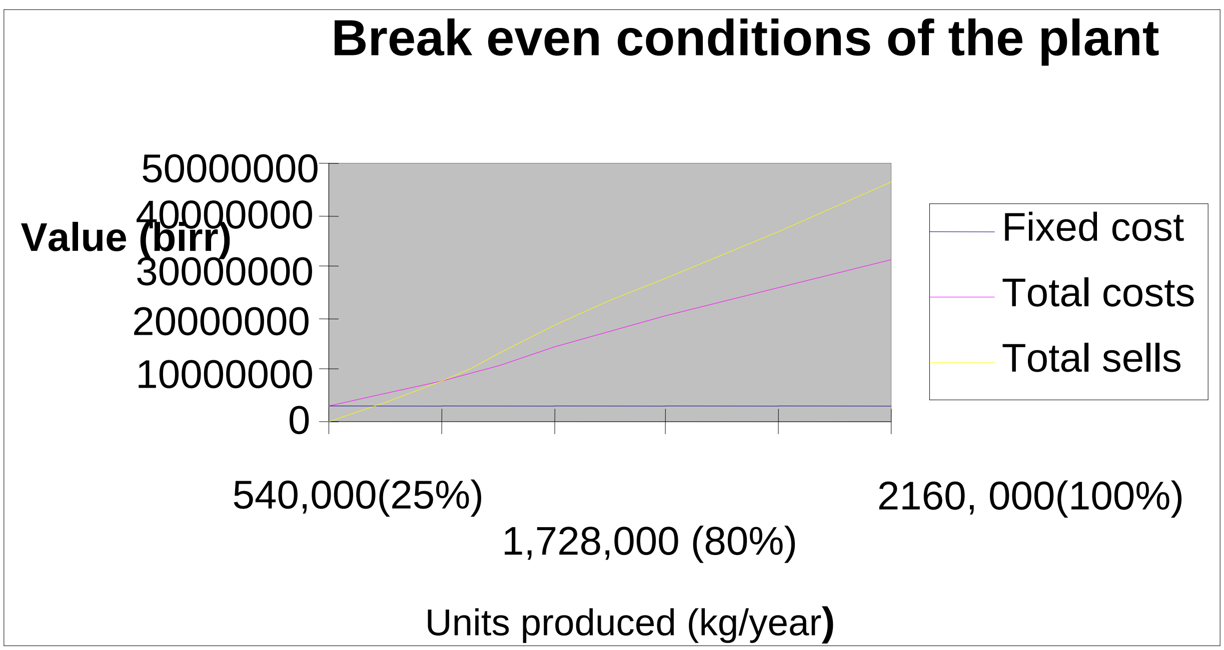


Fig 5.2 Break even graph for the production of supplementary food

♦ **Summary on cost benefit analysis**

For a plant that operates 24h/day, with a processing capacity of 300kg/hr of supplementary food requires. Regarding to profitability, gross earnings will be 21,674,417.51 birr, ROI = 70.91, payback period = 2 year and breakeven point = 25 %

6. CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

This study revealed that ready-to-eat supplementary food products formulated from locally available food commodities, can meet the recommended dietary allowance of the macro nutritional needs of infants and children from 6-12months. The blend powder of moringa with maize and soy bean flour has led to the development of supplementary blends of high nutritive food which will guarantee good and healthy living for infants and the problem of protein - energy malnutrition can be reduced those formulations. The protein content of all diets met or exceeds the recommended dietary allowance (20-33g) for infant 6-12 month; the fat content also met all the formulated diets (10-18g) and also the energy content except diet 4 all diets are met the RDA values. The formulated diets can be used to substitute the more expensive proprietary formula products, the researcher believe that supplementary foods formulated from locally available food commodities, have great potential in this aspect. The results from this study suggest that proper reformulation and fortification of these formulated diets can provide nutritious foods that are suitable not only for weaning, but also as rehabilitation diet to malnourished children that can be more cost effective.

This is believed to be a practical food –based approach aimed at combating the problem of malnutrition among infants and children in Ethiopia and other developing countries.Soybeans and moringa can effectively be used in cereal based weaning foods as an acceptable protein supplements. The process parameters and formulation developed through this study successfully produced a high protein energy weaning food with acceptable functional and sensory characteristic as well as excellent nutritional quality.The five formulated diets (Diet-1 – Diet-5) were organoleptically evaluated and the result showed that the overall acceptability's of all the five diets were almost equal and similar to the control.

The overall bacteriological status of the product was observed most satisfactory. Total bacterial counts of the foods were 1×10^3, which is yeast/ mould, and coliform were found to be absent in the formulated diets. Lower bacterial counts exhibited which is lower than the standard. Chemical, microbial and organoleptical observations suggested that the foods prepared were nutritious and suitable for infants 6-12 month years old.

6.2 RECOMMENDATIONS

During post-natal sessions, mothers should be encouraged to supplement the diet of their children with soybean moringa/flour as the main protein source in weaning food preparation for most part of the weaning period. Fortification with appropriate micronutrient and macronutrient-dense food stuff will be necessary since the diets were found to be low in mineral content such as iron and magnesium for infants between the ages of 6-12 months.

Human dietary interventions should be carried out with weaning children to assess its effect on growth in general since nutrients present in food may not give the expected effect it known to have. Further studies should also be comments to determine the amino acid profile, the anti nutritional factors (if present) in supplemented foods, the essential amino acids profile as well as shelf life studies play a crucial role in maintain a weaning food from food safety point of view.

The department should also have facility to develop food products according to the requirement of the country.

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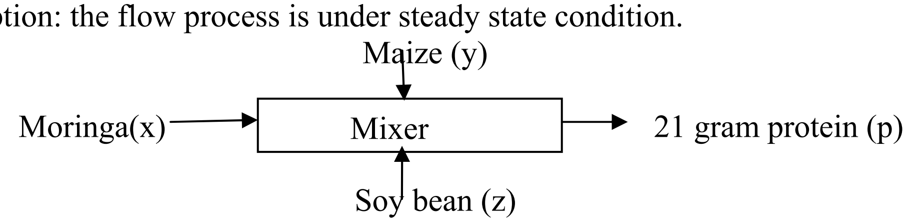
APPENDIX 1

CALCULATION OF % COMPOSITIONS USING MATERIAL BALANCE METHOD FOR DIET 3

Assumption: the flow process is under steady state condition

Assumption: the flow process is under steady state condition.



Let Y= Maize X= Moringa
Z= Soy bean P= Product

Y= 7.3% Protein	382.01 kcal /100g
P =23g protein	403.32 kcal= 100 g
X= 28.3% Protein	386.74 kcal/100g
Z =39.9% Protein	441.22 kcal/100g

X + Y+ Z = P

Total Balance

X + Y + Z= 100 g ……………………………………………. (1)

Component Balance on energy in kcal

0.95y +0.96x +1.09z = 100 gram…………………………… (2)
Component Balance on Protein
0.0737y+ 0.2829x +0.3999Z = 21 ……………………… (3)
From (1) y = 100-z-x ……………………………………… (1)*
Substitute (1)* into (2)
0.95 (100-z-x) + 1.09z + 0.96x = 100g
0.01x + 0.148z = 5………………………………… (4)
Substituted * in to 3
0.0737 (100-(x+z)) +0.399z +0.2829x=21
0.3262z +0.2092 x = 13.63…………… (5)
From equation (4)
X = 500- 14z …………… (6)
Substitute (6) into (5)
0.2092 (500-14z) +0.3262 z= 13.63
2.603z = 90.16
Z=34.66
Substitute z value into (6)
x=500- (14* 34.64)
x=15
Substitute z and x into (*)
y= 100 – (15+ 34.64)
y= 50.34

APPENDIX 2

CALORIC ENERGY CALCULATION FOR DIET - 3

1g Fat = 9 calories energy
1g Carbohydrate = 4 calories energy
1g Protein = 4 calories energy
Protein = 20.77 g
Carbohydrate = 52.9 g
Fat = 10.75 g
1g Fat = 9 calories energy
=> 10.79 g Fat = 10.75 x 9
= 97.11 calories

1 g carbohydrate = 4 calories energy
=> 52.9g carbohydrate = 53.9x 4
= 215.67calories
1g protein = 4 calories energy
=> 20.77 g protein = 20.77x 4
=83.01 calories
Total calories = 408.88
% protein = 19.06

% carbohydrate = 54.47
% fat = 24.53

APPENDIX 3

Questionnaire for sensory evaluation by untrained panelist

Msc Food Engineering Research project, Department of chemical Engineering

SENSORY EVALUATION FORM: ACCEPTABILITY TEST USING UNTRAINED PANALIST

NAME………………………………………………………………

DATE………………………………………………………………

PRODUCT…………………………………………………………

INSTRUCTION

You are provided with six cooked samples A-F. They are samples of a weaning food Formulated from moringa powder and soybeans and maize flour. Evaluate them for the following characteristics: appearance, flavour/aroma, taste, mouth feel, after taste, colour and overall acceptability.

	A	B	C	D
Appearance				
Flavour/Aroma				
Mouth feel				
Colour				
Taste				
Overall acceptability				

Score the samples based on the ff.

1= Like extremely
2= Like very much
3= Like slightly
4= neither like nor dislike
5= Dislike slightly
6= Dislike very much
7= Dislike extremely

Comment ……………………………………………………………………………..
………………………………………………………………………………………
………………………………………………………………………………………

APPENDIX 4

Table 6 **Descriptive analysis of the mean value of proximate analysis one-way ANOVA**

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean: Lower Bound	95% Confidence Interval for Mean: Upper Bound	Minimum	Maximum
protein	1	3	16.3067	.02517	.01453	16.2442	16.3692	16.28	16.33
	2	3	20.5933	.12055	.06960	20.2939	20.8928	20.48	20.72
	3	3	20.9700	.66302	.38280	19.3230	22.6170	20.43	21.71
	4	3	21.0400	.01000	.00577	21.0152	21.0648	21.03	21.05
	5	3	33.2700	.01000	.00577	33.2452	33.2948	33.26	33.28
	6	3	18.0000	.00000	.00000	18.0000	18.0000	18.00	18.00
	Total	18	21.6967	5.62253	1.32524	18.9006	24.4927	16.28	33.28
fat	1	3	10.9400	.43000	.24826	9.8718	12.0082	10.51	11.37
	2	3	12.4867	.08021	.04631	12.2874	12.6859	12.41	12.57
	3	3	10.7933	.33501	.19342	9.9611	11.6256	10.46	11.13

	4	3	10.8000	.04583	.02646	10.6862	10.9138	10.76	10.85
	5	3	18.1000	.01000	.00577	18.0752	18.1248	18.09	18.11
	6	3	5.1000	.00000	.00000	5.1000	5.1000	5.10	5.10
	Total	18	11.3700	3.91601	.92301	9.4226	13.3174	5.10	18.11
CHO	1	3	59.9133	.43501	.25115	58.8327	60.9940	59.48	60.35
	2	3	52.9767	.24583	.14193	52.3660	53.5873	52.70	53.17
	3	3	53.9367	.32501	.18765	53.1293	54.7440	53.61	54.26
	4	3	52.1900	.02646	.01528	52.1243	52.2557	52.17	52.22
	5	3	33.6200	.01732	.01000	33.5770	33.6630	33.60	33.63
	6	3	70.5000	.00000	.00000	70.5000	70.5000	70.50	70.50
	Total	18	53.8561	11.32672	2.66973	48.2235	59.4888	33.60	70.50

APPENDIX 5

Table 7; **Descriptive analysis of the mean value of functional properties one-way ANOV**

Descriptives

						95% Confidence Interval for Mean			
		N	**Mean**	**Std. Deviation**	**Std. Error**	Lower Bound	Upper Bound	**Minimum**	**Maximum**
protein	1	3	16.3067	.02517	.01453	16.2442	16.3692	16.28	16.33
	2	3	20.5933	.12055	.06960	20.2939	20.8928	20.48	20.72
	3	3	20.9700	.66302	.38280	19.3230	22.6170	20.43	21.71
	4	3	21.0400	.01000	.00577	21.0152	21.0648	21.03	21.05
	5	3	33.2700	.01000	.00577	33.2452	33.2948	33.26	33.28
	6	3	18.0000	.00000	.00000	18.0000	18.0000	18.00	18.00
	Total	18	21.6967	5.62253	1.32524	18.9006	24.4927	16.28	33.28
fat	1	3	10.9400	.43000	.24826	9.8718	12.0082	10.51	11.37

	2	3	12.4867	.08021	.04631	12.2874	12.6859	12.41	12.57
	3	3	10.7933	.33501	.19342	9.9611	11.6256	10.46	11.13
	4	3	10.8000	.04583	.02646	10.6862	10.9138	10.76	10.85
	5	3	18.1000	.01000	.00577	18.0752	18.1248	18.09	18.11
	6	3	5.1000	.00000	.00000	5.1000	5.1000	5.10	5.10
	Total	18	11.3700	3.91601	.92301	9.4226	13.3174	5.10	18.11
CHO	1	3	59.9133	.43501	.25115	58.8327	60.9940	59.48	60.35
	2	3	52.9767	.24583	.14193	52.3660	53.5873	52.70	53.17
	3	3	53.9367	.32501	.18765	53.1293	54.7440	53.61	54.26
	4	3	52.1900	.02646	.01528	52.1243	52.2557	52.17	52.22
	5	3	33.6200	.01732	.01000	33.5770	33.6630	33.60	33.63
	6	3	70.5000	.00000	.00000	70.5000	70.5000	70.50	70.50
	Total	18	53.8561	11.32672	2.66973	48.2235	59.4888	33.60	70.50

Declaration

I, the undersigned, declare that this thesis is my original work, has not been presented for a degree in any other University, and that all sources of materials used for the thesis have been duly acknowledged.

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Signature: ______________________________

Place: Addis Ababa

Date of submission: _______________________________

This thesis has been carried out under my supervision and submitted for examination with my approval as University Advisors.

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Signature: ________________________