

**COMPOSITIONAL, PHYSICAL, MICROBIOLOGICAL AND KEEPING  
QUALITY OF FORMULATED DEHULLED TOASTED MAIZE – EGG  
FLOUR WEANING FOOD. ||**

**BY**

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**A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE DEGREE OF  
MASTER OF SCIENCE IN FOOD SCIENCE AND TECHNOLOGY IN THE  
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AGRICULTURE, UNIVERSITY OF NAIROBI.**

**(2,000)**


## DECLARATION

I, Wilberforce Adeli Amugune, hereby declare that this thesis is my original work and has not been presented for a degree in any other university.

signed :  29-10-01

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This thesis has been submitted for examination with our approval as University supervisors.

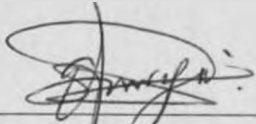
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## **DEDICATION**

**This thesis is dedicated to my wife Scholastic Adeli and our children Eugene Kinyanya, Rebecca Uside and Trevor Undusu; plus my parents Shadrack Adeli and Rosa Adeli.**

**They all endured my absence and greatly encouraged me.**

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## ABSTRACT

Dehulled Toasted Maize – Egg Flour (DTMEF) , a cereal-based food for infants and young children made from dehulled maize, was prepared by a procedure in which millet amylase rich flour (MARF) ( for viscosity reduction) was incorporated to dehulled toasted maize flour (DTMF) - dried whole egg powder (DWEF) porridge at levels of 2-8%, as a means of determining the level at which it could be added to the mixture in the dry form. The objective was to have a final product of lower dietary bulk.

There was no significant difference between the viscosity reduction percentages at 2, 4, 6 and 8 percent MARF level. For economic reasons, a 2% MARF level was chosen. At this rate of usage, viscosities obtained compared well with the recommended range of 1,000-3,000 cP.

Physico-chemical and microbiological properties were determined as an evaluation of the product's quality. It was low in moisture (3.2%), an indication of good storage stability, high in protein (17.9%) and fat (10.3%) with a calcium content of 57.2 mg/100 g and energy content of 423 Kcal/100 g. These results compare well with the Protein Advisory Group (PAG) guidelines for weaning foods which recommend that the protein content should be at least 20% (on a dry weight basis), fat levels up to 10%, moisture 5 to 10%, and total ash not more than 5%. It had a neutral pH (7.1). Its yeast and mould count, expressed as the logarithm to base ten of the colony forming units per gram of sample, was low (3.3) and **Salmonella** was undetected. These results are a good indication that the developed weaning food is likely to supply (to a greater extent) the protein and energy requirements of weaning children if adopted for feeding.



## CHAPTER ONE

### INTRODUCTION

#### 1.1 Background

Cereal-based foods are those intended for feeding infants as a complement to breast milk or infant formula from the age of 4 to 6 months onwards. At this age (and thereafter), breast feeding alone or infant formula is not sufficient to satisfy the nutritional requirements (FAO/WHO, 1998). Such weaning foods are not intended to replace infant formula or breast milk (Walker, 1990). In most countries, the introduction of these foods is recommended when an extra source of energy and other nutrients, such as iron, is required in addition to those present in human milk. Weaning age is dependent on the milk quantity, size and requirement of the infant and other factors, such as health of the mother and baby. A Weaning food is a solid or semi-solid food given to a baby at a time when the mother's milk is being gradually withdrawn. Usually, it contains higher protein and starch contents, being more bulkier compared to humanized baby foods. Public health nutrition programmes often neglect consideration of the quality of weaning foods and their potential importance for a variety of functional outcomes, including their relation to appetite and energy consumption (Brown, 1991). To ensure that weaning foods contain nutrients that meet the recommended dietary allowances (RDA), fortification processes are normally undertaken. Fortification entails the addition of nutrients to foods, where the nutrients being added are not normal components of the foods or are naturally present only in small amounts (Stewart & Amerine, 1982). Supplementation involves the addition of a nutrient-rich food, whereas complementation is done to take care of deficiency or excess of one or more nutrients. A food that is deficient in one nutrient is compensated for by one food, while a deficiency in the latter is compensated for by the former. Presently, employment and increased economic role of women in Kenya are major constraints to breast-feeding. This is coupled by the fact that statutory maternity leave is short. It is not also possible for day nurseries (where they exist) to be near the mothers' place of work. Even if they were available, few, if any, employers would allow mothers time-off

to breast-feed (Dobbing, 1988). Immediate introduction of nutritious weaning foods under such circumstances is of absolute necessity. This is in line with the requirement that at some stage in the development of a baby, such foods, hygienically prepared, are required. Extra considerations aimed at maximising the likelihood that the weaning food will be affordable are of utmost importance. Maintenance of a high level of hygiene is required to ensure production of a high quality product. Even the most hygienic and nutritious weaning foods can be rendered unsafe by exposure to contaminated environments or through handling by persons with poor personal sanitary practices (Hofvander & Underwood, 1987). This should be safeguarded against. Maize, the cereal used in the weaning food formulation, contributes significantly to the traditional dishes of the Kenyan people. As a whole grain, it is mixed with beans to give a dish that is eaten by several tribes in Kenya. The Luhya of western province call it "*amahengere*", the Luo of Nyanza province "*nyoyo*", and the Kikuyu of Central province "*githeri*" (Oniang'o, 1982). From maize flour, "*uji*" and "*ugali*" are similarly prepared. The former is a thin porridge (gruel) of about 10 – 12 % solids, whereas the latter is a stiff porridge of about 60% solids. Both products are popular among Kenyans.

Common diets used for weaning in Kenya are based on the local staple foods, usually a cereal such as maize, millet or sorghum and sometimes roots and tubers like potatoes and cassava. These foods are low in energy and nutrient density. The bio-availability of nutrients is also low. Coupled with infrequent food intake, nutrients become inadequate (Lorri, 1993). Young children remain particularly at risk because they have great energy and nutrient needs, and are vulnerable to infection (Lorri, 1993).

According to the National Development Plan of 1997-2001 (Republic of Kenya, 1997), the area under maize cultivation has stabilized at around 1.4 million hectares. Due to the changes in weather conditions, maize production fluctuates, sometimes leading to serious shortfalls. Production in

1993/94 cropping season was 23.4 million 90 kg bags. This dropped to 17.7 million bags in the 1994/95 cropping season due to poor conditions.

Due to the fact that maize products are popular among Kenyans, one way in which the health of infants and young children can be maintained is through fortification of maize flour (intended for porridge) with protein rich foods, and later using amylases to reduce the dietary bulk. Maize flour is commonly prepared as a liquid gruel, being voluminous with a low energy and nutrient density. Young children cannot consume adequate quantities to cover for their nutrient requirements since they have low capacity stomachs. In this way, their nutritional status is affected (Lorri, 1993). This is what this research work intended to address. Food materials that were used in this respect were maize flour, dried whole egg powder (DWEF) and millet amylase rich flour (MARF).

The formulation and development of nutritious weaning foods from local and readily available raw materials has received a lot of attention in many countries (Annan & Plahar, 1995). The widespread problem of infant malnutrition in the developing world has stimulated efforts in research towards this end. To date, several blends using legumes singly or in combination have been developed. Despite these advantages, the use of dried whole egg has not received much attention. Soybean has been extensively used in this regard, due to its high protein content. Its universal acceptance does not imply that other food materials with desirable attributes some better than soybean cannot be used. An example of such is dried whole egg. It contains 900mg/100g edible portion of retinol whereas soybean contains none. Its riboflavin levels are higher than soybean's (which is also poorly available). It has the highest protein score hence high quality, which guarantees adequate nutrition. Egg is not limiting in cystine and methionine, whereas soybean is. Also, egg has fewer antinutrients than soybean. However, the use of whole dried egg has not received much attention.

It is of utmost importance that the nutrient composition of formulated weaning foods be adapted to local circumstances since these foods are meant to provide such nutrients as are lacking in the basic staple food as defined by the Codex Alimentarius Commission (CAC). Local economic, cultural and social acceptability factors also may influence the proposed composition of the main ingredients (Hofvander & Underwood, 1987). In addition, adjustments to a base formulation to reflect local conditions of use may require additions or deletions of certain vitamins and minerals to ensure that the daily total intake remains within safe limits.

Fortification is generally accomplished in different foods for several reasons. The first is to restore nutrients lost during food processing, a process known as enrichment (Mejia, 1994). In this case, the amount of nutrients added is approximately equal to the natural content in the food before processing. Secondly, nutrients that may not be naturally present in the food, or present in very trace amounts, may be added, a process known as fortification. Here, the amount of nutrients added may be higher than that present before processing. Fortification also standardises the contents of nutrients that show variable concentrations.

Although fortification primarily aims at combating a nutritional problem apparent in a particular target group, it may also have benefits to those outside the immediate target group, depending on the nutrient intake of other groups involved (Simmons, 1990).

In an effort to tackle the serious and widespread problem of malnutrition during the weaning period, and given the inability of lower income groups to purchase high cost commercially marketed infant foods, formulation of such complementary foods from locally available food sources is seen as the most effective way of tackling the problem. Whole egg can make up for the deficits in energy and protein intakes since it is a reference protein. A standard hen's egg contains 436, 362, 320 and 93

mg/gN of lysine, methionine and cystine, threonine and tryptophan respectively. These amino acid patterns are higher than those of FAO/WHO, which are 340, 220, 250, and 60 respectively. Egg when incorporated in a cereal will help to improve protein digestibility, since it has negligible fibre. This is because, protein digestibility of cereals is lower than that of animal protein partly due to the presence of tannins and fibres. Although non-heme iron content of cereal foods is generally high, factors known to stimulate its absorption are meat, poultry products (such as egg), sea foods and various organic acids such as ascorbic. Besides these, the egg yields 160 Kcal energy and has significant amounts of calcium, iron, vit.A, B1, B2, D and nicotinic acid

## **1.2 Problem Statement**

Weaning foods used by many communities in Kenya are low in energy density and nutrient level. Due to this, the energy and nutrient intakes of children undergoing weaning are low, often less than the protein intakes, relative to their recommended levels. The bio-availability of nutrients in cereals (which are abundantly used), is low. Coupled with infrequent food intake, the nutritional inadequacy of the child is further aggravated.

Inadequate nutrient intake interacts in a mutually reinforcing manner with increased levels of infection. A child with inadequate nutrient intake runs a higher risk of contracting infectious diseases due to impaired immunity. In turn a sick child has more difficulties meeting his/her nutrient requirements due to conditions like anorexia, food withdrawal, mal-absorption and nutrient loss.

An early consequence of inadequate intake of specific nutrients may be a reduction in appetite and a consequent decrease in energy consumption.

### 1.3 Justification

Chicken eggs are used for the fortification of cereal flour baked goods such as cakes.

Whereas cereal based weaning foods have not received much attention. In food Processing, eggs have desirable attributes such as foaming capacity, gel formation, water-holding capacity and emulsifying activity. These are likely to improve the functional properties of the weaning food.

Eggs have a high biological value, are nutritious, easy to cook, contain long-chain poly-unsaturated fatty acids, negligible fibre and have significant amounts of calcium, phosphorus, iron, vitamins A, B<sub>1</sub>, B<sub>2</sub> and nicotinic acid and natural vitamin D.

Many rural Kenyan mothers prefer to sell eggs in a bid to buy other food stuffs, often less nutritious than eggs. In Kenya, estimates of prevalence of malnutrition indicate that about 34 percent of children are stunted and 25 percent are underweight (UNICEF, 1999). The food to be developed is likely to help in the alleviation of such problems if used.

The purpose of this thesis was to formulate and determine the composition, physical properties and keeping quality of dehulled toasted maize-egg flour weaning food. More specifically, the study had sort to address the following objectives;

- (1) to determine proximate composition of whole maize flour, dehulled maize flour and dried whole egg flour,
- (2) to determine the levels of millet-amylase rich flour required to give an acceptable viscosity,
- (3) to formulate dehulled toasted maize-egg flour cereal-based weaning food for infants (4-6 months) and determine its proximate composition,
- (4) to determine the calcium content of dehulled toasted maize-egg flour weaning food,
- (5) to determine p<sup>H</sup> of dehulled toasted maize-egg flour weaning food,

- (6) to determine the bulk density of dehulled toasted maize-egg flour weaning food,
- (7) to determine the particle size of dehulled toasted maize-egg flour,
- (8) to determine the extent of rancidity of dehulled toasted maize-egg flour weaning food by accelerated storage through measurement of peroxide values, and
- (9) to determine the microbial load of dehulled toasted maize-egg flour weaning food, specifically total mesophilic aerobic, yeasts and moulds and **Salmonella** counts.

## **1.4 Objectives.**

### **1.4.1 Main Objective**

To formulate and determine the composition, physical properties and keeping quality of Dehulled Toasted Maize-Egg Flour (DTMEF) Weaning Food.

### **1.4.2 Specific Objectives.**

To determine proximate composition of whole maize flour (WMF), dehulled maize flour (DMF), and dried whole egg powder (DWEF).

To determine the levels of millet-amylase rich flour (MARF) required to give an acceptable viscosity.

To formulate DTMEF and determine its proximate composition.

To determine the calcium content of DTMEF.

To determine pH of DTMEF.

To determine bulk density of DTMEF.

To determine particle size of DTMEF.

To determine the extent of rancidity of DTMEF by accelerated storage through measurement of peroxide values

To determine the microbial load of DTMEF specifically total mesophilic aerobic, yeasts and moulds and salmonella counts.



## CHAPTER TWO

### 2.0 LITERATURE REVIEW

#### 2.1 Nutritional Aspects in Weaning Foods Formulation.

##### 2.1.1 Energy Density

The energy content of the main components of weaning foods (Cereals, Pulses and defatted oilseed flours) is low and after reconstitution with water and cooking, the resulting gruel is bulky and voluminous (Hofvander & Underwood, 1987). Such foods are unsuitable for infants and young children, whose stomach capacities are limited. Therefore, they cannot consume such foods in sufficient amounts to adequately meet their energy and nutrient requirements. Thriving in childhood implies a state of positive energy balance, the energy intake in excess of the requirement for maintenance and activity directed/stored for growth (Duggan & Milner, 1986). Young children have high nutrient requirements in relation to their body size, and relatively small stomach capacities.

The amount of food that children can eat per meal is influenced by their ability to chew, and the capacity of their stomachs; both of which increase with age (Lorri, 1993 ). On the other hand, the amount of food that a child actually eats depends on his/her appetite, the consistency and palatability of the food and the patience of the person feeding the child.

The concept of dietary bulk refers to the factors in the food that make it difficult for an individual to consume the food in sufficient amounts to cover his/her energy and nutrient requirements. The energy/nutrient density and the consistency of the diet are the two characteristics identified as dietary bulk factors (Lorri, 1993). Under normal circumstances, a staple cereal food is commonly prepared as

a liquid gruel for young children. A suitable consistency for feeding children would have a large amount of water and thus becomes voluminous, with a low energy and nutrient density. Inherent in weaning foods prepared in this way are factors that directly influence the nutritional status of the child. Special processing techniques of the main ingredients of food aimed at reducing bulkiness includes toasting (roasting), sprouting and malting, extrusion cooking, puffing and enzymatic predigestion (Lorri, 1993).

For a given type of raw material, the chemical and physical changes various cultivars undergo during roasting are similar, though they vary in degree (Svetz & Desrosier, 1979). Roasting is a process of exposing materials to a warming process that is sufficiently fast to drive off the free and bound moisture. With further heating, pyrolysis, or thermal decomposition and chemical change occur. In a short period of time, chemical reactions occur, with an accompanying loss in weight of the material being roasted. The higher the percent loss, the darker the roast colour. The brown colour development occurs during this period of rapid loss in weight. Most of the sugar is altered and most of the swelling (to almost twice the original volume in case of intact grains) also occurs during this period. Roast weight losses occur at two rates. The first is slow (low slope), and is due to evaporation of water from the food material. The second rate (steep slope) is pyrolysis. Roasting dextrinizes starch, which reduces cooking time when the flour is later made into a gruel (Hayes.etal.,1995). Roasting and grinding makes cereals and pulses highly digestible and increases their acceptability by imparting a desirable flavour to the product.

Germination of cereals effects predigestion of the starchy components resulting in reduced bulk and increased energy density. According to Wahed *et al* (1994), the use of amylase-rich flour from germinated wheat liquefied the thick, sticky porridges. The addition of amylase – rich flour reduced viscosity by 98% in rice porridge, 97% in *khichuri*, and 87% in wheat porridge. The reduction in

viscosity is consistent with an increase in amylase content of the seeds from which the gruel has been prepared. This practice allows preparation of gruels with a much higher solid content (Walker, 1990).

### **2.1.2 Protein**

High levels of protein in weaning foods may not be damaging but a significant proportion may not be required for growth and, may be broken down and used as an energy source. This constitutes a waste of resources and results in the production of weaning foods which are too expensive for rural mothers to purchase for their infants (Walker, 1990). From birth through 4 months, proteins account for about 12% of the total weight gain. This same weight gain is achieved during the period of 4 months to 1 year (Packard, 1982).

The protein content of human milk tends to hold quite steady and uninfluenced by the state of nutrition of the mother during the earliest months of lactation (Packard, 1982). Only when the infant is 3-4 months of age, as his/her need for protein increasing with increasing size, does the protein of human milk possibly become limiting if no supplemental supplies are present (Packard, 1982).

The recommended daily allowance (RDA) for proteins by NAS/NRC, unchanged for the 1980 revision of these guidelines, remains 2.2-g/ kg of body weight for infants from birth through 6 months. For infants aged 6-12 months, the RDA is 2.0-g/ kg of body weight.

According to the Codex Alimentarius Commission recommendation (FAO/WHO, 1998), if the weaning food is intended to be mixed with water before consumption, the minimum content of protein shall not be less than 15% on a dry weight basis and the quality of the protein shall not be less than 70% that of casein. However, when the chemical index of the protein is at least equal to 80% that of casein, the minimum protein content shall not be less than 12%.

### **2.1.3 Fibre**

Dietary fibre normally binds water and decreases faecal transit time. It may therefore be beneficial, or its absence deleterious. Its dilution effect reduces the probability of carcinogenic materials coming into contact with the epithelium of the large intestine. Rapid transit time decreases the time available for the production of carcinogenic materials and their contact with the epithelium (Tobin & Muller, 1980)

The binding of water by dietary fibre dilutes the contents of the gastro-intestinal tract and increases faecal bulk. This tends to make defaecation easier. Fibre may also bind cholesterol and bile salts and increase their excretion.

Dietary fibre has therefore an important role in the prevention of gastro-intestinal disorders. Because it is slowly absorbed and fermented by intestinal flora, causing a laxative effect, its content in infant foods should not exceed 5 g per 100 g edible matter (Hofvander & Underwood, 1987).

### **2.1.4 Mineral deficiencies**

Mineral and vitamin deficiencies are estimated to cost some countries the equivalent of more than 5 per cent of their Gross National Productivity (UNICEF, 1998).

During the formulation of cereal-based infant foods, the addition of extra minerals should take into account the following; 1) The mineral content of the ingredients of the food itself. 2.) The local nutrition, and health problems. 3) The relevant national legislation.

Ingestion of calcium, phosphorus and iron at toxic levels in the natural diets is unusual in the age groups for which weaning foods are meant (Hofvander & Underwood, 1987 ). In addition, the absorption efficiency of calcium is regulated by vitamin D.

#### 2.1.4.1 Calcium

Calcium enters the body in food. Some of it is inevitably lost each day in faeces and urine (Mottram, 1985). Urinary calcium excretion is decreased by phosphorus (Spenser, *et al.*, 1986). Increased protein intakes can increase excretion, or loss of calcium, while increased phosphorus intake will increase the re-absorption of calcium, and the body will retain it (Clarkson, 1992). A balance exists in healthy and well fed people between dietary intake and the losses. If bone growth is occurring in childhood or pregnancy, then the intake has to rise to meet these needs as well as the inevitable losses in urine and faeces (Mottram, 1985). During the early years of life, calcium balance is generally positive, except in the case of very restricted intakes (Matkovic & Heaney, 1992). If milk or sweat is being secreted, calcium enters the secretions, and these calcium must be equalled by an increased intake of calcium from the food if the balanced state is to be maintained.

Most diets are inadequate in calcium, hence the practice of calcium supplementation through tablet intake. On a diet containing 1,000 mg of calcium, 200-300 mg may be absorbed and the rest lost in faeces (Mottram, 1985). Once in the body, this enters a pool, in blood and body fluids of some 4-7 grams. This pool is continuously exchanging calcium with the calcium of bones (Mottram, 1985). The urinary loss of calcium is withdrawn from 4-7 gram pool in the blood, as are any losses in sweat or milk. The pool is maintained constant by two mechanisms. One is the action of hormones which control the rate of calcium deposition into and re-absorption from bone. The other is the action of a hormone which controls the rate of calcium absorption from the food in the gut (Mottram, 1985). This hormone is liberated by the kidneys when the blood calcium concentration falls. The hormone is made in two stages by the liver and the kidneys from cholecalciferol..

The main dietary sources of calcium are milk and cheese. Fish is moderately good, especially small fish the bones are eaten (Mottram, 1985).

There are two substances known to precipitate calcium from the food and prevent its absorption. The first is oxalic acid. Oxalates are present in spinach, sorrel and rhubarb. These form small amounts of oxalic acid in the stomach, which, if any soluble calcium salt is present will promptly precipitate as calcium oxalate (Mottram, 1985). The other substance is phytic acid. In plants this is usually present as calcium magnesium inositol hexaphosphate. In the stomach, the highly acid medium splits off the calcium and magnesium, forming their chlorides, but when the food enters the small intestine and the acidity is largely neutralized, then di-calcium phytate (dicalcium inositol hexaphosphate) is formed, which is even more insoluble than the calcium magnesium phytate. Calcium and phosphorus have a reciprocal relationship. High phosphorus content of some foods prevents calcium absorption (Mottram, 1985).

According to the FAO/WHO Codex Alimentarius Commission (CAC) recommendation (1998), the calcium content of cereal-based infant foods shall not be less than 20 mg/100 KJ (80 mg/100 Kcal) for such products as; (1) Simple cereals which are or have to be reconstituted with milk or other appropriate nutritious liquids. (2) Cereals with an added high protein food which are or have to be reconstituted with water or other protein-free liquids. (3) Pasta which are to be used after cooking in boiling water or other appropriate liquids.

Similarly, the calcium content should not be less than 12 mg/100 KJ (50 mg/100 Kcal) for rusks and biscuits with milk added after pulverization. The limited availability of iron, especially in cereal-based diets, makes toxicity of concern only when iron supplements exceed the range of 25-

40 mg daily for older infants and young children. The desired range of daily iron intake is about 10-15 mg (Hofvander & Underwood, 1987).

#### **2.1.4.2 Iron**

Iron deficiency anaemia is one of the most prevalent nutritional deficiencies in the world (Brunser, 1993). It affects approximately 30% of the world's population, increases maternal morbidity, and decreases physical work capacity owing to reduction in oxygen delivery to the tissues (Nakazawa, 1996).

Iron supplementation is widely used to treat and prevent anaemia; however, it has two kinds of side effects. One is parenchymal tissue injury caused by iron overload; the other is a condition termed as re-feeding malaria, in which iron supplementation makes malaria worsen and accelerates anaemia.

Infancy is one of the most susceptible age groups because of the high requirements for growth and a relatively monotonous diet low in bio-available iron. There is agreement among experts that the best long term approach to preventing iron deficiency is food fortification (Stekel, 1988). Milk and cereals are vehicles that have advantages because they are commonly used and well accepted means for infant nutrition. Nutritional iron deficiency appears after the age of 6 months and is undoubtedly linked to inappropriate feeding practice. High bio-availability of iron in weaning foods is of paramount importance in preventing iron deficiency, whether using family foods or commercially available products (Fairweather-Tait, 1992).

### **2.1.4.3 Iodine**

It has long been known that iodine deficiency in women increases the risk of stillbirths and miscarriages. There is some evidence that in highly iodine deficient areas, another result of this deficiency may be increased maternal mortality through severe hypothyroidism (UNICEF).

### **2.1.5 Vitamin deficiencies**

#### **2.1.5.1 Vitamin A**

Annually, 250,000-500,000 pre-school children suffer from preventable blindness because of lack of sufficient dietary vitamin A (Tanumihardjo, 1990). Preformed dietary vitamin A (retinol and retinyl ester) is obtained exclusively from foods of animal origin, and is the predominant form in most vitamin supplements (Ross & Ternus, 1993).

As a public health measure, children who are at high risk have been treated in some countries with large doses of vitamin A. Concurrently, much larger groups of children, generally in less developed countries, also suffer from increased morbidity and mortality even though few show clinical signs of vitamin A deficiency (Tanumihardjo, 1990).

Vitamin A deficiency, which affects about 100 million young children worldwide, was long known to cause blindness. But it has become increasingly clear that even mild vitamin A deficiency also impairs the immune system, reducing childrens' resistance to diarrhoea, which kills 2.2 million children a year, and measles, which kills nearly 1 million annually (UNICEF).



### 2.1.6 Lipids

Human milk-fat and most vegetable oils are well absorbed by infants of up to 6 months of age, whereas butterfat is relatively poorly absorbed (Fomon, 1974). The better absorption of human milk-fat than of butterfat appears to be explained more by triglyceride arrangement of the fatty acids than by percentages of fat accounted for by individual fatty acids. Palmitic acid accounts for a substantial percentage of the weight of total fatty acids of each of these fats but, in butterfat, is nearly equally distributed among the three positions of the triglyceride molecule, whereas the palmitic acid in human milk is primarily esterified in the 2 -position. Also faecal losses of fat are greater in butterfat than milk-fat.

According to the Codex Alimentarius Commission (FAO/WHO, 1998), the lipid content of weaning foods shall not exceed 0.8 g/100 KJ (3.3 g/100 Kcal) for; (1) Simple cereals which are or have to be reconstituted with milk or other appropriate nutritious liquids, (2) Rusks and biscuits, which are to be, used either directly or, after pulverization, with addition of water, milk and other suitable liquids. Also, the lipid content should not exceed 1.1 g/100 kJ (4.5 g/100 Kcal for cereals with an added high protein food which are or have been reconstituted with water or other protein-free liquid. Available weaning foods in Kenya and many other developing countries are based on cereals (maize, sorghum, millet, or rice) and sometimes roots and tubers like potatoes and cassava, respectively. A variety of beans, peas and vegetables are seasonally added to the diet, but rarely any foods of animal origin. The staple food is commonly prepared as a thin gruel for young children. Prepared in this way, such foods are low in energy and nutrient density compared to the standard specifications.

## 2.2 The State of Malnutrition.

In most developing countries, about 50% of all pre-school children are chronically malnourished, and about 7% of these are severely malnourished. According to UNICEF's report on "The state of the world's children 1998", malnutrition is implicated in more than half of all child deaths world-wide - a proportion unmatched by any infectious disease. Millions of its survivors are left crippled, vulnerable to illness and intellectually disabled. Long recognized as a consequence of poverty, malnutrition is increasingly viewed as a cause of poverty (UNICEF, 1998). It imperils women, families, and ultimately, the viability of whole societies; it is a violation of the rights of children. Despite these effects on humanity, the worldwide crisis of malnutrition has stirred little public alarm. This can be evidenced by the fact that the absolute number of malnourished children worldwide has continued to grow. Half of the children of South Asia are malnourished. In Africa, one out of every three children is underweight, and in several countries on the continent, the nutritional status of children is worsening (UNICEF, 1998).

The toll from the effects of malnutrition is alarming. Over 6 million children under five die (representing 55 percent of deaths from preventable causes) in developing countries directly or indirectly from causes attributed to malnutrition. The World Health Organization (WHO) estimates that 51 percent of children under the age of four in developing countries are anaemic (UNICEF, 1998). Once a child has been weaned, there is hardly a proper substitute for the high quality protein found in the mother's milk (Oniang'o, 1982). Due to these, malnourished children rarely develop to their full potential. Studies have shown that alterations occur primarily in brain activity in undernourished children particularly those under four years of age. Children who are treated and recover from *marasmus* and *kwashiorkor* symptomatically retain brains, which do not function to full capacity (Oniang'o, 1982).

Worldwide, 226 million children are stunted, (shorter than they should be for their age) owing to malnutrition (UNICEF, 1998). In Kenya alone, 1.8 million weaning children are stunted. This represents about 30 percent of all weaning children who form close to 20 percent of the total population. A part from this, there hasn't been a decrease in the infant mortality rate. The recently released Kenya Demographic and Health Survey 1998 states that in 20 years Kenya has witnessed an increase in infant mortality rate (Kichamu, 1998). The 300-page report, which was compiled after 6 month of research in 15 Districts, indicates that early childhood mortality has increased by 24 % in the past decade. The infant mortality rate exhibited a slow but steady improvement (decline) from 102(in 1980) to 90 deaths/1000 Live Births (in 1985). Thereafter, the rate began to rise, reaching 100 deaths/1000 Live Births in 1990. The increase became more pronounced during the period between the early and mid-1990s, reaching a record 115 deaths/1000 Live Births.

There is a link between reduced growth in foetal life and in infancy, and higher death rates from ischaemic heart disease (IHD) and higher levels of risk factors for the disease in adult life (Fall, 1992). Since birth-weight and growth in infancy are strongly influenced by environmental factors, researchers suggest that an adverse environment in early life predispose an individual to heart disease in late life. It has also been shown that adult serum cholesterol concentrations and death rates from IHD are related to the method of feeding in infancy and age at weaning.

Malnutrition can take a variety of forms that contribute to each other, such as protein-energy and deficiencies of micronutrients such as iodine, iron and vitamin A.

### **2.2.1 Protein - Energy Malnutrition (PEM).**

Protein has been entwined with energy in the nutritional disease state that has come to be known as PEM (Packard, 1982). PEM describes a complex group of deficiency diseases that particularly affect

children under five years of age and mostly infants in developing countries (Muller & Tobin, 1980). Whilst improved nutrition helps in treatment, prevention may involve general improvements in public health, such as in housing and sanitation, in the economy of the country or region and changes in social attitudes. When protein intake drops to less than 6% of energy intake, poor growth and poor brain development appear likely possibilities. Rarely should this be a problem for healthy infants feeding solely on mothers' milk during the first 3 months of life - even if the mother suffers from moderate under-nourishment (Packard, 1982).

PEM is still widespread in many parts of the world. It is, however, now recognized that energy deficiency is the major problem and that in many countries, protein shortage is less common (Muroki, *et al*, 1997). Since energy spares proteins, its deficiency causes protein deficiency.

*Kwashiorkor* (protein deficiency) and *marasmus* (energy deficit) are the extremes of a spectrum of manifestations of PEM, and young children and infants often show symptoms in between the two (Walker, 1990). It is not usual these days to regard the two diseases as so separate. In the 1960s, *kwashiorkor* was regarded as the predominating manifestation of PEM, and high-protein supplements were promoted through aid programmes in an attempt to bridge the "protein" gap. It is now known that *marasmus* is equally, if not more, common. One basic tenet of the protein gap hypothesis was that the protein requirement of infants was high. On the other hand, low energy intake is critical because lack of energy in the diet jeopardizes the use of protein for growth and maintenance. If the energy intake from other sources is inadequate, then protein is as an energy source and not for its primary function of growth and maintenance (Walker, 1990).

If we improved weaning foods by fortifying them, problems associated with PEM (which are prevalent among infants and pre-school children in most developing countries) would be tackled to a

greater extent. This is because, the supply of nutritious foods such as meat, eggs, milk, and milk products is inadequate, and animal sources of protein and commercially manufactured baby foods are usually too expensive for most families (Akpapunam&Sefa-Dedeh, 1995).

## 2.3 Maize

### 2.3.1 Introduction

Maize is a staple food for large groups of people. It is the second largest cereal grain in the world (Pedersen, et al, 1989). As a food, the whole grain, either mature or immature, may be used; or the maize may be processed by dry milling techniques to give a relatively large number of intermediary products, such as maize grits of different particle size, maize meal, maize flour and flaking grits (FAO, 1992). These materials in turn have a great number of applications in a large variety of foods.

Maize is a warm-season crop requiring warmer growing temperatures than the small grains. It shows little growth at temperatures below 0 C or above 45 C (Pedersen *et al*, 1989). It also requires abundant moisture and is not as well adapted to hot, dry conditions. Nevertheless, maize has proved to be as adaptable and variable as any other crop.

For food use, white maize appears preferable but, in practice, maize that are white, yellow and other colours are used depending upon the country or region (Pedersen et al, 1989). However, hard flinty maize is generally preferred in many areas of the world, and the acceptance of the high-lysine maize opaque-2, which originally has a soft, floury endosperm and improved nutritional value, is poor. The soft maize varieties have poor storage properties, break easily and cannot be efficiently dry milled into grits, flour or meal that contain low oil and pericarp levels (Pedersen et al, 1989). The choice of maize for this study was based on the fact that, it constitutes a major part of the staple diet for the majority of the Kenyan population.

## **2.3.2 Composition of Maize.**

### **2.3.2.1 Starch.**

The maize kernel contains approximately 75 percent starch (Pedersen *et al.* 1989). It is made up of two glucose polymers; amylose, an essentially linear molecule, and amylopectin, a branched form (FAO, 1992). The composition of maize starch is generally controlled.

Compared with other food starches, maize starch is hydrolysed very rapidly by alpha-amylase (Pedersen *et al.* 1989).

### **2.3.2.2 Protein.**

The protein content varies from 8 to 11 percent of the kernel weight, most of it being found in the endosperm (FAO, 1992). The protein is deficient in lysine and tryptophan (Pedersen *et al.* 1989).

Compared with other cereals, the protein score for maize is fairly low. As in other cereal grain proteins, glutamin acid is a major amino acid (AA). In addition, maize protein is characterized by a high content of leucine (Pedersen, *et al.* 1989). However, about 50 percent of protein in endosperm is constituted by zein, which lacks lysine and tryptophan (Pedersen, *et al.* 1989). It is also low in threonine, valine and the sulphur amino acids. The nutritional significance of these deficiencies is that they lower the protein quality of maize

Zein is an alcohol-soluble fraction, usually absent from the immature kernel but whose proportion increases with maturity, and eventually becomes the predominant protein (Kent, 1970). The amino acids found in significant amounts in zein (isoleucine, leucine, phenylalanine, arginine) increase, while those present in smaller amounts (lysine, tryptophan, methionine) decrease, both on a nitrogen and kernel basis, during maturity. In addition, excessive levels of leucine may antagonize the utilization of isoleucine (Pedersen, *et al.* 1989).

The mutant opaque-2 maize has a reduced level of zein, elevated quantities of other fractions, and hence increased level of lysine and tryptophan. Therefore, quality protein opaque-2 maize has a better nutritional quality (Pedersen, et al, 1989).

### **2.3.2.3 Oil and Fatty Acids.**

The maize kernel's oil and fatty acids come from mainly the germ, being genetically controlled, and ranging from 3 to 18 percent (FAO, 1992). The oil in maize contributes about 10-12 percent of the total metabolizable energy provided by maize. Maize oil is highly digestible (93-97 percent), and because maize oil is highly polyunsaturated, it supplies essential fatty acids (Pedersen, *et al.* 1989). It has a low level of saturated fatty acids, thus on average 11 percent palmitic and 2 percent stearic acids. Maize oil is relatively stable, since it contains high levels of natural antioxidants (FAO, 1992).

### **2.3.2.4 Dietary Fibre.**

The dietary fibre of maize kernels comes from the pericarp and the tip cap, although it is also provided by the endosperm cell walls and to a smaller extent the germ cell walls (FAO, 1992).

One by-product of the milling process which has been of particular interest because of its potential as a source of dietary fibre is maize bran (Pedersen, et al, 1989). It has been shown to display high resistance to digestion in the small intestine and colon. When fibre is fermented in the lower intestine by bacterial action, it produces hydrogen, methane and short chain fatty acids (Pedersen, et al, 1989). Maize bran is more effective than wheat bran in decreasing faecal transit time.

Although whole meal is clearly superior to degermed flour (Pedersen, et al, 1989), its dietary fibre content averaging 9 percent is very high. Because dietary fibre is slowly absorbed and fermented by intestinal flora, thus causing a laxative effect, the crude fibre content of a weaning food should not

exceed 5 g per 100 g dry matter according to the CAC's proposed model (Hofvander & Underwood, 1987).

### **2.3.2.5 Minerals.**

The concentration of minerals and trace elements in maize is lower than in other cereals (Pedersen, et al, 1989), the level being about 1.3 percent. The germ is relatively rich in minerals, with an average value of 1.1 percent compared to less than 1 percent in the endosperm (FAO, 1992). The germ provides about 78 percent of the whole kernel minerals. The most abundant mineral is phosphorus, found as phytate of potassium and magnesium. The context of minerals and phytate in maize products is largely determined by the extent to which the germ is retained (Pedersen, *et al*, 1989).

Maize, like other cereal grains, is very low in calcium. The diet of many children consuming maize-based diets after they are weaned tend to be very deficient in calcium, but a calcium deficiency alone has never been proved to cause rickets (Pedersen, et al, 1989).

### **2.3.3 Dehulling and Fortifying Maize.**

It is important to dehull maize in order to lower its dietary bulk from about 9 to less than 5 percent. This helps to avoid the laxative effect (in children) attributed to the slow absorption of fibre since its fermentation by intestinal flora is not fast.

Fortification of dehulled maize is aimed at the improvement of protein quality. Food fortification will continue to be an important tool, not only to treat or prevent specific nutritional deficiencies, but also to promote a general state of well – being in different populations. The identification and development of fortifying agents that will guarantee and high availability are technical and scientific



challenges. Fortified weaning foods introduced to compliment human milk or infant formula should have sufficient protein and energy to cover the infant's nutritional requirements.

Since maize starch is rapidly hydrolysed by alpha – amylase enzyme, great use can be derived from this property in the course of lowering the viscosity of maize gruels through the use of millet – amylase rich flour.

#### **2.4 Hen's Egg.**

The egg is important as a food and food ingredient. It is one of the most nutritious foods we consume and can be prepared in many different ways by itself. A perception of eggs as an unhealthy food may exclude an excellent source of an inexpensive high-quality protein and several vitamins and minerals in the diet (Vorster. *et al*, 1992).

Whole egg is a mixture of the white and yolk in natural proportions. There are 60 parts by weight of liquid white to 40 parts by weight of liquid yolk (Bergquist, 1974).

Egg white is composed almost entirely of water and proteins and this makes it exceptional for an animal tissue (Shenstone, 1968). Water is the major constituent of the egg white (Powrie, 1977). The moisture content decreases from the outer to inner layers. Its total solids content ranges from 11 to 13 percent. Carbohydrates are in the free form and in combination with protein (Powrie, 1977). The amount of free carbohydrates usually present as glucose, is 0.4 percent of the albumen and 0.5 percent is present in glycoproteins which contain mannose and galactose units. Ninety-eight percent of uncombed carbohydrates is glucose and total amount is 0.5 percent. The functional significance of egg white proteins is that the globulins (including lysozyme) will produce foam after whipping air into the mixture, ovomucin has the property of stabilizing the foam after a short whipping time, and the ovalbumin imparts structural rigidity after being heart-

denatured during cooking. Ovalbumin molecules in a solution heated for 1hr at 80°C in the absence of NaCl remain soluble, but they form a transparent gel when heated in the presence of NaCl within a narrow range of concentrations (Ikura, *et al.*, 1992).

The yolk's total solids content is generally about 50 percent and is influenced by the age of the layer. Egg yolk contains about 1.1% mineral elements. The major element is phosphorus, which is mostly found in the proteins and lipids. Calcium and Potassium are the major cations, but calcium, magnesium and iron all seem to be important in the microstructure of the granules (Causeret, *et al.*, 1991). Half of the water in egg is distribute as free water and the rest is bound to three distinct fractions; the water soluble protein, the high density lipoprotein and the low density lipoprotein (Bergquist, 1974). During the storage of shell eggs, water migrates from the albumen to the yolk as well as being lost through the porous surface. "As a consequence, the yolk solids decreases (Powrie, 1977). The major constituents of the solid matter in yolk are proteins and lipids. The former ranges from 15.7 percent, to 16.6 percent, whereas the latter is between 32 and 36 percent. Yolk when used in foods behave essentially as a lipid, but one which is readily dispersed in water and which has the ability to emulsify other materials (Shenstone, 1968). It also imparts desirable flavour, mouth-feel and colour (Bringe, *et al.*, 1996). These properties depend upon the high lipid content (63 percent of the solids), the high proportion of phospholipids (31 percent of total lipid) and the fact that all of the lipid including the triglycerides appears to be associated with at least two of the proteins, vitellin and vitellinin (Shenstone, 1968). Protein - phospholipid complexes (yolk lipovitellenins and lipovitellins) are the components of egg yolk responsible for stabilizing fat droplets in water (Bringe, *et al.*, 1996). Egg yolk emulsifying properties may be retained even if it lacks triacylglycerols and cholesterol. Some important functional properties of eggs are outlined below.

### **2.4.1 Leavening Power.**

This is sometimes called the aerating, foaming or whipping property of eggs. It is the ability of the egg to incorporate air by itself or in a mixture with other ingredients and to hold the aerated structure long enough so that it can be set by heat, drying or other means (Bergquist, 1974). A foam is a colloidal dispersion in which a gas phase is dispersed in a liquid phase (Baldwin, 1977). Foams created by egg white are somewhat different from those created by whole egg and yolk, and are more stable (Bergquist, 1974).

When egg white is beaten (whipped), air bubbles are trapped in the liquid albumen, and a foam is formed (Baldwin, 1977). During the beating of egg white, the air bubbles decrease in size and increase in number, and the translucent albumen takes on an opaque but moist appearance. As increased amounts of air are incorporated, the foam becomes stiff and loses its flow characteristics (Baldwin, 1977). If beating is continued, the foam becomes friable and loses its moist, glossy appearance.

### **2.4.2 Coagulating Properties.**

Coagulation is the change from sol to gel state. It entails changes in the structure of the egg protein molecules resulting in the loss of solubility and thickening, and may be brought about by heat, mechanical means, salts, acids, alkalis, and other reagents such as urea. Proteins that form gels after heating are referred to as thermotropic proteins, e.g. egg albumen and ovalbumin (Hsien and Regenstein, 1992). On heating, the heat-induced conformation of the protein molecules leads to their aggregation into filaments or densely branched clusters, which interact as "sticky" reactive molecules rather than as unfolded random coils. Coagulated protein's have the ability to bind pieces of food together or thicken them.

The success of many cooked foods depends upon irreversible heat coagulation of egg proteins. Both the white and the yolk are utilized because of their ability to coagulate (Baldwin, 1977) The coagulum formed in some mixtures may be so firm (over-coagulated) that it squeezes liquid out and separates into liquid and curd phases. This phenomenon is referred to as syneresis.

All egg white protein fractions are coagulable by heat except ovomucoid. Conalbumin is especially heat - sensitive unless it is complexed with a metal ion such as iron or aluminium (Baldwin, 1972). Most of the proteins of the yolk are subject to heat coagulation, but phosphovitin is not.

### **2.4.3 Emulsifying Properties.**

The egg yolk has excellent emulsifying properties, which are attributed to lecitho-proteins. Egg yolk reacts to mechanical and thermal stress, the former worsening the emulsification process and the latter improving it (Heinzelmann, 1995). Egg yolk is itself an emulsion, a dispersion of oil droplets in a continuous phase of aqueous components (Baldwin, 1977). In addition, the yolk is an efficient emulsifying agent. Drying enhances the emulsifying property of whole eggs (Bergquist, 1974). Emulsifying property of eggs is important wherever eggs are used together with other fats and oils.

The ether - insoluble portion of egg (protein and lipoprotein) is the most important emulsifying substance in whole egg (Baldwin, 1977). Emulsifying capacity of whole egg is unaltered by changes in fatty acid composition of egg yolk accomplished through dietary regimen of the laying hens.

#### **2.4.4 Tenderizing.**

Eggs contribute to smoothness, moistness, and a desirable texture to foods (Bergquist, 1974). One reason for this is that they are known to retard crystallization of sugar. This is accomplished by egg white through the process of "cutting the grain" (Baldwin, 1977).

#### **2.4.5 Nutritive Value.**

Eggs have the highest quality protein and most of the essential vitamins (Bergquist, 1974). The lipids are easily digested, and there are more unsaturated fats than in any other animal product.

The yolk comprises slightly over one-third of the edible portion, but it yields three-fourths of the calories and provides all or most of the fat, iron, vitamin A, thiamine, calcium and almost half of the protein and riboflavin of the whole egg (Cook and Briggs, 1977). Protein and riboflavin are less concentrated in the white, but because there is almost twice as much white as yolk, more than the total protein and riboflavin is in the white.

#### **2.4.6 The Importance of Fortification with Egg.**

Eggs have the highest protein quality; due to this, it can complement the lower protein quality of maize attributed to deficiency in lysine, tryptophan and methionine. Apart from this, eggs have negligible fibre; therefore, its proportion cannot unduly increase the dietary fibre content of the final weaning food. Eggs have easily digestible lipids with more unsaturated. This is likely to combine well with the highly digestible and polyunsaturated oils of maize. This is of utmost importance because finally there will be a high proportion of the much needed essential fatty acids in the cereal – based infant food.

## 2.5 Some Local Weaning Foods in Kenya and other African Countries.

### 2.5.1 Kenya.

In parts of Vihiga and Kakamega districts, very thin plain maize, sorghum or millet porridge (**ovosera**) is given when the baby has just began to reach for food. At times, this porridge is mixed with milk. Sometimes back, this practice used to commence (among certain groups) after birth.

The first solid food given to babies in Meru used to be **tuu tuu**. This was prepared from a special variety of small, sweet banana peeled and roasted in hot ashes. The outer layer was then removed and the banana chewed well by the mother to ensure that it was thoroughly mixed with her saliva. This paste was then introduced into the baby's mouth with the mother's finger. Yams were prepared in a similar way. For slightly older children, **tuu tuu** was prepared in advance and stored in a special calabash fitted with a lid. An almost identical preparation of masticated used to be made by the Kikuyus of Kiambu district.

In Uasin Gishu, the first supplementary food to be given to babies is fermented cow's milk (**mursik**). Milk is fermented in a cleaned gourd, the inside of which is rubbed with a special charcoal prepared from a type of wattle tree wood. The milk is then left to ferment for up to 3 days. Milk that is very sour is not, however, given to babies.

In Mbita, South Nyanza district, dehulled red sorghum used to be considered ideal, being preferred to white sorghum because it gave children less stomach problems. Nowadays, **wimbi** (swahili name for finger millet) is preferred because the passage of stool is easier than in children fed sorghum porridge.

Over the last 30 years or so, maize has become increasingly popular in Kenya as a porridge ingredient for weaning children. It is either used singly or in combination with pulses like soya bean.

In several districts of Kenya, raw hens' eggs are added to porridge. This technique has been widely encouraged by health workers. The addition of a raw egg to very hot porridge is a quick and convenient way of lightly cooking the highly nutritious egg (Oniang'o & Alnick, 1988).

### 2.5.2 Botswana.

Women roast maize or millet meal in a thick black iron pot until it is just brown. They stir it well to stop it from burning, and add a little salt and some sugar. For use, it is stirred into milk or water, and some pounded protein food added. A child's porridge can be made in this way without lighting the fire to boil water every time. This is useful when fuel is scarce (King, *et al.*, 1972).

### 2.5.3 Malawi.

A mixture of maize, beans and groundnuts in the ratio of 2:1:1 called **Likuni phala** (Likuni porridge) is made. The meal is put through a mill twice so that the particles of the meal are very small. This is a rich mixture. The **phala** can be made with more maize, and less beans and groundnuts, if they are scarce. It is this mixture which is used in making porridge (King, *et al.*, 1972).

#### 2.5.4 Zambia.

Groundnuts are fried, then pounded to make a soft oily butter (groundnut butter). In Bemba, it is called **Chinkonko** and in Nyanja **Chimande**. This is added to maize porridge after it has been cooked. Sometimes, pounded fresh groundnuts can be cooked with porridge (King, *et al.* 1972).

#### 2.5.5 Zimbabwe.

Within the first few days after birth (among the Shona), the mother gives the baby **bota**- a thin liquid mixture made of specially ground millet (**rukweza**) which has been carefully sieved. For several days, she adds to this, powdered roots of certain trees which she hopes will prevent abdominal pains or the much dreaded gastroenteritis.

To feed the baby, a small amount of **bota** just sufficient to fill the palm of her left hand is poured into it. She places the side of this hand along the baby's lower lip and with a little gentle pressure, opens its mouth. She then directs the flow of the liquid into the mouth, dividing it gently with the little finger of her right hand. This method of feeding is known as **kuita chisuku** or **kukika mwana**.

This thin millet gruel is given to the baby once or twice a day by the mother as a supplement for the next four or five months and thereafter in increased amounts. Should the mother have plentiful supply of milk, **bota** is only given once a day.

**Bota** is given to the child for as long as it is breastfed. usually upto crawling (**kukambaira**) period. It is gradually made thicker until the mother considers that the baby can eat stiff porridge satisfactorily.



When the baby's teeth appear, he/she is given not only stiff porridge but relish (**muriwo**) with **dowi** (ground monkey nuts). The ground butter is stored in a special pot (**tseme** or **nhembatamba**) and when it needed, the mother takes a little and boils it with some little water. The child is shown how to dip a piece of stiff porridge into the mixture (Gelfand, 1971).

### 2.5.6 Nigeria.

In the northern states, many traditional weaning foods are prepared mainly from cereals and grain legumes, either singly or in combination. Examples are **ogi** or **akamu**, a fermented cereal gruel; **kunun zaki**, a sweet beverage from cereals alone; **mardam**, an overcooked cereal porridge; **kunun tsir**, a beverage made of cow-peas; and **kunun gyada**, a beverage based on groundnuts and cereal.

To prepare **kunun gyada**, groundnuts are partially roasted, skins removed and the resulting nuts ground into a paste. Water is added and the mixture sieved to obtain to obtain groundnut milk. This is boiled prior to addition of reconstituted cereal flour (without grits). The mixture is further boiled for 10-15 minutes, sweetened and flavoured (Nkama, *et al.*, 1995).

### 2.5.7 Benin.

Fermented maize foods are derived from two types of intermediate products, namely **ogi** and **mawe`**.

**Ogi** is a gruel obtained by fermentation of a suspension of wet-milled maize in water. **Ogi** is also known as **akamu** by the Hausa of Nigeria. A similar product is known as **uji** in Kenya and **mahewu** in South Africa. In Benin, when consumed as a liquid porridge, it is referred to as **koko**.

**Mawe`** is a fermented dough. It is suitable as a basis for the preparation of many dishes, including two porridge types, **akluyonu** and **koko** (Hounhouigan, 1994).

## CHAPTER THREE

### 3.0 MATERIALS AND METHODS

#### Preparation of study materials.

Porridge was produced from dehulled toasted maize flour blended with egg flour and millet-amylase rich flour, for weaning infants (4-6 months). Dehulled maize flour was mixed with water, dried at 60° C for 14 hr, before toasting at 105° C for 5min and ultimate storage at -10° C. Finger millet (*Eleusine coracana*), initially purchased when brown in colour, was fermented to a dark brown colour, sundried and threshed, winnowed and stored. It was later cleaned, washed and finally covered to germinate for 48 hr at room temperature (21-23°C). During germination, thorough washing was done after every 24 hr. The germinated grains were again dried at 50° C for 12hr. Dried grain was then ground (both seeds and shoots) to a fine flour (millet-amylase rich flour), packaged and stored at -10° C. Three lots of whole eggs were then pasteurized at 64° C/2.5 min, cooled to 32° C before stabilization by wet yeast. The stabilized eggs were dried at 54° C/24 hr. The egg flakes obtained were cooled to 21-23° C then milled to produce dried whole egg flour (DWEF). The flour was then packaged and stored at 4.2±0.2° C. Finally, nutrient content (protein, crude fat, crude fibre, ash, moisture content and PH) were then determined and total energy values calculated.

#### 3.1.1 Maize.

Hybrid 512 maize variety was obtained from the National Agricultural Research Laboratories (NARL), Nairobi. It was grown on NARL's field plots, following common cultural practices. The maize was harvested on the cobs and sun-dried in this state. It was then threshed, winnowed and

bagged, and kept in the NARL store. At the time of procuring the maize for use, its moisture content as determined by *Dickey John* multigrain portable moisture tester (type 1174-B086) was 11-13%.

Prior to experimentation, the unwanted kernels were picked by hand and then sifted on a 2mm sieve to remove extraneous matter. The grains were divided into two lots. The first was milled to produce maize flour (D.M.F) while the second was milled and processed into the Egg-Fortified Maize Flour (EFMF).

#### **3.1.1.1 Preparation of Whole Maize Flour.**

The first lot was milled to produce whole maize flour (WMF) using a *Ndume ND30* hammer mill. Whole maize flour was screened by metal sieve with 1x1 mm apertures. It was packaged in polyethylene bags and stored at  $-10^{\circ}\text{C}$ .

#### **3.1.1.2 Preparation of Dehulled Maize Flour.**

The second lot was dehulled and milled to produce dehulled maize flour (DMF) using a *Ndume ND30* hammer mill. Dehulled maize flour was screened by metal sieve with 1x1 mm apertures. It was packaged in polyethylene bags and stored at  $-10^{\circ}\text{C}$ .

#### **3.1.1.3 Preparation of Dehulled Toasted Maize Flour.**

A portion of DMF was mixed with water in the ratio of 11:8 (DMF:water) using the kitchen machine (*Lips, Urdorf, Zurich, type C-IRB*). The mixture was transferred to trays and dried in a ventilated Memmert oven drier (*Bremen, F.R of Germany*) at  $60^{\circ}\text{C}$  for 14 hr. The product was lightly toasted at  $105^{\circ}\text{C}$  for 5min. Finally, it was milled using a *Condux* disc attrition mill (type LV 15K, *Wolfgang, Germany*) to produce dehulled toasted maize flour (DTMF). which was packaged in 200 gauge polyethylene bags and stored at  $-10^{\circ}\text{C}$  for use as an ingredient of the weaning food.

### 3.1.2 Millet.

*Nakuru local* variety of finger millet (*Eleusine coracana*) was purchased from Njoro County Council Market, Nakuru district. The finger millet had been harvested when light brown in colour, heaped in a room to ferment in order to attain a dark brown colour. It was sun-dried and threshed, re-dried again, winnowed and stored.

#### 3.1.2.1 Preparation of Millet-Amylase Rich Flour (MARF).

The grains were re-winnowed (Fig. 1), cleaned of extraneous matter and one kilogram portion steeped in an equal volume of cold water for 12 hours at room temperature (21-23°C). The steep water was drained off and the grains washed thoroughly with more water. Excess water was drained off the grains, which were then spread over an area of 0.3 square metres to make a depth of approximately one centimetre, and finally covered by a black cloth and germinated for 48 hours at room temperature (21-23°C).

The grains were washed after every 24 hours during the entire germination period. The germinated grains were thoroughly washed before drying in a *Wilhelm Fessman* cabinet drier type T1200 at 50 °C for 12 hours.

The dried grain (both seeds and shoots) was ground to a fine flour with a *Condux* disc attrition mill (type LV 15K) (Fig.2). The millet amylase rich flour (here in after referred to as MARF) was packaged in 200 gauge polyethylene plastic bags and stored at -10 °C for use as an ingredient of the weaning food and analyses.



Fig. 1 Re-winnowing millet

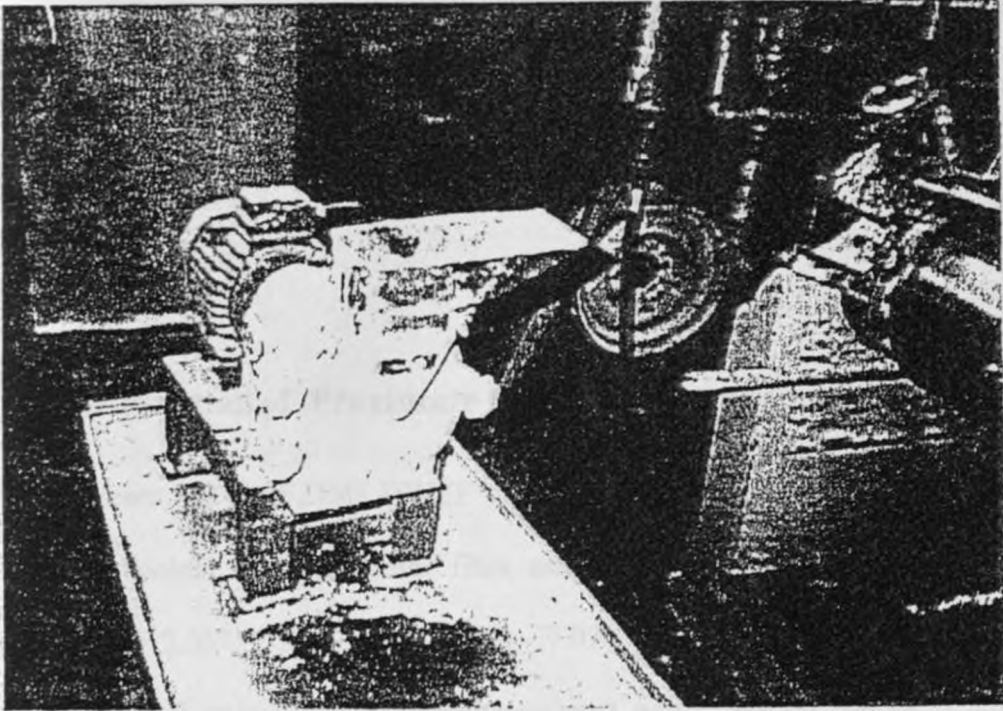


Fig. 2 A Condux Disc Attrition Mill

### **3.1.3 Eggs.**

Hen eggs, produced by a flock of *Issa Brown Egger* were purchased from the Department of Animal Production (University of Nairobi). Three lots of whole egg powder were produced as follows; the eggs were cracked and blended for 5 seconds. The eggs were pasteurized at 64°C./2.5 min, cooled to 32°C before stabilization by wet yeast. The stabilized eggs were dried in a ventilated Memmert oven drier (*Bremen*, F. R of Germany) at 54°C./24 h. The egg flakes obtained were cooled to 21-23 °C then milled using a *Condux* disc attrition mill (type LV15K) to produce dried whole egg powder (DWEF). The powder was packaged in 200 gauge polyethylene bags and stored at 4.2 ± 0.2°C.

## **3.2 Analyses**

### **3.2.1 Determination of Proximate Composition and Energy Content.**

Moisture content of WMF,DMF,DWEF and DTMEF was determined using method 14.004, AOAC 1984. Protein, crude fat, crude fibre, ash content and pH were determined using AOAC methods 2.056 – 2.057, 7.060 – 7.062, 7.066 – 7.070, 14.004 – 14.009 and 14.022 (AOAC, 1984) respectively. Total energy values were calculated using Atwater values. Carbohydrate was calculated by difference.

### **3.2.2 Determination of DWEF Level to be used through Sensory Evaluation.**

Three blend formulations were prepared using DTMF and DWEF. The first sample contained 100% DTMF and 0% DWEF (zero level of DWEF). The second and third contained 75% DTMF and 25% DWEF (one level of DWEF) and 50% DTMF and 50% DWEF (two levels of DWEF) respectively.



Porridge preparations of the three blend formulations were made for each sample separately by cooking the DTMF-DWEP-water mixture on a hot plate, uncovered for 12 min. The three samples were transferred to separate thermos flasks prior to being presented to a sensory evaluation panel of eight (selected on the basis of interest and familiarity with the product), who were asked to rate on a 9 – point hedonic scale, where 1 represented dislike extremely and 9 represented like extremely. The data were subjected to Analysis of Variance (ANOVA). Differences between means were analysed using Duncan's Multiple Range Test .

### **3.2.3 Determination of Effect of MARF on the Viscosity of DTMF – DWEP Porridge.**

The effect of MARF on the viscosity of DTMF –DWEP porridge was determined as follows; different levels of MARF (2– 8%) were added to DTMF – DWEP porridge at 5 – 20% flour concentration, to determine the effect of MARF on their viscosity. First,the porridges were made according to the method described by Wahed (1994). Secondly, the porridges were cooled to an average temperature of 56°C before addition of MARF, then the mixture was allowed 10 min for enzyme action. Viscosity measurements were taken using an *Epprecht* Rheometer (Contraves, AG Zurich) (Fig. 3). MARF level beyond, which there was no significant difference in viscosity, was taken as the ideal for economic reasons. Then, DTMEF was formulated as shown in Fig. 4.

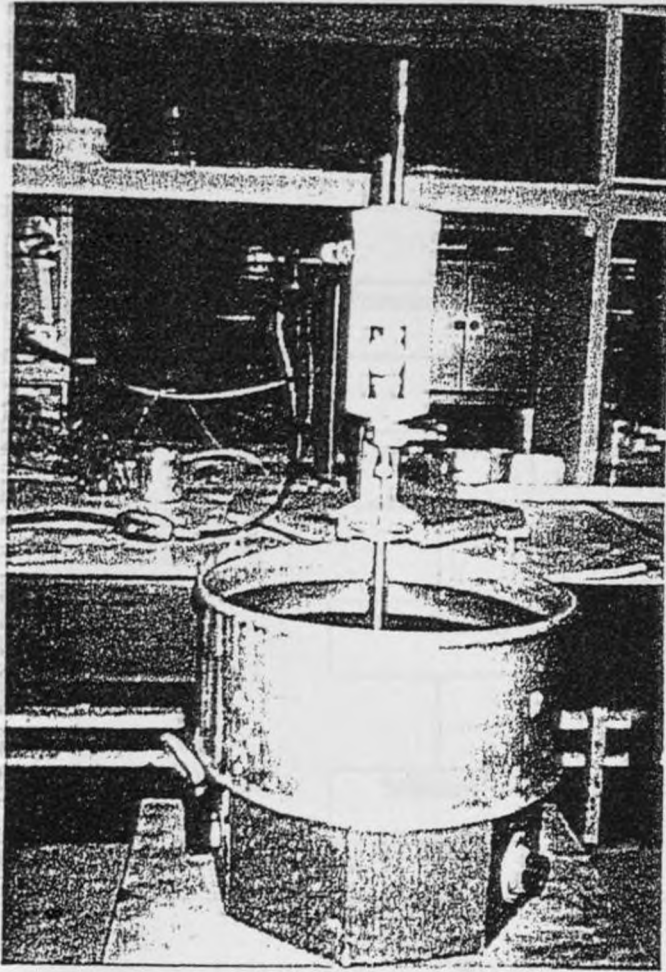


Fig. 3 An Epprecht Rheometer

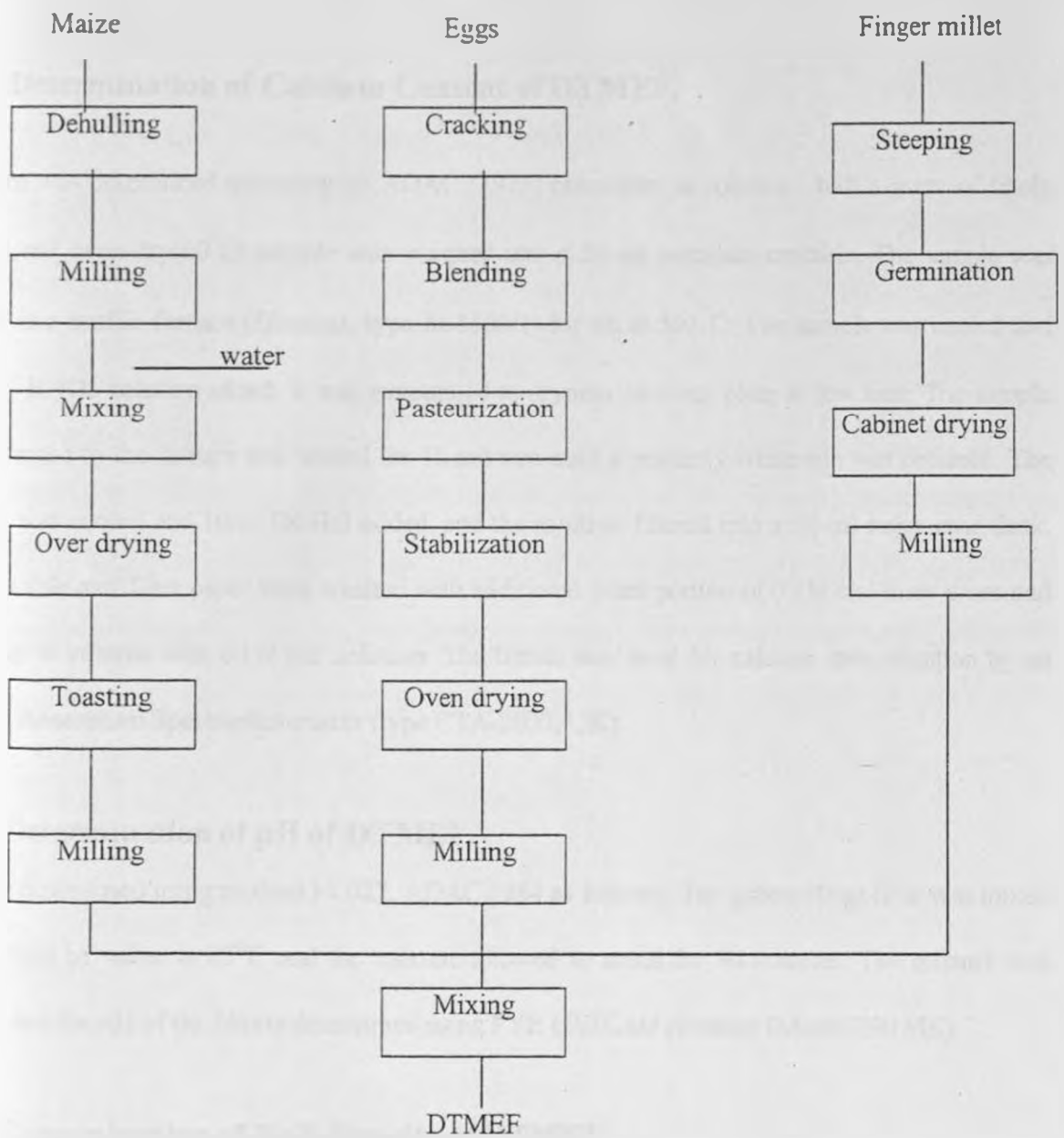


Fig.4 Dehulled Toasted Maize-Egg Flour production

### 3.2.4 Determination of Calcium Content of DTMEF.

Calcium was determined according to AOAC (1973) procedure as follows ; half a gram of finely ground and oven-dry( $60^{\circ}\text{C}$ ) sample was weighed into a 30-ml porcelain crucible. The sample was ignited in a muffle furnace (*Heracus*, type M 1100/1) for 6h at  $500^{\circ}\text{C}$ . The sample was cooled and 5ml 1N  $\text{HNO}_3$  solution added. It was evaporated to dryness on a hot plate at low heat. The sample was returned to the furnace and heated for 10 minutes until a perfectly white ash was obtained. The sample was cooled and 10ml 1N  $\text{HCl}$  added, and the solution filtered into a 50-ml volumetric flask. The crucible and filter paper were washed with additional 10ml portion of 0.1N  $\text{HCl}$  three times and made up to volume with 0.1N  $\text{HCl}$  solution. The filtrate was used for calcium determination by an Atomic Absorption Spectrophotometer (type CTA-2000, UK).

### 3.2.5 Determination of pH of DTMEF.

pH was determined using method 14.022, AOAC 1984 as follows; Ten grams (10g) flour was mixed with 100ml of water at  $25^{\circ}\text{C}$  and the mixture allowed to stand for 30 minutes. The mixture was filtered and the pH of the filtrate determined using *PYE UNICAM* pHmeter (Model 290 MK).

### 3.2.6 Determination of Bulk Density of DTMEF.

Bulk density was determined according to the method described by *Onian 'go* (1987) as follows; fifty grams (50g) of the sample was introduced into a 100ml graduated cylinder. The cylinder was tapped 10 times on soft ground for the sample to settle. The results were expressed in  $\text{g}/\text{cm}^3$ .

### **3.2.7 Determination of Particle Size of DTMEF.**

Particle size was determined according to the method described by Hounhouigan (1994) using the *Fritsch analysette* mechanical shaker (type 03.502, W.Germany).

### **3.2.8 Determination of Rancidity of DTMEF.**

Rancidity was determined through measurement of peroxide values after subjecting DTMEF samples to accelerated storage conditions of 55°C. Apart from this, smell was used to assess the degree of rancidity according to the method described by Oniang'o (1987).

### **3.2.9 Microbiological Analyses.**

Fifty grams (50g) DTMEF was weighed under aseptic conditions into a sterile dry container. The sample was transferred into a sterile blender jar. Then, 450ml diluent was added and the mixture homogenized. Starting from this  $10^{-1}$  homogenate, a decimal dilution series was prepared using 9ml portions of sterile diluent. Total aerobic mesophilic counts were made after incubation (24 – 48hr, 30°C) on plate count agar. Yeasts and moulds were counted after 5 days at 25°C on Potato Dextrose Agar. Salmonella were counted using methods described by *Harrigan and McCance* (1976).

## CHAPTER FOUR

### RESULTS AND DISCUSSION

#### 4.1 Proximate Composition .

Proximate composition is important since it helps in assessing the nutritional value of foods. The determinations have a bearing on the keeping quality since a high moisture content is undesirable, while a high fat can cause rancidity.

The protein content of WMF (7.1%) was lower than that of DMF (8.7%) as shown in table 1. This represents a very high increase (23%). This value was lower than the Protein Advisory Group (PAG) guidelines for weaning foods which recommend that, the protein content should be at least 20% (on a dry weight basis). The crude fat contents for the two products were 3.8 and 4.4% respectively. Although this represented an increase of 15.9%, it was still lower than the recommended level in accordance with PAG guidelines of 10%. There was no difference between the crude fibre and moisture contents of WMF and DMF. The moisture contents were much higher than the recommended PAG value of 5 to 10%.

There were slight decreases in ash, carbohydrate and calcium contents. The energy content of both WMF and DMF was practically the same (355 and 358 Kcal/100g). These results are for practical purposes valid because the fibre content of DMF is relatively low. The proximate composition of dried whole egg powder (DWEF) is as shown in table 6.

Table 1. Average Proximate Composition of WMF and DMF.

COMPONENT	PRODUCT		
	WMF	DMF	% INCREASE
Moisture content (%)	11.8 ± 0.6 <sup>1</sup>	12.0 ± 0.2	1.6
Crude protein (% dwb) <sup>2</sup>	7.1 ± 0.2	8.7 ± 0.3	22.7
Crude fat (% dwb)	3.8 ± 0.3	4.4 ± 0.4	15.9
Crude fibre (% dwb)	2.5 ± 0.3	2.5 ± 0.5	- 1.6
Ash (% dwb)	1.7 ± 0.7	1.5 ± 0.4	- 0.1
Carbohydrate	84.9 ± 0.9	82.9 ± 0.5	- 2.3
Total Energy (Kilocal/100g)	354.8 ± 2.6	357.8 ± 4.4	0.8
Calcium (mg/100g)	53 ± 63.2	51 ± 86	- 3.8

1. Mean and standard deviation.

2. Dry weight basis

Dehulling has a bearing on the nutritional value of food since it can affect the nutrient composition, dietary bulk and residence of food in the gastro-intestinal tract.

#### 4.2 DWEF Use Level and Sensory Evaluation.

During blending, premixes, including nutrients are metered into the continuous stream of food at an appropriate stage, or added in weighed quantities to unit weights of food in batch mixers

(Baurenfeind & Brooke, 1973). This is a method for increasing the protein content of DTMF. It is advantageous since there's an open choice of protein sources. The method is simple with regard to use by groups with low technological capabilities.

Results of the sensory evaluation scores are shown in table 2 below.

Table 2: Average Sensory Evaluation Scores of DTMF-DWEF Porridges at 3 levels of DWEF

Characteristic	Rating		
	DTMF-DWEF (4:0) porridge	DTMF-DWEF (3:1) porridge	DTMF-DWEF (2:2) porridge
Colour	5.0	6.6	6.9
Texture	5.3	7.1	7.0
Flavour	5.1	6.4	6.0

When the above results were subjected to ANOVA, there was significant difference (at the 5% level) for colour and texture. Using the Duncan's Multiple Range Test to determine which samples were significantly different from the others, it was found that the samples with 0 (zero) and one level of DWEF were not significantly different from each other. These two were also more preferable to the one with two levels of DWEF. Also, results of the ANOVA for panel tests for flavour indicated that there was no significant difference in flavour between the samples at the 5% level.



### 4.3 Effect of MARF Use Level on the Viscosity of DTMF – DWEF Porridges.

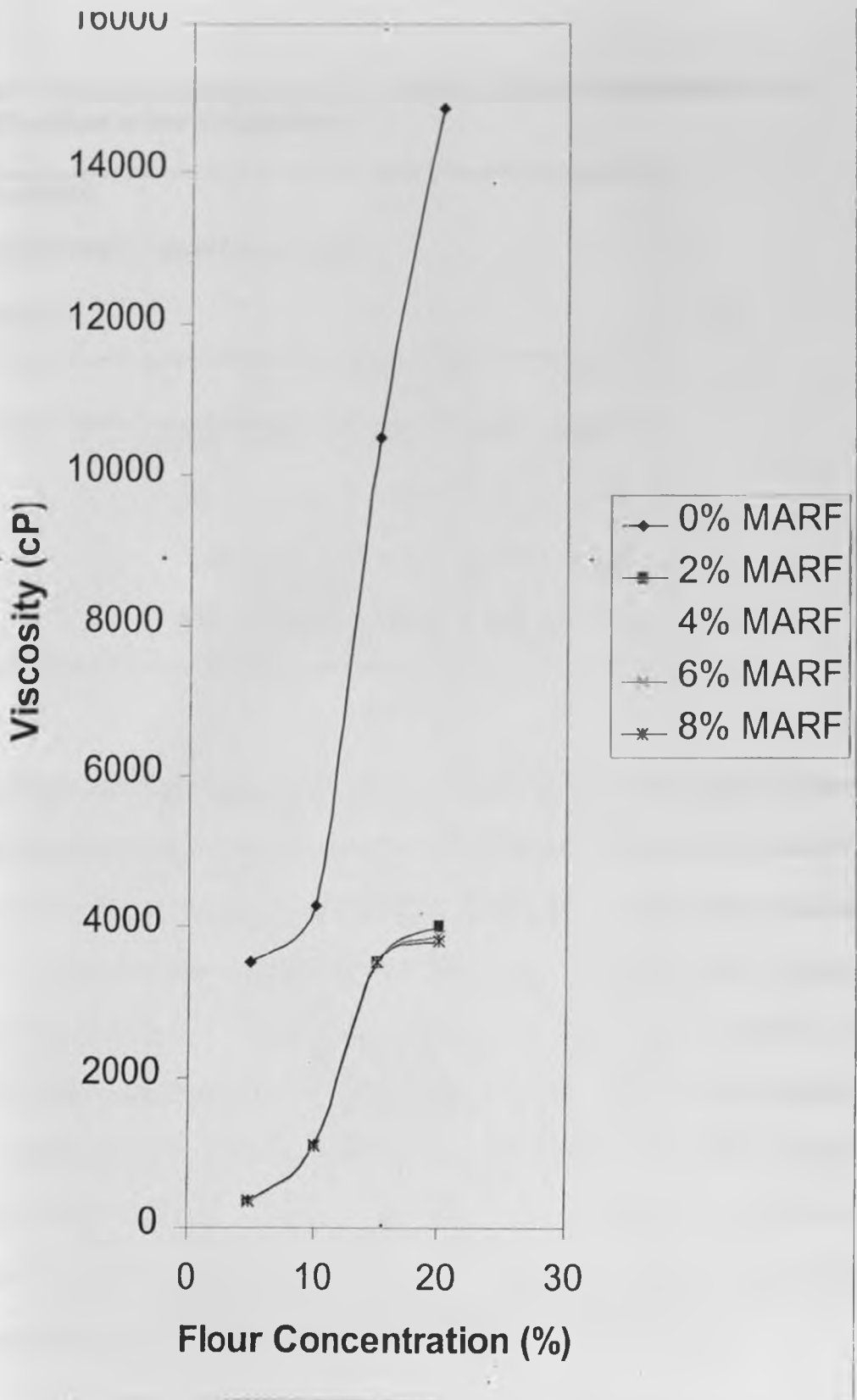
The viscosity of a food is critical weaning. An infant needs gradual transition from fluid to solid foods over this period to develop feeding skills. Early in weaning, the infant the infant will reject very viscous foods of high dietary bulk by spitting them out. High dietary bulk is also a limiting factor in the intake of weaning foods made from maize and other cereals, which decrease energy and nutrient density. The most important food constituents determining dietary bulk of weaning foods are starch and water. When starch is heated in water, gelatinization occurs with an increase in apparent viscosity. Starch granules undergo swelling and partial solubilization, especially regarding amylose. Cooling such a hot starch paste of a high enough concentration leads to the formation of a gel with a continuous, three dimensional network of swollen granules entrapping water (Walker, 1990). Reducing the viscosity of such food permits children to feed better, with higher energy intake per volume consumed. It was therefore a logical extension to add an alpha - amylase source (MARF) to decrease the thickness of porridges at high concentrations to form an energy-rich cereal based weaning food. Compared with other food starches, maize starch is hydrolyzed very rapidly by alpha – amylase (Pedersen, *et al*, 1989).

The viscosities of DTMF-DWEF Porridge preparations at 5,10,15, and 20% are as shown in Table 3. For all the flours, the viscosities fell rapidly to between 341 and 4,010cP at 2-8% MARF Level, compared to between 3,522 and 14,865 cp. at 0% MARF level. The fall in viscosity when MARF was added at levels of 2-8% to porridge preparations with 5-20% flour concentration is depicted in figure 1. There was no significant difference in reduction of viscosity when the MARF levels of 2,4,6, and 8% were added ( $p>0.05$ ). Therefore for economic reasons, a 2 % MARF level is required for viscosity reduction. This level is lower than 4 % wheat amylase rich flour, which was

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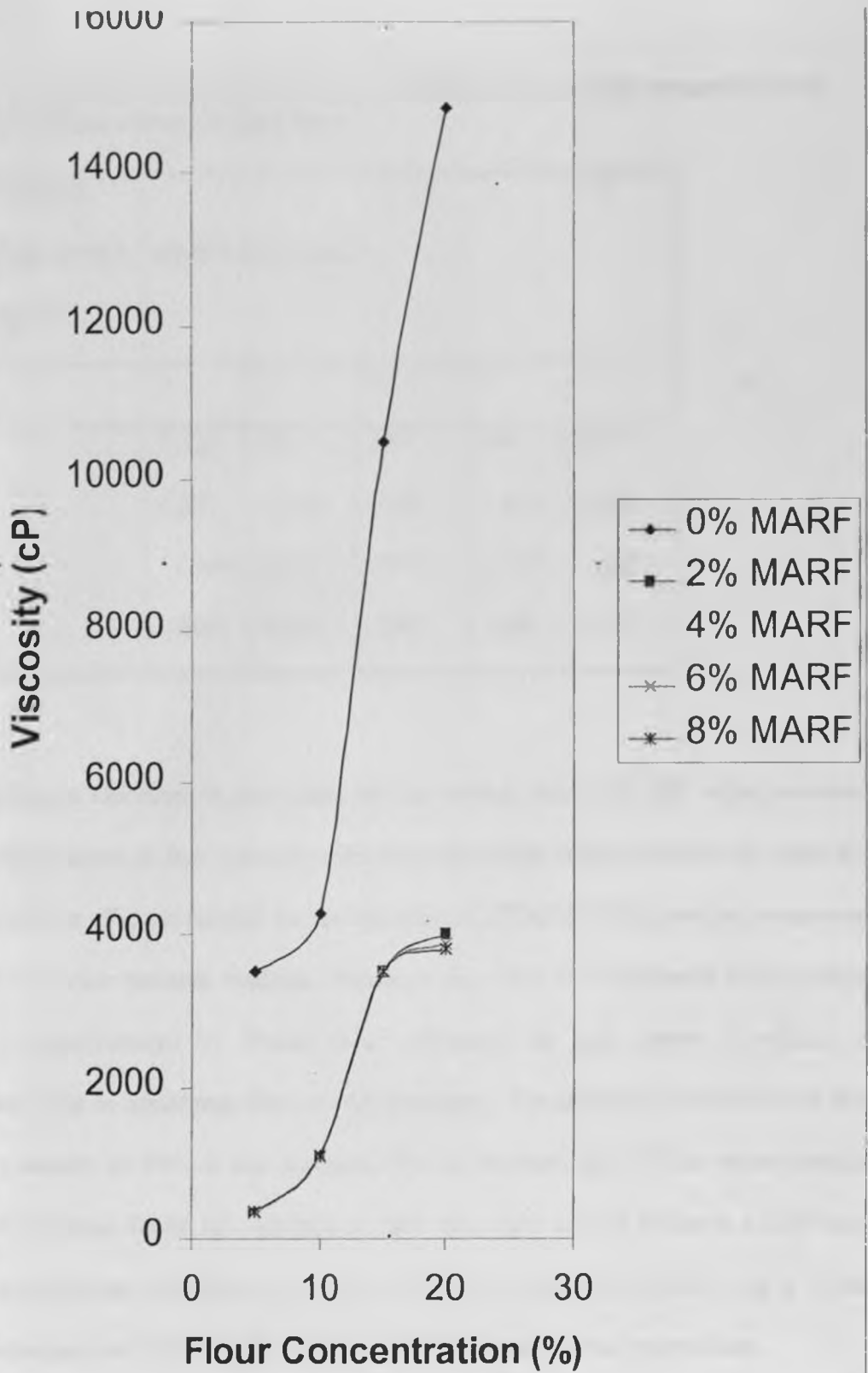
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**Figure 5. Relationship between Flour Concentration and Viscosity in DTMF-DWEF at Different MARF Levels.**

found to reduce the viscosity of soy – fortified *bulgur* wheat (Chinnamma & Gopaldas, 1988). The same investigation by Chinnamma & Gopaldas showed that a similar reduction in the viscosity of 20% and 25% slurries can be achieved whether amylase-rich flour at 4% is added before cooking or to the hot, cooked food. These results of the effect of MARF on the viscosity of DTMF – DWEF porridge preparations compare well with earlier research findings by Wahed, *et al.*, (1994). The effect of alpha-amylase on starch is that it degrades amylose at 1,4 glycosidic linkage, and similarly amylopectin (both randomly), forming dextrans in both cases.

The viscosity reduction at all flour levels was practically the same for all the levels of MARF added. The observation that there was no increase in viscosity decrease as the MARF levels increased may be explained by the fact that the enzyme activity increases with an increase in substrate concentration, this being only up to a point where the active - sites of the enzyme are saturated by the substrate molecules. Thereafter, substrate-enzyme inhibition results after all active sites have been taken up; any further increase in MARF contributes to increase in viscosity since there is no additional enzyme to act on the already available starch. Additional substrate molecules beyond a certain critical point do not result in an appreciable increase in enzyme activity since it has already leveled off.



**Figure 5. Relationship between Flour Concentration and Viscosity in DTMF-DWEF at Different MARF Levels.**

Table 3: Viscosity (in centipoises) of the DTMF-DWEP porridge preparations with MARF addition at four concentrations

Concentration of DTMF-DWEP porridge (%)	MARF level (g %)				
	0	2	4	6	8
5	3,522	341	344	346	348
10	4,271	1,076	1,081	1,072	1,089
15	10,494	3,517	3,532	3,512	3,523
20	14865	4,010	3,807	3,881	3,799

The viscosity reduction expressed in percentage for the various level of MARF added are shown in table 4. The trend shown is that, viscosity reduction percentage ranged between 66.3 and 90.3 %. These results of the effect of MARF on the viscosity of DTMF-DWEP porridge preparations compare well with earlier research findings (Wahed *et al.*, 1994 & Chinnamma and Gopaldas, 1988). Viscosity measurements by Wahed *et al* confirmed the high degree of efficacy of germinated wheat flour in liquefying thick, sticky porridges. The addition of amylase-rich flour (ARF) reduced viscosity by 98% in rice porridge, 97% in *khichuri*, and 87% in wheat porridge. Chinnamma and Gopaldas found that addition of ARF at 1-7g% of total solids to a 20% slurry liquefied it. Near-maximum thinning of the slurry occurred on addition of ARF at 4g%. At this rate, viscosity reduction was 90%. Beyond that level, further thinning was insignificant.

Table 4: Viscosity reduction % of DTMF-DWEP porridge preparations at four concentrations.

MARF - Level	Porridge concentration			
	5	10	15	20
0				
2	90.3	74.8	66.5	73.0
4	90.2	74.7	66.3	74.4
6	90.2	74.9	66.5	73.9
8	90.1	74.5	66.4	74.4

#### 4.4 Proximate Composition and Calcium Content of DTMEF.

In order to assess the nutritional value of foods, one of the first tasks should include the determination of proximate composition. Analyses are required for protein, fat, fibre, ash and moisture in order to ascertain if the formulated weaning food meets Codex Alimentarius Standards. The determinations have a bearing on the keeping quality of the product since a high moisture food is not preferable, while high fat content would cause rancidity. The ratio of DTMF: DWEP: MARF was ascertained as 73.5:24.5:2. The three different flours after being mixed thoroughly resulted in a composite flour (DTMEF), whose proximate composition is as shown in table 5.

Table 5: Comparison of average proximate composition and calcium contents of WMF & DTMEF

Component	Product	
	WMF	DTMEF
Moisture content (%)	11.8 ± 0.6 <sup>1</sup>	3.2 ± 0.1
Crude protein (% dwb) <sup>2</sup>	7.1 ± 0.2	17.9 ± 0.4
Crude fat (% dwb)	3.8 ± 0.3	10.3 ± 0.1
Crude fibre (% dwb)	2.5 ± 0.3	2.9 ± 0.7
Ash (% dwb)	1.7 ± 0.7	1.9 ± 0.2
Carbohydrate	84.9 ± 0.9	67 ± 1.0
Total energy (Kilocal/100g)	354.8 ± 2.6	423 ± 3.8
Calcium (mg/100g)	53 ± 63.2	57.2 ± 42.7

1. Averages and standard deviations. 2. Dry weight basis

The moisture content for DTMEF (3.2%) was very low compared to that for WMF (11.8%). Incorporation of dried whole egg powder increased the protein content from 7.1% to 17.9% thus, nearly twice as much. The fat content was doubled from 3.8% to 8.7%. These percentages for DTMEF were significantly higher than those of WMF ( $p < 0.05$ ). The crude fibre content increased from 2.54 to 2.9%. The ash content of DTMEF (1.9%) was higher than that of DMF (1.7%). The carbohydrate content of DTMEF (67.0%) was however significantly lower ( $p < 0.05$ ) than that of WMF (84.92%). The total energy content (expressed as kilocalories per 100g) increased by 68 kilocalories from 354.82 to 423 kilocalories. The calcium content of WMF and DTMEF were practically the same (53 and 57 mg/100g).



The higher crude fibre value for DTMEF may be due to the incorporation of undecorticated MARF since DWEP has insignificant fibre content. The increase in energy density is attributed to increase in fat content. Proximate composition data for DTMEF is comparable to earlier research findings (Annan&Plahar. 1995; Akpapunam & Sefa-Dedeh. 1995). Annan & Plahar's FRI weaner (formulated to contain 75% maize-groundnut flour, 20% full-fat soy flour, and 5% full-fat milk powder) contained 10.6% fat, 17...1% protein, 2.0% ash, 67.8% carbohydrate and total energy value 442.6Kcal/100g. The Protein Advisory Group (PAG) guidelines for weaning foods recommends that, the protein content should be at least 20%(on a dry weight basis), fat levels up to 10%, moisture 5 to 10%, and total ash not more than 5%. The protein and energy contents for EFMF are close to the PAG guidelines for weaning foods. Fibre content of EFMF though higher than that of DMF is lower than the 5% minimum allowed in infant foods.

A special feature is that the moisture content for DTMEF (3.2%) is within the recommended range (2-4%) which is suitable in order to decrease non-enzymatic browning and rancidity. It is also lower than the level recommended to be satisfactory for cereal products (12-14%) ideal for the prevention of microbial spoilage. With the exception of only protein whose value is slightly lower than the recommended, all the other results for the composition of DTMEF full within the acceptable ranges of the recommendations given. DMF is well below the standards. The low moisture contents in DTMEF may be attributable to the drying and toasting process. The high protein content may be due to the incorporation of DWEP which had a protein value of 43.9% as shown in (Table 6).

Table 6. Proximate composition and pH of DWEP used in the formulation.

Component	DWEP
p <sup>n</sup>	9.6 ± 0.02
Moisture content (%)	3.4 ± 0.1
Crude protein (%)	44.6 ± 1.0
Crude fat (%)	29.8 ± 1.1
Crude fibre (%)	0.1 ± 0.1
Ash (%)	3.5 ± 0.2
Carbohydrate (%)	18.5 ± 1.6

In view of the fact that a higher level of protein (up to a maximum of 20 %) is advisable for weaning foods, the upward adjustment of its level (from 8.7 % in DTMF to 17.9 % in DTMEF) is a good indication that the developed weaning food is likely to supply (to a greater extent) the protein requirements.

Due to the fact that protein and energy deficiencies are entwined in what is referred to as Protein – Energy Malnutrition (PEM) the higher protein and higher energy contents of DTMEF are likely to reverse the ill – effects attributed to PEM in case it is fed to weaning children. Normally, deficient intakes of energy and protein are common in many traditional foods. Many such foods are bulky and limit the infant's ability to eat enough. A new formulation such as DTMEF is one of the most effective ways of tackling the problem.

The composition of DTMEF compared well with the Kenya standard specification for processed cereal - based foods for infants and children (Ks 05 - 349) shown in Table 7.

Table 7: Composition of DTMEF and requirements for processed cereal foods for infants and children (KS 05 - 349)

Component	DTMEF	KS 05-349
Moisture content, % by mass	3.2	4
Total protein, % by mass, min	17.9	14
Fat, % by mass, max	10.3	8.5
Total carbohydrate, % by mass, min	67	60
Total ash, % by mass, max	1.9	5.0
Crude fibre, % by mass, max	2.9	1.0

When DTMEF and the compositional requirement by Kenya Bureau of Standards for processed cereal food for infants and young children were compared, DTMEF had lower moisture and total ash contents. Apart from this, it had higher contents of protein, fat, fibre and carbohydrate. Some fibre is required in order to improve fat mobility and thus prevent constipation.

Since DTMEF aims at addressing PEM (if adopted for use), its high protein and energy contents are of utmost importance in this regard.

#### 4.5 pH of DTMEF.

pH is a very important factor in the formulation of weaning foods. Although low pH inhibits diarrhoea-causing pathogens, some children cannot withstand continuous consumption of such foods. Under such circumstances, mothers prefer high pH (>4.0). Such high pH value (>4.0) were noted in Songea, in the southern part of Tanzania (Lorri, 1993). Weaning foods with higher pH

values (near 7.0) and low moisture contents have good keeping qualities with less chances of developing rancidity.

pH values for WMF and DTMEF were 6.13 and 7.08 respectively (Table 8). The favourable neutral pH of EFMF eliminates the need for use of any pH adjusting agents such as sodium hydrogen carbonate, Potassium hydrogen carbonate, calcium Carbonate, < (+) Lactic acid or citric acid or citric acid as recommended by the Codex Alimentarius Commission (1998).

Akpapunam and Sefa-Dedeh (1995) reported the pH range for maize-cowpea blends as 4.4 to 6.7. Similarly, Hounhouigan (1994) and Fields, *et al.*, (1981) found pH values of 3.8 to 4.2 to 6 respectively. These differences could be due to the fermentation process involved in the manufacture of these products.

#### **4.6 Bulk Density of DTMEF.**

The concept of bulk density in cereal-based weaning foods is of utmost importance. This is because it relates to packaging. Ideally, if a product can occupy less space in storage, the better. Results of bulk density and pH are shown in Table 8. There was no significant difference ( $p>0.05$ ) in bulk density of WMF ( $0.7\text{g/cm}^3$ ) and that of DTMEF ( $0.6\text{g/cm}^3$ ). The bulk density of DTMEF was lower than that reported by Oniang'o (1987) of  $0.7\text{g/cm}^3$  for a weaning food made from a mixture of maize meal, bean meal and whey protein concentrate. Bulk densities have economic implications if the product is to be marketed. A higher value means that a unit weight of the product will occupy a smaller space and make marketing more profitable (Oniang'o, 1982).

Table 8. Average Bulk densities ( $\text{g/cm}^3$ ) & pH of WMF and DTMEF

Product	Bulk density	pH
WMF	$0.7 \pm 0.0$	$6.1 \pm 0.2$
DTMEF	$0.6 \pm 0.0$	$7.1 \pm 0.0$

#### 4.7 Particle Size Distribution of DTMEF.

Particle size distribution is of utmost importance in cereal-based weaning foods since it determines the extent of granularity of such foods. The extent to which children consume such foods depends on the degree of fineness or coarseness. Ideally they prefer the former. Since their chewing ability is less developed, less food intake affects their nutritional status negatively. Apart from this, enzymatic hydrolysis can only be achieved within a reasonable time if the particles within which starch may be trapped are finely milled.

Table 9 Compares particle size distribution for WMF and DTMEF. For DTMEF, it was observed that there were no particles for the fraction  $> 1000$  micrometres; whereas for WMF, the proportion was 0.3 %. The proportion of the fraction  $> 500 < 1,000$  micrometres for WMF (36.9 %) was significantly higher ( $p > 0.05$ ) than that of DTMEF (6.3 %). The same trend was exhibited for the proportions of the fractions  $>250 < 500$ ,  $>125 < 250$  and  $<125$  micrometres.

It can be concluded that DTMEF contained a smaller proportion of the coarse particles and a higher proportion of fine particles compared to WMF.

Table 9: Particle Size distribution of WMF and DTMEF (weight %)

Particle size ( $\mu\text{m}$ )	WMF	DTMEF
> 1000	0.3 $\pm$ 0.2	0.0 $\pm$ 0.0
> 500 < 1,000	36.9 $\pm$ 0.4	6.3 $\pm$ 0.8
> 250 < 500	15.7 $\pm$ 0.2	23.4 $\pm$ 0.7
> 125 < 250	11.5 $\pm$ 2.7	16.3 $\pm$ 0.7
< 125	35.6 $\pm$ 2.6	54.0 $\pm$ 3.1

The proportion for DTMEF was lower than the one for the finest particle size reported by Hounhouigan (1994) for *mawe* (a maize product of Benin) which was 61.9% (Home-produced *mawe*) and 63.8% (Commercial *mawe*) respectively. This difference may be attributed to different methods of milling employed in the two different products.

#### 4.8 Extent of Rancidity of DTMEF.

Fats undergo changes during storage, which result in the production of an unpleasant taste and odour, which is commonly referred to as rancidity. Results of the rancidity tests (by smell) are shown in table 10.

Table 10 Test for rancidity by smell in DTMEF of varying lengths of storage at 55°C.

Length of time At 55°C (days)	Mean Score (out of 5)
2	4.6
4	4.4
6	4.1
8	4.2

There was no significant difference ( $p>0.05$ ) in the mean scores, and the product was still acceptable in flavour after the eighth day.

Results also showed that no peroxides were formed for the entire period of storage. This indicates that the product has good storage stability. This could be attributed to the fact that DTMEF had a moisture content (3.2%) below the lower limit (4.0%) required for the initiation of oxidative rancidity.

#### 4.9 Microbiological Quality of DTMEF.

Microbial safety of weaning foods is of utmost importance with regard to processing and handling methods. Weaning foods should not contain *Salmonella sp* in view of its deleterious effects. Sanitation and recommended manufacturing practices largely eliminate *Salmonella sp*. Apart from these practices, additional requirements to safeguard against contamination and maintain food

safety includes the creation of awareness and increased vigilance on the part of those directly handling the foods.

The microbial counts showed that the most dominating microorganisms in DTMEF were the total aerobic mesophilic counts (Table 11). Yeasts and mould followed these whereas *Salmonella sp* were absent. These results meet the KBS standard specifications regarding infant foods, which require that there should be nil (0) *Salmonella sp* counts. The yeast and moulds count of 3.3 is lower than that of Hounhouigan (1994) of 5.8, 6.4 and 6.9 for home-produced, fresh commercial *mawe* sold at markets (considering Yeasts alone). Considering the low moisture content and high microbial quality, this product (DTMEF) is expected to have a long shelf life.

Although many new cereals based processed weaning foods are of high quality without known adverse effects with regard to safety, potential dangers must be equally appreciated. Therefore, measures that provide maximum feasible assurance of microbial safety should be put in place. This is because, contamination of infant food with pathogenic micro-organisms always raises concern about infectious diarrhoea (Wahed, et al, 1994).



Table 11: Microbial composition of DTMEF (log<sub>10</sub> cfu/g)

Type of Micro-organism	DTMEF	KBS STANDARDS
Total aerobic mesophilic counts	$6.2 \pm 0.3^1$	3.7
Yeasts and Moulds	$3.3 \pm 0.1$	Not given
<i>Salmonella</i>	Nil	Nil

## CHAPTER FIVE

### 5.0 CONCLUSION AND RECOMMENDATIONS.

#### 5.1 Conclusion.

- (1) Addition of millet – amylase rich flour to dehulled toasted maize – egg flour porridge (5 – 20% solids) reduces the viscosity to satisfactory level of 1,000 – 3,000cP.
- (2) The pH of DTMEF is higher such that no p<sup>H</sup> adjusting agents are needed as required by Codex Alimentarius Commission guidelines.
- (3) DTMEF meets the compositional requirements set out by Kenya Standard Specification for Infant Food Formula in terms of moisture, protein, carbohydrate and ash, as well as microbiological requirements with regard to pathogenic micro – organisms.
- (4) The product has higher calcium and total energy contents of 57.2 mg/100g and 423 KiloCal/100g respectively. DTMEF has a high keeping quality.

#### Recommendations.

- (1) Studies are needed in ascertaining the full impact of the consumption of DTMEF on the nutrition status of infants and young children.
- (2) Research work aimed at the determination of the economics of large-scale production and marketing is required.

(3) Clinical trials are necessary for the purpose of evaluating EFMF for efficacy in infants and young children with acute watery diarrhoea (which afflicts many children), often leading to severe Protein - Energy Malnutrition.

(4) Further research aimed at effective use of DTMEF should only be complimentary, not aimed at replacing the existing formulas.

(5) More work needs to be done with specific Kenyan communities (especially women groups) involving the utilization of DTMEF as an infant food.

(6) Water used in the formulation should be potable; maize should be of high quality and free from pesticide residues and aflatoxin.

(7) More work needs to be done with a view of ascertaining how frequent DTMEF should be fed to children.

## BIBLIOGRAPHY

- Akpapunam, M. A & Sefa - Dedeh, S (1995) Traditional Lactic Acid Fermentation, Malt addition, and Quality Development in Maize-Cowpea Weaning Blends. **Food Nutr. Bulletin** 16(1): 75-80.
- Akita, E. M & Nakai, S (1992) Immunoglobulins from Egg Yolk; Isolation and Purification. **J. Food Sc.** 57(3): 629.
- Annan, N. T & Plahar, W. A (1995) Development and Quality Evaluation of Soy-fortified Ghanaian Weaning Food. **Food Nutr. Bulletin** 16(3): 263-8.
- AOAC (1984) **Official Methods of Analysis of the Association of Analytical Chemists**. 14th Ed.: Virginia: 16, 159-60, 160-1, 249,252.
- Au, P.M & Fields, M. L (1981) Nutritive Quality of Fermented Sorghum. **J. Food Sc.** 46: 652-4.
- Baldwin, R. E (1977) **Functional Properties in Foods**. **Egg Science & Tech.** 2nd Ed.: Avi, Connecticut: 246-66.
- Baurenfeind, J.C & Brooke, C.L (1973) Guidelines For Nutrifying 41 Processed Foods. **Food Engineering** 45(6). Chilton: 91-105.
- Bergquist, D. H (1973) **Egg**. **Food Dehydration** 2. 2nd Ed.: Avi, Connecticut: 363-6, 368-9.
- Bringe, N.A, Howard, D.B & Clark, D.R (1996) Emulsifying Properties of Low-fat, Low-cholesterol Egg yolk prepared by supercritical CO<sub>2</sub> Extraction. **J. Food Sc.** 61(1): 9-23.
- Bergquist, D. H (1974) **Egg & Egg Products**. **Encyclopaedia of Food Technology** 2. Avi, Connecticut: 351-61.

- Brown, K. H (1991) The Importance of Dietary Quality Versus Quantity for Weaning in Less Developed Countries. **Food Nutr. Bulletin** 13(12): 86-92.
- Brunser, O, Espinoza, J, Araya, M, Pacheco, I & Cruchet, S (1993) Chronic iron intake and diarrhoeal disease in infants. A field study in a less developed country. **Eu J Clin Nutr** 47(5): 317-25.
- Chinnamma, J & Gopaladas, T (1988) Reduction in the dietary bulk of Soya-fortified *bulgur* wheat gruels with wheat-based amylase-rich food. **Fd Nutr Bulletin** 10(4). UNU:50-3.
- Clarkson, P.M (1992) Minerals: exercise performance and supplementation in athletes. **Foods, Nutrition & Sports Performance**. 1st Ed. E & FN SPON. London: 111-46.
- Cook, F & Briggs, G. M (1977) Nutritive Value of Eggs. **Egg Sc. & Tech.** 2nd Ed.: Avi, Connecticut: 94-95.
- Cotterill, O. J, Chang, C.C, Mcbee, L.E & Heymann, H (1992) Metallic Cations Affect Functional Performance of Spray-dried Heat-treated Egg-White. **J. Food Sc.** 57(6): 1321-3.
- Causeret, D., Matringe, E & Loriet, D (1992) Mineral Cations Affect Microstructure of Egg Yolk Granules. **J. Food Sc.** 57(6): 1323-5.
- Dixon, D. K & Cotterill, O.J (1981) Electrophoretic and Chromatographic Changes in Egg-Yolk Proteins due to heat. **J. Food Sc.** 46: 981-3.
- Dobbing, J (1988) Medical and Scientific Commentary on Changes made against the Infant Food Industry. **Infant Feeding**. Springer – Verlag: London: 24-5.
- Duggan, M.B & Milner, R.D.G (1986) The Maintenance Energy Requirement for Children: An Estimate based on Study of Children Associated Feeding. **Am. J. Clin. Nutr.** 43(6): 870-8.
- Fairweather-Tait, S.J (1992) Iron deficiency in infancy; easy to prevent-or is it? **Eu J Clin Nutr** 46(4): S9-14.

- Fall, C (1992) Nutrition in Early Life and Later Outcome. *EU. J. Clin. Nutr.* 46(4). Suppl. 4 : 57-63.
- FAO/WHO (1994) Cereals, Pulses, Legumes, Derived Products and Vegetable Proteins. *Codex Alimentarius Commission* 7: 9-22.
- FAO/WHO (1998) Proposed Draft revised Standard for Processed Cereal-based Foods for Infants and Young Children. *Codex Alimentarius Commission*. Agenda Item 6: 1-7.
- FAO (1992) Maize in Human Nutrition 25. Rome: 16 - 26.
- FAO (1995) Sorghum and Millets in Human Nutrition. Rome: 52, 113-127.
- Feeney, R.E (1969) Egg Proteins. *Symposium on Foods: Proteins and Their Reactions*. 2nd print: Avi, Connecticut: 209-20.
- Fields, M.L. Hamad.A.M & Smith.D.K (1981) Natural Lactic Acid Fermentation of Corn Meal. *J. Food Sc.*46:900-2.
- Forsythe, R.H (1968) The Science and Technology of Egg Products Manufacture in the United States. *Egg Quality. A Study of the Hen's Egg*. 1st Ed: Oliver & Boyd: Edinburg: 278-9.
- Fomon, S. J (1974) Infant Nutrition. 2nd Ed: W.B Saunders: Philadelphia: 162-7.
- FAO (1998) Food Outlook. *Global Information and Early Warning System on Food and Agriculture* 4. 4/5.
- Froning, G. W (1988) Nutritional and Functional Properties of Egg Products. *Developments in Food Proteins* 6. Elsevier Appl. Sc: London: 8
- Gacula, M. C & Singh,J (1984) Statistical Methods in Food and Consumer Research. Academic Press: Orlando: 88-90.
- Galyean, R.D & Cotterill, O. J (1981) Ion Exchange Chromatographic Determination of Lysozyme in Egg-white. *J. Food Sc.* 46. 127-8.

- Gelfand, M (1971) Diet and Tradition in an African Culture. E & S Livingstone. Edingurg:28-56.
- Golden, B.E & Golden, M.H (1991) Relationships among Dietary Quality, Children's Appetite's, Growth stunting, and Efficiency of growth in Poor Populations. **Food Nutr. Bulletin** 13(2). 105-8.
- Hayes, R.E, Mwale, J.M, Tembo, P & Wadsworth, J.I (1995) Computer Optimized Weaning Food Blends. **Fd Nutr Bulletin** 16(3): 245-58.
- Harrigan, W. F & McCance, M.E (1976. Laboratory Methods in Food and Dairy Microbiology. Academic Press: London: 139-44, 150-5, 157-8, 168-70.
- Heinzelmann, K (1995) The Interface provides the opening. **Lebensmitteltechnik** 27 (J Fd Tech 27). Quakenbruck:12, 31-34.
- Hofvander, Y. & Underwood, B. A (1987) Processed Supplementary Foods for Older Infants and Young Children, with special reference to Developing Countries. **Food Nutr. Bulletin** 9(1). 1-7.
- Hounhouigan, D. J (1994) Fermentation of Maize (*Zea mays*) Meal for *Mawe'* Production in Benin. PhD. Thesis: Wageningen: 2-22.
- Hsieh, Y. L & Regenstein, J. M (1992) Modelling Gelation of Egg Albumen and Ovalbumin. **J. Foods** 57(4). 856-7.
- Hsieh, Y. L & Regenstein, J. M (1992) Elastic Attributes of Heated Egg Protein Gels. **J. Food Sc.** 57(4). 862-3.
- Hsieh, Y. L & Regenstein, J. M (1993) Gels Point of Why and Egg Proteins using Dynamic Rheological data. **J. Food Sc.** 58(1). 116-9.

- Ikura, K. Higashiguchi, F, Kitabatake, N, Doi, E, Narita, H, & Sasaki, R (1992) Thermally induced Epitope Regions of Ovalbumin Identified with Monoclonal Antibodies. **J. Food Sc.** **57(3)**. 635-7.
- Johnson, T. M & Zabik, M. E (1981) Ultrastructural Examination of Egg Albumen Protein Foams. **J. Food Sc.** **46**. 1237-9.
- Kent, N. L (1970) Structural and Nutritional Properties of Cereal Proteins. Proteins as Human Food. Butterworths: London: 293; 296-7.
- Kichamu, G (1998) Early Childhood Mortality. Kenya Demographic and Health Survey 1998. Macro International Inc: Maryland: 91.
- Kim, H. & Nakai, S (1996) Immunoglobulin Separation from Egg-Yolk; A Serial Filtration System. **J. Food Sc.** **61(3)**. 510-2.
- King, M.H, King, F.M.A, Morley, D.C, Burgess, A.P (1972) **Nutrition for Developing Countries**. Oxford University Press. Nairobi: 7.11-14.
- Kenya Bureau of Standards (1983) Specification for Processed Cereal-based Foods for Infants and Children. 4-8.
- Lorri, W. S. M (1993) Nutritional and Microbiological Evaluation of Fermented Cereal Weaning Foods. Thesis: Chalmers, Goteborg: 1-2.
- Ma, C. V. Paquet, A. & McKellar, R. C (1993) Effect of Fatty N-acylamino Acids on some Functional Properties of Two Food Proteins. **J. Agr. Food Chem.** **41(8)**. 1182-86.
- Matkovic, V & Heaney, R.P (1992) Calcium balance during human growth: evidence for threshold behavior. **Am J Clin Nutr** **55(5)**:992-5.
- Mejia, L. A (1994) Fortification of Foods. Historical Development and Current Practices. **Food Nutr. Bulletin** **15(4)**. 278-81.



- Meyer, L. H (1966) Food Chemistry. 4th Print: Reinhold. NY: 146.
- Muller, H. G & Tobin, G (1980) Nutrition and Food Processing. 1st Ed: Av1, Connecticut: 267-76.
- Mottram, R.F (1985) Human Nutrition. 3<sup>rd</sup> Ed. Edward Arnold: 84-95.
- Muroki, N.M, Nzioki, D.J & Wachira, A (1997) Detoxification of Cassava and Improvement of its Protein and Nutritional Value by Incorporation of Soybean and Fermentation with *Rhizopus arrhizius* Mould and *Saccharomyces cerevisiae* Yeast and the Organoleptic Quality of Fermented Flour Mixtures. **J Fd Health Nutr** 4(3):43-9.
- Nakazawa, M, Ohtsuka, R, Kawabe, T, Hongo, T, Inaoka, T, Akimichi, T, Suzuki, T (1996) Iron nutrition and anaemia in a malaria-endemic environment: haematological investigation of the Gidra-speaking population in lowland Papua New Guinea. **Brit J Nutr** 76(3):331-45.
- Nkama, I, Iiiyas, A & Jato, A (1995) Studies on the Preparation and Nutrient Composition of kunun gyada, a traditional Nigerian groundnut-cereal based weaning food. **Fd Nutr Bulletin** 16(3). UNU:238-40.
- Oniang'o, R. K, Kayongo-Male, H & Saint-Hilaire, P (1982) Formulation of a High Protein Weaning Food using Local Raw Materials. PhD Thesis: Univ. of Nairobi: 1-7.
- Oniang'o, R. K, Kayongo- Male, H & Saint-Hilaire, P (1987) The Chemical and Physical composition, Keeping Quality and Acceptability of selected rations for Infant feeding. **EA Med J** 64(6): 358-67.
- Oniang'o, R & Alnick, D.J (1988) Weaning Foods in Kenya: Traditions & Trends. **Improving Young Child Feeding in Eastern and Southern Africa**. Proceedings of a Workshop held in Nairobi, Kenya, 12-16 October 1987. IDRC. Ottawa: 76-80.
- Oyeyiola, P. G (1991) Fermentation of Millet to Produce *Kamu*, a Nigerian Starch-Cake Food. **World J. Micr. Biotec.** 7(2): 196-201.
- Packard, V. S. 1982. Human Milk and Infant Formula. Academic Press: NY: 23.

- Parry, D. A (1970) The Organoleptic Qualities of Protein Foods. **Proteins as Human Food**. Butterworths: London: 376-7.
- Pearson, D (1976) The Chemical Analysis of Foods. 7<sup>th</sup> Ed: Edinburgh: 494-7.
- Pedersen, B., Knudsen, K.E.B, Eggum, B. O (1989) Nutritive Value of Cereal Products with emphasis on the Effect of Milling. **World Rev. Nutr. Diet** 60. 22-39.
- Potter, N. N (1987) Food Science. 3rd Ed: CBS: New Delhi: 455:507.
- Powrie, W. D (1977) Chemistry of Eggs and Egg Products. **Egg Sc. & Tech.** 2nd Ed: Avi, Connecticut: 67-70.
- Republic of Kenya (1997) National Development Plan of 1997-2001:54-5.
- Ross, A.C & Ternus, M.E (1993) Vitamin A as a hormone; Recent advances in understanding the actions of retinol, retinoic acid, and beta carotene. **J Am Diet Assoc** 93(11): 1285-90.
- Rosenfield, D (1970) Enrichment of Plant Protein. **Proteins as Human Food**. Butterworths: London: 266-71.
- Shenstone, F. S (1968) The Gross Composition, Chemistry and Physico-chemical basis Organisation of the Yolk and White. **Egg Quality, A study of the Hen's Egg**. Oliver & Boyd: Edinburgh: 29-32.
- Shrimpton, D. H (1970) Eggs & Poultry. **Proteins as Human Food**. Butterworths; London; 231-3.
- Simmons, W. K (1990) Food Fortification in the English Speaking Caribbean. **Food Nutr. Bulletin** 12(3): 240-5.
- Spenser, H, Krammer, L, Rubio, N & Osis, D (1986) The effect of phosphorus on endogenous fecal calcium excretion in man. **Am J Clin Nutr** 43(5): 845-51.
- Sivetz, M. & Desrosier, N. W (1979) Coffee Technology. Avi, Connecticut: 248-50.

- Stekel, A, Olivares, M, Cayazo, M, Chadud, P, Liaguno, S & Pizzaro, F (1988) Prevention of Iron deficiency by milk fortification. 11 A field trial with a full fat acidified milk. *Am J Clin Nutr* 47: 265-9.
- Stewart, G. F. & Amerine, M. A (1982) Introduction to Food Science & Tech. 2nd Ed. Academic Press: Paris: 172-4.
- Suskind, R (1976) Complement Activity in Children with Protein - Calorie Malnutrition. *Am. J. Clin. Nutr.* 29(10): 1089-92.
- Tanumihardjo, S.A. Yuniar, Y. Permaesih, D, Sulaiman, Z, Karyadi, D. & Olson J.A (1990) Vitamin A status in pre-school Indonesian children as assessed by modified relative-dose response assay. *Am J Clin Nutr* 52(6):1068-72.
- Umoh, V. & Fields, M (1981) Fermentation of Corn for Nigerian *Agidi*. *J. Food Sc.* 46: 903-5.
- UNICEF (1998) The State of the World's Children 1998: 1-11
- UNICEF (1999) 1999-2003 Country Programme Cooperation between Government of Kenya and UNICEF. Nairobi: 6-82.
- Vorster, H. H, Benade, A.J.S, Banard, H.C, Locke, M.M, Silvis, N, Venter, C.S, Smuts, C.M, Engelbrecht, G.P. & Marais, M.P (1992) Egg Intake does not change Plasma lipoprotein and coagulation profiles. *Am. J. Clin. Nutr.* 55(2): 100-10.
- Wahed, M. A, Mahalanabis, D, Begum, M, Rahman, M & Islam, M.S (1994) Energy Dense Weaning Foods liquefied by Germinated- Wheat Amylase; Effects on Viscosity, Osmolality, Macronutrients, and bacterial growth. *Food Nutr. Bulletin* 15(3): 257-61.
- Walker, A. F (1990) The Contribution of Weaning Foods to Protein-Energy Malnutrition. *Nutrition Research Review* 3: 25-47.

## APPENDIX

### Moisture determination.

In a cooled and weighed dish (provided with cover, metallic of diameter 55 mm and height 15 mm, with inverted slip-in cover fitting tightly on inside), previously heated to  $130 \pm 3^\circ \text{C}$ , accurately weigh 2 g well mixed sample, and dry dish, cover and contents 1 hr in oven provided with opening for ventilation and maintained at  $130 \pm 3^\circ \text{C}$  (1 hr drying period begins when oven temperature is actually  $130^\circ \text{C}$ ). Cover dish while still in oven, transfer to desiccator, and weigh soon after reaching room temperature. Report loss in weight of flour as moisture.

### Protein determination

Place weighed sample (0.7-2.2 g) in digestion flask. Add 15 g powdered potassium sulphate or anhydrous sodium sulphate, and 25 ml sulphuric acid. If sample  $> 2.2$  g is used, increase sulphuric acid by 10 ml for each gram sample. Place flask in inclined position and heat gently until frothing ceases (if necessary add a small amount of paraffin to reduce frothing); boil briskly until solution clears and then  $\geq 30$  min longer (2 hr for sample containing organic material). Cool, add 200 ml water, cool  $< 25^\circ \text{C}$ , add 25ml of the sulphide or thiosulphate solution and mix to precipitate. Add a few zinc granules to prevent bumping, tilt flask and add a layer of NaOH without agitation (for each 10ml sulphuric acid used, or its equivalent in distilled water, add 15 g solid NaOH or enough solution contents strongly alkaline).

Note: Thiosulphate or sulphide solution may be mixed with the NaOH solution before addition to the flask.

Immediately, connect the flask to the distilling bulb on condenser, add, with tip of condenser immersed in standard acid and 5-7 drops indicator in receiver, rotate flask to mix contents thoroughly; then heat until all ammonia has distilled ( $\approx$  150 ml distillate). Remove receiver, wash tip of condenser and titrate excess standard acid in distillate with standard NaOH solution.

Correct for blank determination on reagents.

$$\% N = \frac{(\text{ml std acid} \times \text{normality acid}) - (\text{ml std NaOH} \times \text{normality NaOH}) \times 1.4007}{\text{g sample}}$$

g sample

Multiply %N by 5.7 for wheat and 6.25 for others to obtain % protein.

### Determination of crude-fat.

Large amounts of water soluble components such as carbohydrates, urea, lactic acid, glycerol and others may interfere with the extraction of fat; if present, extract 2 g sample on small paper in funnel with five 20 ml portions of water prior to drying for ether extraction.

Extract 2 g sample (dried). Use thimble with porosity permitting rapid passage of ether. Extraction period may vary from 4 hr at condensation rate of 5-6 drops/sec to 16hr at 2-3 drops/sec. Dry the extract 30 min at 100°C, cool, and weigh.

## Determination of crude fibre

Note: The experiment should be carried out carefully, strictly adhering to the heating times and the filtration procedures.

Weigh accurately 2 g sample into a graduated 600 ml beaker (modified procedure). Add a small amount of boiling distilled water and 250 ml of 2.04 N sulphuric acid. Make the volume to 200 ml and maintain it whilst boiling for 30 min on a hot plate. Filter the contents of the beaker through a Buchner funnel lightly packed with glass wool and wash the residue three times with boiling distilled water. Transfer quantitatively both the residue and glass wool back into the beaker. Add a small amount of boiling distilled water and 25 ml of 1.78 N KOH solution. Make the volume to 200 ml with boiling distilled water and maintain this volume whilst boiling for 30 min as above. Filter again using glass wool as filter aid and wash as above. Finally wash the residue three times with small amounts of ethanol and transfer quantitatively the residue and glass wool to a porcelain dish. Dry in an air oven at  $130 \pm 2^\circ \text{C}$  for 2 hr, cool in a desiccator and weigh. Ignite the dish and contents at  $600 \pm 15^\circ \text{C}$  for 30 min or to a constant weight, cool and weigh. Calculate the crude fibre content of the sample on a fresh weight basis or on the dry weight basis as follows

$$\% \text{ Crude fibre} = c = \frac{\text{Loss in wt on ignition} - \text{Loss in wt of ceramic fibre}}{\text{wt of sample}} \times 100$$

$$\% \text{ Crude fibre on desired moisture basis} = \frac{c \times 100 - \text{desired moisture content}}{100 - \% \text{ moisture in ground sample}}$$

## Determination of ash

Weigh 3-5g of well mixed sample into a shallow, relatively broad ashing dish that has been ignited, cooled in desiccator, and weighed soon after reaching room temperature. Ignite in furnace

at  $550^{\circ}\text{C}$  (dull red) until light grey ash results, or to constant weight. Cool in desiccator and weigh soon after reaching room temperature.

### **Particle size determination**

A series of cooled and weighed sieves are attached to a mechanical shaker. One hundred grams (100g) of flour are weighed and introduced to the top most sieve. It is shaken for 30 min. All the compacted sieves are removed at once, splashed with water, dismantled and individually at  $130\pm 3^{\circ}\text{C}/1\text{hr}$ . Each is transferred to a large desiccator, and weighed soon after reaching room temperature. The flour residue weight is reported as percent particle size.