

**EVALUATION OF TRADITIONAL WEANING MEALS,
SUPPLEMENTED WITH PROTEIN-RICH FOODS TO
PROMOTE GROWTH IN MALNOURISHED
PRESCHOOL CHILDREN**

**A Ph.D RESEARCH THESIS PRESENTED TO THE
DEPARTMENT OF NUTRITION AND FOOD SCIENCE,
FACULTY OF SCIENCE, UNIVERSITY OF GHANA, LEGON.**



BY



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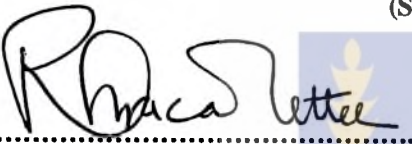
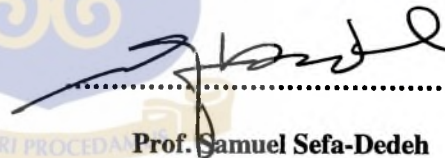
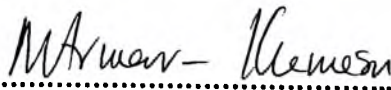
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DECLARATION

I, Clara Opare-Obisaw, hereby declare that except for references to other peoples' work which have been duly cited, this work is the result of my own original research and that this thesis had neither in whole nor in part been presented for another degree elsewhere.

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DEDICATION

This piece of work is dedicated to God, my rock and fortress; to my husband Steve and our children, Lisa, Ernest, Stephen, Stephanie and to the malnourished children of Ghana.



ABSTRACT

This study was aimed at constituting nutritious home-made weaning meals, using local foods that would curtail malnutrition among pre-school children and facilitate a smooth transition from breast milk and cereal porridges to adequate post weaning food consumption.

Nine weaning meals were formulated. Three meals each were formulated using corndough, cornmeal and yam as staple. To one meal in each group of 3 meals, cowpeas, fish or melonseeds were added as the effective source of protein supplement. The same quantities of palm oil, tomatoes, onion and cocoyam leaves were added to each of the meals. Proportions of ingredients were selected so that one third of energy and half of the protein requirements of a 1-3 year old child is met. Considerations were made to incorporate the minimum amount of supplement that would maximize protein nutritional value, at minimum cost, and to provide enough food to suit the stomach capacity of the child at a sitting.

Biological utilisation of the protein in the meals was determined by nitrogen retention in rats and compared with casein and *koko* [a favourite local maize weaning food]. Protein quality determined by using analysed amino acid compositions to calculate amino acid scores, were compared with *koko*. Protein, fat, energy, vitamin and mineral contents of the meals were also determined.

Thirty-five malnourished children aged 1-3 years were assigned to the experimental meals and fed for 4 weeks. Mean weight and height gains as well as increases in haemoglobin levels of the experimental children were determined and compared with those of 10 children, who served as controls.

Comparisons of data employed Analysis of Variance or Analysis of Covariance and Tukey's HSD test where appropriate. Differences were considered significant when the probability of obtaining them was 5% or less.

Protein, fat, ash and total energy contents of all the meals were greatly improved over that of *koko*. Protein concentrations of the meals were satisfactory and adequate to support catch-up growth of 20-30g per day. Energy densities were all well above 85 kcals/100g of food, considered adequate for supporting rapid growth. Protein quality as expressed by BV% and NPUop%, although lower than casein values, were significantly higher ($P < 0.003$) than *koko* values, and supported growth in rats.

The essential amino acid compositions showed great improvement upon that of *koko*. Consequently, the protein scores of the meals ranged from 1½ times to over double that of *koko*. Except for calcium, the mineral and vitamin contents of the meals were adequate.

The mean weight gained by the children in the experimental group was 410 grams, which was significantly higher ($p = 0.007$) than the gain of 50g by the control group. Irrespective of staple or supplement used, differences in weight gains among the experimental groups were not significant. However, the group fed yam meals gained about twice as much weight as those fed corndough and cornmeal. The group fed meals supplemented with melonseeds gained about 1/3 more weight than those fed cowpeas and fish. The gains in WAZ and WHZ scores for the experimental group were significantly higher ($p = 0.027$ and $p = 0.40$ respectively) than those of the control group. The height gains by the experimental and control groups were not significantly different. The mean increase of 8% in haemoglobin level by the

experimental group was significantly higher (($p=0.012$) than the decrease of 1% in the control group.

The study has demonstrated that, carefully constituted weaning meals, using local foods can meet energy, protein, mineral, and vitamin needs and are capable of promoting growth even in malnourished children. The meals prepared with corndough and yam are particularly recommended for weaning, because they are not bulky and therefore suit the stomach capacities of young children. The use of melonseeds must be encouraged in meals for young children. Yam, which produces softer meals, must be encouraged for weaning meal preparation, because it yields meals that are as nutritious as meals prepared with cereals, when supplemented with protein-rich foods.



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A study of such coverage would not have been possible but for the grace of God manifested through several people by their diverse contributions towards its completion. To these very special people and institutions I wish to acknowledge with deep gratitude and appreciation.

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ACRONYMS

| | |
|----------|--|
| AAU | Association of African Universities |
| ACC/SCN | Administrative Committee on Co-ordination – Subcommittee on Nutrition. |
| AID | Agency for International Development. |
| AOAC | Association of Official Analytical Chemists |
| CIIFAD | Cornell International Institute for Food, Agriculture and Development. |
| CSIR | Council for Scientific and Industrial Research. |
| CSM | Corn-Soy-Milk. |
| DHS | Demographic Health Survey. |
| FAO | Food and Agriculture Organisation. |
| GLSS | Ghana Living Standards Survey. |
| GOG | Government of Ghana. |
| GSS | Ghana Statistical Service. |
| HOVIPREP | Home and Village – Prepared Weaning Foods. |
| ICN | International Conference on Nutrition. |
| INCAP | Institute of Nutrition of Central America and Panama. |
| MIC | Malnutrition-infection complex. |
| MOH | Ministry of Health. |
| NCHS | National Centre for Health Statistic. |
| PAG | Protein Advisory Group |
| PAHO | Pan American Health Organisation. |
| PER | - Protein Efficiency Ratio. |
| RDI | Recommended Dietary Intake. |
| UN | - United Nations |

| | | |
|--------|---|---|
| UNICEF | | United Nations International Children's Fund |
| UNU | - | United Nations University. |
| USAID | - | United States Agency for International Development. |
| WHO | - | World Health Organisation. |

1.0

INTRODUCTION

The United Nations General Assembly designated 1979 as the International Year of the Child to create awareness about the bleak future facing most children in an environment of malnutrition and disease among others, in order to stimulate programmes to improve these conditions. Two decades have elapsed, but the situation of children has changed little. It is estimated that 199 million children under the age of five suffer from acute or chronic protein and energy deficiencies most of whom are found in developing countries. (FAO, 1996).

Child malnutrition in the developing world in 1990 showed that 26% (30 million) are from Africa (UNICEF, 1991), which accounts for 19% of the child population and has the highest percentage of severely malnourished children in the world (UN, 1987). Infant mortality is unacceptably high in many parts of the world with an estimate of 40,000 children dying from malnutrition and disease each day (UNICEF, 1991). In most parts of the world, infant and child mortality rates have reflected improvement. However, in Sub-Saharan Africa, the total numbers of infant and child deaths are thought to be still rising (UN, 1987; USAID, 1993).

Protein-Energy Malnutrition (PEM), the major form of childhood malnutrition, in its severest form, manifests as marasmus and kwashiorkor. Marasmus is the more widely prevalent type and usually occurs during the first year of life. Kwashiorkor occurs most commonly in the second and third years of life. In Ghana, PEM is the most widespread health and nutritional problem among young children, many of whom suffer from moderate to severe forms (MOH, 1992). The incidence of malnutrition in Ghana among young children seems to have changed little over the years. Davey in 1962 reported an incidence of 30%, UNICEF (1986) reported 58%, and Catholic Relief Services records in 1988 showed 34%. Reports of the Ghana Demographic Health Surveys of 1988 and 1993 showed the incidence of malnutrition as 30% and 28% respectively.

The physical, social and economic costs of child malnutrition have far-reaching consequences. It contributes to high child mortality and morbidity, (Jelliffe, 1973) with the median case fatality from severe malnutrition having remained at 20-30% over the past 5 decades (Schofield and Ashworth, 1996). Malnutrition causes poor physical development, which may persist throughout adulthood (Martorell *et al.*, 1994). Poor intellectual development as a result of child malnutrition has been documented by several researchers (Cravioto and Delicardie, 1971; Winnick, 1974; Martorell *et al.*, 1994). It has been estimated that one child in every three in the developing world is prevented from growing to his or her mental and physical potential by malnutrition (UNICEF, 1991).

Child malnutrition also generally increases the economic burden of the country and of the family. Malnutrition must therefore be addressed quickly, because intervening later may be costly or have only limited effect.

The major underlying causes of PEM have been attributed to social, economic and environmental factors. An outstanding problem arising from an interaction of these factors is inappropriate feeding practices, which have been identified as leading contributors of child malnutrition in Ghana and in other developing countries. For instance, the Ghana Ministry of Health has reported a high incidence of the practice of abrupt stoppage of breast feeding, making the children lose appetite and refused to eat, which predisposed them to PEM (MOH, 1989).

Prolonged breast-feeding in Ethiopia and Ghana has been associated with malnutrition, since it reduces total food intake as breast milk can no longer provide sufficient nourishment for the child (Abate and Yohannes, 1984; Brakohiapa *et al.*, 1988). Mutamba (1988) in Zimbabwe has confirmed the role inappropriate weaning practices as important causes of malnutrition among children less than 5 years.

In Nigeria, it has been noted that early introduction of supplementary foods, especially where food preparation takes place in unsanitary conditions, increased colonization of the intestines with bacteria, increasing risks to diarrhoea in young children, and predisposing them to PEM (Elegbe and Ojofeitimi, 1984).

One of the major issues concerning inappropriate feeding practices is the lack of special weaning preparations for feeding young children in developing countries (Cameron and Hofvander, 1971). This problem has been specifically identified in countries including Ghana (Davey, 1962; Orraca-Tetteh, 1972), Ethiopia (Abate and Yohannes, 1984) and in India (Gopaldas *et al.*, 1991). Most young children, during the weaning and transitional periods are therefore fed porridges, which are bulky in nature or adult diets, which are inadequate to meet the needs of the fast growing children. In Ghana, fermented corndough porridge (*Koko*) has remained the single favourite weaning food. *Koko* has poor protein quality and low energy density and does not support good growth (Orraca-Tetteh, 1972; Asiedu *et al.*, 1993a).

The need and benefits of supplementary food and weaning formulations have been long recognized (Platt *et al.*, 1961; Cameron and Hofvander, 1976; Pellet and Mamarbachi, 1979; Beaton and Ghassemi, 1982). The search for nutritious weaning formulations from local foods has for many years engaged the attention of several international and local organizations as well as researchers. The Protein Advisory Group for instance, has for over four decades, been concerned with development and testing sources of low-cost, protein-rich weaning foods (PAG, 1975).

Researchers in many developing countries have also worked on local weaning formulations (Uwaegbute and Nnanyelugo, 1987a; Luhila and Chipula, 1988; Gupta and Sehgal, 1992). In Ghana, the Ministry of Health with support from UNICEF, World Bank, World Vision International, and WHO, has developed and promoted the use of Weanimix, a cereal/legume weaning blend, since 1986. A workshop on National Food and Nutrition Policy in 1988 addressed the need to promote local production and utilization of low-cost weaning foods including cereal-legume blends and using fish for feeding young children. The Association of African Universities (AAU) Food and Nutrition Project has organized workshops to discuss issues related to the development of “high-protein-energy foods” from grain legumes for weaning (AAU, 1993). Indeed, several suitable formulations based on Ghanaian cereals and legumes have been made by local researchers (Abbey and Mark-Balm, 1988; Sefa-

Dedeh and Ampadu, 1991; Plahar and Hoyle, 1991; Nti and Plahar, 1995; Addo *et al.*, 1996). A maize/fish blend has been formulated by Asiedu *et al.*, (1993a). All these efforts prove the determination by researchers to find solutions to the feeding problems of young children.

Most of the formulations however, are double mixes, generally aimed at infants but there is a need for multi mixes, which closely resemble the family diet for the child one-year and above. Such mixes or meals would not only supply protein and energy but also provide natural sources of vitamins and minerals needed for the total development of the fast-growing child. Such meals would also enhance a smooth transition to adult meals by the toddler. Although traditional meals as fed to toddlers have been criticized as poor in quality, many people will continue to depend on it. Therefore, in the face of declining incomes, modified home-made traditional weaning meals are workable alternatives to promote.

Improving existing traditional meals by making them appropriate for young children therefore, must be seriously addressed to support the recommendations of researchers of home-made weaning foods like Platt, Miller and Payne (1961), Cameron and Hofvander (1971), Orraca-Tetteh (1972), and Pellet and Mamarbachi (1979). Improvement of the traditional diet could be made by simple, but effective modifications of the texture, flavor, energy and nutrient density and reduction of bulk.

The protein quality of most common staples, legumes, animal products and other foods is known, but there is limited information on Ghanaian mixed meals. There is also a recognized need to analyze and ascertain the nutritional quality of such local mixtures, and to find out their capacities to support growth, especially in humans (FAO/WHO/UNU, 1985). An additional need is the determination of the extent to which amino acid scores and biological assays in rats give realistic estimates of the protein value of human meals. In Africa and particularly in Ghana, little work has been done on human feeding trials for the purposes of evaluating the quality of meals.

1.1 Aim of the Study

From the background presented, this study aims at formulating nutritious, home-made meals using local foods, with the view to promote traditional weaning foods for solving malnutrition among young children especially those from poor families.

1.2 Objectives

The specific objectives are:

1. To determine the energy, protein, mineral, and vitamin contents of the test meals and compare with *koko*.
2. To determine the amino acid composition of the test meals, and thus calculate their protein scores as a measure of their protein quality.
3. To assess the biological utilisation of the protein quality of the test meals by nitrogen balance in rats.
4. To assess the overall nutritional value of the test meals and their capacities to rehabilitate malnourished pre-school children.
5. To make inferences about the relationship between the results of the chemical and biological determinations of protein quality, and between the results of the animal and human experiments.

1.3 Significance of the Study

The results of this study hold much relevance to ensuring feeding nutritionally adequate local meals to young Ghanaian children during the transitional period of weaning, through the use of modified home-made traditional meals. It is hoped that the demonstration of the efficacy of the test meals, will help promote wide-scale use of local meals, especially among the poor sections of our communities who cannot afford commercial toddler foods, and in the nutrition rehabilitation centres to feed malnourished pre-school children back to normal nutritional status. The data derived from the study will provide additional information on traditional weaning foods.

1.4 Definition of Terms

Certain terms used in this presentation are defined below as used in the present study.

Weaning Period - the period during which a young child is being fed breast milk as well as supplementary foods.

Transitional weaning period - refers to the period especially from 1 year to 3 years when young children may or may not have been taken off the breast and are being fed semi-adult or adult meals.

Transitional weaning foods - are dishes specifically prepared for a young child between 1 and 3 years with modified texture to suit the child.

A meal - is used to mean a mixture of foods prepared for consumption at one sitting.

Composite dish - a mixture of foods prepared and presented as one dish and not as two separate dishes of a staple with a stew or soup as is traditionally presented for family meals in Ghana.

Study Children - include all the children who participated in the study comprising of those who were fed the meals and those who served as “control”.

Experimental Children –those who were fed the test meals.

Cornmeal – is the same as maize meal.

Corndough – is fermented maize dough.

Corndough Porridge - is fermented maize dough porridge also known as “*Koko*”.



2.0

REVIEW OF LITERATURE

2.1. Food and nutritional requirements of preschool children

For the normal growing infant, the major source of energy and nutrients is breastmilk. The current procedure considered appropriate for feeding infants follows the Innocent Declaration in 1990, which endorsed health experts' recommendations of four to six months exclusive breast feeding as a means of decreasing infant morbidity and mortality. Hence most nutritionists like Jelliffe and Jelliffe (1989), in their discussion of the dietary management of young children with acute diarrhoea and Hendricks and Badruddin (1992) in making weaning recommendations, support the exclusive breast feeding proposal. Paediatric groups also recommend the idea as a practical recommendation to solve some of the current health problems among young children (Hervada and Newman, 1992).

Complementary foods are to be added gradually, changing the variety and quantity as the child's nutritional needs and ability to handle greater complexity of foods increase during the first year of life (Guthrie, 1989). In a review of current scientific knowledge on complementary feeding of young children in developing countries (WHO, 1998), it is recommended that the age of introduction of complementary feeding should start from about 6 months. From this period, the infant should begin to receive a variety of locally available and safely prepared foods rich in energy in addition to breast milk. Guthrie (1989) further explains that by one year, the capacity of the child's stomach has increased so that smaller, more frequent feedings are no longer necessary. Besides, the digestive system, liver and kidneys are mature enough to handle a wide variety of foods.

Although growth rate slows down after the first year of life, the child's nutrient needs are still relatively higher than adult needs. Therefore, the diet must

provide appropriate amounts of energy and nutrients to support steady growth. Harper (1994) in his discussion of recommended dietary intakes (RDI) explains that the FAO/WHO Safe Intakes of nutrients are for meeting needs of essentially all individuals in the specified age and sex groups.

The FAO/WHO recommendations for preschool children presented in Table 2.1 will be used as reference requirements in this study since these have been adopted widely as appropriate safe intakes for public health recommendations.

Table 2.1 FAO Recommended Dietary Intakes for Children

| Age (yrs) | Median Wt (kg) | Energy ^a (kcal) | Protein ^a (g) | Ca ^b (mg) | Fe ^c (mg) | Zn ^d (mg) | Vit. A ^c (µg RE) | Thiam ^e (mg) | Ribo ^e (mg) | Niac ^e (mg NE) | Vit. C ^f (mg) |
|-----------|----------------|----------------------------|--------------------------|----------------------|----------------------|----------------------|-----------------------------|-------------------------|------------------------|---------------------------|--------------------------|
| 1-2 | 11.0 | 1150 | 13.5 | 600-700 | 10 | 4 | 400 | 0.6 | 0.6 | 8 | 20 |
| 2-3 | 13.5 | 1350 | 15.5 | 600-700 | 10 | 4 | 400 | 0.7 | 0.7 | 9 | 20 |
| 3-5 | 16.5 | 1550 | 17.5 | 600-700 | 10 | 4 | 400 | 0.8 | 0.9 | 10 | 20 |

Sources:
 a. FAO/WHO/UNU (1985)
 b. FAO/WHO (1962)
 c. FAO/WHO/UNU (1988)
 d. WHO (1973)
 e. FAO/WHO (1967)
 f. WHO (1970)

Harper (1994) stresses that the RDI must be met from as wide a variety of foods as is possible. The pattern of increase varies for different nutrients in relation to their role in growth of specific tissues.

Increase in energy is needed for basal metabolism, physical activity and amount to be stored as adipose tissue. The energy needs of the average preschool child (1-3 years) are estimated at 100kcal per kilogram body weight per day. Therefore, a child who eats three meals a day would require 30-35kcal per kilogram body weight from each meal to satisfy his requirements. The increase in muscle mass that accompany bone growth is met by protein intakes of 1.5g to 2g per kilogram body weight, although studies have shown that protein intakes around 1g per kilogram

body weight were enough to support normal growth. For instance, Torun *et al.* (1981) in their study of protein requirement of preschool children arrived at safe levels of intakes of 0.94g protein/kg/day for milk and 1.01g protein/kg/day for soybean isolate.

Similarly, Intengan *et al.* (1981) working with Filipino children consuming the local diet found that all the children had good nitrogen retention with intakes of 0.9g protein/kg/day and calculated the safe level of intakes as 1.0g/kg/day. However, Intengan and colleagues (1981) noted that when protein intake is too low, dietary energy is not used efficiently and weight gains are reduced, therefore it would be wise to stick to the higher values of the RDI as much as possible.

Water-soluble vitamins, thiamin, riboflavin and niacin are involved primarily in energy metabolism, so increases in their requirements are in proportion to total energy needs (Guthrie, 1983). Hence, requirements for the preschool child are set at 0.5mg/1000kcal for thiamin, 0.55mg/1000kcal for riboflavin, and 6.6mg/1000kcal for niacin. There are increased demands for vitamin A and C for maintaining epithelial cells and for synthesis of collagen respectively. The expansion of the vascular system in response to increase in body size makes demands for nutrients needed in blood formation including iron and protein.

Bone growth creates a need for calcium, phosphorus, vitamin D in addition to protein and other mineral elements. Van Wouwe (1995) relates the great significance of zinc in human nutrition to its role as a co-factor of over 200 enzymes and active in all metabolic pathways. Several investigators including Golden and Golden (1981), Clegg *et al.* (1989), Prasad (1991) and Van Wuowe (1995) have all noted the necessary role of zinc in protein synthesis, cell replication and appetite control. It is important to note that since RDI's are not rigid daily requirements but average

amounts to be consumed over a period of several days, small deficits on one day can be readily compensated for by a small surplus on another. Therefore, judging the adequacy of dietary intakes must be done with care.

2.2 Feeding Practices, Food Intakes and Quality of Diets of Pre-School Children

Adequate intakes of good quality food are necessary to ensure adequate supply of energy and nutrients for optimal healthy growth of preschool children. Although nutritional needs are known, UNICEF (1991) indicated that many children, especially in developing countries suffer from malnutrition. It is important therefore to examine the characteristics of feeding practices, food intakes and quality of food fed to children during the weaning and transitional periods.

2.2.1 Feeding Practices

Several studies and reviews have found that in most developing countries breast feeding is still practised for long periods (WHO, 1981 and 1982; Latham *et al.*, 1986). The universal practice of breast feeding has been reported by Diamond and Ashworth (1987) in Kenya, Mexico and Malaysia and Jackson *et al.* (1992) found the same in Thailand. Uwaegbute and Nnanyelugo (1987b) and Nnakwe (1995) have also reported that breast feeding is universal in Nigeria. In Ghana over 90% of mothers breast feed their babies for periods ranging from 15-20 months and no significant changes have occurred over the years as reported by Gomez (1993).

However, much as there is a need to continue and strengthen the tradition of breast feeding, it is now increasingly being recognized that timely supplementation with appropriate weaning foods are critical to the maintenance of healthy growth in young children. Beaton and Ghassemi (1982) in their review of supplementary

feeding programs for young children in developing countries found continuation of breast feeding together with complementary foods as desirable for 12 months or more. They recommended the use of supplementary foods that are locally available and prepared at minimal cost at home. This practice they realised would facilitate a gradual transition to good food consumption patterns of later years.

However, a look at supplementary feeding in many developing countries including Ghana reveals the common practice of early introduction of cereal porridges within the first three months of life. Abate and Yohannes (1984), reported this practice in Ethiopia so did Mokwena (1988), in Botswana, Ramakvelo (1988), in Rwanda and Nnakwe (1995), in Nigeria. In Ghana, the Ministry of Health (MOH, 1989 and 1992) has documented the practice of early introduction of cereal porridges. Fermented corndough porridge (*koko*), has remained the single favourite weaning food reported by many studies over the years (Commey, 1970; Gershon, 1978; MOH, 1992; Denueme, 1993).

Almost all children are first introduced to *koko* with or without sugar and milk, and continues to be fed well into the second and third years often as the only food supplement. Similarly, a study of severely malnourished children in Nigeria revealed that most of the mothers fed only pap (maize porridge like *koko*) to their children with salt or sugar and none used multimix feeds (Ighogboja, 1992).

It is a recognized fact that in most developing countries, there are no specially formulated weaning foods as pointed out by Orraca-Tetteh (1972) and Gershon (1978) in Ghana and in East Africa by Seenapa (1987). Abate and Yohannes (1984) and Gopaldas *et al.*, (1991) have also recognized the lack of special weaning foods in Ethiopia and India respectively.

Mothers' lack of information on what and how much to feed, how to prepare and when to introduce solid foods as observed by Uwaegbute and Nnanyelugo (1987b) in Nigeria probably explains why there are not many such weaning formulations. Consequently, young children are weaned onto bulky family diets prepared in such a way that the child cannot eat enough to meet his growing needs (Svanberg *et al.*, 1987; Seenapa, 1987).

In Ghana, family meals offered to children commonly consist of bulky staples served with small quantities of vegetable sauce, stew or soup often spiced with hot pepper making it difficult for the child to eat (MOH, 1989; Ferguson *et al.*, 1993). Reports of high consumption of purchased cooked foods, which are generally not prepared to meet the needs of children have been found by studies of preschool children in Ghana (Denueme, 1993; Ferguson *et al.*, 1993). The quality and safety of such foods have also been questioned by some patrons of ready-to-eat foods in studies like that of Opare-Obisaw (1998) and by the Ghana Ministry of Health (1992).

2.2.2 Quality of Weaning Foods

Golden and Golden (1991) have attributed growth failure in developing countries to be due in part to the monotonous, unbalanced diets deficient in energy and tissue synthesis nutrients. Allen *et al.* (1991) have linked malnutrition among Mexican preschool children to poor quality diet. Similarly, studies like those of Akinrele and Edwards (1971) and Ighogboja (1992) in Nigeria; Orraca-Tetteh (1972) in Ghana and Mokwena (1988) in Botswana have found traditional weaning foods to have poor quality protein and low energy density, which do not support good growth.

2.2.3 Food and Nutrient Intakes of Pre-school Children

Guthrie (1989) recommends three meals for the pre-school child plus snacks, which are essential because small children may not be able to eat sufficient amounts of food to satisfy nutrient needs in three meals. However, this pattern is not practised in most developing countries. For instance, in Rwanda as reported by Ramakvelo (1988) and in Mozambique by Lechtig and Srivastava (1988) most children are fed only one or two meals daily. Reports from Ghana indicate that pre-school children especially those off breastmilk consume three meals daily with generally no snacks given (Woolfe *et al.*, 1987; MOH, 1989; Denueme, 1993; Ferguson *et al.*, 1993b). Generally, inadequate energy, protein and deficiencies of iron, zinc, vitamins A and D have been found to be the most common during early childhood (Hendricks and Badrudin, 1992).

For children still breast feeding beyond fifteen months of age, Brakohiapa *et al.* (1988) found their energy and protein intakes to be lower than those eating solid foods alone due to the late introduction of solid foods.

Child care is an important factor affecting the child's dietary intake and therefore his nutritional status. In a recent discussion paper, Engle *et al.* (1996) defined 'care' as behaviours performed by caregivers that affect nutrient intake, health, and cognitive and psychosocial development of the child. The authors referred to findings in many societies where care-givers are passive feeders, leaving the initiative to eat to the child. They described feeding young children as an active process whereby care givers can encourage, cajole, offer more helpings, talk to the child while eating, model eating behaviour and monitor how much the child eats. All these activities ensure adequate dietary intakes of young children.

FAO/WHO (1992) reports studies from Mexico, Bangladesh, Nicaragua, Columbia, United States of America, Great Britain and Jamaica which give significant associations among one to two year olds between the caregivers' active role in child feeding and the child's food ingestion and nutritional status. Engle (1995) in a review of evidence of influences of child care on infant and pre-school child nutrition, pointed out that altered nutritional status may be significantly affected by the manner in which the mother or other primary caregivers respond to and care for the child. Similarly, Torun *et al.* (1984) in a study of malnourished preschool children on habitual Guatemalan diets observed the great need for someone to help the child eat at meal times to ensure good food intakes.

In Ghana, Woolfe *et al.* (1977) also acknowledged the role of constant encouragement to eat on good food intakes among pre-school children. FAO/WHO (1992) has therefore noted that time and patience during child feeding are essential to ensuring optimal infant growth and development. Therefore, linkages between food availability, care-giving behaviours and child nutrition are now being recognised.

2.3. Measuring Growth in Pre-school Children

A well-nourished child has good physical and emotional growth. Anthropometric measures are generally the best global indicators of physical well-being in children because inadequate food intake, poor nutritional quality of the diet and various infections affect growth (Martorell, 1995). In order to detect early health and nutritional problems that could lead to growth faltering or failure in growing children, growth monitoring is essential.

Growth monitoring involves following changes in the child's physical development, by regular measurement of weight, and sometimes of length

(ACC/SCN, 1990). Growth monitoring provides a basis for communicating with mothers and with health workers concerning child health and nutrition. Growth charts are used in both developed and developing countries, where children are regularly weighed and the results recorded on the charts. Monthly weight gain is the most important single indicator of a child's growth and is used as such in many countries the world over (UNICEF, 1991). A child's weight is a good indicator of his nutritional status especially for the under 5 years. As Torun & Chew (1994) put it, weight gain is the most practical criterion for recovery from PEM. If the weight is compared to a reference weight data of children the same age, the status can be quickly determined. As such, the most usual and widely recognized indicator of PEM is weight for age. However, the use of weight for age does not differentiate between wasting and stunting. But growth failure being failure to gain weight, length or both, requires measuring length to give more direct information on linear growth.

The best anthropometric assessment of nutritional status is therefore based on measurements of weight and height and records of age to calculate two indices; weight for height, as an index of current nutritional status; and height for age, an index of past nutritional history. Waterlow (1976) suggested the terms wasting for a deficit in weight for height, and stunting for a deficit in height for age. The intensity of wasting and stunting is determined by calculating percentage deviations from the reference median or standard deviations from the mean or Z-scores.

These indicators are derived from those obtained from an international reference population. WHO (1983) has recommended the use of the United States National Centre for Health Statistics (NCHS) growth percentiles as an international reference data. The use of standard deviation (SD) scores are recommended for evaluating anthropometric data from less industrialised countries (Gibson, 1990).

2.4 PEM in Pre-School Children



2.3.1. Description of PEM

West (1991) describes growth failure as representing the most prevalent expression of childhood malnutrition in developing countries. Cameron and Hofvander (1983) describe a child experiencing growth failure as one who has stopped growing or growing slowly weeks or months before clinical signs appear. Growth faltering or failure is often associated with weaning and usually occurs before children are three years old. Martorell (1995) has pointed to data from Egypt, Kenya and Mexico which indicate that most of the deceleration in growth occurs before 2 years. Nweze (1995) in a review of the effects and causes of PEM in Nigeria found that the most vulnerable age in Nigeria is two to three years. Similarly the Ghana Demographic Health Survey (GDHS, 1993) puts the peak levels of PEM in Ghana at between 15 and 24 months.

Description of PEM by Torun and Chew (1994) and Schofield and Ashworth (1996) show that dietary energy and protein deficiencies usually occur together in malnourished children but sometimes one predominates. Severe forms lead to the clinical syndromes of kwashiorkor (predominant protein deficiency) or marasmus (predominant energy deficiency). Kwashiorkor is a word from the Ga language, Accra, Ghana. The word indicates “the disease of the deposed baby when the next one is born” (Williams, 1963). The word was first introduced into medical history in 1933 by Dr. Cicely Williams, then working in Ghana, to describe an oedematous disease she observed in weanlings who, shortly after being taken off the mother’s breast began to exhibit the symptoms of protein malnutrition.

Kwashiorkor is often associated with late weaning and poor protein and high energy intakes, while marasmus, a Greek word meaning wasting is really due to starvation or not having enough of any kind of food. Marasmus is often associated with early weaning or infrequent feeding and diarrhoea.

2.4.2 Classification of PEM

Gibson (1990) summarises systems available for classifying malnutrition based on anthropometric indices. All utilise at least one anthropometric index and one or more reference limits drawn from an appropriate reference data to identify individuals at risk of malnutrition and in some cases identify the type and severity.

When using standard deviation scores or Z-scores, an underweight child is one who has a weight for age Z-score below $-2SD$ of the NCHS reference median. This condition is a result of chronic or acute under-nutrition or both. A stunted child has a height for age Z-score below $-2SD$ of the NCHS reference median. Such a child is short for his age as a result of chronic under-nutrition or illness. A wasted child is too thin for his height and has a weight for height Z-score below $-2SD$ of the NCHS reference median. The condition is the result of recent failure to receive adequate nutrition and may be affected by acute illness, particularly diarrhoea.

Schemes like the Gomez and Wellcome classifications referred to by Gibson (1990) utilise weight-for-age for the anthropometric index and reference limits corresponding to specified percentages of the Harvard weight-for-age reference median. In the Gomez classification, malnutrition is classified into first, second and third degrees, corresponding to 90% to 76%; 75% to 61%; and <60%; of the median Harvard weight for age reference data respectively. This classification does not differentiate between marasmus and kwashiorkor.

The Wellcome classification includes the occurrence of oedema to assist distinguish between marasmus and kwashiorkor. When the percentage expected weight for age of the child is 80% to 60% and there is oedema, the child has kwashiorkor. However, in the absence of oedema, the child is described as underweight.

If the percentage expected weight for age is less than 60%, the child has marasmic- kwashiorkor when oedema is present. In the absence of oedema, the child has marasmus. Like the Gomez classification, the Wellcome classification does not differentiate between wasting and stunting because height is not taken into account.

The Waterlow classification uses two anthropometric indices, height for age and weight for height together with risk categories designed to indicate the severity as well as type of malnutrition. This classification defines four broad categories of nutritional status (a) normal; (b) wasting; (c) stunting and wasting; (d) stunting only. By using this system, a distinction can be made between children who are wasted, those who are stunted, or those who are both wasted and stunted.

2.4.3. Prevalence of PEM

The World Food Summit report by FAO (1996) indicated that 199 million children below 5 years in developing countries suffer from acute to chronic protein and energy deficiencies. UNICEF (1991) reported that of the malnourished children in the developing world in 1990, 26% came from Africa. Data compiled by ACC/SCN (1997) from 1980 to 1995 showed that 34% of preschool children in developing countries were stunted and the prevalence of underweight was 31%. For the African region as a whole, no progress was made in reducing the prevalence of child malnutrition over the fifteen-year period, and there is some indication that the prevalence has increased. Stunting has increased by 62% during the period. Trends in the prevalence of underweight are similar to those of stunting with an increase in prevalence from 1985-1995.

In East Africa, Sserunjogi (1988) in Uganda reported that 30% of preschool children suffer from chronic malnutrition and Lechtig and Srivastava (1988) estimated prevalence of acute and chronic malnutrition in Mozambique as 57%.

In Ghana, the Ministry of Health (MOH, 1992) reported PEM as the most widespread and serious health and nutritional disorder among children. Between 1980 and 1987, 30% of all children under 5 years were malnourished. Findings from the 1993 Ghana Demographic Health survey showed that about one quarter (28%) of children 0-35 months were stunted almost the same as the 30% reported in 1988 (USAID, 1995). The data also showed that 30% of 3-35 months old children were underweight and the prevalence had not changed since 1988 (31%). It is a matter of

concern that the high level of acute under-nutrition (wasting) in Ghana was second only to Niger in Sub-Saharan countries surveyed.

2.4.4. Causes of PEM

The major underlying causes of PEM have been attributed to social, economic and environmental factors. These factors interact in several ways to give rise to several problems, which cause and or precipitate malnutrition in young children. Outstanding among these problems are poverty; inappropriate feeding practices; ignorance; lack of weaning foods; poor care practices; beliefs, taboos and misconceptions about foods; poor sanitation and poor water supplies.

The FAO on World Food Day in 1992 stressed that poverty is the main cause of malnutrition in the world. Poverty is a major constraint to access to food as reported by Ighogboja (1992), and Nnakwe (1995) in Nigeria, and in Rwanda by Ramakvelo (1988). In Jamaica, Golden and Golden (1991) attributed the monotony and poor diets to poverty, and in Ghana, the Ministry of Health (MOH, 1992) attributed the lack of food leading to PEM to poverty.

Inappropriate feeding practices including early introduction of supplementary food, abrupt weaning or breast feeding for too long without adequate complementary feeding lead to PEM. Mutamba (1988) in Zimbabwe confirmed the role of inappropriate weaning practices as an important cause of malnutrition among children under 5 years. Elegbe and Ojofeitimi (1984) noted that early introduction of supplementary foods, especially where food preparation takes place in unsanitary conditions, increased colonization of intestines with bacteria, therefore increasing risks to diarrhoea in young children and predisposing them to PEM.

The problem of abrupt weaning without adequate complementary feeding has been implicated in the development of PEM (Torun and Chew, 1994). The Ghana Ministry of Health (MOH, 1989) reported high incidence of the practice of abrupt stoppage of breast-feeding in Ghana, making the children lose appetite and refuse to

eat which predisposed them to PEM. Prolonged breast-feeding beyond the age of 19 months was associated with malnutrition by Brakohiapa *et al.* (1988) since it reduces total food intake and breast milk can no longer provide sufficient nourishment.

Ignorance as a result of illiteracy leads to lack of knowledge about food, nutrition and health needs of young children, which can lead to PEM. A study of 400 severely malnourished children in the Middle Belt of Nigeria by Ighogboja (1992) indicated that besides poverty, illiteracy and ignorance of appropriate supplements to feed were root causes of PEM in the children. It has also been documented that mothers who have some education are better able to bring up children with better nutritional status than do illiterate mothers (Piwoz and Viteri, 1981; Chandhury, 1986). In Ghana, under-nutrition has been found to be considerably higher among children of mothers with no education or only primary education than among those with secondary or higher education (USAID, 1995; GSS/MACRO INT., 1998).

The lack of special diet or food appropriate for weaning has long been identified as a major contributor to child malnutrition in developing countries (Davey, 1974). Ramakvelo (1988) in reporting the causes of malnutrition in Rwanda said that persistent child malnutrition in Rwanda is largely attributed to the lack of special diet for children because mothers have no time or money to prepare such foods. Abate and Yohannes (1984) reporting from Ethiopia also made the same remarks about the lack of appropriate foods to feed young children. As a result of this lack of appropriate weaning foods, most young children are mainly fed porridges with low concentrations of energy and nutrients or bulky adult diets, which they cannot eat enough of to meet their needs.

FAO/WHO (1992a) has stated that while the immediate causes of malnutrition may be inadequate dietary intake in relation to needs, the underlying causes may be related to problems including child care. The common constraints to providing care, including feeding was identified as due to the heavy workload of women, the primary caregivers. Sserunjogi (1988) mentioned the lack of time by mothers in Uganda to prepare extra meals for children resulting in infrequent feeding as is also the case in

Rwanda (Ramakvelo, 1988). There is growing evidence on how nutritional status of young children may be significantly affected by the manner in which the mother or other primary caregivers respond to and care for them.

Other underlying factors causing PEM are beliefs, taboos and misconceptions about the use of certain foods which restrict variety in the diets (Abate and Yohannes, 1984), or cause uneven distribution of food in the family (Mothibe, 1990), thus affecting the quality of diets consumed. In Ghana for instance, there is the belief in certain areas that children should not get accustomed to too much fish as it may not always be available. Again, there is the belief that regular provision of eggs and meat may encourage petty thievery (MOH, 1992).

ACC/SCN (1997) made reference to UNICEF's current thinking that the immediate causes of malnutrition are poor diet and disease. Poor sanitation, poor water supply and overcrowding are major factors leading to repeated episodes of diarrhoea and other infectious diseases, which increase the risk of development of malnutrition in young children (Cameron and Hofvander, 1983; Torun and Chew, 1994). The 1993 Ghana Demographic Health Survey showed that where an adequate supply of good quality water is not available and hygiene is poor, the risk of food contamination increased the risk of diarrhoeal disease and under-nutrition among children under three years of age.

2.4.5. Infectious And Parasitic Diseases Associated with PEM

At the International Conference on Nutrition in 1992, it was pointed out that the interaction between nutrition and infection remains the most prevalent public health problem in the world today (FAO/WHO, 1992). The malnutrition infection complex (MIC) contributes to increased incidence of growth faltering, PEM and micro-nutrient deficiencies. MIC is illustrated by Cameron and Hofvander (1983) like this: "Children from poor homes are likely to have frequent episodes of infections and likely to be malnourished. A sick child does not want to eat, so he becomes more

malnourished. A malnourished child is less able to fight infection, so infections make malnutrition worse and vice versa.”

Infections that contribute to and precipitate malnutrition include diarrhoea, respiratory infections, and measles. Intestinal parasitic diseases also result in poor growth in children causing PEM in the long run. Infections affect protein requirements by inducing some degree of depletion of body nitrogen (Pellet, Vernon and Young, 1980) and tend to cause anorexia, reducing food intake and metabolic disturbances like decreased nutrient absorption and increased catabolic processes (Torun and Chew, 1994). Frequent episodes of infections are known to reduce the rate and increase in both weight and height (FAO/WHO/UNU, 1985). Ashworth (1980) in a study of practical aspects of dietary management during rehabilitation from severe PEM observed that superimposed infections and infestations influenced rates of recovery in spite of optimal food intakes, leading to poor weight gain.

Diarrhoea and vomiting cause a child, who is marginally malnourished to develop frank malnutrition through decreased dietary intake, decreased nutrient absorption and increased catabolism. It has been found that during an episode of diarrhoea, total energy intake can be reduced by as much as 20-40% (FAO/WHO/UNU, 1985). Acute watery diarrhoea is often associated with decreased absorption from 90% to 70% of both macro and micro-nutrients (FAO/WHO, 1992). The study of Ighogboja (1992) in Nigeria showed that diarrhoea was the commonest disease (67.3%) associated with malnutrition. In Ghana, diarrhoea is common among preschool children, with about 34% of children having severe diarrhoea each year (MOH, 1992).

Acute respiratory infections are associated with growth faltering as a result of the associated fever which increases metabolic rate and because of anorexia, vomiting and difficulty in breathing and swallowing, a reduction in food intake occurs (UNICEF, 1993).

Measles can precipitate malnutrition where increased fever and painful mouth lesions depress food intake. It frequently precipitates vitamin A deficiency too.

Pneumonia and persistent diarrhoea often complicate measles causing growth faltering and micro-nutrient deficiency (FAO/WHO, 1992a). Available information, indicates that 75% of all children in Ghana have measles before 2 years of age (MOH, 1992).

The impact of malaria on nutritional status in young children depends on the intensity of infection. The fever causes reduction in food intake and loss of iron, which may lead to anaemia. Treating malaria rapidly prevents weight loss and anaemia (FAO/WHO, 1992a). Several intestinal parasites have been found to be associated with malnutrition. Ascaris infection is associated with growth faltering and deficiencies of vitamin A and Zinc. Minakami *et al.* (1992) examined 269 pre-school children and found the overall infection prevalence as 39.8% and the commonest parasite was ascaris in 26% of the children. Giardia can cause growth faltering and in severe cases can produce marked weight loss, nutrient malabsorption, and deficiencies of vitamin A and folic acid. Hookworm is well known as a cause of iron deficiency anaemia.

2.4.6 Micro-nutrient Deficiencies Associated with PEM

Micro-nutrient deficiencies that are commonly associated with PEM are vitamin A, iron and zinc deficiencies. Vitamin A deficiency (VAD) is usually associated with PEM. Vitamin A deficiency is associated with a wide range of disorders, from blinding xerophthalmia to apparent compromises in growth, resistance to infection and survival (West, 1991; ACC/SCN, 1997). Data compiled by ACC/SCN (1997) show that in the early 1980's, xerophthalmia was estimated to afflict 4-8 million preschool children and to cause half a million cases of childhood blindness, two thirds of whom died. VAD prevalence and trend estimates for 1985 and 1995 show global reduction from 5 million children clinically afflicted in 1985 to 3.3 million in 1995. However, the goal to eliminate VAD related blindness by the end

of the decade will not be achieved at the rate of the decline. Vitamin A deficiency has long been associated with increased risk of infection (West, 1991).

There is considerable evidence suggesting that clinical and possibly sub-clinical vitamin A deficiency may be associated with increased risk of mortality from infection (Tomkins and Husey, 1989). Studies in North Sumatra by Sommer *et al.* (1986) showed a direct effect of vitamin A supplementation on reducing child mortality by as much as 34%. Although improving Vitamin A intakes for young children will carry numerous benefits, prevention and control programmes, using mainly periodic high-dose supplements frequently fail to reach those at greatest risk. Besides, the intervention tends to be expensive (McLaren *et al.*, 1965). Improving the diet so that the child receives regular low intakes of vitamin A provided naturally by food is considered a worthwhile long-term solution(ACC/SCN, (1997)).

Iron deficiency anaemia (IDA) is said to be the most prevalent nutritional deficiency worldwide, with over 90% of affected persons living in developing countries (ACC/SCN, 1997). It affects particularly women of reproductive age and pre-school children. Current Ghanaian data (MOH, 1998) show over 70% prevalence of anaemia among school-age children. Children are known to be especially susceptible to the development of iron deficiency anaemia between 6 and 18 months of age. Nnakwe (1995) has reviewed the effects and causes of PEM in Nigeria which showed that the reduction in haemoglobin often accompanied severe PEM. Iron deficiency anaemia is reported in children suffering from PEM.

Prominent causes of iron deficiency anaemia include low dietary intakes of iron and low bioavailability of dietary iron in some foods especially plant foods (ACC/SCN, 1997). Yartey (1990) studied the bioavailability of iron in some Ghanaian weaning foods, and showed that bioavailability was much higher in fermented cereal foods than in the unfermented ones. The relative biological value (RBV) of iron was higher in the fermented maize *koko* (76%) and fermented maize and fish (80%) than in the weanimixes based on the unfermented cereals of maize

(63%), sorghum (49%), and millet (48%). This supports the promotion and use of fermented cereal foods.

A diet lacking in protein is usually deficient in iron, folic acid and sometimes vitamin B₁₂, all of which are primary nutrients in haemoglobin synthesis. Blood loss caused by intestinal helminths especially hookworm infections and malaria are prime causes of iron deficiency anaemia. There is also evidence that iron metabolism is disrupted when vitamin A is deficient in the diet and this may aggravate the consequences of iron deficiency (ACC/SCN, 1991).

The consequences of IDA are numerous as iron plays a central role in the mechanism for oxygen transport, and essential in many enzyme systems. Of greatest concern is that IDA in infants and children is associated with impaired physical and cognitive development (Pollitt, 1991; ACC/SCN, 1991). For instance, Pollitt (1991) reviewed findings of three studies on effects of diets deficient in iron on growth and development of pre-school and school-age children, and reported that: children who were anaemic did not learn concepts of identity and differences nor perform as well as children with replete iron stores. Attention has also been drawn to the increased susceptibility to infection by anaemia, a condition which leads to and aggravates PEM (ACC/SCN, 1991).

Clinical findings show a possibility that PEM may be an overlapping of the deficiency of the symptoms of both protein and zinc (Asibey-Berko, 1990; Clegg *et al.*, 1989; Prasad, 1991). Growth retardation is a well- recognised feature in mild zinc deficiency in children (Hambidge, *et al.*, 1972). A number of symptoms of PEM also occurring during zinc deficiency have long been recognized (Smit and Pretorius, 1964) and recently confirmed by Prasad (1991) and Wouwe (1995). They include growth failure, lethargy, loss of appetite, skin defects, hair loss, and enlarged liver. ACC/SCN (1997) report acknowledges that the prevalence of zinc deficiency is not known, but that the prevalence is probably similar to that of nutritional iron deficiency because the same dietary pattern induces both.

Preschool children studied in Ghana by Ferguson *et al.* (1993a) had sub-optimal zinc status and this may not be any different in other developing countries. There is evidence to show that zinc supplementation reduces the prevalence, severity and duration of diarrhoea, reduces malarial morbidity and produces more rapid weight gain in severely malnourished children (ACC/SCN, 1997). However, dietary strategies suggested for improving zinc nutriture by Ferguson *et al.* (1995) for pre-school children in Ghana and Malawi, would be a more sustainable approach.

2.5. The Consequences of Malnutrition

The physical, social and economic costs of early childhood malnutrition have far-reaching consequences. Kwashiorkor and marasmus, the severe forms of malnutrition in children are fatal if left untreated. In 1973, Jelliffe described death rates among severely malnourished children as being twenty to fifty times the death rate of children in rich and prosperous communities in Europe and America. UNICEF (1991) describes child and infant mortality as unacceptably high in many parts of the world in that, each day about 40,000 children die from malnutrition and disease. This high death rate leads to waste of potential manpower.

Recently, Schofield and Ashworth (1996) reviewed literature over the past 5 decades and found that the median case fatality from severe malnutrition has remained unchanged over the period and it is typically 20-30%, with the highest levels, 50%-60% among those with oedematous malnutrition. In Nigeria, Nnakwe (1995) showed a 40% mortality rate among hospital cases of PEM, and that it is the second cause of death in children under six years.

Malnutrition increases morbidity and undermines a child's health. As USAID (1970) puts it, even if the child survives PEM, he may fail to reach his potential of physical and mental growth. Growth retardation accompanies malnutrition in childhood. Torun and Chew (1994) explain that treatment of mild to moderate PEM corrects the acute signs of the disease, but children's catch-up growth in height may take a long time or might never be achieved. This results in stunting and a small body

size, which may influence maximal adult working capacity and increased obstetric risk for women.

ACC/SCN (1990) has made reference to growth studies carried out in poor societies indicating that all the growth retardation occurred in the first 2 or 3 years of life. The studies from Guatemala and India showed that growth failure in early childhood is not addressed through catch-up growth in later childhood and adolescence. Cross-sectional studies reviewed by Martorell *et al.* (1994) have also indicated that the retardation of early childhood growth appears to persist into adulthood with only modest attenuation. However, stunting can be reduced in early childhood if the environment is improved through supplementary feeding.

Champakan *et al.* (1968) concluded from their studies that despite the fact that a good treatment of PEM is life saving, it is not always sufficient to protect children from future mental disorders. They observed learning disabilities and poor performance in intelligence tests among children who had suffered severe PEM between 18-36 months. School-age children who had been hospitalised because of severe malnutrition before 30 months of age, were reported to have had significantly lower performances in hearing and visual exercises than their siblings (Cravioto and Delicardie, 1973). This lag in neuro-integrative development, increases the children's chances of becoming poor readers. Ebrahim (1983) has also cited studies from Jamaica, South Africa and Uganda, connecting the persistence of low I.Q. well into adolescence with damage to mental function as a result of severe malnutrition in the first 2 years of life. For example, the 74 Jamaican school-age boys who had suffered severe malnutrition in early childhood were compared with male siblings closest in age and classmates or neighbours matched for age and sex. The IQ was found to be significantly lower in all aspects of measurements. The study in South Africa followed up 20 children who were severely malnourished in infancy until 15-18 years. They all scored low on full scale verbal quotient and 17 of them also showed a marked disturbance of visual-motor perception.

Martorell *et al.* (1994) have also pointed out that the effects of early childhood malnutrition on learning and behaviour may not be redressed fully by the conditions which can produce catch-up growth. Autopsies of children who died of malnutrition before 2 years have revealed a smaller number of brain cells (Winnick, 1974) which probably explains the reduced mental capability of children in the studies mentioned above. Ritchie (1983) further points out that, even if possible consequences of malnutrition on brain development are disregarded, poor nutrition still has damaging effect on learning. This is explained by the fact that the malnourished child has little energy to run or walk about and be curious. He is often sick leading to decreased participation in learning experiences. Hence, the malnourished child is disadvantaged and will know much less than children who are well nourished.

Ritchie (1983) has drawn attention to the fact that the cost of malnutrition in a country increases her economic burden as well as that of the family.

A malnourished child in the family causes a drain on family resources by his frequent illness and puts so much strain on limited national health facilities.

The consequences of malnutrition in later life resulting in absenteeism, illness, lassitude, stunted physique and generally poor performance capacity, all slow down the economic and social progress of developing nations (AID, 1970).

2.6 Evaluating Protein Quality in Foods and Meals

The nutritional value of a dietary protein or mixture of proteins depends primarily on its capacity to satisfy the needs for nitrogen and essential amino acids for the synthesis of nitrogen-containing compounds in the body. This concept provides the fundamental basis for all methods that attempt to assess the protein nutritive value of a food. Many attempts have been made to give a numerical value to the quality of both individual dietary proteins and mixtures of proteins present in various human diets.

2.6.1. Animal Experimentation

The protein to be tested is fed to rats and its capacity to maintain nitrogen balance or to promote growth is measured. The nitrogen balance technique involves the determination of the difference between the intake of nitrogen and the amount excreted in urine, faeces, together with minor losses by other routes.

Nitrogen balance results are commonly expressed simply as the percentage of nitrogen intake retained without taking into account integumental, obligatory urinary, and obligatory faecal nitrogen losses because these are relatively constant and hard to measure (UNU, 1980). The experimental animal is said to be in nitrogen balance when the nitrogen intake (I) in the diet equals the nitrogen output in the urine (U) and faeces (F). When the balance is negative, it is interpreted as a loss of tissue protein. When the balance is positive, the experimental animal is presumed to be laying down tissue protein.

The most commonly used indices derived from nitrogen balance results, which are used to describe the protein-quality are Biological Value (BV), and Net Protein Utilisation (NPU). The BV is a measure of the proportion of absorbed nitrogen that is retained for maintenance and/or growth. The measured urinary and faecal nitrogen is corrected by subtracting the quantities lost on a protein-free diet. Njaa (1963) worked out the obligatory loss of nitrogen in faeces as 0.02mg N/g feed . The obligatory loss of nitrogen in urine he obtained was $W^{0.75} \times k$, where W represents the average body weight (g) of the animal during the 5 day balance period, and k is equal to 0.645. The BV makes no allowance for losses of nitrogen in digestion but this is included in NPU, which is a combined measure of digestibility and efficiency of utilisation of the test protein for protein synthesis. It is normally measured with the protein intake at or below maintenance levels. However, FAO/WHO/UNU (1985) explains that when practical diets are concerned, it is necessary to consider the digestibility of the mixed dietary proteins. Therefore in animal assays, the human diets are fed without modifications and the net protein utilisation obtained is termed operative (NPUop).

For a combined measure of both the quantity and quality of protein in the diet, the Net Dietary Protein Calories percent (NDpCals%) is calculated. This index was introduced by Platt *et al.*, (1961) and described as an estimate of utilisable protein content of the diet in terms of calories expressed as a percentage of the total metabolizable energy (kcal). It is often convenient to express the protein content of a food in terms of the percentage of energy provided by protein (PE). The NDpCals% is calculated as the product of the NPUop% and PE%.

2.6.2. Utilising Amino Acid Profile

A chemical grading of the quality of a protein can be made by comparing the amino acid composition and its pattern in a food or mixture with the reference pattern which is considered ideal for human requirements (Cameron and Hofvander, 1976). The essential amino acid reference pattern by FAO (1973) is recommended for use by UNU (1980). The value obtained by this assessment is called the chemical score, amino acid score or protein score. The score may be taken as a first approximation to the probable efficiency of utilization of the test protein or mixture. Ideally, the score should be calculated for all essential amino acids and the lowest score taken. In practice however, scores based on lysine, total sulphur-containing amino acids, tryptophan and threonine found to be limiting in most foods and diets are used to evaluate them (UNU, 1980). The amino acid that gives the lowest score is the one, which limits the value of the protein and it is called the limiting amino acid. To improve on the accuracy of protein scoring procedures, the amino acid score must be corrected for digestibility especially where children are concerned in order to make adjustments for safe protein intakes (FAO/WHO/UNU, 1985).

Digestibility appears to be the most important factor determining the capacity of the protein in a usual mixed diet to meet protein needs of both young children and adults. The usefulness of the score is reflected by the Codex Committee on Vegetable Proteins, which has recommended amino acid scores, corrected for true digestibility (as determined by Nitrogen balance method) as the most suitable routine method for

evaluating protein quality of vegetable protein products and other food products (Sarwar and McDonough, 1990).

Another index derived from the amino acid composition of the test food or meal, useful in the evaluation of dietary protein is the proportions of total amino acids (T) that are supplied as essential amino acids (E). This index known as the E/T ratio can be used to determine the effectiveness of a protein in meeting the requirements of infants and young children (FAO/WHO/UNU, 1985).

2.7. Combating PEM : Considerations for Catch-Up Growth

The nutritional therapy of malnourished children must aim at repairing existing abnormalities of body composition, replenishing micro-nutrient reserves and permitting accelerated rates of weight gain. From experience in the dietary management of severe PEM, Ashworth (1980) is of the opinion that after the acute phase, diet plays a crucial role during the rehabilitation period. She further suggests that if milk is not available, simple modifications of the local diet can improve rates of recovery and reduce mortality. Brown (1991b) in considering appropriate diets for rehabilitation of malnourished children has also suggested that nutritional rehabilitation can be completed in the community setting using locally prepared mixtures when the acute phase is over. However, in planning these mixtures, the needs for catch-up growth must be considered.

FAO/WHO/UNU (1985) has stated that at all rates of catch-up growth, there will be some increase in the ratio of protein to energy requirement, over and above that appropriate to the age of the child. For catch-up growth to occur, there is a relatively greater need for protein than for energy. For instance, the percentage increase in protein and energy to allow for twice the "normal" growth rate for the 1 to 2 year old child is 25 to 32% and 3.5 to 5% respectively.

The apparent relationship between energy and protein supplies led to the introduction of the ratio of protein energy to total energy (PE%) by Platt *et al.* (1961). Generally, a diet providing 12% of total energy as protein is considered as a good

source of protein (Harper, 1974). For rapid catch-up growth during recovery from PEM, Ashworth (1979) suggested that protein must provide at least 10% of total dietary energy. However, calculations by Whitehead (1977) indicate that 8.6% of energy as protein supported catch-up growth of 30g/day (3 times normal gains) and 9.7% is needed to support catch up growth of 50g/day (5 times normal gains in pre-school children). Intengan *et al.* (1981) in their study noted that there was a trend towards increased rates of weight gain with protein energy above 4%.

When protein requirements are considered in terms of the grams per kilogram body weight, the normal child, 1 to 4 years requires 1.09 – 1.26 grams protein per kilogram body weight per day of reference protein (FAO/WHO, UNU, 1985). However, Torun *et al.* (1981) had found that 0.94g/kg/day of milk protein and 1.01g/kg/day of soy protein supported growth in preschool children who had recovered from malnutrition. Using the calculations by Whitehead (1977) a 1-3 year old child needs 1.79g protein/kg/day to produce catch-up weight gain of 30g per day.

Intengan *et al.* (1981) who worked on an improved habitual Philippine diet to produce catch-up growth in malnourished preschool children, observed good nitrogen retention with intakes of 0.9g protein/kg/day of non-milk protein. However, they noted appreciable weight gains when protein intakes were 1.7g/kg/day.

MacLean and Graham (1980) have noted that inadequate protein: energy ratio may result in reduced rates of weight gain or greater proportions of body weight may be gained as fat than fat-free mass. Platt *et al.* (1961) recommended NDpCals% of 7.8 for preschool children and 5.9% for older children. However, Pellett and Mamarbachi (1979) have recommended NDpCals% of 6.5-7.0% as adequate for pre-school children. Whitehead (1977) also worked out NDpCals% to allow for catch-up growth in children and arrived at 5% for normal growth (10g/day) 6.5% and 7.3% to gain 30g and 50g per day respectively.

The energy needs of the average 1-3 year old child were estimated by FAO (1973) as 100 kcal/kilogram body weight per day. The Protein Advisory Group (1972) recommended that for malnourished children, 120-150 kcal/kg/day may be

necessary. Torun *et al.* (1981) have showed that energy needs of 2-4 year olds can be satisfied on improved habitual Guatemalan diet with intakes of 80-85 kcal/kg/day. They further observed that intakes of 95-105 kcal/kg/day allowed catch-up growth in mild to moderate malnutrition. The calculations by Whitehead (1977) for energy requirements for different rates of growth during recovery from PEM, indicate an intake of 123 kcal/kg/day to produce catch-up weight gain of 30g per day (three times the normal rate) and 133 kcal/kg/day would produce 50g/day.

Indeed several studies have demonstrated positive linear relationship between the level of dietary energy intake and the rate of weight gain in recovering malnourished children (Ashworth, 1980; Fjeld *et al.*, 1989; Brown, 1991a; Rivera *et al.*, 1991).

Growth, be it normal or catch-up requires all other nutrients. It has however been noticed that few studies have specifically addressed the micro-nutrient requirements for rehabilitation of severely malnourished children. Brown (1991b) has suggested that until more specific information is available, it would be seen appropriate to recommend micro-nutrient density that maintains as a minimum, the Recommended Dietary Allowances for healthy children.

2.8. Improving Weaning Foods

The search for nutritious weaning formulations have engaged the attention of several international organisations and researchers for many years. The Agency for International Development (AID) has listed several protein-rich formulations like Incaparina in Central America, Vitasoy in Hongkong, and Superamine in Algeria among others, which have been used to cure protein-energy malnutrition in young children. For many years, large-scale supplementary feeding of malnourished children with nutritious supplements including some of the above-mentioned products has often been used as emergency solutions. However, it has been observed that such food distribution programmes are rather expensive for the measured benefit (Beaton and Ghassemi, 1982).

2.8.1. Supplementation

The need to look for local solutions has been investigated by researchers in many developing countries who have made several efforts to improve the mainly carbohydrate foods fed to toddlers. Others have formulated and evaluated blends using local foods. Most efforts have targeted improving the energy and protein densities by incorporating fish, legumes and oil seeds into the mainly carbohydrate-rich foods based on cereals and root crops.

In Ghana, the need to formulate nutritious weaning foods from local foods has long been recommended by (Davey, 1961/62). Studies by Yartey (1990) and Asiedu (1993a) revealed that growth performance of rats on fermented maize supplemented with fish was comparable to casein diet. Hence the authors recommended that fortifying the traditional Ghanaian fermented maize porridge (*koko*) with a protein-rich source like fish could enhance its nutritive value. It is a recognized fact that animal foods like fish are the best protein sources but they tend to be expensive and not always available to poor families. Under such circumstances, complementing the staple food (usually maize) with legumes could permit a good essential amino acid complementation and improve the biological value of the dietary protein. Brown *et al.* (1988) drew attention to potential supplements including cowpeas, groundnuts, melonseeds and soybeans. However, they noted that groundnuts and melonseeds are not ideal because of their relatively low lysine contents.

Supplementing cereals with legumes to provide weaning blends with improved protein quality and quantity has therefore received a lot of attention. In Ghana, fermented maize supplemented with soybeans improved the protein quality (Plahar and Leung, 1983). A combination of soybeans with maize pap, '*soy-ogi*' by Akinrele and Edwards (1971) was found to be valuable in the management of malnutrition. Cowpea/cereal blends have also been extensively investigated.

Earlier studies by Orraca-Tetteh (1970, 1972) reported an improvement of NPU% and NdpCals% of maize/cowpea mixture over that of maize porridge, '*koko*'. The NPU% of the maize/cowpeas was 56% compared to 44.5% for *koko*, and the

NdpCals% was 8.7% for maize/cowpeas and 3.8% for *koko*. Later studies by Akinyele and Fasaye (1988) and recently by Nti and Plahar (1995) have also demonstrated that supplementing maize gruel “*ogi*” and “*koko*” with cowpeas increase protein concentration from 8.1% in *ogi* to 13.2% and 9.0% in *koko* to 13.2%.

Similarly, Uwaegbute and Nnanyelugo (1987) found that PER increased threefold when they supplemented “*ogi*” with cowpeas. They also concluded that cowpeas could be as effectively used instead of soybean in dietary formulation. Over two decades ago Oke (1975) recognized that though fishmeal and soybeans are good sources of protein for supplementing cereals, they are more costly and sometimes high levels produce unacceptable products. Besides, since they have no advantage over cowpeas the former need not be preferred to the latter.

Anti-nutritional factors like trypsin inhibitors in beans which limit their nutritional value have been recognized (Del Rosario *et al.* 1980). Soaking for 16-24 hours followed by 1-2 hours of cooking has been found to be effective in removing most inhibitory factors in legumes (Babar *et al.*, 1988; Akinyele, 1989). Nti and Plahar (1995) in addition to soaking, dehulled the cowpeas before cooking and blending with maize demonstrated an increase in BV and NPU by 23% more than the plain *koko*.

In Ghana, an internationally sponsored project through the Nutrition Division of the Ministry of Health, aimed at reducing growth faltering in infants by enriching locally made cereal porridges with legumes, yielded a product called “*weanimix*” which was introduced in 1986. This product investigated by Yartey (1990) using various combinations of different cereals and legumes did not support growth adequately in rats though better than plain “*koko*”. It is worth noting, that this practical way of improving protein quality of cereal porridges, by supplementation with legumes is widely being recommended and followed in many countries like Tanzania (Keregero and Kurwijila, 1988) and in Lesotho, Ethiopia and Nigeria, where Seenapa (1987) reported that a number of recipes based on cereal and legumes for household preparation are being promoted.

2.8.2. Role of Germination and Fermentation

The main problem limiting the efficiency of most of the cereal/legume blends is their bulky nature, which makes it difficult for the toddler to eat enough to meet his needs. Attempts have, however, been made to modify the starch to reduce bulk by using traditional processes like malting or germination and fermentation. Sprouting of cereals has a potential to reduce viscosity (Mosha and Svanberg, 1983; Luhila and Chipula, 1988; Gopaldas *et al.*, 1986; Kulkarni *et al.*, 1991). The mechanism behind reduction in viscosity is that amylolytic enzymes developed and activated in the germination process rapidly breakdown the starch in the cereal, reducing its water-holding capacity. As a result, the water trapped in the gel structure is released, producing a more liquid gruel (Mosha & Svanberg, 1990). Kulkarni *et al.* (1991) have reported that in addition to reduction in viscosity, germination improves the digestibility of grains.

Germinated cereals are known to have high energy densities (Mosha and Svanberg, 1983). It has also been demonstrated that germination improved the B-vitamin content in cereals (Asiedu *et al.*, 1993b). The properties of malted flour known as "Power Flour" (P.F.) in most parts of East Africa have provided opportunities for its promotion (Seenapa, 1987). In India, Gopaldas *et al.* (1991) have reported the high acceptance rate of germinated cereal flours or amylase-rich foods (ARF) among mothers of an urban slum.

The advantages of fermented foods in improving young child feeding in several parts of Africa have been well reviewed by Tomkins *et al.* (1987). The texture, taste and aroma of fermented food are generally considered more attractive and desirable than those of unfermented food. Fermentation has been found to reduce bulk (Lechtig and Srivastava, 1988; Mokwena, 1988; Asiedu *et al.*, 1993b). Fermentation has also been found to improve carbohydrate digestibility which is caused by the enhanced proteolytic activity of the fermenting microflora (Kpodo, 1995, Addo *et al.*, 1996). Although some studies found that fermentation and sprouting of cereals do not seem to improve the protein quality significantly (Asiedu

et al., 1993b), others have reported cases of improved general nutritional value by fermentation (Tomkins *et al.*, 1988) or specifically increases in the content of certain B vitamins (Keregero and Kurwijila, 1988). Improvement of nutrient bioavailability has also been observed in fermented foods compared to the unfermented. For example, Yartey (1990) observed an enhancing effect of fermentation on iron bioavailability in fermented maize and fish porridge.

Additional advantages of fermentation include improvement in shelf life, hence lessening mothers workload (Tomkins *et al.*, 1988, Lechtig and Srivastava, 1988). Linked with extended shelf life is the demonstration that fermentation reduces bacterial contamination of weaning food and so reduces gastro-enteritis in young children (Mensah *et al.*, 1988; Svanberg and Lorri, 1992).

2.9. Formulating Multimix Nutritious Home-made Weaning Foods

2.9.1. Need for acceptance

Any meal or food no matter how nutritious, is useful to the body only when it is accepted and eaten. Among the characteristics of good dietary quality, Brown (1991b) mentioned affordability, ease of preparation and appropriate organoleptic qualities. Some weaning blends developed so far have not had wide usage for lack of some of these characteristics. For instance, some blends developed for semi-commercial production are popular in supplementary feeding programmes at rehabilitation centres and in hospitals. However, Seenapa (1987) reported that these foods are yet to be affordable for household use in most parts of East Africa.

In Ghana, studies have revealed that *weanimix* has not been readily adopted by most mothers because they were not accustomed to it (Sosi *et al.*, 1991; Lartey and Quarshie, 1991). Again, while 84% of mothers studied by Lartey and Quarshie (1991) knew about *weanimix* only 21.9% fed it to their children because the preparation procedure was tedious, the product is expensive and the children refused to eat it. It is not always an easy task to persuade people to use unfamiliar food which

may have a new flavour, a different appearance and texture and which is not already a household commodity. As a result of familiarity with local foods, many authors including Ferguson *et al.* (1993) and Denueme (1993) have found that most mothers in Ghana use locally available foods for weaning.

2.9.2. Call For Improvement of Traditional Weaning Foods

A call for more research into traditional weaning practices as a strategy to combat child malnutrition in Zimbabwe made by Mutamba (1988) is certainly appropriate. Along the same lines, Abate and Yohannes (1984) have recommended support for practical and appropriate initiatives that address the improvement of the nutritional value for traditional and locally used weaning foods in Ethiopia as a means of improving feeding of young children. Hendrata (1987) on the other hand has stressed that since many efforts to improve young child feeding have failed, especially those made through weaning food projects, efforts must be made to promote traditional weaning foods. Sserunjogi (1988) has made a strong point worth noting that, "In the past, much criticism of African diets have been based on the high carbohydrate content. However, they still remain the major sources of nutrients and energy and many people will continue to survive on them".

Orraca-Tetteh (1972) found over two decades ago that, it was possible to improve the protein and energy values of local foods by properly making combinations such as cereals and legumes for feeding toddlers following the usual customary cooking procedures. In fact, Woolfe *et al.* (1977) in their study of food intakes of some 1-3 year olds showed that the traditional Ghanaian diet can adequately satisfy a healthy child's energy needs even as prepared in non-affluent families without addition of milk and other Western foods.

Torun *et al.* (1984) have demonstrated that the habitual Guatemalan diet can satisfy protein and energy needs of healthy and malnourished preschool children by increasing dietary diversity, providing sufficient food and helping the child to eat. It is not out of place therefore when Ighogboja (1992) recommended that since

commercial milk and cereal weaning products are expensive, weaning problems in Nigeria should be tackled by educating mothers on balanced weaning diets through the use of locally available foods such as cereals, legumes and green leafy vegetables. The Iringa project in Tanzania is a classic example of how rather than supplying supplementary foods, mothers were taught how to use local foods to meet their children's nutritional needs (Engle, 1995).

2.9.3. Providing Home-made-Mixtures

When considering promotion of local diets, it is obvious that formulations should involve multi mixes or combinations of more than two ingredients to resemble those the child will eat later on in life. Beaton and Ghassemi (1982) recommended the use of supplementary foods that are locally available and prepared at minimal cost at home. This will facilitate an orderly transition to nutritionally adequate post-weaning food consumption. Most communities have by age-long experiment come to use foods in mixtures, so that their nutrients complement one another (Jelliffe, 1969). In fact, an important generalisation in relation to human diets is that the wider the variety of foods included, the less the likelihood of nutritional deficiency occurring. Cameron and Hofvander (1971) and Pellett and Mamarbachi (1979) have demonstrated several supplementary food mixtures as suitable alternatives to manufactured products and proposed that the solution to the inadequate feeding of young children in developing countries lies in home-made mixtures.

2.9.4. Obtaining Proper Balance of Nutrients

Considerations to achieve proper balance of nutrients of the weaning diet have been emphasised. Seenapa (1987) emphasised the need to examine the weaning plate as a whole in terms of chemical composition. For years, most studies done on weaning foods have concentrated on increasing the energy and protein densities. Brown (1991a) has pointed out the neglect of due consideration of the quality and quantity of the weaning diet and recommended improvements. Similarly, Golden and

Golden (1991) have recommended that attention should be paid to both the nutrient quality and quantity of diets formulated for children.

It is a generally accepted fact that young children need more than energy and protein to grow properly. Therefore, all meals formulated for them must meet their needs for energy and all nutrients including protein. FAO/WHO/UNU (1985) has emphasised the need to recognize that the concentration of all other necessary nutrients should be considered when assessing the adequacy of a particular diet. It was stressed that it is potentially dangerous to consider energy or protein alone.

2.9.5 Appropriate Food Texture and Quantity

The need to consider texture appropriate for the young child necessitates that the child's meal be specially prepared. Since adults and older children can take care of themselves, special efforts must be made to prepare soft food with little or no hot spices so that the young child can eat enough to meet his needs. Some mothers do not prepare the child's food separately but feed him portions of the adult diet (Ministry of Health, Ghana, 1989; Gopaldas *et al.*, 1991). It is however important that the child's food be prepared separately, to provide an appropriate texture to feed him, until he has the stomach capacity and skill to eat adult food. Besides ensuring the right texture, one must also ensure that the serving portion of food offered the child is reasonable so that the child can consume all of it to benefit from all the dietary components incorporated.

2.9.6. Simple Modifications of Traditional Methods

Jelliffe (1969) advocated for simple but effective modifications of traditional methods of preparing food to provide suitable food for young children. In recent times, Mothibe (1990) has stressed the need to make small changes in traditional diets to provide simple, feasible, culturally acceptable meals that are nutritionally sound to improve young child nutrition. Jelliffe (1969), Cameron and Hofvander (1971, 1976) and, Pellett and Mamarbachi (1979) have suggested that the local staple, preferably a

cereal should be used to serve as base to which other food items will be added. The staple food would provide the main source of energy in the weaning food.

The next food item to select should be a good source of protein, which could be an animal product like fish or a legume. However, the review so far indicates that animal products as protein supplements tend to be expensive and according to the Ghana Living Standard Survey of 1988, adequate access to animal products like meats is restricted to relatively high income groups. In such a case, legumes are cheaper and more available protein sources to use.

Since groundnuts and melon seeds have relatively low lysine contents - the former being lower than the latter - and, soybeans being less widely used, cowpeas emerge as the preferred choice of supplement of cereal/legume mixtures. In fact, cowpeas are cheaper and more widely used as a source of food in Africa than soybeans. Prinyawiwatkul *et al.* (1996) have reported that West Africa produces 90% of the world's supply of cowpeas. Despite the relatively low lysine content of melon seeds, Cherry (1986) is of the opinion that the plants which thrive even in arid regions of West and South Africa are an under-exploited nutrient source. They are high in protein (28%), oils (up to 52%), calcium and niacin. Cherry (1986) believes that melon seeds in Africa have the same potential that soybean had in the United States decades ago.

2.9.7. Constituting Weaning Mixtures

Pellett and Mmarbachi (1979) following the procedure of Cameron and Hofvander (1976) varied the quantities of staples and supplements so as to meet the required NDpCals % with the minimum quantities, as well as supply approximately one third of the child's daily food energy requirement. The mixture proportions were adjusted for least bulk by including sugar or oil. Oil, a concentrated source of energy increases the energy density without adding to the volume of food.

Most recommended weaning blends (double mixtures) have high protein contents but because the energy is usually low (about 350 kcal per 100g dry weight

basis) the addition of oil in home-made preparations is ideal to increase energy density. For instance, the cereal/legume blend by Oyeleke *et al* (1985) contained 393 kcal, those by Enchill (1991) had energy values between 325 kcal and 398 kcal, and that by Nti and Plahar (1995) contained 356 kcal per 100 grams.

Jelliffe (1969) points out that if the staple is a tuber or plantain it would be necessary to add oil to provide “compact calories” to the meal since these foodstuffs are bulky due to the high water and fiber contents. Additional ingredients recommended for home-made weaning formulations are dark green leafy vegetables and other red or yellow foods to provide excellent sources of beta carotene and natural food sources of other vitamins and minerals.

2.10. Human Feeding Trials

Feeding of young children with new food or improved local food mixtures is generally intended to correct the problem of malnutrition. The beneficial effects of food supplementation on malnourished pre-school children have been demonstrated. Rivera *et al.* (1991) have demonstrated that supplementary feeding has substantial effect on recovery from moderate wasting even in populations with high prevalence of diarrhoea. Gardner *et al.* (1995) have also showed that supplementation among stunted pre-school children resulted in improved growth and development. According to the PAHO/INCAP group (1975), a field feeding trial to promote new or improved product serves as impartial scientific justification for its use by the target group. Therefore, the final stage of the nutritional evaluation of dietary protein is the determination of the capacity of the protein to meet nutritional requirements of the human target group (UNU, 1980). Hence, the field trial is entered into after data from pre-clinical and clinical testing have provided adequate evidence of safety and potential effectiveness (Gordon, 1970). Guzman (1969) maintains that field trials among children will provide data to support the potential effectiveness of the diets often demonstrated by clinical testing using animal models.

2.10.1 Tolerance and Acceptability

Among the recommendations for human testing of food mixtures are tests for tolerance and acceptability among the target group prior to full scale trials (PAG., 1972; PAHO/INCAP, 1975). Tolerance indicates the physiological reaction of the subject to the food, characterised by good digestibility, lack of vomiting, diarrhoea, constipation, or other undesirable effects.

Acceptability indicates the psychological reaction of the subject to the food in terms of liking or not liking its consistency, flavour, odour or any other organoleptic characteristic.

2.10.2. Experimental Subjects

The subjects best suited for definite results when testing the nutritive value of recommended diets for children are those under five years, the age group experiencing the highest incidence of malnutrition and the most rapid growth (P.A.G., 1969; Gordon, 1970; PAHO/INCAP, 1975; Ashworth, 1979).

Observations have shown that weight gains in children recovering from malnutrition are higher than in normal counterparts and thus the differences are more easily observed (Hansen and Waterlow, 1964; UNU, 1980). To determine whether an observed improvement in nutritional status of the test group is the result of the feeding programme, WHO (1983) recommends a 'control' or comparison group as part of the study design.

2.10.3. Location and Duration

Many field-feeding trials have been carried out in the community, but the P.A.G. (1972) recommends recuperation centres such as nutrition rehabilitation centres or hospital metabolic units as suitable for carrying out human testing for effective monitoring.

Many reported feeding trials vary in duration probably as a result of the study objectives or the financial and other logistical strength. PAHO/INCAP (1975)

recommends that where facilities exist, medium-term (4-6 months) growth studies in pre-school children (1-4 years.) would be ideal, but Ashworth (1980) from her own experience has suggested 6 to 8 weeks as maximum period necessary to rehabilitate even the severest cases of PEM.

However, Hansen and Waterlow (1964) are of the view that if weight gain is the only criterion used, weight gain must be measured over not less than 4 weeks. Parpia (1966) has reported studies of dietary treatment of children suffering from malnutrition in 4 weeks feeding period which yielded clear, measurable growth and clinical responses. DeMaeyer (1975) also found that trial periods of 2 to 5 weeks were acceptable for assessing the progress on human testing of protein food mixtures among pre-school children.

3.0 MATERIALS AND METHODS

The study was divided into five phases.

1. Development and Preparation of the Test Meals.
2. Acceptability and Tolerance Tests.
3. Chemical Analyses of the test Meals.
4. Animal Experiment.
5. Human study.



3.1 Development Of The Test Meals

Nine mixtures were formulated based on two widely used staples, maize and yam. **Maize** is the most widely used cereal in Ghana and it is used in the form of fermented corndough or cornmeal. **Yam** is used because it is a tuber crop, always available and commonly used for feeding young children (Asima, 1992; Mantey, 1992; Ferguson et al., 1993; Denueme et al 1993). Three meals each were prepared using corndough, cornmeal and yam. Each group of 3 meals was supplemented with either ground fish, cowpeas or melonseeds (locally called *agushi*), as the effective source of protein. **Fish** is used because it has high protein value, is easily available, reasonably cheap, and mothers claim using it for infant feeding. **Cowpeas** and **melonseeds** are used because they are high in protein and will provide relatively cheaper alternative sources of protein. White cowpeas are used because protein inhibitor activity is lower than in the red variety and therefore requires less cooking time to deactivate the inhibitor (Nti & Plahar, 1996). White cowpeas actually cook faster than red cowpeas. The white variety is also the most preferred in the Volta and Northern Regions of Ghana, where cowpeas are widely grown and consumed (Plahar and Dovlo, 1986).

Palm oil, the most available and commonly used oil was added to prepare all the meals as a concentrated source of energy and together with added green leaves, to supply carotene, a rich source of provitamin A. **Tomatoes** and **onions**, which are

common soup and stew ingredients were added to each formulation. Proportions of ingredients were selected in such a way that the energy content will meet approximately one third, and the protein content to meet about half of the daily requirement of a 1 - 3 year old child. Considerations were made to incorporate the minimum amount of supplement that would maximize protein nutritional value at minimum cost and provide a reasonable amount of meal that can be consumed by a 1 to 3 year old child at one sitting.

In order to estimate the protein quality of the meals, each was scored using Sulphur-containing amino acids (SAA) as basis. The scoring was based on the SAA because investigations have shown that the protein quality of 75% to 80% of meals and diets tested have been limited in the SAA (Cameron and Hofvander, 1976; FAO/WHO/UNU, 1985). The scoring consists of calculating the quantity of SAA contained in the mixture of proteins. The value is expressed in proportion to the content of the corresponding FAO (1973) reference pattern requirement (Appendix I). Calculations were made so that all the meals have similar protein contents with a NDpCals % of 8% or more which has been found suitable for feeding the young child (Pellet and Mamarbachi, 1979). Appendix 2 gives the calculated energy and protein contents and protein quality values.

An evaluation panel of six mothers evaluated the meals for smell, taste, texture and quantity as judged appropriate for young children. Three sessions of evaluations were carried out.

3.2 Preparation of Test Meals

All ingredients were obtained from local markets at Mamobi and Madina in Accra. The white local variety of **maize** (*Zea mays*) was used to prepare cornmeal and corn dough.

Cornmeal was prepared by cleaning the maize to get rid of foreign matter and milled at the local mill.

Corndough was prepared by washing the maize thoroughly and soaked for 24 hours. The water was drained and the corn was milled at the local mill.

The meal was mixed with water into a firm dough in the proportion of four parts of maize to one part of water and fermented for 24 hours. The dough was weighed into portion sizes and kept in the freezer until ready to use.

Yam (*Dioscorea* sp.) was peeled and cut into small pieces and used fresh at each meal preparation. The yam variety called “Pona” in Akan was used because it is soft and mashes easily.

Cowpeas (*Vigna unguiculata*)

The local white variety of cowpeas which are easy to dehull were used. The beans were washed and soaked for 10 - 15 minutes, dehulled and soaked for 12 hours. The beans were cooked until soft, mashed, and incorporated into the meal. This procedure is said to support growth better in rats by improving protein digestibility (Nti, 1991).

Melonseeds (*Citrillus vulgaris* sp.) were washed thoroughly and ground into a smooth paste, and mixed with a little water before using.

Fish Smoked Sprats (*Sardinella* sp.) were cleaned by removing the skin and heads, and milled with a kitchen electric mill. The fish meal was kept in an airtight bottle until needed.

All ingredients were weighed using a Philips electronic scale type HR2385/A (Max 5kg d =1g). When all ingredients were assembled, customary cooking procedures were followed to prepare the meals to soft, dropping consistencies. It takes 20-25 minutes to prepare any of the test meals, excluding soaking and dehulling cowpeas. The composition of the experimental meals are given in Table 3.1.

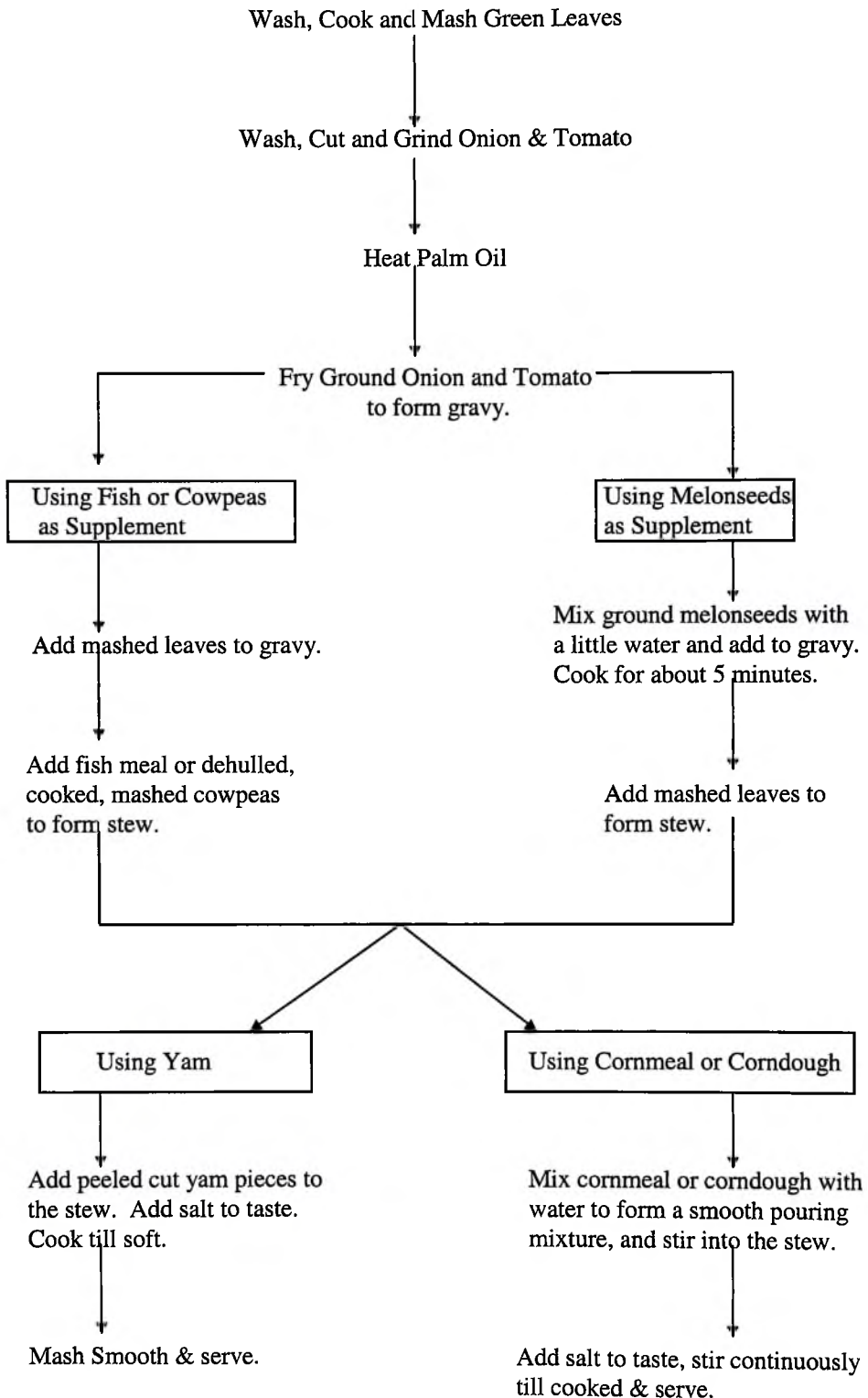
TABLE 3.1 Composition Of Experimental Meals

| Ingredients | Meals and amounts of ingredients used (g) | | | | | | | | | |
|---|---|-----|------|------|-----|------|-----|------|------|--|
| | Cd/C | Y/C | Cm/C | Cm/F | Y/F | Cd/F | Y/M | Cm/M | Cd/M | |
| <u>Staple</u> | | | | | | | | | | |
| Corndough | 120 | - | - | - | - | 120 | - | - | 120 | |
| Yam | - | 150 | - | - | 150 | - | 150 | - | - | |
| Cornmeal | - | - | 60 | 75 | - | - | - | 60 | - | |
| <u>Source of Protein Supplement</u> | | | | | | | | | | |
| Cowpeas | 30 | 40 | 30 | - | - | - | - | - | - | |
| Fish | - | - | - | 5 | 10 | 5 | - | - | - | |
| Melon seeds | - | - | - | - | - | - | 20 | 15 | 15 | |
| <u>Additional Ingredients Common to all meals</u> | | | | | | | | | | |
| Cocoyam leaves | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | |
| Tomatoes | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | |
| Onions | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | |
| Palm Oil | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | |

- Cd/C Corndough + Cowpeas + additional ingredients
- Y/C - Yam + Cowpea + additional ingredients
- Cm/C - Cornmeal + Cowpeas + additional ingredients
- Cm/F Cornmeal + Fish + additional ingredients
- Y/F - Yam + Fish + additional ingredients
- Y/M - Yam + Melonseeds + additional ingredients
- Cm/M Cornmeal + Melonseeds + additional ingredients
- Cd/M - Corndough + Melonseeds + additional ingredients

3.2.1. Procedure for Preparing a Serving Portion of Each Meal

The steps for the preparation and cooking of the meals are illustrated by Figure 1.

Fig. 1 Flow Chart for Preparation of Test Meals

3.3 Preparation of Samples for Chemical Analyses and Animal Experiments

Samples of the test meals were freshly prepared and dried for 6-7 hours in a laboratory air-oven at 60°C. The samples were cooled and sealed in polythene bags, and stored in a freezer until needed. Chemical analyses and animal experiments were carried out at the Institute of Nutrition, Directorate of Fisheries in Bergen, Norway. The dried samples were milled with a kitchen electric mill and further ground in a porcelain mortar by hand, packed and sealed in polythene bags and stored in the cold room (-4° to -5°C) until ready for use.

Freshly prepared samples of test meals were freeze-dried and chemically analysed to provide data for the energy, nutrients and amino acid compositions to represent as closely as possible the value of the meals as they are usually consumed.

3.4 Proximate And Nutrient Analyses of Meals

3.4.1 Moisture

Moisture was determined by the official methods of AOAC (1990). Five grams of the wet samples (in duplicate) were weighed and placed in an oven at 104°C for 20 hours. The cooled samples were weighed, dried and reweighed till constant weights were obtained.

3.4.2. Ash

Ash was determined according to Mortensen and Wallin (1989). One gram samples (in duplicate) were put in porcelain crucibles and placed in a muffle furnace. The samples were ignited and temperature was gradually increased to 550°C and left for 20 hours. The samples were cooled and weighed.

3.4.3. Fat

Fat was determined using ethyl acetate as the extraction medium, as described by Losnegard et al. (1979). Each determination was in duplicate. Freeze dried samples (2-5g) were mixed with 30ml ethyl acetate, and stirred for 2 hours. The samples were filtered through a folded filter paper (Schleicher and Shuell 597, 1/2, Ø 150mm), and 10ml transferred to a glass crucible with known weight. The ethyl acetate evaporated overnight in a fume cupboard. The extracts were dried for 2hrs in an oven at 70°C. After cooling, the samples were weighed and the fat content calculated.

3.4.4. Energy

Gross energy was determined using a Gallenkamp Autobomb automatic adiabatic bomb calorimeter CB - 100 (London, UK). Benzoic acid was used as the thermochemical standard. Duplicate samples were determined for each meal. The gross energy value was calculated from the increase in temperature of the water in the calorimeter vessel and the mean effective heat capacity of the system.

3.4.5 Protein

Crude protein (percent Nitrogen x 6.25) was determined using the Perkin Elmer 2410 Series II Nitrogen Analyzer. The equipment employs the combustion chemistry of the classical Dumas and Liebig method to release the nitrogen. The gas is then measured as a function of thermal conductivity. EDTA (9.59% Nitrogen) was used to calibrate the analyzer. To determine the nitrogen content in test foods, a known weight (40-60g) of each sample was used. Replicates of 2 - 4 of each sample were analyzed.

3.4.6 Nitrogen in Faecal and Urine samples

The nitrogen content in rat faecal samples was determined using a known weight (40 to 60 g) of each sample. For the rat urine, 100µl sample was weighed and

then cellulose added to soak the liquid to enhance combustion of the sample without spilling. Replicates of 2 - 4 of each sample were analyzed.

3.4.7 Amino Acids (excluding Tryptophan)

The amino acid composition of the meal samples was determined using a modification of the Pico-Tag Method (Cohen *et al.*, 1989) and carried out as described in the Quality Handbook of the Institute of Nutrition, Directorate of Fisheries, Norway (1996). Duplicate samples equivalent to about 30mg of protein were hydrolysed in 60ml of 6M HCl, for 22 hours at 110°C in closed flasks in an oven (Termaks by Heigar & Co, Oslo). Norleucine was used as an internal standard. The amino acids were separated and analyzed with a Waters HPLC system (Millipore Corp. 1987).

3.4.8 Tryptophan

Tryptophan was determined following the procedure in the Quality Handbook of the Institute of Nutrition, Directorate of Fisheries, Norway (1996). The method is based on a Ba(OH)₂ hydrolysis as described by Sachse (1981) and the tryptophan was detected by using a SUPERCOSIL™ LC - 18HPLC - column. 0.45g of samples were hydrolysed with barium hydroxide for 20 hours at 110°C, and then cooled to room temperature. The pH was adjusted with hydrochloric acid to be in the range 3 - 4. The hydrolysates were diluted with distilled water to 50ml, an aliquot was filtered into a cromacol glass tube. Tryptophan was determined in a HPLC-system (Shimadzu 6A/6B), equipped with a Suelguard LC-18 precolumn and a supelcosil LC -18 column, and detected by a spectrophotometer at 280nm. A mobile phase composed of 0.7g natriumacetate and 0.8L distilled water (pH adjusted with acetic acid to 4.0) was used. The tryptophan content was calculated using L-tryptophan 0.1mg ml⁻¹ as a standard.

3.4.9 Thiamin

Thiamin was determined using *Lactobacillus viridescens* (ATCC 12706) after Diebel et al. (1957). The vitamin was extracted with 0.1N H₂SO₄ for 30 minutes in flowing stream autoclave. The extract was incubated with 0.15M sodium acetate buffer overnight at 37°C. The turbidity of the solutions was measured at 660nm by a spectrophotometer. A standard curve was plotted and from this, the concentration in the samples was determined.

3.4.10 Riboflavin

Riboflavin was determined using *Leuconostoc mesenteroides* (ATCC 10100) after the method of Barton-Wright (1963). Riboflavin is very sensitive to both visible and ultraviolet light so all analyses were carried out in subdued light. Measurement of growth was done as described under thiamin determination.

3.4.11 Niacin

Niacin was determined using *Lactobacillus plantarum* (ATCC 8014), a modification of the AOAC (1980) method. The vitamin was extracted with 0.5M H₂SO₄ for 30 minutes at 116 - 120°C and pH adjusted to 6.8 with NaOH. This was inoculated at 37°C for 22 hours. Turbidity was measured at 575nm. A standard curve was plotted and from this, the concentration in the samples was determined.

3.4.12 Vitamin A

Vitamin A (isomers of retinal and retinol) was analyzed in samples with a minimum of 20mg of each sample using saponification and an HPLC method modified after Lambertsen (1983). The samples were homogenized and saponified (20min at 100°C) using ethanol (4ml, 96%), KOH(0.5ml, 20% w/v) with the addition of pyrogallol, ascorbic acid, and EDTA (0.5ml) saturated solution. The samples were then extracted three times with n-hexane. The HPLC determinations of the retinol and retinal isomers were performed with a Shimadzu (LC-9A) pump, uv-detector

(Shimadzu, SPD-2A, 325nm) by an autoinjector (Shimadzu, SIL-6B/9A), a column (4.6 * 1150mm) packed with silica gel (LiChrosorb, 3µm) and 10% 2-propanol in n-hexane (v/v) as mobile phase. The method determines total retinol and does not differentiate between the free and esterified form.

The HPLC determinations of carotenoids were performed with a spectra Physics Analytical pump (P1000), a uv-detector (Shimadzu- SPD-2A, 450nm) by an autoinjector (Shimadzu, SIL-6B/9A), and a column (Vydac, 218BTP54, 4.6 * 250mm, 5µm). Two percent tetrahydrofuran in n-hexane (v/v) was used as the mobile phase. The amounts of the different isomers were calculated using retinyl acetate as standard.

For vitamin A values, the Retinol Equivalent (RE) was determined on the basis that $1\mu\text{gRE}=6\mu\text{g } \beta\text{-carotene}$.

3.4.13 Minerals

Five mineral elements, Calcium (Ca), Iron (Fe), Zinc (Zn) Potassium (K) and Phosphorus (P) were determined. The samples were digested in $\text{HC10}_4/\text{H}_2\text{SO}_4$ as described by Julshamn et al. (1982). All the elements were measured by atomic absorption spectrophotometer (AAS). Ca, Fe, Zn and K were determined by acetylene-air-flame atomic absorption (Perkin Elmer 3300) and phosphorus by graphite furnace AAS (Perkin Elmer 4110ZL).

3.5 Animal Study: Evaluation of Protein Quality

The quality of the mixture of proteins in the test meals was evaluated by Nitrogen balance method. Casein was used as standard control diet. Corndough porridge (*koko*) was also fed for purposes of comparison. The compositions are presented in Tables 3.2 and 3.3 respectively.

Table 3.2: Composition of Casein Diet

| Content | Amount (%) |
|---------------------|------------|
| Fat | 5 |
| Protein (Casein) | 8 |
| Mineral/Vitamin mix | 17 |
| Dextrin | 70 |
| Total | 100 |

Table 3.3: Composition of Corndough Porridge (*Koko*)

| Ingredient | Amount (g) |
|------------|------------|
| Corndough | 120 |
| Sugar | 20 |

Albino Møll-Wistar male rats (obtained from Møllegaard Avls laboratorium, Køge, Denmark) were used as experimental animals, with body weight in the range of 64 – 79g. Six rats were randomly assigned to each meal. The animals were housed in individual metabolic cages and kept in a room with constant temperature of $20^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and maintained on a 12h cycle of light and dark. The animals were fed with the meals ad libitum. Water was also available ad libitum.

A four-day preliminary and acclimatization period was followed by five days experimental balance period. The animals were weighed at the beginning and at the end of the acclimatization period, and at the end of the experimental period. The animals were not fed or given water 3 hours before weighing. Faeces were collected from each animal during the experimental period, air dried, ground into a fine powder in a mortar, and the nitrogen content determined. Urine was collected for each animal

during the balance period. One milliliter of 5% sulphuric acid (H_2SO_4) was put into each urine collecting receptacle at the beginning of the balance period. The nitrogen contents of urine samples were determined.

3.6 Acceptability & Tolerance Tests

Before initiating the experimental feeding of the test meals to the malnourished children, acceptability by both children and their mothers and also tolerance of the children to the meals were determined.

The Maamobi Nutrition Rehabilitation Centre at the Maamobi Polyclinic in Accra was the site for the Trials. Children who were malnourished and needed rehabilitation were used. Five to six children aged between 12 months and 23 months attending the center, were randomly assigned to each meal. The trials took 5 days. One meal was prepared on the 1st day and 2 meals prepared on each of the remaining 4 days. Meals were freshly prepared each day with the assistance of mothers, and served at lunch time (between 12.45 and 1.00pm). A little of the food was given to the child's mother to taste, and to give her opinions on the taste, smell, colour and texture and also to comment on the preparation time and ingredients used. One hundred grams of the test meal was weighed into individual bowls for mothers to feed the children. Note was taken of how much food was consumed and the zeal with which each child ate the meal.

Mothers were asked to observe and report the day after the feeding, any signs of ill health in their children following the eating of the test meals. Acceptability was judged by how much food the child consumed. The test meal is accepted if the child ate more than half of the food served. Tolerance was judged by the absence of diarrhoea, flatus, bloating, vomiting and undigested food in the stool. (See Appendix 8 for the evaluation format followed).

3.7 Human Study

3.7.1 Study Location and Subjects

The main feeding trial was carried out at a nutrition rehabilitation center run by the Nutrition Division of the Ministry of Health at the Mamobi Polyclinic in Accra, the same place where the acceptability and tolerance tests were done. The center functions actively, therefore many cases of PEM are referred there for the children to be rehabilitated to normal nutritional status. The clinic serves a large number of people especially those from the slum areas in Northwestern section of Accra.

When a mother or caregiver brought the malnourished child to the centre, the child was examined, weighed and registered. The mother is then interviewed for a record of demographic data. Clinical data on the child were also noted. Mothers/caregivers report in the morning and go back home after lunch. At the time of the study, each child received porridge prepared with wheat-soy blend (WSB) for breakfast, and a local dish was served for lunch from Monday to Friday, by the Centre. Each mother contributed ₵100 towards the meals. Mothers are given nutrition and health education talks once a week and showed how to combine local foods to obtain nutritious meals for feeding their children and themselves. The mothers cooked all the meals served at the centre. The centre usually catered for 20 to 30 children daily. Children are weighed weekly, usually on Fridays and weight records are kept on individual Child Welfare cards, as well as in a general register. When a child recovers, he is discharged from daily attendance but is required to report weekly for weighing until the centre staff can trust the mother to maintain the child's health for a whole month before reporting for weighing. All registered children are given take-home food ration (donated food aid) when it is available on weighing days. Sixty children recruited for the study were aged between 1 and 4 years, whose mothers or caregivers consented to take part. The children were stratified by age groups and randomly assigned to the test meals and the comparison group. Forty-five were assigned experimental meals and 15 served as controls.

3.7.2 Test Feeding and Dietary Assessment

Three feeding trials were conducted between August 1997 and February 1998. In the first trial, the 3 meals prepared with cornmeal were fed. In the second trial, the 3 meals prepared with corndough were fed and in the third trial, the 3 meals prepared with yam were fed. Each trial lasted four weeks. Groups of 5 experimental children were randomly assigned to each meal and five served as controls in each trial period. The test meals were freshly prepared each day and fed at lunch time (12.30pm. and 1.30pm.) from Monday to Friday. Each child received his weighed ration in an individual bowl and was fed by hand or with a spoon by their care givers. Left over food was recorded to estimate the food intakes of the test meals of each child. The control children were not fed any of the test meals. The whole study group ate the centre's porridge for breakfast, but at lunch time, while the test meals replaced the centre's lunch for the experimental group, the controls were fed the centre's lunch. A typical day's menu at the centre was wheat/soy blend porridge served for breakfast, and *banku* with palmfruit soup or groundnut soup served for lunch.

Estimated daily food intakes were determined for two days during the study period for both experimental and control groups. The estimates were made using a combined 24 hour dietary recall of food consumed at home, and weighed food consumed at the centre. The mother or care-giver was asked to recall all foods and beverages consumed by the child during the previous 24 hours, beginning with the morning meal and ending with the last meal of the day. The quantities of purchased foods were estimated by recording their monetary equivalents and purchasing them and weighing later. The quantities of other foods were estimated in household measures. For example, soup and stew ladles used at the centre which the mothers were very familiar with were used to assist in estimating the amounts of stew and soup consumed. Porridges were estimated using each individual child's cup, the volume of which had already been recorded. *Fufu*, *Banku*, and *Tuo* were estimated by asking mothers to show in adult or child's fist sizes.

Mothers were asked to estimate intakes like fish, yam, banana, orange by showing them real food items. The foods consumed were converted into weights by weighing the size of the actual food mentioned. For soups and stews, the weights of equivalent portion of similar soups and stews served at the centre were used. For those not served at the center, samples were prepared and the equivalent portions weighed. The intakes were used to calculate the energy and nutrient intakes.

3.7.3 Anthropometric Assessment

The main nutritional treatment effect was measured in terms of physical growth. Weight and height or length were the parameters measured. Nude weight was measured at the beginning of the study and weekly thereafter till the end of the feeding programme. Height or length was measured at the beginning and at the end of the feeding programme. All measurements were taken by the researcher assisted by the nutrition technical officers at the center. A Seca electronic paediatric scale which weighs to the nearest 10g was used to take the weights. The scale was calibrated before each weighing session.

3.7.4 Laboratory Investigations

All study children except for those in the first trial (Cornmeal dishes) were tested for intestinal and malaria parasites, hemoglobin status, and sickling traits prior to the commencement of the feeding programme. Those who had worms and malaria were treated before the feeding began. Haemoglobin was determined again after the feeding programme.

The children in the first group had no laboratory investigations done prior to the feeding trial, because the mothers were initially unco-operative. But at the end of the study when rapport had been established, mothers agreed to have stool samples of their children tested. Those found with worms were treated.

3.7.5 Morbidity data

A daily record of episodes of diarrhoea, fever, respiratory tract infections, vomiting, and other illnesses among the study children were kept throughout the study period. Each morning as the children were brought in, mothers were asked for any observed changes in health of their children. The researcher also examined the children for any visible signs of illness. Weekly summaries of observations were made and collated for the final summary at the end of the feeding trial.

3.7.6. Background data

Mothers or caregivers of the study children were interviewed using a general questionnaire to obtain demographic and background information on the study children and their families. Additional information obtained included the child's eating patterns, health history, home living conditions and the mother's opinion of the test meals.

3.8 Data Analysis

The energy and nutrient intakes were calculated using food composition tables and literature values (Ferguson et al., 1990; Cameron & Hofvander, 1983; Eyson et al., 1975; Watson, 1971). The average daily intakes of energy, protein and other nutrients of the children were compared to the FAO/WHO requirements given in Table 2.1.

The gains in weight and height were the principal indices of growth. The Z-scores of the indices; height-for-age (HAZ), weight-for-age (WAZ), and weight-for-height (WHZ) were calculated for each child, and compared with the NCHS reference data (WHO, 1983). The analyses of the data consisted of comparisons of experimental and control groups in terms of the observed response variables. Analysis of Covariance was used to determine the significance of differences in anthropometric

indices after the study. Differences between means were evaluated by Tukey's Honest Significant Difference (HSD) test. Differences were considered significant at the 5% level of significance.

Amino acid scores of the meals were calculated using the essential amino acid values obtained from the chemical analyses. The amino acid reference pattern recommended by FAO/WHO (1973) and reproduced by Pellet and Young (UNU, 1980) as well as the pattern recommended by FAO/WHO/UNU (1985) for the pre-school child were used as reference standards.

Apparent digestibility (AD%), True digestibility (TD%), Biological Value (BV%), Net Protein Utilization operative (NPUop%) and Net Dietary Protein Calories percent (NDpCal%) were calculated from the data obtained from the balance studies.

Analysis of the data from the animal study consisted of straight comparisons of experimental and control groups and among experimental groups, using Analysis of Variance (ANOVA). Differences between means were evaluated by Tukey's Honest Significant Difference (HSD) test. Differences were considered significant when the probability of obtaining them by chance was 5% or less.

Calculations

All statistics were calculated using SPSS 9.0 computer software. The formulae used for calculating all indices are given in Appendix 3.

4.0 RESULTS AND DISCUSSIONS

4.1 CHEMICAL ANALYSES OF TEST MEALS

Selected proximate factors as well as mineral and vitamin contents of the test meals and plain corndough porridge (*koko*) were determined. The need to achieve nutrient balance of weaning foods has been emphasized by many authors (Seenapa,1987; Brown, 1991a; Goden and Golden, 1991). FAO/WHO/UNU (1985) have also stressed the need to recognize that the concentration of all necessary nutrients need to be considered when assessing the adequacy of a meal or diet.

4.1.1 Selected Proximate Factors

The composition of selected proximate factors of the test meals and *koko* are given in Table 4.1. The addition of fish, cowpeas or melonseeds increased the energy, protein, fat and ash contents of the corndough, cornmeal and yam meals. The incorporation of 10 grams of palm oil contributed greatly to the higher energy contents of the test meals.

Similar improvements have been reported by other workers who employed cowpea supplementation of maize porridge (Uwaegbute and Nnanyelugo, 1987; Nti and Plahar, 1995), and by fish supplementation of maize porridge (Asiedu *et al.*, 1993a). The good supply of protein from melonseeds makes the protein contents of the meals containing melonseeds comparable to those containing fish and cowpeas.

TABLE 4.1 Levels of selected proximate factors in test meals and *koko* (g/100 g, dry matter basis)

| Meals # | Crude Protein (g) | Fat (g) | Ash (g) | Energy | | Protein Energy % |
|-------------|----------------------|------------|------------|--------|------|---------------------|
| | | | | Kcal | kJ | |
| Cd/C | 11.7 | 12.8 | 3.8 | 481 | 2011 | 9.7 |
| Cm/C | 10.8 | 13.2 | 3.8 | 461 | 1927 | 9.3 |
| Y/C | 9.1 | 11.2 | 4.1 | 465 | 1944 | 7.9 |
| Cd/F | 10.1 | 12.3 | 4.0 | 430 | 1797 | 9.4 |
| Cm/F | 12.1 | 14.2 | 3.8 | 440 | 1839 | 11.0 |
| Y/F | 10.8 | 12.4 | 4.3 | 418 | 1747 | 10.3 |
| Cd/M | 12.6 | 19.3 | 4.3 | 454 | 1898 | 11.1 |
| Cm/M | 11.1 | 21.9 | 3.2 | 448 | 1873 | 9.9 |
| Y/M | 10.5 | 21.2 | 3.4 | 452 | 1889 | 9.3 |
| <i>Koko</i> | 6.0 | 1.1 | 1.9 | 350 | 1463 | 6.7 |

#

Cd/C Corndough + Cowpeas + common ingredients.

Cm/C - Cornmeal + Cowpeas + common ingredients.

Y/C - Yam + Cowpeas + common ingredients.

Cd/F Corndough + fish + common ingredients.

Cm/F Cornmeal + fish + common ingredients.

Y/F Yam + fish + common ingredients.

Cd/M - Corndough + melonseeds + common ingredients.

Cm/M Cornmeal + melonseeds + common ingredients.

Y/M Yam + melonseeds + common ingredients.

Koko - Corndough + sugar.

Common ingredients - Green leaves, palm oil, tomato and onion.

Since practical meals are usually not consumed in the dried form, further discussions of the proximate composition, mineral and vitamin contents will be based on the amounts of these food components in a serving size of each test meal as consumed by the experimental subjects. The composition of selected proximate factors was therefore translated into how much each serving size contains and are presented in Table 4.2.

TABLE 4.2 Selected proximate factors in individual serving sizes of test meals

| Meals | Wt. per Serving size (g) | Moisture % | Crude Protein (g) | Fat (g) | Ash (g) | Energy (kcal) |
|-------|-----------------------------------|---------------|-------------------------|------------|------------|------------------|
| Cd/C | 327 | 71.2 | 11.0 | 12.1 | 3.6 | 453 |
| Cm/C | 342 | 70.2 | 11.0 | 13.4 | 3.4 | 470 |
| Y/C | 331 | 68.7 | 9.1 | 11.2 | 4.1 | 465 |
| Cd/F | 287 | 67.0 | 9.6 | 11.6 | 3.8 | 408 |
| Cm/F | 351 | 72.9 | 11.5 | 13.5 | 3.6 | 418 |
| Y/F | 287 | 68.1 | 9.8 | 11.3 | 3.9 | 381 |
| Cd/M | 318 | 69.6 | 12.2 | 18.6 | 4.1 | 439 |
| Cm/M | 325 | 71.5 | 10.3 | 20.3 | 2.9 | 415 |
| Y/M | 317 | 68.5 | 10.5 | 21.1 | 3.3 | 451 |

The protein contents of the test meals are approximately 10 grams per serving.

The protein contents were corrected for digestibility and calculations made to determine the contribution of each meal towards the daily protein requirement of the pre-school child. The contributions to energy requirements were also calculated and graphically presented with those of protein in Figs. 2 and 3. Diets Y/F and Cd/M contributed 61% and 86% respectively of the daily protein requirement for 1-2 year olds (13.5g). For the 2 – 3 year olds, the contributions were between 53% (Y/F) and 75% Cd/M) of the daily protein requirement of 15.5 grams.

Although two of the yam meals (Y/C and Y/F) and one corndough meal (Cd/F) are lower in protein than the others, they still provide more than the 50% of the daily pre-school child's requirement. The high protein content of the melonseed supplemented meals suggests that melonseeds, an under-utilised protein source can

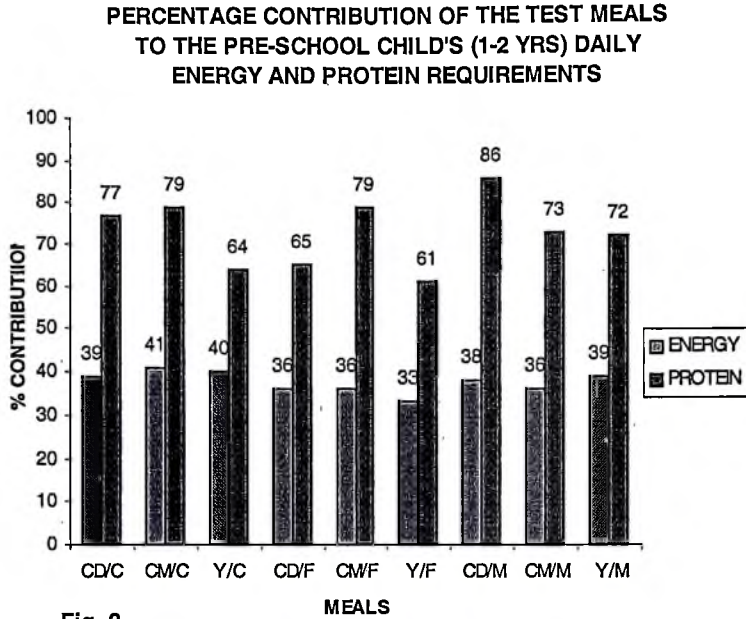


Fig. 2

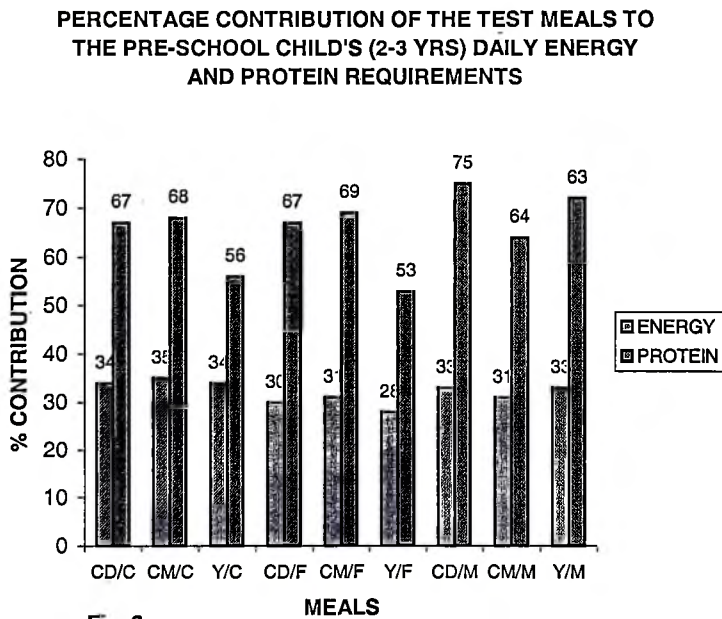


Fig. 3

make significant contributions to the pre-school child's protein intake when animal products are inaccessible. A field trial of supplementary feeding of 1-4 year old Thai Hilltribe children with a traditional diet of rice and soybean flour and sugar, enriched with 15g of oil, providing 483 kcal and 8.8g protein supported growth and reduced malnutrition among the children (Viseshakul *et al.*, 1979). The energy content of the Hilltribe meal is comparable to that of the test meals, and even though the protein content was lower compared to the present meals, it supported growth. The test meals containing more protein than the Hilltribe meal can therefore support growth.

The percentage daily contributions of the test meals towards energy requirement of the 1 – 2 year old child ranged between 33 % (Y/F) and 41% (Cm/C) as illustrated in Fig. 2. For the 2-3 year old, the range is between 28% (Y/F) and 35% (Cm/C) as illustrated in Fig. 3. The contributions are generally equal to or more than the one third of the daily energy needs.

The percentage of energy provided by fat ranged between 22% in Y/C and 44% in Cm/M. The melonseed-supplemented meals contributed the highest percentage between 38% and 44% of total energy as fat mainly due to the fat content of the seeds. However, in spite of their higher fat content, the total energy per serving size of the cowpea-supplemented meals were slightly higher.

Viseshakul *et al.*, (1979) reported a 30% contribution of fat as energy, in the Hilltribe improved, supplementary traditional diet. Similarly, Intengan *et al.*, (1981) also found that fat contributed 30% of energy in their improved habitual Filipino diet for pre-school children. However, FAO/WHO/UNU (1985) recommended that a fat intake of 30-40% of total energy is considered reasonable for growth and development. The fat content of the test meals are therefore reasonable.

4.1.1.1 Energy densities of experimental meals

Energy density is the energy content per gram of food, an index of the adequacy of energy supply of a meal or diet (FAO/WHO/UNU, 1985). The energy densities of the test meals are given in Table 4.3.

TABLE 4.3 Energy densities of test meals as consumed

| Meals | Weight per serving size (g) | Energy content per Serving size (kcal) | Energy density (kcal/g of food) |
|-------|-----------------------------|--|---------------------------------|
| Cm/C | 342 | 470 | 1.37 |
| Cm/M | 325 | 415 | 1.28 |
| Cm/F | 351 | 418 | 1.19 |
| Y/C | 331 | 465 | 1.40 |
| Y/M | 317 | 451 | 1.42 |
| Y/F | 287 | 381 | 1.33 |
| Cd/C | 327 | 453 | 1.39 |
| Cd/M | 318 | 439 | 1.38 |
| Cd/F | 287 | 408 | 1.42 |

The energy densities of the test meals range between 1.19 in Cm/F and 1.42 kcal per gram of food in Y/M and Cd/F. Brown (1991) in his work on appropriate diets for rehabilitation of malnourished children in the community setting suggested that, a good diet must provide 85 kcal or more per 100 grams of food to promote rapid growth. The values for all the test meals are above the minimum density suggested and are therefore adequate to support rapid growth.

Alternatively, energy density of food may be expressed in terms of calories per kilogram body weight per day. FAO (1973) suggested 100 kcal/kg body weight for the average 1 – 3 year old child. Therefore, a child who eats 3 meals a day requires 30–35 kcal/kg from each meal to meet theoretical needs (FAO/WHO/UNU,1985). However, earlier on in 1972, the Protein Advisory Group recommended that for malnourished children, 120-150 kcal/kg/day may be necessary, meaning 40-50 kcal/kg from each of the 3 meals per day are required. Table 4.4 presents the energy contributions of the test meals per kilogram body weight. The mean weight of 8.09kg (Table 4.25) of the experimental children at the beginning of the study was used to calculate the energy per kilogram body weight per meal.

TABLE 4.4 Energy contribution of test meals per kilogram mean body weight of experimental children.

| Meals | Energy per serving size(kcal) | kcal/kg/meal |
|-------|-------------------------------|--------------|
| Cm/C | 470 | 58 |
| Cm/M | 415 | 51 |
| Cm/F | 418 | 52 |
| Y/C | 465 | 56 |
| Y/M | 451 | 56 |
| Y/F | 381 | 47 |
| Cd/C | 453 | 56 |
| Cd/M | 439 | 54 |
| Cd/F | 408 | 50 |

All the test meals have high calorie values per kilogram body weight, ranging from 47 to 58, which compare favourably with what is recommended. If any of the test meals is served twice in the day, this would mean an intake of 94-116 kcal/kg/day which compares favourably with intakes of 95-105 kcal/kg/day which Torun *et al.* (1981) observed to have allowed catch-up growth in malnourished 2-4 year olds. Judging by all indices of energy content and concentration, the test meals, seem adequate to be able to support catch-up growth.

4.1.1.2 Protein Concentration

The protein contributed by the test meals per kilogram body weight of pre-school children are given in Table 4.5. The values were arrived at on the assumption that each of the meals is served twice daily to provide all the protein requirement of the pre-school child for the day. Since the meals were formulated to provide at least half of the day's protein needs, the values per serving were doubled and divided by the respective median weight for age for the two age groups represented.

By this calculation, the protein values per kilogram body weight per day from all the meals are high especially in view of the fact that the protein values have been corrected for digestibility. The range is between 1.56 to 2.11g/kg/day and 1.21 to 1.72g/kg/day for the 1-2 and 2-3 year old child respectively.

The normal 1-4 year old child requires 1.09g-1.26g protein per kilogram body weight per day (FAO/WHO/UNU, 1985). Whitehead (1977) has calculated that, a 1-3 year old child needs 1.79g/kg/day to produce catch-up weight gain of 30g per day (3 times the normal weight gain). However, other studies have reported catch-up growth on lower than these recommended values.

TABLE 4.5 Contribution of test meals to protein intake per kilogram body weight of pre-school children per day

| Meals | Protein Content ^a per serving size (g) | g / kg / day | |
|-------|--|---|--|
| | | 1-2 years median wt. (11kg) ^b | 2- 3 years median wt. (13.5kg) ^b |
| Cm/C | 10.6 | 1.93 | 1.57 |
| Cm/M | 9.9 | 1.80 | 1.47 |
| Cm/F | 10.7 | 1.95 | 1.59 |
| Y/C | 8.6 | 1.56 | 1.27 |
| Y/M | 9.7 | 1.76 | 1.44 |
| Y/F | 8.2 | 1.49 | 1.21 |
| Cd/C | 10.4 | 1.89 | 1.54 |
| Cd/M | 11.6 | 2.11 | 1.72 |
| Cd/F | 8.8 | 1.60 | 1.30 |

a Protein value has been adjusted for digestibility.

b Source: FAO/WHO/UNU, 1985.

In a study to determine the protein requirements of pre-school children, milk or soybean isolate were fed to children, who had been treated for severe malnutrition and had recovered at least a month before the study began. The results showed that 0.61g protein of milk/kg/day and 0.75g protein of soybean isolate/kg/day supported catch-up growth (Torun *et al.*, 1981). The authors further calculated safe levels for the two proteins and obtained 0.79g-0.94g protein/kg/day for milk and 0.98g-1.01g protein/kg/day for soybean isolate. The values for both protein sources are lower than the 1.19g milk protein/kg/day suggested by FAO/WHO (1973). Similarly, Intengan *et al.*, (1981) observed good nitrogen balance in malnourished pre-school children with intakes of 0.9g protein /kg/day of non-milk protein. However, they noted appreciable weight gains when protein intakes were 1.7g/kg/day.

The protein concentrations given in Table 4.5 therefore show that the test meals are adequate to support catch-up growth of 20g-30g or more per day especially among 1-2 year olds, following the calculations by Whitehead (1977).

Even if the meals are eaten only once a day and provide the only source of protein, the protein concentration could provide catch-up growth in the malnourished children in the present study. Using the mean starting weight of 8.09kg of the experimental children to calculate the protein per kg/day, a range from 1.01g in Y/F to 1.43g in Cd/M per kg/day is obtained. All the test meals provide 1.0 gram or more protein per/kg/day similar to, or higher than the calculated safe levels of protein for soybean isolate obtained by Torun *et al.* (1981).

4.1.2 Mineral Content of the Test Meals

The calcium, iron, zinc, potassium and phosphorus contents of the meals and plain corndough porridge are given in Table 4.6a and Table 4.6b.

Table 4.6a Mineral Content of test meals and plain corndough porridge (*koko*)

| Meals | (mg/100 g, dry matter basis) | | | | |
|-------------|------------------------------|--------------|--------------|--------------------|-------------------|
| | Calcium (mg) | Iron (mg) | Zinc (mg) | Phosphorus (mg) | Potassium (mg) |
| Cd/C | 63.3 | 9.4 | 2.3 | 178.0 | 686.5 |
| Cm/C | 39.8 | 5.3 | 1.7 | 161.5 | 582.6 |
| Y/C | 58.9 | 6.6 | 1.2 | 103.0 | 870.8 |
| Cd/F | 133.6 | 10.2 | 1.9 | 335.0 | 584.6 |
| Cm/F | 139.6 | 7.8 | 1.9 | 250.0 | 580.6 |
| Y/F | 118.9 | 4.5 | 1.0 | 121.0 | 895.0 |
| Cd/M | 55.4 | 11.3 | 2.6 | 288.0 | 503.1 |
| Cm/M | 43.1 | 7.3 | 2.4 | 319.0 | 449.5 |
| Y/M | 46.4 | 4.8 | 1.7 | 273.0 | 727.8 |
| <i>Koko</i> | 3.8 | 3.7 | 2.2 | 224.0 | 317.9 |

TABLE 4.6b Mineral content of test meals per serving size as consumed by the experimental children

| Meal | Cooked wt. (g) | Ca (mg) | Fe (mg) | Zn (mg) | P (mg) | K (mg) |
|------|-------------------|------------|------------|------------|-----------|-----------|
| Cd/C | 327 | 59.7 | 8.9 | 2.2 | 167.8 | 647.2 |
| Cm/C | 342 | 40.5 | 5.4 | 1.7 | 164.5 | 593.6 |
| Y/C | 331 | 58.9 | 6.6 | 1.3 | 103.0 | 870.8 |
| Cd/F | 287 | 126.6 | 9.7 | 1.8 | 317.5 | 554.0 |
| Cm/F | 351 | 132.7 | 7.4 | 1.8 | 237.6 | 551.9 |
| Y/F | 287 | 108.3 | 4.1 | 0.9 | 110.2 | 814.9 |
| Cd/M | 318 | 53.6 | 10.9 | 2.5 | 278.8 | 487.0 |
| Cm/M | 325 | 39.9 | 6.8 | 2.2 | 295.6 | 416.5 |
| Y/M | 317 | 46.3 | 4.8 | 1.7 | 272.4 | 726.3 |

Table 4.6a shows that except for zinc which, is about the same or slightly lower in the test meals than in *koko*, the mineral contents of the test meals are generally higher than in *koko*. Supplementation of traditional staples therefore improved the mineral content of the meals.

Iron and Zinc

Fig. 4 illustrates the proportions of the daily requirements of iron and zinc met by each test meal. The daily iron requirements of the 1-3 year old is 10mg (WHO, 1988). The iron contents of the meals are all high, supplying from 41% in Y/F to over 100% in Cd/M of the pre-school child's daily needs. The corndough meals supplied the highest amounts of iron (89% - 109%).

PERCENTAGE CONTRIBUTION OF THE TEST MEALS TO THE PRE-SCHOOL CHILD'S (1-3 YRS) DAILY ZINC AND IRON REQUIREMENTS

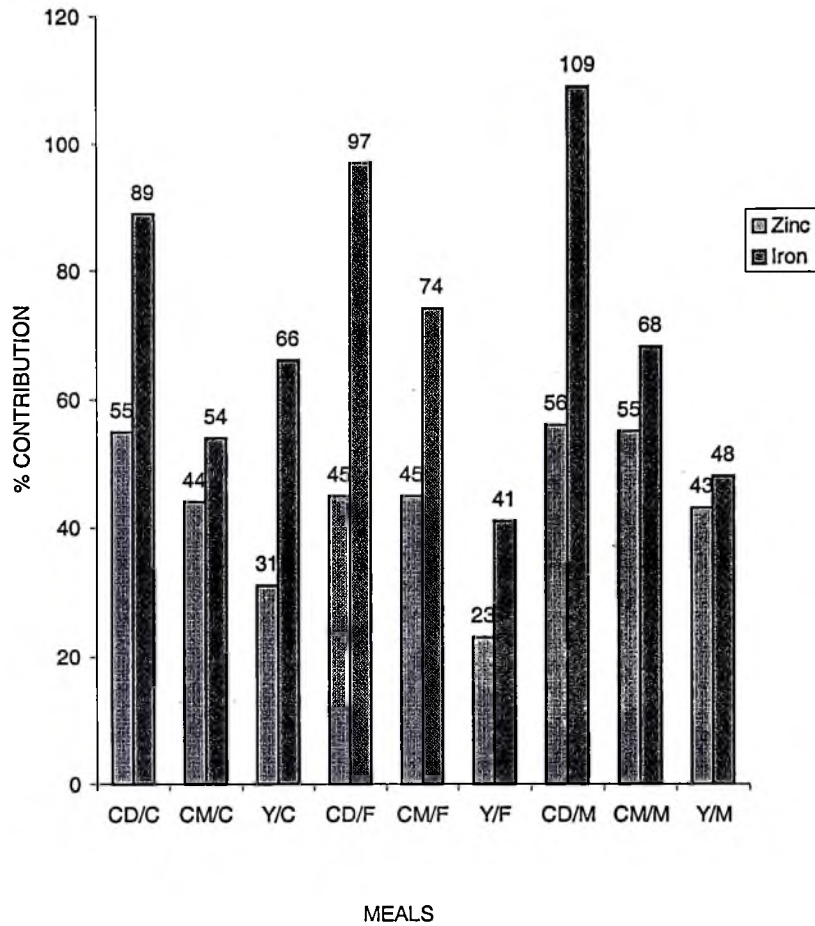


Fig. 4

Yartey (1990) observed that the bioavailability of iron is enhanced by fermentation. Therefore, the iron provided by the corndough meals could be available for absorption. Iron deficiency influences the immune system and therefore the body's risk to infection (Fairbanks, 1994). Iron deficiency anaemia is a cause for public health concern in Ghana, being one of the leading causes of death in the 1-4 year age group (MOH, 1992). Since one of the main causes of iron deficiency anaemia is due to low dietary intakes, the high iron contents of these test meals may be valuable.

The daily zinc needs of the 1-3 year old is 4mg (WHO,1973). The meals provided 40% or more of the zinc requirements except for the cowpea and fish supplemented yam meals (Fig. 4). Melonseeds appear higher in zinc than the fish and cowpea supplements. However, Y/F with the lowest value even supplied approximately one quarter of the child's daily needs. A study of Malawian and Ghanaian rural pre-school children by Ferguson *et al.* (1993b) revealed that, the children who consumed mainly plant-based diets were at risk for sub-optimal zinc nutriture. The Ghanaian diets had low zinc contents and 53% of children studied had low hair zinc.

Since zinc deficiency can seriously impair protein synthesis, cell replication, linear growth, and reduce appetite, (Hambige,1989; Prasad, 1991; Van Wuowe,1995) Ferguson *et al.* recommended dietary strategies for improvement using indigenous foods. Fermentation has been found to improve zinc bioavailability (Asibey-Berko, 1990; Ferguson *et al.*, 1993a). Hence, Ferguson and co-workers recommended the use of fermented maize dough instead of the unfermented maize meal. The high zinc contents of the corndough test meals therefore, support the advantage of using traditional foods in preparing meals for the fast growing pre-school child.

Calcium

The daily calcium needs of the 1-3 year old is 600-700mg (FAO/WHO,1962). Although the calcium content of the test meals are many times higher than the plain corn dough porridge, the contributions are low with reference to the daily requirement. Apart from the fish-supplemented meals, which supplied nearly one quarter of the daily requirements (Fig. 5), the legume-supplemented meals, irrespective of staple used were very low in calcium. The supply was 10% or less of the daily requirements. A means of improving the calcium content of the meals is necessary. Baobab leaves, very rich in calcium could be used in place of cocoyam leaves. "Dawadawa," a local condiment obtained by fermenting locust bean seeds and dried baobab leaves "kuka" which are rich in calcium could be added to the meals without increasing the bulk.

Phosphorus

FAO has no reference values for phosphorus. However, the reference values for Canada recommend 350 mg/day for the 1 – 3 year old (Shils *et al.*, 1994). The phosphorus contents of the test meals per serving ranged between 103mg for Y/C and 317 mg for Cd/F. These values translate to contributions of 29% to 91% of the daily needs of the pre-school child. The melonseed-supplemented meals irrespective of staple used were very high in phosphorus, supplying over 75% of the pre-school child's needs. However, the fish-supplemented maize meals also provided 68% in Cm/F and in Cd/F provided the highest amount of 91%.

Except for calcium, the mineral contributions of the test meals are generally very good.

PERCENTAGE CONTRIBUTION OF THE TEST MEALS TO THE PRE-SCHOOL CHILD'S (1-3 YRS) DAILY CALCIUM REQUIREMENTS

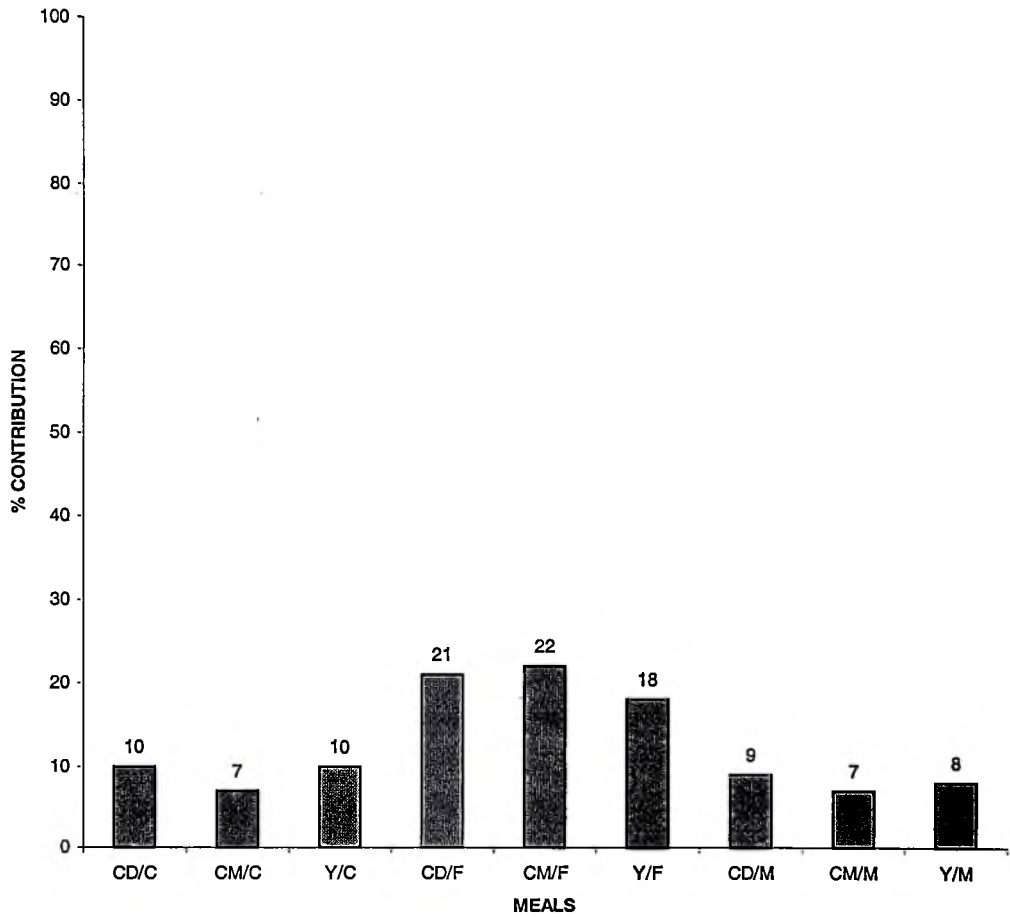


Fig. 5

4.1.3 Vitamin Contents of the Test Meals

The vitamin A, thiamin, riboflavin and niacin contents of the test meals and plain corn dough porridge are presented as unit/100g on dry matter basis in Table 4.7a and per serving size as consumed by the experimental children in Table 4.7b.

Table 4.7a Vitamin Content of test meals and plain koko
(unit/100g, dry matter basis)

| Meals | Thiamin (mg) | Riboflavin (mg) | Niacin (mg) | β -carotene (μ g) | β -carotene as μ g RE |
|-------------|-----------------|--------------------|----------------|---------------------------------|------------------------------------|
| Cd/C | 0.28 | 0.17 | 1.72 | 6498 | 1083 |
| Cm/C | 0.27 | 0.13 | 1.76 | 6540 | 1090 |
| Y/C | 0.23 | 0.13 | 1.59 | 6024 | 1004 |
| Cd/F | 0.14 | 0.23 | 3.32 | 7716 | 1286 |
| Cm/F | 0.25 | 0.18 | 2.78 | 5952 | 992 |
| Y/F | 0.13 | 0.17 | 2.59 | 7398 | 1233 |
| Cd/M | 0.18 | 0.10 | 2.04 | 7272 | 1212 |
| Cm/M | 0.22 | 0.14 | 1.89 | 6540 | 1090 |
| Y/M | 0.12 | 0.10 | 1.69 | 7512 | 1252 |
| <i>Koko</i> | 0.31 | 0.14 | 3.70 | 0 | 0 |

Note: No retinol was detected in any of the samples. β -carotene values are expressed as Retinol Equivalent.

TABLE 4.7b Vitamin content of test meals per serving as consumed

| Meals | Serving size (g) | Thiamin (mg) | Riboflavin (mg) | Niacin (mg) | β-carotene (μg) | β-carotene as μg RE |
|-------|---------------------|-----------------|--------------------|----------------|--------------------|------------------------|
| Cd/C | 327 | 0.26 | 0.16 | 1.6 | 6126 | 1021 |
| Cm/C | 342 | 0.28 | 0.13 | 1.8 | 6660 | 1110 |
| Y/C | 331 | 0.23 | 0.13 | 1.8 | 6024 | 1004 |
| Cd/F | 287 | 0.13 | 0.22 | 3.2 | 7314 | 1219 |
| Cm/F | 351 | 0.24 | 0.17 | 2.6 | 5658 | 943 |
| Y/F | 287 | 0.12 | 0.16 | 2.4 | 6738 | 1123 |
| Cd/M | 318 | 0.16 | 0.10 | 2.0 | 7038 | 1173 |
| Cm/M | 325 | 0.20 | 0.13 | 1.8 | 6060 | 1010 |
| Y/M | 317 | 0.12 | 0.10 | 1.7 | 7494 | 1249 |

It is noted that apart from the very high vitamin A values, the test meals do not seem to have improved on the thiamin, riboflavin and niacin supplies compared to *koko*. Asiedu *et al.* (1993b) observed lower values for both the thiamin (0.21mg/100g) and niacin (2.05mg /100g) in plain corndough porridge than that obtained in this study. The difference could be due to the varieties of maize used.

Vitamin A

Fig. 6 illustrates the percentage contribution of retinol equivalent to the pre-school child's daily needs. No detectable retinol was found in any of the test meals. However, all of them were very rich in beta-carotene due to the use of palm oil and green leaves. All the meals supplied over 200% of the pre-school child's daily Retinol Equivalent needs, while the plain corndough porridge contained none. The values ranged between 236% in Cm/F and a high of 312% in Y/M.

PERCENTAGE CONTRIBUTION OF THE TEST MEALS TO THE DAILY VITAMIN A REQUIREMENTS OF THE PRE-SCHOOL CHILD (1-3 YRS)

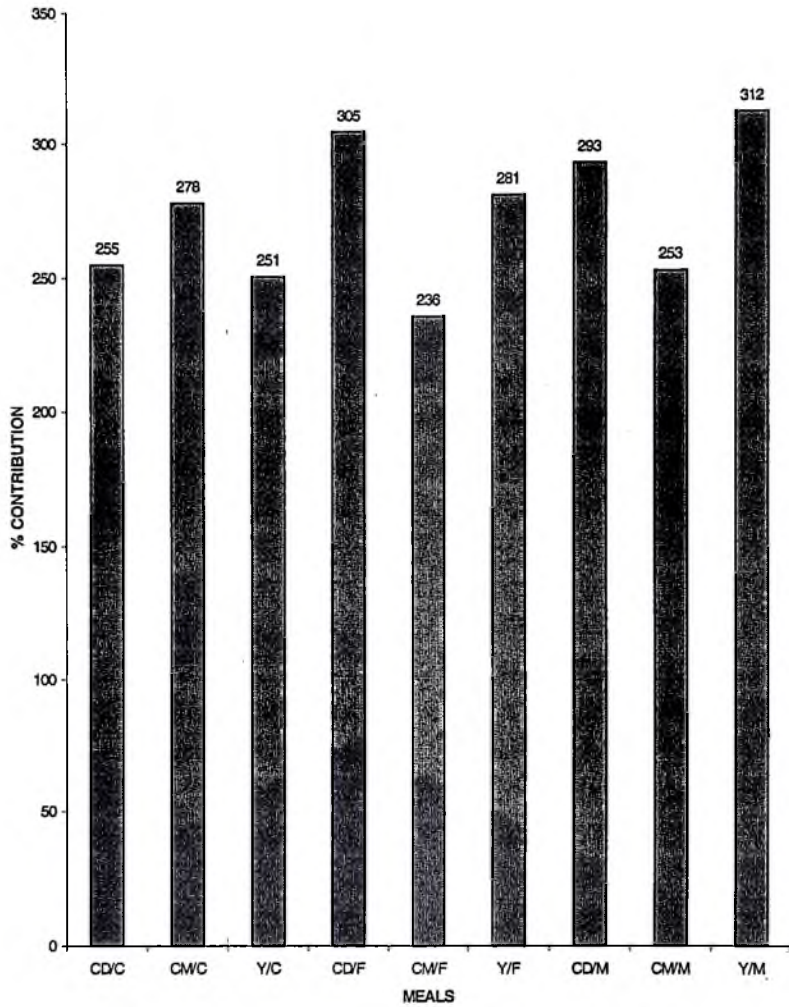


Fig. 6

Vitamin A deficiency is a noted deficiency during childhood (Hendricks and Badruddin, 1992). It is also one of the micro-nutrients of public health importance in Ghana, because pre-school children have been found to have low serum retinol levels (GOG, 1995).

The FAO/WHO (1992) have suggested that for long-term solution for the prevention and control of vitamin A deficiency, the diet must be improved so that the child receives regular low-doses provided naturally by food instead of the periodic high-dose supplements. The high carotene contents of the test meals will therefore make important dietary contributions.

Thiamin, Riboflavin and Niacin

The thiamin, riboflavin and niacin contents of the test meals did not generally show improvement over the plain corn dough porridge (Table 4.7a). The thiamin contribution towards the daily needs of the 1 – 3 year old, ranged from 17% in Y/M and Y/F to 46% in Cm/C. The cowpea-supplemented meals have the highest concentration of thiamin, providing over one third of the child's daily requirement. The meals based on cornmeal, irrespective of the supplement used, are also high in thiamin.

The proportion of thiamin contributed by the test meals were however good, in view of the fact that five of the meals supply one third or more of the daily requirements of the 1-3 year old.

The riboflavin contents of the meals were fairly low. However, the cowpea and fish-supplemented meals provided a quarter or more of the child's daily needs, with Cd/F providing one third of the daily needs.



Similarly, the niacin contents of the test meals were fairly low except for the fish-supplemented meals, which provided between a quarter and over one third of the child's daily requirements. Cd/F provided nearly 40% of the requirements. The cowpea and melonseed-supplemented meals supplied approximately 20% of the requirements. However, Table 4.9 shows that practically all the meals supplied over 100% of the tryptophan requirement by the FAO reference pattern. Since tryptophan is a precursor of niacin, the excess could contribute to the niacin needs.

Neuman *et al.* (1979) in a review of dietary surveys in Ghana since 1968, showed that dietary thiamin intakes were 50% - 80% of requirements and also established that riboflavin deficiency was also widespread. The authors, in their study of pre-school children, 60% of whom were aged 1 – 3 years, revealed that there was widespread biochemical evidence of thiamin deficiency in the children. This problem is attributed to destruction of thiamin by heat and to the possible role of anti-thiamin factors like those heat-stable thiaminases found in foods like cowpeas and pumpkin leaves. It is likely that other legumes like melonseeds also contain anti-thiamin factors, hence the low values of the vitamin in the meals supplemented with melonseeds. Ogunmodede (1972) noted losses of thiamin, riboflavin and niacin by soaking cowpeas in water before cooking. It is however surprising that in this study, the cowpea-supplemented meals had the highest thiamin contents.

On the whole, the contributions of the meals to the B-vitamin needs of the pre-school child are good.

4.1.4 Chemical Evaluation of Protein Quality

The nutritive value of a protein depends primarily on its capacity to satisfy the need for essential amino acids and nitrogen for growth and maintenance. Protein quality in this study was therefore determined using amino acid scores and also by biological utilisation in young rats.

4.1.4.1 Amino acid profiles and scores of test meals

The amino acid composition of the test meals are presented in Table 4.8. The essential amino acid contents of all the test meals are well above that of plain corn dough porridge. But for the sulphur-containing amino acids and lysine, almost all the meals supplied the rest of the essential amino acids in excess of both the FAO reference pattern and the reference requirements of the 2-5 year old pre-school child. Only Y/M was slightly short of meeting the pre-school child's requirement for valine but it supplied more than the FAO reference requirement. The cowpea-supplemented corn dough meal (Cd/C) was the only meal which did not meet any of the two reference patterns' requirements for tryptophan.

TABLE 4.8 Amino acid composition of test meals (mg/gN) ^a

| Amino acid (AA) | Cd/C | Y/C | Cm/C | Cm/F | Y/F | Cd/F | Y/M | Cm/M | Cd/M | Koko | FAO Ref. + |
|-----------------|------|------|------|------|------|------|------|------|------|------|------------|
| Val | 747 | 936 | 1024 | 526 | 778 | 654 | 602 | 540 | 553 | 244 | |
| Leu | 1551 | 1402 | 1548 | 1334 | 1266 | 1541 | 1250 | 1474 | 1508 | 700 | |
| Met | 28 | 0 | 41 | 38 | 31 | 52 | 32 | 27 | 13 | 0 | |
| Ile | 411 | 418 | 423 | 335 | 333 | 384 | 313 | 373 | 363 | 178 | |
| Thr | 300 | 291 | 296 | 293 | 376 | 354 | 328 | 334 | 339 | 140 | |
| Trp | 185 | 168 | 181 | 176 | 190 | 223 | 127 | 164 | 179 | 113 | |
| Pro | 506 | 612 | 490 | 391 | 500 | 449 | 863 | 676 | 688 | 244 | |
| Arg | 302 | 308 | 317 | 289 | 370 | 363 | 265 | 291 | 314 | 150 | 250 |
| His | 449 | 348 | 446 | 486 | 461 | 565 | 313 | 482 | 449 | 269 | |
| Lys | 501 | 326 | 520 | 537 | 298 | 567 | 252 | 521 | 483 | 365 | |
| Ala | 396 | 388 | 387 | 360 | 404 | 423 | 294 | 364 | 346 | 161 | 219 |
| Asp + cys | 175 | 113 | 186 | 206 | 191 | 210 | 182 | 275 | 160 | 125 | 220 |
| Glu | 317 | 338 | 308 | 276 | 348 | 331 | 266 | 287 | 335 | 120 | 250 |
| Tyr | 787 | 604 | 791 | 784 | 621 | 886 | 472 | 793 | 733 | 373 | 440 |
| Val + Phe | 768 | 737 | 721 | 619 | 624 | 715 | 568 | 696 | 667 | 325 | 380 |
| Ser | 347 | 437 | 322 | 252 | 561 | 370 | 193 | 193 | 194 | 124 | 340 |
| Pro | 52 | 92 | 73 | 84 | 88 | 91 | 99 | 109 | 109 | 25 | 60 |
| Total AA | 7822 | 7518 | 8074 | 6486 | 7440 | 8178 | 6419 | 7599 | 7433 | 3656 | |
| Total EAA | 3144 | 3017 | 3108 | 2870 | 3207 | 3389 | 2339 | 3008 | 2858 | 1403 | |
| Ratio | 2.83 | 3.51 | 2.99 | 2.56 | 3.56 | 3.64 | 2.41 | 2.81 | 2.38 | 2.33 | |
| E/T_N | | | | | | | | | | | |

^a Analyses were ran in duplicates and 5% deviations between parallels were accepted.

* Essential Amino acids.

• The ratio of essential amino acids to total nitrogen. Total nitrogen calculation is based on protein corrected for digestibility.

+ FAO/WHO essential amino acid reference pattern.

Note: E/T_N of FAO/WHO Pattern (1973) = 2.25

Lysine was overall, the least essential amino acid in most of the test meals (Cm/C; Cm/F; Y/M; Cm/M; Cd/M) with respect to both reference patterns. The melon seed-supplemented meals produced the least of the required lysine. However, cornmeal supplemented with melonseeds (Cm/M) was the only meal which supplied sulphur-containing amino acids in excess of both reference patterns. The yam supplemented with cowpeas (Y/C) contained levels of sulphur-containing amino acids below both reference pattern requirements. Yartey (1990) observed that fermented maize dough and fish blend, using 80g of the maize powder and 20g of fish had no limiting amino acid. The corndough meal supplemented with fish in this study was slightly short of the FAO reference requirements for sulphur-containing amino acids, but met all of the pre-school child's requirements even though less fish (5g fish to 120g corndough) was used.

In spite of these short-comings, the ratios of essential amino acids to total nitrogen for all the meals were good, exceeding the FAO/WHO (1973) reference pattern's value of 2.25 and even that for infants (2.33). The excess ranged from 7% in Y/M to 62% in Cd/F. On the whole, the melonseed-supplemented meals had lower E/T_N ratios which may be due to their low lysine contents. It is however surprising that, the *koko* in this study has an E/T_N ratio equivalent to the reference value for infants and yet, it did not support rat growth.

It is interesting to observe that in two of the yam meals, those supplemented with cowpeas (Y/C) and fish (Y/F) had the highest E/T_N ratios second only to fish-supplemented maize meals. This observation draws attention to the fact that, although yam is very low in protein, it is possible to obtain amino acid balance through supplementation with protein-rich foods. Uwaegbute and Nnanyelugo (1987) who compared yam/cowpea blend with rice/cowpea and corn/cowpea blends among others, found that the yam/cowpea meal was comparable to the cereal/cowpea meal blends.

4.1.4.2 Amino Acid Scores

The amino acid score which may be taken as a first approximation to the probable efficiency of utilisation of the test protein (UNU, 1980) was calculated for each meal using both the FAO essential amino acid reference pattern (Appendix 4) and the pre-school child's (1-5yrs) essential amino acid requirement pattern (Appendix 5). Then, following the procedure by FAO (1990), which is illustrated in Appendix 6, the amino acid scores were corrected for protein digestibility for each meal. These are given in Tables 4.9 and 4.10.

TABLE 4.9 Amino Acid Scores of test meals corrected for protein digestibility using FAO Reference Pattern

| Meals | Met/Cys | Lys | Try | Thr | Protein Score |
|-------------|---------|-----|-----|-----|---------------|
| Cd/C | 75* | 96 | 82 | 114 | 75 |
| Cm/C | 82* | 92 | 117 | 123 | 82 |
| Y/C | 49* | 122 | 145 | 116 | 49 |
| Cd/F | 88* | 100 | 139 | 133 | 88 |
| Cm/F | 87 | 69* | 131 | 108 | 69 |
| Y/F | 73* | 138 | 122 | 124 | 73 |
| Cd/M | 69 | 54* | 172 | 119 | 54 |
| Cm/M | 121 | 55* | 177 | 113 | 55 |
| Y/M | 76 | 52* | 153 | 98 | 52 |
| <i>Koko</i> | 58 | 37* | 42 | 61 | 37 |

* Limiting amino acid in each meal.

Generally, the amino acid score using the FAO reference pattern shows that the sulphur-containing amino acids were the first limiting amino acids in cowpea and fish-supplemented meals followed by lysine. The opposite though is true of the melonseed-supplemented meals, where lysine is the first limiting amino acid and the sulphur-containing amino acids are second.

The scores show that protein supplementation of the staple foods, maize and yam, increased the protein scores over that of *koko* by 32% in Y/C to 138% in Cd/F. Among the test meals, the cowpea-supplemented yam meal (Y/C) had the lowest score (49), as a result of the very low content of sulphur-containing amino acids, which happened to be the only limiting amino acid. Otherwise, all the other amino acids were supplied in excess of requirements. The melonseed-supplemented meals had generally lower scores as a result of their low lysine contents.

**TABLE 4.10 Amino Acid Scores corrected for protein digestibility using
Pre-School Child: 2-5 yrs. Requirement pattern**

| Meals | Met/Cys | Lys | Try | Thr | Protein Score |
|-------------|---------|-----|-----|-----|---------------|
| Cd/C | 105 | 90 | 71* | 134 | 71 |
| Cm/C | 116 | 86* | 102 | 145 | 86 |
| Y/C | 69* | 114 | 126 | 137 | 69 |
| Cd/F | 124 | 94* | 121 | 156 | 94 |
| Cm/F | 123 | 65* | 114 | 127 | 65 |
| Y/F | 102 | 130 | 106 | 146 | 102 |
| Cd/M | 97 | 51* | 149 | 140 | 51 |
| Cm/M | 171 | 52* | 153 | 133 | 52 |
| Y/M | 108 | 49* | 133 | 115 | 49 |
| <i>Koko</i> | 81 | 35* | 37 | 72 | 35 |

* Limiting amino acid in each meal.

When the pre-school child's essential amino acid requirements are used for scoring, the scores for two cowpea-supplemented meals (Y/C and Cm/C) and two fish-supplemented meals (Y/F and Cd/F) were higher. Except for the melonseed-supplemented meals, the other meals had scores more than double the score of *Koko*. In fact, Y/F had no limiting amino acid when this scoring pattern is used. Therefore it is the most commendable meal on the basis of protein scores. The higher scores when the pre-school child's requirement pattern is used are due to the lower sulphur-containing amino acid requirements of the pre-school child.

It is also observed that, by using the pre-school child's amino acid requirements for scoring the meals, apart from Y/C and Cd/C, the first or only limiting amino acid was lysine. Although it is reported that most diets in developing countries have sulphur-containing amino acids as first limiting amino acids, when some diets from developing countries were compared with human requirements, lysine in the Nigerian and Guatemalan diets was the most limiting (FAO/WHO/UNU, 1985).

Nti (1991) used the pre-school child's amino acid requirements to score a blend of unfermented maize and cowpea and pure unfermented maize porridges. The scores for the blend ranged between 48 and 57 while the maize only had a score of 37, similar to the score obtained for *Koko* in this study.

The test meal prepared with unfermented maize supplemented with cowpeas however, had a score of 87, showing improvement of the multimix compared with the doublemix.

4.2 BIOLOGICAL EVALUATION OF PROTEIN QUALITY

The results and discussion of the protein quality evaluation of the test meals determined by nitrogen balance studies, are presented according to the type of staple food used. The protein quality indices calculated from the nitrogen balance data include True Digestibility (TD%), Biological Value (BV%), Net Protein Utilization Operative (NPUop%), and Net Dietary Protein Calories percent (NDpCals%). A comparison of the mean values of the protein quality indices was made between the test meals, casein and *koko* using Analysis of Variance (ANOVA). The Tukey Honest Significant Difference statistic (HSD) was then used for paired comparisons.

4.2.1 Biological Utilization of Test Meals Prepared with Corndough

The mean values of the protein quality indices of the three meals prepared with corndough, supplemented with cowpeas, fish or melonseeds as well as values for casein standard diet and *koko* are given in Table 4.11.

Despite the higher digestibility value of *Koko* compared to the test meals, the latter had significantly ($p \leq 0.001$) better protein quality with respect to BV%, NPUop% and NDpCals%. Orraca-Tetteh (1972) obtained NPUop % of 44.5% and NDpCals % of 3.8% for maize porridge. Asiedu *et al.*, (1993b) also obtained a NPUop of 59, and NDpCals % of 5% for maize dough porridge. These values are close to the NPUop% value of 52.1% and NDpCals% value of 3.5 obtained in this study.

TABLE 4.11 Comparison of protein quality of corndough test meals with casein and *Koko* (Mean values \pm SD)

| Parameters | Test Meals | | | Casein | <i>Koko</i> |
|-------------|-----------------------------|------------------------------|------------------------------|-------------------------------|-------------------------------|
| | Cd/C | Cd/F | Cd/M | | |
| TD(%)** | 94.7 \pm 2.3 ^a | 91.9 \pm 2.8 ^{be} | 95.4 \pm 2.5 ^c | 98.5 \pm 2.1 ^e | 98.9 \pm 2.6 ^{abc} |
| BV(%)*** | 76.9 \pm 3.1 ^f | 80.6 \pm 3.4 ^g | 72.4 \pm 3.1 ^h | 92.8 \pm 2.1 ^{fgh} | 51.2 \pm 3.9 ^{fgh} |
| NPUop(%)*** | 72.8 \pm 2.1 ^m | 74.1 \pm 2.5 ⁿ | 71.2 \pm 2.0 ^o | 91.5 \pm 3.3 ^{mno} | 52.1 \pm 2.0 ^{mno} |
| NDpCals(%)* | 7.1 \pm 0.4 ^x | 7.0 \pm 0.2 ^y | 7.9 \pm 0.3 ^{xyz} | 7.1 \pm 0.5 ^z | 3.5 \pm 0.5 ^{xyz} |

Means in each row with the same superscript differ significantly.

* p = 0.005

** p = 0.001

*** p < 0.0001

All the meals have high protein digestibility values of over 90% irrespective of the source of protein supplement used. The difference in digestibility were not statistically significant. A TD% of 78 of a mixture of maize and beans protein has been reported in man by FAO/WHO/UNU (1985). Asiedu *et al.* (1993a) obtained TD% of 96 for sprouted maize plus 5% fish, comparable to the fish-supplemented test meal (Cd/F).

The differences in BV% among the test meals were not significant. The casein standard protein had a significantly higher BV% than the test meals (p < 0.0001). It is observed that Cd/F, which has the least TD % value among the corndough meals had a significantly higher BV%, than Cd/M. *Koko* had a significantly lower BV% than the test meals (p < 0.0001).

The NPUop% of the test meals were significantly higher than that of *Koko* (p < 0.0001). Similarly, Orraca-Tetteh (1972) obtained NPUop% of 44.5% for maize porridge and Asiedu *et al.* (1993b) obtained 59% for maize dough porridge. The

NPUop% values did not differ among the meals, but they differed significantly from the higher value of casein ($p < 0.0001$). Asiedu *et al.* (1993a) obtained NPUop% of 61 for sprouted maize plus 5% fish compared to 74 obtained for the fish-supplemented corn dough test meal. All three meals however, have NPUop% values of 70 and above, which is regarded as a good protein diet (FAO/WHO/UNU, 1985).

With respect to NDpCals%, the test meals have double the value of *Koko*, a difference which is very significant ($p < 0.0001$). Orraca-Tetteh (1972) obtained NDpCals% of 3.8% for maize porridge and Asiedu *et al.* (1993b) obtained 5% for maize dough porridge, both values being similar to that obtained for *Koko* in this study. Among the test meals Cd/M has a significantly higher value than Cd/C and Cd/F because it recorded the highest protein content. The NDpCals% of Cd/F is the same as that obtained for sprouted maize supplemented with 5% fish by Asiedu *et al.* (1993a). In spite of the higher NDpCals % of Cd/M, as a result of its higher fat content, its protein utilisation indices (BV%, NPUop%) are lower than the other two meals.

4.2.2. Biological Utilisation of Test Meals Prepared with Cornmeal

The mean values of the protein quality indices of the three meals prepared with cornmeal, supplemented with cowpeas, fish or melon seeds as well as values for casein and *koko* are given in Table 4.12.

TABLE 4.12 Comparison of the protein quality of the cornmeal test meals and with casein and *Koko* (Mean values \pm SD)

| Parameters | Test Meals | | | Casein | <i>Koko</i> |
|--------------|-----------------------------|------------------------------|-----------------------------|-------------------------------|-------------------------------|
| | Cm/C | Cm/F | Cm/M | | |
| TD(%) * | 96.7 \pm 1.9 ^a | 93.0 \pm 1.9 ^{bd} | 96.8 \pm 1.8 ^c | 98.5 \pm 2.1 ^d | 98.9 \pm 2.6 ^{abc} |
| BV(%)*** | 77.4 \pm 3.4 ^e | 77.4 \pm 2.8 ^f | 73.5 \pm 2.6 ^g | 92.8 \pm 2.1 ^{efg} | 51.2 \pm 3.9 ^{efg} |
| NPUop(%)*** | 74.8 \pm 2.4 ^m | 72.0 \pm 2.7 ⁿ | 69.0 \pm 3.1 ^o | 91.5 \pm 3.3 ^{mno} | 52.1 \pm 2.0 ^{mno} |
| NDpCals(%)** | 7.0 \pm 0.2 ^x | 7.9 \pm 0.3 ^{xyz} | 6.8 \pm 0.3 ^y | 7.1 \pm 0.5 ^z | 3.5 \pm 0.5 ^{xyz} |

Means in each row with the same superscript differ significantly.

* p < 0.012

** p < 0.005

*** p < 0.0001

A comparison of the TD% values obtained shows that all the cornmeal-based meals have high protein digestibilities, which are not significantly different from each other. The meals supplemented with cowpeas and melonseeds have protein digestibilities comparable to that of casein, but the fish-supplemented meal has a significantly lower (p<0.012) protein digestibility than casein and the other two

meals. The TD% of *Koko* is however significantly higher ($p < 0.0001$) than the test meals. Nti and Plahar (1995) obtained a TD% of 94 for unfermented maize plus cooked cowpeas, which is slightly lower than the value obtained for the test meal Cm/C in this study. Torun *et al.* (1984) obtained a TD% of 73.7% for a Guatemalan habitual diet of corn and black beans.

With regards to the BV% and NPUop%, casein is significantly higher ($p < 0.0001$) than the test meals, while *koko* is significantly lower ($p < 0.0001$) than the test meals. The test meals do not however differ significantly from each other. Nti and Plahar (1995) obtained for unfermented maize and cooked cowpeas, BV% and NPUop% values of 76 and 71 respectively, slightly lower than Cm/C values obtained in this study. FAO/WHO/UNU (1985) has stated that good diets should have a NPU% value of around 70. The NPUop% values of the meals are therefore indicative of good protein diets. When Whitehead (1977) made calculations of NDpCals% to allow for catch-up growth, he arrived at 5% for normal growth, that is, a gain in weight of 10g/day, 6.5% and 7.3% for gain in weight of 30g and 50g per day respectively. Therefore the test meals with NDpCals % of approximately 7% and above suggest that they will be capable of supporting catch-up growth of 30g or more per day.

4.2.3. Biological Utilization of Test Meals Prepared with Yam

The mean values of the protein quality indices of the three meals prepared with yam, supplemented with cowpeas, fish or melonseeds as well as values for casein and *koko* are given in Table 4.13.

TABLE 4.13 Comparison of protein quality of yam test meals and with casein and *Koko* (Mean values \pm SD)

| Parameters | Test Meals | | | Casein | <i>Koko</i> |
|-------------|------------------------------|-------------------------------|------------------------------|-------------------------------|-------------------------------|
| | Y/C | Y/F | Y/M | | |
| T/D(%)* | 94.1 \pm 1.8 ^a | 83.4 \pm 1.9 ^{abc} | 92.3 \pm 2.1 ^{bc} | 98.5 \pm 2.1 ^c | 98.9 \pm 2.6 ^{ab} |
| BV(%)* | 73.4 \pm 2.2 ^{eg} | 87.3 \pm 3.1 ^{ef} | 76.4 \pm 1.8 ^{fg} | 92.8 \pm 2.1 ^g | 51.2 \pm 3.9 ^{efg} |
| NpUop(%)*** | 69.1 \pm 2.0 ^m | 72.9 \pm 1.7 ⁿ | 70.5 \pm 2.7 ^o | 91.5 \pm 3.3 ^{mno} | 52.1 \pm 2.0 ^{mno} |
| NDpCals(%)* | 5.5 \pm 0.3 ^{xz} | 7.5 \pm 0.4 ^{xy} | 6.6 \pm 0.4 ^y | 7.1 \pm 0.5 ^{yz} | 3.5 \pm 0.5 ^{xyz} |

Means in each row with the same superscript differ significantly.

* $p < 0.003$

*** $p < 0.0001$

It is clear from Table 4.13 that *koko* has a significantly lower ($p < 0.0001$) BV%, NpUop% and NDpCals% than the test meals, suggesting a marked improvement of protein quality of the meals over that of *koko*. A comparison of the yam-based meals with casein shows that, although the test meals have high protein

digestibilities, casein is significantly higher ($p < 0.003$) than Y/F and Y/M but comparable to Y/C.

The fish-supplemented yam has the least protein digestibility, which is significantly different from the cowpea and melonseed-supplemented meals.

The BV% values of the meals reveal that the cowpea and melonseed-supplemented meals are not different but both have significantly lower BV% ($p < 0.003$) than the fish-supplemented meal. Compared to standard casein, two of the yam meals, Y/C and Y/M have significantly lower ($p < 0.0001$) BV% but Y/F is not different. It is interesting to note that although the yam supplemented with fish (Y/F) has the least protein digestibility, it has a significantly higher BV% ($p < 0.0001$) than the meals containing cowpeas and melonseeds. It is also observed that the BV% of Y/F is also significantly higher ($p < 0.0001$) than the meals prepared with maize supplemented with fish.

The NPUop% of the three yam meals were not different from each other but they were each significantly ($p < 0.0001$) lower than casein. However, since the NPUop% for all three meals are approximately 70%, this indicates good protein utilisation (FAO/WHO/UNU, 1985).

The comparison of the NDpCals % of the yam meals with casein shows that the fish-supplemented meal is not different from casein. However, the cowpea and melonseed-supplemented meals are significantly lower ($p < 0.05$) than the fish-supplemented meal and casein. The cowpea-supplemented meal has the lowest NDpCals % among the yam meals, but it can still support normal weight gain of 10g/day, which can be achieved on NDpCals % of 5% (Whitehead, 1984).

4.2.4. Comparison of Protein Scores with Net Protein Utilization (NPUon%) of Test Meals

The determination of the essential amino acid content in protein foods is the logical first step in the chemical evaluation of protein quality. This study provides

information on both the amino acid composition and the biological utilisation. Since there is a known relation between protein utilisation and protein score, a comparison is made here to examine this relationship. The relationship permits the assumption that protein score corrected for digestibility corresponds roughly to the NPUop%, particularly in mixed diets (UNU, 1980).

Table 4.14 presents the protein scores corrected for digestibility using the FAO essential amino acid reference pattern and FAO/WHO/UNU (1985) reference requirement for 2-5 year old pre-school children. The NPUop% values obtained from the nitrogen balance studies are also given for comparison.

Table 4.14 Protein Scores of test meals and their corresponding NPUop% Values

| Test Meals | Protein Scores | | NPUop% |
|------------|-----------------------|------------------------------|--------|
| | FAO Reference Pattern | Pre-school Child Requirement | |
| Cd/C | 75 ^a | 71 ^c | 73 |
| Cm/C | 82 ^a | 86 ^b | 75 |
| Y/C | 49 ^a | 69 ^a | 69 |
| Cd/F | 88 ^a | 94 ^b | 74 |
| Cm/F | 69 ^b | 65 ^b | 72 |
| Y/F | 73 ^a | 102 | 73 |
| Cd/M | 54 ^b | 51 ^b | 69 |
| Cm/M | 55 ^b | 52 ^b | 71 |
| Y/M | 52 ^b | 49 ^b | 71 |

- a. Sulphur-containing amino acids are the most limiting
- b. Lysine is the most limiting essential amino acid
- c. Tryptophan is the most limiting essential amino acid.

Except for the melonseed-supplemented meals, the rest of the test meals have protein scores comparable to the NPUop% values, using both essential amino acid reference patterns. Although the scores for the melonseed-supplemented meals are much lower than their corresponding NPUop% values, the agreement between them is fair. It is interesting to note that, despite their low scores, the NPUop% values are high and comparable to the values obtained in the cowpea and fish-supplemented meals. Nti (1991) observed a protein score of 53 for maize/cowpea blend with NPU% of 71. The question as to whether the lysine availability in a multimix is sufficient to support infant or child growth may be partially answered by these observations. That is, even though lysine was very limiting in the meals supplemented with melonseeds, it was observed that all the other essential amino acids were within or over the reference requirements. The general balance of essential amino acids was probably good enough for effective utilisation, hence the high NPUop% values. It is a fact that the NPU% index indicates the actual nitrogen retention most likely available for maintenance and growth. Additional evidence that the amino acid balance was good enough for effective utilisation is provided by the E/T_N ratios of the test meals, which were higher than the FAO/WHO recommended ratio, considered effective in meeting the requirements of children and adults.

On the whole, the results of the calculated Protein Scores using the analysed amino acid contents of the test meals are in good agreement with the biologically determined Net Protein Utilisation operative (NPUop%). The correlation (r) between the FAO and the Pre-school child's patterns and the NPUop% values is good, 0.92 and 0.71 respectively. This is a substantiation of the prediction of protein values of diets using their amino acid contents (Miller and Payne, 1961a).

4.3. HUMAN STUDY

4.3.1 The Study Subjects

Fifty-five malnourished children were initially recruited for the study but ten were excluded from the final data analysis as a result of poor attendance or failure to continue with the study. The majority of the children, 28 (62%) had been referred to the rehabilitation centre, because they had failed to gain weight for months. Fourteen (31%), were recovering from severe illness, which had resulted in weight loss, anaemia and lack of appetite, and they needed rehabilitation. The remaining 3 (7%) children, were referred for looking bloated or puffy (manifestations of frank kwashiorkor).

Of the forty-five who participated in the study, thirty-five were fed the test meals for four weeks excluding week-ends and ten served as the 'control' or comparison group. Six (13%) of the children were motherless so their grandmothers were their caregivers. Sixteen (36%) were first borns, while 11 (24%), were second borns. There were 8 (18%), third or fourth borns and the remaining 10 (22%), were fifth or sixth borns.

Children of higher birth orders run the risk of being malnourished because as the number of children increases, household resources to provide adequate nutrition and health care for each child is scarce. However, in this study 27 (60%) of the 45 study children were first or second borns. The world fertility survey studies reported by Haaga (1995) have revealed that the well-being of children of first-time mothers are at risk due to the mothers' lack of knowledge about and access to health facilities. The lack of experience of the mothers in childcare and especially child feeding is also a factor contributing to the poor nutritional status of children of low birth orders. It was observed in this present study that, the motherless children had poor nutritional status probably because they had to be taken care of by aged, illiterate grandmothers. The sex and age distribution and other characteristics of the children are given in Table 4.15.

TABLE 4.15 Characteristics of Study Children

| Variable | Experimental Group | Control Group | N | Total % |
|-------------------------------|--------------------|---------------|-----------|------------|
| - Sex | | | | |
| Male | 21 | 5 | 26 | 58 |
| Female | 14 | 5 | 19 | 42 |
| Total | 35 | 10 | 45 | 100 |
| - Age (yrs.) | | | | |
| 1-2 | 22 | 9 | 31 | 69 |
| 2-3 | 12 | 1 | 13 | 29 |
| 4-5 | 1 | 0 | 1 | 2 |
| - Still Breast-fed | 17 | 7 | 24 | 53 |
| - Sickling Positive | 4 | 2 | 6 | 13 |
| - Worm infested | 5 | 1 | 6 | 13 |
| - Malaria Parasites ++ | 24 | 5 | 29 | 64 |

4.3.1.1 Sex and Age distribution

Of the 45 children comprising both experimental and control groups, 26 (58%) were males and 19 (42%) females. Sixty percent (21) of the experimental group were males.

The mean age of the study group was 19.6 ± 7.7 months with a range of 12 and 47 months. However, only one child was more than 36 months old. This is evidence to suggest that chronic undernutrition among the 1-3 year age group reported by the Ghana Demographic Health Survey in 1993 may not have changed. It also confirms literature reports that the highest prevalence of malnutrition occurs in the 1-3 year age group (Wilson *et al.*, 1979).



4.3.1.2 Parasitic infestation

Stool examination revealed that six of the children (13%); 4 experimental and two in the control group had worms. They were all treated before the study began. Studies in India have suggested that deworming of heavily infested children is a prerequisite to obtaining maximum benefit from food consumption (Beaton and Ghassemi, 1982). In Ghana, intestinal parasites were ranked 6th in 1989 and 8th in 1990 as a cause of nutrition-related illnesses among children (MOH, 1992).

Table 4.15 shows that almost two-thirds (64%) of the study children had malaria parasites. They were all treated prior to the inception of the study. Malaria fever is known to cause reduction in food intake and loss of iron, which may lead to anaemia (FAO/WHO, 1992a). In Ghana, anaemia among pre-school children is reported to be due to low iron intakes, loss of iron from malaria and some intestinal worm infestation (MOH, 1992). The Ghana Ministry of Health also maintains that malaria fever is a leading cause of death in the 1-4 year age group.

4.3.2 Description of the Nutritional Status of the Study Children at the Inception of the Study.

Using the NCHS reference data, the study children were classified according to their nutritional status with respect to three anthropometric indices: weight for age (WA); weight for height (WH), and height for age (HA) using Z-scores. Haemoglobin levels were also used to estimate the prevalence of possible anaemia among the children.

4.3.2.1. Weight for Age Z-score (WAZ)- Underweight

Among the experimental group, 83% (29) had WAZ below - 2SD with 42% (14) below -3SD of the reference median. Among the control group, 80% (8) were below -2SD with 70% (7) below -3SD of the reference median. The rest in each group had scores between - 1.5 and 2SD. By this classification, majority of both experimental and control children were moderately to severely underweight for their

ages. Findings from the 1993 Ghana Demographic Health Survey (DHS), revealed that more than one quarter (30%) of children below 3 years were underweight. The condition was found to peak at 12 months and persisted through the second and third years (USAID, 1995). This condition resulting from chronic or acute under-nutrition or a combination of both is probably very far from being reduced since the 1993 figure of 30% is not statistically different from the 1988 Ghana Demographic Health Survey figure of 31%.

4.3.2.2 Weight for Height Z-score (WHZ)-Wasting

Forty-three percent (15) of the experimental group had WHZ below -2SD of the reference median. Only 6% (2) had WHZ below -3SD. Among the control group, 70% (7) had WAZ below -2SD with 30% (3) below -3SD of the reference median. Of the rest of the experimental group, 23% (8) had WHZ between -1.5 and -2SD, and the remaining 34% (12) had values just below the reference median. The rest of the control group had WHZ values between -1.5 and -2SD. By this classification, half of the study children were moderately to severely wasted and the other half were mildly wasted. The 1993 Ghana DHS recorded that 12% of children below 3 years were wasted. This is 6 times above the level expected in a healthy, well-nourished population and registers a substantial increase in the proportion of children wasted in 1988 (8%). Wasting also was found to peak at 23 months. Among Sub-Saharan countries surveyed, the high level of wasting in Ghana was second only to Niger (USAID, 1995).

4.3.2.3 Height for Age Z-scores(HAZ)-Stunting

Sixty percent (21) of the experimental group had HAZ below -2SD of which 34% (12) had values below -3SD of the reference median. Among the control group 50% (5) had HAZ below -2SD with 30% (3) falling below -3SD. Except for 11% (4) of the experimental children, who were just below the reference median, the remaining 29% (10) had scores between -1.5SD and -2SD. Of the remaining half of

the control group 30% (3) had scores between $-1.5SD$ and $-2SD$ and the rest were just below the reference median.

By this classification, about 60% of the study children were moderately to severely stunted. The 1993 Ghana DHS showed that 28% of children below 3 years were stunted, the proportion being about the same as reported in 1988 (30%) (USAID, 1995). The report also indicated that nearly 50% of Ghanaian children became stunted by 21 months. Among Sub-Saharan countries surveyed, Ghana was in the lower range for the proportion of children who were stunted.

4.3.2.4 Haemoglobin levels

Values of haemoglobin levels before the study were obtained for 24 experimental and 7 control children, whose mothers consented to the tests. Thirteen in the experimental group and all the 7 control children had Hb levels below 12g/dl, which is indicative of anaemia (ACC/SCN,1991). It is not surprising that most of the children had low haemoglobin, because Table 4.15 indicates that, about two thirds of the study children had malaria parasites, and malaria is a well-known cause of anaemia (FAO/WHO, 1992a).

The different classifications employed showed that the study children were moderately to severely malnourished and needed intervention, hence they formed a suitable group for testing the efficacy of the test meals.

4.3.3 Feeding History of the Study Children

4.3.3.1 Breast-feeding Practices and Supplementary foods

Except for one orphan, all the study children had been breast-fed. Twenty four (53%) were still being breastfed on demand.

Comdough porridge (*koko*) was the main food supplement first introduced to the children by 35 (78%) of the mothers. *Koko* has remained one single favourite weaning food in Ghana reported by several investigators (Orraca-Tetteh,1961; Commey, 1970; Baidoo, 1975; Gershon, 1978). Sixteen mothers (36%) said they

served the porridge with sugar only, while 11 (24%) added soybean flour, and 8 (18%) added milk. Three mothers added either ground fish, groundnut paste or egg yolk. Two mothers each, introduced weanimix, mashed kenkey, infant formula, cerelac, and sorghum or millet porridge as first supplements besides breast milk, respectively.

The age at which supplementary feeding was initiated varied from less than one month to over eighteen months. Only one child received first supplementary food at 18 months while 4 received it at one month or less. Seven (16%) were first introduced to supplements between 6-8 months whilst the remaining 33 (73%) were introduced at between 2-5 months. These observations suggest that, the WHO recommendations for exclusive breast-feeding from birth to 6 months are not being practised. The Ghana DHS of 1993, revealed that 40% of infants under 4 months are given some form of supplementary food, which has deleterious effect on the nutritional status of children (USAID, 1995).

The supplementary foods fed to most study children prior to their admission to the nutrition rehabilitation centre, were generally of poor nutritional quality. Over one third (38%) were fed adult foods which are normally small amounts of the staple and a little soup or stew, because it is spiced with pepper. Very little or no fish or meat is given (Gershon, 1978; Denueme 1993; Ferguson *et al.*, 1993b). The adult meals consumed by the children included boiled rice, *Akple or Banku*, and *Tuo* served with vegetable soup or stew.

Twenty-three (51%) of the mothers said they purchased cooked foods for their children. Nine mothers did so regularly, claiming that their children preferred those to home prepared meals. Popular cooked food items purchased from food vendors were rice and beans with hot sauce (*waakye*), and rice and stew. Others bought rice balls, *tuo*, *banku* or *kokonte* plus vegetable soups. Studies have revealed a high consumption of purchased cooked meals among Ghanaian pre-school children (Asima, 1992; Ferguson *et al.*, 1993b). The Ghana Ministry of Health (MOH, 1992) reports that many mothers buy such foods for their children because they claim they

do not have time to cook or because the child becomes hungry and the vended foods are conveniently available.

The practice of feeding adult food to the child after 12 months has also been documented by the Ghana Ministry of Health (MOH, 1992).

Nearly one third (29%) of the children did not consume any supplements besides breastmilk. The late introduction of supplementary foods has been implicated in the development of PEM. Gershon (1978) noted that if the child objects to the weaning food, it is withdrawn and given to someone else and offered the breast, thus delaying consumption of solid foods. Prolonged breast-feeding beyond 19 months has been associated with malnutrition in pre-school children (Brakohiapa *et al.*, 1988), since the breastmilk can no longer provide adequate nourishment at this stage. Cereal porridges were the only supplements fed to nearly one third (27%) of the children. Plain *koko* which has been amply demonstrated as a low protein food that does not support good growth (Orraca-Tetteh, 1972; Nti, 1991) was the most popular cereal porridge used.

4.3.3.2 Frequency of Feeding and Preparation of the Child's Food

Twenty-three mothers (51%) claimed feeding their children food three times a day and these were mainly those on adult meals. The three meal pattern has been reported in other studies in Ghana (Woolfe *et al.*, 1987; Ferguson *et al.*, 1993b). Five (11%) of the children were fed four to five times daily and these were fed mainly porridges. A child over one year eating only porridge, the bulk of which is water, certainly will need to be fed many times during the day to obtain the little nourishment in the porridge. Four (9%) of the children were fed one to two times with porridge or adult meals besides breast milk.

Very few mothers said they prepared the child's food separately, mainly because the child was not eating solid foods yet. Although most mothers (71%) said it was appropriate to prepare the young child's food separately, only a few practised it.

The main reason given for not practising what they knew to be right was not having enough money and time, to do so.

Time and money constraints have been reported by the Ghana Ministry of Health (MOH, 1992) as major reasons given by mothers for not preparing the child's food separately. Similarly, mothers in Uganda and Rwanda also mentioned lack of time as a constraint for not being able to prepare separate meals for their young children (Sserunjogi, 1988; Ramakvelo, 1988).

However, most mothers like those in this study fail to realise how much time they lose when the child develops PEM and they have to quit or suspend their jobs.

4.3.3.3 Caring for the Child

Since most mothers were either petty traders at home or unemployed, 41 (91%) said they were the sole caregivers of the children. The rest left the children at home on occasion with their mothers or daughters. There is growing evidence on how nutritional status of young children may be significantly affected by the manner in which the mother or other primary caregivers respond to and care for them. It was observed during the study that most mothers had little patience for feeding their children and had to be given a lot of encouragement not to give up trying when the child refused or was playful. To ensure good food intakes by pre-school children, whether malnourished or normal, it has been demonstrated that there is great need for someone to help the child to eat (Torun *et al.*, 1984) and the need for constant encouragement to eat (Woolfe *et al.*, 1977).

4.3.3.4 Mother's Opinion of the quality of the feeding and care of the child

Mothers were asked to evaluate the quality of the feeding of their children before they fell ill. Half of the mothers said, they considered the feeding and food intakes of their children adequate mainly because the children ate everything offered them. Two mothers remarked that they thought breastmilk alone was good enough for a child even when he eats no supplements. The rest of the mothers considered the

food intakes of their children not good enough because the children ate so little or nothing at all. A few actually said their children failed to gain weight, which reflected poor feeding. Ignorance of the nutritional needs of the pre-school child, and of appropriate food mixtures to use to improve the nutritive value of the diet was observed in a study of severely malnourished children in Nigeria (Ighogboja, 1992). The inability to detect the signs of growth failure needs to be addressed so that mothers do not delay in seeking medical and nutrition intervention for their children.

4.3.4 Mothers' Concept of Good Food for Children

The child learns to eat what the mother feeds him. Therefore what she believes is suitable food is what the child gets, if she can afford it. What a mother considers unsuitable is often denied the child. Mothers were asked if there were any foods which in their opinion are good for feeding young children. Twenty-one (47%) said they did not know. This information is further evidence that many of the mothers were ignorant of the type of food mixtures they could use to improve the nutrient intakes of their pre-school children. Mothers and caregivers must be taught what to feed their toddlers so that they inculcate the right eating habits in their children. The remaining 24 mothers (53%), however, mentioned a variety of items including: leaves stew with legumes (8), composite foods and meals like *apapransa* and *mpotompoto* (8); fish (7); beans (5); palmfruit and groundnut soups (5); mashed yam with margarine, egg yolk or groundnuts (3); and soft foods (3).

The main reasons given for their opinions included: "healthy and promotes growth"; and that "the foods are soft so the child can eat enough of it to grow". Six mothers however, said they did not know why the foods they mentioned are good for children, for they only heard neighbours or friends making those claims. The attributes given to the foods considered suitable for pre-school children suggest that the mothers have had some nutrition education. If the meals they mentioned are properly constituted, they certainly will provide good nourishment for the toddler.

It has been documented that the traditional Ghanaian diet can adequately nourish the pre-school child, even as prepared in non-affluent families, without addition of milk and other Western foods (Woolfe *et al.*, 1977). It is interesting to note the awareness of the need for soft texture of food for toddlers expressed by mothers. To obtain this texture however, the child's food needs to be handled separately. Mothers therefore must be encouraged to accept this concept. The influence of neighbours and relations in passing on nutrition and health information must be recognised, hence, the need for correct information through primary health care for everyone.

4.3.5 Mothers' Concept of Bad Food for Children

With respect to foods mothers considered bad or unsuitable for young children, 18 (40%) said they didn't know of any such foods. Twenty-seven (60%) mentioned heavy foods like *fufu*, *tuo*, *banku* (8); hard foods like boiled yams (6); starchy foods like *fufu*, *kokonte*, *gari* (5); pepper (3); and two mothers each mentioned sweets, tea, *Koko* plus sugar, and purchased cooked foods.

Reasons given for the claims included the fact that young children have few teeth to chew hard food (6); children cannot eat enough of heavy foods to grow well (8); that *gari*, *fufu* and plain *koko* retard growth (6); that pepper limits food intakes and causes diarrhoea (4); and that purchased cooked foods are unhealthy (1). It is worth noting that, most mothers indicated that they were aware of the need for appropriate texture and quality of foods that the pre-school child needs. The study of malnourished children by Gershon (1978) at the same clinic, recorded foods similar to those currently reported as those considered unsuitable for toddlers by 50% of the mothers. The need to bridge the gap between knowledge and practice must be given serious attention so that preventing malnutrition among pre-school children will become a reality.

4.3.6 Mother's Knowledge of Symptoms of Malnutrition

Mother's were asked whether they associated their children's condition with food or feeding. Half of them said they did, because the children were not eating well. This information indicates that half of the mothers actually were aware that their children were not eating adequately and were likely to be, or to fall sick. However, sixteen mothers (35%), said the child's condition had nothing to do with food but that the child was simply sick. Seven mothers (16%) did not know the cause of their children's condition. When mothers were shown two pictures, one of a child with kwashiorkor and the other, a child with marasmus, 17 (38%) of the mothers associated both conditions with poor feeding or inappropriate food. Sixteen (35%) said they did not know what caused the conditions. Twelve (27%) said the conditions had nothing to do with food, and that the children were sick and needed medication to treat them. A few said the conditions were caused by evil spirits. On the whole, 62% of the mothers did not seem to know the causes of malnutrition in young children.

Gershon (1978) reported that 98% of mothers in his study did not know the causes of marasmus and kwashiorkor. In Nigeria, only 32% of mothers of malnourished pre-school children implicated poor nutrition in the development of PEM (Ighogboja, 1992). The view that PEM has nothing to do with food has also been discussed by Engle (1996) with reference to the process of "medicalization of hunger" in shanty towns in north-west Brazil, where mothers believe that symptoms of nutritional deficiencies should be treated with medicine not food. The belief that PEM is an act of God or the activities of evil spirits have also been reported in Nigeria (Ighogboja, 1992).

4.3.7 Health History of Study Children

Mothers were asked to indicate common morbidities encountered in their children and the frequency of these illnesses. The responses are given in Table 4.16. The most frequent illnesses afflicting over one third of the children included malaria fever, diarrhoea, and respiratory tract infections.

The high incidence of malaria among the study children gives support to the leading role the disease plays in the death of children in the 1-4 year group in Ghana (MOH, 1992). Since the fever causes reduction in food intake, it is not surprising that one third of the children were said to have had no appetite.

Table 4.16 Common illnesses among study children and the frequency of affliction

| Illnesses | Frequency of Affliction | | | | | |
|------------------|-------------------------|----|------------------------|----|--------------|----|
| | Very Often/Monthly | | Sometimes/Occasionally | | Seldom/Never | |
| | N | % | N | % | N | % |
| -Malaria fever | 38 | 85 | 5 | 11 | 2 | 4 |
| -Diarrhoea | 24 | 53 | 10 | 22 | 11 | 25 |
| -Running nose | 20 | 44 | 11 | 25 | 14 | 31 |
| -Coughs | 18 | 40 | 12 | 27 | 15 | 33 |
| -Sore nose/mouth | 11 | 25 | 0 | 0 | 34 | 75 |
| -Vomiting | 10 | 22 | 13 | 29 | 22 | 49 |
| -Boils | 4 | 9 | 1 | 2 | 40 | 89 |

Total Number = 45

The interaction between nutrition and infection remains the most prevalent public health problem in the world today. Infections that contribute to and precipitate malnutrition include diarrhoea and respiratory infections. In Nigeria, it has been noted that diarrhoea is the commonest disease associated with malnutrition, followed by broncho- pneumonia (Ighogboja, 1992).

The Ghana Ministry of Health has reported that about 34% of pre-school children have severe diarrhoea each year (MOH, 1992). Acute respiratory infections are associated with growth faltering as a result of the associated fever increasing metabolic rate, causing anorexia, vomiting, difficulty in breathing and swallowing, all of which cause reduction in food intake (UNICEF, 1993). What is worrying about achieving success in preventing these diseases is the attitude and beliefs held by mothers concerning these dangerous diseases. A study in Ghana reported that 88% of

mothers of malnourished children believed that diarrhoea, malaria, respiratory diseases among others, are normal diseases of children (Gershon, 1978).

In Zimbabwe, diarrhoea and upper respiratory tract infections are seen as part of the normal development of the child (Engle *et al.*, 1996). With attitudes like these, it is not surprising that despite the frequency of such illnesses, 11 (25%) of the mothers, were of the opinion that their children were healthy when they first arrived at the rehabilitation centre.

Note: The Socio-economic and demographic characteristics of caregivers and families of the study children are given in Appendix 8.

4.3.8 Morbidity Data of Study Children During Study Period

Records of episodes of diarrhoea, respiratory tract infections, malaria fever, activity levels and the general well being of all the study children were kept throughout the study period. As already indicated, all children who had any illness were treated before the study began. It was generally observed that all the children were in reasonably good health throughout the study period.

Running nose with or without coughs was the commonest infection which afflicted ten (22%) of the children during the study period. Five of these children had persistent running nose, which did not seem to visibly affect their activity levels or food intakes. The respiratory tract infections can probably be explained by the poorly ventilated and congested rooms, which the children occupied with their families.

Malaria fever was the second commonest affliction which affected eight (17%) of the study children. An episode usually lasted four to five days which caused some reduction in food intake. This could be the reason why some experimental children couldn't eat as much of the test meal as they would otherwise be capable of eating. Most families had no mosquito screening on their windows and doors and the environment children lived in was mosquito infested, so it is even surprising that fewer children suffered from malaria.

Episodes of diarrhoea were also fewer than expected, considering the insanitary environment that the children lived in. Only six (13%) of the children were reported to have had diarrhoea lasting more than a day during the study period. Two mothers of the experimental group were initially unwilling to feed their children the test food (Cd/M) when the children had diarrhoea but they were encouraged to try and see what happens. To their surprise, the children accepted the food and the diarrhoea did not last. Inadequate feeding during illness has been implicated in the development and aggravation of PEM (Torun & Chew, 1994). Therefore, mothers need to be encouraged to overcome the fear that feeding their children solid foods when they have diarrhoea would worsen their condition.

A period of heat wave caused heat rashes in some children but it did not seem to bother them much. Boils affected seven (16%) of the children including three controls. By the end of the study, all boils had cleared except in one of the control children. One experimental child with open sores all over the body, made a fast recovery and by the end of the feeding period, the sores were healed.

Another experimental child with severe marasmic kwashiorkor, had no appetite whatsoever at the start of the study. She however, after great persistence, and encouragement accepted the food (Cd/F) by the end of the first week of the feeding programme. By the end of the study, the oedema had greatly subsided, and the dermatosis in her groins had healed and she could sit upright (Fig.18).

Most of the children were inactive and fretful at the beginning of the study clinging to their mothers. But the experimental group became generally more active, involving in play activities as the study progressed. The increase in activity could be due to the fact that the children had become familiar with the environment and with the other children. It could also be that as the children increased their food intakes by consuming the test meals regularly, they began regaining their strength as it became obvious with the modest weight gains recorded. It was also observed that crying among the experimental children was reduced and they were not as listless as before, or as the control children were. Beaton and Ghassemi (1982) in their review of the

impact of morbidity on food intake, provided evidence that both medical care and supplementary feeding impacted favourably on morbidity and mortality.

4.3.9 Food Intakes During the Experimental Period

4.3.9.1 Intakes of test meals by experimental children

Records of the amounts of test meal consumed by each experimental child was kept for the twenty days duration of the feeding trials. Table 4.17 gives data on the food intakes.

Table 4.17 Intakes of test meals by experimental children in twenty days

| Test Meals | No of Subjects | Mean Daily Serving Size per child (g) | Mean Daily Consumption per child (g) | % of Daily Portion child is capable of Eating | Mean Available food eaten in 20 days per child % |
|-------------------------------|----------------|--|---|---|--|
| <u>Cornmeal Meals</u> | | | | | |
| Cm/C | 4 | 342 | 75 | 43 | 23 |
| Cm/M | 4 | 325 | 104 | 54 | 34 |
| Cm/F | 3 | 351 | 118 | 76 | 34 |
| Average | | 339 | 99 | 58 | 30 |
| <u>Yam Meals</u> | | | | | |
| Y/C | 4 | 331 | 200 | 86 | 61 |
| Y/M | 5 | 317 | 208 | 100 | 72 |
| Y/F | 4 | 287 | 166 | 86 | 65 |
| Average | | 312 | 191 | 91 | 66 |
| <u>Corndough Meals</u> | | | | | |
| Cd/C | 4 | 327 | 229 | 85 | 70 |
| Cd/M | 3 | 318 | 183 | 100 | 64 |
| Cd/F | 4 | 287 | 160 | 95 | 62 |
| Average | | 311 | 191 | 93 | 65 |

Table 4.17 shows that the serving size of the meals prepared with cornmeal are heavier than those prepared with yam and corndough. It is observed that the serving sizes of the yam and corndough meals with similar supplements weighed almost the same. The meals supplemented with cowpeas are generally heavier than those

supplemented with melonseeds and fish. The bulky nature of the cornmeal dishes resulted in reduced food intakes by the children fed those meals. They consumed about half the intakes of those fed yam and corndough meals. Consequently, whereas children on yam and corndough meals are capable of eating over 90% of the serving sizes at a sitting, those on cornmeal could eat only 58% of the servings. Since the ultimate nutritional benefit of a meal depends on how much is consumed, of the nine test meals, the results seem to indicate that the six meals based on yam and corndough are good, because pre-school children with small stomach capacities, could eat sufficient quantities of the meals to supply their food and nutrient needs.

Fermented cereal porridges have been recommended in Botswana as against unfermented cereal porridges fed as weaning food, due to the bulky nature of the latter (Mokwena, 1988).

4.3.9.2 Group averages of quantity of each test meal consumed per kilogram body weight per sitting

The quantity of food a child on each of the test meals consumed per kilogram body weight per day was calculated by working out the average daily intakes for each group on a specific meal, and dividing it by the average weight of each group at the beginning of the study. Table 4.18 gives the data on the food intakes.

TABLE 4.18 Estimates of the quantity of test meals consumed by the experimental children per kg body weight per sitting

| Test Meals | No. | Average Food intake Per sitting (g) | Average wt. at beginning of study (kg) | Quantity of Meal consumed (g/kg B.Wt/ sitting) |
|------------------|-----|-------------------------------------|--|--|
| Corndough | | | | |
| Meals | | | | |
| Cd/C | 4 | 229 | 8.85 | 25.9 |
| Cd/F | 4 | 160 | 7.22 | 22.2 |
| Cd/M | 3 | 183 | 7.90 | 23.2 |
| Average | | 191 | 7.99 | 23.9 |
| Cornmeal | | | | |
| Meals | | | | |
| Cm/C | 4 | 75 | 8.54 | 8.8 |
| Cm/F | 3 | 118 | 8.43 | 14.0 |
| Cm/M | 4 | 104 | 8.98 | 11.2 |
| Average | | 99 | 8.65 | 11.4 |
| Yam Meals | | | | |
| Y/C | 4 | 200 | 8.46 | 23.6 |
| Y/F | 4 | 166 | 6.35 | 26.1 |
| Y/M | 5 | 208 | 8.13 | 25.6 |
| Average | | 191 | 7.65 | 25.0 |

The average food intakes per sitting show that the cornmeal dishes recorded the lowest intakes, giving an average of approximately 11g/kg body weight of food consumed at a sitting. On the other hand, the average intake per kilogram body

weight per sitting for yam and corndough dishes were 24g and 25g respectively. Woolfe *et al.* (1977) observed food intakes up to 35g/kg at a sitting among healthy 1-3 year old Ghanaian children. In that case, an 8kg-9kg child could consume between 280g and 315g of food at a sitting. The functional gastric capacity of young children is reported to be approximately 40g to 50g per kilogram body weight per feeding (Brown, 1991b). In this case an 8kg child could consume 320g-400g of food per sitting and a 9kg child can consume 360-450g of food at a sitting. The weight per serving of the test meals compare favourably with the intake capacities of the pre-school child. Although the intakes in this study were lower than the references above, had the study continued, the children could have recovered and may have been able to eat the serving sizes. The results indicate that the serving sizes of the test meals are appropriate for the pre-school child.

4.3.9.3. Estimates of Energy And Nutrient Intakes During The Study Period

During the third week of feeding, when the experimental children had accepted the test meals, a two day combined repeated 24hour- recall and weighed food intakes were obtained for both experimental and control groups. The intakes were used to estimate and compare the daily energy and nutrient intakes of the experimental and control groups. The proportion of total daily energy and selected nutrient intakes supplied by the test meals were also calculated. Table 4.19 gives the group mean of daily energy and nutrient intakes of the study children.

TABLE 4.19 Estimated mean (\pm SD) daily energy and nutrient intakes of experimental and control children during study period*

| Age (yrs.) | Group | Energy (kcal) | Protein (g) | Calcium (mg) | Iron (mg) | Zinc (mg) | Vit. A (μ gRE) | Thiamin (mg) | Riboflavin (mg) | Niacin (mg) |
|------------|--------------|---------------|----------------|--------------|----------------|---------------|---------------------|-----------------|-----------------|-----------------|
| 1-2 | Experimental | 629 \pm 268 | 18.7 \pm 3.4 | 87 \pm 37 | 8.2 \pm 3.8 | 1.9 \pm 0.9 | 1723 \pm 254 | 0.32 \pm 0.16 | 0.20 \pm 0.07 | 5.00 \pm 1.14 |
| | Control | 501 \pm 102 | 12.5 \pm 3.8 | 65 \pm 44 | 6.5 \pm 2.4 | 1.4 \pm 0.7 | 780 \pm 073 | 0.29 \pm 0.17 | 0.18 \pm 0.12 | 3.02 \pm 1.21 |
| 2-3 | Experimental | 808 \pm 121 | 20.2 \pm 3.8 | 113 \pm 30 | 10.3 \pm 3.8 | 2.7 \pm 0.7 | 2485 \pm 339 | 0.38 \pm 0.09 | 0.25 \pm 0.05 | 4.67 \pm 1.21 |
| | Control | 690 \pm 120 | 16.4 \pm 1.4 | 85 \pm 23 | 7.2 \pm 1.6 | 2.1 \pm 0.4 | 870 \pm 042 | 0.29 \pm 0.04 | 0.23 \pm 0.03 | 3.33 \pm 1.03 |

*Mean intakes obtained from a repeated 24-hour recall and weighed food record during the study period.

Except for protein and vitamin A intakes of the experimental group and only vitamin A intakes of the control group, intakes of energy and the rest of the nutrients fell below the FAO recommended dietary requirements. However, the iron intakes in the experimental 1-2 year group met over 80% of the RDI while the 2-3 year group met over 100% of the RDI. It is not surprising that all the children failed to meet the recommended dietary intakes, because most of them had lost appetite prior to the inception of the study and they were just beginning to regain their appetites. Despite the lower than recommended intakes, a look at the intakes of the experimental and control groups shows higher intakes in the experimental than in the control group. This observation suggests that the test meals made some contributions towards the daily intakes of the experimental group.

4.3.9.4 Estimates of Percentage Contributions of Test Meals to Experimental Group's Energy and Selected Nutrient Intakes During the Study Period.

In order to estimate the contributions of test meals towards the daily energy and selected nutrient intakes of the experimental group, the mean group values were calculated. Table 4.20 gives the estimates obtained.

TABLE 4.20 Mean percentage contributions of test meals of experimental group's daily energy and selected nutrient intakes

| Age(yrs.) | Mean % contribution towards intakes per day | | | | | |
|-----------|---|---------|---------|------|------|-------|
| | Energy | Protein | Calcium | Iron | Zinc | Vit.A |
| 1-2 | 38 | 32 | 43 | 49 | 52 | 63 |
| 2-3 | 35 | 33 | 42 | 44 | 39 | 41 |

Table 4.20 shows that the mean percentage energy contributions of the test meals consumed by the experimental group met over one third of the day's needs. Protein intakes met one third instead of the half of the RDI expected from each meal. This may be explained by the fact that some children ate wheat-soy-blend porridge for supper on the recall days so that, the protein contributed by the test meals appears lower. However, the contributions of protein from the test meals would have been higher if the children had eaten their usual home meals for supper. Although the overall calcium intakes were low (Table 4.19), the test meals provided 45% of the daily intakes. The iron, zinc and vitamin A contributions of the test meals consumed provided 40% and over, of the daily intakes. The results indicate that, the test meals made substantial contributions to the daily energy and nutrient intakes of pre-school children.

4.3.10. Growth Performance of Study Children

4.3.10.1. Weights and Heights

Increases in weights and heights were the main indicators of growth used in this study. Table 4.21 gives the data on the comparison of mean weights and heights before and after the study of the experimental and control groups.

TABLE 4.21 Comparison of anthropometric data before and after the study
(Mean \pm SD)

| Group | No. | Measurement | Initial | Final | Gain | Gain % |
|--------------|-----|-------------|------------------|------------------|------------------------------|---------------|
| Experimental | | | | | | |
| | 35 | Weight (kg) | 8.09 \pm 1.76 | 8.50 \pm 1.76 | 0.41 \pm 0.40 ^a | 5.3 \pm 1.8 |
| | 35 | Height (cm) | 74.71 \pm 3.16 | 75.76 \pm 3.08 | 1.05 \pm 0.24 | 1.4 \pm 1.1 |
| Control | | | | | | |
| | 10 | Weight(kg) | 7.29 \pm 1.22 | 7.34 \pm 1.45 | 0.05 \pm 0.16 ^a | 0.6 \pm 0.2 |
| | 10 | Height (cm) | 73.17 \pm 3.60 | 74.04 \pm 3.89 | 0.87 \pm 0.24 | 1.2 \pm 0.3 |

Vertical means with the same superscript differ significantly ($p = 0.007$).

Analysis of Covariance was used to test the significance of gains in weights and heights between the experimental and control groups.

The results in Table 4.21 show that the experimental group recorded 5% increase in weight while the control group recorded an increase of 0.6%. The weight gained by the experimental group is significantly higher ($p = 0.007$) than that gained by the control group.

Fig.7 graphically presents the trend of weight gain by the experimental and control groups. The figure shows how steadily the experimental group gained weight throughout the study, while the control remained stationary. Gains in weight and height over a 12-week feeding period of malnourished Guatemalan pre-school children, fed an improved traditional diet recorded 10.8% and 2.5% increases above initial values of weight and height respectively. The height gained by the experimental group is however not statistically significant from that of the control group.

The improvements in weight in the present study are encouraging, indicating that the test meals are capable of supporting growth.

THE MEAN WEGHTS OF EXPERIMENTAL AND CONTROL GROUPS AT THE BEGINNING, DURING AND AT THE END OF THE STUDY

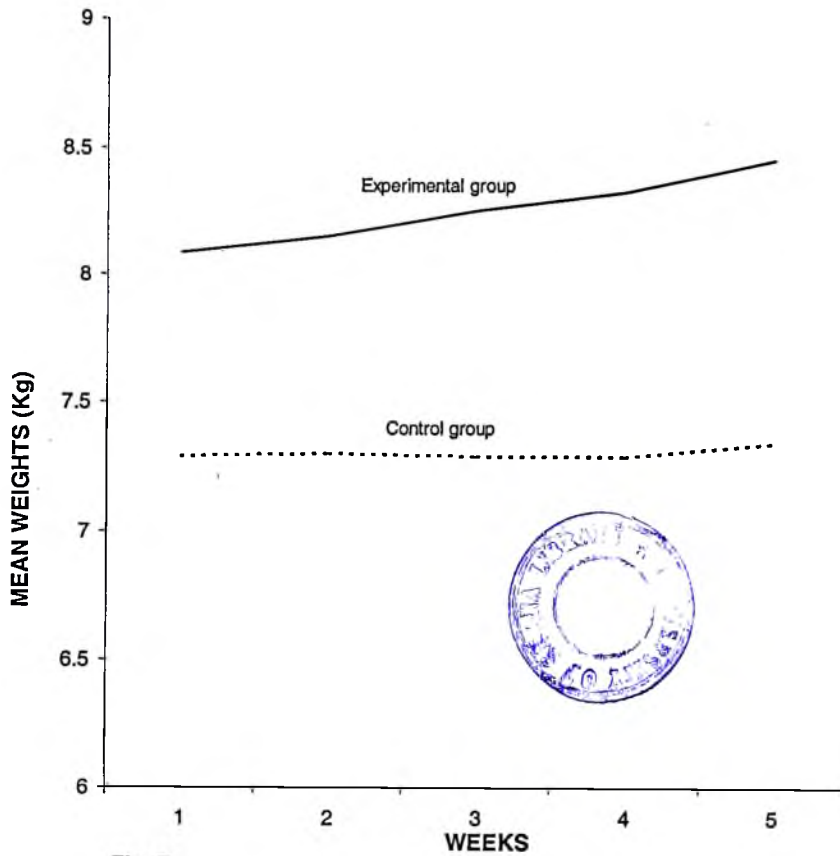


Fig. 7

4.3.10.2 Weight gained per day and per/kg body weight

The information on mean weight gain per child in the experimental and control groups are given in Table 4.22. The estimate of the mean weight gained per day per child was arrived at by dividing the mean total weight gained at the end of the study in each of the groups (experimental or control) by the number of children comprising each group.

The weight gained per kilogram body weight per day was calculated by dividing the mean weight gained per day per child by the initial mean weight of the children in each group.

TABLE 4.22 Weight gained per kilogram body weight in experimental and control groups

| Group | No | Mean Initial Weight (kg) | Mean Final Weight (kg) | Mean Weight Gained* (g) | Mean Weight gained/day (g) | Wt gained /kg body wt./day (g) |
|--------------|----|--------------------------|------------------------|-------------------------|----------------------------|--------------------------------|
| Experimental | 35 | 8.09 | 8.50 | 410 | 16 | 2.0 |
| Control | 10 | 7.29 | 7.34 | 50 | 2 | 0.3 |

*Weight gained as measured at the end of the feeding trials.

Table 4.22 shows that the experimental children made modest weight gains, eight times that gained by the controls. The weight gains are comparable or higher than those observed in similar studies. For instance, a one-year study of Thai Hilltribe malnourished pre-school children fed an improved local meal, which improved the mean growth curve, reported mean weight gains of 1.4kg and 1.0kg per year among the 1-3 year old experimental and control groups respectively (Viseshakul *et al.*, 1979). These weight gains translate to 3.9g/day among the experimental group and 2.8g/day among the control group.

With reference to Table 4.5, it was observed that the average protein content of the test meals per kilogram body weight could support growth of 20-30 g/day in the pre-school child. The weights gained per day in this study as given in Table 4.25 therefore confirm that the test meals actually supported growth, close to what was expected.

A comparison of the weight gain/kg body weight/day with that of malnourished Guatemalan pre-school children who experienced catch-up growth on an improved local diet shows that the average value of 2g /kg/day observed in this present study is over three times the average value of 0.6g/kg/day obtained in the twelve weeks Guatemalan study by Torun *et al.* (1984).

4.3.10.3 Comparison of weight and height gains among experimental groups with respect to type of supplement used.

The weight gained after the study was compared among experimental groups of children on the different supplements regardless of staple used and with the control group using Analysis of Covariance and the Tukey Honest Significant Difference statistic (HSD) to determine whether there are any differences in growth performance. Table 4.23 presents the comparison.

TABLE 4.23 Comparison of weight and height gains among experimental groups of children on meals with three different supplements and the control group. (Mean \pm SD)

| Group | No. | Mean Weight gain (kg) | Mean Height gain (cm) |
|-----------------------|-----|------------------------------|-----------------------|
| Cowpea supplement | 12 | 0.37 \pm 0.02 | 1.06 \pm 0.17 |
| Melonseeds supplement | 12 | 0.55 \pm 0.05 ^a | 1.08 \pm 0.12 |
| Fish supplement | 11 | 0.38 \pm 0.13 | 1.13 \pm 0.19 |
| Control Group | 10 | 0.05 \pm 0.03 ^a | 0.89 \pm 0.13 |

Vertical means with the same superscript differ significantly ($p < 0.012$).

Analysis of Covariance (ANCOVA) revealed a significant difference ($p=0.007$) between the weight gains of the experimental and the control groups. Further comparisons of the means using Tukey HSD static showed no significant differences among the experimental groups. However, the gain by the group on melonseed supplement was significantly higher ($p<0.012$) than the control group, although the mean weight gained by the groups on the other two supplements were also higher than the control group.

Figs. 8 and 9 are graphic representations of the weight and height gains with respect to supplement used. The results suggest that the three sources of protein supplements are equally effective in supporting growth among the children. The group on melonseeds however, gained one third more weight than those on cowpeas and fish. This observation points to the potential value of this under-utilised oil seed as a source of protein in child feeding.

MEAN WEIGHT GAINED AMONG EXPERIMENTAL CHILDREN ON MEALS WITH 3 DIFFERENT SUPPLEMENTS AND THE CONTROL GROUP

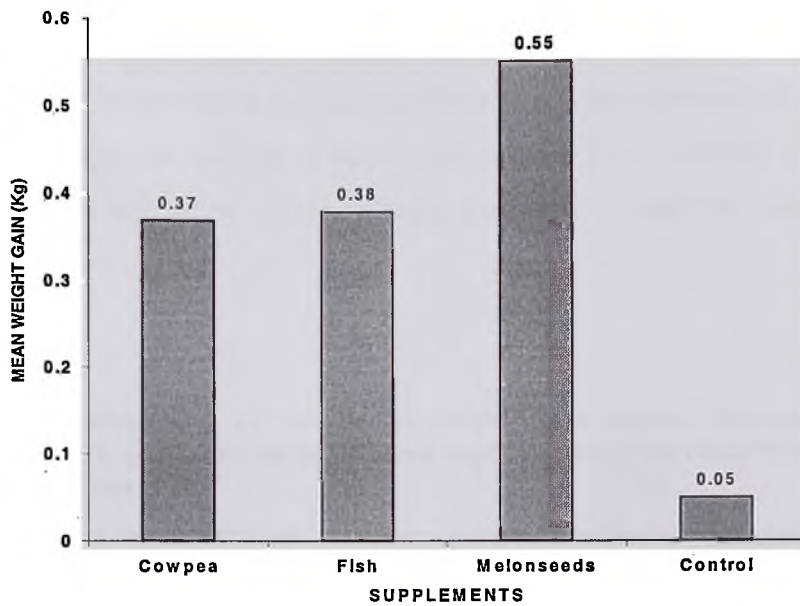


Fig. 8

MEAN HEIGHT GAINED AMONG EXPERIMENTAL CHILDREN ON MEALS WITH 3 DIFFERENT SUPPLEMENTS AND THE CONTROL GROUP

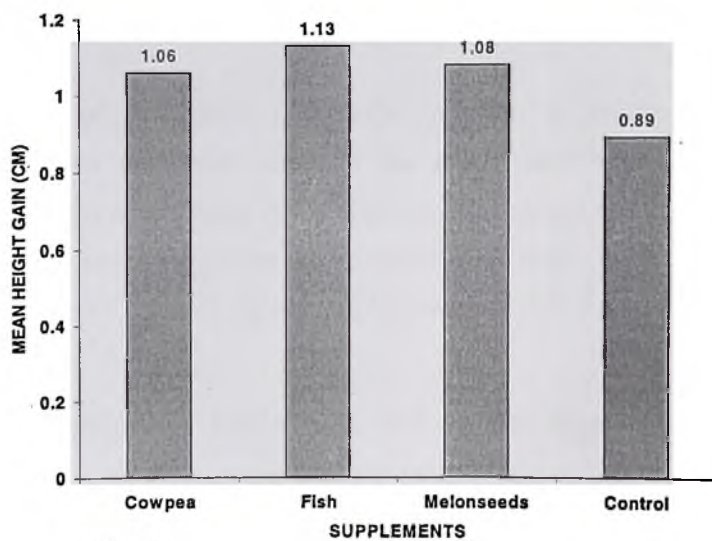


Fig. 9

4.3.10.4 Comparison of weight and height gains among experimental groups with respect to the type of staple used.

A further comparison of the weight and height gains among the experimental groups with respect to the type of staple used is made to see whether growth performance was affected by the type of staple food used. Table 4.24 gives this information.

TABLE 4.24 Comparison of weight and height gains among experimental groups of children on the three staple meals and the control group (Mean \pm SD)*

| Group | No. | Mean Weight Gain (kg) | Mean Height Gain (cm) |
|-----------|-----|------------------------------|-----------------------|
| Corndough | 11 | 0.39 \pm 0.01 | 1.06 \pm 0.38 |
| Cornmeal | 11 | 0.30 \pm 0.02 | 1.11 \pm 0.36 |
| Yam | 13 | 0.65 \pm 0.19 ^a | 1.31 \pm 0.31 |
| Control | 10 | 0.05 \pm 0.03 ^a | 0.89 \pm 0.23 |

*Vertical means with the same superscript differ significantly ($p = 0.008$).

Analysis of Covariance (ANCOVA) revealed a significant difference ($p < 0.015$) between the weight gains of the experimental and control groups. Comparisons of the means using Tukey HSD statistic revealed that the weight gains among the experimental groups are not significantly different. However, the weight gain by the group on Yam was significantly higher ($p = 0.008$) than that of the control group.

The differences in height gains were neither significant between the experimental and control groups nor among the experimental groups. The low height gains is probably due to the fact that height is not sensitive to change in a short period. Figures 10 and 11 graphically present the differences among the groups, which

show that the group on yam gained both more weight and height than the groups on corndough and cornmeal. Yam has always been branded as “starchy” food and considered inferior to cereals but there is evidence here to show that when yam is supplemented with protein-rich foods, the meal can support growth comparable to, or probably better, than a cereal.

MEAN WEIGHT GAINED AMONG EXPERIMENTAL CHILDREN ON 3 STAPLE MEALS AND THE CONTROL GROUP

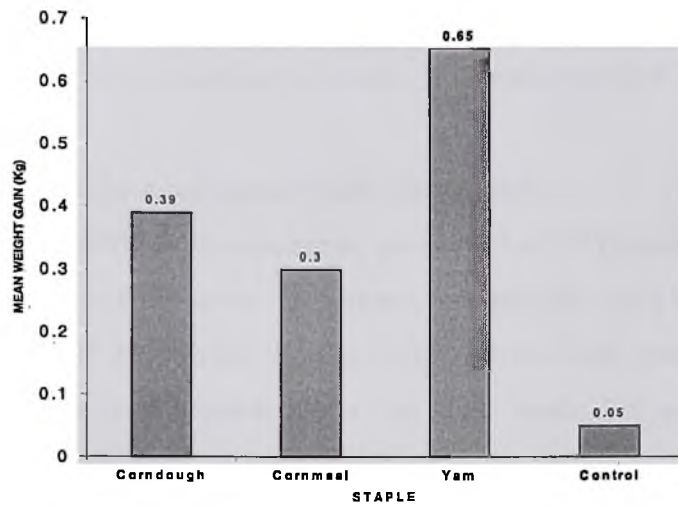


Fig. 10

MEAN HEIGHT GAINED AMONG EXPERIMENTAL CHILDREN ON THE 3 STAPLE MEALS AND THE CONTROL GROUP

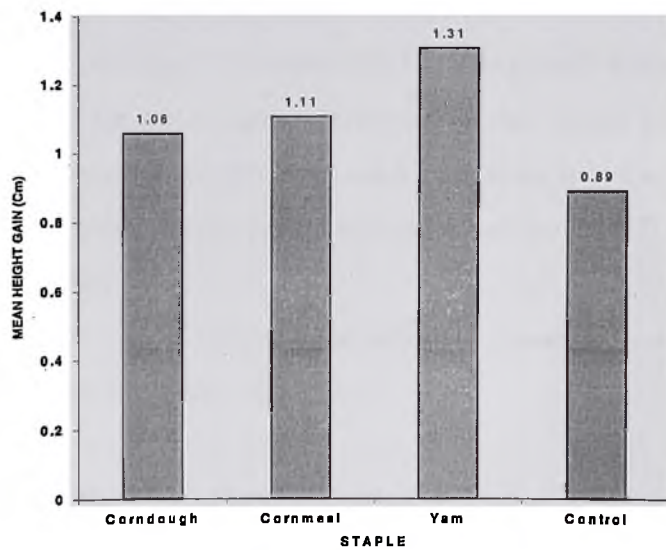


Fig. 11

4.3.11 Description of the Nutritional Status of the Study Group After the Study

A summary of the nutritional status at the end of the study with respect to the anthropometric indices of WAZ, WHZ, HAZ is described. The gains in Z-score values of the experimental and control groups are compared using analysis of Covariance.

4.3.11.1. Weight for Age Z-score (WAZ) - Underweight

Although 80% of the experimental group still had WAZ scores below -2SD, 69% had improved WAZ scores. For instance, one child who had a WAZ of -4.2SD at the inception of the study had WAZ of -2.6SD after the study. Among the control group 30% made slight improvements in their WAZ scores. The rest remained the same or deteriorated, with 70% still having WAZ below -3SD.

A comparison of the gain in WAZ between the experimental and control groups using ANCOVA revealed a significantly higher ($p = 0.027$) gain in the experimental group than in the control group.

4.3.11.2. Weight for Height Z-score (WHZ) - Wasting

Wasting among the experimental group reduced considerably. At the end of the study, those who had WHZ below -2SD had reduced to 23% from 43% and on the whole, 69% of the group made improvements in their weight for height Z-scores. Among the control group, 20% made small improvements in their WHZ with 40% having deteriorated. Thirty percent still had values below -3SD and another 30% were below -2SD.

The gain in WHZ by the experimental group is statistically significant ($p = 0.040$) from that of the control group.

4.3.11.3. Height for Age Z-score (HAZ) - Stunting

Stunting among both the experimental and control groups showed very little reduction after the study, probably due to the short duration of the study since height increases are generally slower than weight increases. However, 46% of the

experimental group had slight improvements in their HAZ scores. While the proportion with scores between -1 to -2SD had reduced from 40% to 35% the proportion below -2SD increased slightly from 60% to 65%. Since the children had grown older without growing taller, the observation is not unexpected. Among the control group, the proportion with scores below -2SD (50%) remained the same as at the beginning of the study. Those with values between -1 to -2SD (50%) also remained the same.

The gain in HAZ by the experimental group is not significantly different ($p = 0.234$) from that of the control group.

4.3.11.4 Haemoglobin levels

Table 4.25 gives the haemoglobin levels before and after the study for both the experimental and control groups.

**TABLE 4.25 Comparison of Haemoglobin levels before and after the study
(Mean \pm SD)**

| Group | No. of Subjects | Haemoglobin Level (g/dL) | | | Gain % |
|--------------|--------------------|--------------------------|----------------|-----------------------------|----------------|
| | | Initial | Final | Gain | |
| Experimental | 24 | 9.5 \pm 1.4 | 10.3 \pm 1.3 | 0.8 \pm 0.2 ^a | 8.4 \pm 2.1 |
| Control | 7 | 9.4 \pm 1.2 | 9.3 \pm 1.4 | -0.1 \pm 0.1 ^a | -1.1 \pm 1.5 |

Vertical means with the same superscript differ significantly ($p = 0.012$)

It is worth noting that there is a mean increase of 8% in haemoglobin level of the experimental group as against a loss of 1% in the control group. Using Analysis of Covariance to compare the gain in the experimental and control group revealed that

the gain in the experimental group is significantly higher ($p = 0.012$) than that of the control group. For instance three of the 13 experimental children who had haemoglobin levels below 12g/dL at the onset of the study reached 12g/dL at the end of the study, indicating normal levels. However, none of the 7 control children attained more than 11g/dL and the data shows a decrease in the mean haemoglobin levels for the group. Improvement in Haemoglobin levels in the present study is fairly high since in only 4 weeks the gain percent was 8.4% about the same as the 8.5% obtained by Torun *et al.*, (1984) in 12 weeks in Guatemalan pre-school children.

On the whole the nutritional status of the experimental group of children improved as evidenced by diminution of wasting ,underweight and improvement in haemoglobin levels.

Figures 13 to 21 show pictures of experimental children before and after the study and Figures 22 to 24 are the pictures of control children before and after the study.

A: Underweight child before the study.

B: The same child one month later after being fed experimental meal of cornmeal supplemented with cowpeas.



Fig. 14.

A: Underweight child before the study.

B: The same child one month later after being fed experimental meal of cornmeal supplemented with cowpeas.



Fig. 15.

A: Marasmic child before study.

B: The same child one month later after being fed experimental meal of cornmeal supplemented with fish.



Fig. 16

A: A marasmic child before the study.

B: The same child one month later after being fed experimental meal of yam supplemented with melon seeds

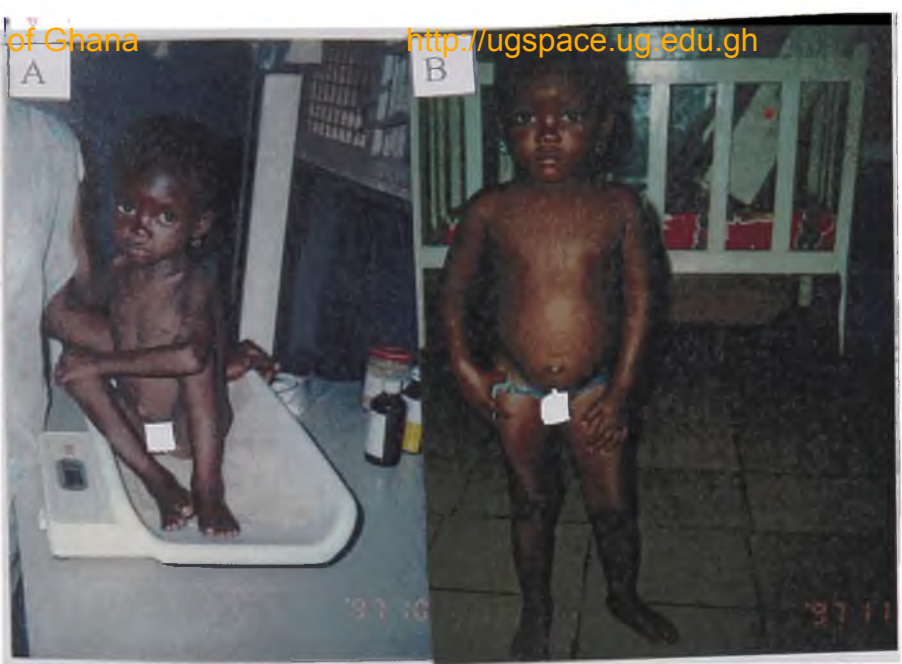


Fig. 17

A: A marasmic child before the study.

B: The same child a month later after being fed experimental meal of yam supplemented with cowpeas.



Fig. 18

A: A Kwashiorkor child before the study.

B: The same child a month later after being fed experimental meal of yam supplemented with fish.



Fig. 19

A: Malnourished child before study.

B: The same child one month later after being fed experimental meal of corndough supplemented with melon seeds.

**Fig. 20**

A: Malnourished child before study.

B: The same child one month later after being fed experimental meal of corndough supplemented with cowpeas.

**Fig. 21**

A: Malnourished child before study.

B: The same child one month later after being fed a meal of corndough supplemented with fish.



Fig. 22

A: Control malnourished child at the start of the study.

B: The same child at the end of the study, looking almost the same as before.



Fig. 23

A: Control malnourished child at the start of the study.

B: The same child at the end of the study looking almost unchanged.



Fig. 24

A: Control malnourished child at the start of the study.

B: The same child at the end of the study looking almost the same as before.



4.3.12 Mothers of the Experimental Group's Opinion of the Test Meals

All the mothers of the experimental children made favourable remarks about the test meals. This may be because they observed weight gain restored in their children, most of whom had had static weights for several weeks prior to the study. The comments mothers made are presented in Table 4.26.

TABLE 4.26 Mothers' opinion of the test meals

| Opinion/Comments | N | % |
|---|----|----|
| • The meal is nutritious/The meal is good. | 22 | 63 |
| • Child likes the meal so much and eats most or almost all of it. | 20 | 57 |
| • The meal has restored weight gain and is making the child grow. | 20 | 57 |
| • The meal is tasty/appropriate for young children. | 19 | 54 |
| • The meal is satisfying and sustains the child for a long time. | 16 | 46 |
| • The meal is easy to prepare. | 13 | 37 |
| • The meal is easy to feed because it is one dish. | 13 | 37 |
| • It has restored child's appetite. | 11 | 31 |
| • The looks of the child have changed. | 10 | 29 |
| • Child is becoming active. | 9 | 26 |
| • Child just loves the meal. | 5 | 14 |
| • Noticed improvement in child's skin/health. | 4 | 11 |
| • The meal must be fed to all young children. | 4 | 11 |

Total number of mothers = 35

Mothers in the study considered the meals beneficial to child growth, and most of the mothers were keen to continue feeding their children with the different varieties at home. Table 4.26 shows that nearly two thirds of the mothers recognised

the nutritional value of the meals as an important consideration in feeding their children. Two of the mothers with children suffering from kwashiorkor remarked at the beginning of the study, that if medications could not improve the health of their children, they doubted what food could do. But at the end of the study, they were both impressed with the changes in their children. The pictures of these children are those in Fig. 19 and Fig. 20.

The acceptance of the test meals by the mothers may also be largely due to the familiarity with the ingredients, the cooking procedure, the organoleptic qualities of taste, flavour and texture, and the fact that the meals were easy to feed, or the child could eat it by himself. Studies in Ghana have reported that most mothers use locally available foods during weaning of their children (Ferguson *et al.*, 1993; Denueme, 1993) and these must be encouraged.

The meals prepared with yam received very ready acceptance because mothers were very familiar with the presentation which is similar to a local yam preparation (*mpotompoto*), often used for weaning. Mothers were initially not too keen about the cornmeal and corndough meals because they were not accustomed to using cereal in place of yam and cocoyam for preparing *mpotompoto*.

However, after persistent encouragement and having them first taste the food, they realised that the taste, flavour and textures were all acceptable. They were even surprised that the children readily accepted the meals and eagerly ate them, which helped them a lot in overcoming their misgivings.

An interesting observation made was that, both mothers and the staff in charge of the rehabilitation centre did not detect any differences among the meals with regards to which supplement was added. The mothers did not even detect that their children were fed the same supplement throughout the entire study period.

The acceptance of the meals by the children may be related to their soft textures and mild flavours because no hot pepper was added. Young children have been observed to prefer foods that are soft textured and mildly flavoured (Guthrie, 1989).

5.0 CONCLUSIONS & RECOMMENDATIONS

5.1 CONCLUSIONS

In the light of the results of the study the following conclusions are made that:

- Good quality weaning meals can be formulated from combinations of locally available foods which can be used to rehabilitate malnourished pre-school children successfully
- The study confirms the recommendation from previous studies that traditional diets supplemented with fish and cowpeas increase protein content and the addition of fat increases energy densities to support growth. This underscores the potential for using foods that are locally available to solve nutrition problems in children.
- Corndough and yam, more so than cornmeal, supplemented with fish, melonseed or cowpea, and palm oil could be constituted into weaning meals that could provide adequate energy, protein of good quality and other essential nutrients especially vitamin A, which could promote growth in pre-school children.
- The use of yam in weaning food preparation was as good as using a cereal like maize when properly supplemented with protein-rich food sources such as cowpea, fish and melon seed.

Yam and melon seed supplement was the best meal and therefore a demonstration of good amino acid complementation of a staple root crop with a legume.
- Melon seed was the best supplement and therefore this under-utilised food shows great potential as supplement in weaning meals.

- The agreement between the protein scores and the NPUop% values is a confirmation of the prediction of protein qualities of weaning diets using amino acid content.
- The human experiment confirmed animal studies in the biological evaluation of the diets, suggesting that results from animal experiments could be used to infer the outcome in humans.



5.2 RECOMMENDATIONS

Based on the conclusions drawn and despite some limitations of the study, including the small sample size of study children and the short duration of the study, the following recommendations are made:

The test meals, especially those prepared with corndough and yam are recommended for use as weaning meals for pre-school children. The need to increase the calcium contents, without increasing the bulk of the meals can be achieved by adding small quantities of dried baobab leaves (*kuka*) and a local condiment obtained by fermenting locust bean (*dawadawa*), which are local rich sources of calcium.

It is also recommended that greater efforts in the use of local foods in child feeding need to be pursued. This means that more home-prepared local weaning foods must be formulated and tested so that deprived segments of society, who cannot afford commercially prepared toddler foods could return to traditional alternatives, which they are familiar with, and meals that could cost less, to solve the chronic problem of malnutrition among children of poor families. The more the weaning meals to choose

from, the better the chance of speeding up the hope of achieving the projected increase from 9% to 65% of Ghanaian mothers administering nutritionally balanced foods to their pre-school children.

There is a need for further studies using a much larger human sample and allowing a period of one or two weeks acclimatization before data collection begins.

Finally, for successful introduction of improved local weaning foods, and to sustain their use, there is the need for great determination on the part of facilitators for persistent encouragement of mothers to be patient when feeding young children, especially when they are sick. Nutrition education must be intensified, making efforts to bridge the gap between knowledge and practice, and educating mothers on good hygiene practices, to reduce the incidence of infections and infestations, which lead to, and precipitate malnutrition.

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APPENDIX 1**Scoring of Test Meal For Protein Value Using FAO
Reference SAA Requirements as Basis**

| Food Ingredients | From Food Tables | | | | Amount in Ingredients | | |
|---------------------|------------------|-------------------|------------------|--------------|---------------------------|--------------------------|------------------|
| | Wt in grams | Protein g/100g | Kcal per 100g | SAA Mg/gN | N (g) <u>AB</u> 625 | kcal <u>AC</u> 100 | SAA Mg DxE |
| | A | B | C | D | E | F | G |
| Cornmeal | 60 | 9.5 | 360 | 0.217 | 0.9120 | 216.0 | 0.1979 |
| Cowpeas | 30 | 23.4 | 350 | 0.141 | 1.1232 | 105.0 | 0.1584 |
| Green Leaves | 15 | 2.9 | 33 | 0.234 | 0.0696 | 5.4 | 0.0163 |
| Tomato | 30 | 1.1 | 18 | 0.074 | 0.0528 | 5.4 | 0.0039 |
| Onion | 5 | 1.0 | 33 | - | 0.0080 | 1.7 | - |
| P. Oil | 10 | 0.0 | 900 | - | 0.0000 | 90.0 | - |
| | | | | | 2.1656 | 423 | 0.3765 |

Crude Protein Content of Diet = 13.5 grams

$$PE\% = \frac{\text{Total Nitrogen} \times 2500}{\text{Total kcals}} \times 100$$

$$= \frac{2.1656 \times 2500}{423} = 12.7\%$$

$$\text{Score} = \frac{\text{Total SAA}}{\text{Total Nitrogen}} \times \frac{100}{\text{Ref. Requirement}}$$

$$= \frac{0.3765 \times 100}{2.1656 \times 220} = 79\%$$

$$\text{NDpCals \%} = \frac{\text{Score} \times PE\%}{100}$$

$$= \frac{79 \times 12.7}{100} = 10.0\%$$

APPENDIX 2**Calculated Energy And Protein Quality Values of The Test Meals**

| Diets# | | | | Actual | *Total | Total | PE % | Score | NDpcals % |
|--------------|--------|--|--------|-----------------------------|--------------------------------|---------------------|-----------------|----------------|---------------|
| Sample | Wt (g) | Additional Effective Source of Protein | Wt (g) | Protein Content of Meal (g) | Digestible Protein in Meal (g) | kcal in Meal (kcal) | Quantity Factor | Quality Factor | Protein Value |
| 1. Cornmeal | 75 | Smoked Small Herrings | 5 | 11.4 | 9.7 | 389 | 11.8 | 101 | 11.9 |
| 2. Cornmeal | 60 | Cowpeas | 30 | 13.5 | 11.5 | 423 | 12.7 | 79 | 10.0 |
| 3. Cornmeal | 60 | Melonseeds | 15 | 10.9 | 9.3 | 405 | 10.8 | 95 | 10.2 |
| 4. Corndough | 120 | Smoked Small Herrings | 5 | 10.9 | 9.3 | 365 | 12.0 | 101 | 12.1 |
| 5. Corndough | 120 | Cowpeas | 30 | 14.4 | 12.0 | 453 | 12.7 | 80 | 10.2 |
| 6. Corndough | 120 | Melonseeds | 15 | 11.8 | 10.0 | 434 | 10.9 | 95 | 10.4 |
| 7. Yam | 150 | Smoked Small Herrings | 10 | 11.4 | 9.7 | 350 | 13.0 | 99 | 12.8 |
| 8. Yam | 150 | Cowpeas | 40 | 13.8 | 11.7 | 447 | 12.3 | 70 | 8.7 |
| 9. Yam | 150 | Melonseeds | 20 | 10.3 | 8.8 | 431 | 9.6 | 90 | 8.6 |

*Total Digestible Protein = Actual Dietary Protein x 85% digestibility

Additional Ingredients in each Diet are:

- Green Leaves - 15g
- Tomatoes - 30g
- Onion - 5g
- Palm Oil - 10g
- Salt to Taste

APPENDIX 3

Calculations

All statistics were calculated using SPSS 9.0 computer software.

Protein Evaluation

The following parameters were calculated using the nitrogen content of feed, faeces and urine from the balance studies.

Apparent Digestibility (AD%)

AD measures the proportion of ingested nitrogen that is absorbed without taking account of the metabolic faecal nitrogen losses.

Expressed as:

$$AD(\%) = \frac{I - F}{I} \times 100$$

I

True Digestibility (TD%)

It measures the proportion of food nitrogen that is absorbed taking into account the metabolic losses in faeces.

Expressed as:

$$TD(\%) = \frac{I - (F - F_c)}{I} \times 100$$

I

Nitrogen Balance (Bal%)

It measures the proportion of the ingested nitrogen that is retained within the body.

Expressed as:

$$Bal(\%) = \frac{I - F - U}{I} \times 100$$

I

Net Protein Utilization Operative (NPUop%)

NPU is a combined measure of digestibility and efficiency of utilization of the test protein or absorbed amino acids for protein synthesis. If a meal is fed as it is consumed without standardizing the protein content, it is termed NPU operative.

Appendix 3 continued.

Expressed as
$$\text{NPUop}(\%) = \frac{I - (F - F_o) - (U - U_o)}{I} \times 100$$

I

Biological Value (BV%)

BV is a measure of the proportion of absorbed nitrogen that is retained for maintenance and /or growth.

Expressed as:

$$\text{BV}(\%) = \text{NPUop} \times \text{TD}$$

or
$$\text{BV}(\%) = \frac{I - (F - F_o) - (U - U_o)}{I - (F - F_o)} \times 100$$

I - (F-Fo)

where: I = Nitrogen intake (mg)

F = Faecal nitrogen (mg)

F_o = Obligatory loss of nitrogen in faeces (2.02mg faecal nitrogen/g feed, after Njaa, 1963)

U = Urinary nitrogen (mg)

U_o = Obligatory loss of nitrogen in urine ($W^{0.75} \times k$, where W = average body weight (g) of animal during the 5 day balance period, and k= 0.645, after Njaa, 1963).

Net Dietary Protein Calories Percent (NDpCals%)

It is an estimate of utilizable protein content of the meal in terms of calories expressed as a percentage of the total metabolizable energy (kcal).

It is the product of the NPUop and the protein calories (PE) in the meal.

Expressed as:

$$\text{NDpCal\%} = \text{PE} \times \text{NPUop} \div 100$$

where: PE is the metabolizable energy of protein, i.e. $N \times 6.25 \times 4.0$ where 4.0 is the metabolizable energy of protein and 6.25 is the conversion factor for crude protein.

Protein Score or Chemical Score (CS)

It is an estimate of the probable efficiency of utilization of the test meals. The amino acid scoring pattern proposed by FAO (1973) was used for the calculations.

Expressed as:

$$\text{CS} = \frac{\text{mg of amino acid per g N in test meal} \times 100}{\text{mg of amino acid per g in reference pattern}}$$

The amino acid scoring for children 2 - 5 years recommended by FAO/WHO/UNU 1985 were also used to score the test meals.

Expressed as:

$$\frac{\text{mg of amino acid per g protein in test meal} \times 100}{\text{mg child's requirement for amino acid}}$$

Anthropometry**Height-for-Age (HAZ)**

Calculated as:

$$\text{S.D. Score} = \frac{\text{Height of subject} - \text{median reference height for age}}{\text{S.D. below median reference height for age}}$$

S.D. below median reference height for age

Weight-for-height (WHZ)

Calculated as:

$$\text{S.D. Score} = \frac{\text{Weight of subject} - \text{median reference weight for height}}$$

S.D. below median reference weight for height

Weight-for-age (WAZ)

Calculated as:

$$\text{S.D. Score} = \frac{\text{Weight of subject} - \text{median reference weight for age}}$$

S.D. below median reference weight for age



APPENDIX 4**DETERMINATION OF PROTEIN DIGESTIBILITY-CORRECTED AMINO ACID SCORE**

To calculate a protein digestibility-corrected amino acid score FAO, 1990, the test protein must be analyzed for amino acid composition, and a protein digestibility value must be obtained from a base or determined by the rat balance method. Chemical score could then be calculated using the FAO patterns of Amino Acid Requirements for evaluation of proteins. The lowest amino acid ratio is termed the chemical score.

The protein-digestibility-corrected amino acid score of the test food could then be calculated by multiplying the lowest amino acid ratio and true digestibility.

Example of Calculation of Corrected Score for lysine in Corndough supplemented with cowpea diet

From N - balance studies TD Corndough plus cowpeas = 0.95

% protein in 100g Cd/C diet = 11.7g

Correction for digestibility = $11.7 \times .95 = 11.1\text{g}$

Total available lysine per 11.1g protein = 11.1×347

= 3852mg

mg lysine per gram protein = $3852 \div 11.7$

= 329.2mg.

Protein Score = $\frac{329.2}{340} \times 100$

FAO Requirement Value

= $\frac{329.2}{340} \times 100$
340

Corrected Protein score = 96.8

APPENDIX 5**Amino Acid Score not corrected for protein digestibility
FAO Reference Pattern ^a**

| Meals | Met/Cys | Lys | Try | Thr | Protein Score |
|-----------------------|---------|-----|-----|-----|---------------|
| Cd/C | 80* | 102 | 86 | 121 | 80 |
| Cm/C | 85* | 95 | 121 | 127 | 85 |
| Y/C | 51* | 128 | 153 | 123 | 51 |
| Cd/F | 95* | 109 | 151 | 145 | 95 |
| Cm/F | 93 | 74* | 141 | 115 | 74 |
| Y/F | 87* | 165 | 146 | 148 | 87 |
| Cd/M | 73 | 57* | 181 | 125 | 57 |
| Cm/M | 125 | 57* | 182 | 116 | 57 |
| Y/M | 83 | 57* | 116 | 106 | 57 |
| Corndough Porridge | 57 | 37* | 42 | 60 | 37 |

a.Source: FAO 1973. * Most limiting amino acid in each meal.

APPENDIX 6**Amino Acid Score not corrected for protein digestibility
Pre-School Child: 2-5 yrs. requirement ^a**

| Meals | Met/Cys | Lys | Try | Thr | Protein Score |
|-------------|---------|-----|-----|-----|---------------|
| Cd/C | 112 | 96 | 75 | 142 | 75 |
| Cm/C | 119 | 89* | 105 | 149 | 89 |
| Y/C | 72* | 108 | 134 | 145 | 72 |
| Cd/F | 134 | 102 | 132 | 171 | 102 |
| Cm/F | 132 | 69* | 123 | 135 | 69 |
| Y/F | 122 | 155 | 127 | 174 | 122 |
| Cd/M | 102 | 54* | 158 | 148 | 54 |
| Cm/M | 176 | 53* | 159 | 137 | 53 |
| Y/M | 116 | 53* | 145 | 125 | 53 |
| <i>Koko</i> | 80 | 34* | 36 | 71 | 34 |

a. Source: FAO/WHO/UNU 1985.

* Most limiting amino acid in each meal.

APPENDIX 7

PICTURES OF RESEARCH ACTIVITIES

FIGURES 25&26.....PICTURES OF CHEMICAL ANALYSES & ANIMAL
EXPERIMENT.

FIGURES 27-44.....PICTURES OF FEEDING STUDY ACTIVITIES.

Study Activities in Pictures



Fig. 25: Chemical analysis of experimental diets.



Fig. 26: Nitrogen balance study using rats

Appendix I continued.

The Human Study

Fig. 27

At the
Nutrition
Rehabilitation Centre.



Fig. 28

Nutrition
education in progress.



Fig. 29

Mothers,
centre staff and study
children after teaching
session.



Appendix 1 continued.

Fig. 30

Mothers being taught amounts of ingredients for preparing experimental meals.



Fig. 31

Mothers observing and helping in the preparation of the meals.



Fig. 32

Meals ready to serve.



Appendix 7 continued.

Fig. 33

Weighing portion size of each experimental meal into individual bowls.



Fig. 34

A study child holding his meal after serving



Fig. 35

A study child being fed by the mother with the experimental meal.



Appendix 7 continued.

Fig. 36

A study child eating his portion of the experimental meal with a spoon.

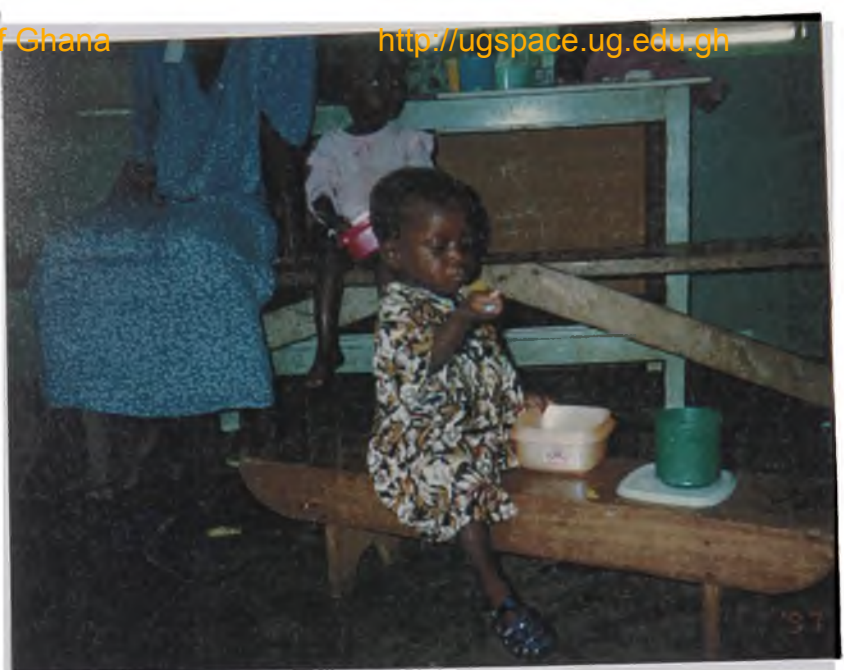


Fig. 37

Two study children eating the experimental meal with their hands (washed) under mother's supervision



Fig. 38

Interviewing a mother to collect data on the child and the family.



Appendix 7 continued.

Fig. 39

End of study get-together of mothers, the study children and centre staff.



Fig. 40

Study children and their mothers at the end of study party.



Fig. 41

Caregiver receiving award for participating in the study.



Appendix 7 continued.

Fig. 42

Mothers interacting with doctors from the clinic at end of study party.



Fig. 43

Mothers looking at exhibition of photographs of their children taken before and after the study.



Fig. 44

Doctor-in-charge of the clinic and Nutrition Technical Officer in charge of centre at the photo exhibition at end of study.



APPENDIX 8

SOCIO-ECONOMIC CHARACTERISTICS OF PARENTS/CAREGIVERS

Age and Occupation

The age of the fathers ranged between 21 and 60 years or over, while the mothers or female caregivers were aged between 19 and 60 years or over.

The occupational status of the mothers seems to have changed little since Gershon (1978) recorded at the same clinic twenty years ago, that 40% of the mothers, compared to 36% in this study were unemployed.

However, concerning the employment status of the fathers, only 13% of fathers in this study, compared to 36% reported by Gershon were unemployed. Most of the occupations of the fathers are those in the low-income earning sector.

Income

All the mothers claimed they had no idea how much the child's father earned. Of the working mothers, most did not keep record of their earnings and could not therefore say how much they earned. A few, who seemed to know how much they earned were unwilling to disclose their income. Looking at the occupational profiles, most families earned very little income, which may discourage mothers from feeding supplementary foods besides breastmilk. The poverty rate in Sub-Saharan Africa is estimated at 40% and is said to be increasing (ACC/SCN, 1991).

Table 4.27 Distribution of Age and Occupation of Parents/Caregivers

| Variable | Frequency Distribution | |
|--------------------------|------------------------|--------|
| | Mother/Caregiver | Father |
| <u>Age (yrs)</u> | | |
| 19-24 | 10 | 2 |
| 25-30 | 15 | 15 |
| 31-40 | 14 | 13 |
| 41-60 | 1 | 4 |
| Over 60 | 5 | 2 |
| Don't know | 0 | 9 |
| <u>Occupation</u> | | |
| Unemployed | 16 | 6 |
| Petty trader | 16 | 3 |
| Food Vendor | 6 | 0 |
| Basket Weaver | 3 | 0 |
| Dressmaker | 2 | 0 |
| Charcoal Seller | 2 | 0 |
| Securityman | 0 | 9 |
| Cleaner/Labourer | 0 | 5 |
| Artisan | 0 | 4 |
| Mechanic/Driver | 0 | 4 |
| Teacher/shop attendant | 0 | 4 |
| Other | 0 | 4 |
| Total Number = 45. | | |

Educational Background

Over half of the mothers 25 (55%), and almost half (44%) of the fathers, had no formal education. Ten (22%) mothers attained primary school level and another ten reached middle/junior secondary school levels. Eighteen (40%) of the fathers attained middle/junior secondary school training.

The educational background of both parents of the children, especially the mothers is low, and therefore not surprising that many mothers were unemployed or both parents were engaged in low-income earning jobs. It has been found that higher educational level of mother alone, independent of household income is positively related to better nutritional status of children and to lower infant mortality (FAO/WHO, 1992a). There is also evidence that mothers who have some education are better able to bring up children with better nutritional status than do illiterate mothers (Piwoz and Viteri, 1981; Chandhury, 1986). In Ghana, malnutrition is reported to be considerably higher among children of mothers with no education or only primary education than among children of mothers with secondary or higher education (MOH, 1992). However, the educational status of both fathers and mothers in this study seems to be better, compared to study reports of similar groups in the 1970s. Forty-nine percent (49%) and 57% of fathers of malnourished children were reported by Commey (1970) and Baidoo (1975) respectively, as having had no formal education, compared to 44% in this study. For mothers, 70% (Commey, 1970), and 66% (Baidoo, 1975), compared to 55% in this study had no formal education.

Religious Background

Twenty-six (58%) of the mothers and 22 (49%) of the fathers were Christians. Eighteen (40%) of the mothers and 35% (16) of the fathers, were Muslims while 1 mother and 2 fathers practised traditional religion.

Ethnic Origin

Most parents were of Northern ethnic origin including 13 (29%) mothers, and 12 (27%) fathers. Nine (20%), each of mothers and fathers were Ewes; eight (18%) mothers and six (13%) fathers were Akans; six (13%) mothers, and five (11%) fathers were Gas; and nine (20%) mothers, and thirteen (29%) fathers were non-Ghanaians hailing from neighbouring countries of Togo, Mali, Burkina Faso, Niger and Ivory Coast.

Marital Status of the Mother or Caregiver

Twenty-six (58%) of the mothers, said they were married and lived with the child's father. Fourteen (31%), were single while 5 (11%), mainly the grandmothers serving as mother substitutes, were widowed. The problem of single parenthood confounded by illiteracy and unemployment in women, certainly aggravates poverty, a leading cause of PEM. In the middle belt of Nigeria, family instability as a result of separation of parents, was a factor in the development of malnutrition in pre-school children (Ighogboja, 1992).

Support from the Child's Father

Thirty-two (71%) of the mothers, said the child's father provided some financial support, but thirteen (29%) received no form of support from the child's father. It was noted that the unemployed mothers, who were also single or widowed lived on charity. FAO/WHO (1992a) reports that, fathers' commitment to the welfare of their children can substantially improve the welfare of their children, and has been shown to be a significant factor in child nutritional status in Latin America. The report also points out that when

families break up, women continue to have responsibility for the basic needs of others including their children. Fathers' commitment to the welfare of their children is reported to be much less in West Africa, where providing for the child's food is largely the mother's responsibility. If mothers are not helped to achieve economic emancipation, the problem of malnutrition in childhood will be difficult to solve.

Household Size

The number of people in the households of the study children ranged between 3 and 14 persons. By local standards, one could say that most of the children, thirty-one (69%) are from reasonably small families, since they belonged to households of three to six persons.

Thirteen (29%) were from families of seven to ten people and only one belonged to a family of fourteen members. If parents were gainfully employed, with these relatively small family sizes, there is no reason why they cannot cater adequately for their families. The issue of poverty keeps emerging as a force to reckon with in providing adequate care in most families.

Food Taboos and Avoidances

Food taboos, beliefs and food avoidances have been found to be underlying factors causing PEM by restricting the use of certain foods, which affect variety in the diet (Abate and Yohannes, 1984).

Table 4.28 lists the foods mothers do not eat and their reasons for avoiding them.



Table 4.28 Food taboos and avoidances observed by caregivers

| Food Item | No. | Reason for avoidance |
|---------------|-----|---|
| 1. Snails | 5 | - Custom forbids |
| 2. Pork | 5 | - Religion/Custom forbids - Causes diarrhoea - Don't know |
| 3. Mudfish | 4 | - Causes rashes |
| 4. Crab | 3 | - Custom forbids |
| 5. River fish | 3 | - Religion forbids |
| 6. Fresh meat | 1 | - Too much blood |
| 7. Goat meat | 1 | - Don't know |

Thirty (67%) of the mothers, said they observed no food taboos or had no knowledge of such foods which they should avoid. The remaining 15 (33%), mentioned items which were all animal products. Gershon (1978) however, recorded in his study that 82% of the mothers observed taboos concerning foods like pork, snails and fish powder. The low observance of food taboos in this study, if it represents a national situation, offers opportunity for positive impact of nutrition education on food choice, selection and consumption.

Living Conditions and Home Facilities

Area of residence

Most of the children (89%) lived in areas close to the rehabilitation centre. Seventeen (38%) were from Nima, thirteen (29%) from Maamobi, ten (22%) from Newtown/Kotobabi/ Malata area, and five (11%), from areas including Alajo, Abeka and Achimota. Most parts of these areas provide cheap accommodation for low income, poor families and migrants.

Type of Accommodation and Number of Rooms Occupied by Child's Family

Only two of the children lived in self-contained houses with private facilities. The rest, 42 (93%) lived in compound houses with rooms arranged in rows or encircling a courtyard and shared facilities with other tenants. Thirty (67%) of the families were tenants while thirteen (29%) lived in rooms belonging to the extended family. One family each, owned the accommodation or lived in rented government quarters. Almost three quarters, 32 (71%) occupied only one room, 11 (24%) occupied two rooms and 2 families occupied three rooms. Twenty-one (47%) families had verandas in front of their rooms but twenty (44%) had no verandas, so the children had no access to quiet and safe play areas. Only four families had living rooms. The majority of families 37 (82%) had no mosquito netting on the windows or doors. It is not surprising that 85% of the children were reported to suffer frequently from malaria attacks, since the areas of habitation are mosquito infested.

Most of the rooms had low roofs, no ceilings, and had one or two small windows providing inadequate ventilation. The rooms were therefore stuffy and congested with personal belongings making the rooms dark and hot. The family accommodation of the study children as observed, offered a poor chance for child development and survival.

Source of Water Supply

All the families had access to pipe borne water. However, they all fetched and stored water in plastic, metal or enamel containers due to the erratic nature of the water supply. Most families, 29 (64%), obtained water from taps outside their homes at costs of ₵40 and ₵50 per bucket (approximately 15 litres). Fourteen (31%) families, had taps in their compounds which they paid for per container fetched. Only two families had their own private taps.

Water can easily be contaminated by the transfer of water from one container to the other. Fetching drinking water from open containers with cups carelessly handled, also added to the risk of contamination, leading to diarrhoeal disease which was reported as a frequent illness among 53% of the study children. The 1993 Ghana DHS implicated inadequate water supply in the development of malnutrition. Limited supply of water leads to poor maintenance of good hygiene in the home, resulting in increased risk of diarrhoea, leading to under-nutrition (USAID, 1995). A wide range of household factors such as nature of housing and water supply were found to be related to child caring capacity and child malnutrition (FAO/WHO, 1992a).

Bath and Toilet Facilities

Short enclosures made with wood, cement blocks or galvanised iron sheets provided shared bathing areas for 40 (89%) of the families, while only three families had roofed bathrooms and one family had a private shower. One family used a public bathhouse in the neighbourhood.

Toilet facilities were mainly by use of pan or pit latrines in compounds shared by all occupants in 23 (51%) families, or by public pit (KVIP) toilets in 18 (40%) families. Two families each had their own private flush or pan toilets. The toilets in compound houses are paid for monthly, while the public toilets are “pay as you use”, with charges between ₵40 or ₵50 per visit. Almost all mothers who used public paid toilets said they dumped their children’s faeces into nearby gutters because they couldn’t afford the charges. These practices present an unsafe environment for all the inhabitants, especially the children. In Ghana, it has been found that the type of toilet is representative of both household wealth and environmental sanitation. Poor households are less likely to have adequate toilet facilities. Children from households with pit latrines or with no toilet facilities are three times more likely to be stunted, and at least five times more likely to be wasted than those from households with access to flush toilets (USAID, 1995).

Cooking Facilities

Only two families (4%), had enclosed kitchen areas. Of the rest, twenty-one (47%) cooked on coalpots with charcoal, on verandas in front of their rooms, while eighteen (40%) cooked on coalpots or with firewood in the courtyard. Food contamination for the study children is very much possible, since most of the compounds were shared with roaming domestic animals.

Home and Environmental Sanitation

All the study children were followed to their homes to observe first-hand their living conditions. Almost all the children lived in congested, dirty neighbourhoods which can at best be described as unsafe for habitation, and thus offered a limited chance for child survival. Access to the houses are through dirty, winding paths criss-crossed by choked open gutters, spilling smelling waste water. Water pipes were seen exposed.

There were no refuse collection dumps, so garbage was dumped in front or behind the houses. Animals are reared in courtyards already crowded with family activities, thus reducing the space for child's play.

Some of the children lived right along a large gutter running the length of the suburbs of Mamobi, Nima, Newtown and Alajo. The gutter was filled with rotting garbage and sewage, with flies all over the place. Under such insanitary conditions, offering little protection for the young growing child, it is no wonder that the study children were afflicted by all sorts of infections and infestations and hence their failure to thrive. The personal hygiene of most mothers was poor and many were observed carelessly handling faecal material and then touching food without washing their hands. FAO (1992a) has commented that the urban poor may have greater access to food but often, they live in overcrowded areas without safe water and sanitation, increasing the risk of infection and disease. From this information on living conditions of the study children, one could agree more with the statement that, 'most diseases and deaths of children in

developing countries are unnecessary and could be prevented by better nutrition, better hygiene, better housing and better health care (Cameron and Hofvander, 1983).

APPENDIX 9**MEAL ACCEPTABILITY TRIAL FORMAT**

Type of Meal:.....
 Date:.....
 Name of Mother or Caretaker:.....
 Name of Child:.....M [] F []
 Age of Child:.....
 Condition of Child:.....
 Date of First Attendance:.....

QUESTIONS FOR MOTHER OR CARETAKER.

1. What do you think about the following qualities of the weaning meal you are eating?

| | TASTE | SMELL | COLOUR | TEXTURE |
|--------------|-------|-------|--------|---------|
| V. GOOD | | | | |
| GOOD | | | | |
| UNACCEPTABLE | | | | |
| REMARKS | | | | |

2. Do you think the time for preparing this meal for a child is reasonable to fit into your daily time plan?

Yes [] No []

Remarks.....

3. Do you think it is a good meal that you would like to use to feed your child?

Yes. Explain why.....

No. Explain why

4. Did your child eat the meal offered him/her?

Remarks

| | |
|---------------------|-----|
| All of it | [] |
| Half of it | [] |
| Just a little of it | [] |
| None of it | [] |

5. Do you think your child would like to eat it if you prepare it everyday?

Remarks

Yes []
 No []

• **OBSERVATIONAL REMARKS BY RESEARCHER**

.....
.....

CHILD'S TOLERANCE OF THE MEAL (MOTHER TO ANSWER)

6. Did your child have any problem after eating the meal yesterday?

Yes [] No []

7. If yes, what type of problem did he have?

Diarrhoea []

Vomiting []

Flatus []

Bloating []

Stool with undigested food []

Others (specify).....

APPENDIX 10**SOCIO-DEMOGRAPHIC DATA OF STUDY CHILD AND FAMILY****The Child**

- | | | |
|----|------------------------------|---|
| 1. | Name..... | 7. Wt. before study..... |
| 2. | Sex: Male..... Female..... | 8. Wt. at beginning of study..... |
| 3. | Age..... Months | 9. Height at beginning of study..... |
| 4. | Date of birth..... | 10. Birth order..... |
| 5. | Wt. at birth..... | 11. Has child completed all inoculations? |
| 6. | Wt. 2 wks. before study..... | Yes..... No..... |

Feeding History and Family Food Beliefs

12. Did you breast feed the study child? Yes..... No.....
13. If Yes, for how long?.....
14. If No, give reasons why?.....
15. If child is weaned, how was breast feeding stopped?
Gradually.....Abruptly.....
16. What supplements to breastmilk did you start the child with and at what age?.....
.....
17. What supplements were being fed before the child fell ill?.....
18. How often were you feeding the child daily?.....
19. In your opinion, was the way you were feeding the child good enough? Yes/No
20. If Yes, what was special about your pattern?.....
21. If No, what do you think you were doing wrong?.....
22. What foods do you consider good for feeding young children who cannot eat adult food yet?

Foods**Reasons**

.....
.....

.....
.....

23. What foods do you consider unsuitable for feeding young children who cannot eat adult food yet.

Foods**Reasons**

.....
.....

.....
.....

24. Do you take the child along to work? Yes..... No.....

25. If No, where do you leave him?

At home.....

At neighbours house.....

At day care centre.....

At nursery school.....

Other.....

26. Who takes care of the child in your absence?

Househelp.....

Neighbour.....

- A relative.....
 Sibling.....
 Other.....
27. Who feeds the child in your absence?.....
 28. Do you prepare the child's food separately? Yes..... No.....
 29. Is there any advantage in preparing the child's food separately? Yes..... No.....
 - Give reasons for your response.
 30. Who usually prepares family meals?.....
 31. What foods do you feed the child with when at the work place with him?

32. Are there any foods that your family considers as taboo or unacceptable for consumption?
- | <u>Foods</u> | <u>Reasons</u> |
|--------------|----------------|
| | |
| | |

Health History

33. What are the common ailments of your child and how often is he/she afflicted?
- | <u>Ailment</u> | <u>Always/Monthly</u> | <u>Occasionally</u> | <u>Never</u> |
|----------------------|-----------------------|---------------------|--------------|
| Vomiting | | | |
| Diarrhoea | | | |
| Coughs | | | |
| Running Nose | | | |
| Malaria Fever | | | |
| Lack of Appetite | | | |
| Sore mouth/sore nose | | | |
| Boils | | | |
| Other | | | |
34. Did you consider your child as healthy before you were asked to come to the centre?
 Yes..... No.....
35. Why were you asked to attend the rehabilitation clinic?.....
 36. Do you think your child's condition had anything to do with food? Yes..... No.....
 37. If yes explain.....
 38. Has attendance at the clinic improved the child's conditions? Yes..... No.....
 39. If Yes, in what way?.....
 40. How are you going to prevent the recurrence of your child's condition?

Family Data

- | | <u>Mother</u> | <u>Father</u> |
|--------------------------------|---------------|---------------|
| 41. Age of Parents | | |
| 42. Occupation of Parents | | |
| 43. Income per month | | |
| 44. Educational level attained | | |
| 45. Ethnic origin | | |

46. Marital status of mother
47. Is mother living with child's father?
48. Is father responsible for upkeep of the child?
49. How many siblings does child have? Alive..... Dead.....
50. What is the age range?
51. What is the size of the household?.....
52. Does mother intend having more children? Yes. How many?.....
No. reasons.....
53. If you had the choice, would you prefer being a full-time housewife or a working mother?
- | | <u>Choice</u> | <u>Reason</u> |
|------------------------|---------------|---------------|
| - Full-time house wife | | |
| - Working mother | | |
54. Does the family own the house you live in? Yes..... No.....
Tenant..... Owner..... Extended family house.....
55. What type of accommodation is it?
Compound house..... Self-contained Private.....
56. How many rooms does the family occupy?.....
57. **Bathroom facilities**
Open space.....
Short enclosure.....
Public bathhouse.....
Shower/bathtub.....
58. **Source of water**
Private tap.....
Public tap in compound.....
Public tap outside the home.....
Bought in containers & brought from distance.....
Well.....
Other.....
59. **Toilet facilities**
Water closet.....
Private Pit in compound.....
Private Pan latrine.....
Public Pit/pan.....
Free range.....
60. **Means of transport available for family**
Public transport -trotro/taxi.....
Own car/lorry.....
Motorcycle..... Guthrie, H. A. 1983
Introductory Nutrition. 5th Edition. The C.V. Mosby Company. St.
Louis, Missouri.
- Bicycle.....
By foot.....

61. For Experimental group only. What is your opinion of the test meal you have fed your child for four weeks now.

Waste Disposal and General Sanitation(Observations During Home Visits)

APPENDIX 11**GLOSSARY**

| | | |
|-------------------|---|--|
| <i>Akple</i> | - | Boiled and stirred mixture of corndough with or without cassava dough. |
| <i>Aprapransa</i> | - | Roasted cornmeal cooked in palmfruit soup. |
| <i>Banku</i> | - | Boiled and stirred mixture of corndough and cassava dough. |
| <i>Fufu</i> | - | Boiled, pounded cassava with boiled cocoyam or plantain. |
| <i>Gari</i> | - | Fermented, grated cassava, roasted dry. |
| <i>Kenkey</i> | - | Fermented corndough dumpling. |
| <i>Koko</i> | - | Fermented corndough porridge. |
| <i>Kokonite</i> | - | Boiled and stirred cassava flour. |
| <i>Mpotompoto</i> | - | Yam or cocoyam pieces cooked in soup or stew and mashed. |
| <i>Tuo</i> | - | Boiled rice, millet, corn, or sorghum, stirred and shaped. |
| <i>Waakye</i> | - | Boiled rice with cowpeas, served with hot pepper sauce. |

