

**ASSESSMENT OF COWPEA (Vigna unguiculata Walp)
PRODUCTION, CONSUMPTION AND NUTRITIONAL
EVALUATION OF COWPEA - FORTIFIED FERMENTED
MAIZE**

BY

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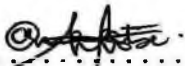
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DECLARATION

I certify that this research was conducted by me as presented, under supervision, in the Department of Nutrition and Food Science, University of Ghana, Legon, and the Institute of Nutrition, University of Bergen, Norway.


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Dedication

To Samuel, Lucy, Moses, uncle Sheriff and aunty Fati, who have supported and traversed "the way" with me, in the valleys with sorrowful tears, on the mountain tops with joyous laughter, and to my dear friend Linda Boatin, with whom I share a common Soul.

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Abstract

In an effort to evaluate the nutritional value of cowpea - fortified maize-dough, and to assess the availability and utilization of cowpeas in the Ga - district, this study was carried out. The study was designed to ascertain the socio-economic factors associated with cowpea production, consumption, Post-harvest handling and distribution, as well as the nutritional benefit and efficacy of using cowpea as a fortifying-agent in fermented maize dough, a popular base for both traditional weaning gruel and coastal staple diets in Ghana.

Eighty-nine (89) cowpea farming households, drawn from 23 rural communities in the Ga - district of the Greater Accra Region, were involved in the study (interviewed with their consent).

Four (4) cowpea fortified fermented maize doughs (CFFMD's), two each of a 60:40 maize : cowpea constitution by weight, were prepared by the traditional and an "improved" method of fermentation, respectively, for the nutritional evaluation; using wistar moll rats.

The outcome of the study suggested that Cowpea production in the study area was beset with numerous problems pertaining to cultivation, crop management, storage and marketing. This accounted for the observed low yields and short household cowpea stock durations, in other words, household cowpea availability for consumption, in the farming communities studied. Farmers in the study population regarded, and hence treated cowpea as a secondary crop to maize and cassava which

constituted their staple foods.

In addition, cowpea consumption rate was high, that is, when available in the population studied. Furthermore, indigestion, diarrhoea and flatulence were identified as the common problems associated with cowpea consumption.

The method of fermentation used; traditional or "improved", seemed to have an effect on the resultant protein quality of the cowpea-fortified maize doughs. The observed improvement in protein quality was slightly higher in the maize doughs traditionally fermented. Nonetheless, fortification with dehulled cowpea flour did improve the protein quality of all the maize doughs considerably. Relative to ordinary maize dough, high protein digestibility and utilisation values were obtained for the CFFMD's, though found limiting in lysine and tryptophan. The following range of values were obtained -

Essential amino acid total of 289.68 - 314.89 mg/g crude protein; Apparent digestibility of 83 - 86%; True digestibility of 100 - 103%; Biological value of 82 - 86%; Balance values of 54 - 59%; and Net Protein Utilization values of 81 - 88%. The range of Chemical Scores of limiting amino acids Lysine and Tryptophan obtained were 57.33 - 63.33% and 58.18 - 80.36% respectively.

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1.0 INTRODUCTION:

Cowpea is a popular cash crop widely grown and consumed in Ghana. The production is high in the savannah areas and the margins of the semi-deciduous forest (forest-savannah transition zone). In the forest zone its cultivation is recommended primarily in the minor season because of excessive vegetative growth and a higher incidence of diseases in these areas during the major rainy season (GGDP, 1991).

Although Ghana is considered as one of the major producers of cowpeas in Africa, production level and land area under cultivation have been low, with slight increases in the last five years (Ghana Statistical Service, 1992). Inefficient cultural practices and constraints notably farmers perception of cowpeas as a secondary crop, low farm mechanisation and marginal crop management, high susceptibility to disease and pests attack, low yield and storage problems, may account for the low production levels.

It is a common practice for farmers to dispose off a greater proportion of their produce at low prices for money to use for family and home maintenance as well as other social commitments and obligations. This is partly because the farmers are unable to find efficient cowpea storage facilities which can prolong the duration of stocks.

According to Sefa-Dedeh and Plahar (1989), maize and cowpea are very important cereal and legume grains in Ghana in terms of production, commerce, demand and traditional food uses. Thus, cowpea can contribute immensely to securing a stable food availability at the national, regional and

household level.

Available data and reports on the Ghanaian nutritional situation (NNS, 1986; FAO/WHO, 1988; Joint FAO/WHO Report, 1989-1991; Alderman, 1990; Lartey, 1991; and Armar-Klemesu and Kennedy, 1992), have consistently indicated a high prevalence of malnutrition. Large proportions of households (especially low income/rural) are threatened by malnutrition in Ghana. Consequently, the nutritional status of pregnant and lactating mothers and pre-school children in these households is likely to deteriorate. This is because most of these households lack available protein foods, and intra-family distribution and consumption patterns often deprive children and women of their required protein. Other contributing factors include - ignorance of suitable and nutritionally adequate weaning foods and their preparation, as well as poor sanitation and infections.

The situation is further aggravated by the fact that the staple diet in Ghana consist mostly of root crops and cereals. Vegetables, legumes and accompanying animal foods are mostly used as relishes and to improve the palatability of the diet. The most popular traditional weaning gruel - "Akasa", for instance, is predominantly a maize-based diet, prepared from fermented dough. The promotion and inclusion of more plant proteins, especially cowpeas in the staple diets will be nutritionally beneficial. This is because a mixture of cereal and legumes can provide all the amino acids needed by the body (Ebrahim, 1983).

The adequate protein content, high lysine content, excellent protein supplementation of cereal grains and good source of dietary fibre, calories, minerals and vitamins make blends of cowpea with maize nutritionally and economically beneficial. Moreover, Ghanaians are more familiar with cowpeas and are more likely to use in feeding and product formulations intended for nutrition intervention. Notwithstanding the above nutrition and health related positive attributes of cowpeas, negative factors such as the presence of antinutritional factors - enzyme inhibitors, hemagglutinins, flatulence factors, tannin, phytic acid, saponin, hard-to-cook defect, high fuel consumption, prolonged cooking time, the characteristic beany flavour and indigestion associated with cowpea processing and consumption are common factors mitigating against increased cowpea utilization.

It is from these viewpoints that this research sought to establish the extent of cowpea production and utilization, assess the nutritional status of cowpea farming families, and the nutritional value of cowpea-fortified fermented maize dough. Thus a study to assess cowpea production and consumption as well as the nutritional evaluation of cowpea-fortified fermented maize dough, was carried out in 23 rural communities of the Ga District of Greater Accra Region.

1.1 Objectives:

To investigate cowpea production, consumption, nutritional status of cowpea farming families, as well as the biological evaluation of protein quality of cowpea-fortified fermented maize dough.

Specific Objectives:

1. To study socio-economic factors in relation to production and consumption of cowpea.
2. To assess the nutritional status of cowpea farming households in the rural communities using nutritional anthropometry.
3. To do proximate analyses and amino acids composition of cowpea-fortified fermented maize dough.
4. To evaluate protein quality of cowpea-fortified fermented maize dough, using rat bioassay.

2.0 LITERATURE REVIEW:

2.1 Cowpea production:

2.1.1 Varieties and production areas

In Ghana, the different varieties of cowpea are known by their different sizes, shapes and especially seed colour (Sefa-Dedeh, 1991). Almost all the white varieties available in the market comes from the Northern region, Upper West and Upper East regions; the red and brown varieties are predominantly from the Brong Ahafo region (Techiman) and Ashanti, and the Eastern region (Afram plains), respectively. Other varieties also produced include the black, cream and mottled cowpeas; these varieties are known to be of minor commercial importance.

2.1.2 Production levels

There appears to be an inconsistency in the available figures on cowpea production levels in Ghana. Figures obtained from the Ministry of Food and Agriculture (PPME, 1991), indicates the following - the average area planted to cowpeas increased from 94.6 thousand hectares for the period 1977-1979 to 146.9 thousand hectares in the 1987-1989 cultivation period; that is, a growth rate of 4.5%. A production growth rate of 7.2% was reported for the period between 1977-1979 cultivation period (8.6 thousand Mt) to 1987-1989 cultivation period (17.2 thousand Mt). In a related report (Ghana Statistical Service, 1992), it was indicated that there have been slight increases in production level and land under cultivation between 1987-1990; that is, from 14,000

Mt in 1985 to 19,000 Mt in 1990, obtained from 110,000 and 168,300 hectares of land cultivated respectively.

2.1.3 Problems associated with cowpea production

Low yields continue to be a significant attribute of production estimates in Ghana about 0.1 metric tonne/hectare (i.e. from 14,000 Mt/110,000 hectares, Ghana Statistical Service, 1992). Yields ranging between 240-300 Kg/ha have been reported by Singh and Rachie (1985), as typical in Africa and Asia.

The reasons advanced for these low yields were as follows

1. Insects and pests which often affect the plant throughout its life cycle and the seeds in storage
2. Excessively high temperatures; and drought or excessive moisture (i.e. unfavourable climatic conditions)
3. Inadequate management and plant protection
4. Poor soil physical properties and fertility
5. Mixed cropping and
6. Low populations and inadequate crop canopy for effective weed control (GGDP, 1991; Singh and Rachie, 1985)

Majority of farmers in Ghana can hardly afford the adoption of recommended agronomic practices and technologies to maximise production. Other constraints includes the unavailability of credit to farmers (for the purchase of inputs and hiring of labour); inefficient input supplies and pricing system (fertilizers, seeds storage facilities and marketing opportunities); inadequate Extension Systems and poor organization (Dapaah, 1989).

2.2 Cowpea Marketing:

The internal marketing system for cowpeas, like other foodstuffs is characterized by a large number of intermediaries and petty traders (mostly women) who often provide several links in the long chain of distribution (Marketing Channels) from producers to consumers (Dankyi, 1993).

Sefa-Dedeh and Plahar (1989), indicated that marketing and distribution of cowpeas (local grains in general) is controlled solely by the traditional marketing system which is dominated by the private sector. The Ghana Food Distribution Corporation handles only a small proportion of the total marketed surplus from farmers. They indicated further, that cowpea marketing is not characterized by any set out quality or grading system. Very little grading of grains is practised and this is mainly based on the degree of insect infestation. Food grains are normally sold by volume rather than weight, this makes grading by extent of insect infestation and grain damage crucial.

Some preliminary results of a Cowpea Marketing Study reported by Dankyi (1993), revealed that colour is an important preference characteristic of cowpea for farmers and consumers. The main colours of commercial importance were white and red/brown beans. The study also found that local varieties attracted higher prices than the improved ones.

Constraints to enhanced cowpea marketing often reported include - inadequate feeder roads to producing centres; high transport charges; lack of appropriate and adequate storage

facilities at the farm level as well as marketing centres; poor bargaining ability of farmers/cheap farm gate prices and farmers ignorance of market trends; absence of uniform weights, measures and grading systems; and lack of co-ordination and co-operation between the Ghana Food Distribution Corporation and other agencies or individuals involved in cowpea marketing.

Sefa-Dedeh and Plahar (1989), have stated the need to address the following issues pertaining to cowpea marketing in Ghana -

1. Supply and demand distortions as a result of low production levels. Inadequate supply of cowpeas compels consumers to accept low grade grains.
2. Non-availability of large-scale processing industries using technologies that require the use of grains with specific characteristics for the production of intermediate and final products, and
3. Lack of facilities and support for organized marketing systems to handle bulk of farmers' produce.

2.3 Cowpea Utilization:

Cowpea as a food is eaten in the form of dry seeds, green pods, green seeds and tender green leaves, which are normally cooked like spinach (Rachie, 1985).

Techniques employed for processing cowpeas for utilization are often traditional, involving one more of the following steps - soaking, dehulling, grinding into a paste, steaming, cooking by boiling in excess water (with or without the addition of salt and spices), and the addition of fat or frying.

The most common form in which cowpeas are used, the many fancy dishes being developed and prepared in Ghana using cowpeas, and their method of preparations have been outlined by Dovlo et al., 1985, in their book entitled - What shall we Eat?

Notwithstanding the nutritional value of cowpea, its utilization and consumption is less than desirable in most Ghanaian households, especially among preschool children. Estimated levels of per capita consumption of cowpeas compared with the commonly consumed staple roots and tubers, and cereals is presented on the table below.

Table 1:

Estimated levels of per capita consumption of
selected food crops.

Commodity	kg/head/year		
	1980	1985	1990
1. Roots & Tubers			
Cassava	145.2	146.3	148.0
Yam	44.2	43.8	43.3
Cocoyam	-	-	54.0
2. Plantain	82.2	82.5	83.0
3. Cereals			
Maize	84.8	85.4	88.2
Rice	38.4	39.2	40.3
Rice	12.4	12.0	13.3
Millet	17.0	17.1	17.3
Sorghum	17.0	17.1	17.3
4. Pulses & Nuts			
Groundnuts	22.4	22.5	22.6
Groundnuts	21.5	21.6	21.7
Cowpeas	0.9	0.9	0.9

Source: PPME(1991). Agriculture in Ghana. Facts and Figures.
p12

Even though these estimates (conservative) are not true reflections of actual cowpea consumption levels, they do suggest the need for improvements in cowpea utilization at the household level in Ghana.

The following constraints to increased cowpea utilization have been reported

1. Laborious food processing and storage losses

Phillips et al. (1985), indicated that laborious food processing and storage losses are some of the constraints in converting whole grains to popular food items. To this end, McWatters (1985), has reported studies conducted in Nigeria with the objective of developing appropriate techniques in

producing cowpea meal or flour, that consumers can use by simply adding water. These studies are geared towards eliminating the soaking, dehulling and grinding steps often associated with cowpea processing and to provide cowpeas in a form convenient to use.

2. Cooking time

Cooking time is another important constraint in bean consumption and preparation, not only for the time involved but because of the high fuel consumption required to cook both freshly harvested beans, and in particular, beans which have been kept under poor storage conditions. Bressani (1993), have indicated that cooking times under normal atmospheric pressure may vary from 24 to 240 min with most families reporting values between 60 and 95 min.

3. Hard-to-cook defect

Grain legumes which are capable of absorbing water, but do not soften even when they are fully hydrated and cooked are called "hard-to-cook" (Bressani, 1993). This problem develops when beans are improperly stored at high relative humidity and temperature. The defect is characterized texturally by the restricted softening of the bean cotyledons upon cooking. This is thought to be the result of changes within the lamella/cell wall complex that inhibits cell separation. Water penetration in the cotyledon is of great importance for separation, and it allows heat transfer, starch gelatinization, and protein denaturation to take place (Bressani, 1993).

Methods proposed to improve storage stability of beans (counteract the Hard-to-cook defect) have been reviewed by Bressani, 1993. It results in important post production losses, extremely high fuel consumption, and poor quality beans that are unacceptable to the consumer. Furthermore, due to the prolonged cooking time, the nutritional value of the protein decreases because of methionine and lysine losses (Antunes and Sgarbieri, 1980).

4. Characteristic beany flavour

The characteristic beany flavour of cowpeas result from the action of lipoxygenase enzymes on free fatty acids present in the seeds. This leads to the formation of ketones, giving undesirable flavours (Kon et al., 1970). This off-flavour has been a constraint in feeding cowpeas to children especially, and incorporation of cowpeas into other foods, during product development.

5. Anti-nutritional factors in legumes

Another important constraint to increased cowpea utilization is the presence of anti-nutritional factors, such as reported by Liener, 1983 and Evans and Banderman, 1976. These are known to interfere with protein digestibility and the biological utilization of nutrients.

Numerous studies reported in literature have indicated that cowpea is one of the legumes with the highest concentration of tannin. Scientists have discovered that tannin can cause anaemia, growth retardation and can contribute to protein-calorie malnutrition in children. However, it is now known that the effect of tannin on growth could be balanced by a

diet rich in milk products. In addition, certain processing methods such as the following will remove the tannin -

1. Dehulling the seed coat (this is the best method, where the colour and tannin are concentrated, although some fibre is lost in the process)
2. Soaking the legumes for 12 to 15 hours in a litre of water containing a tablespoon of sodium bicarbonate (this removes up to 60% of the tannin, and also softens the legumes, halving the cooking time required for the beans soaked in plain water).
3. Germinating the seed (this accomplishes the same effect as sodium bicarbonate and has the added advantage of reducing other anti-nutritional agents such as phytate and flatulence factors. (Restrec Newsletter, 1993)

It has been demonstrated that legume consumption results in flatulence because of the lack of intestinal α -galactosidase enzyme to hydrolyse oligosaccharides to absorbable monosaccharides. When oligosaccharides escape digestion and absorption in the small intestine, they become exposed to colonic bacteria flora which ferment them, with gas production usually accompanying this fermentation. This may be a possible explanation for the abdominal distension, hence pain, as well as flatulence (Rachis, 1975; Wagner et al., 1977). These problems continue to hamper the increased incorporation of cowpeas into the diets of the vulnerable

groups of our population who need more protein. Undigested bean starch, protein and fibre residues have been implicated as contributing substrates to colonic fermentation and flatus production (Fleming, 1980). Sathe et al. (1984), have mentioned galactose-containing oligosaccharides including raffinose, stachyose and verbascose as the components in legume seeds which are responsible for flatulence.

2.4 Effect of processing on Cowpea

At least six methods are used for processing food grain legumes - Thermal processing, Germination, Fermentation, Dehulling and Milling, and Irradiation. The effects of all these processes on physical structure and texture, antiphsiological factors and on the protein digestibility and nutritional value has been reviewed by Bressani (1993).

The effect of germination on beans includes increase in vitamin content and an increase in nonphytate phosphorus at the expense of phytic acid. It appears therefore, that germination improves the absorption of minerals. In addition, Bressani (1993), reported the use of a combination of germination and cooking to improve protein and carbohydrate digestibility.

Studies have shown that fermentation increases the level of water soluble vitamins in beans (Van Veen and Steinleraus, 1970;); decreases phytate content as well as increases the digestibility of pulses, improves flavour and reduces cooking time (Tamang and Sarkar, 1988).

The dehulling method has been shown to reduce cooking time affect textural grading of cowpeas. Dehulling also improves in- vitro protein digestibility probably due to the removal of dietary fibre and tannin present in the seed coat. Milling and air classification of food legumes have been employed to obtain high-protein and high-carbohydrate fractions (Bressani, 1993).

It is well known that appropriate exposure of beans to heat treatment does improve their texture, palatability and nutritive value (Tobin and Carpenter, 1978). Reduction of beany flavour by drum drying (Kon et al. 1970), and losses of lysine (Almas and Bender, 1980), have been reported also.

Other effects due to specific types of heat treatment reported includes the following -

The effects of moist cooking as reviewed by Bressani (1993), include -

1. Solubilization of the middle lamella.
2. Losses in protein solubility and leaching of soluble constituents and electrolytes.
3. Loss of minerals particularly K and P, and Mg to a lesser extent.
4. Changes in enzyme inhibitors such as, inactivation of trypsin inhibitors ; inactivation of hemagglutinin and lectin activities and amylase inhibitors (Antunes and Sgarbieri, 1980; Jaffe, 1980).
5. Changes in tannin and polyphenols content and redistribution between cooking broth and cooked beans.
6. Reduction in phytic acid content. This was achieved by

a combination of treatments - addition of phytase, germination, fermentation, and soaking prior to cooking.

7. Reduction in saponin content by soaking and cooking of food grain legumes.
8. Decrease in oligosaccharide content with soaking and cooking, although not as much as by a combination of germination, fermentation and roasting.

The effects of Roasting and Extrusion cooking as reviewed by Bressani (1993), include -

A. Roasting

1. Dry roasting of beans in the absence of moisture has been regarded as an inefficient means of improving the nutritive value of common beans. However, following a review of studies involving roasting of beans, concluded that dry roasting could be an acceptable process, even though it may result in products of lower protein quality and digestibility. In addition, there may also be some residual levels of trypsin inhibitor activity.

2. Control of the development of hard-to-cook beans .

3. Preservation of storage quality of beans by sand roasting has been reported. Roasting treatment after field drying is useful for disinfecting grains and reducing moisture content in the seed. Notwithstanding, roasted beans will slowly harden with time.

B. Extrusion Cooking

The extrusion cooking process not only improves the nutritive value of the grain legume, but it introduces beneficial

functional properties (Bressani, 1993).

The effects of extrusion cooking include -

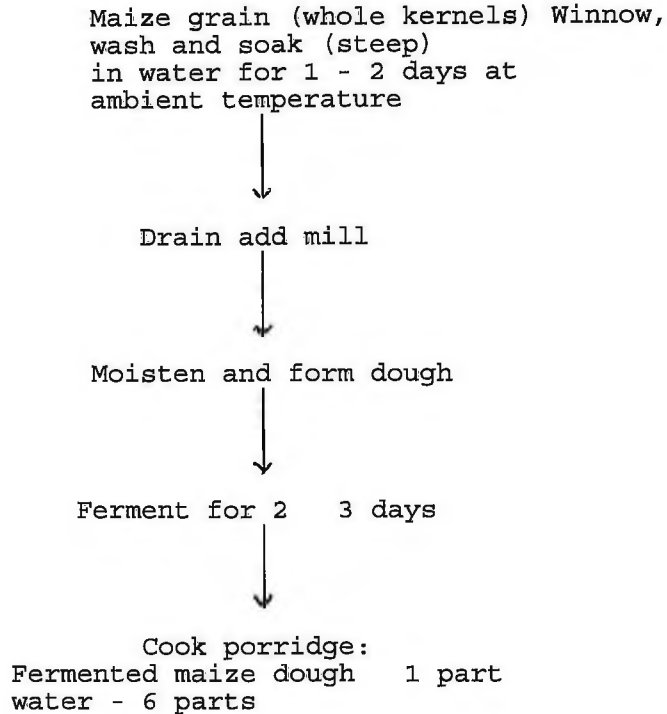
1. Production of high energy digestibility for extruded cowpeas.
2. Inactivation of trypsin inhibitor activity to values obtained by pressure cooking.
3. Affords effective means of cooking hard-to-cook beans, resulting in high protein quality as well as good functional properties.
4. Gives flour of high quality, useful in the preparation of cereal blends for feeding young children. Similar results were also reported by Singh and Rachie (1985), for extruded cowpea-maize and cowpea-cassava mixtures, probably as a result of increased availability of the carbohydrates and susceptibility of protein to enzymic action.

2.5. Fermentation of Maize Cereal:

The most important substances for fermented foods in tropical Africa are cereal grains (Odunfa, 1985), and in general, profound biochemical and nutritional changes occur during the fermentation of food grains. Maize is consumed mainly in the form of a fermented sour dough which form the basis of the principal dietary staples in the four coastal regions of Ghana (Plahar and Leung, 1983), as well as the most popular component of the traditional weaning gruel - "Akasa".

Cereals and legumes play an important role in the diet of the infant. At some stage in its development the breastfed infant requires nutritionally adequate and hygienically prepared weaning foods. In Ghana, porridge and gruel made from maize, millet and sorghum are popular foods used during the weaning period. However, the traditionally recommended weaning food is prepared from fermented maize dough. The preparation of this porridge or pap, known as "akasa" or "koko", is outlined on the next page.

Fig. 1 Preparation of fermented maize dough porridge - "Akasa"



The fermentation process during the formulation of weaning foods is crucial. The changes occurring during fermentation include enzymatic activity brought about by microorganisms depending on the organic components of the food.

Mensah et al. (1988), showed that fermented maize dough was inhibitory to 4 strains of *shigella flexineri*. This observation has been attributed to the reduction in pH, as a result of the production of a range of fatty acids - lactic, acetic, butyric, propionic and formic acids. It therefore appears that fermentation of foods could produce an

environment that is inhibitory to a variety of bacteria although the substrate for fermentation may vary.

In Ghana, *shigella flexneri* is the commonest species of shigella bacterium; its infection may lead to severe dehydration and malnutrition and usually requires treatment with antibiotics. Prevention of infection by shigellas is therefore of great importance. Therefore the antimicrobial property of fermented foods could be an important strategy for the reduction of the high levels of faecal bacteria in weaning foods in developing countries. Thus, guaranteeing the hygiene and safety of prepared weaning foods.

Studies conducted by Ackom-Quayson and Sefa-Dedeh (1993), indicated that steeping of maize and fermentation of maize dough were the most time consuming unit operations in traditional 'Komi' processing, and that initial moisture content of the dough had significant influence on rate of fermentation of the dough. Further studies intended to reduce processing time and optimize process conditions indicated that cracking the maize and soaking in warm water made the dough ferment in a shorter time i.e., reduced to half. Using response surface methodology, it was found that the optimum processing conditions were soaking time 20 minutes, soaking temperature 60°C, initial moisture 55% and fermentation time of 21 hours.

The performance of steam-treated cowpea in solid-state fermentation of cereal dough - 'Aboloo' system has been studied by Osei and Sefa-Dedeh (1993). Central Composite Rotatable Design (CCRD), for $K = 3$ (cowpea level, fermentation

time, steaming time) was used to develop models for assessing changes in dough pH, acidity and some functional properties. Results indicated differences in the fermentation time of corn dough containing the two cowpea varieties. A significant interaction between cowpea content and steaming time was observed. Dough pH and acidity were affected by cowpea variety during fermentation. A steaming time of 7.5 minutes was also observed as the critical points in water absorption properties of dough fortified with Asontem.

2.6. Evaluation of Protein quality

The evaluation of a protein quality usually starts with nitrogen and amino acid analysis, moves through a series of specific chemical measurements and ends with biological test. Animal assays have been widely used to evaluate protein quality. They have tended to gain such esteem that the results obtained are often regarded as providing all the information required. However, the need to emphasize that limitations in the amount and type of information that can be derived has been stated (Pellett and Young, 1980). Biological assays are based on measurement of growth or nitrogen balance (Mc Lauren, 1981) in experimental animals, such as rats, or in humans, as a function of protein intake. For reliable accuracy and meaningfulness of the data, Pellett and Young (1980), have indicated that several animals must be used per test, the results analyzed statistically, and test conditions standardized.

The protein level of the diet is generally kept low (approximately 8 - 10% by weight) so that protein intake remains below requirements, and the supply of energy and other nutrients must be adequate. Under these conditions, growth is slow, the protein is efficiently utilised (little protein is degraded to energy) and the experimental results emphasize differences in nutritive values among proteins and reflect the maximum nutritive value of each protein tested. However, the test value obtained overstates how the protein will perform under the practical conditions of human consumption (Cheftel et al, 1985)

2.6.1. Protein Efficiency Ratio (PER)

Since 1919, the PER has been recognised as the preferred method of evaluating protein quality in many countries because it was believed to be the best predictor of clinical test outcomes (Henley and Kuster, 1994). PER is simple and , generally speaking, gives a fair idea of protein quality. PER is the ratio of the weight gain per protein consumed. In the light of current human amino acid needs, the limitations of the PER method have become increasingly evident. The shortcomings of the PER assay was also listed Mclaughlan (1974). Further, Henley and Kuster(1994), indicated that even though PER measures the ability of a protein to support growth in young growing rats, it severely overestimates the value of some animal proteins for human growth while underestimating the value of some vegetable proteins for that purpose. The more rapid growth of rats, which increases their need for certain essential amino acids, compared to human growth rates and the differences between the amino acid requirements of rats vs humans are the reasons for this discrepancy.

2.6.2 Net Protein Ratio (NPR)

The NPR assay is a considerable improvement over PER with little extra work or expense. Bender and Doell (1957), proposed the use of NPR assay to correct some of the Faults of the PER method. Basically, it is simplified Net Protein Utilization (NPU) (Mclaughlan, 1974). NPR is similar to PER except that the weight loss of rats fed a non-protein diet is added to the weight of the test group.

2.6.3. Protein Digestibility - Corrected Amino Acid Scoring (PDCAAS)

The PDCAAS of a food protein is determined by comparing the essential amino acid profile of the food, corrected for digestibility, to the FAO/WHO 2 5yrs old essential amino-acid requirement pattern. The 2 5yrs old pattern is used because it is the most demanding pattern of any age group other than infants.

$$\text{Uncorrected amino acid Score} = \frac{\text{mg of EAA in 1g of test protein}}{\text{mg of EAA in 1g of *reference protein}}$$

*Reference protein EAA profile = 1985 FAO/WHO 2 5yrs old
requirement pattern

$$\text{PDCAAS} = \frac{\text{Lowest uncorrected amino acid Score}}{\text{Protein digestibility (TD)}}$$

The PDCAAS obtained through actual analysis or estimated from published data sources is directly proportional to the value of the particular protein source to human protein Nutrition (Henley and Kuster, 1994). According to Henley and Kuster (1994), the PDCAAS method, initially recommended by the FAO/WHO Joint Expert Consultation on Protein Quality Evaluation (1989), has an underlying basis of amino acid scoring. The methodology takes into account 3 critical parameters of protein quality evaluation:

- i. the food protein's essential amino-acid profile;
- ii. its digestibility; and
- iii. its ability to supply the essential amino acids in amounts required by humans.

The Food and Drug Administration (FDA), in its Nutrition Labelling Regulations (FDA, 1993), required that the PDCAAS method of protein quality evaluation be used for nutrition labelling purposes for all food products intended for children over 1 year of age and adults. PDCAAS therefore replaces the previous PER requirement.

2.6.4. Nitrogen - Balance Studies

The quality of a protein may be determined by nitrogen-balance studies. Test on human subjects are more difficult to perform than on animals. The rat which has amino acid requirements similar to man is often used (McLauren, 1981). Young and Scrimshaw (1974), concluded that the Nitrogen - balance index approach represents the most appropriate research technique for comparing data derived in rats and children. Current tests of protein quality are mostly based on estimations of the N-balance (Passmore and Eastwood, 1986), often involving definitive tests which are expressed as percentages - Apparent Digestibility (AD), True Digestibility (TD), Biological Value (BV) and Net Protein Utilisation (NPU).

True digestibility, Biological value and Net Protein Utilisation (definitive test used in balance experiments expressed in percentages) enable a ranking of protein sources on an assumedly absolute scale (Eggum, 1973). The BV makes no allowance for losses of nitrogen in digestion. This is however included in the NPU, which is an index of both digestibility and nitrogen balance. According to Passmore and Eastwood (1986), standard BV and NPU measurements, which

consider only one intake level and zero, tend to overestimate the nutritional quality of some proteins. The best biological estimates of protein quality are provided by the slope of the intake - response line from several points in the range of intakes where the line is linear; it should not include zero protein intake. If carcass nitrogen retentions are used in this way, the index is the relative nutritive value and the test protein is related to a standard (egg or lactalbumin).

In the evaluation of protein quality it was considered appropriate to employ the nitrogen-balance tests using rats. The following are the definitions of the tests used in the balance experiments expressed in percentages -

2.6.4.1. Apparent Digestibility (AD)

Measures the differences between intake and faecal excretion of proteins, given as a percentage of protein intake.

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

I

Where : I = Nitrogen intake

F = Faecal nitrogen

2.6.4.2. True Digestibility (TD)

Measures the amount of protein absorbed during digestion, taking into account the obligatory excretion of nitrogenous compounds into the digestive tract.

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

I

Where : F' = Obligatory loss of nitrogen in the faeces (i.e., the total nitrogen free diet providing sufficient energy to meet requirements).

2.6.4.3. Net Protein Utilization (NPU)

Measures the utilization of the test protein for body protein synthesis. It is defined as the product of the coefficient of digestibility and of the biological value or the percentage of dietary nitrogen (or protein) retained.

$$NPU = \text{balance \%} + 100 (F' / I + U' / I)$$

Where : $\text{Balance \%} = \frac{I - F - U}{I} \times 100$

I

U = Urinary nitrogen

U' = Obligatory loss of nitrogen in the urine.

2.6.4.4. Biological Value (BV)

Measures the balance between nitrogen intake and total nitrogen excretion, taking into account the endogenous nitrogen losses. It shows the percentage absorbed nitrogen retained in the body. The BV reflects the balance of essential amino acids in the absorbed protein digest.

$$BV = \frac{NPU}{TD} \times 100$$

TD

2.7 Assessment of Nutritional Status:

Protein Energy Malnutrition, as assessed by physical growth and body measurements, is still widespread throughout Ghana (NNS, 1986). Nutritional status is affected by a wide range of factors that may lead to inadequate or excessive nutrient intakes or may impair their optimal utilization (FAO/WHO, 1992).

Nutritional anthropometry provide objective data and an approximate reflection of nutritional status (FAO/WHO, 1992). The indicators used most often are body weight and height, in relation to a subject's age and sex. Others include arm circumference, head circumference, chest circumference and skin-fold thickness. The main anthropometric indices used are: weight-for-height, height-for-age, weight-for-age and Body Mass Index (BMI). $BMI = W/H^2$, that is, weight in kilograms divided by the square of height in metres. The WHO uses the United States' National Centre for Health Statistics (NCHS) data as a standard since many studies have shown that the growth of normal, healthy and adequately nourished children almost always approximates these reference values. The WHO prefers anthropometric data for children to be quoted in terms "Z-scores", based on standard deviations (SDs) above or below the median reference value for a person of a given age. The level of median minus 2 SD is usually taken as the cut-off point or threshold, below which the status is considered unsatisfactory, that is, undernutrition exists.

Like all measurements, anthropometry is subject to bias and errors in recording, if the indicators used are not

properly standardized, using the WHO (WHO, 1983) recommended standardization process. A common difficulty associated with the indicators of "acute undernutrition" or "wasting" and "chronic undernutrition" or "stunting" (i.e. weight-for-age, weight-for-height and Height-for-age), is that in most cases parents do not know the ages of their children (Ebrahim, 1983). The need therefore for an age-independent criteria of assessing malnutrition led to the suggested ratio of weight/height, which may overcome this difficulty, besides providing a more sensitive measure of wasting. Refinements have been made to this measure in the form of the regression lines and various indices which have been derived, including the Quetelet index or BMI (Ebrahim, 1983). The WHO and FAO are currently studying the BMI parameter with a view to deriving thresholds that would allow a more scientific interpretation of this index. This parameter according to the WHO, is apparently also applicable to children, however, cut-off points have not yet been established (WHO, 1986). Another recommended "age-independent" measurement often used in rapid nutritional status assessment of pre-school children is the mid-arm circumference.

3.0 Methodology:

3.1 Data Collection -

A. Field data Collection

Eighty-nine (89) cowpea farming households were randomly selected from 23 villages in all 4 sub-districts of Ga district in the Greater Accra Region, for the study.

3.1.1. Socio-economic data

Questionnaires were administered to collect information on cowpea production and consumption. Information collected comprised among others the following:

- Knowledge, attitudes, beliefs, and practices (KABP) with respect to cowpea production, consumption, storage and marketing.
- Cowpea utilization and consumption patterns (please see questionnaire attached. Appendix 1)

3.1.2. Anthropometry

Appropriate anthropometric measurements were taken on all members of selected households as follows:

Adults (18+):

Body weight, Height, Arm Circumference.

Children (<18 years):

Body weight, Height/Recumbent length, Arm Circumference.

The WHO recommended standardization process to minimize bias and errors in recording anthropometric measurements (WHO, 1983), was taken into account in all the indicator measurements taken. The standard methods of taking anthropometric measurements after Gibson (1990), were employed.

B. Laboratory Investigations

3.1.3. Sample preparation and analysis

Maize (Zea mays var "Abelehi") and cowpea (Vigna unguiculata Walp var "Asontem") samples were obtained from the Ghana Grains Development Board, Accra and the Crop Research Institute, Kumasi, respectively.

Four doughs were prepared in all; two each from the traditional and "improved" (after Ackom-Quayson and Sefa-Dedeh, 1993) methods of fermentation. The method of preparation of the cowpea-fortified fermented maize doughs (60% maize flour: 40% dehulled cowpea flour, on dry matter basis) are outlined in figures 2 - 5. Four cowpea-fortified fermented maize dough samples (TNS, TS, ~~INS~~ and ~~IS~~) were prepared. Samples TNS and TS were prepared by soaking whole maize in tap water overnight, milled into a flour, and fortified with dehulled cowpea flour (TNS) or steam treated dehulled cowpea flour (TS). The cowpea-fortified blends TNS and TS were then fermented traditionally (without inoculation). ~~INS~~ and ~~IS~~ were also prepared by soaking cracked maize in water 60°C for 20 minutes, milled into a flour, and fortified with dehulled cowpea flour (~~INS~~) or steam treated

dehulled cowpea flour (IS). Samples ~~INS~~ and ~~IS~~ were fermented by inoculating the cowpea-fortified blends with old dough (10% by weight).

Fig. 2. Preparation of Maize flours

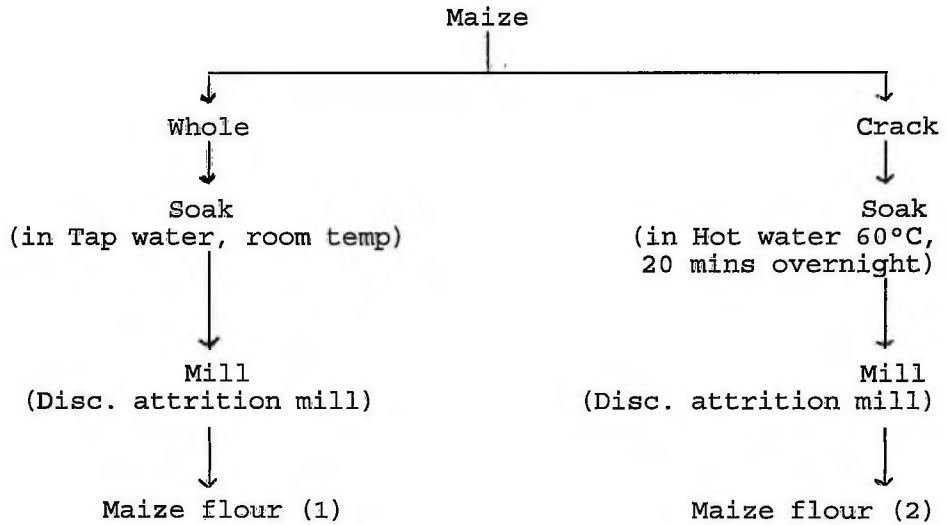


Fig. 3.

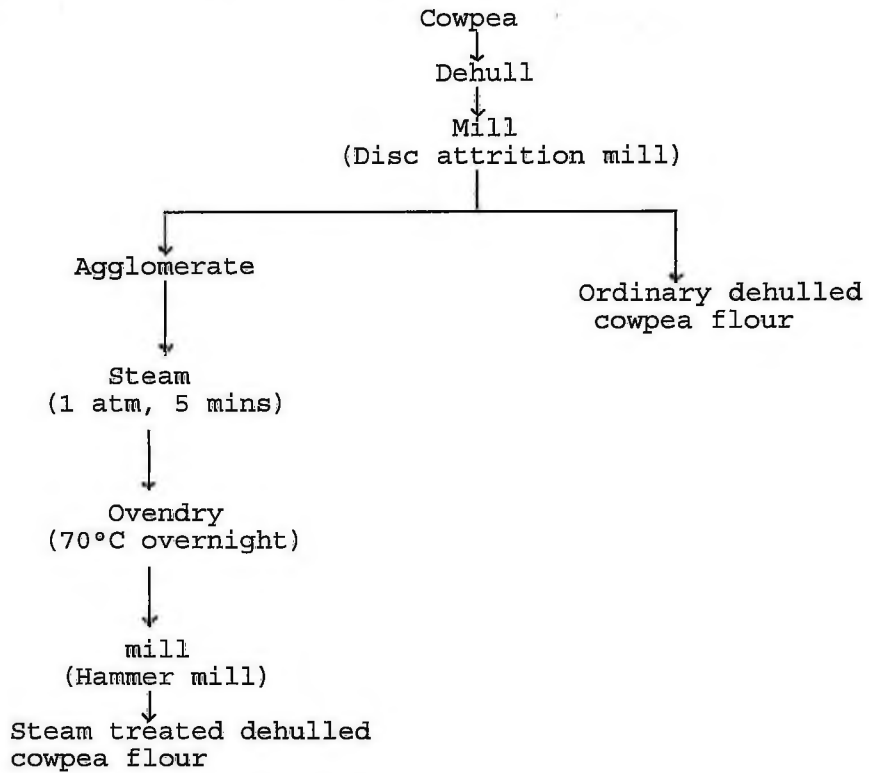
Preparation of Cowpea flours

Fig. 4. Preparation of Cowpea-fortified fermented maize doughs by traditional method:

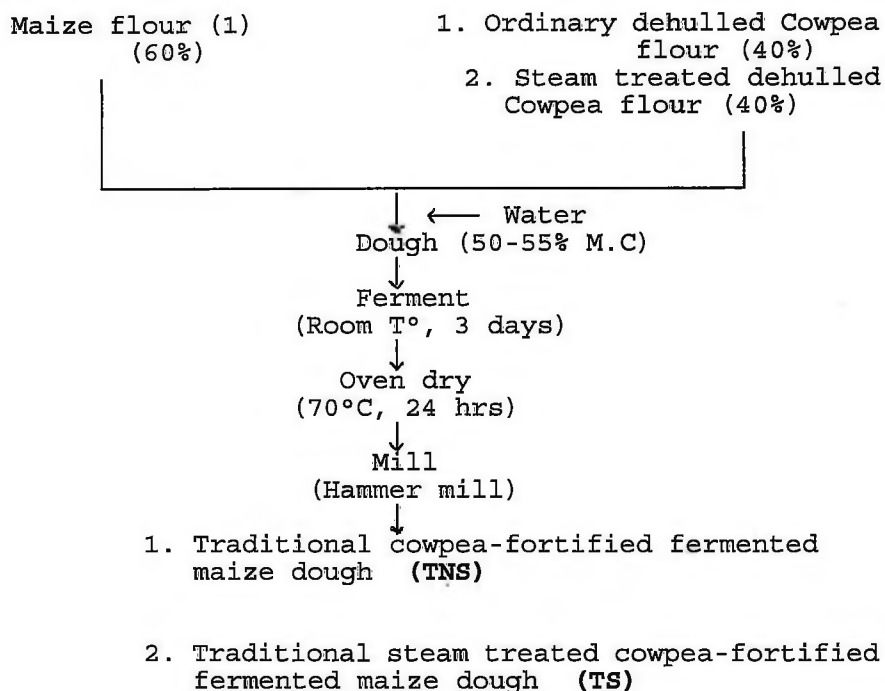
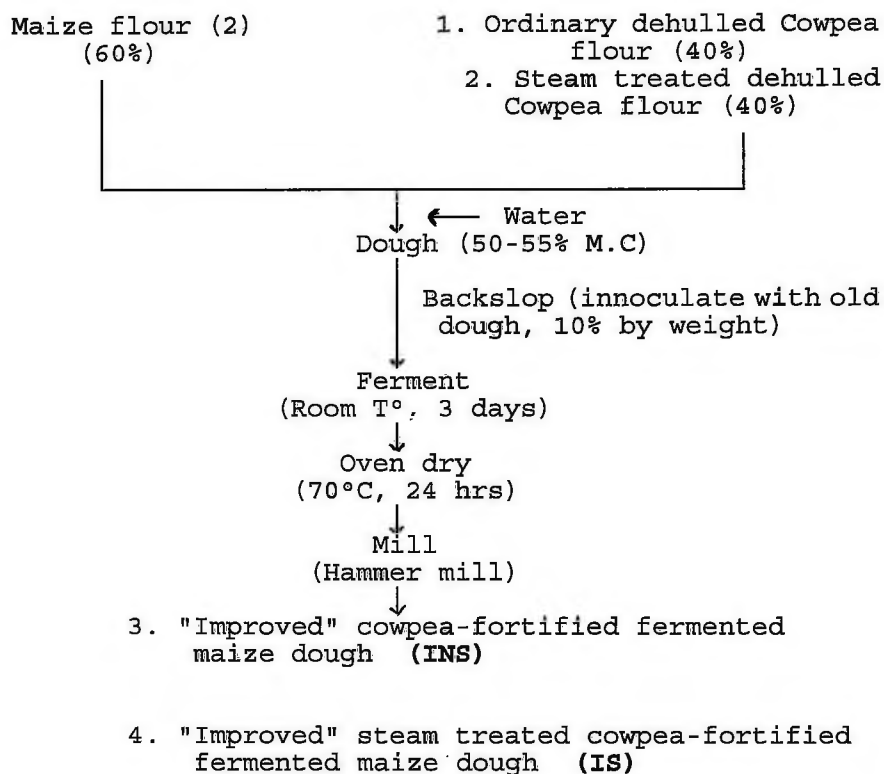


Fig. 5. Preparation of Cowpea-fortified fermented maize doughs
by "improved" method:



3.1.4. Analytical Procedures

3.1.4.1. Proximate analysis:

Ashing was carried out in a furnace at 550°C according to Mortensen and Wallin (1989). Nitrogen was determined by the method of Cooke and Simpson (1971) after sulphuric acid digestion of CFFMD samples in a Tecator block digester (Høganäs, Sweden) at 370°C. Protein was calculated as N x 6.25. Fat was determined after extraction with ethyl acetate according to Losengard et al. (1979)

3.1.4.2. Gross energy:

Gross energy was determined in an automatic adiabatic bomb calorimeter (Gallenkamp, London).

3.1.4.3. Amino Acids:

Total amino acid composition of the blends was determined according to a modification of the Pico-tag method (Millipore, 1987) in a Waters HPLC system after digestion of samples with 6N HCL at 110°C for 22 hours. Norleucine was used as an internal standard. Tryptophan was determined after alkali (barium hydroxide) hydrolysis of the CFFMD protein according to Sachse (1981) and AOAC (1990).

3.1.4.4. Biogenic amines:

Biogenic amines were extracted after precipitation of the CFFMD proteins with 0.6N perchloric acid and elution through Bio - Rex 70 resin. Analysis of biogenic amines was done in an HPLC system according to a modification of the Gill and Thompson, Rapid, Automated Ion-Moderated Partition HPLC method (1984).

3.1.4.5. Protein quality:

Wistar-Møll rats imported from Møllegaard, Denmark, were used in nitrogen balance experiments to determine the protein quality. AD, TD, NPU, BV and Bal% were calculated using the standard formulae. Endogenous faecal nitrogen (F') was calculated as 2.02mg faecal nitrogen per gram feed the Endogenous urinary nitrogen (U') mgN/day was calculated as $W^{0.75} \times K$; where W is the average body weight(g) of the animal during the five days experimental period, K is 0.645, after Njaa (1963). Twenty-four rats with weights between 47 - 59g at the start of the experiment were randomly assigned to four experimental groups of six. Four diets of identical basal composition (Table below) but differing in protein source (i.e, TNS, TS, INS & IS) were tested.

<u>COMPOSITION OF BASAL DIET</u>	
<u>Component</u>	<u>Quantity(%)</u>
Protein	8
Fat (Soya Oil)	5
Vitamins	1
Minerals	4
Cellulose	1
Sugar	11
Dextrin (to make up to 100)	-

4.0 RESULTS AND DISCUSSION:

4.1. Household Characteristics

Eighty-nine farming households with 375 members were involved in the study.

4.1.1. Age-sex Composition

Table 2 shows the age-sex distribution, depicting a high proportion of children and low proportion of old age due to high levels of fertility.

Table 2:

Age and Sex distribution of household members

Age group	Sex				Total (%)
	Male	(%)	Female	(%)	
0 - 5	39	(10.4)	51	(13.6)	90 (24.0)
6 - 17	64	(17.1)	56	(14.9)	120 (32.0)
18 - 29	24	(6.4)	35	(9.3)	59 (15.8)
30 - 40	30	(8.0)	24	(6.4)	54 (14.4)
41 - 50	20	(5.3)	12	(3.2)	32 (8.5)
51 - 60	8	(2.1)	3	(0.8)	11 (2.9)
> 60	1	(0.3)	8	(2.1)	9 (2.4)
	186	(49.6)	189	(50.4)	375 (100)

The age distribution suggest that most households in the communities studied were composed of children aged between 0-17 years (56%). This implies about half the population of the communities studied are likely to be dependants. It is generally known that the more producers (especially contributors to household food security and general maintenance) a household has, the better its position is to providing adequate food, health care, education and other

determinants of optimum nutritional status. Accordingly, the presence of this high number of dependants (i.e, less productive household members) may have some negative effects on the study-communities present socio-economic development as well as their nutritional status.

A closer look at the sex distribution reveals there are more female children and young adults (i.e. aged between 0-29 years) than their male counterparts. Mothers usually spend most of their time working out on the farm leaving their children at home in the care of the older female siblings. This form of child care provided by the siblings often entails child feeding as well. Consequently, most of these mothers are unable to provide effective child care. However sound feeding practices and maternal care, that is, the provision in the household of time, attention and support to meet the physical, mental and social needs of the growing child and other family members, are essential elements of good nutritional well-being and health. Of particular importance, as noted by the FAO/WHO (FAO/WHO, 1992), is child feeding: both breast-feeding and adequate weaning practices are crucial to good nutrition, and success depends on good nurturing and emotional support by household care-givers, especially the mother. Therefore, with more female children and young adults in the communities studied it is possible to speculate some beneficial supportive child care being provided in the population studied.

4.1.2. Household Headship

Of the 89 households assessed, men headed 82 with only 7 households headed by women. This observation is consistent with reports by some researchers that females appear to head proportionately less households in rural than urban areas (Merricu and Schmink, 1993).

4.1.3. Educational background

Table 3: Educational level of Household Heads

Educational level	Sex				Total (%)
	Male	(%)	Female	(%)	
None	37	(41.6)	6	(6.7)	43 (48.3)
Elementary	38	(42.7)	1	(1.1)	39 (43.8)
Secondary	4	(4.5)	-	-	4 (4.4)
Vocational	3	(3.4)	-	-	3 (3.5)
	82	(92.1)	7	(7.8)	89 (100)

A high illiteracy level (48.3%) is evident among the heads of households in the communities studied. The highest educational level attained by majority of the household heads (43.8%) was elementary education. Low literacy level is a common feature in rural communities in Ghana (Nabilla, 1989). The implications of low literacy levels are that of ignorance (a contributory cause to malnutrition, Lartey, 1991), a slow cultural, agricultural and nutritional transformation and poorly developed human resource and increased unemployment. As acknowledged by the FAO/WHO (FAO/WHO, 1992), improved maternal education and literacy can influence the skills and knowledge needed for successful child care practices as well

as for parental decisions regarding expenditures of time and resources. Furthermore, improved literacy and education among fathers can enhance their contributions to the nutritional well-being of children as well.

4.1.4. Household Size

Table 4:

Distribution of Households by Household size

Household size	Number of Households	(%)
< 5	37	(41.6)
6 - 10	40	(44.9)
11 - 15	7	(7.9)
> 15	5	(5.6)
<u>Total</u>	<u>89</u>	<u>(100)</u>

From the table, it is seen that majority of households (44.9%) in the sample comprised 6-10 members, followed by 1-5 member sized households (41.6%). Larger households (> 10 members) were however observed among 13.6% of the households studies. It was observed that female headed households were comparatively small-sized than their male counterparts.

The high proportion of large sized households (1-6 members) is likely to affect the nutritional status of household members; by simply increasing the number of people to be fed by family income/food resources.

4.2 ORGANIZATION OF COWPEA PRODUCTION:

None of the 23 villages studied seemed to have any organized cowpea producers group or co-operative union.

4.2.1. Planting and Haversting

In anticipation of good crop performance, farmers in the study grew cowpeas between late May to mid July (i.e. major growing season), depending on the onset of the rains. The farmers mentioned that it was necessary to plant cowpeas at a strategic time depending on the variety's maturation period. This precaution was taken to ensure that the flowering and pod maturation periods do not coincide with the peak rainy season. The torrential rains often destroys flowers and facilitate pod rot, thereby causing poor yields and crop losses. Hence, this early planting practised by the farmers is vital and must be encouraged. This is because as noted by Singh and Rachie (1985), early planting as soon as rains become well established in mid June to July, has been associated with high yield.

It was noted that farmers in the study harvested mainly dried pods rather than the fresh green pods or their leaves. Cowpeas were harvested as soon as majority of the pods looked dry. Harvesting is done at 3-4 days intervals till the entire farm is harvested. Delay in harvesting often results in shattering of pods, yield loss and poor-quality seeds, if intended for use in the next cropping season. The harvested pods are normally piled up, threshed and allowed to dry 2-3 days before beans are stored.



4.2.2. Other Crops grown in addition to Cowpeas

Table 5:

Distribution of farmers by other crops grown
in addition to cowpea

Crop	No. of farmers	(%)
1. Cereals		
Maize	81	91.0
Sorghum	1	1.1
2. Legumes		
Groundnuts	19	21.3
Soybean	1	1.1
3. Fruits		
Pawpaw	1	1.1
pineapple	2	2.2
plantain	2	2.2
Watermelon	4	4.5
4. Roots & Tubers		
Cassava	79	88.8
Cocoyam	3	3.4
Sweet potato	1	1.1
Yam	5	5.6
5. Vegetables		
Cabbage	1	1.1
Carrots	1	1.1
Cucumber	2	2.2
Garden eggs	27	30.3
Okro	15	16.9
Onions	4	4.5
Pepper	46	51.7
Tomatoes	26	29.2
6. Others		
Oil palm	1	1.1

Maize, cassava and pepper were the crops predominantly grown by the farmers in addition to cowpea. Other crops grown are garden eggs, tomatoes, water melon and pineapples.

The production of other essential crops by farmers can contribute to enhancing access to varied diets. Consumption of more varied diets is essential to improving one's

nutritional status. This is because a diet that contains a variety of foods most likely affords an adequate supply of the nutrients (carbohydrate, protein, vitamins and minerals) needed to promote a good state of health and development. Mixed cropping as practised by these farmers is known to be profitable; it reduces the risk of crop loss, and diversifies the availability of food. On the contrary, mixed cropping has been mentioned as a contributing factor to cowpea low yields (Singh and Rachie, 1985). On-station studies by the GGDP have demonstrated that Asontem is too aggressive for mixed cropping with maize. However, Soronko was found to be more suitable for mixed cropping.

4.2.3. Agricultural Extension Services

Agricultural extension services have been shown to contribute significantly to increased production. It was found that 55.1% of the farmers interviewed had access to the services of Agricultural Extension Officers. This can enhance the adoption of the new technologies to improve productivity.

4.2.4. Sources of information on cowpea

Table 6, shows the distribution of farmers by source(s) of information on cowpea.

Table 6:

Farmers' source of information on cowpea

SOURCE	NO. OF FARMERS	(%)
Agric Ext. Officers	25	28.1
Experienced farmers	10	11.2
Family members	45	50.6
Agric college / school	3	3.4
Radio	1	1.1
Friends	2	2.2
No response	5	5.6

Access to requisite information on cost-effective agronomic and crop management practices is indispensable for increased productivity. Majority (50.6%) of the farmers obtained information on Cowpea from family members. About 28% obtained from Agricultural Extension Officers. It appears that the family linkages have a greater influence on knowledge on farming techniques.

4.2.5. Years in cowpea cultivation

Table 7:

Distribution of cowpea farmers by years in cowpea production

YEARS	NO. OF FARMERS	(%)
> 5	29	32.6
6 - 10	25	28.1
11 - 15	13	14.6
16 - 20	6	6.7
21 - 25	4	4.5
> 25	12	13.5
TOTAL	89	(100.0)

The majority (32.6%) of cowpea farmers interviewed have been producing cowpea for the past five years. In addition, 28.1% of the farmers have been farming cowpea for the past 6-10 years, and 13.5% for the past 25 years (Table 7). Generally, the longer the number of years in cultivation, the more "experienced" a farmer becomes. From the above figures it is possible to deduce there are quite a number of "experienced" cowpea farmers from whom the new farmers could learn.

4.2.6. Factors affecting cowpea production

A list of important factors which have a negative effect on cowpea production in the communities studied is presented on Table 7. Notably, low yields, financial constraints, problems with land acquisition and fertility, inadequate storage and marketing avenues, are some of the problems encountered during cowpea production. It is obvious therefore that cowpea production in these communities are beset with numerous problems. These constraints certainly affects the amount of cowpeas produced. This in turn determines the proportions of cowpeas to be sold as well as cowpeas available for household consumption. These factors in turn also determines income to be generated to augment household food purchases and health care, nutrients to be obtained by family members, and hence the status of individual household members.

4.2.7. Varieties of cowpea grown:

The varieties of cowpea commonly grown were Asontem, mottled varieties and Bengpla, followed by Soronko and Ayiyi. Amantin (perhaps because of its black colour and insignificant commercial importance), Global 2000 (perhaps because of seed unavailability and ignorance of proper cultivation practice) were the least grown varieties (Table 8).

Table 8:

Distribution of farmers by varieties of cowpea usually grown

VARIETY	NO. OF FARMERS	(%)
AMANTIN	2	2.2
ASONTEM	38	42.7
AYIYI	8	9.0
BENGPLA	16	18.0
GLOBAL 2000	3	3.4
MOTTLED	40	44.9
SORONKO	8	9.0

Farmers' reasons for not growing particular varieties of cowpea are presented in Table 9.

Table 9. Reasons for not growing other varieties of cowpea other than that normally grown

Reason	Frequency (farmers)	Percent (%)
Not tried other varieties yet	5	5.6
Just wants to be conservative of cultural varieties passed on by parents	10	11.2
Low prices of other varieties	1	1.1
Not sure of the yeild of other varieties	2	2.2
Low yeild of other varieties	3	3.4
Creeps, waste more growing space	5	5.6
Leaves are not as good manure as others	1	1.1
More prone to insect attack/infestation	3	3.4
Longer maturation period of other varieties	17	19.1
Longer cooking time of other varieties	2	2.2
Lack of knowledge in the cultivation of the other varieties	2	2.2
Require more water to thrive best	1	1.1
Other varieties not suitable for the land	13	14.6
Low preference by customers/marketability	11	12.4
Seeds of other varieties are more expensive/unavailable	2	2.2
Other varieties require more attention and special crop management	2	2.2
Other varieties have smaller bean sizes	1	1.1

4.2.8. Cowpea Storage

Storage, processing, distribution and utilization constitute the elements of the post-harvest system. Proper drying and storage of farm produce are therefore crucial operations in the post-harvest system to ensuring premium prices and good grain quality.

All farmers interviewed stored part or all of their cowpeas for a few months before sale. Adequate storage of farm produce, is needed for two main reasons: to enhance income of producers through adequate prices, and to ensure household food availability during the lean season. Table 10, presents mode of distribution of produce (harvested cowpea) by farmers.

A farmers' decision to store produce is greatly influenced by the price at sale relative to price at harvest, quantity harvested and purpose of storage. In the communities studied it was noted that in addition to the farmers reserving a portion of produce for consumption and sale, they also gave some away (Table 10). Farm-helpers, friends, relatives and landlords were the main recipients of the cowpea give-aways by farmers (Table 10b).

Table 10a:

Mode of distribution of produce

Mode	Freq. (farmers)	Percent
Reserved for home consumption	85	95.5%
Market	85	95.5%
Give-aways	48	53.9%

Table 10b.

Recipients of cowpea Give - aways

Recipient	Freq. (farmers)	Percent
Friends	16	18.0%
Relatives	13	14.6%
Landlords	5	5.6%
Labourers / Farm helps	28	31.5%

It was noted that the farmers ate and sold most of their cowpeas after harvest. This is nutritionally desirable in view of cowpeas excellent protein supplementation of the traditional cereal and root crop based staple diets (weaning foods inclusive) consumed in the communities. Moreover, the proportion of cowpeas sold can generate money to enhance households purchasing power. With an enhanced purchasing power, households are in a better position to select foods that are more nourishing (eg. animal proteins and vegetables) rather than foods that merely satisfies hunger (i.e. carbohydrate foods). In other words, cowpea most likely contributes immensely to enhancing the physical and economic access to foods that are adequate in terms of quantity, quality and safety (i.e. household food security), in the communities studied.

The method of cowpea storage employed by farmers in the study are presented in Table 11.

Table 11:

Distribution of farmers by cowpea storage method

STORAGE METHOD	NO. OF FARMERS	(%)
1. Intermittent drying of bagged cowpeas (i.e., threshed or unthreshed)	50	56.2
2. Preservation with chemical pesticides and storage in a bag or in airtight container	24	27.0
3. Preservation with palm kernel oil (i.e., beans were smeared before bagging)	2	2.2
4. Store by the fire-place in kitchen (i.e., preservation with smoke)	5	5.6
5. Preservation with Wood ash	1	1.1
7. Preservation with a mixture of Wood ash and kerosine	2	2.2
8. Preservation with kerosine	1	1.1
10. Store in airtight bottles / gallons	2	2.2
11. Preservation with 'Magic chalk' insecticide	1	1.1
12. Preservation with Moth balls	1	1.1
TOTAL	89	(100.0)

Table 12:

Distribution of farmers by problems associated
with cowpea storage

STORAGE PROBLEM	NO. OF FARMERS	(%)
Insect (Weevil) infestation	59	66.7
Mould infestation	2	2.2
Inadequate finance to acquire chemicals	1	1.1
Rodent attack	1	1.1
Improper storage materials	1	1.1
No response	25	28.1
TOTAL	89	(100.0)

Problems associated with cowpea storage reported by the farmers are presented in Table 12. Insect infestation was identified by 66.7% of the farmers as the chief storage problem. Mould infestation, financial constraint to acquiring pesticides, Rodent attack and improper storage materials were the other storage problems indicated by the farmers (Table 4.10). The farmers attributed these problems to lack of proper cowpea storage facilities. Loss of cowpea during storage due to the bruchid beetle *callosobruchus maculatus* F. occurs worldwide and not in the study communities only. Singh (1978), reported up to 100% seed damage after 5 months cowpea storage due to *callosobruchus maculatus* F. infestation. Storage of bagged cowpeas under damp conditions (corners of farmers rooms) is known to be favourable for mould growth.

Moulds can cause serious deterioration of stored cowpea with the danger of producing toxins such as aflatoxin (common in groundnut storage). Poor cowpea storage as practised by farmers in the study can have some effects on food quality and nutrient availability. Nutrient losses are often due to destruction of the embryos and endosperm of grains and legumes by the infested insects. This pests activity results in weight loss as well. Not only is total weight loss of seed important, but also the proportion of seeds damaged, since this not only affects palatability and food value, but also the germination potential. Loss in weight, nutrients and physical breakage of grains constitute loss in grain quality.

Broken grains are more susceptible to insect and fungal attack and also increase the rate of hydrolysis and oxidation of oil within the plant cells. These activities increase the free fatty acid content of legumes, oil seeds and also milled grain. The increase in acidity makes the produce rancid and not acceptable for food. Thus, improper storage can deprive farmers and their households of consuming cowpeas with full nutrients that are also wholesome. In addition, farmers incomes can be affected, since customers often reject or pay very low prices for damaged, weevil or mould infested grains. Consequently, reducing their income and purchasing power for that matter.

4.3. COWPEA CONSUMPTION:

4.3.1. Consumption frequency

Cowpea was consumed in virtually all the sampled households.

Table 13:

Household Cowpea consumption frequency

Frequency/week	No. of Households	%
1	13	14.6
2-3	44	49.4
4-5	6	6.7
6-8	21	23.6
Once a month	3	3.3
Twice a month	3	3.3
Doesn't eat	1	1.1
TOTAL	89	100.0

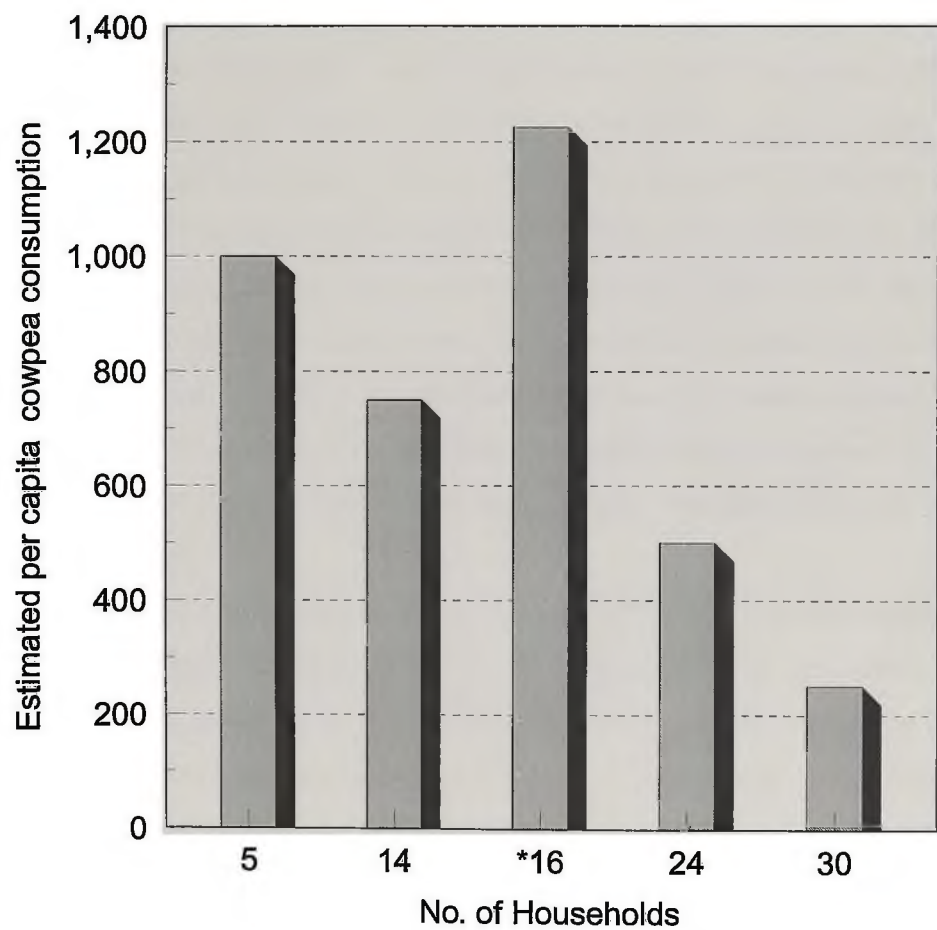
Except in one household where cowpea was not consumed, 49.4% (44) households consumed cowpeas 2-3 times a week, while 23.6% (21); 14% (13) and 6.7% (6) consumed 6-8 times a week, once a week and 4-5 times a week, respectively (Table 13). Generally, it appears cowpea consumption frequency in the population studied is high .

Fig. 6 Distribution of households by *estimated per capita
cowpea consumption (g/week)

*Per capita consumption of cowpea =

Estimated amount of cowpea consumed by household per week

Household size



*These Households had per capita cowpea consumption > 1225g/week

4.3.2. Estimated Amount of Cowpea Consumed

Fig. 6 shows the distribution of households by estimated per capita cowpea consumption observed in the survey. There was a general decrease in the number of households with increasing per capita cowpea consumption. Of the 89 households surveyed, 33.7% (30) had estimated per capita consumption of about 250g/week, whereas only 5.6% (5) recording 1000g/week. It is quite puzzling to observe that among the cowpea farming families, there were relatively small number of people consuming relatively high amounts of cowpea. This could be due to various reasons including selling so much of the cowpea produced leaving a relatively small amount for domestic consumption. However a considerably number of the households (about 18%) had per capita consumption of over 1,200g/week.

The national estimate of cowpea consumption as reported by the PPME of the Ministry of Agriculture in 1991 was 0.9kg/head/year (i.e. 17.31g/head/week). This estimate seem conservative, very low and not a true estimate of the national per capita intake. Nonetheless, comparing the estimates obtained in the study to that of the national estimate reported by the PPME, indicates that cowpea consumption is higher among the cowpea farming communities studied. This is probably so, because these cowpea farming households by virtue of cultivating cowpeas tend to have more access to cowpea. It can therefore be said that an important factor in cowpea

consumption or utilization is availability.

It is necessary to state however, that the consumption figures reported are only estimates and not based on actual weighed food - intake assessments. Hence these may not be a true reflection of the levels of cowpea consumption in the sampled households. Besides the amounts of cowpeas consumed is greatly determined by the season and the quantity available to the household. However, these estimates do suggest to a reasonable extent that cowpeas contribution to household protein intakes could be high in the population studied.

4.3.3. Cowpea dishes

Table 14, presents the various dishes encountered and the methods of preparation by cowpea farming households assessed.

Table 14:

DISHES PREPARED FROM COWPEA IN THE FARMING HOUSEHOLDS ASSESSED

DISH	METHOD OF PREPARATION	NO. OF (%) FAMILIES
Ayidubagbli	Boil cowpea and maize to cook, add ripe pawpaw and mix.	3 (3.4)
Ayigbli	Boil cowpea and maize till both grains are tender. Salt and Spices may be added to taste.	13 (14.6)
Ayikple/ Gogli/Yorku	Boil cowpea till grains are tender. Add cornflour (from dry maize), stir to form a dumpling. Salt may be added to taste.	19 (21.3)
Aprapansa	Prepare palmnut soup, incorporate roasted maize and cowpea flour, stir to form a dumpling.	5 (5.6)
Gari & Beans	Boil cowpea till grains are tender. Edible oil, preferably palm oil, Salt and Spices may be added if desired. Serve with Gari and/or fried ripe plantain.	68 (76.4)
Groundnut & Beans	Boil cowpea to partly cooked, add Groundnuts, continue boiling till both grains are tender. Salt and Spices may be added to taste.	1 (1.1)
Palmnut soup with beans	Boil cowpea to almost-cooked, add to cooked palmnut soup to thicken or enrich.	17 (19.1)
Waakye	Boil cowpea together with rice till both grains are tender and cooked. Salt, Spices and traditional food colour (Karen dafa) may be added to enhance sensory qualities.	14 (15.7)

Koose	Add water to cowpea flour, whip, and fry in edible oil. Salt and Spices may be added to taste.	1 (1.1)
Koko	Obtain flour from roasted cowpea and maize, make a slurry, boil to obtain porridge.	2 (2.2)
Boiled beans	Boil cowpea to cook. Edible oil, preferable palm oil, Salt and Spices may be added if desired.	4 (4.5)
Beans Stew	Boil cowpea to almost-cooked, add to Simmering tomato stew to thicken or enrich. Serve with fried ripe plantain, Ampesi, Rice or Kenkey.	4 (4.5)

Gari and beans was the most common dish prepared and eaten, followed by Ayikple, palmnut soup with beans, waakye, Ayigbli, Aprapransa, Ayidubagbli and Beans stew, in that order. The method of preparation essentially comprised a prior boiling of cowpeas, followed by the incorporation of other cereals or ingredients and spices to serve as complements of diets and for taste respectively. Boiled cowpea was also used as a soup thickener.

4.3.4. Cowpea consumption problems

The reported problems associated with cowpea consumption by household heads are presented on Table 15, below.

Table 15:

Problems associated with cowpea consumption

PROBLEM	NO. OF FAMILIES	(%)
Flatulence	5	5.6
*Indigestion / Constipation	11	12.4
Diarrhoea	7	7.9
Vomiting	1	1.1
*Sores in stomach	1	1.1
Distended stomach	3	3.4
Shortens one's life span	1	1.1

* - When eaten too much/often

Indigestion, diarrhoea and flatulence were the most common problems identified. This observation was in agreement with the report by Hussain et al, (1992). In their survey to ascertain the perception of mothers as to the problems encountered by children consuming cowpea, 9.9% of the mothers reported that their children had problems after the consumption of cowpea foods. These problems included diarrhoea, vomiting, offensive stool, abdominal pain, bad breath, abdominal distension and gas production. However, these problems were reported to disappear later in life (Hussain et al, 1992).

4.3.5. Availability of Cowpea stock

Table 16:

Duration of stock of cowpea produced

DURATION (months)	NO. OF FAMILIES	(%)
< 1	5	5.6
1 - 2	33	37.1
3 - 4	18	20.2
5 - 6	9	10.1
12 (All year round)	20	22.5
Can't tell	4	4.5
TOTAL	89	100.0

The families of cowpea farmers keep stocks of cowpeas produced in their farms for periods ranging from 1 month to 1 year. Most of the families (37%) kept stocks for 1 2 months. About 22% kept cowpeas for home consumption all year round and 20% kept cowpeas for 3 - 4 months.

As a result of the relatively short duration of household cowpea stocks for the greater majority of households, about 33% of cowpea farming households stopped eating cowpeas till the next harvest season. It was noted that 37 out of the 40 households who continued eating cowpeas after their stocks were exhausted obtained their cowpea from the market. The remaining three households obtained cowpeas for consumption

from friends (2) and waakye / gari and beans food vendors (1). Inadequate household cowpea stocks per se does not necessarily imply inadequate protein intakes by the household members. However, households with very short cowpea stock duration are at more risk of protein undernutrition, and hence malnutrition. This is because most of these households lack other rich protein foods, and their staple diet consist mostly of root crops and cereals.

4.4. Nutritional Status Assessment:

In a bid to access the nutritional status of households encountered in the study, anthropometry was used.

Preschool Children (0 - 5yrs)

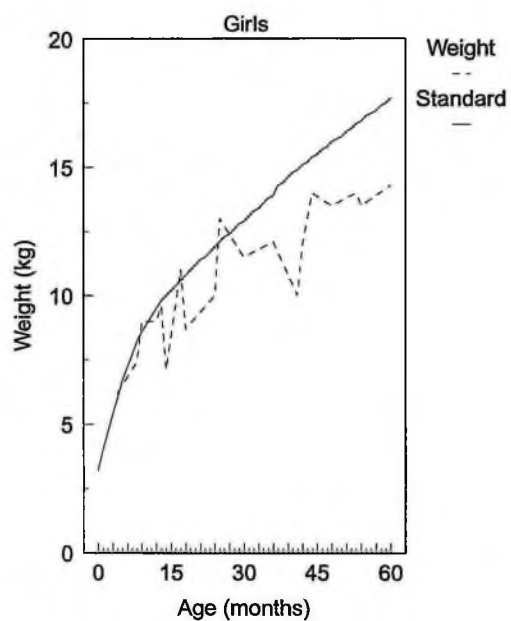
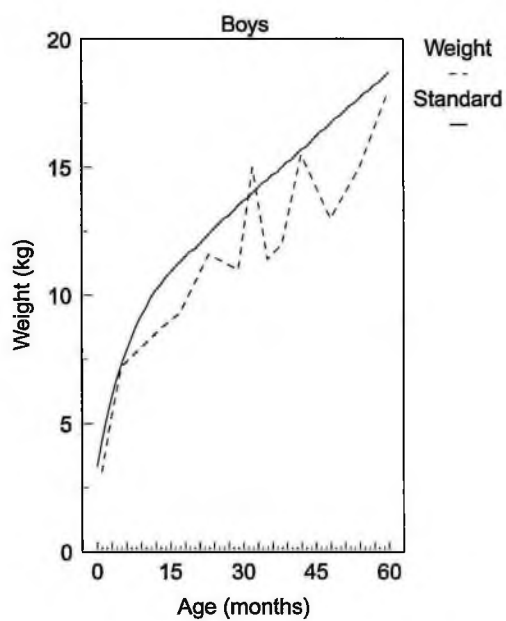
a) Weight for age as a measure of wasting (PEM):

The weight by age of preschool children in the study compared with NCHS reference standards are presented in figure 7. It was observed that except for preschool boys aged 33 months the rest had weights below the reference NCHS standards. The deviation below the standard curve was quite pronounced after 9 months of age. A similar trend was observed also for the preschool girls. However, in their case, the deviation below the standard reference curve was pronounced after 14 months.

The weight-for-age Z - Scores were then used to classify the preschool children according to the degree of wasting; that is, an indication of the degree of PEM. The above classification obtained is presented in figure 8. Thus, 50% of the preschool boys were undernourished or suffered wasting. This comprised, 28.9% mild wasting, 15.8% moderate wasting and 5.3% severe wasting. The Z - Scores for weight of pre-school girls indicated that 60% of the girls were undernourished or suffered some level of wasting. This comprised, 34.0% mild wasting, 16.0% moderate wasting and 10% severe wasting.

Since the weight-for-age index can be used as an indication of the individual's present nutritional status, it is likely that these pre-schoolers suffer from an acute form of Protein-Energy Malnutrition.

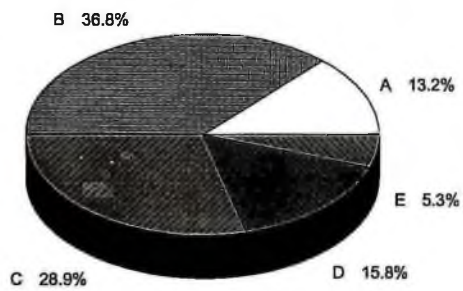
Fig. 7 Differences between weight of Preschool children
and NCHS reference weights



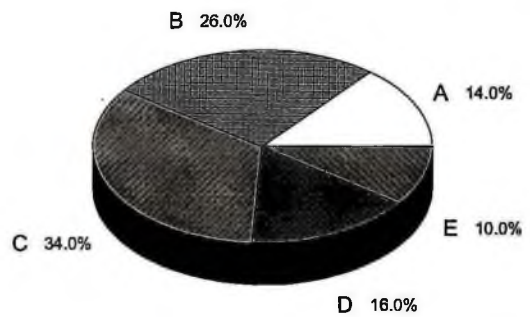
Weight of Pre-school children aged (0-60 mths) compared with NCHS reference standards

Fig. 8. Z-Score for weight : Preschool children

BOYS



GIRLS



A = REFERENCE STANDARD (NORMAL)

B = -1SD C = -2SD

D = -3SD E = -4SD

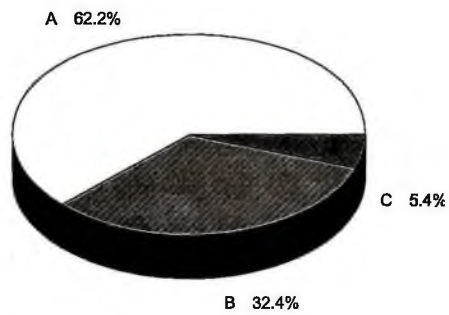
b) Arm Circumference As a measure of Muscle development and Wasting (PEM):

The distribution of preschool children by percent of standard arm-circumference for age met, is presented in figure 9. It is observed that 32.4% and 5.4% of the preschool boys assessed might have suffered mild to moderate inadequate muscle development and/or muscle wasting, respectively. This is attributed to protein-energy malnutrition. Similarly, 42% of the preschool girls most probably suffered some level of poor muscle development or wasting. This comprised 36% mild level and 6% moderate level of inadequate muscle development or wasting.

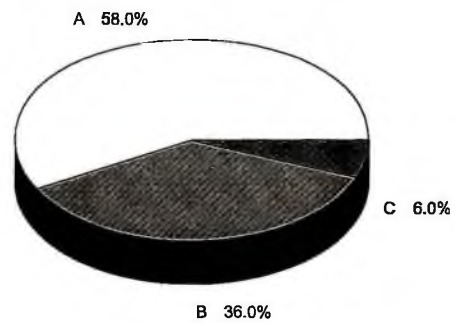
Thus analysis of the arm circumference data seems to suggest that slightly more preschool girls in the communities studied suffered some level of poor muscle development and wasting. Accordingly, since poor muscle development and wasting are cardinal features of PEM it may be true in the communities studied that there are slightly more malnourished preschool girls than their male counterparts.

Fig.9 Levels of percent of standard Arm-Circumference for
Age met: Preschool Children

BOYS



GIRLS

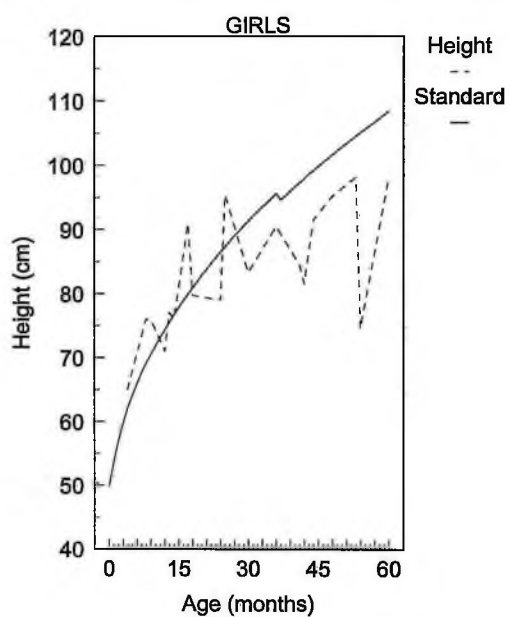
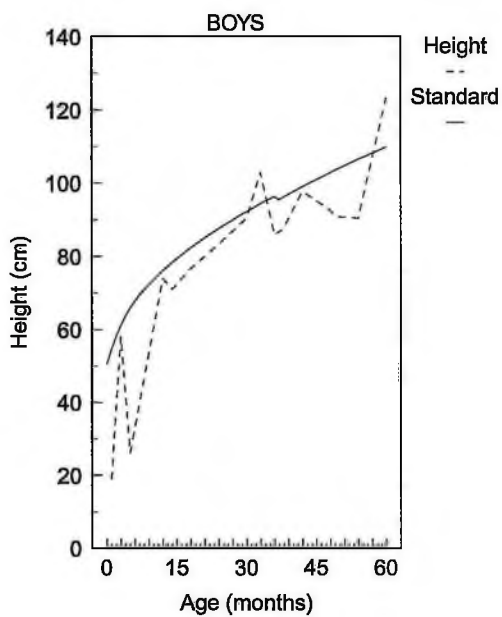


A = 90% and Above Standard

B = 90% - 81% of Standard

C = 80% - 71% of Standard

Fig. 10. Differences between height of preschool children
and NCHS reference heights



Height of Pre-school children aged (0-60mths) compared with NCHS reference standards

c) Height for Age as a measure of Stunting:

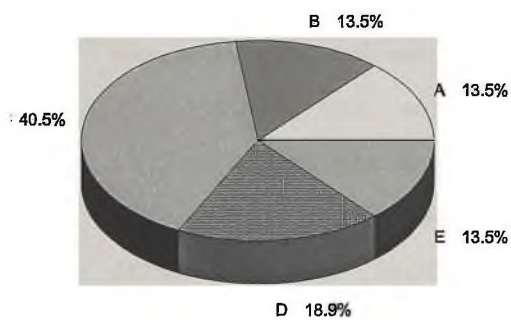
Figure 10, shows a graphical representation of the Height by Age of preschool children in the study. It is observed that except for preschool boys aged about 33 months and those above 57 months whose heights for age were slightly above the NCHS standard reference curve, the rest showed lower heights for age. On the other hand, preschool girls aged less than 18 months showed slightly higher heights for age than the NCHS reference heights.

The height-for-age Z - Scores were then used to the classify the preschool children according to the degree of stunting. The classification obtained is illustrated in figure 11. Thus, 72.9 % of the preschool boys were stunted (i.e, from -2SD to -4SD). This comprised 40.5% mild stunting 18.9% moderate stunting and 13.5% severe stunting. As illustrated by the figure also, 62% of preschool girls were also stunted. This comprised 22% mild stunting, 22% moderate stunting and 18% severe stunting.

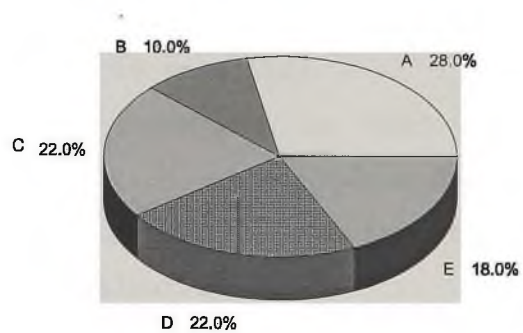
Since the height for age index can be used as an indication of the individual's past or chronic nutritional status, it is possible that 72.9% and 62% of the preschool boys and girls respectively were chronically stunted. Thus, at least two-thirds of the preschool children in the study communities might have suffered some form of growth retardation.

Fig. 11. Z-Score for height : Preschool children

BOYS



GIRLS



A = REFERENCE STANDARD (NORMAL)

B = -1SD C = -2SD

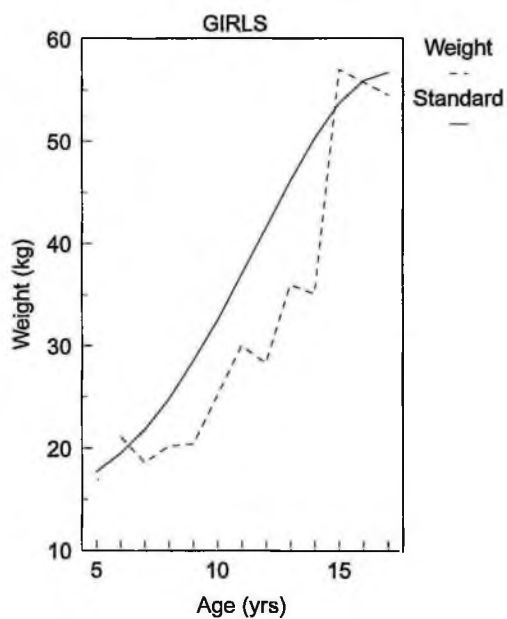
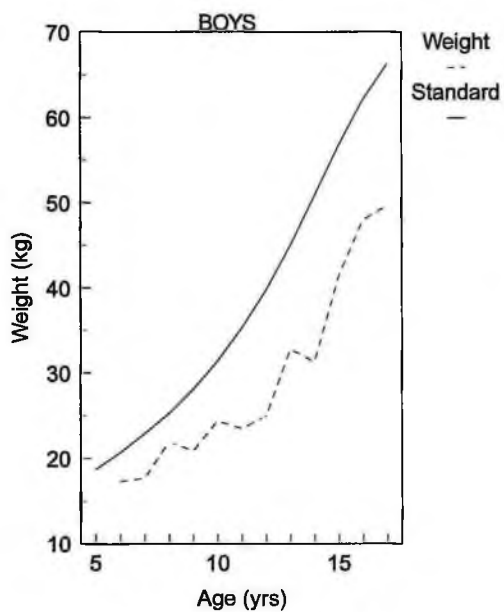
D = -3SD E = -4SD

Boys and Girls (Children) aged 6 - 17yrs**a) Weight for age as a measure of wasting (PEM):**

The weight by age of Boys and Girls (Children) aged 6 - 17yrs in the study compared with NCHS reference standards are presented in figure 12. It was observed that all the boys had weights below the reference NCHS standards. The differences in weight (deviation from the NCHS standard curve) continue to increase with increasing years of the boys. A similar trend was observed for the girls. However, in their case, the differences in weight (deviation from the NCHS standard curve) was only noticed among the 6½ to 15 year olds.

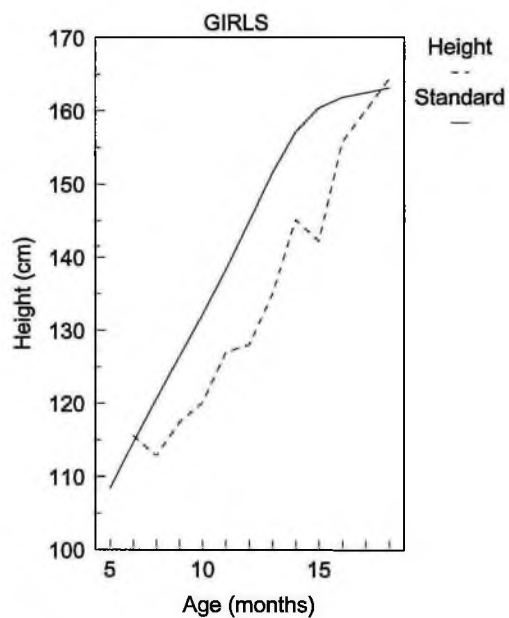
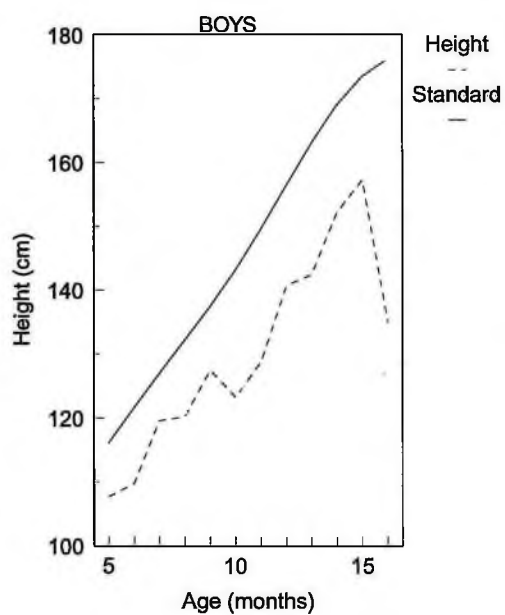
Since the weight-for-age index can be used as an indication of the individual's present nutritional status, it is likely that these children also suffer one form or the other of acute Protein-Energy Malnutrition.

Fig. 12 Differences between weight of Children and NCHS
reference weights



Weight of Children aged (6-17yrs) compared with NCHS reference standards

Fig. 13 Differences between height of Children and NCHS
reference heights



Height of children aged (6-17yrs) compared with NCHS reference standards



b) Height for Age as a measure of Stunting:

Figure 13, shows a graphical representation of Height by Age of Boys and Girls (Children) aged 6 - 17yrs in the study compared with NCHS reference standards. It was observed that all the boys had heights below the reference NCHS standards. The differences in height (deviation from the NCHS standard curve) continue to increase with increasing years of the boys till about age 15. The highest difference was observed in the 15 - 17 age group. A similar trend was observed for the girls. However, in their case, the differences in height (deviation from the NCHS standard curve) was only noticed after 6½ years of age. However, the difference gap begins to close amongst the 16 and above year olds.

Since the height for age index can be used as an indication of the individual's past or chronic nutritional status, it is possible that almost all the boys and a very high percentage of the girls assessed suffer one degree of stunting or the other.

Adults (> 18 years)

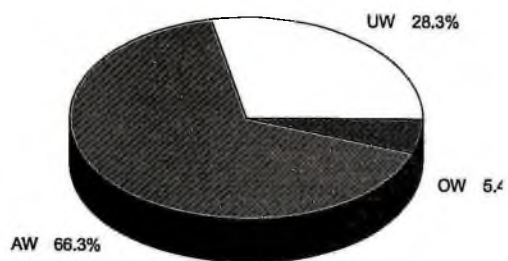
The standard Body Mass Classification (BMI) of adults assessed in the communities are presented in figure 14. It was found that 33.7% of the adult males were of unsatisfactory nutritional status. This comprised 28.3% underweight and 5.4% over weight. On the other hand, 39% of the adult females were

also of unsatisfactory nutritional status. This comprised 11.0% underweight, 19.5% over weight and 8.5% obese. The BMI cut-off points used are presented in appendix 2.

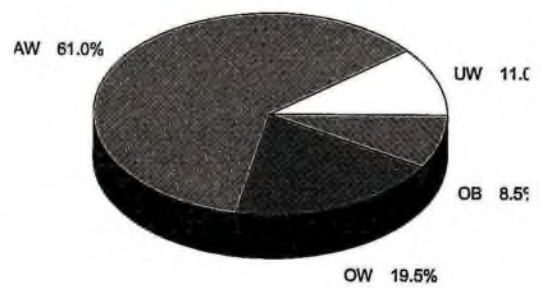
Thus, in the communities studied malnutrition was more prevalent among the children than in the adults. Therefore, prompt nutritional intervention is imperative in these communities so as to restore the normal growth potential in these pre-school children that is commensurate with their genetic potential. This is because the growth failure of early childhood is not made up by later growth. The provision of more nourishing diets, which are not protein, energy and micronutrient deficient rather than the usual cereal and tuber based staples, can provide an opportunity for catch-up growth in these pre-school children.

Fig. 14. Standard Body Mass Index (BMI) Classification for
Adults

MALES



FEMALES



UW - UNDER WEIGHT
AW - ACCEPTABLE
WEIGHT
OW - OVER WEIGHT
OB - OBESE

4.5. Suggestions made by farmers:

Table 17:

Suggestions made by cowpea farmers for improvement in
production and consumption

SUGGESTIONS	NO. OF FARMERS	(%)
Assist / institute a cowpea price control system favourable to both producers and customers	2	2.2
Assist in providing credit facilities / subsidies on farm inputs	8	9.0
Come up with means of reducing cost of production	5	5.6
Come up with simple but effective ways of cowpea storage to curb post harvest losses	4	4.5
Come up with affordable yet efficient means of improving soil fertility / other soil-related problems	4	4.5
Assist in the provision of more marketing avenues	3	3.3
Develop tasty and highly marketable varieties of cowpea	3	3.3
Develop insect & draught resistant, fast maturing and high/big seed yielding varieties of cowpea	35	39.3
Develop affordable and more potent pesticides / other agro-chemicals	17	19.1
Research on cost-effective ways of cowpea Production by irrigation / assist in the provision of dams for irrigation farming in the communities	2	2.2
Provide accessible cowpea-demonstration farms with adequate numbers extension workers to teach farmers	1	1.1
Intervene in Land acquisition by tenet farmers	2	2.2
Assist in securing incentives / motivation packages (e.g. farm tools) for cowpea farmers	1	1.1

Continuation of Table 17.

Assist in the provision of high efficiency tools (Tractors, Threshing & spraying machines)	3	3.4
Endeavour to pay periodic visits to farmers to interact, learn, share, and also impart their research findings / improve upon the dissemination of information on cowpea production, marketing and utilization	5	5.6
Suggest ways of getting around the problem of unfavourable climatic conditions	1	1.1
Formation of a cowpea growers association	1	1.1

These suggestions made by cowpea farmers in the population studied tend to draw attention for measures to be put in place for increased cowpea production. In view of the low cowpea yields and short duration of household cowpea stocks, it is expedient to stimulate, promote and sustain increased cowpea production. This will certainly help to provide sufficient and relatively affordable protein-rich foods and also minimise the occurrence and cost of malnutrition. No suggestions were made by farmers on processing and utilization of cowpeas. Perhaps this is an indication that irrespective of the problems associated with cowpea consumption and the time expense associated with cooking cowpea, which were known to the farmers, they would rather have measures taken by concerned research agencies to boost cowpea cultivation in their communities.

4.6. Nutritional Evaluation of Cowpea-Fortified fermented maize doughs

4.6.1. Proximate analysis:

Table 18:

PROXIMATE COMPOSITION OF COWPEA FORTIFIED FERMENTED MAIZE DOUGH (on dry matter Basis)

CFFMD	1	2	3	4
*TREATMENT	TNS	TS	INS	IS
Dry matter (%)	95.96	93.18	96.01	94.35
ENERGY (KJ/100g)	1877.87 $\pm$ 0.09	1923.0 $\pm$ 0.06	1870.64 $\pm$ 0.09	1889.77 $\pm$ 0.04
Protein (%)	20.35 $\pm$ 0.11	20.32 $\pm$ 0.71	19.88 $\pm$ 0.01	19.52 $\pm$ 0.47
Fat (%)	3.73 $\pm$ 0.01	3.95 $\pm$ 0.02	3.48 $\pm$ 0.03	3.46 $\pm$ 0.04
Ash (%)	1.77 $\pm$ 0.01	1.77 $\pm$ 0.04	1.75 $\pm$ 0.03	1.79 $\pm$ 0.01

*TREATMENT:

TNS - Traditional method of fermentation, No extra heat applied

TS Traditional method of fermentation, extra heat applied

INS 'Improved' method of fermentation, No extra heat applied

IS 'Improved' method of fermentation, extra heat applied

The proximate compositions of test cowpea-fortified fermented maize doughs (CFFMD's) are presented in Table 18. All the dough samples have similar composition. Minor differences were observed in the protein and fat contents of the traditionally processed fortified samples. The traditionally fermented cowpea-fortified maize doughs showed slightly higher values for protein. This might be due to the growth of more microorganisms during the fermentation process in the traditional method than in the improved method. Sefa-Dedeh (personal communication), stated values of 24.11%, 4.64% and 4.14% as the protein, fat and ash contents of the Asontem variety of cowpea. Comparing these values with those obtained, indicates that on the average the test doughs



contains about 17% less Protein, 21.5% less Fat and 56.5% less Ash than that reported for the Asontem variety of cowpea used as the fortifying agent. The Ash content of the cowpea-fortified dough samples were quite low. Dehulling of the cowpeas during sample preparation might have effected the observed low % Ash contents.

4.6.2. AMINE CONTENT:

No biogenic amines were detected in any of the samples analyzed. Hence, the cowpea-fortified doughs (CFFMD's) did not suffer any significant deteriorative loss of amino acids due to decarboxylation by the microbial activity during the fermentation period.

4.6.3. AMINO ACID COMPOSITION:

Table 19:

Amino acid profile of cowpea-fortified fermented
maize doughs

DOUGH	1	2	3	4
TREATMENT	TNS	TS	INS	IS
Amino acid	composition	(mg/g	protein)	
Glu	148.06	151.4	160.92	159.22
*Leu	80.58	79.18	83.65	86.17
Asp	76.95	75.59	81.04	81.56
Pro	50.22	51.47	52.46	53.38
Arg	46.49	48.13	47.38	49.28
Ala	46.43	45.89	48.49	49.23
*Phe	44.42	42.71	45.27	46.52
Ser	42.65	41.58	44.41	46.98
*Val	39.41	38.53	40.19	41.85
*Thr	36.75	35.58	35.61	37.55
*Lys	35.77	33.80	33.25	36.73
*Ileu	32.97	31.64	32.95	34.78
Gly	29.68	28.05	29.98	31.66
*His	19.60	16.53	19.27	20.08
*Try	8.84	6.64	6.58	6.40
*Met	3.69	5.07	8.20	4.81
Hyp	1.71	4.04	1.00	1.95
Tau	1.71	3.15	1.45	
*EAA TOTAL	302.03	289.68	304.97	314.89

Table 19, shows the amino acid profile of the cowpea-fortified fermented maize doughs (CFFMD's). All 18 amino acids were determined in duplicates. The essential amino

acids in highest concentration is leu, followed by Phe, Val, Thr, Lys, Ile, His, and Trp. Values obtained for Methionine were very low. Average values of 4.38 and 6.51mg/g were obtained from the traditional and "improved" methods of fermentation respectively. Generally, the amino acid profile of the doughs showed slightly higher amino acid and total EAA values for doughs subjected to "improved" method of fermentation (especially blend IS) than the traditionally fermented blend protein sources. The EAA total for dough IS (314.89) was slightly higher followed by INS (304.97) then TNS (302.03) and TS (289.68), in that order.

The high levels of isoleucine, lysine and tryptophan (amino acids often limiting in maize, Passmore and Eastwood, 1986) observed in the doughs underscores the benefits of mixing proteins of various origins to increase their nutritive value, viz, the complementation effect, which provides a better overall amino acid balance. The 40% substitution with Cowpea may have accounted for the low methionine (amino acid often limiting in cowpea but not in maize) content in the doughs. It is also likely that the method employed for methionine determination was not sensitive and precise enough. Strong oxidizing agents are able to oxidize methionine residues into residues of methionine sulphone. Steiner-Asiedu (1989), noted that determination of methionine by acid hydrolysis may give low results. Perhaps the acid hydrolysis (6N HCl, 110°C for 20 hours) and/or process treatments of the blends may have reduced or nullified any inherent methionine-sparing effect in the doughs. Consequently, exposing and

unfolding the protein structure, thus rendering the amino acid more susceptible to transmethylation reactions.

It is important to mention that these comparisons on their own are inconclusive. A conclusive comparison for protein quality can only be made based on actual results of a biological experiment (balance studies). This is because the nutritive value of a protein is known to depend on the biological availability of constituent amino acids to the body and not necessarily on the levels of amino acids present in a food per se.

4.6.4. CHEMICAL SCORES DOUGHS:

Table 20:

Chemical scores of cowpea-fortified and fermented maize doughs

Amino acid	CHEMICAL SCORES (%)							
	Preschool child (2 - 5yrs)				Adults			
	Dough				Dough			
	TNS	TS	INS	IS	TNS	TS	INS	IS.
*Ile	117.75	113.00	117.68	124.21	253.62	243.38	253.46	267.54
Leu	122.09	119.97	126.74	130.56	424.11	416.74	440.26	453.53
*Lys	<u>61.67</u>	<u>58.28</u>	<u>57.33</u>	<u>63.33</u>	223.56	211.25	207.81	229.56
Thr	108.09	104.65	104.74	110.44	408.33	395.33	395.67	417.22
*Try	<u>80.36</u>	<u>60.36</u>	<u>59.82</u>	<u>58.18</u>	176.80	132.80	131.60	128.00
Val	112.60	110.09	114.83	119.57	303.15	296.38	309.15	321.92

a Based on FAO (1985) Essential amino acids provisional pattern.

* Amino acids often limiting in maize (Passmore and Eastwood, 1986)

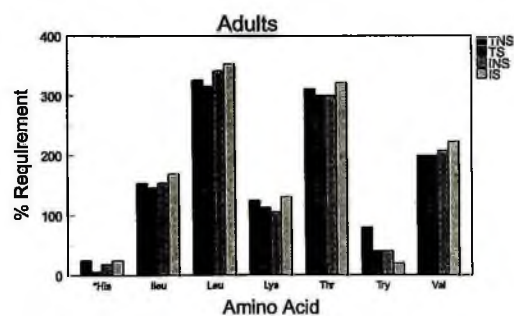
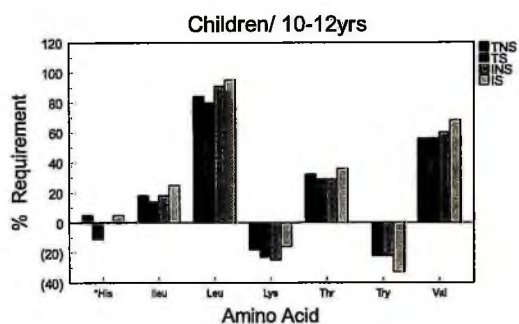
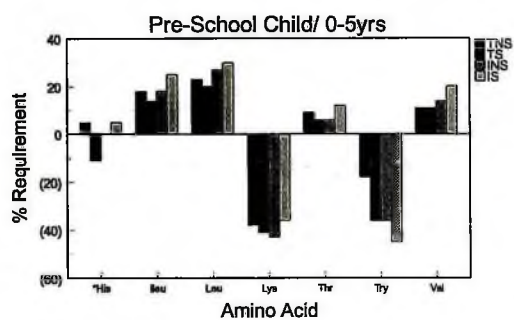
The amino acid Scores of the fortified doughs are presented in Table 20. Lysine followed by Tryptophan are the two most limiting amino acids in the cowpea-fortified doughs. The Scores suggest that sources rich in lysine and tryptophan are needed to improve the amino acid content of maize for the growing child. Steiner-Asiedu (1989), reported tryptophan followed by lysine as the two most limiting amino acids in maize and kenkey. The report also suggested the use of fish with scores of 134.5 and 98.2 (preschool child) for lysine and tryptophan, respectively, as a good supplement for maize.

4.6.5 Composition of doughs in relation to FAO/WHO Recommended Amino Acid requirements:

In order to evaluate how much amino acid requirements can be met on feeding the test doughs, the percent requirements met on each test dough, (i.e, TNS, TS, INS, and IS) were calculated. The results obtained are illustrated in figure 15.

It was observed that the FAO/WHO preschool child requirements for the essential amino acids isoleucine, leucine, threonine and valine were met in excess. Notably, leucine and isoleucine were the two essential amino acids whose requirements were met well in excess of the FAO/WHO recommendation for the preschool child on the test doughs. However deficits were observed in the percent requirement met for lysine (38 - 43%) and tryptophan (18 - 45%) on the test doughs. Additionally, a deficit in percent requirement met for histidine was observed only on test dough TS. Similar observations were made on the percent requirements of these essential amino acids for children aged

Fig. 15 Percentage of Amino acid requirement met



Zero line represents 100% of the FAO/WHO (1985) Requirement.
 * = FAO/WHO (1984)

10 12 years. Nonetheless, the deficits in percent requirement met for lysine (16 - 23%) and tryptophan (22 - 33%) were not as pronounced as those observed for the preschool child. Also leucine, valine and threonine were the essential amino acids whose requirements were met well in excess of the FAO/WHO requirements for children aged 10 - 12 years on the test doughs.

As illustrated by Fig. 15, if an adult eats an adequate amount of any of the test cowpea fortified doughs, S/he is most likely to meet the amino acid requirement well in excess of what is required to maintain nitrogen balance. That is, provided S/he's caloric intake is adequate and physiological state is normal. Leucine, threonine and valine were the amino acids whose requirements by adults was highly met on the fortified test doughs.

From the above discussion it is evident that lysine and tryptophan; essential amino acids required for maintenance and growth in children, cannot be adequately met on feeding these test cowpea fortified fermented doughs alone. Hence, additional high quality protein supplements are required.

4.6.6. Protein Digestibility - Corrected Amino Acid Scoring:

The Protein Digestibility Corrected Amino Acid Scorings (PDCAAS's) obtained for the CFFMD's are presented in Table 21 below. The lowest corrected amino acid Score for the test doughs were 0.64, 0.59, 0.58, 0.58 for TNS, TS, INS and IS respectively, corresponding to the essential amino acids lysine in TNS, TS and INS, and tryptophan in cowpea-fortified

dough IS. It is evident from the results that lysine in particular followed by tryptophan (PDCAAS values < 1) are the essential amino acids lacking in the cowpea-fortified doughs. This is not surprising to find in blends containing 60% maize, since from theory lysine and tryptophan have been reported to be the amino acids often limiting in maize. The result therefore buttresses the need for another protein with a higher supplementary value (i.e. the capacity of proteins to make good one another's deficiencies, Passmore and Eastwood, 1986) for lysine and tryptophan for protein quality improvement in the CFFMD's.



Table 21:

Calculation of Protein Digestibility - Corrected Amino Acid Scoring of the fortified doughs:

I	II *EAA profile				III *FAO/WHO Reference pattern	IV Uncorrected amino acid Score ^a			
Essential amino acid	DOUGHS					DOUGHS			
(EAA)	TNS	TS	INS	IS		TNS	TS	INS	IS
His	19.60	16.53	19.27	20.08	19	1.03	0.87	1.01	1.06
Ileu	32.97	31.64	32.95	34.78	28	1.18	1.13	1.18	1.24
Leu	80.58	79.18	83.65	86.17	66	1.22	1.20	1.27	1.31
Lys	35.77	33.80	33.25	36.73	58	0.62	0.58	0.57	0.63
Thr	36.75	35.58	35.61	37.55	34	1.08	1.05	1.05	1.10
Trp	8.84	6.64	6.58	6.40	11	0.80	0.60	0.60	0.58
Val	39.41	38.53	40.19	41.85	35	1.13	1.10	1.15	1.20

V ^b True digestibility of Blends (%)			EAA	TNS	VI ^c PDCAAS of Blends		
					TS	INS	IS
TNS	103		His	1.06	0.89	1.02	1.06
			Ileu	1.21	1.15	1.19	1.24
TS	102		Leu	1.26	1.22	1.28	1.31
			Lys	0.64 ^d	0.59 ^d	0.58 ^d	0.63
INS	101		Thr	1.11	1.07	1.06	1.10
			Trp	0.82	0.61	0.61	0.58 ^d
IS	100		Val	1.16	1.15	1.16	1.20

^aUncorrected amino acid score : column II / column III

^bTrue digestibility from Balance experiments with rats (Table 7)

^cPDCAAS = column IV x column V

^dLowest corrected amino acid Score

*(mg/g protein)

Table 22:

<u>PDCAAS of Selected Food Proteins^a</u>	
<u>Protein Source</u>	<u>PDCAAS</u>
Isolated Soy Protein ^b	1.00
Casein	1.00
Egg White	1.00
Beef	0.92
Pea flour	0.69
Kidney beans (Canned)	0.68
Rolled oats	0.57
Lentils (Canned)	0.52
Peanut meal	0.52
Whole Wheat	0.40
<u>Wheat gluten</u>	<u>0.25</u>

^aProtein Quality Evaluation,
Report of the Joint FAO/WHO, 1989

^bValues for Supro[®] brand isolated
Soy Protein provided by Protein
Technologies International as
determined through actual analysis.
through actual analysis.

(source: Table 5, Henley & Kuster, 1994)

Table 22, shows a comparison of select protein sources and their Scores. The PDCAAS obtained for the doughs fell between that for Kidney beans (canned) and Rolled Oats. Comparatively, the fortified dough TNS's PDCAAS came very close to that of the Kidney beans (canned) as well as the PDCAAS for Pea flour. All the test doughs were of higher PDCAAS values than that for Rolled Oats, Lentils (canned), Peanut meal, Whole Wheat and Wheat gluten.

The basis for and mode of interpretation of PDCAAS has been explained by Henley and Kuster (1994), as follows:

When calculating the PDCAAS of a food protein, any Score above 1.0 is rounded down to 1.0. There is absolutely no nutritional advantage to consuming proteins with Scores greater than 1.0, since excess amino acids are not utilized by the body as amino acids, per se. Rather, excess amino acids are deaminated by the body and nitrogen excreted as urea while the remaining carbon skeleton is either utilized for energy or stored. All proteins with a PDCAAS of 1.0 are considered to be high - quality proteins and are equivalent in protein quality. They are complete proteins that meet the essential amino acid requirements of humans. Based on the above interpretation, all the CFFMD's do not qualify as high - quality protein sources. This finding is consistent with available literature on vegetable protein quality, since almost all vegetable and vegetable-mixes sources of protein often have one or more limiting amino acids.

4.6.7. Biological Utilisation of cowpea-fortified fermented maize doughs:

The values obtained for protein quality of the cowpea-fortified doughs are shown on Table 23, below.

Table 23:

Protein Quality of Cowpea- Fortified Fermented Maize Doughs

Index	TNS	TS	INS	IS
Balance (%)	59 ± 0.04	54 ± 0.08	55 ± 0.02	54 ± 0.05
AD (%)	86 ± 0.02	83 ± 0.03	86 ± 0.01	84 ± 0.03
TD (%)	103 ± 0.03	102 ± 0.02	101 ± 0.01	100 ± 0.02
NPU (%)	88 ± 0.02	86 ± 0.06	83 ± 0.02	81 ± 0.04
BV (%)	86 ± 0.02	84 ± 0.05	82 ± 0.02	82 ± 0.02

PROTEIN DIGESTIBILITY

The high True Digestibility (TD) values obtained for the blends might be due to the positive or enhanced effect of the dehulling process (i.e., removal of testa which contains most of the anti-nutritional factors) prior to fermentation. A decrease in protein digestibility due to prolonged heating has been reported in *Phaseolus* beans (Bressani and Elias, 1974). The TD values obtained in this study showed that the doughs subjected to prolonged or additional heat treatment (i.e., soaked in 60°C hot water for 30 min; agglomerated steamed treated for 5 min; oven dried overnight), i.e. blends INS and IS, which were also fermented by the "improved" method of

fermentation, were slightly lower than the TNS and TS, which were subjected to the traditional method of fermentation; though with minimal exposure to heat. Kadam et al. (1987), in a study of the effects of heat treatments on anti-nutritional and quality of proteins in Winged Bean, observed that the digestibility of proteins in the diet improved from 50 - 84% due to infrared and boiling water treatments, whereas a noticeable decrease in protein digestibility was observed in oven - heated meal diet. Thus, the additional heat treatment may have influenced to some extent the observed TD values.

BIOLOGICAL VALUE

Supplementing diets in which either lysine or the sulphur amino acids or both are limiting is known to increase Biological Value (BV) of the said diet. Accordingly, the inherent lysine, methionine and tryptophan deficiencies in the fermented cowpea-fortified maize doughs might have caused the relative lower BVs measured in the rats fed on the test diets, i.e, 86, 84, 82, and 82 for TNS, TS, INS and IS respectively.

Differences in BV not attributable to amino acid content have been observed among protein sources (Mauron, 1973). Adibi (1985), explained this observation by attributing it to the differences in the capacity of digestive enzymes to release amino acids in particular forms and sequences. Depending on the process treatment(s), each protein source has its own digestibility and rate of amino acid release. Therefore it is likely that the different test dough

preparation process treatments might have affected to different extent the capacity of the digestive enzymes to release amino acids for assimilation and anabolism, hence the observed differences in BV.

NET PROTEIN UTILIZATION

Net protein utilization (NPU) is a derived factor ($TD \times BV/100$) which only indicates the actual retention (protein nitrogen) in the organism. It appears from the present work with rats that NPU in test doughs TNS and TS (Traditionally fermented doughs) were slightly higher (88 and 86 respectively) than the values obtained for INS and IS ("Improved" method of fermentation employed 83 and 81 respectively). This is because of the corresponding high TD and BV values obtained in the blends. The lowest NPU of 81% was obtained in blend IS. This means only less than 20% of the protein in the test dough consumed is not retained, hence excreted. The remaining 80% and above is most likely available for maintenance of nitrogen balance and growth.

On the whole, the cowpea-fortified doughs subjected to traditional method of fermentation with or without (especially without) additional heat treatment showed higher protein digestibility and utilization values, hence of high nutritive value. This might have resulted from differences in the efficiency and extent to which enzymatic activity by microorganisms on the organic substrate (cowpea-fortified maize doughs) to release more soluble proteins were accomplished. This factor also stems from the concentration

of microorganisms present to initiate and enhance the fermentation process. It has long been recognised that the traditional soaking process, which involves the addition of a large volume of water to whole maize grains, allows the selection of desirable organisms, such as lactic acid-producing bacteria, yeasts and mould. The relatively longer soaking period for test doughs TNS and TS in ordinary tap water, at room temperature overnight, as against that for INS and IS (soaked in hot water, at 60°C for 30 minutes), might have produced a better initiation and enhancement of fermentation in the traditionally fermented cowpea-fortified maize doughs (i.e. TNS and TS), hence the concomitant higher digestibility and utilization values.

Aliya and Geervani (1981), in an assessment of the protein quality and vitamin B content of commonly used fermented products of legumes and millet, reported that temperature seems to have an adverse effect on the growth of microorganisms responsible for the synthesis of riboflavin during fermentation. Thus, it seems plausible to suggest that, exposure of test doughs INS and IS to more heat treatment during and after the soaking process may have adversely affected the microorganisms responsible for release of soluble proteins, resulting to their comparative low digestibilities and protein utilization values observed. Also, the likelihood of reduced nutritive value in test doughs INS and IS, due to oxidative and milliard reactions, the formation of poorly digestible lysine isopeptides, as well as unavailable lysine derivatives of carbohydrates, lipids,

nucleic acids, polyphenols and vitamins, due to increase acidity, moisture and exposure to additional heat treatment (Cheftel et al., 1985), cannot be ignored.

Table 24:

The chemical Score and Net Protein Utilization (NPU)
of some common foods^a

Protein	^a Chemical Score on children	NPU determined on children	NPU determined on rats
Maize	49	36	52
Millet	63	43	44
Rice	67	63	59
Wheat	53	49	48
Soya	74	67	65
Whole eggs	100	87	94
Human milk	100	94	87
Cow's milk	95	81	82
<u>*Cowpea-fortified doughs</u>			
TNS	62	-	88
TS	58	-	86
INS	57		83
IS	63	-	81

^aFAO/WHO (1973), Energy and Protein requirements.
WHO Tech Rep Ser no 522. (Source Table 5.6,
Passmore and Eastwood, 1986)

*Chemical Scores based on lysine.

Table 24, compares the NPU values of proteins from single foodstuffs with the cowpea-fortified doughs. The NPU values determined on rats fed the test doughs were found to be higher than NPU values for maize, millet, rice, wheat and soybean,

also determined on rats. Even though the NPU values for human milk (87) corresponds to that of the average for test doughs TNS and TS, and NPU values for TNS, TS and INS seemed to be higher than that reported for cow's milk, no comment can be made since the experimental conditions and methods for NPU determination were different. Moreover, there is no controversy over the proven fact that proteins of animal origin are of a higher quality than vegetable sources. Nonetheless, the results does suggest that the protein quality of the fermented maize doughs have improved considerably after fortification with cowpea. Thus the results obtained agrees sufficiently well with the finding of earlier researchers, who have consistently established the benefits of mixing protein of various origins to increase nutritive value of the resultant blend diet (Bressani, 1977; Adolph et al 1955; De Groft and Vanstratum, 1963; Phansalker et al, 1957; Bressani and Elias, 1983; and Ebrahim, 1983). Moreover, Passmore and Eastwood (1986). have indicated that most good mixed diets have NPU value of around 70, and this figure is little affected by the amount of protein of animal origin in the diet. These authors have also indicated that the NPU value of a food becomes of great importance and may determine whether or not protein requirements are met, when 70 per cent or more of the dietary proteins come from a single staple food, eg. maize, cassava or wheat. With a 60 : 40 maize/cowpea fortification formulae in the test doughs this concern may not be necessary.

4.6.8. STATISTICAL ANALYSIS OF BIOLOGICAL DATA:

Nitrogen intake was found to correlate ($p < 0.05$) very well with the final weight of rats ($r = 0.59^*$). Nonetheless, a significant correlation ($p < 0.05$) was also found between nitrogen-intake and urinary nitrogen excretion values ($r = 0.56^*$), as evidenced by the higher commensurate compensatory urinary nitrogen values observed in rats fed on blends INS and IS. This perhaps explains why no significant differences ($p \leq 0.05$) were found in the initial weight of the rats at the start of the preliminary and balance periods, or in the final weight at the end of the balance period, between all four groups of rats.

Overall, the process treatments seemed to have an effect only on the % Net Protein Utilization. No significant differences ($p \leq 0.05$) were observed in the digestibility and biological values of the fortified doughs (Table 25).

Table 25.

ANOVA summary Table of protein quality indices (1)

Source of variation	Parameter	F-ratio	Sig. level
Between groups (i.e. TNS, TS, INS, IS)	Nitrogen balance (Bal)	1.341	0.2894
	Apparent Digestibility (AD)	1.264	0.3136
	True Digestibility (TD)	2.789	0.0671
	Net Protein Utilisation (NPU)	4.310	0.0169*
	Biological value (BV)	2.691	0.0737

* Significant at $p \leq 0.05$

Further analysis of variance considering the responses of doughs subjected to similar heat treatment (analysis 1) and fermentation treatment (analysis 2) versus those which were not however revealed the following (Table 26):

Table 26.

ANOVA summary Table of protein quality indices (2)

Source of variation	Parameter	F-ratio	Sig. level
Heat treatment (HT)	TD	4.005	0.0578
	BV	0.333	0.5758
	NPU	1.124	0.3006
Method of Fermentation (MF)	TD	5.101	0.0342*
	BV	7.856	0.0104*
	NPU	11.424	0.0027**
(HT) * (MF)	TD	0.981	0.3443
	BV	0.268	0.6158
	NPU	0.076	0.7890

* Significant at $p \leq 0.05$

**Significant at $p \leq 0.01$

i) Additional heat treatment showed no effect on the protein quality indices measured.

ii) The method of fermentation, i.e., with or without inoculation had a significant effect $p \leq 0.05$ on the TD%, BV% and NPU% protein quality indices.

iii) No interaction was found between the effects of additional heat treatment and method of fermentation. The effects of additional heat treatment and fermentation method on the protein quality indices were independent of each other.

The observed non-significant effect of heat treatment is perhaps an indication that the effect due to additional heat treatment was not pronounced enough to produce any distinctive or substantial observable difference. In other words, there was a seeming uniformity in the inactivation of enzyme-inhibitors and the extent to which the thermal process alone destroyed the antiphysiological substances in all the doughs.

The principal factors known to influence protein quality as a result of heat treatment are the duration of the heat treatment, temperature level and the presence of moisture and reducing substances. In order to explain the absence of a significant difference in protein quality between the doughs subjected to additional heat treatment and those which were not subjected to any further heat treatment, there is the need to investigate further the effect of duration and temperature level of heat treatments applied during sample preparation. This would unravel any critical discriminative heat treatment level required to offset the effect if any, of prior mild heat treatments on protein quality.



5.0 Conclusions and Recommendations:

Conclusions

1. Household characteristics:

1.1 More than one-half of household members in the study communities comprised children aged between 0-17 years.

1.2 The age-sex distribution suggests a high presence of an active child bearing population in the communities studied.

2. Cowpea production:

1.1 There are no cowpea farmers co-operative groups in the population studied.

1.2 Cowpeas are regarded as secondary crops and hence receive marginal crop management.

1.3 Farmers in the communities were observed to be lacking in the use of modern farming techniques and equipment.

1.4 Cowpea production in the study area was beset with numerous problems pertaining to cultivation, crop management, storage and marketing.

1.5 Numerous constraints encountered by the farmers resulted in low yields. This was reflected in the inadequate household cowpea stocks kept for their families, which could not last the whole year.

3. Cowpea consumption:

3.1 Cowpea consumption rate is high when available in the population studied.

3.2 Indigestion, diarrhoea and flatulence were identified as common problems associated with cowpea consumption in the population studied.

4. Nutritional status:

4.1 Malnutrition is more prevalent among children than adults in the population studied.

4.2 Majority of the boys and a very high percentage of the girls assessed were stunted.

5. Nutritional quality of cowpea-fortified fermented maize doughs:

5.1 Protein quality of fermented maize dough was improved considerably with cowpea fortification.

5.2 The method of fermentation used; traditional or "improved", affected the protein quality of cowpea-fortified maize doughs.

5.3 Fortification of maize dough with dehulled cowpea flour and fermentation by the traditional method improved protein quality of the popular traditional staple, i.e, maize dough.

Recommendations:

Based on the findings of this study the following recommendations are being made :

1. Cowpea farmers in the communities studied should be encouraged to form cowpea growers associations and co-operative societies. This will make them recognised and also enhance their chances of attracting credit facilities and other necessary support required to boost cowpea production.
2. It is recommended that a closer working relationship be fostered between research scientists, extension workers and farmers at the sub-district and district levels. This should be geared towards facilitating the quick dissemination and adoption by farmers of relevant research findings, for enhanced and sustained productivity.
3. It is suggested that the Ministry of Food and Agriculture in conjunction with the Ministry of Finance and Economic Planning, could come to the aid of farmers by introducing a price support programme for cowpea. This will certainly serve as a buffer against crop failure and also, as a sure stimulant or bait to attract more farmers into cowpea production.
4. The Ghana Food Distribution Corporation (GFDC), just like the Produce Buying Company (COCOBOD), could be

commissioned and assisted to buy cowpeas directly from farmers or farmer's co-operatives for proper storage and subsequent distribution.

5. Research into simple, affordable and effective cowpea Storage facilities is highly recommended. This will enable farmers to store their produce with minimum post harvest and nutrient losses. In addition, farmers' could also benefit from the sale at high prices in the lean season to make more profits, thereby enhancing their household food purchasing power.
6. Since household cowpea consumption is high in the population studied, farmers should be taught simple and appropriate cowpea processing and utilisation methods that can enhance optimum utilization of the nutrients present in cowpeas. In this regard, it is necessary to educate farmers and their families on the nutritional benefits of dehulling cowpeas prior to utilization as well as incorporating cowpeas in the weaning the gruel and their normal cereals and roots based diets.
7. There is currently an IDRC / IITA supported, Soy-bean utilization programme carried out by the Food Research Institute (FRI). In a bid to promote increased cowpea utilization, a similar programme on cowpea may be started or run alongside the on-going programme for

Soy-bean; so as to cut down cost, as the case may be.

8. Development of community-based growth monitoring and promotion programmes is highly recommended in view of the high prevalence of malnutrition among the children studied. This is vital since early detection of growth faltering in infants and children and the promotion of their growth are important for breaking the malnutrition-infection complex. In this regard the extension of Maternal and Child Health (MCH) and Primary Health Care (PHC) services to these farming communities can do much to alleviate infection and malnutrition, thereby improving their nutritional status.
9. Drawing from the suggested general principle that the more mixed or varied a diet, the more balanced it is, the incorporation of some animal proteins into cowpea-fortified maize doughs is nutritionally desirable. The dried fish Anchovies (*Keta school boys*), which is nation-wide available and affordable, for instance, when incorporated into cowpea-fortified maize doughs would adequately improve the blend's nutritional value. Consequently, a further study perhaps based on Mixture designs or a Central Composite Design involving optimization studies on a Triple mix (i.e, staple / animal / vegetable) all from locally produced and available foods (cowpeas inclusive) is hereby

recommended. This is necessary since infants may have to consume a considerable amount of the bulky cereal legume blends before meeting their essential amino acids requirement.

10. To get a better overview of the nutritional value and nutrient composition of cowpea and the cowpea-fortified maize doughs, it would have been ideal to have analyzed all the varieties of cowpeas locally grown or available in Ghana for proximate composition and micro-nutrient analysis. This no doubt would have given a range of the composition and profile of most if not all of the essential nutrients in cowpeas. Due to time limit, the above was not possible. The time factor also limited the number of process treatments and their levels as well as the levels of cowpea-fortification to permit comparative cost and benefit analysis to be made on such formulations. It is hoped that the above will be considered in the near future.
11. The ability of the cowpea-fortified maize doughs studied to support growth and enhance total protein and immunoglobular protein synthesis constitutes another relevant research worth undertaking.
12. The textural characteristics of any weaning formulation constitutes a critical determinant of product acceptability by the infant or child. It would

therefore be of interest and relevance to perform field trials of the cowpea-fortified maize doughs to ascertain consumer acceptability, and to also study their functional / rheological properties.

13. To derive the maximum nutritional benefit from any food, its safety or wholesomeness must be assured. Hence, the safety aspect of the cowpea-fortified maize doughs studied is also worth investigating with the view to establishing their storage / keeping quality and microbiological safety / profile.

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Appendix 1: (Questionnaire)

Dear Survey Participant, Sir/Madam, Mr./Mrs.

We are seeking your permission to ask you some questions concerning your farming practices and eating habits with respect to cowpea. The answers to these questions will allow us to find ways of improving cowpea production, storage and use.

We promise that your answers to these questions will be kept confidential. That is, you will not be identified as part of the survey to anyone else and you will only be identified by code number to make sure this is true. I promise to carefully control access to this information and to use it only for the purpose we state in this letter.

If you agree to participate in this survey, please sign your name below or clearly state your agreement to the person who has given you this letter or read it to you. Thank you for your cooperation.

Sincerely,

Professor Sam Sefa-Dedeh
Department of Nutrition and Food Science
University of Ghana-Legon

Participant Code:

Signature of consenting participant

Signature of witness to oral or written consent
.....

Signature of witness to oral or written consent
.....

FORM 04.

UNIVERSITY OF GHANA CRSP COWPEA PROJECT

BASELINE SOCIO-ECONOMIC SURVEY ON COWPEA FARMERS

PRODUCTION AND CONSUMPTION.

(To be completed by household heads)

- ```

1. Region..... 2. District.....
3. Town/village.....
4. Name of Respondent..... 5. House No.....
6. Sex..... 7. Age..... 8. Status in family.....
9. Highest Educational level
None..[] Elem..[] Sec..[] Tech..[] Voc..[]
Univ .[] Dip. college..[] Adult Literacy Class..[]
10 Major occupation (if not farming).....
11 Household size (No. of people eating from the same pot)
.....

```

## 12. Household characteristics

[illegible]

**COWPEA PRODUCTION**

13. No. of years in cowpea production.....

14. Other crops produced.....

15. Acres (ropes) of total farm land.....

16. Acres (ropes) of land cultivated with cowpea.

|                      |  |  |  |  |
|----------------------|--|--|--|--|
| YEAR                 |  |  |  |  |
| AREAS (HT)           |  |  |  |  |
| TOTAL YEILD          |  |  |  |  |
| PRODUCTION COST      |  |  |  |  |
| Land (if rented)     |  |  |  |  |
| Land preparation     |  |  |  |  |
| Hired Labour         |  |  |  |  |
| Fertilizers/Chems    |  |  |  |  |
| Storage              |  |  |  |  |
| -Irrigation(if used) |  |  |  |  |

17. What variety of cowpeas do you normally grow? (Indicate the breeder's agronomic) name if known.

| Local name | Breeders name | Description |
|------------|---------------|-------------|
| .....      | .....         | .....       |
| .....      | .....         | .....       |
| .....      | .....         | .....       |

18. Are there other types of cowpeas which you do not produce?

Y[ ]      N[ ]

19. If yes, name (or describe) and indicate why you do grow the variety.

| VARIETY | DESCRIPTION | REASON FOR NOT CULTIVATING |
|---------|-------------|----------------------------|
|         |             |                            |
|         |             |                            |
|         |             |                            |

20. Where do you obtain your planting materials.

Previous year's stock [ ] Agric. Ext. Officer [ ]

Market [ ] Other (specify).....

21. What is the major problem you now encounter (if any) during cultivation ?

.....  
 .....  
 .....  
 .....

22. How long does it take to go through the following activities associated with cowpea production ?

|                  |  |
|------------------|--|
| Land preparation |  |
| Planting         |  |
| Weeding          |  |
| Harvesting       |  |
| Other.....       |  |

23. Do you have access to the services of Agric. Ext. Officers?  
 Y[ ] N[ ]

24. What do you consider as important factors which have a negative effect on the production of cowpea in your area ?

.....  
 .....

25. What usually happens to the cowpea you produce ?  
 (Please indicate the proportions below )

|                |                 |
|----------------|-----------------|
| Consume.....   | proportion..... |
| Market.....    | proportion..... |
| Give away..... | proportion..... |
| Lost.....      | proportion..... |

26. If you give a proportion of your produce away, please indicate the recipients.

.....  
 .....

### COWPEA CONSUMPTION

27. How often does your family eat cowpea dishes ?

...../day ...../week ...../month

28. Estimate the amount of cowpea consumed based on the rate of consumption in (27)...../day ...../week ...../month

29. How do you prepare cowpeas for consumption. (Please list the foods in which cowpeas are used and the method of preparation.)

| FOOD | METHOD OF PREPARATION |
|------|-----------------------|
|      |                       |
|      |                       |
|      |                       |

30. Please provide the information below. You can estimate the quantity of cowpea you normally use.

| TYPE OF FOOD / DISH | FREQUENCY | QUANTITY OF COWPEA USED PER WEEK (HOUSEHOLD MEASURES) | COST OF PREPARATION |               |
|---------------------|-----------|-------------------------------------------------------|---------------------|---------------|
|                     |           |                                                       | TIME (HOURS)        | MONEY (CEDIS) |
|                     |           |                                                       |                     |               |
|                     |           |                                                       |                     |               |
|                     |           |                                                       |                     |               |
|                     |           |                                                       |                     |               |

31. Do you feed cowpea to children in the family ?

Y[ ] N[ ]

32. If answer to (31) is no, please give reasons.

.....  
 .....  
 .....

33. Is there any member of the family who does not eat cowpea?  
Y[ ] N[ ]

34. If answer to (33) is yes, please give the reasons.  
.....  
.....  
.....

35. Do you know of other problems associated with cowpea consumption ? Y[ ] N[ ]

36. If answer to (35) is yes, please describe the nature of the problem. Diarrhoea[ ] Indigestion[ ] Flatulence[ ]  
Other(specify) .....

37. Do you always have a stock of cowpea for consumption throughout the year ? Y[ ] N[ ]

38. If answer to (37) is no, please indicate how long the stock you produce last year lasted.  
.....  
.....

39. Do you still consume cowpeas when the one you produce is finished ? Y[ ] N[ ]

40. If answer to (39) is yes, please indicate where you obtain the cowpea from.  
.....  
.....

#### COWPEA MARKETING

41. What do you do to cowpeas before you sell ?  
.....  
.....

42. In what units and how do you sell the produce ?  
Middlemen at the farm gate[ ].....(unit)  
At the market to middlemen[ ] .....(unit)  
Wholesalers [ ].....(unit)  
At the market (retail) [ ] .....(unit)  
GFDC [ ].....(unit)  
Other (specify) [ ] .....(unit)

43. Who determines the price of your produce ?  
Farmer [ ] GFDC [ ] Min Food & Agric [ ]  
Customers [ ] Co-operative Union [ ]  
Other(specify).....

44. How much did you sell the following units at the last harvest?

Unit: [1] bowls [2] mini bag [3] maxi bag [4] other

| Price: | ..... | ..... | ..... | ..... |
|--------|-------|-------|-------|-------|
|--------|-------|-------|-------|-------|

45. What do you consider as the major problems associated with cowpea marketing. (Please list in order of decreasing importance)

.....

.....

.....

46. Are there price differentials in the cowpea varieties?

Y[ ] N[ ]

4 7 . I f y e s , p l e a s e d e s c r i b e

.....

.....

.....

48. Are there any seasonal variations in the prices? Y[] N[]  
Please describe a typical price variation over the last two  
years.

| Harvest period | Non harvest period |
|----------------|--------------------|
| 1991 .....     | .....              |
| 1992 .....     | .....              |
| 1993 .....     | .....              |

49. Are cowpeas graded before marketing ? Y[ ] N[ ]

50. Please describe the grading method

.....

## COWPEA STORAGE

51. How do you store your produce ? Please indicate the effectiveness of the method you use.

.....

.....

.....

.....

52. If you use agro-chemicals, please indicate the types and the quantities you use. Indicate also the minimum allowable period from the day of treatment after which the produce could be consumed.

| Agro-chemical used | Quantity used per bag of cowpea | Minimum time before product can be consumed |
|--------------------|---------------------------------|---------------------------------------------|
|                    |                                 |                                             |
|                    |                                 |                                             |
|                    |                                 |                                             |

53. For how long is the chemical treatment able to maintain the quality of the produce ?

.....

54. What are some of the problems associated with cowpea storage?

.....  
 .....

#### ORGANIZATION OF PRODUCTION

55. How many people in your estimation are involved in cowpea production at this village?.....

56. Is there a cowpea growers association in the area ?  
 Y[ ] N[ ]

57. If yes, are you a member ? Y[ ] N[ ]

58. What benefits do you derive from being a member?  
 .....

59. How is the association promoting cowpea production in the area ?  
 .....

60. Generally do you see an increasing or decreasing trend in cowpea production in the area with the years? (Give reasons)  
 .....  
 .....

61. What do you suggest to research institutions involved in cowpea research for improvement in cowpea production and consumption in the country.  
 .....  
 .....

62. Please indicate below your source(s) of information on cowpea. ....

[illegible]

|                                                                                                                                                                                                   |  |  |  |  |  |  |  |  |  |  |  |  |  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|--|--|--|--|--|--|--|--|
| D. CLINICAL SIGNS OF DEFICIENCY (Y/N)                                                                                                                                                             |  |  |  |  |  |  |  |  |  |  |  |  |  |
| I. Vitamin A<br>Bitot spot<br>Xerophthalmia                                                                                                                                                       |  |  |  |  |  |  |  |  |  |  |  |  |  |
| II. Iodine<br>Goitre                                                                                                                                                                              |  |  |  |  |  |  |  |  |  |  |  |  |  |
| III. P. E. M.<br><br>Oedema/Moon face<br>Flaky paint dermatosis<br>Lack of lustre of hair<br>Sparseness of hair<br>Depigmentation of hair<br>Miserable expression<br>Anxious look<br>Thin muscles |  |  |  |  |  |  |  |  |  |  |  |  |  |
| IV. OTHER VITAMINS<br><br>Pale Conjunctiva<br>Bleeding gum<br>Glossitis<br>Reddish tongue<br>Angular stomatitis<br>Cheilosis                                                                      |  |  |  |  |  |  |  |  |  |  |  |  |  |

COMMENTS.....  
 .....  
 .....

## APPENDIX 2:

\*BMI Reference Standards:

$$\text{BMI} = \frac{\text{Wt (kg)}}{(\text{Ht})^2 (\text{m}^2)}$$

| Classification    | Standards ( males ) | Standards ( females ) |
|-------------------|---------------------|-----------------------|
| Under weight      | 20                  | 18                    |
| Acceptable weight | 20 - 25             | 18 23                 |
| Over weight       | 25 - 30             | 23 28                 |
| Obese             | >30                 | >28                   |

Source: British Journal of Nutrition, 1990, 64, 3 - 11.

## Appendix 3:

EXPERIMENTAL DATA - RAT EXPERIMENT  
(12/9 - 20/9, 1994)

| RAT #   | W <sub>0</sub> | W <sub>s</sub> | dW    | U'    | F'  | I       | U      | F      | AD   | TD   | NPU  | BAL  | RV   |
|---------|----------------|----------------|-------|-------|-----|---------|--------|--------|------|------|------|------|------|
| GROUP 1 | g              | g              | g     | mgN   | mgN | mgN     | mgN    | mgN    |      |      |      |      |      |
| 1       | 60.17          | 67.32          | 63.75 | 72.76 | 101 | 597.293 | 145.16 | 107.57 | 0.82 | 0.99 | 0.87 | 0.58 | 0.88 |
| 2       | 60.39          | 69.98          | 65.19 | 73.98 | 101 | 601.13  | 147.34 | 89.07  | 0.85 | 1.02 | 0.90 | 0.61 | 0.88 |
| 3       | 60.59          | 69.09          | 64.84 | 73.69 | 101 | 635.663 | 157.48 | 82.11  | 0.87 | 1.03 | 0.90 | 0.62 | 0.87 |
| 4       | 60.77          | 70.01          | 65.39 | 74.16 | 101 | 634.384 | 169.08 | 83.51  | 0.87 | 1.03 | 0.88 | 0.60 | 0.85 |
| 5       | 55.40          | 63.17          | 59.29 | 68.90 | 101 | 589.619 | 165.46 | 63.92  | 0.89 | 1.06 | 0.90 | 0.61 | 0.85 |
| 6       | 60.25          | 65.18          | 62.72 | 71.87 | 101 | 509.042 | 164.73 | 85.94  | 0.83 | 1.03 | 0.85 | 0.51 | 0.82 |
| MEAN    | 59.60          | 67.46          | 63.53 | 72.56 | 101 | 594.52  | 158.21 | 85.35  | 0.86 | 1.03 | 0.88 | 0.59 | 0.86 |
| SD      |                |                |       |       |     |         |        |        | 0.03 | 0.02 | 0.02 | 0.04 | 0.02 |
| GROUP 2 |                |                |       |       |     |         |        |        |      |      |      |      |      |
| 1       | 52.70          | 61.25          | 56.98 | 66.88 | 101 | 480.816 | 122.7  | 93.22  | 0.81 | 1.02 | 0.90 | 0.55 | 0.89 |
| 2       | 65.23          | 67.83          | 66.53 | 75.13 | 101 | 498.624 | 203.87 | 90.72  | 0.82 | 1.02 | 0.76 | 0.41 | 0.75 |
| 3       | 63.63          | 70.08          | 66.86 | 75.40 | 101 | 597.84  | 153.86 | 69.13  | 0.88 | 1.05 | 0.92 | 0.63 | 0.88 |
| 4       | 62.83          | 66.96          | 64.90 | 73.74 | 101 | 466.824 | 141.54 | 92.81  | 0.80 | 1.02 | 0.87 | 0.50 | 0.86 |
| 5       | 54.30          | 65.18          | 59.74 | 69.30 | 101 | 632.184 | 177.78 | 87.72  | 0.86 | 1.02 | 0.85 | 0.58 | 0.83 |
| 6       | 61.02          | 67.96          | 64.49 | 73.39 | 101 | 567.312 | 158.93 | 96.91  | 0.83 | 1.01 | 0.86 | 0.55 | 0.85 |
| MEAN    | 59.95          | 66.54          | 63.25 | 72.31 | 101 | 540.60  | 159.78 | 88.42  | 0.83 | 1.02 | 0.86 | 0.54 | 0.84 |
| SD      |                |                |       |       |     |         |        |        | 0.03 | 0.02 | 0.06 | 0.08 | 0.05 |
| GROUP 3 |                |                |       |       |     |         |        |        |      |      |      |      |      |
| 1       | 58.61          | 68.49          | 63.55 | 72.59 | 101 | 581.99  | 174.15 | 86.10  | 0.85 | 1.03 | 0.85 | 0.55 | 0.83 |
| 2       | 63.81          | 70.47          | 67.14 | 75.64 | 101 | 688.94  | 196.62 | 90.01  | 0.87 | 1.02 | 0.84 | 0.58 | 0.83 |
| 3       | 62.73          | 70.97          | 66.85 | 75.40 | 101 | 647.27  | 177.78 | 96.86  | 0.85 | 1.01 | 0.85 | 0.58 | 0.84 |
| 4       | 57.24          | 66.05          | 61.65 | 70.95 | 101 | 601.44  | 198.80 | 89.46  | 0.85 | 1.02 | 0.81 | 0.52 | 0.79 |
| 5       | 59.70          | 68.11          | 63.91 | 72.89 | 101 | 691.72  | 206.77 | 104.68 | 0.85 | 0.99 | 0.80 | 0.55 | 0.81 |
| 6       | 62.79          | 71.82          | 67.31 | 75.78 | 101 | 651.44  | 212.57 | 83.21  | 0.87 | 1.03 | 0.82 | 0.55 | 0.80 |
| MEAN    | 60.81          | 69.32          | 65.07 | 73.88 | 101 | 643.80  | 194.45 | 91.72  | 0.86 | 1.01 | 0.83 | 0.55 | 0.82 |
| SD      |                |                |       |       |     |         |        |        | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 |
| GROUP 4 |                |                |       |       |     |         |        |        |      |      |      |      |      |
| 1       | 55.74          | 66.27          | 61.01 | 70.40 | 101 | 596.75  | 193.72 | 115.09 | 0.81 | 0.98 | 0.77 | 0.48 | 0.79 |
| 2       | 57.24          | 69.14          | 63.19 | 72.28 | 101 | 669.00  | 203.87 | 110.58 | 0.83 | 0.99 | 0.79 | 0.53 | 0.80 |
| 3       | 64.17          | 69.86          | 67.02 | 75.54 | 101 | 592.73  | 189.37 | 116.39 | 0.80 | 0.97 | 0.78 | 0.48 | 0.80 |
| 4       | 62.15          | 73.61          | 67.88 | 76.27 | 101 | 636.89  | 171.98 | 86.41  | 0.86 | 1.02 | 0.87 | 0.59 | 0.85 |
| 5       | 59.37          | 70.49          | 64.93 | 73.77 | 101 | 660.97  | 196.62 | 87.95  | 0.87 | 1.02 | 0.83 | 0.57 | 0.82 |
| 6       | 57.79          | 69.91          | 63.85 | 72.85 | 101 | 664.99  | 184.30 | 94.44  | 0.86 | 1.01 | 0.84 | 0.58 | 0.83 |
| MEAN    | 59.41          | 69.88          | 64.65 | 73.52 | 101 | 636.89  | 189.98 | 101.81 | 0.84 | 1.00 | 0.81 | 0.54 | 0.82 |
| SD      |                |                |       |       |     |         |        |        | 0.03 | 0.02 | 0.04 | 0.05 | 0.02 |

W<sub>0</sub> = weight of rats at start of balance experimentW<sub>s</sub> = weight of rats at end of balance experimentdW =  $\frac{W_0 + W_s}{2}$

**Appendix 4 (Elaborate procedures):****Reagent preparations:****1. Sodium salicylate solution**

85g sodium salicylate ( $C_7H_5NaO_3$ ) are dissolved in 850 ml distilled water and 0.6g sodium nitroprusside ( $Na_2Fe(CN)_5NO \cdot 2H_2O$ ) and 3g NaOH (for urine and faeces). Dilute to 1000 ml with distilled water.

**2. Sodium cyanurate**

24g NaOH was dissolved in 900 ml distilled water, cooled and 5g cyanurate added and diluted to 1000 ml with distilled water.

**3. Derivatization reagent**

350  $\mu$ l methanol, 50  $\mu$ l HPLC grade water, 50  $\mu$ l triethylamine and phenylisothiocyanate (PITC) were mixed.

**4. Internal standard (5 mM DL-Norleucine)**

0.1312g DL-norleucine was added to 4 ml 6 N HCL. This was diluted to 200 ml with newly prepared distilled water.

**5. Redrying solution**

200  $\mu$ l methanol, 200  $\mu$ l 0.2N sodium acetate and 100 $\mu$ l trimethylamine were mixed.

**Fat determination:**

About 5 grams of the dried sample were weighed in a bottle with tight fitting cork and 30 ml ethyl acetate added. The samples were shaken at full frequency for five minutes and then reduced to 6 for an hour. The samples were allowed to stand over night and then filtered using filter paper 595.5. Ten ml of the filtrate was pipetted into a weighed pyrex petri dish, and allowed to stand in the fume chamber for an hour to

evaporate the ethyl acetate. Thereafter the dish was placed in an oven between 80°C and 90°C overnight. The dish was removed the next day, allowed to cool and weighed.

**Ash determination:**

After fat determination the rest of the sample in the filter paper was washed two times with 20 ml ethyl acetate and left to dry in the fume chamber overnight. From this sample about 0.5g was weighed into a petri dish and placed in a furnace oven at 200°C. The temperature was increased by 100°C every 2 hours till the temperature got to 550°C. The sample was kept at this temperature overnight. The oven was switched off while the sample stayed in it to cool till the next day when it was taken and weighed.

**Amino acids:**

About 17 mg protein were weighed, 3ml 5mM DL-norleucine (as internal standard) and 60ml 6N HCl added. The mixture was cooked in a pressure cooker and placed in an oven at 110°C for 20 hours to hydrolyse. The cooled sample was diluted to 100ml with freshly prepared distilled water. Freshly prepared distilled water was used through out to eliminate interferences. Ten ml was then pipetted in a round bottomed flask and evaporated to dryness on a rotary evaporator at 60°C, dissolved with 3ml 0.1N HCl and filtered using millipore HA 0.45m filter paper. Twenty  $\mu$ l of the filtrate was carefully pipetted into 6 x 50 mm tubes and placed into drying vessels and dried in a work station with the vacuum gauge

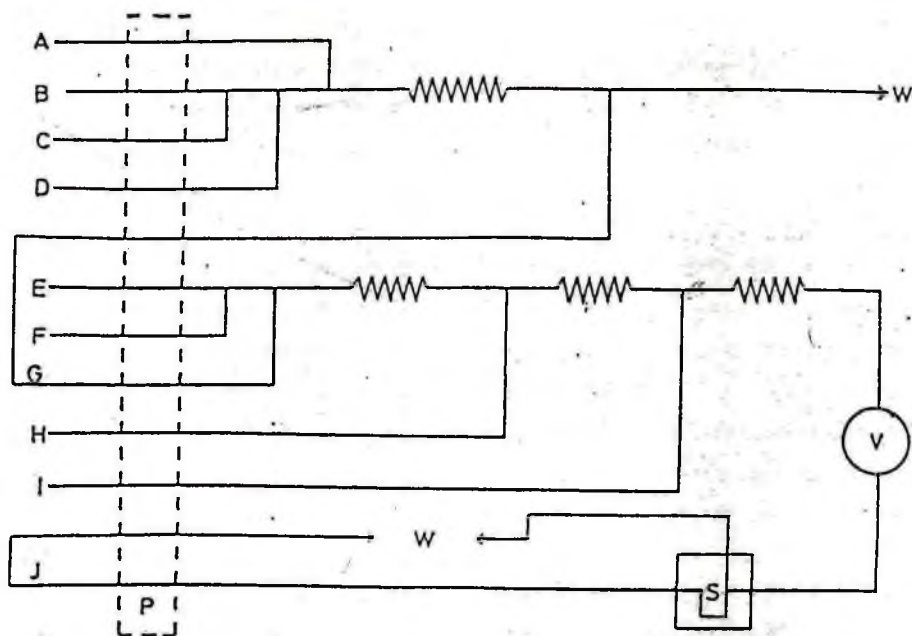
reading less than 50 millitorr. Drying was completed in 10-15 minutes. The tubes were removed, 30  $\mu$ l of redrying solution added and mixed thoroughly on a vortex. Tubes were dried again in the work station. Thirty  $\mu$ l freshly prepared derivatization reagent was added to the tubes, vortexed, capped and allowed to react for 20 minutes. The tubes were dried again in the work station for 15 minutes, removed and 30  $\mu$ l of HPLC grade methanol added and vortexed to resuspend the solution. Drying was resumed until the vacuum gauge read less than 70 millitorr. The total time was about one hour. Two hundred  $\mu$ l of the sample diluent was added to the tubes, vortexed and transferred into injection vials. Twenty  $\mu$ l were injected. Standards were prepared by mixing 5 ml standard (1.25 mM of each amino acid) with 5 ml internal standard. The standards were handled as outlined in the first paragraph. The amino acid contents of the samples were calculated in relation to the standards.

**Protein Determination:**

About 0.2g sample were weighed into 75ml digestion tubes. Three ml concentrated sulphuric acid was added for 40 minutes till the temperature was 200°C. One tablet of Kjeldahl catalyst (contains 1.5 g  $K_2SO_4$  and 7.5 mg Se; increases the boiling point of  $H_2SO_4$  and acts as catalyst respectively) was added and the temperature set at 380°C. The tubes were covered with sucking tubes connected to an alkaline (NaOH) bath which aided in the removal and neutralization of the acidic steam. It was heated for 2 hours at this temperature,

the heat was turned off and then left to cool down for an hour. The tube was taken from the source of heat, placed in the fume chamber and allowed to cool for further 25 minutes. Thereafter, it was diluted to 75 ml with distilled water and allowed to stand overnight to precipitate any other solids. Standard casein was used as a control. The digested sample was mixed with sodium salicylate and sodium cyanurate (p. 128) in a manifold with water and 1% Brij-solution as diluting liquid (Appendix fig.1). Brij lowers the surface tension in the manifolds.

With the help of the technicon auto analyzer, the nitrogen content of the samples were taken. The complex colour was developed in a water bath at 37°C. Base line was drawn using all the reagents. Standards of concentrations between 7.0 and 70.0  $\mu\text{g}$  nitrogen per ml were run before and after the samples. The manifolds were washed with water and brij for 50 seconds after each sample. A driving chart attached drew out the absorption. The nitrogen contents in the samples were determined from a linear regression line based on 8 standards and multiplying the result by 6.25 to obtain the protein content.



| Material     | Tube colour   | Flow rate<br>ml/min. |
|--------------|---------------|----------------------|
| A Sample     | orange/yellow | 0.16                 |
| B Brij       | purple/purple | 2.50                 |
| C            |               |                      |
| D Air        | red/red       | 0.80                 |
| E Brij       | purple/purple | 2.50                 |
| F Air        | yellow/yellow | 1.20                 |
| G Resample   | black/black   | 0.32                 |
| H Salicylate | red/red       | 0.80                 |
| I Cyanurate  | orange/orange | 0.42                 |
| J Waste      | white/white   | 0.60                 |

P = Peristaltic pump

S = Spectrophotometer

V = Water bath at 37°C

W = Waste

**APPENDIX 5:**Essential amino acids provisional pattern (FAO,1985)

| <u>mg amino acid per g protein</u> |                                             |                                         |              |
|------------------------------------|---------------------------------------------|-----------------------------------------|--------------|
| <u>Amino acid</u>                  | <u>Preschool child</u><br><u>(2 - 5yrs)</u> | <u>*Children</u><br><u>(10 - 12yrs)</u> | <u>Adult</u> |
| Ile                                | 28                                          | 28                                      | 13           |
| Leu                                | 66                                          | 44                                      | 19           |
| Lys                                | 58                                          | 44                                      | 16           |
| Phe + Tyr                          | 63                                          | 22                                      | 19           |
| Met + cys                          | 25                                          | 22                                      | 17           |
| Thr                                | 34                                          | 28                                      | 9            |
| Trp                                | 11                                          | 9                                       | 5            |
| Val                                | 35                                          | 25                                      | 13           |
| *His                               | 19                                          | 19                                      | 16           |

\*Suggested patterns of amino acid requirements. FAO/WHO (1984)