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Some Anthropometric, Biochemical and Haematogical Studies of Rats Fed on Different Composite Diets Prepared from Maize, Groundnut and Soybean

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Abstract: The effect of oral administration of two different composite diets prepared from maize, groundnut and soybean on some anthropometric, haematological and biochemical indices of albino rats was investigated. In this study, the material balance method under steady state conditions was employed to prepare a composite diet of one part of groundnut to eight parts of soybean to sixteen parts of maize. Ninety rats divided into three groups (A, B and C) of thirty rats each were used. Group A was placed on maize diet alone (diet 3) which serves as control, whereas groups B and C were placed on the composite diets (diets 1and 2) containing soybean flours ('Anidaso' and 'Salintuya') respectively with groundnut cake and fermented maize. The length, weight, total protein, serum albumin, haemoglobin and white blood cell were measured at week zero (0) and every two (2) weeks for 10 weeks. The results revealed that rats fed on the composite diets had normal growth (Length: 35-40 cm; Weight: 190-230 g), acceptable biochemical (Total Protein: 75-80 g L^{-1}; Serum albumin: 45-50 g L^{-1}) and haematological (Haemoglobin: 12.5-14.0 g dL^{-1}; White blood cell: $6.0\text{-}6.5\times10^9$ L^{-1}) indices, whereas the control rats showed the reverse (Length: 35-37 cm; Weight: 180-185 g; Total Protein: 65-72 g L^{-1}; Serum albumin: 35-43 g L^{-1}, Haemoglobin: 10.5-12.0 g dL^{-1}; White blood cell: $7.0\text{-}8.0\times10^9$ L^{-1}) with $p< 0.5$. The composite diets can therefore be used as a weaning food to improve the nutritional and health status of growing infants in Ghana.

Key words: Soybean, anthropometry, haemoglobin, fermented maize

INTRODUCTION

Research has shown that most of the weaning foods consumed in communities of developing countries are deficient in essential nutrients (FAO/WHO, 1998). Several strategies have been employed to improve the nutritive value of these weaning foods in those countries (Gopaldas *et al*., 1998). However, the necessary impart has still not been realized. As a result malnutrition has become one of the major health problems facing children of developing countries. Throughout the developing world, malnutrition affects almost 800 million people which is 20% of the world population (WHO, 2000). The high price of proprietary weaning foods, vegetables, animal proteins and non-availability of low-priced nutritious foods, combined with bad feeding practices and late introduction of

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supplementary foods are mostly responsible for aggravating the under nourished condition of children (Dutra-de-Oliveira,1991). Good nutrition particularly during infancy can promote adequate physical and mental development leading to good health (Berggren, 1982). According to Wardlaw (2000), an infant typically increase in length by 50% in the first year and such rapid growth requires nourishment. When an infant is inadequately fed there is the risk of stunted growth and a range of biochemical changes that can impair development to a larger extent. During the first four to six months of life, all nutrient required by an infant can be provided by breast milk and so there is no dietary need for the introduction of solid food before then (Trussel, 2003). By the age of 6 months, most infant need additional foods, the purpose of which is to complement the breast milk and make available certain nutrients that the young child would need to grow normally (Bradley *et al.*, 1987). This goal is only achieved when these foods are prepared and fed to the infants under hygienic conditions and given in adequate proportions (Akaninwor and Okechukwu, 2004). Soybeans, groundnuts and maize are readily available local crops that can complement each other to meet the recommended daily food allowance for growing infants because of its nutritional composition. Soybeans have recently become popular in the West African sub-region due to their high protein content and quality and are being cultivated at a steadily increasing rate. Its protein content (40%) is higher and more economical than that of beef (18%), chicken (20%), fish (18%) and groundnut (23%), (IITA, 1990). Apart from proteins, soya beans also contain carbohydrate (32%), fat (20%), minerals/vitamins (5%) and fiber (3%), (Lovati *et al.*, 2000). Groundnut has adequately high concentrations of proteins, carbohydrates, fibres, fats, vitamins and essential minerals. The maize grain is also composed mainly of carbohydrates but it also has appreciable amount of minerals, vitamins and amino acid especially methionine (Matz, 1991). The high lysine content of legumes improves the nutritional quality of cereals by complementing its limiting sulphur containing amino acids (Bressani and Ellias, 1966). Even though soybeans and groundnut contain anti-nutritional compounds including trypsin inhibitors, haemgglutinnins, goitrogens, saponins and phytic acid, all these nutritive factors are destroyed or reduced to minimum through traditional cooking and processing techniques such as soaking in water and roasting (Ologhobo and Fetuga, 1984). It is against this background that the study looked at improving the traditional African weaning foods by combining locally available crops that can meet the nutritional needs of the growing infants in developing countries. The study was therefore undertaken to evaluate the anthropometric characteristics, biochemical and haematological indices of albino rats fed on composite diets prepared from these crops.

MATERIALS AND METHODS

Source of Material

In may 2007 two varieties of soybeans, Glycine Max (Salintuya and Anidaso), maize (‘Obaatampa’) and groundnut (Chinese) were obtained from Grains and Legumes Development Board at Abuakwa a suburb of Kumasi, Ghana. Appropriate technology was employed to prepare the groundnut cake, soybean grit and fermented maize flour. A mixture of one part of groundnut to eight parts of soybean to sixteen parts of maize were used to formulate the composite diets by employing the material balance method under steady state conditions so that the blended flour will meet the standard set by the Protein Advisory Group (PAG, 1971).

Animal Studies

Ninety albino rats aged 4 weeks with average weight of 175 g were obtained from the animal house of Faculty of Pharmacy, KNUST, Kumasi-Ghana. The rats were acclimatized on 75 g of their own commercial pellets for 4 weeks and this was followed by another 2 weeks of starvation on 25 g of the same diet before treatment. The rats were randomly assigned to three groups (A, B and C) of thirty rats per group. Each group contains six cages of five rats per cage. The cages were numbered from 1 to 6 in each group. Group A, B and C were fed on the diet 1 (Fermented maize flour), diet 2 (Fermented maize flour, groundnut and blanch soybean-'Anidaso') and diet 3 (Fermented maize flour, groundnut and blanch soybean (Salintuya 1) respectively. The rats in the first cage in each group was sacrificed for the baseline determination of the anthropometric (length and weight), biochemical (total protein and serum albumin) and haematological (haemoglobin and white blood count) measurements. After that the rats in the other cages were daily fed on 75 g of the different diets. The rats in the second to the sixth cage in each group were respectively sacrificed at every two weeks for similar determinations.

Anthropometric Measurements

The length (cm) and weight (g) of the rats were measurement using the rotring metre rule and weighing balance (Salter electronic scale, model 1036 BKDR), respectively.

Blood Analysis

Blood samples were collected from rats by jugular incision into EDTA bottles and Serum containers. Auto analyzer was used to measure the blood indices: Haemoglobin (Hb), White Blood Count (WBC), Total protein and Serum Albumin, according to the details reported in Cheesebrough (2000). All samples were analyzed at the Clinical Analysis Laboratory of Biochemistry Department, KNUST, Kumasi-Ghana.

Statistical Analysis

Experimental data was analyzed using one-way Analysis of Variance (ANOVA) and Duncan's multiple range tests to determine significant difference between means. The SPSS software version 10 was used for this analysis. A p-value less than 0.05 was considered statistically significant.

RESULTS

Anthropometric, Biochemical and Haematological Indices

All the values of the anthropometric and blood parameters among the rats under study fell within the reference range (Length -30-40 cm, Weight -180-250 g, Total protein -60-80 g L^{-1}, Serum albumin -30-55 g L^{-1}, Haemoglobin -12.5-18.0 g dL^{-1} and White blood cell -4.0-10.0 x10^9 L^{-1}) after the first two weeks except the Haemoglobin (10.5-12.0 g dL^{-1}) of the control rats (Cheesebrough, 2000). The test rats (Diet 1: 10.1%; Diet 2: 33.5%) significantly gained weight ($p<0.5$) more than that of the control rats (Diet 3: 8.3%) as shown in Fig. 1. In the length, there was a similar trend in which the gain in length was also significantly greater in the test rats (Diet 1: 9.0%; Diet 2: 13.5%) as compared to the control rats (Diet 3: 9.0%) (Fig. 2). The total protein content in rats fed on diets 1 and 2 increased steadily from approximately 75.0 to 80.0 g L^{-1} after two weeks as compared to the other rats fed on diet 3 which decreased sharply from approximately 72.0 to 65.0 g L^{-1} over the same period of time (Fig. 3). Similarly, the serum albumin in rats fed on diets 1 and 2 increased from

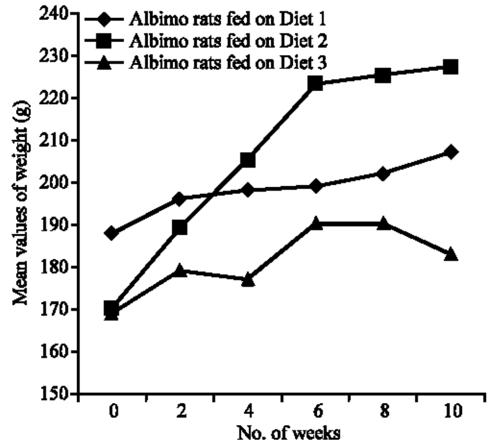

Fig. 1: The trend in weight measurements of albino rats over a period of time

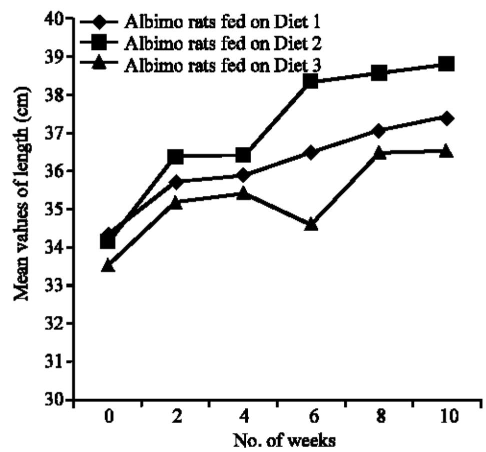

Fig. 2: The trend in length measurements of albino rats over a period of time

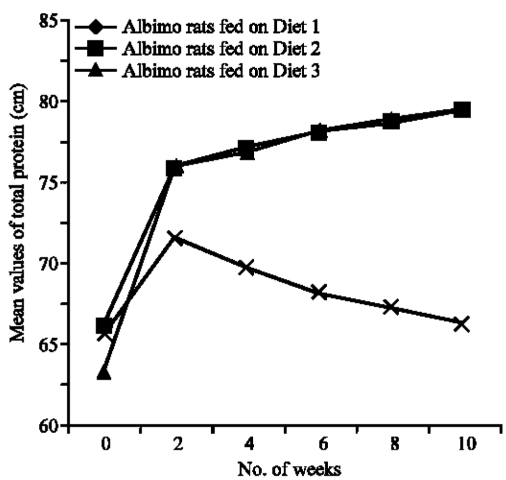

Fig. 3: The trend in total protein measurement of albino rats over a period of time

approximately 45.0 to 50.0 g L^{-1} after two weeks, whereas that of the other rats fed on diet 3 decreased from approximately 43 to 35 g L^{-1} over the same time (Fig. 4). Also, the haemoglobin increased from approximately 12.5 to 14.0 g dL^{-1} for rats fed on diets 1 and 2, whereas that of the other rats fed on diet 3 decreased from approximately 12.0 g dL^{-1} to 11.0 after the same period of time (Fig. 6). However, the WBC values for the control diet 3 increased from approximately 7.0 to 8.0 $\times 10^9$ L^{-1} after two weeks, whereas that of the composite diets (6.3 to 6.5$\times 10^9$ L^{-1}) remained almost independent of the time after the same time (Fig. 5).

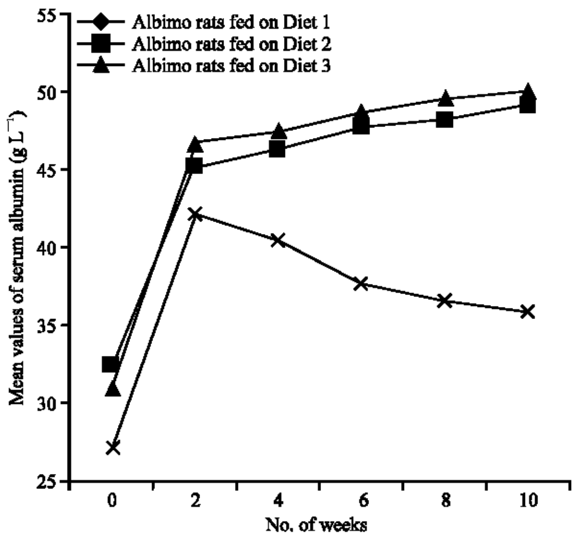

Fig. 4: The trend in serum albumin measurement of albino rats over a period of time

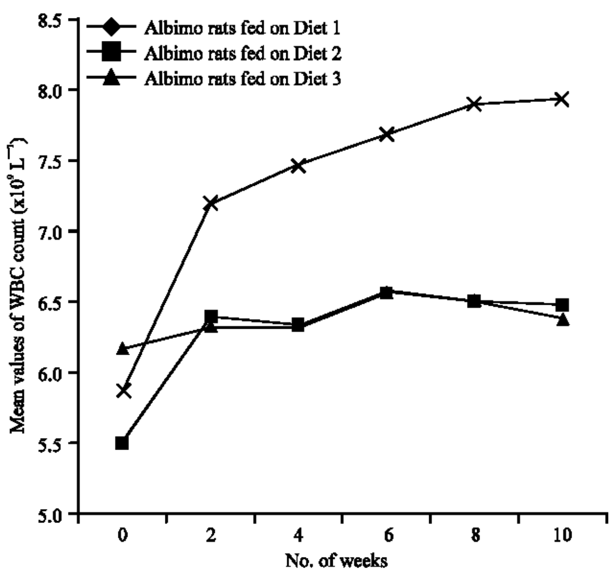

Fig. 5: The trend in white cell count measurement of albino rats over a period of time

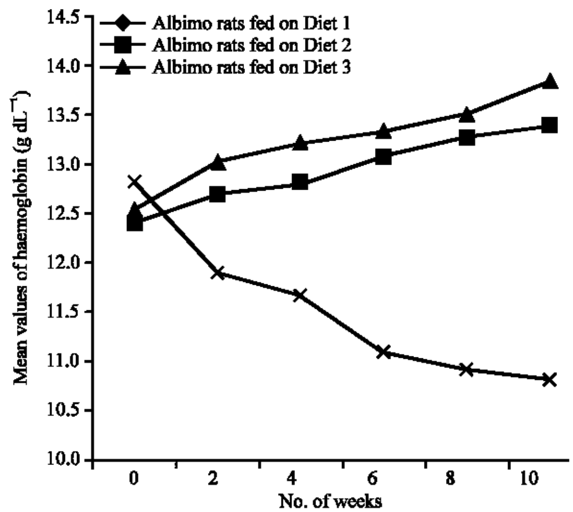

Fig. 6: The trend in haemoglobin measurements of albino rats over a period of time

DISCUSSION

The effect of the composite diets on the growth of the rats in terms of weight gain was very prominent in the animal model. Thus diet 1 and diet 2 had remarkable effect on the growth of the rats as compared to those on diet 3 which had irregular growth. This information indicates that the composite diet can maintain normal growth, but the control diet lacked the necessary amino acid for the body. Cereals are deficient in lysine but have sufficient sulphur-containing amino acids that are limiting in legumes. Therefore, the combination of cereals and legumes was able to produce amino acid compositions that adequately promote normal growth. These results support the fact that traditional West African weaning foods could be improved by combining locally available foods that complement each other in such a way that new pattern of amino acids created by such combination is similar to that recommended for infants (Fashakin and Ogunsola, 1982). The composite diets therefore contain enough essential amino acids which were able to support the production of complete protein to sustain growth and development. Even though the range of values for the total protein and serum albumin fell within the recommended range as reported by Cheesebrough (2000), it is envisaged that beyond the study period of ten weeks the biochemical indices of the control rats could go below the accepted range. It is important for protein-containing foods to maintain normal circulation of total protein and serum albumin in animals. These results were also consistent with the report of Bolarinwa *et al.* (1991), in which there was a significant reduction in the levels of total protein in protein-calorie malnourished rats. Similarly, Hegsted (1968) and Laditan (1976) had earlier on drawn a correlation between total protein levels and severity of protein energy malnutrition. The protein content of soybean and groundnut in the composite diet was quite high and could be responsible for the normal levels of the indices. In fact, the protein content of soybean is considerably higher than that of meat, fish, egg and other diary products on the same weight basis (McArthur *et al*., 1988).

The observed Hb and WBC values could be attributed to the differences in the amount of protein present in the various diets. The composite diets contained the required amount of essential amino acids hence the test rats being able to increase their Hb levels. However, the control diet showed a sharp decrease in the Hb values because of absence of certain essential amino acids. These results were in line with other researchers in which several protein-rich foods had been shown to increase Hb concentrations in human and animal studies (Bolarinwa *et al*., 1991; Mitchell, 1966). In addition, animals fed on protein calorie malnourished diets had been reported to have significant reduction in haemoglobin concentrations (Bolarinwa *et al*., 1991). It is also well-documented that Kwashiorkor and marasmus (Protein Energy Malnutrition) patients had low levels of haematological indices (Mitchell, 1966; Adesola, 1968; Coward and Whitehead, 1972).The high level of Hb is an indication that the test rats were not anaemic, whereas the lower level was a sign of anaemic condition in the control rats (Cheesebrough, 2000). Anaemia impairs normal development in children and it constitutes a major public health problem in young children in the developing countries with wide social and economic implications (Montalemberk and Girot, 1996). This implies that growing infants that depend solely on cereals as food is likely to develop stunted growth. The steady increase in WBC counts with time for the control rats as against almost constant values for the test rats shows that beyond the tenth week study period, the control rats are more likely to become malnourished. This is because high WBC counts may indicate malnutrition (Cheesebrough, 2000). The protein-containing foods provide the immunological factors which are required to maintain the necessary protection for the animals. It must be noted that the soybean contains minerals and vitamins such as iron, zinc, copper, thiamine, riboflavin, niacin and patholenic acid (McArthur *et al*., 1988). Also, the groundnuts are useful sources of thiamine, niacin, vitamin and folic acid (Smart, 1994). Most of these minerals and vitamins are well-known haematinics and are essential in the formation of red blood cells (Mitchell, 1966; Ganong, 1993). The data gathered from this study shows that the composite diet prepared from maize, groundnut and soybean is safe, has stimulatory effect on both the haematological and biochemical indices and has the potential to enhance normal growth in terms of weight gain.

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