# PROTEIN QUALITY OF PROTEIN SUPPLEMENTED NIGERIAN FOODS

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# CHAPTER I

## INTRODUCTION

Protein-calorie malnutrition (PCM) is widespread among children in developing areas of the world, including various parts of Africa (Fuller et al. 1972). It is estimated that 74 percent of the calories in the Nigerian diet are derived from starchy roots such as cassava (Jansen and Howe, 1964). Animal protein supplements that might alleviate PCM in childhood are economically inaccessible and, consequently, the reported intake of animal foods is no more than 2 ounces per person (Maclean, 1966).

Statistics for 1975 from the Food and Agriculture Organization of the United Nations revealed that for low-income people in the developing countries, animal protein is either too expensive or is available only in limited quantities. Belden et al. (1964) investigated and reported that the bulk of the diet in the developing countries is composed of cereal grains and starchy foods. Rice, corn, and wheat, the common cereal grains, have protein content of 7-15 percent and even less, if they are milled. With such foods composing the bulk of the diet, it is easy to understand how people can have sufficient calorie intake and still be malnourished with respect to protein.

The addition, however, of small amounts of vegetable protein to these diets would have nutritional benefits far beyond the proportion of food added. These foods would also be available at a relatively lower cost than the animal protein. The malnourished individuals can afford to buy vegetable protein.

The following discussion of nutritive values and the problem of food supplementation, therefore, emphasizes the need to develop high protein, low cost foods to provide an efficient pattern of amino acids for protein synthesis.

The specific objective of this study was to determine the protein quality of three staple Nigerian foods: chin-chin, puff-puff and bean-ball (akara). The effects of supplementing each food with full-fat cottonseed flour, defatted cottonseed flour or defatted peanut flour on protein quality of the three Nigerian foods was investigated.

## CHAPTER II

## REVIEW OF LITERATURE

Malnutrition, the rapidly expanding population, and the deteriorating world food situation are major problems of crisis proportions in the world today. These problems demand high priority in national and international planning and in the related multiple aspects of public health. Goldsmith (1975) reported that in many of the developing countries, the most common form of malnutrition is protein-calorie deficiency in infants and young children. This inadequacy in the food supply is associated with mortality rate. The prevalence of protein-calorie malnutrition in children less than 5 years of age, between 1966 and 1969, was reported in 24 countries by the World Health Organization.

According to Belden et al. (1964), the existence of malnutrition, the number one public health problem today, is a paradoxical situation. The diets of many people lack protein, yet this essential nutrient is fairly abundant in some of the areas where it is needed. Unfortunately, those who are malnourished often do not know their nutrient needs, and even if they did, protein is not available in the form they would accept or could afford. Protein is present in various legumes, which are not eaten; and in oil-seed residues, such as soybean, cottonseed, or peanut meal, which are inefficiently used as animal feed or fertilizer.

Altschul (1967) also reported that a major low-cost source of protein is the oilseeds, particularly soybeans, cottonseed, and peanuts. Together, oilseeds have the potential of furnishing almost as much protein annually for man as that available from animal sources. An investigation by Bressani and Elias (1974) showed that the protein of leguminous seed is considered to be a rich source of lysine and that its major deficiency lies in the sulfur-containing amino acids. On the other hand, cereals have a low protein content, and are, in general, lysine deficient, but have adequate amounts of sulfur-containing amino acids. These chemicals and nutritive characteristics of legumes place them as natural complements to cereal or other starch-based diets.

Similarly, a tremendous amount of research has pointed out that the protein of oilseeds, such as soybeans, cottonseed and peanut can effectively be used to increase the quantity and upgrade the quality of protein in the diets. Eboh (1980) developed and supplemented three staple Nigerian foods (chin-chin, puff-puff and bean-ball) with soybean, cottonseed, sesame seeds, and peanut flours. She reported that the foods were given high acceptability ratings by both African and non-African taste panels.

Cottonseed and peanut flours contain protein of high nutritive value and offer an excellent means of supplying dietary protein to extend and partially replace protein foods of animal origin. Cottonseed protein concentrate has been demonstrated to be suitable for human consumption. Cottonseed protein has great virtue in that it comes from a plant that is indigenous to protein-poor tropical areas of Asia, Africa and Latin America.

Spadaro and Gardner (1979) reported that cottonseed, available in many countries located in both temperate and tropical climates, is rarely used as a source of edible protein, even though its use as a food was developed as early as 1876. Development of edible protein products from cottonseed has been impeded by the presence of pigment glands containing gossypol and by the importance placed on the economic value of the oil. With recent advances in breeding glandless cottonseed, processing glanded cottonseed (e.g. liquid cyclone process) and related technology, the potential of cottonseed protein for food uses has increased. Flour concentrates as well as their texturized counterparts are acceptable as functional and nutritive additives to meat products and for use in baked goods and cereal.

In the studies reported by Reber and Pyke (1980), and by Pyke (1977), glandless cottonseed kernel (20 percent) was added to laboratory chow (80 percent) and fed to rats to study the toxicity of this strain of cottonseed. The level of gossypol considered to be safe was not more than 450 parts per million (ppm). In the reproduction phase there were no differences between the rats fed the cottonseed diets and those fed the control diet. Growth of the offspring was similar for all groups as was the food consumption. The cottonseed kernels were not toxic to the rats, indicating that there was no detrimental effect from feeding glandless cottonseed kernels at the level of 20 percent in the diet (Fince, 1976).

In a study conducted by Castro, Yang and Harden (1976), young rats were fed an otherwise adequate but protein-free diet, or the same diet supplemented with 10 percent protein from casein, LCP cottonseed flour, soy isolate, triticale, wheat or rye. The average weight gain of the rats fed a 10 percent LCP cottonseed protein diet was significantly greater than that of the rats fed any other experimental diet. The protein efficiency ratios (PER) of casein and cottonseed were similar but were higher than those for all other diets. Jones and Divine (1944) supplemented white wheat flour with cottonseed flour and found that the addition of as little as 5 parts of cottonseed flour to 95 parts of wheat flour produced mixtures containing 16 to 19 percent more protein than the wheat flour alone. This protein combination was definitely superior in its growth-promoting value in rats than the same quantity of wheat flour.

In an evaluation of baked goods, Ridlehuber and Gardner (1974) replaced 3 percent wheat flour with Liquid Cyclone Process (LCP) flour which produced an excellent white bread, with only slight darkening of crumb color. In a cake doughnut, Ridlehuber and Gardner substituted LCP for up to 13 percent of the wheat flour. A desirable yellow color, comparable to an egg-rich product, was produced. In 1974, the Grain Processing Corporation conducted a similar study on the protein content of the LCP flour produced by the Southern Regional Research Center. The corporation reported that the nutritional quality of the flour was excellent and the protein efficiency ratio (PER) ranged from 2.51-2.67.

Marco (1977) used the PER procedure to evaluate the nutritional quality of cottonseed protein in various baked and heated products fed to rats. The PER values obtained indicated that there was a relationship between the protein intake and weight gain in the growing animals.

Peanut flour has been evaluated for use in a variety of food products as a replacement for animal protein. In breakfast cereals and snack foods, peanut flour blends well with cereal flours to yield products with excellent flavor, texture and color. In bakery products, peanut flour can be used at levels up to 20 percent to provide protein supplementation without the astringent flavor of other oilseed flours (Ayres and Davenport, 1977). Peanut flour contains lower levels of lysine and leucine than soy flour, however, due to the lack of beany flavor of the peanut, higher levels of the peanut flour can be used for fortification of lysine-deficient cereal flour (Ayres, Branscomb and Rogers, 1974).

The supplementary value of peanut and soybean flours to poor wheat and kaffir corn diets has been studied with albino rats (Narayanaswany et al. 1973). The poor wheat and kaffir corn diets were prepared at 10 and 20 percent levels to provide 1.5 and 3.0 percent extra protein in the diets. Highly significant increases in the growth rate and PER were observed. The improvement in the growth rate was of the same magnitude as that obtained with a supplement of skim milk powder. Rooney et al. (1972) and Khan et al. (1975) found that acceptable bread could be obtained when up to 20 percent of the wheat flour was replaced by peanut flour. When comparing peanut flours obtained by solvent extraction and aqueous processed peanut protein with full-fat soy flour, Khan et al. found loaf volumes, flavor and texture of peanut flours to be superior to full fat soy breads containing comparable protein levels.

Webb et al. (1964) studied a clinical trial of two protein blends developed by Subrahmanyan and associates containing peanut protein isolates combined with either dry skimmed milk or lysine, methionine and casein. These blends were compared to skimmed milk in the treatment of severe kwashiorkor. The clinical response was satisfactory in all groups of children. There was no significant difference in the number of days needed for edema to disappear, for achievement of minimum body weight or for gain in weight per gram of nitrogen ingested. Diarrhea persisted a little longer in children fed skimmed milk than in those given the experimental blends. There was no significant difference in the rate of regeneration of serum-proteins or in the levels of hemoglobin in the children receiving either the blends or the skimmed milk.

The concept of PER was introduced in 1919 by Osborne, Mendel and Ferry. The PER was defined as the ratio of the weight gained to the weight of protein consumed by a group of ten weanling rats fed a diet containing about 10 percent protein over a 28 day period. Since that time the technique of evaluating the protein quality of foodstuff has been comprehensively reviewed, tested and criticized (Hurt, Forsythe and Krieger, 1975; and McLaughan, 1972). In spite of the numerous shortcomings of the method, the PER assay remains the method of choice for evaluating the protein quality of foods (Schmidt, 1973).

Staub (1978) has suggested that the PER method can be used for simple protein sources; mixtures, both simple and fabricated; and complex sources. High moisture, high fat diets stretch the PER assay to its limits. According to Staub (1978), two cooked bacon samples containing 25 percent fat and 10 percent moisture were studied several years apart. The investigator was unable to determine the PER due to the high fat content of the bacon. Hurt, Forsythe and Krieger (1975) studied the effect of level of dietary fat on food consumption, weight gain, and PER of casein and beef-vegetable products. They reported that food consumption, weight gain, and efficiency of food utilization for the rats fed casein reference diet and test material were significantly influenced by the amount of fat contained in the diets. Weight gain was inversely related to the fat content of the diet. This trend was noted for the rats fed both the casein and test diets.

The purpose of this study was to evaluate, by the use of animal studies and laboratory analyses, the protein quality of three staple Nigerian foods supplemented with cottonseed and peanut flours.

# CHAPTER III

## MATERIALS AND METHOD

The bioassay procedures outlined by the Association of Official Agricultural Chemists, AOAC (1975), for biological evaluation of protein quality were followed, unless otherwise stated. Weanling male, Holtzman rats were purchased from Holtzman Company, Madison, Wisconsin. The initial weights were recorded and the rats were subjected to a 2-day acclimation period. The rats were housed in individual galvanized steel cages (size 7 in. x 9½ in. x 7 in.) with open wire floors suspended over slide-out trays. The room temperature was set at $22 \pm 2^{\circ}C$. The lighting was adjusted to make available a period of 12 hours of light and 12 hours darkness for each 24 hour period.

This study was conducted at two different periods of time. The first study evaluated chin-chin products. The experimental animals for the chin-chin diets included 70 male Holtzman rats, 21-24 days of age weighing 55g to 60g. The rats were randomly assigned to 7 groups (Table 1) in such a manner that the weight range did not exceed 5 grams. The second study evaluated puff-puff and bean-ball products. The experimental animals for the puff-puff and

TABLE 1

DIETARY TREATMENT OF EACH PROTEIN QUALITY EVALUATION GROUP FOR CHIN-CHIN DIETS

| Group* | Protein Source of the Diet** |
|---|---|
| I | 100% wheat flour |
| II | 70% wheat flour/30% FFCS |
| III | 70% wheat flour/30% DFCS |
| IV | 70% wheat flour/30% DFPN |
| V | ANRC casein; 8% fat |
| VI | ANRC casein; 18.5% fat |
| VII | ANRC casein; 32.7% fat |

*Ten rats per group

**Abbreviations for types of flour are as follows: "FFCS"--full-fat cottonseed, "DFCS"--defatted cottonseed, "DFPN"--defatted peanut.

bean-ball diets included 110 male Holtzman rats, 21-24 days of age, weighing 50g to 55g. The rats were randomly assigned to 11 groups (Table 2) in such a manner as to balance the total weight of each group. The range of mean weights for both groups did not exceed 2 grams. Water and diets were provided to each group of animals ad libitum.

The recognized procedure by AOAC (1975) was used to determine the PER. This method, expressing growth promoting values of protein numerically, was developed by Osborne, Mendel and Ferry (1919). At the end of the assay period, weight gain and protein consumption were calculated for each rat. The PER was calculated by dividing the weight gained (g) by the protein consumed (g) for each rat. The means were then calculated for each protein group. Data obtained from the test groups were corrected by multiplying the PER for each group by the following fraction (Bodwell, 1977).

$$\frac{2.5}{\text{PER of reference ANRC casein}}$$

Blood urea nitrogen levels were measured according to the Annino and Giese (1976) procedure. At the end of the study, the rats were anesthetized with ether in a dessicator and blood samples were drawn through a heart puncture with a 3 millimeter syringe. The blood samples were collected

TABLE 2

DIETARY TREATMENT OF EACH PROTEIN QUALITY EVALUATION GROUP FOR PUFF-PUFF AND BEAN-BALL DIETS

| Group* | Protein Source of the Diet** |
|---|---|
| Puff-puff diets | |
| I | 100% wheat flour |
| II | 70% wheat flour/30% FFCS |
| III | 70% wheat flour/30% DFCS |
| IV | 70% wheat flour/30% DFPN |
| V | ANRC casein; 8% fat |
| VI | ANRC casein; 25% fat |
| Bean-ball diets | |
| VIII | 100% cowpeas |
| IX | 75% cowpeas/25% FFCS |
| X | 75% cowpeas/25% DFCS |
| XI | 75% cowpeas/25% DFPN |

*Ten rats per group

**Abbreviations for types of flour are as follows: "FFCS"--full-fat cottonseed, "DFCS"--defatted cottonseed, "DFPN"--defatted peanut.

for each rat in a vacuum test tube containing sodium heparin to prevent coagulation.

The 3 staple Nigerian foods--chin-chin, puff-puff and bean-ball--were prepared according to the recipes (Appendix A) reported by Eboh (1980). The staple foods were prepared, dried at 65°C in the oven (Blue M model or -18C -52348 -150) for 24 hours. The foods were ground in a Blakeslee mixer, model B-20. Samples of each food were taken for proximate analysis (Appendix B) and the remaining foods were stored in the freezer (-15°C).

The assay diets were calculated as shown in Table 3. The diets were prepared as presented in Tables 4 and 5. Samples of each diet were analyzed for nitrogen content (Appendix B). Due to the high moisture content, as determined by proximate analysis (Appendix B), the products of puff-puff (full-fat cottonseed and defatted cottonseed) and bean-balls (cowpeas, full-fat cottonseed, defatted cottonseed and defatted peanut), were re-dried separately in the oven at 65°C for 24 hours and re-analyzed for moisture content. The analyses of the foods were adjusted for moisture content before the diets were prepared.

TABLE 3

COMPOSITION OF DIETS[a]

| Ingredients | |
|---|---|
| Protein source[b] | $S^c = \frac{1.60 \times 100}{\%\ \text{nitrogen of sample}}$ |
| Corn oil[d] | $8 - \frac{S \times \%\ \text{ether extract}}{100}$ |
| Salt mixture[e] | $5 - \frac{S \times \%\ \text{ash}}{100}$ |
| Vitamin mixture[f] | 1.00 |
| Cellulose[g] | $1 - \frac{S \times \%\ \text{crude fiber}}{100}$ |
| Water | $5 - \frac{S \times \%\ \text{moisture}}{100}$ |
| Corn-starch to make[i] | 100.00 |

[a]Calculated according to procedure given by the Association of Official Analytical Chemists (1975)

[b]Animal Nutrition Research Council (ANRC) casein; U.S. Biochemical Corporation, Inc.; or chin-chin or puff-puff or bean-balls.

[c]Sample; percentage figure refers to sample itself.

[d]Mazola corn oil

[e]AIN-76 mineral mixture, U.S. Biochemical Corporation, Inc.

[f]AIN-76 vitamin mixture, U.S. Biochemical Corporation, Inc.

[g]Celufin, U.S. Biochemical Corporation, Inc.

[i]Corn-starch, U.S. Biochemical Corporation, Inc.

TABLE 4

CALCULATED COMPOSITION (g) OF THE CHIN-CHIN DIETS

| COMPOSITION | Casein Control Diets | | | Flour Sources for Chin-Chin Diets* | | | |
|---|---|---|---|---|---|---|---|
| | V | VI | VII | 100% Wheat | 70% Wheat 30% FFCS | 70% Wheat 30% DFCS | 70% Wheat 30% DFPN |
| Protein source | 10.00 | 10.00 | 10.00 | 103.09 | 74.07 | 61.72 | 57.47 |
| Moisture | 5.00 | 5.00 | 5.00 | 0.00 | 4.48 | 4.20 | 3.56 |
| Corn oil | 8.00 | 18.50 | 32.70 | 0.00 | 3.00 | 0.00 | 1.84 |
| Salt mixture | 5.00 | 5.00 | 5.00 | 4.17 | 3.38 | 3.58 | 4.02 |
| Crude fiber | 1.00 | 1.00 | 1.00 | 0.69 | 0.56 | 0.38 | 0.54 |
| Vitamin mixture | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Corn starch | 70.00 | 59.50 | 45.30 | 0.00 | 13.51 | 29.12 | 31.57 |
| Total fat | 8.00 | 18.50 | 32.70 | 32.70 | 29.70 | 18.50 | 16.67 |

*Abbreviations for types of flour are as follows: "FFCS"--full-fat cottonseed, "DFCS"--defatted cottonseed, "DFPN"--defatted peanut.

TABLE 5

CALCULATED COMPOSITION (g) OF PUFF-PUFF AND BEAN-BALL DIETS

| | Casein Control Diets | | | Flour Sources for Puff-Puff Diets* | | | |
|---|---|---|---|---|---|---|---|
| COMPOSITION | V | VI | VII | 100% Wheat | 70% Wheat 30% FFCS | 70% Wheat 30% DFCS | 70% Wheat 30% DFPN |
| Protein | 10.00 | 10.00 | 10.00 | 75.19 | 60.97 | 55.93 | 55.24 |
| Moisture | 5.00 | 5.00 | 5.00 | 1.02 | 2.93 | 2.54 | 2.24 |
| Corn oil | 8.00 | 18.00 | 25.00 | 3.20 | 0.37 | 1.62 | 0.27 |
| Salt mixture | 5.00 | 5.00 | 5.00 | 4.03 | 3.84 | 3.70 | 3.68 |
| Crude fiber | 1.00 | 1.00 | 1.00 | 0.70 | 0.41 | 0.01 | 0.12 |
| Vitamin mixture | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Corn starch | 70.00 | 60.00 | 53.00 | 14.86 | 30.48 | 35.20 | 37.45 |
| Total fat | 8.00 | 18.00 | 25.00 | 21.80 | 24.63 | 16.38 | 17.73 |

TABLE 5--Continued

| COMPOSITION | Flour Sources for Bean-Ball Diets* | | | |
|---|---|---|---|---|
| | 100% cowpeas | 75% cowpeas 25% FFCS | 75% cowpeas 25% DFCS | 75% cowpeas 25% DFPN |
| Protein | 49.36 | 47.17 | 42.95 | 40.21 |
| Moisture | 3.67 | 4.06 | 3.63 | 3.91 |
| Corn oil | 6.05 | 1.04 | 4.65 | 6.52 |
| Salt mixture | 2.99 | 3.22 | 3.30 | 3.13 |
| Crude fiber | 0.06 | 0.01 | 0.02 | -0.33 |
| Vitamin mixture | 1.00 | 1.00 | 1.00 | 1.00 |
| Corn starch | 36.87 | 43.50 | 44.45 | 45.23 |
| Total fat | 11.95 | 16.96 | 13.35 | 11.48 |

*Abbreviations for types of flour are as follows: "FFCS"--full-fat cottonseed, "DFCS"--defatted cottonseed, "DFPN"--defatted peanut.

# CHAPTER IV

## RESULTS AND DISCUSSION

The objective of this study was to evaluate the protein quality of 3 staple Nigerian foods--chin-chin, puff-puff and bean-balls. Each food was supplemented with full-fat cottonseed (FFCS), defatted cottonseed (DFCS) or defatted peanut flours (DFPN).

The percentage protein and fat composition of the total solids of the foods before and after frying is shown in Table 6. Following frying the percentage fat increased and the percentage protein decreased in all the products, resulting in a decrease in nutritive value. These data exemplify the problems encountered with high fat products.

The official AOAC (1975) procedure for the determination of protein quality states that the minimum level of fat shall be 8 percent of the diet fed to rats. Protein quality evaluation of foods having greater fat content than the prescribed level of 8 percent has not met with great success.

Hurt, Forsythe and Krieger (1975) investigated the protein quality of a beef-vegetable product and a casein control diet at 8, 16 and 24 percent fat levels. Food

TABLE 6

PERCENTAGE PROTEIN AND FAT COMPOSITION OF TOTAL SOLIDS OF THE FOOD BEFORE (CALCULATED) AND AFTER FRYING (PROXIMATE ANALYSES)

| PRODUCTS* | Before** | | After*** | |
|---|---|---|---|---|
| | Protein | Fat | Protein | Fat |
| Chin-Chin | | | | |
| 100% wheat flour | 11.1 | 21.0 | 9.8 | 32.0 |
| 70% wheat/30% FFCS | 16.7 | 27.5 | 13.6 | 40.4 |
| 70% wheat/30% DFCS | 20.8 | 21.3 | 16.4 | 30.3 |
| 70% wheat/30% DFPN | 20.8 | 20.6 | 17.8 | 29.7 |
| Puff-Puff | | | | |
| 100% wheat flour | 17.3 | 7.5 | 14.0 | 30.6 |
| 70% wheat/30% FFCS | 22.4 | 13.7 | 17.0 | 41.9 |
| 70% wheat/30% DFCS | 25.4 | 7.9 | 18.7 | 30.6 |
| 70% wheat/30% DFPN | 26.2 | 7.4 | 19.1 | 33.8 |
| Bean-Ball | | | | |
| 100% cowpeas | 27.5 | 6.0 | 20.9 | 24.9 |
| 75% cowpeas/25% FFCS | 30.8 | 14.0 | 21.7 | 36.9 |
| 75% cowpeas/25% DFCS | 34.7 | 6.8 | 24.0 | 32.0 |
| 75% cowpeas/25% DFPN | 35.5 | 6.2 | 25.7 | 29.5 |

*Abbreviations for types of flour are as follows: "FFCS"--full-fat cottonseed, "DFCS"--defatted cottonseed, "DFPN"--defatted peanut.

**Composition of foods; raw, processed, prepared. USDA Handbook No. 8 (1964).

***Proximate analyses, Pope Testing Laboratory, Dallas, Texas (Appendix B).

consumption, weight gain and efficiency of food utilization for the rats fed the casein control diet and the beef-vegetable product were significantly decreased by the amount of fat contained in the diets. The animals consumed less of the diet as the level of fat was increased. This trend was noted for the rats fed both the casein and the test diet. However, when the caloric content of the diets was considered, it was apparent that growth was less efficient for the rats fed the diets with higher fat content. Staub (1978) has suggested that the PER method can be used to evaluate both simple and complex food products; but studying high moisture and high fat diets stretch the PER assay to its limit.

In this present study, the mean PER values for the casein control diet containing 8 percent fat (3.11), and the casein control diet containing 18.5 percent fat, (3.07) were significantly ($p=0.05$) higher than the means for all of the chin-chin products. With the puff-puff and bean-ball diets, the mean PER values for the casein control diet containing 8 percent fat (3.22) and the casein control diet containing 18 percent fat (2.98) were significantly ($p=0.05$) higher than for all of the other puff-puff and bean-ball products. The linear regression line for the percentage fat composition and the PER for the control groups is shown in Figure 1.

## Chin-Chin

The individual weight gain and amount of protein consumed for each rat in the experimental groups are shown in Appendix C. The calculated fat content for the chin-chin containing wheat flour was 32.7 percent, for full-fat cottonseed 18.5 percent, for defatted cottonseed flour 29.7 percent and for defatted peanut flour 16.7 percent. The three casein control groups containing 8.0, 18.5 and 32.7 percent fat were included in the assay.

The mean PER for defatted cottonseed flour (2.07) was significantly ($p=0.05$) higher than the means for the rest of the experimental groups for chin-chin. The PER values for the full-fat cottonseed flour (1.66) and the defatted peanut flour (1.74) were significantly ($p=0.05$) higher than the PER for wheat flour (1.24). A summary of the analysis of variance is shown in Table 7.

## Puff-Puff

The individual weight gain and amount of protein consumed for each rat in the experimental groups are shown in Appendix C. The calculated fat content for puff-puff containing wheat flour was 21.8 percent, for

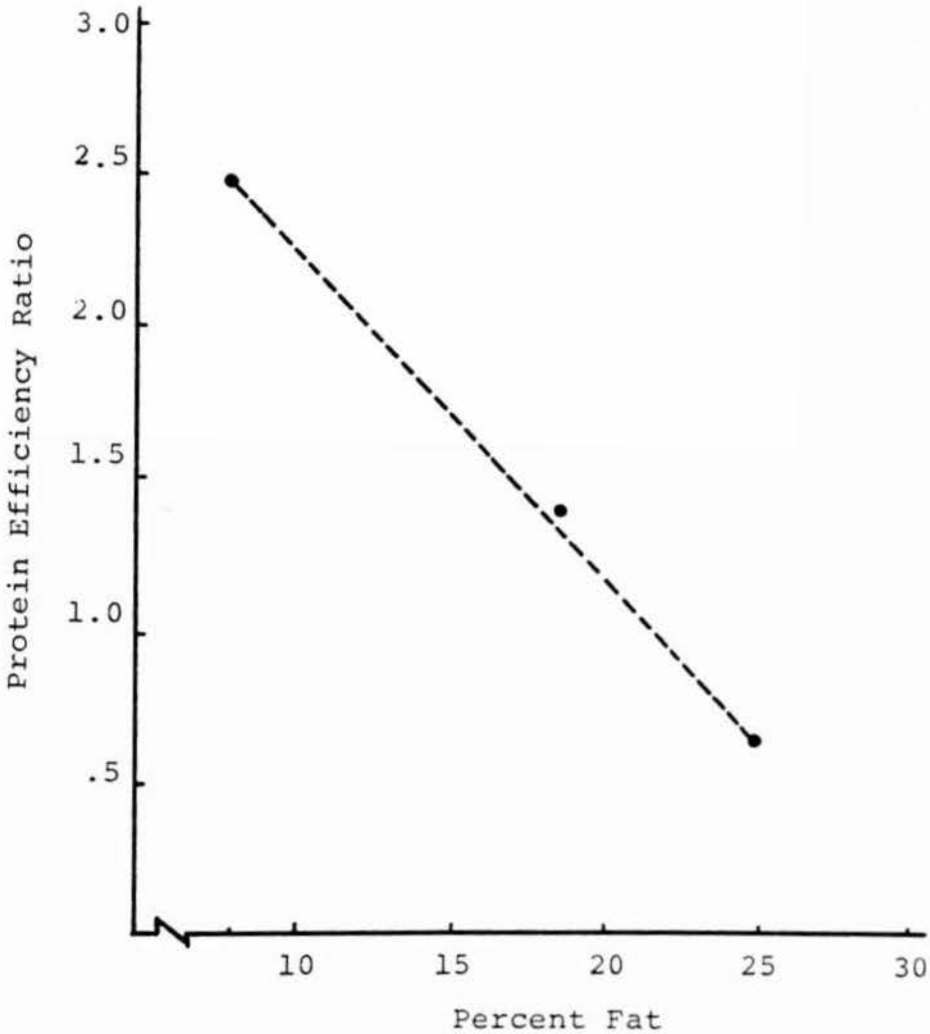


Figure 1. The Linear Regression for the Percentage Fat Composition and the Protein Efficiency Ratio for the Control Groups

TABLE 7

ANALYSIS OF VARIANCE OF WEIGHT GAIN AND PER FOR
RATS FED THE CHIN-CHIN DIETS

| | Means | | |
|---|---|---|---|
| PRODUCT* | Weight Gain (g) | PER | BUN** (mg/dl) |
| 100% wheat flour | 20 | 1.24[c] | 28.4 |
| 70% wheat/30% FFCS | 35 | 1.66[b] | 26.8 |
| 70% wheat/30% DCCS | 59 | 2.08[a] | 19.9 |
| 70% wheat/30% DFPN | 47 | 1.74[b] | 22.7 |

| ANOVA | df | ss | ms | F-ratio | F-probability |
|---|---|---|---|---|---|
| Between groups | 3 | 3.4956 | 1.1656 | 17.683 | 0.0001 |
| Within groups | 36 | 2.3730 | 0.0659 | | |
| TOTAL | 39 | 5.8607 | | | |

*Abbreviations for types of flour are as follows: "FFCS"--full-fat cottonseed, "DFCS"--defatted cottonseed, "DFPN"--defatted peanut.

**Blood urea nitrogen

a is significantly (p=0.05) higher than b and c; b is significantly (p=0.05) higher than c (Newman-Keuls multiple range test).

full-fat cottonseed flour 24.6 percent, for defatted cottonseed flour 16.4 percent and for defatted peanut flour 17.7 percent. Casein control groups containing 8, 18 and 25 percent fat were included in the study.

The mean PER for wheat flour (0.05) was significantly ($p=0.05$) higher than the means for the rest of the experimental groups for puff-puff. There were no significant differences between the PER values for full-fat cottonseed (-0.13), for defatted cottonseed (-0.07) and for defatted peanut (-0.32). A summary of the analysis of variance is shown in Table 8.

Protein supplementation did not improve the protein quality of the puff-puff products. This was attributed to the high fat content of the diets. Food consumption, weight gain and the PER decreased as the level of fat was increased. These results are in agreement with previous reports by Hurt, Forsythe and Krieger (1975), that animals consumed less protein as the level of fat increased. The fat contents of the diets were more than doubled as a result of frying. Consequently, the caloric density of the diet was increased, which in turn decreased the consumption of protein.

TABLE 8

ANALYSIS OF VARIANCE OF WEIGHT GAIN AND PER FOR RATS
FED THE PUFF-PUFF DIETS

| | Means | | |
|---|---|---|---|
| PRODUCT* | Weight Gain (g) | PER | BUN** (mg/dl) |
| 100% wheat flour | 12 | $0.57^{a}$ | 46.0 |
| 70% wheat/30% DFCS | -1.6 | $-0.13^{b}$ | 46.7 |
| 70% wheat/30% DFCS | -0.8 | $-0.07^{b}$ | 52.3 |
| 70% wheat/30% DFPN | -0.43 | $-0.32^{b}$ | 45.1 |

| ANOVA | df | ss | ms | F-ratio | F-probability |
|---|---|---|---|---|---|
| Between groups | 3 | 4.5467 | 1.5156 | 20.540 | 0.0001 |
| Within groups | 36 | 2.6563 | 0.0738 | | |
| TOTAL | 39 | 7.2030 | | | |

*Abbreviations for types of flour are as follows: "FFCS"--full-fat cottonseed, "DFCS"--defatted cottonseed, "DFPN"--defatted peanut.

**Blood urea nitrogen

a is significantly (p=0.05) higher than b (Newman-Keuls multiple range test).

Bean-Ball

The individual weight gain and amount of protein consumed for each rat in the experimental groups are shown in Appendix C. The calculated fat content for bean-ball containing cowpeas was 12.0 percent, for full-fat cottonseed 17.0 percent, for defatted cottonseed 13.0 percent and for defatted peanut 12.0 percent. The same control casein groups were used for these diets as for the puff-puff study.

The statistical analysis and the Newman-Kuels multiple range test did not show any significant ($p=0.05$) difference between the PER values of cowpeas (2.16), full-fat cottonseed flour (2.34), defatted cottonseed flour (2.09) and defatted peanut flour (2.00). A summary of the analysis of variance is presented in Table 9.

The importance of urea concentration in blood lies in its value as an indicator of kidney function (Annino and Giese, 1976). Thus, people who are malnourished or who are on low protein diets may have blood nitrogen levels that are not accurate indicators of kidney function. Blood urea nitrogen is an expression of metabolic nitrogen and not urea. The concentration of urea nitrogen in the blood of healthy adults ranges between 10 and 20 mg per deci-liter. This is 32 to 42 mg per deci-liter of urea.

TABLE 9

ANALYSIS OF VARIANCE OF WEIGHT GAIN AND PER FOR RATS FED THE BEAN-BALL DIETS

| | Means | | |
|---|---|---|---|
| PRODUCT* | Weight Gain (g) | PER | BUN**(mg/dl) |
| 100% cowpeas | 62 | 2.16 | 22.6 |
| 75% cowpeas/25% FFCS | 74 | 2.34 | 33.1 |
| 75% cowpeas/25% DFCS | 68 | 2.09 | 22.6 |
| 75% cowpeas/25% DFPN | 50 | 2.00 | 34.0 |

| ANOVA | df | ss | ms | F-ratio | F-probability |
|---|---|---|---|---|---|
| Between groups | 3 | 0.6204 | 0.2068 | 1.913 | 0.1449 |
| Within groups | 36 | 3.8914 | 0.1081 | | |
| TOTAL | 39 | 4.5118 | | | |

*Abbreviations for types of flour are as follows: "FFCS"--full-fat cottonseed, "DFCS"--defatted cottonseed, "DFPN"--defatted peanut.

**Blood urea nitrogen

F(3,36) = 1.913, P=0.1449, not significant (Newman-Keuls multiple range test).

The results of studies performed with rats (Eggum, 1970; Scrimshaw and Young, 1974) have demonstrated that serum urea levels are influenced by three factors: the quality of protein, quantity of protein, and the time of bleeding. Other reports have indicated that length of storage of blood following bleeding should also be considered as a major factor. For these reasons, any conclusions derived from these data might not be precise.

The statistical analysis of blood urea nitrogen (BUN) for rats fed the chin-chin diets showed no significant difference between the four test diets. The BUN content (mg/dl) for the casein control groups was not different from the four test diets.

For the puff-puff diets, the BUN content (mg/dl) values showed no significant difference between the four test diets. The statistical analysis showed a significant difference between the controls and the four test diets ($p=0.001$).

The BUN content (mg/dl) analysis on bean-ball showed significant differences between the four test diets ($p=0.001$). The blood urea nitrogen levels as related to the PER for all control groups were not significantly different. The correlation coefficient was -0.096.

CHAPTER V

SUMMARY

Three staple supplemented Nigerian foods--chin-chin, puff-puff and bean-ball were fed to rats to evaluate the nutritive quality of cottonseed and peanut proteins. Male weanling rats of the Holtzman albino strain were fed diets containing full-fat cottonseed flour, defatted cottonseed flour or defatted peanut flour according to the AOAC (1975) procedure.

The protein efficiency ratio (PER) and blood urea nitrogen (BUN) were calculated for each rat at the end of each study period. The mean PER for defatted cottonseed flour (2.07) was significantly (p=0.05) higher than the means for the rest of the experimental groups for chin-chin. The PER values for the full-fat cottonseed flour (1.66) and defatted peanut flour (1.74) were significantly (p=0.05) higher than the PER for wheat flour (1.24).

The mean PER for wheat flour (0.57) was significantly (p=0.05) higher than the means for the rest of the experimental groups for puff-puff. There were no significant differences between the PER values for full-fat cottonseed

flour (-0.13), defatted cottonseed flour (-0.07) and defatted peanut flour (-0.32). There were no significant differences between the PER values of cowpeas (2.16), full-fat cottonseed (2.34), defatted cottonseed (2.09) and defatted peanut (2.00) for the bean-balls.

The findings from these animal studies suggested that cottonseed and peanut proteins could be a feasible source of protein at a lower cost than animal protein. The study also indicated that full-fat cottonseed, defatted cottonseed and defatted peanut flours could be used to increase the quality of the protein in foods at a lower cost than for protein from animal sources.

In case of a future study, extreme care should be taken to balance the ratio of the protein and fat in the foods used in the diet in order to provide a meal of better protein quality.

# APPENDIX A

# CHIN-CHIN RECIPE

| Ingredients | Quantity |
|---|---|
| Hydrogenated shortening | 25g |
| Sugar, granulated | 25g |
| Egg | 48g |
| All purpose wheat flour | 100g |
| Baking powder, double action | ½ tsp |
| Salt | ½ tsp |
| Vanilla | ½ tsp |
| Cinnamon | ¼ tsp |
| Vegetable oil for deep fat frying | |

## Variations and Symbols

| | |
|---|---|
| Control 100% wheat flour | 100g |
| FFCS--Full-fat cottonseed flour (30%)<br>Wheat flour (70%) | 30g<br>70g |
| DFCS--Defatted cottonseed flour (30%)<br>Wheat flour (70%) | 30g<br>70g |
| DFPN--Defatted peanut flour (30%)<br>Wheat flour (70%) | 30g<br>70g |

# PUFF-PUFF RECIPE

| Ingredients | Quantity |
| --- | --- |
| All purpose wheat flour | 100g |
| Egg | 96g |
| Water, warm | 60g |
| Sugar, granulated | 37.5g |
| Yeast, active dry | 14g |
| Salt | ½ tsp |
| Vanilla | ½ tsp |
| Cinnamon | ½ tsp |
| Vegetable oil for deep fat frying | |

## Variations and Symbols

| | |
| --- | --- |
| Control 100% All wheat flour | 100g |
| FFCS--Full-fat cottonseed flour (30%) | 30g |
| All wheat flour (70%) | 70g |
| DFCS--Defatted cottonseed flour (30%) | 30g |
| All wheat flour (70%) | 70g |
| DFPN--Defatted peanut flour (30%) | 30g |
| All wheat flour (70%) | 70g |

# BEAN-BALL RECIPE

| Ingredients | Quantity |
| --- | --- |
| Whole cowpeas | 100g |
| Onions | 70g |
| Egg | 48g |
| Salt | ½ tsp |
| Cayenne pepper | ½ tsp |
| Vegetable oil for deep frying | |

## Variations and Symbols

| | |
| --- | --- |
| CP--Control 100% whole cowpeas | 100g |
| FFCS--Full-fat cottonseed flour (25%) | 25g |
| Whole cowpeas (75%) | 75g |
| DFCS--Defatted cottonseed flour (25%) | 25g |
| Whole cowpeas (75%) | 75g |
| DFPN--Defatted peanut flour (25%) | 25g |
| Whole cowpeas (75%) | 75g |

# APPENDIX B

# POPE TESTING LABORATORIES, INC.

CONSULTING ANALYITICAL CHEMISTS
AND TESTING ENGINEERS

FOODS, FEEDS, DAIRY PROD.
WATER, MISCL. ANALYSES
COTTON SEED PRODUCTS
PACKING HOUSE PRODUCTS
SEED GERMINATION
FERTILIZERS

P. O. BOX 903
DALLAS, TEXAS
75221

OFFICIAL CHEMISTS
WEIGHERS AND INSPECTORS
NATL. COTTONSEED PRODUCTS ASS'N.
NATL. SOYBEAN PROCESSOR'S ASS'N.
REFEREE CHEMISTS
AMERICAN OIL CHEMISTS SOCIETY

TO Texas Woman's University
Denton, Texas

File No.

Date Rec'd 11-5-80

Report of Tests on Flour

Received from You

Identification Marks As Below

| | Nitrogen |
|---|---|
| 100% Wheat Flour Chin Chin | 1.46% |
| 70/30 Full Fat Cottonseed Chin Chin | 1.60 |
| 70/30 Defatted Peanut Chin Chin | 1.64 |
| 70/30 Defatted Cottonseed Chin Chin | 1.61 |
| 32.7% Fat Control Chin Chin | 1.44 |
| 18.5% Fat Control Chin Chin | 1.60 |
| 18.5% Fat Control Chin Chin | 1.58 |

Remarks

LAB NO. 88896 thru 88902 Incl.

POPE TESTING LABORATORIES, INC.

By Leon Hunter

F.. 0—40M

# POPE TESTING LABORATORIES, INC.

CONSULTING ANALYITICAL CHEMISTS
AND TESTING ENGINEERS

FOODS, FEEDS, DAIRY PROD.
WATER, MISCL. ANALYSES
COTTON SEED PRODUCTS
PACKING HOUSE PRODUCTS
SEED GERMINATION
FERTILIZERS

P. O. BOX 903
DALLAS, TEXAS
75221

OFFICIAL CHEMISTS
WEIGHERS AND INSPECTORS
NATL. COTTONSEED PRODUCTS ASS'N.
NATL. SOYBEAN PROCESSOR'S ASS'N.
REFEREE CHEMISTS
AMERICAN OIL CHEMISTS SOCIETY

TO Texas Woman's University
Denton, Texas

File No.

Date Rec'd 11-5-80

Report of Tests on Flour

Received from You

Identification Marks As Below

| | Moisture |
|---|---|
| 70/30 Defatted Cottonseed Puff-Puff | 4.4% |
| 70/30 Full Fat Cottonseed Puff-Puff | 3.4 |
| 100% Cow Pea Bean Ball | 2.7 |
| 75/25 Defatted Cottonseed Bean-Ball | 3.2 |
| 75/25 Full Fat Cottonseed Bean-Ball | 2.0 |
| 75/25 Defatted Peanut Bean-Ball | 2.7 |

Remarks

LAB NO. 88890-95 Incl. POPE TESTING LABORATORIES, INC.

By [signature]

50--40M

# POPE *Testing* LABORATORIES, Inc.

CONSULTING ANALYTICAL CHEMISTS
AND TESTING ENGINEERS

FOODS, FEEDS, DAIRY PROD.
WATER, MISCL. ANALYSES
COTTON SEED PRODUCTS
PACKING HOUSE PRODUCTS

P. O. BOX 903
DALLAS, TEXAS 75221
AC 214 742-8491

OFFICIAL CHEMISTS
WEIGHERS AND INSPECTORS
NATL. COTTONSEED PRODUCTS ASS'
NATL. SOYBEAN PROCESSOR'S ASS'
REFEREE CHEMISTS
AMERICAN OIL CHEMISTS SOCIETY


December 1, 1980


Texas Woman's University
Department of Nutrition and Food Sciences
Room 223 Austin Hall
Denton, Texas 76201


Report of Tests on: Flour

| Identification | Nitrogen |
|---|---|
| 25% Fat Control | 1.46% |
| 18% Fat Control | 1.58 |
| 8% Fat Control | 1.53 |
| 100% Cow Pea Bean Ball | 1.60 |
| 100% Wheat Flour Puff Puff | 1.51 |
| 75/25 Full Fat Cottonseed Bean Ball | 1.68 |
| 75/25 Defatted Cottonseed Bean Ball | 1.69 |
| 75/25 Defatted Cottonseed Puff Puff | 1.50 |
| 75/25 Defatted Peanut Bean Ball | 1.43 |
| 70/30 Full Fat Cottonseed Puff Puff | 1.56 |
| 70/30 Defatted Peanut Puff Puff | 1.50 |

************

Respectfully submitted,

POPE TESTING LABORATORIES, INC.

Leon Hunter

# POPE TESTING LABORATORIES, INC.

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WEIGHERS AND INSPECTORS
NATL. COTTONSEED PRODUCTS ASS'N.
NATL. SOYBEAN PROCESSOR'S ASS'N.
REFEREE CHEMISTS
AMERICAN OIL CHEMISTS SOCIETY

**To** Texas Woman's University
Denton, Texas

**File No.**

**Date Rec'd** 4-21-80

**Report of Tests on** Wheat Flour

**Received from** Dept. of Nutrition & Food Sciences

**Identification Marks** None P.O. #41073-0-0009

| | |
|---|---|
| **Moisture** | 10.4% |
| **Protein** | 10.69 |
| **Fat** | 1.00 |
| **Fiber** | 0.2 |
| **Ash** | 0.46 |
| **Nitrogen Free Extract** | 77.25 |

**Remarks**

**LAB NO.** 75987

**POPE TESTING LABORATORIES, Inc.**

By Leon Hunter

F-58—2M—10-79

# POPE TESTING LABORATORIES, INC.

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AND TESTING ENGINEERS

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WATER, MISCL. ANALYSES
COTTON SEED PRODUCTS
PACKING HOUSE PRODUCTS
FERTILIZERS

P. O. BOX 903
DALLAS, TEXAS
75221

OFFICIAL CHEMISTS
WEIGHERS AND INSPECTORS
NATL. COTTONSEED PRODUCTS ASS'N.
NATL. SOYBEAN PROCESSOR'S ASS'N.
REFEREE CHEMISTS
AMERICAN OIL CHEMISTS SOCIETY

**To** Texas Woman's University
Denton, Texas

**File No.**

**Date Rec'd** 4-21-80

**Report of Tests on** Defatted Cottonseed Flour

**Received from** You

**Identification Marks** None P.O. #41073-0-0009

| | |
|---|---|
| **Moisture** | 9.0% |
| **Protein** | 55.41 |
| **Fat** | 3.24 |
| **Fiber** | 0.8 |
| **Ash** | 7.43 |
| **Nitrogen Free Extract** | 24.12 |

**Remarks**

**LAB NO.** 75983

POPE TESTING LABORATORIES, Inc.

By Leon Hunton

F-58—2M—10-79

# POPE TESTING LABORATORIES, INC.

CONSULTING ANALYTICAL CHEMISTS
AND TESTING ENGINEERS

FOODS, FEEDS, DAIRY PROD.
WATER, MISCL. ANALYSES
COTTON SEED PRODUCTS
PACKING HOUSE PRODUCTS
FERTILIZERS

P. O. BOX 903
DALLAS, TEXAS
75221

OFFICIAL CHEMISTS
WEIGHERS AND INSPECTORS
NATL. COTTONSEED PRODUCTS ASS'N.
NATL. SOYBEAN PROCESSOR'S ASS'N.
REFEREE CHEMISTS
AMERICAN OIL CHEMISTS SOCIETY

**To** Texas Woman's University
Denton, Texas

**File No.**

**Date Rec'd** 4-21-80

**Report of Tests on** Cow Peas (Black-Eyed Peas)

**Received from** Dept. of Nutrition & Food Sciences

**Identification Marks** None P.O. #41073-0-0009

| | |
|---|---|
| **Moisture** | 8.9% |
| **Protein** | 21.88 |
| **Fat** | 1.20 |
| **Fiber** | 2.7 |
| **Ash** | 3.80 |
| **Nitrogen Free Extract** | 61.52 |

**Remarks**

**LAB NO.** 75989

**POPE TESTING LABORATORIES, Inc.**

By Leon Hunter

F-58—2M—10-79

TABLE 10

PROXIMATE ANALYSIS OF THE NIGERIAN STAPLE FOODS*

| PRODUCTS** | Moisture % | Protein % | Fat % | Fiber % | Ash % | NFE % |
|---|---|---|---|---|---|---|
| Chin-Chin | | | | | | |
| 100% wheat flour | 0.9 | 9.7 | 31.8 | 0.3 | 0.8 | 56.5 |
| 70% wheat/30% FCCS | 0.7 | 13.5 | 40.1 | 0.6 | 2.2 | 42.9 |
| 70% wheat/30% DFCS | 1.3 | 16.2 | 29.9 | 1.0 | 2.3 | 49.3 |
| 70% wheat/30% DFPN | 2.5 | 17.4 | 29.0 | 0.8 | 1.7 | 48.6 |
| Puff-Puff | | | | | | |
| 100% wheat flour | 5.3 | 13.3 | 29.0 | 0.4 | 1.3 | 50.7 |
| 70% wheat/30% FFCS | 11.3 | 15.1 | 40.4 | 0.9 | 1.8 | 33.8 |
| 70% wheat/30% DFCS | 13.9 | 16.1 | 26.4 | 1.6 | 2.1 | 39.9 |
| 70% wheat/30% DFPN | 5.0 | 18.1 | 32.1 | 1.6 | 2.4 | 40.8 |
| Bean-Ball | | | | | | |
| 100% cowpeas | 28.5 | 14.9 | 17.8 | 1.4 | 3.0 | 34.4 |
| 75% cowpeas/25% FFCS | 12.1 | 19.1 | 32.4 | 1.9 | 3.4 | 31.1 |
| 75% cowpeas/25% DFCS | 19.2 | 19.4 | 25.9 | 1.9 | 3.3 | 30.3 |
| 75% cowpeas/25% DFPN | 18.5 | 20.9 | 24.0 | 2.8 | 3.9 | 29.9 |

*Pope Testing Laboratories, Inc., Dallas, Texas.

**Abbreviations for types of flour are as follows: "FFCS"--full-fat cottonseed, "DFCS"--defatted cottonseed, "DFPN"--defatted peanut.

TABLE 11

PROXIMATE ANALYSIS OF FULL-FAT COTTONSEED FLOUR*

| | |
|---|---|
| Moisture and Volatiles | 6.20% |
| Ash | 4.30% |
| Oil | 35.45% |
| Protein | 39.13% |
| Crude fiber | 1.48% |
| Gossypol (free) | 0.037% |
| Gossypol (total) | 0.042% |
| Free fatty acid | 0.8% |
| Lead | 1.5 ppm |
| Arsenic | 0.1 ppm |
| Heavy metals | 10.0 ppm |
| Salmonella | negative |
| Aflatoxin | 0 ppb |

*Analysis performed at the Food Protein Research and Development Center, Texas A & M University, and Pope Testing Laboratories, Inc.

TABLE 12

PROXIMATE ANALYSIS OF DEFATTED PEANUT FLOUR*

| | |
|---|---|
| Moisture | 5.80% |
| Protein | 60.24% |
| Fat | 0.60% |
| Fiber | 2.80% |
| Ash | 4.65% |
| Nitrogen Free Extract | 25.91% |

*Analysis performed at the Food Protein Research and Development Center, Texas A & M University, and Pope Testing Laboratories, Inc.

# APPENDIX C

TABLE 13

DATA FROM RATS FED CHIN-CHIN DIET (32.7%fat) IN WHICH PROTEIN WAS SUPPLIED ENTIRELY BY 100% WHEAT FLOUR

| Rat No. | Weight gain (g) | Protein consumed (g) | PER | Blood Urea Nitrogen (mg/dl) |
|---|---|---|---|---|
| 1 | 22 | 16.42 | 1.34 | 32.1 |
| 2 | 12 | 12.31 | 0.97 | 17.0 |
| 3 | 22 | 17.98 | 1.22 | 34.2 |
| 4 | 17 | 14.78 | 1.15 | 34.2 |
| 5 | 21 | 16.52 | 1.27 | 27.8 |
| 6 | 14 | 14.51 | 0.96 | 25.7 |
| 7 | 19 | 16.43 | 1.16 | 25.7 |
| 8 | 24 | 17.16 | 1.40 | 34.2 |
| 10 | 19 | 14.78 | 1.29 | 38.5 |
| Mean | 20 | 15.88 | 1.23 | 28.4 |
| S.D. | | | 0.158 | 7.75 |
| Adjusted PER | | | 1.25 | |

TABLE 14

DATA FROM RATS FED CHIN-CHIN DIET (29.7% fat) IN WHICH PROTEIN WAS SUPPLIED BY 70% WHEAT AND 30% FULL-FAT COTTONSEED FLOURS

| Rat No. | Weight gain (g) | Protein consumed (g) | PER | Blood Urea Nitrogen (mg/dl) |
|---|---|---|---|---|
| 1 | 40 | 22.60 | 1.77 | 19.3 |
| 2 | 35 | 20.90 | 1.67 | 21.4 |
| 3 | 32 | 20.00 | 1.60 | 19.3 |
| 4 | 32 | 20.20 | 1.58 | 25.7 |
| 5 | 41 | 23.60 | 1.74 | 38.5 |
| 6 | 48 | 21.70 | 2.21 | 25.7 |
| 7 | 30 | 20.30 | 1.48 | 32.1 |
| 8 | 13 | 14.00 | 0.93 | 25.7 |
| 9 | 36 | 20.30 | 1.77 | 21.4 |
| 10 | 39 | 21.20 | 1.84 | 38.5 |
| Mean: | 35 | 20.48 | 1.66 | 26.8 |
| S.D. | | | 0.327 | 7.27 |
| Adjusted PER | | | 1.69 | |

TABLE 15

DATA FROM RATS FED CHIN-CHIN DIET (18.5% Fat) IN WHICH PROTEIN WAS SUPPLIED BY 70% WHEAT AND 30% DEFATTED COTTONSEED FLOURS

| Rat No. | Weight gain (g) | Protein consumed (g) | PER | Blood Urea Nitrogen (mg/dl) |
|---|---|---|---|---|
| 1 | 66 | 30.29 | 2.18 | 21.4 |
| 2 | 37 | 21.84 | 1.69 | 34.0 |
| 3 | 48 | 23.45 | 2.05 | 21.4 |
| 4 | 76 | 31.19 | 2.44 | 8.6 |
| 5 | 57 | 27.67 | 2.06 | 25.7 |
| 6 | 74 | 31.09 | 2.38 | 19.3 |
| 7 | 43 | 24.85 | 1.73 | 30.0 |
| 8 | 66 | 31.60 | 2.09 | 4.3 |
| 9 | 54 | 26.46 | 2.04 | 21.4 |
| 10 | 66 | 30.79 | 2.14 | 12.8 |
| Mean: | 59 | 27.92 | 2.08 | 19.9 |
| S.D. | | | 0.241 | 9.20 |
| Adjusted PER | | | 1.69 | |

TABLE 16

DATA FROM RATS FED CHIN-CHIN DIET (16.7% Fat) IN WHICH PROTEIN WAS SUPPLIED BY 70% WHEAT AND 30% DEFATTED PEANUT FLOURS

| Rat No. | Weight gain (g) | Protein consumed (g) | PER | Blood Urea NITROGEN (mg/dl) |
|---|---|---|---|---|
| 1 | 33 | 23.47 | 1.41 | 34.2 |
| 2 | 58 | 27.88 | 2.08 | - |
| 3 | 50 | 29.52 | 1.69 | 34.2 |
| 4 | 55 | 30.24 | 1.82 | 21.4 |
| 5 | 29 | 20.09 | 1.44 | 25.7 |
| 6 | 32 | 23.37 | 1.37 | 17.1 |
| 7 | 51 | 27.27 | 1.87 | 25.7 |
| 8 | 38 | 21.94 | 1.74 | 25.7 |
| 9 | 68 | 31.78 | 2.14 | 17.1 |
| 10 | 57 | 30.75 | 1.85 | 25.7 |
| Mean. | 47 | 26.63 | 1.74 | 22.7 |
| S.D. | | | 0.272 | 9.88 |
| Adjusted PER | | | 1.42 | |

TABLE 17

DATA FROM RATS FED PUFF-PUFF DIET (21.8% Fat) IN WHICH PROTEIN WAS SUPPLIED ENTIRELY BY 100% WHEAT FLOUR

| Rat No. | Weight gain (g) | Protein consumed (g) | PER | Blood Urea Nitrogen (mg/dl) |
|---|---|---|---|---|
| 1 | 8.0 | 14 | 0.57 | 41 |
| 2 | 7.0 | 18 | 0.38 | 28 |
| 3 | 13 | 17 | 0.76 | 57 |
| 4 | 8.0 | 16 | 0.50 | 57 |
| 5 | 21 | 20 | 1.05 | 43 |
| 6 | -3.0 | 11 | -0.27 | 69 |
| 7 | 10 | 16 | 0.63 | 30 |
| 8 | 17 | 19 | 0.89 | 47 |
| 9 | 12 | 19 | 0.63 | 47 |
| 10 | 11 | 18 | 0.61 | 45 |
| Mean | 12 | 17 | 0.6 | 46.0 |
| S.D. | | | 0.353 | 12.4 |
| Adjusted PER | | | 0.63 | |

TABLE 18

DATA FROM RATS FED PUFF-PUFF DIET (24.5%) IN WHICH PROTEIN WAS SUPPLIED BY 70% WHEAT AND 30% FULL-FAT COTTONSEED FLOURS

| Rat No. | Weight gain (g) | Protein consumed (g) | PER | Blood Urea Nitrogen (mg/dl) |
|---|---|---|---|---|
| 1 | -1 | 12 | -0.08 | 21 |
| 2 | 4 | 14 | 0.29 | 30 |
| 3 | -2 | 14 | -0.14 | 41 |
| 4 | -7 | 13 | -0.54 | 81 |
| 5 | -4 | 11 | -0.36 | 39 |
| 6 | 1 | 14 | 0.07 | 39 |
| 7 | 1 | 14 | 0.07 | 47 |
| 8 | 0 | 13 | 0.00 | 81 |
| 9 | -5 | 13 | -0.39 | 75 |
| 10 | -3 | 15 | -0.20 | 13 |
| Mean | -1.6 | 13 | -0.13 | 46.7 |
| S.D | | | 0.251 | 24.4 |
| Adjusted PER | | | -0.12 | |

TABLE 19

DATA FROM RATS FED PUFF-PUFF DIET (16.4% Fat) IN WHICH PROTEIN WAS SUPPLIED BY 70% WHEAT AND 30% DEFATTED COTTONSEED FLOURS

| Rat No. | Weight gain (g) | Protein consumed (g) | PER | Blood Urea Nitrogen (mg/dl) |
|---|---|---|---|---|
| 1 | 4 | 15 | 0.27 | 30 |
| 2 | 0 | 12 | 0.00 | 47 |
| 3 | -2 | 13 | -0.15 | 60 |
| 4 | -4 | 14 | -0.29 | 60 |
| 5 | 0 | 14 | 0.00 | 47 |
| 6 | -5 | 11 | -0.45 | 41 |
| 7 | 0 | 15 | 0.00 | 39 |
| 8 | -1 | 15 | -0.07 | 45 |
| 9 | 0 | 14 | 0.00 | 73 |
| 10 | 0 | 14 | 0.00 | 81 |
| Mean | -0.8 | 14 | -0.07 | 52.3 |
| S.D | | | 0.19 | 15.9 |
| Adjusted PER | | | -0.06 | |

TABLE 20

DATA FROM RATS FED PUFF-PUFF DIET (17.7% Fat) IN WHICH PROTEIN WAS SUPPLIED BY 70% AND 30% DEFATTED PEANUT FLOURS

| Rat No. | Weight gain (g) | Protein consumed (g) | PER | Blood Urea Nitrogen (mg/dl) |
|---|---|---|---|---|
| 1 | -6 | 14 | -0.43 | 34 |
| 2 | 2 | 17 | 0.12 | 35 |
| 3 | -7 | 13 | -0.54 | 39 |
| 4 | -8 | 13 | -0.62 | 66 |
| 5 | -8 | 13 | -0.62 | 56 |
| 6 | -7 | 13 | -0.54 | 39 |
| 7 | -4 | 15 | -0.27 | 30 |
| 8 | -2 | 17 | -0.12 | 34 |
| 9 | -2 | 15 | -0.13 | 75 |
| 10 | -1 | 14 | -0.07 | 43 |
| Mean | -4.3 | 14 | -0.32 | 45.1 |
| S.D | | | 0.263 | 15.2 |
| Adjusted PER | | | -0.27 | |

TABLE 21

DATA FROM RATS FED BEAN-BALL DIET (12.0% Fat) IN WHICH PROTEIN WAS SUPPLIED ENTIRELY BY 100% COWPEAS

| Rat No. | Weight gain (g) | Protein consumed (g) | PER | Blood Urea Nitrogen (mg/dl) |
|---|---|---|---|---|
| 1 | 59 | 26 | 2.27 | 19 |
| 2 | 46 | 24 | 1.92 | 15 |
| 3 | 70 | 30 | 2.33 | 26 |
| 4 | 52 | 26 | 2.00 | 21 |
| 5 | 78 | 31 | 2.52 | 28 |
| 6 | 70 | 30 | 2.33 | 21 |
| 7 | 75 | 31 | 2.42 | 30 |
| 8 | 53 | 28 | 1.89 | 28 |
| 9 | 58 | 29 | 2.00 | 19 |
| 10 | 62 | 31 | 2.00 | 19 |
| Mean | 62 | 29 | 2.17 | 22.6 |
| S.D. | | | 0.22 | 5.01 |
| Adjusted PER | | | 1.82 | |

TABLE 22

DATA FROM RATS FED BEAN-BALL DIETS (17.0% Fat) IN WHICH PROTEIN WAS SUPPLIED BY 75% COWPEAS AND 25% FULL-FAT COTTONSEED FLOUR

| Rat No. | Weight gain (g) | Protein consumed (g) | PER | Blood Urea Nitrogen (mg/dl) |
|---|---|---|---|---|
| 1 | 76 | 34 | 2.24 | 21 |
| 2 | 57 | 26 | 2.19 | 49 |
| 3 | 107 | 34 | 3.15 | 36 |
| 4 | 86 | 34 | 2.53 | 39 |
| 5 | 64 | 28 | 2.29 | 26 |
| 6 | 71 | 31 | 2.29 | 21 |
| 7 | 84 | 34 | 2.47 | 47 |
| 8 | 79 | 33 | 2.39 | 34 |
| 9 | 69 | 34 | 2.03 | 32 |
| 10 | 48 | 26 | 1.85 | 26 |
| Mean | 74 | 31 | 2.34 | 33.1 |
| S.D | | | 0.35 | 9.91 |
| Adjusted PER | | | 1.96 | |

TABLE 23

DATA FROM RATS FED BEAN-BALL DIETS (13.4% Fat) IN WHICH PROTEIN WAS SUPPLIED BY 75% COWPEAS AND 25% DEFATTED COTTONSEED FLOUR

| Rat No. | Weight gain (g) | Protein consumed (g) | PER | Blood Urea Nitrogen (mg/dl) |
|---|---|---|---|---|
| 1 | 66 | 30 | 2.20 | 15 |
| 2 | 88 | 35 | 2.51 | 24 |
| 3 | 80 | 35 | 2.29 | 15 |
| 4 | 94 | 40 | 2.35 | 15 |
| 5 | 53 | 26 | 2.04 | 30 |
| 6 | 82 | 35 | 2.34 | 36 |
| 7[1] | 13 | 15 | 0.87 | - |
| 8 | 84 | 35 | 2.40 | 17 |
| 9 | 61 | 30 | 2.03 | 30 |
| 10 | 55 | 28 | 1.96 | 21 |
| Mean | 68 | 31 | 2.10 | 22.6 |
| S.D. | | | 0.467 | 10.30 |
| Adjusted PER | | | 2.10 | |

[1] Died on the 26th day of the study of starvation.

TABLE 24

DATA FROM RATS FED BEAN-BALL DIETS (11.5% Fat) IN WHICH PROTEIN WAS SUPPLIED BY 75% COWPEAS AND 25% DEFATTED PEANUT FLOUR

| Rat No. | Weight gain (g) | Protein consumed (g) | PER | Blood Urea Nitrogen (mg/dl) |
|---|---|---|---|---|
| 1 | 47 | 25 | 1.88 | 39 |
| 2 | 35 | 20 | 1.75 | 36 |
| 3 | 50 | 25 | 2.00 | 24 |
| 4 | 55 | 25 | 2.20 | 43 |
| 5 | 74 | 32 | 2.31 | 29 |
| 6 | 45 | 22 | 2.05 | 21 |
| 7 | 36 | 22 | 1.64 | 26 |
| 8 | 62 | 29 | 2.14 | 47 |
| 9 | 48 | 24 | 2.00 | 34 |
| 10 | 45 | 22 | 2.05 | 36 |
| Mean | 50 | 25 | 2.00 | 34 |
| S.D | | | .202 | 8.4 |
| Adjusted PER | | | 1.68 | |

TABLE 25

DATA FROM RATS FED A DIET IN WHICH 10% PROTEIN

WAS SUPPLIED BY CASEIN AND

WHICH CONTAINED 8% FAT

| Rat No. | Weight gain (g) | Protein consumed (g) | PER | Blood Urea Nitrogen (mg/dl) |
|---|---|---|---|---|
| 1 | 114 | 44.72 | 2.55 | 12.8 |
| 2 | 131 | 44.04 | 2.97 | - |
| 3 | 140 | 44.42 | 3.15 | 25.7 |
| 4 | 108 | 41.84 | 2.58 | 30.0 |
| 5 | 152 | 48.59 | 3.13 | 38.5 |
| 6 | 164 | 47.20 | 3.47 | 30.0 |
| 7 | 167 | 46.69 | 3.58 | 23.5 |
| 8 | 139 | 40.15 | 3.46 | 25.7 |
| 9 | 144 | 45.41 | 3.17 | 15.0 |
| 10 | 137 | 45.61 | 3.00 | 21.4 |
| Mean | 140 | 44.87 | 3.11 | 22.3 |
| S.D | | | | 10.8 |
| Adjusted PER | | | 2.50 | |

TABLE 26

DATA FROM RATS FED A DIET IN WHICH 10% PROTEIN WAS SUPPLIED BY CASEIN AND WHICH CONTAINED 18% FAT

| Rat No. | Weight gain (g) | Protein consumed (g) | PER | Blood Urea Nitrogen (mg/dl) |
|---|---|---|---|---|
| 1 | 100 | 30.21 | 3.31 | 17.1 |
| 2 | 83 | 29.91 | 2.77 | 21.4 |
| 3 | 112 | 35.18 | 3.18 | 21.4 |
| 4 | 125 | 39.55 | 3.16 | 12.8 |
| 5 | 148 | 43.03 | 3.44 | 38.5 |
| 6 | 109 | 41.44 | 2.63 | 25.7 |
| 7 | 130 | 38.86 | 3.34 | 30.0 |
| 8 | 115 | 38.46 | 2.99 | 10.7 |
| 9 | 110 | 36.97 | 2.98 | 12.8 |
| 10 | 103 | 36.07 | 2.86 | 15.0 |
| Mean | 114 | 36.97 | 3.07 | 20.5 |
| S.D | | | | 8.81 |

TABLE 27

DATA FROM RATS FED A DIET IN WHICH 10% PROTEIN WAS SUPPLIED BY CASEIN AND WHICH CONTAINED 32.7% FAT

| Rat No. | Weight gain (g) | Protein consumed (g) | PER | Blood Urea Nitrogen (mg/dl) |
|---|---|---|---|---|
| 1 | 36 | 22.50 | 1.60 | 30.0 |
| 2 | 65 | 24.75 | 2.63 | 23.5 |
| 3 | 48 | 21.15 | 2.27 | 30.0 |
| 4 | 75 | 27.09 | 2.77 | 25.7 |
| 5 | 75 | 29.25 | 2.56 | 38.5 |
| 6 | 69 | 24.75 | 2.79 | 30.0 |
| 7 | 64 | 22.95 | 2.79 | 23.5 |
| 8 | 69 | 23.76 | 2.90 | 17.1 |
| 9 | 62 | 25.02 | 2.48 | 21.4 |
| 10 | 37 | 20.97 | 1.76 | 21.4 |
| Mean | 60 | 24.22 | 2.46 | 26.1 |
| S.D | | | | 6.13 |

TABLE 28

DATA FROM RATS FED A DIET IN WHICH 10% PROTEIN WAS SUPPLIED BY CASEIN AND WHICH CONTAINED 8% FAT

| Rat No. | Weight gain (g) | Protein consumed (g) | PER | Blood Urea Nitrogen (mg/dl) |
|---|---|---|---|---|
| 1 | 138 | 44 | 3.14 | 30 |
| 2 | 94 | 32 | 2.93 | 28 |
| 3 | 130 | 39 | 3.33 | 34 |
| 4 | 143 | 41 | 3.49 | 28 |
| 5 | 115 | 37 | 3.11 | 28 |
| 6 | 117 | 37 | 3.16 | 39 |
| 7 | 137 | 39 | 3.51 | 47 |
| 8 | 109 | 35 | 3.11 | 43 |
| 9 | 99 | 32 | 3.09 | 43 |
| 10 | 138 | 41 | 3.37 | 21 |
| Mean | 122 | 38 | 3.22 | 34.1 |
| S.D | | | | 8.49 |
| Adjusted PER | | | 2.50 | |

TABLE 29

DATA FROM RATS FED A DIET IN WHICH 10% PROTEIN WAS SUPPLIED BY CASEIN AND WHICH CONTAINED 18% FAT

| Rat No. | Weight gain (g) | Protein consumed (g) | PER | Blood Urea Nitrogen (mg/dl) |
|---|---|---|---|---|
| 1 | 122 | 37 | 3.30 | 17 |
| 2 | 95 | 30 | 3.17 | 13 |
| 3 | 121 | 40 | 3.03 | 26 |
| 4 | 72 | 31 | 2.32 | 30 |
| 5 | 129 | 39 | 3.31 | 21 |
| 6 | 90 | 34 | 2.65 | 17 |
| 7 | 86 | 28 | 3.07 | 26 |
| 8 | 89 | 34 | 2.62 | 26 |
| 9 | 131 | 42 | 3.12 | 17 |
| 10 | 117 | 36 | 3.25 | 26 |
| Mean | 105 | 35 | 2.98 | 21.9 |
| S.D | | | | 5.62 |

TABLE 30

DATA FROM RATS FED A DIET IN WHICH 10% PROTEIN WAS SUPPLIED BY CASEIN AND WHICH CONTAINED 25% FAT

| Rat No. | Weight gain (g) | Protein consumed (g) | PER | Blood Urea Nitrogen (mg/dl) |
|---|---|---|---|---|
| 1 | 86 | 25 | 3.44 | 36 |
| 2 | 67 | 25 | 2.68 | 39 |
| 3 | 68 | 25 | 2.72 | 47 |
| 4 | 44 | 18 | 2.44 | 34 |
| 5 | 99 | 31 | 3.19 | 21 |
| 6 | 71 | 26 | 2.54 | 36 |
| 7 | 61 | 23 | 2.65 | 47 |
| 8 | 91 | 28 | 3.25 | 34 |
| 9 | 66 | 28 | 2.36 | 24 |
| 10 | 63 | 26 | 2.42 | 36 |
| Mean | 72 | 26 | 2.77 | 35.4 |
| S.D | | | | 8.32 |

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