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# Biological Evaluation of Protein Quality of Extruded Soybean and Plantain Blends

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**Abstract:** Soybeans (Glycine max Merr) were dehulled and a batch was fermented before subjecting all to extrusion cooking. Firm unripe (UP) and firm ripe (RP) plantains were also milled and blended together with the soybeans in different proportion of 0, 25, 50, 75 and 100% respectively. The developed complements were evaluated for nutritional quality using albino rats as experimental animals. The values of Protein Efficiency Ratio (PER), Food Efficiency Ratio (FER), Net Protein Retention (NPR), Protein Retention Efficiency (PRE) were significantly different in both unripe and ripe plantain without additional protein source. There were negative growth rate in UP and RP relative to all the other blends. All organ weights of UP and some in RP were significantly different from others. There exist variation in the weight of organs in relation to various diets. Although there were no significant differences in the organs of rats fed with blends relative to those fed the casein diet. Non-fermented soybean compared favourably with other blends which is an indication that extrusion cooking could have reduced antinutritional factors in raw soybean.

**Key words:** Nutritional evalution, extrusion, *Glycine max*, *Musa aab*

## INTRODUCTION

Usually, most traditional African weaning foods are inadequate in energy and protein, which has been a major cause of protein-energy malnutrition in pre-school children in Nigeria[1,2]. The situation has been worsened in recent years by the Economic downturn with a substantial proportion of the population living below the poverty line.

The principle of complementality has been utilized in the production of high protein-energy complementary foods from locally available legumes with cereals or starchy crops[3,4]. Unfortunately, the presence of naturally occurring antinutritional factors including; protease inhibitors, haemaglutinnins, tannins and phytates impair the utilization of legumes including soybean.

Legumes or cereals may be fermented separately or together before use in complementary food formulations to increase digestibility and reduce antinutritional factors[5-7]. Fermentation increase the bioavailability of minerals in cereals and legumes by decreasing phytic acid as a result of the action of phytase synthesized by micro-organisms [8]. The demand for plantain has increased and application in weaning and bakery products has been reported[9, 10]. Extrusion cooking under high temperature and pressure is a more recent method of processing soybeans[11]. Whole, dehulled soybean concentrate or isolate and their blends with other starchy foods have been extruded[12,13]. The proximate composition and properties of extruded soybean with plantain flour blend has been reported[14]. Hence, there is need for scientific report on nutritional and health effects of extruded soybean and plantain products. This study reports the biological evaluation of quality of the protein of the extruded/fermented soybean and plantain blends.

## MATERIALS AND METHODS

Freshly cut, mature unripe and ripe plantains were obtained from a farm in Akure. Soybean was purchased from Oja-Oba in Akure, Nigeria.

**Production of extruded soybean with plantain flour blends:** The plantain separately (i.e., mature unripe and ripe plantain) were peeled, sliced and oven dried at 80°C for 12 h using a Forced-Air Labcon oven. The dried plantain slices were milled into flour using a hammer mill and were packaged separately inside polythene bags. The soybean was picked to remove extraneous materials like stones, dehulled, washed and drained. A batch of it was fermented (uncontrolled fermentation) after which it was oven dried. The other batch was not fermented before oven drying. The soybeans were then extruded at a high temperature of about 140-150°C using a single screw extruder Insta-Pro 600 JR Model (Insta-Pro International St. Ltd. IA USA) at 1750 rpm. After extrusion, the two extruded samples were mixed separately with the unripe and ripe plantain flour respectively at ratio 0, 25, 50, 75 and 100. The resultant samples were packed, coded and stored for further analysis.

Experimental and control isonitrogenous diets containing 7% protein were prepared by incorporating the complementary foods and casein (control) into a basal diet prepared with modification as described[15]: plantain (64.8%), glucose (5%), sucrose (10%), cellulose (5%), vegetable oil (10%), premix (2%), oyster shell (1%), bonemeal (2%) and sodium chloride (0.2%). The diets (experimental and control) were fed to 51 weanling albino rats 26-30 days old weighing 20-100 g, randomly distributed into groups with three replicates each. The rats were housed in individual metabolic cages and water and diets were given *Ad libitum* for 21 days.

Feed consumption and live weights of the rats were recorded. At the end of the test period, the animals were reweighed, killed with chloroform which the liver, heart, kidney and pancreas were quickly excised and weighed. The Food Efficiency Ratio (FER), Protein Efficiency Ratio (PER), the Net Protein Retention (NPR) and protein retention efficiency PRE were calculated[16,17].

## RESULTS AND DISCUSSION

Data on feed intake, weight gain, Food Efficiency Ratio (FER), Protein Efficiency Ratio (PER) and Net Protein Ratio (NPR) of rats fed various extruded and fermented diets are presented in Table 1. Gain in body weight of rats was highest (45.7 g) in the fermented extruded soybean with unripe plantain flour at 75% (FU$_1$). Generally, gain in body weight was observed in all the diets except both unripe and ripe plantain.

There were significant differences in weight gain and rats placed on fermented extruded soybean products revealed better trend in weight gain than non-fermented. This may be as a result of better assimilation. There was no significant difference in PER of blends. Similar results were obtained by[18]. Protein efficiency ratios of 0.60, 0.70 and 1.70 for Nutogi, soy-ogi and cerelac, respectively were reported by[19].

Similar trend was observed in NPR with the highest value (0.35) recorded for NF, FU and FU$_2$. Significant differences were reported[20] in NPR values of rats wheat-based supplements relative to bajra, cerelac and casein. However, no significant difference was reported in NPR values in the work of[21] when rats were fed maized-based complementary foods enriched with tempe. Since PRE is obtained by multiplying NPR by 16, the trend of results obtained is similar to that of NPR (Table 1).

The NPR of casein observed during the present study was lower than that estimated by the workers. NPR is a more accurate measure of protein quality than PRE as it allows the evaluation of maintenance requirement and results are independent of food intake.

Despite the high feed intake in both unripe (UP) and ripe (RP) plantain, there was negative growth rate because of its low content of some essential amino acids or chemical score. This reflects low level of synthesis and

Table 1: Biological response of rats fed with extruded soybean products with plantain blends

| Group | Feed in take | Protein in take | Weight gain | FER | PER | NPR | PRE | Feed conversion |
|---|---|---|---|---|---|---|---|---|
| NF$_o$ | 213.97±17.88$^{bcd}$ | 149.78±12.52$^{bcd}$ | 39.53±11.44$^{cd}$ | 0.18±0.04$^{d}$ | 0.26±0.06$^{b}$ | 0.35±0.04 | 5.63±10.62 | 6.14±11.42$^{b}$ |
| NFU$_1$ | 242.45±22.91$^{d}$ | 169.72±16.04$^{d}$ | 26.28±7.73$^{bcd}$ | 0.11±0.02$^{bcd}$ | 0.15±0.03$^{b}$ | 0.25±0.09 | 3.95±1.39 | 9.82±2.02$^{b}$ |
| NFU$_2$ | 212.40±13.00$^{bcd}$ | 148.68±9.10$^{bcd}$ | 26.81±9.15$^{bcd}$ | 0.13±0.04$^{bcd}$ | 0.18±0.06$^{b}$ | 0.27±0.09 | 4.30±1.44 | 11.28±5.19$^{bc}$ |
| NFU$_3$ | 229.83±16.78$^{bcd}$ | 160.88±11.74$^{bcd}$ | 36.35.11.34$^{cd}$ | 0.16±0.05$^{bcd}$ | 0.22±0.08$^{b}$ | 0.32±0.07 | 5.14±1.14 | 7.41±1.79$^{b}$ |
| FO | 168.96±9.52$^{a}$ | 118.27±6.67 | 13.88±1.75$^{b}$ | 0.08±0.01$^{bc}$ | 0.12±0.01$^{b}$ | 0.24±0.07 | 3.84±1.14 | 11.80±1.57$^{bc}$ |
| FU$_1$ | 245.71±3.92$^{d}$ | 172.00±2.75$^{d}$ | 45.74±4.43$^{d}$ | 0.19±0.02$^{d}$ | 0.27±0.03$^{b}$ | 0.35±0.06 | 5.56±0.99 | 5.49±0.64$^{b}$ |
| FU$_2$ | 194.18±5.91$^{ab}$ | 135.93±4.13$^{ab}$ | 31.89±3.03$^{bcd}$ | 0.16±0.01$^{cd}$ | 0.23±0.02$^{b}$ | 0.35±0.06 | 5.35±1.01 | 6.19±0.59$^{b}$ |
| FU$_3$ | 201.67±6.28$^{abc}$ | 141.17±4.39$^{abc}$ | 18.47±0.53$^{bc}$ | 0.09±0.01$^{bcd}$ | 0.13±0.01$^{b}$ | 0.23±0.04 | 3.66±0.64 | 11.19±0.49$^{bc}$ |
| UP | 208.83±7.00$^{bcd}$ | 146.18±4.90$^{bcd}$ | -14.02±7.04$^{a}$ | -0.10±0.06$^{a}$ | -43±0.38$^{a}$ | - | - | -22.24±7.47$^{a}$ |
| RP | 198.83±12.51$^{ab}$ | 139.18±8.76$^{ab}$ | -14.20±2.71$^{a}$ | -0.07±0.01$^{a}$ | -07±0.03$^{a}$ | - | - | -14.96±2.51$^{a}$ |
| NFR$_1$ | 202.37±10.30$^{abc}$ | 141.66±7.21$^{abc}$ | 25.00±4.00$^{bcd}$ | 0.12±0.01$^{bcd}$ | 0.17±0.02$^{b}$ | 0.28±0.01 | 4.42±0.20 | 8.46±1.15$^{b}$ |
| NFR$_2$ | 228.38±9.96$^{bcd}$ | 159.87±6.97$^{bcd}$ | 32.67±9.33$^{bcd}$ | 0.14±0.04$^{bcd}$ | 0.19±0.07$^{b}$ | 0.30±0.07 | 4.65±1.15 | 8.89±3.33$^{b}$ |
| NFR$_3$ | 229.60±8.79$^{bcd}$ | 160.72±6.15$^{bcd}$ | 22.21±5.79$^{bc}$ | 0.10±0.02$^{bcd}$ | 0.14±0.02$^{b}$ | 0.22±0.02 | 3.59±0.36 | 12.34±3.85$^{bc}$ |
| FR$_1$ | 242.59±8.93$^{d}$ | 166.54±6.79$^{cd}$ | 33.08±6.52$^{bcd}$ | 0.13±0.22$^{bcd}$ | 0.20±0.03$^{b}$ | 0.28±0.05 | 4.50±0.72 | 6.85±0.53$^{b}$ |
| FR$_2$ | 239.81±7.42$^{cd}$ | 167.87±5.20$^{cd}$ | 33.69±2.64$^{bcd}$ | 0.14±0.01$^{bcd}$ | 0.20±0.01$^{b}$ | 0.28±0.02 | 4.61±0.31 | 7.18±0.44$^{b}$ |
| FR$_3$ | 208.04±14.35$^{bcd}$ | 145.63±10.04$^{bcd}$ | 21.69±2.87$^{bc}$ | 0.11±0.02$^{bcd}$ | 0.15±0.02$^{b}$ | 0.25±0.02 | 3.98±0.29 | 9.94±1.51$^{b}$ |
| Casein | 214.55±9.53$^{bcd}$ | 150.19±6.67$^{bcd}$ | 12.93±1.63$^{b}$ | 0.06±0.01$^{b}$ | 0.09±0.01$^{b}$ | 0.18±0.01 | 2.88±0.08 | 19.51±3.31$^{c}$ |

Mean±standard deviation for three determinations, Means within a column with the same superscript were not significantly different (>0.05), Fo = 100% fermented soybeans (extruded) NF$_o$ = 100% non-fermented soybeans (extruded), RS = 100% soybeans flour UP = 100% unripe plantain flour, RP = 100% ripe plantain flour FU$_1$ = 25% fermented soybean (extruded)+75% unripe plantain, FU$_2$ = 50% fermented soybean (extruded)+50% unripe plantain FU$_3$ = 75% fermented soybean, (extruded)+25% unripe plantain, NFU$_1$ = 25% non-fermented soybean (extruded)+75% unripe plantain, NFU$_2$ = 50% non-fermented soybean (extruded)+50% unripe plantain, NFU$_3$ = 75% non-fermented soybean (extruded)+25% unripe plantain, FR$_1$ = 25% fermented soybean (extruded)+75% ripe plantain, FR$_2$ = 50% fermented soybean (extruded)+50% ripe plantain, FR$_3$ = 75% fermented soybean (extruded)+25% ripe plantain, NFR$_1$ = 25% non-fermented soybean (extruded)+75% ripe plantain, NFR$_2$ = 50% non-fermented soybean (extruded)+50% ripe plantain, NFR$_3$=75% non-fermented soybean (extruded)+25% ripe plantain

Table 2: Weight (g) of liver, heart, kidney and pancreas of rats fed with various blends of extruded soybean and plantain

| Groups | Liver | Heart | Kidney | Pancreas |
|---|---|---|---|---|
| NF0 | $3.40\pm0.44^{abc}$ | $0.30\pm0.05^{ab}$ | $0.71\pm0.03^{bc}$ | $0.32\pm0.05^{ab}$ |
| $NFU_1$ | $3.06\pm0.85^{abc}$ | $0.31\pm0.10^{ab}$ | $0.74\pm0.15^{bc}$ | $0.33\pm0.16^{ab}$ |
| $NFU_2$ | $4.00\pm0.83^{c}$ | $0.35\pm0.04^{ab}$ | $0.72\pm0.08^{bc}$ | $0.39\pm0.06^{b}$ |
| $NFU_3$ | $3.91\pm0.43^{abc}$ | $0.35\pm0.11^{b}$ | $0.77\pm0.05^{bc}$ | $0.30\pm0.04^{ab}$ |
| F0 | $2.43\pm0.36^{abc}$ | $0.27\pm0.04^{ab}$ | $0.51\pm0.08^{ab}$ | $0.26\pm0.07^{ab}$ |
| $FU_1$ | $3.59\pm0.49^{bc}$ | $0.31\pm0.06^{ab}$ | $0.66\pm0.07^{bc}$ | $0.30\pm0.06^{ab}$ |
| $FU_2$ | $2.59\pm0.12^{abc}$ | $0.27\pm0.04^{ab}$ | $0.52\pm0.01^{ab}$ | $0.19\pm0.01^{ab}$ |
| $FU_3$ | $3.07\pm0.57^{c}$ | $0.28\pm0.04^{ab}$ | $0.65\pm0.08^{bc}$ | $0.24\pm0.06^{ab}$ |
| UP | $1.86\pm0.45^{a}$ | $0.21\pm0.04^{a}$ | $0.39\pm0.04^{a}$ | $0.15\pm0.06^{a}$ |
| RP | $2.11\pm0.11^{ab}$ | $0.24\pm0.02^{ab}$ | $0.39\pm0.08^{a}$ | $0.23\pm0.03^{ab}$ |
| $NFR_1$ | $3.64\pm0.38^{bc}$ | $0.29\pm0.03^{ab}$ | $0.60\pm0.06^{abc}$ | $0.34\pm0.10^{ab}$ |
| $NFR_2$ | $4.01\pm0.72^{c}$ | $0.32\pm0.04^{ab}$ | $0.80\pm0.13^{c}$ | $0.35\pm0.05^{ab}$ |
| $NFR_3$ | $3.79\pm0.74^{c}$ | $0.38\pm0.06^{b}$ | $0.78\pm0.04^{c}$ | $0.31\pm0.09^{ab}$ |
| $FR_1$ | $3.27\pm0.27^{c}$ | $0.24\pm0.02^{ab}$ | $0.62\pm0.01^{abc}$ | $0.33\pm0.07^{ab}$ |
| $FR_2$ | $3.87\pm0.40^{c}$ | $0.30\pm0.03^{ab}$ | $0.72\pm0.04^{bc}$ | $0.30\pm0.06^{ab}$ |
| $FR_3$ | $3.10\pm0.48^{abc}$ | $0.34\pm0.06^{ab}$ | $0.71\pm0.14^{bc}$ | $0.28\pm0.05^{a}$ |
| Casein | $2.79\pm0.53^{abc}$ | $0.23\pm0.018^{ab}$ | $0.62\pm0.09^{abc}$ | $0.17\pm0.03^{ab}$ |

Mean±standard deviation for three determination, Means within a column with the same superscript were not significantly different ($p>0.05$), Sample codes same as in Table 1, Fo = 100% fermented soybeans (extruded) $NF_o$ = 100% non-fermented soybeans (extruded), RS = 100% soybeans flour UP = 100% unripe plantain flour, RP = 100% ripe plantain flour $FU_1$ = 25% fermented soybean (extruded)+75% unripe plantain, $FU_2$ = 50% fermented soybean (extruded)+50% unripe plantain $FU_3$ = 75% fermented soybean, (extruded)+25% unripe plantain, $NFU_1$ = 25% non-fermented soybean (extruded)+75% unripe plantain, $NFU_2$ = 50% non-fermented soybean (extruded)+50% unripe plantain, $NFU_3$ = 75% non-fermented soybean (extruded)+25% unripe plantain, $FR_1$ = 25% fermented soybean (extruded)+75% ripe plantain, $FR_2$ = 50% fermented soybean (extruded)+50% ripe plantain, $FR_3$ = 75% fermented soybean (extruded)+25% ripe plantain, $NFR_1$ = 25% non-fermented soybean (extruded)+75% ripe plantain, $NFR_2$ = 50% non-fermented soybean (extruded)+50% ripe plantain, $NFR_3$ = 75% non-fermented soybean (extruded)+25

indicated that most of the absorbed amino acids were catabolised to urea due to poor amino acid balance.

The result of the weight of the internal organs excised from the rats fed the various blends of extruded soybeans with plantain blends is presented in Table 2. For liver, rats fed with the unripe plantain had the least weight (1.86 g) while the group fed with 50% soybean and plantain $NFR_2$ had the highest weight (4.01 g). The least weights (0.39 g) for kidney were recorded in both unripe a nd ripe plantains. The highest value (0.80 g) was recorded for $NFR_2$ pancreas ranged between 0.15 and 0.39 g.

The weights of liver ranged between 3.86 and 6.47 g which increased with added methionine level and exceeded the weight (4.80 of the organ on the casein diet as reported by[18] when cowpea powders were dried with graded levels of methionine. Weight of pancreas reported varied from 0.25 to 0.54 g. The pancreas of only the raw cowpea was associated with cellular abnormalities. All other diets produced histologically normal pancreas.

All organ weights of Unripe Plantain (UP) were significantly different with some in Ripe Plantain (RP). There exist variations in the weight of organs in relation to various diets. Although there were no significant differences in the organs of rat fed with blends relative to those fed the casein diet.

## CONCLUSION

Plantains fortified with extruded soybean had the advantage of increased protein qualify content. Extruded soybean products either fermented or non-fermented can be incorporated into the much-needed human nutritional programmes in developing countries instead of being fed to animals.

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