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Efficacy of Fungus Enhancement of Cassava Products and Yam Flour on the Economic Analysis, Performance Characteristics and Blood Parameters of White Albino Rats

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Abstract

Cassava and yam tubers have been exploited as a raw material for human food production, animal feed, industrial use and alternative fuels. Considering the importance and increasing demand of these food due to the quest for cheaper staple food in Nigeria, its increasing consumption could result in malnutrition due to the poor protein content (1-2%). Hence, this study examined the economic analysis, nutritional content and the feeding values of the improved products on the performance features of white Albino rats (n= 180). The cassava flakes, cassava flour and yam flour were processed from freshly harvested cassava tuber and yam tuber respectively before mixed with soyabean flour and then inoculated with the fungus (*Rhizopus oligosporus*) spores. Nine (9) experimental diets were formulated as Treatments A (25% Soyabean flour and 75% Cassava flour) B (100% Cassava flakes) C (50% Soyabean flour and 50% Cassava flakes) D (75% Soyabean flour and 25% Yam flour) E (100% Cassava flour) F (50% Soyabean flour and 50% Cassava flour) G (50% Soyabean flour and 50% Yam flour) H (100% Yam flour) and I (75% Soyabean flour and 25% Cassava flakes). One hundred and eighty (180) Albino rats were purchased for the experiment and randomized against the prepared diets in a Completely Randomized Design experiment with Twenty (20) rats per Treatment. The rats were housed in plastic cages, fed and watered for three (3) weeks *ad libitum*. The result showed significant ($p<0.05$) differences among the parameters measured with highest significant ($P<0.05$) Crude protein content noted for Dietary Treatments G (16.73%) and I (15.02%) and lowest for Dietary

Treatment H. Contrarily, dietary Treatment E was significantly (P<0.05) highest in Crude fibre (0.73%). Additionally, Dietary Treatment F recorded significantly (P<0.05) highest Ether extract and Ash contents. Animals on Dietary Treatment I had the highest feed intake and weight gain compared with other Dietary Treatments. The haematological parameters and Serum indices fell within the normal ranges needed for animal of such age and group. Additionally, the Economic Conversion Ratio (ECR) was best for Dietary Treatments D and G indicating greater economic efficiency leading to increased profitability for farmers and producers. It was concluded that feeding improved protein content of cassava products and yam flour-based diets elicit no negative response in general performance and blood profile of the experimental rats. The study recommended a combination of fungus fermented 75% Soyabean meal and 25% Cassava flake for best production and economic profitability as a key driver for SDG advocacy for zero hunger and end poverty.

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Key words: Albino rats, blood profile, cassava, economic conversion ratio, feed intake, flour, weight gain, yam

Introduction

Cassava (*Manihot esculenta Crantz*) is a drought tolerant, staple food crop grown in tropical and subtropical areas where many people are afflicted with under nutrition and thus, it could be used as potentially valuable food source for developing countries (Adugna, 2019). Cassava can be cultivated in both tropical and subtropical regions and has become a staple food in those regions, because it is able to thrive without irrigation in areas where the dry season is between 1 and 5 months and there is increasing demand due to the quest for cheaper staple foods in urban centres (Kusumayanti *et al.,* 2015, Dudu *et al.,* 2019). Cassava has been exploited as a raw material for human food production, animal feed, industry, and alternative fuels. In Nigeria, most Cassava is processed into various forms for human consumption (lafun, gari, achicha, akpu and puraka and tapioca) (Okechukwu and Okoye 2010). Cassava roots have high carbohydrates content, with a carbohydrate yield of 40% which is 20% higher than in rice and corn, respectively (Bala *et al.*, 2015). But with poor protein content (1–2%) hence, excessive consumption of cassava products without adequate protein supplementation will lead to malnutrition. A practical method of solving the malnutritional problem is to enrich the cassava flour to be used in the production of various cassava products.

Soyabeans which is rich in protein (40% protein) and its functional properties makes it an excellent candidate to be used in enriching Yam and Cassava products. There is also a dearth of information on the inoculation of soyabeans/cassava flour blends with fungus (*Rhizopus oligosporus*). *Rhizopus oligosporus* was used to ferment Soyabeans in Indonesia for the production of Tempeh which is an Indonesia cuisine. Tempeh was noted to have lots of health benefits (Nout, 2015).

Hence, the thrust of the study was to determine the proximate composition of *Rhizopus oligosporus* fermented soyabean and cassava flour blends, and to evaluate the fungus treated blends on the economic and performance characteristics of White Albino rats

Cassava Flakes (*Gari*) is a lactic acid–fermented product of Cassava root that can be processed with palm oil rich in carotenoid ("yellow gari") or without palm oil. In Nigeria, *gari* is widely acceptable and consumed by both the poor, the middle men or average Nigerian, and also the rich because it serves as a major source of carbohydrate. *Gari* can be taken in various forms; some people use it to make *eba* or soak inside water along with groundnut, mashed beans, or bean cake (*akara*). In Ghana, gari is judged by its taste and grain size. The sweeter types with finer grains are more valued over sourer, large grain varieties (Ofori-Mensah, 2018). The major problem of consuming *gari* is the toxicity which may arise from poor processing of Cassava which is rich in cyanogenic glucosides. Consumption of cyanide and its accumulation in human body normally lead to neurological disorders and goiter (Ojo and Akande 2013). Cyanide has been found to be greatly reduced during the processing of Cassava into *gari*.

The Unit operation such as peeling, washing, grating, fermentation, dewatering, and roasting have been found to effectively reduce the residual cyanide contents of the product (Ojo and Akande 2013). Chijioke *et al.* (2010) reported that the traditional method of *gari* production which requires the cassava slurry to be fermented for 72 h during which the cyanides (linamarin and lotaustralin) are hydrolyzed by linamarase enzyme to yield hydrocyanic acid which has low boiling point and easily escape during roasting and this rendered the *gari* safe for consumption. Cutting corners by so many processors for the sake of profit has led to production of *gari* with excess cyanide content (Ojo and Akande, 2013).

Cassava flour (Lafun) is another powdery form of Cassava in Nigeria. Cassava flour when used as a dry powder makes what Yoruba people called Amala-lafun. Lafun made from Cassava free from gluten and a good source of dietary proteins and vitamin-K (Dudu *et al*., 2019). It is rich in a variety of nutrients, including fibers, vitamins, and minerals, and is widely used in the feed, food, and chemical industries (Adesina and Bolaji, 2013).

Yam flour is another important source of food carbohydrate in Nigeria made from yam (Dioscorea species). Yam is a nutritional staple food during times of famine, contains several health-improving nutrients (Lolge *et al*., 2022). After Potatoes, Cassava and Sweet potatoes, it is regarded as the fourth-most significant tuber crop (Lolge *et al*., 2022). Yam contributes about 10% to the total production of roots and tubers in the world. Yam is a popular starchy tuber enjoyed in most parts of the globe (Lolge *et al*., 2022). It can be barbecued, roasted, fried, grilled boiled, grated or converted to flour for use in making yam dough meal locally known as 'swallow'. Yam flour also called Elubo in Yoruba (Nigeria) is simply instant 'raw' yam powder which was created as a way to preserve yam for a long period of time. The flour is usually brown in colour which turns dark brown when stirred in hot water to form of dough popularly called Amala in Yoruba culture. Amala is high in dietary fibre, which helps reduce low-density lipoproteins (one of the carriers of cholesterol). This helps reduce any heart related conditions that high cholesterol in the body can cause. It is highly recommended for people with diabetes as it contains a low glycemic index that will help avoid a rapid increase in glucose level (Lolge *et al*., 2022).

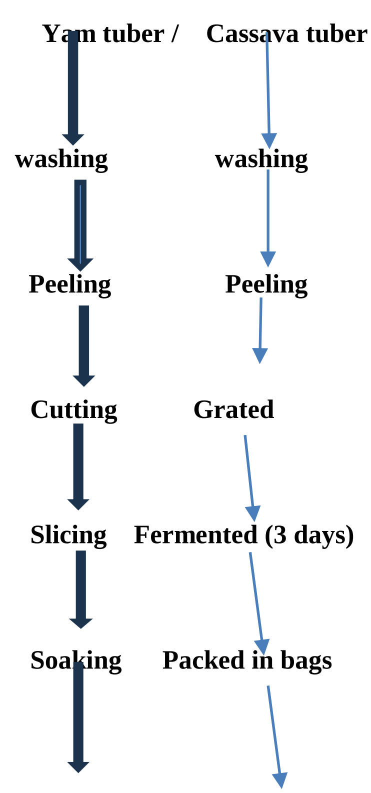
Additionally, yam contains bioactive elements which provide health benefits beyond nutrition (Lolge *et al*., 2022) and these chemicals have a wide range of health advantages from treating degenerative diseases to preventing them. Recently, there have been additional advancements in the therapeutic use of yam compounds including diosgenin and dioscorin (Bailpattar, 2022). The paste prepared from yam flour is used as folk remedy over stomache in south India. Also, wheat flour can be replaced by yam flour up to certain extent in the preparation of chapati. It also acts as a thickener in soups and gravies (Lolge *et al*., 2022).

However, considering the importance of these food materials couple with their nutrients composition there is no doubt in their feeding value. Nevertheless, improving their nutrient composition for enhancing their feeding value cannot be over- emphasized. Hence, the thrust of this study was to evaluate the nutritional efficacy of *Rhizopus oligosporus* fermented Cassava products and Yam flour and their suitability for human consumption using White Albino rat bio-assay.

Materials and Method

Experimental site and duration

The experiment was carried out at Faculty of Agriculture Teaching and Research Farm, University of Ilorin, Ilorin, Kwara State. University of Ilorin is located at latitude 8.482^0, longitude 4.32^0 and elevation of 330m with a mean annual temperature of between 21 and 38^OC and mean annual rainfall of 1,200 millimeters (Olaniran, 2002)



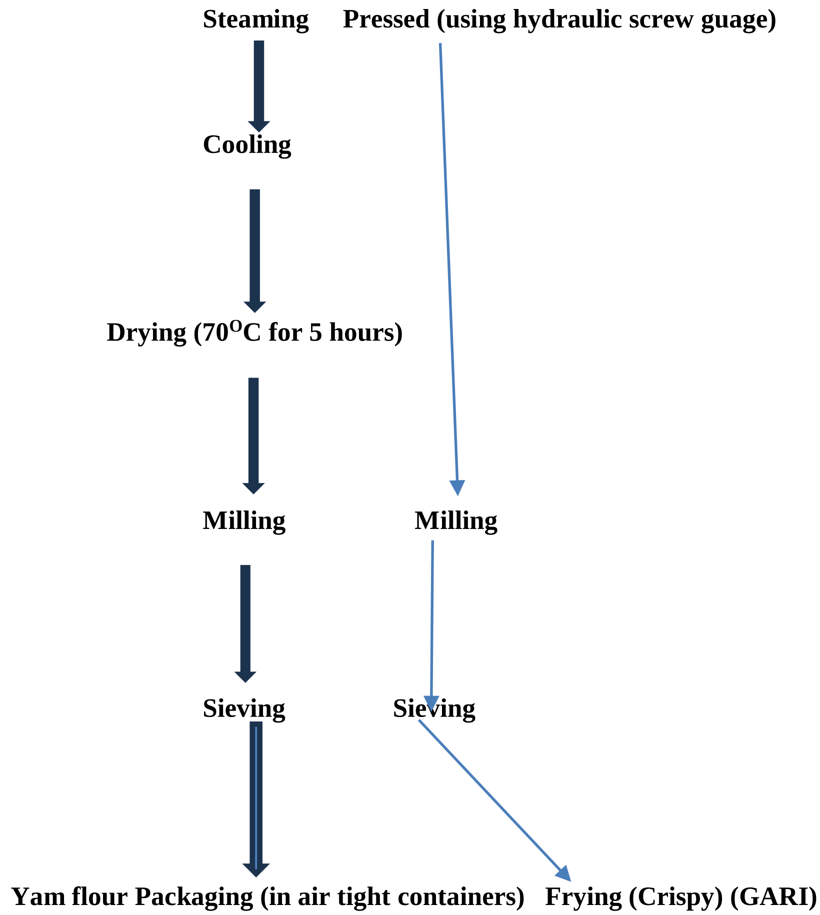
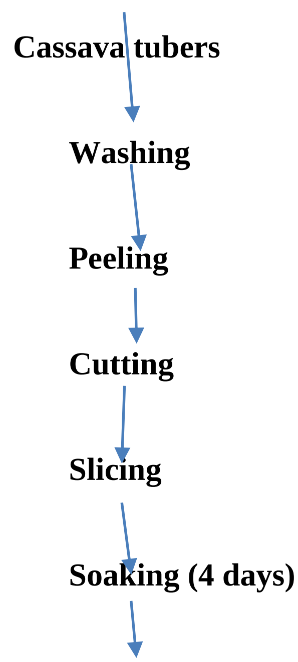


Fig 1: FLOW CHART OF YAM FLOUR & CASSAVA FLAKES (GARI)



Cutting into small pieces

↓

Sun drying

↓

Milling

↓

Sieving

↓

Packaging {Cassava Flour (Elubo lafun)}

Fig 2: FLOW CHART OF CASAVA FLOUR (Elubo lafun)

Preparation of Cassava Flour (Gari)

The flake was prepared from fresh harvested Cassava tuber. The tubers were washed thoroughly, hand peeled and grated. The cassava mash was fermented in a container for 3 days before it was packed in bags to drain the water using hydraulic screw gauge. The resulting cake was milled into smaller pieces known as grit which was sieved and then fried until it was dry and crispy which gave the flakes (Gari) (Fig 1).

Preparation of Yam Flour

Harvested yam tubers were peeled, sliced, soaked, steamed, cooled and dried in oven at 70^{o}C for 5 days. The dried sliced tubers were milled into flour and thereafter sieved to achieve a uniform texture (Fig 1)

Preparation of Cassava Flour (Elubo lafun)

Fresh harvested cassava tubers were cleaned of dirties and sand, manually peeled and later washed in tap water, later cut into uniform chunks and steeped in water for 4 days @30 ± 2^{O}C for fermentation. During the fermentation the water was changed at 24 hours interval until the tubers became soft. The soft tubers were hand peeled and crushed into smaller pieces, sun dried (until uniform lower moisture was achieved). The dried crush tubers were milled using hammer mill (HM 200 model) into flour and sieved (40mesh sieve, British standard) to get a uniform texture. It was later packed in high density polythene bags (0.77mm thickened), sealed and stored before usage (Fig 2).

Preparation of Soyabean Flour:

Raw soybean was purchased from a market in Ilorin metropolis, picked of debris and stones later washed in tap water and soaked overnight in ordinary water to remove the coat. The bean was then oven dried at 80^{o}C for 5 days. The dried bean was then milled, air dried and sieved.

Collection of Organism and Preparation of Inoculum

The organism used *Rhizopus oligosporus* was obtained from Department of Microbiology, University of Ilorin. The organism was maintained and sub-cultured on PDA (Potato Dextrose Agar) containing in Petri dishes for 4 days. The grown organism was crushed and mixed in little quantity of distilled water for easy usage.

Inoculation and Incubation of substrate: The substrates which consisted of Cassava flake, Cassava flour, Soyabean flour and Yam flour in different proportion (Table 1) were inoculated with the prepared *Rhizopus oligosporus* inoculum. The mixed substrate in varied ratio was inoculated in strata to achieve uniform growth of the organism and incubated for two weeks to allow the organism envelope the substrates. The growth of the organism was terminated by oven drying at 70°C for 24 hours.

Experimental Animals and Management

A total of One hundred and eighty (180) Albino rats used for the experiment were randomized against the prepared diets in a Completely Randomized Design experiment with Twenty (20) rats per Treatment (replicated twice with 10 rats per replicate. The animals were housed in a plastic cage with feed and water trough attached to it. Feed and water were provided *ad-libitum* daily throughout the experimental period of 3 weeks.

Parameters measured

The feed intake and weight gain of the animals were measured at the start and end of the experiment. Blood sample of the animals was also taken at the last week of the experiment for haematology and serum biochemical analyses.

Economic Conversion Ratio was calculated (ECR). Recently, economic evaluation is vital and major driver for utilizing alternative ingredient and it reflects both the biological and economic efficiency of a diet (Rust *et al*. 2012; Ogello *et al*., 2014))

Formula = Feed Intake X Diet Price (₦ /kg) X weight gain (kg /Rat)

Feed Conversion Ratio (FCR): $\frac{\text{Total feed intake}}{\text{Total weight gain}}$

Table 1: Composition of the Experimental Dietary Treatments

Treatments	Soyabean flour (%)	Cassava flake (%) (Gari)	Cassava flour (%) (Lafun)	Yam flour (%) (Elubo)	Total
A	25.00	0.00	75.00	0.00	100.00
B	0.00	100.00	0.00	0.00	100.00
C	50.00	50.00	0.00	0.00	100.00
D	25.00	0.00	0.00	75.00	100.00
E	0.00	0.00	100.00	0.00	100.00
F	50.00	0.00	50.00	0.00	100.00
G	50.00	0.00	0.00	50.00	100.00
H	0.00	0.00	0.00	100.00	100.00
I	25.00	75.00	0.00	0.00	100.00

Chemical Analysis

Chemical analysis of the Treatments was carried out for proximate components using AOAC (2009) method of analysis. The moisture content was determined by oven drying the samples at 106^{O}C. The ether extract was determined using Soxhlet apparatus, the ash content was determined using Muffle furnace at 550-600^{O}C. The Crude protein was determined using Kjeldah method and the Nitrogen value obtained was multiplied by 6.25 and NFE was obtained by calculation, while the blood sample was taken from the Rat by restraining the rats and shaving the legs to expose the veins and blood sample was collected using a small needle of size 20-23G to puncture the vein and the blood collected into capillary tubes (one containing EDTA for haematology parameters and the other without EDTA for serum biochemical analysis and immediately transferred to the laboratory

Determination of White Blood Cell Count (WBC): The counting of total white blood cells (WBC) was done using a diluting fluid (Turks fluid) in a ratio of 1:20 and then counted with a standard Neubauer counting chamber under a light microscope (mcArthur microscope) using a x10 objective in an area of 4sqmm. The cells were seen as small black dots.

Determination of Red Blood Cell Count (RBC) : The red blood cells (RBC) count was done using the conventional method of Dacie and Lewis (2001). Blood was diluted to 1:200 with Hayem's fluid which preserved the corpuscles and then counted with an improved Neubauer counted chamber under a light microscope (Mc Arthur Microscope) using a x40 objective in an area of 1 5 sqmm and their typical pink-red colour was used for their identification.

Statistical Analysis

Data obtained were subjected to Analysis of Variance (ANOVA) of a Completely Randomized Design using SAS statistical package and Duncan Multiple Range Test of the same statistical package was used to separate the mean differences.

Results and Discussion

Proximate composition of Dietary Treatment*

The Proximate composition of the Dietary Treatments fed the experimental Albino Rats is shown in Table 2. There were significant ($p<0.05$) differences in the proximate composition of the diets across the Treatments. The dry matter of Dietary Treatment C (89.45%) was significantly ($p<0.05$) different from dietary Treatment A (88.60%) B (88.76%), D (88.47%), E (88.39%), G (88.36%) and I (87.87%). The high Dry matter content corroborates the submission of Belewu and Ishola (2019) who reported that high Dry matter supported low spoilage capability as well as enhanced feed intake.

The crude protein was significantly ($p<0.05$) highest in Dietary Treatment G (16.73%) followed by Dietary Treatment I (15.02), C (14.58%), D (14.44%) and F (13.11%) which were significantly the same but significantly ($p<0.05$) different from other Dietary Treatments. It is generally known that any food that provides more than 12% of their caloric value from protein is considered to be a good source of protein. The Crude Protein content of Cassava flour was in accordance with the reported value in literature (Imoisi *et al.,* 2024).

Dietary Treatment E (0.73%) was significantly ($p<0.05$) highest in crude fibre while Dietary Treatment I (0.02%) was the least. However, the value was within the acceptable limit needed for Rat.

Meanwhile, the ether extract was significantly ($p<0.05$) highest in Dietary Treatment C (9.00%) followed closely by Dietary Treatments B and F (8.17 and 7.73% respectively) which were significantly ($p<0.05$) the same. The high ether extract content of Dietary Treatments E and F contributed to the palatability of the diet.

The Ash content of Dietary Treatments E and F fell within 1.88 and 2.56% reported by Ayo *et a*l. (2018). The reported high Ether extract and Ash content in this study could be attributed to the combination of Soyabeans and Cassava flour (50: 50). Ash represents the mineral matter left after food material is burnt in oxygen and it is used as a tool to measure the mineral content in any sample. This indicates that the Dietary Treatments have good mineral content, hence, can serve as a viable tool for nutritional evaluation

The Crude fibre content reported herein was lower than the reported values (1.21 -1.42%) of Fatoye and Okunade (2024) the variation may be due to the processing methods.

This proved that the Dietary Treatments contain low crude fiber and that Fibre has some physiological effect in the gastrointestinal track and low fibre in diet is undesirable as it may cause constipation. However, Rats on the diets did not suffer any constipation.

Table 2: Proximate composition of the Dietary Treatments

Treatments	Dry matter (%)	Crude protein (%)	Crude fibre (%)	Ether extract (%)	Total Ash (%)
A	88.60^{b}	10.72^{c}	0.52^{b}	3.28^{e}	1.28^{bc}
B	88.76^{b}	10.24^{c}	0.43^{c}	8.17^{ab}	1.41^{b}
C	89.45^{a}	14.58^{b}	0.34^{de}	9.00^{a}	0.96^{c}
D	88.47^{b}	14.44^{b}	0.37^{d}	6.26^{c}	2.92^{a}
E	88.39^{b}	5.56^{d}	0.73^{a}	2.96^{e}	0.87^{c}
F	88.83^{ab}	13.11^{b}	0.43^{c}	7.73^{b}	2.79^{a}
G	88.36^{b}	16.73^{a}	0.43^{c}	4.77^{d}	0.96^{c}
H	89.02^{ab}	9.41^{c}	0.32^{e}	6.94^{bc}	0.45^{d}
I	87.87^{c}	15.02^{aB}	0.32^{f}	4.46^{d}	1.27^{bc}
±SEM	0.21	1.90	0.03	1.03	0.40

Means with the same superscripts along column are not significantly different ($p>0.05$)
*Determination of six replicates each

Feed intake and Body weight Gain of the Experimental Rats fed the Dietary Treatments

The mean Daily Feed Intake (ADFI) and mean Daily Gain (ADG) of the experimental rats were presented in Table 3. The results showed that the ADFI was significantly ($P<0.05$) different among Dietary Treatments. The Rats fed Dietary Treatment I (13.48) was significantly ($p<0.05$) highest. Follow closely by dietary Treatments G, B, C, H and A (11.54, 11.67, 11.67, 11.37, and 11.33 respectively) which were similar ($P>0.05$) but different significantly ($p<0.05$) from Dietary Treatments F (11.10), D (10.72) and E (10.26). The average daily feed intake observed in this study was in agreement with recent reported values of Augustine *et al.* (2020) who reported average daily intake 10.18-13.05g/day of Albino rat fed processed tropical sickle pod (*Senna obtusifolia*) leaf meal-based diets. The value was lower than 17.45-20.00g/day reported by Onigemo *et al.*, (2020) who fed Albino rat raw and thermally processed loofah gourd seed meal-based diet. Conversely, the average daily feed intake reported herein was higher than 8.58 to 2.14g/day observed by Salifu *et al. (*2015) who fed Albino rat different processed false yam seeds. This implies that the fortified diets were well consumed by the experimental rats.

The Mean Daily Gain (ADG) of the experimental rats was significantly (p<0.05) highest in Dietary Treatments A, I, C, H, (2.21, 1.97, 1.16, 1.16 respectively) and were significantly (p<0.05) different from F (0.91), B (0.86), E (0.29), D (0.24) and G (0.16). The results obtained herein were lower than 3.68-4.42g/day (Augustine *et al.*, 2020) and 4.58-7.55g/day (Onigemo *et al.*, 2020). However, the ADG in this present study were higher than 0.23-1.65g/day (Salifu *et al.*, 2015).

Additionally, the Cost per kg diet was least for Dietary Treatment A compared to other Dietary However, the best Feed Conversion Ratio (FCR) was recorded for Dietary Treatments D and G and the least was Dietary Treatment 1. This shows that Dietary Treatment D and G were more efficiently utilized compared to other Dietary Treatments, (indicating less feed is needed to gain weight) however, the Economic Conversion Ratio (ECR) was best for Dietary Treatment D ($1.61) compared to Dietary Treatment G ($1.73). The ECR reflects both the biological and economic efficiency of a diet (Rust *et al*., 2012). It translates to reduction in feed cost per unit output leading to increased profitability for farmers and producers. Hence, ECR contributes to more sustainable food production practices.

Table 3: Feed intake and Body weight gain of the Experimental rats fed the Dietary Treatments

				Dietary Treatments						
Parameters (g/day)	A	B	C	D	E	F	G	H	I	±SEM
Mean Feed intake	11.33[b]	11.67 [b]	11.67 [b]	10.72 [c]	10.26 [c]	11.10 [c]	11.54 [b]	11.37 [b]	13.48[ab]	0.30
Mean Weight gain	2.21[a]	0.86[b]	1.16[a]	0.24[b]	0.29[b]	0.91[b]	0.16[b]	1.16[a]	1.97[a]	1.33
Cost / kg Diet ($)	0.47	0.69	0.81	0.94	0.63	0.63	0.94	0.94	0.75	
Feed conversion Ratio (FCR)	0.16	0.07	0.10	0.02	0.03	0.08	0.01	0.10	0.17	
Economic Conversion Ratio (ECR) ($/kg)	13.96	6.90	10.10	1.61	1.86	6.30	1.73	12.36	16.74	

$1 = ₦1600.00 (March, 2025)

Haematological parameters of the Rats fed the Dietary Treatments

The blood is a vital and reliable medium for evaluating the physiological and health status of livestock (Nseabasi *et al.*, 2013). Additionally, haematology is the study of the morphology and physiology of blood which helps in detecting some changes in the health and physiological status of livestock (Nseabasi *et al.*, 2013).

The haematology profile of the experimental rats was shown in Table 4. The white blood cell (WBC) of the experimental rats fed the Dietary Treatments were significantly ($p<0.05$) different across the Treatments. Higher WBC value was observed in Dietary Treatments G and H (8.00 and 8.07 respectively) which were significantly ($p<0.05$) different from other Treatments. However, the values were within the acceptable levels for Albino rats. The red blood cell (RBC) of animals on dietary Treatments A (7.05) and G (7.10) were significantly ($p<0.05$) higher than other Treatments while animals fed Dietary Treatment B (5.96) was significantly ($p<0.05$) lowest. The high RBC is advantageous due to the carrying capacity of oxygen to various organs and tissues. However, the values are within the normal range.

It was noted that an alteration in one parameter of the haematology will alternately alters another since according to Schalm *et al* (1975) there is a direct relationship between RBC, PCV and Hemoglobin concentration. Consequently, haematocrit, haemoglobin level and RBC count are used to screen for anaemia. It is noteworthy, that haematological parameters vary due to breeds, sex, reproductive status, age, fitness feeding regime, handling during blood withdrawal, health status and fitness of the animal factors.

The PCV (Heamatocrit) measures the percentage of Red Blood Cell in a blood sample and it also assess blood ability to transport oxygen. The PCV percentage reported herein followed the same trend with animals fed Dietary Treatment G (50.50) was significantly ($p<0.05$) highest followed by animals on Treatment A (48.77) which was not different significantly ($p>0.05$) from each other. Meanwhile, the PCV of animals on treatment A (48.77) and 6 (47.70) were significantly ($p>0.05$) the same but significantly ($p<0.05$) different from animals on Treatment B (40.47), C (42.63), D (45.73), H (43.53), I (44.97) and E (36.47) which was significantly ($p<0.05$) lowest. Furthermore, the haemoglobin (Hb) of the animals on treatment A and I (14.30 and 13.90 respectively) were not significantly ($p>0.05$) different but were significantly ($p<0.05$) different from animals on treatment B, C, E and F (11.50, 12.77, 12.17 and 12.60 respectively) meanwhile, the Hb of animals on treatment A was significantly ($p<0.05$) different from animals on treatment D (13.33), G (13.70) and H (13.33). Haematology profiles response gives an insight on status of the animals that could be due to body damage or stress cause by nutritional plane of the animal.

The increase in PCV, Hb and RBC may possibly be as a result of the level of the ash content of the dietary Treatment may have influenced the haemoglobin synthesis.

The higher values of RBC and associated parameters are suggestive of polycythemia (Pillai *et al*.,2023). Therefore, the diets may not have any adverse effect on the bone marrow, kidney and haemoglobin metabolism. The significant increase ($P<0.05$) noted in the packed cell volume (PCV) and haemoglobin may have likely increased the values of these parameters (PCV and Hb).

The white blood cells for instance, indicate the immune response of the animals which was within the normal range reported by Shehani *et al*.(2018). This implies that every treatment did not affect the immune response of the animal. More so, Eric (2015) reported that body systems of an animal produce more WBCs when there is any abnormality, which was not the case in these findings. Also, the RBC, PCV and Hb of the animals fell within the normal range (6-8x10^^{3}/mm^3, 36-54% and 11-19.20g/dl respectively) reported by Wikivet (2012) which indicate that the animals were not aneamic and the blood oxygen level is normal.

Table 4: Haematological parameters of the Rats fed the Dietary Treatments

Treatment	WBC (x10^3/mm^3)	RBC x10^6/ mm^3)	PCV (%)	HGB (g/dl)
A	6.93^{b}	7.05^{a}	48.77^{ab}	14.30^{a}
B	4.08^{d}	5.96^{c}	40.47^{e}	11.50^{e}
C	4.13^{d}	6.36^{b}	42.63^{de}	12.77^{c}
D	7.00^{b}	6.66^{b}	45.73^{c}	13.33^{b}
E	5.93^{c}	6.92^{a}	36.47^{f}	12.17^{d}
F	5.27^{c}	6.45^{b}	47.70^{bc}	12.60^{cd}
G	8.00^{a}	7.10^{a}	50.60^{a}	13.70^{b}
H	8.07^{a}	6.47^{b}	43.53^{cd}	13.33^{b}
I	4.33^{d}	6.27^{b}	44.97^{c}	13.90^{ab}
±SEM	0.93	0.23	2.60	0.51

Mean with the same superscript along column are not significantly different (p>0.05)

Serum Biochemistry Parameters of the Rats fed the Treatment Diet

The blood serum biochemical parameters were presented in Table 5. The Alanine transaminase (ALT) was significantly (P<0.05) highest in animals on Dietary Treatment C (30.68u/L) which was significantly (P>0.05) the same with animals on Treatment F, H and B (30.00, 29.93 and 29.20u/L respectively) but were significantly (P<0.05) different from animals on other treatments. The ALT level was one of the parameters used to assess the liver condition of an animals, and the values obtained in this study were lower than 37.28-45.73u/l (Onigemo *et al.*, 2020) and close to the normal range values (35-80u/l) reported by Wikivet (2012). This shows that the diets did not pose any threat to the experimental rats. The blood urea was not significantly (P>0.05) different across the treatment. The urea parameter was used as evidence for any form of kidney disorder. The result obtained herein fell within the normal range value 2-10mg/dl (Wikivet, 2012) for normal kidney which implies that all Dietary Treatment had no adverse effects on the urea nitrogen level of the rats. This was also true with report of Brookes and Power (2022) who reported that increased and abnormal creatinine and blood urea nitrogen levels was an evidence of kidney disorder and adrenal dysfunction which was not the case in this study.

Table 5: Serum Biochemistry Parameters of the Rats fed the Dietary Treatments

Treatment	ALT (u/l)	Urea (mg/dl)	TCHOL (mg/dl)	TRIG (mg/dl)	HDLC (mg/dl)	LDLC (mg/dl)
A	26.27^{b}	2.68	64.30^{d}	85.06^{b}	26.46^{b}	20.83^{b}
B	29.20^{a}	2.74	63.47^{d}	84.80^{b}	25.53^{c}	20.97^{b}
C	30.68^{a}	2.33	69.81^{c}	84.42^{b}	26.10^{b}	26.83^{a}
D	26.47^{b}	2.63	64.40^{d}	83.01^{bc}	25.57^{c}	22.22^{b}
E	26.80^{b}	2.54	72.71^{bc}	92.34^{a}	27.92^{a}	26.32^{a}
F	30.00^{a}	2.65	77.37^{b}	83.27^{b}	26.30^{b}	24.41^{ab}
G	24.40^{c}	2.36	68.04^{c}	83.91^{b}	27.60^{a}	23.70^{ab}
H	29.93^{a}	2.32	89.04^{a}	80.20^{c}	25.61^{c}	27.39^{a}
I	26.40^{b}	2.84	65.52^{cd}	76.25^{d}	25.81^{c}	24.46^{ab}
±SEM	1.21	1.59	4.80	2.47	0.51	4.93

Mean with the same superscript along column are not significantly different (p>0.05)
ALT-Alanine transaminase, TCHOL- Total Cholesterol, TRIG-Triglyceride, HDLC-High Density Lipoprotein cholesterol, LDLC-Low Density Lipoprotein Cholesterol

There were significant ($p<0.05$) differences among the mean of total cholesterol level of the experimental rats with animals on diet H (89.04) had the highest cholesterol level and the least was observed in Dietary Treatment B (63.47mg/dl). Meanwhile, all were within the normal range value 80.00-129.52mg/dl (Ihedioha *et al*., 2013) and lower than 94.80-133mg/dl (Onigemo *et al.*, 2020). The triglyceride level was highest in animals on Dietary Treatment E (92.34mg/dl) but was not significantly ($p>0.05$) different from Dietary Treatments A, B, C, D, F, and G, but different significantly ($p<0.05$) from treatment H and I (80.20 and 76.35mg/dl respectively). All were within the normal range values 43-108mg/dl (Ihedioha *et al*., 2013). The LDLC (Lower density lipoprotein cholesterol) obtained in this study was within the normal range 20.28-81.55mg/dl (Ihedioha *et al*., 2013) for rats of that age. The HDLC on the other hand were close to the normal range values of 33.33-66.67mg/dl (Ihedioha *et al*., 2013). This implies that the lipid profile of the Dietary Treatment did not elicit negative effect on the health.

Conclusion

The role of Cassava and Yam as major crops to end poverty resulting in zero hunger has necessitated the needs for nutritional improvement of these crops (Cassava and Yam)

The nutritional content of Cassava and Yam showed their suitability as food products which can be fortified with fungus (*Rhizopus oligosporus*) treated Soyabean.

Conclusively, the results obtained in this study also shows the effectiveness of Solid-state fermentation in enhancing the nutritional content of Cassava and Yam products. This is a key factor for SDG advocacy for zero hunger and end poverty.

Additionally, the study revealed the improved nutritional composition of Cassava and Yam products and their suitability for human consumption and finally recommended fungus fermented Soyabean (25%) and 75% Yam flour for best sustainable food production practices.

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