



## Use of Livestock and Plant Agro-Waste in the Production of Organic Feed and Its Effect on the Physiology of Albino Wistar Rats

\*ONYEGEME-OKERENTA, BM; AMADI, BC; WEGWU, MO

*Department of Biochemistry, Faculty of Science, University of Port Harcourt, Rivers State, Nigeria.*  
*\*Corresponding Author Email: [blissing.onyegeme-okerinta@uniport.edu.ng](mailto:blissing.onyegeme-okerinta@uniport.edu.ng); Tel: +234 (0)803 5201 039*

**ABSTRACT:** The need to consider agricultural wastes as resources for organic feed formulation has been of interest to researchers. This study was aimed at investigating the use of some livestock and plant agro-wastes in the production of organic feed and its effect on the physiology of albino Wistar rats. A total of 30 weaning rats were separated into six (6) different groups with 5 rats per group. Groups 1, 2, and 3 were fed with known commercial feed -Vital, Top and Hybrid feeds respectively. Group 4 was fed with corn only, while Groups 5 and 6 were fed with indigenous formulated feed FF1 and FF2 respectively - derived from some local livestock and agro-waste. Phytochemical constituents and proximate composition of the various feeds were carried out. The animals were fed for 7 weeks during which anthropometric measurement and data were collected. Blood samples were collected via venipuncture after seven weeks for biochemical and haematology analysis. The result of the proximate analysis of the formulated feeds showed protein values of  $30.00 \pm 3.00$  (FF1) and  $22.00 \pm 1.00$  (FF2) as against 18%, 21% and 22% for Vital, Top and Hybrid feeds respectively. The haematology indices showed that the various feeds improved erythropoietic functions. Similarly, the Biochemical functions of the commercial feeds and Formulated diets can support growth and maintain homeostasis. Conclusively, this study has demonstrated an added advantage in the use of agro-wastes and their biotransformation into a cost-effective replacement for commercial feeds.

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Agricultural wastes refer to the residues from the growing and processing of raw agricultural products such as fruits, vegetables, meat, poultry, dairy products, and crops (Obi *et al.*, 2016). Agriculture residues can be divided into field residues and process residues. Field residues are residues that present in the field after the process of crop harvesting. These field residues consist of leaves, stalks, seed pods, and stems, whereas the process residues are residues present even after the crop is processed into an alternate valuable resource (Pardeep *et al.*, 2018). Agricultural wastes are likely to significantly increase globally if developing countries continue to intensify farming systems. It is estimated that about 998 million tons of agricultural waste are produced yearly as a result of the increase in the production of agricultural waste (Agamathu, 2009). The increase in global population imposes great demand on food production which in turn increases the output of agricultural wastes. Although some of the waste is utilized as compost or other functions that yield little economic return, much of it is simply left in fields to be ploughed under or deposited in landfills where it contributes to air pollution, water contamination and public health issues. These challenges require that measures be put

in place for environmentally friendly recycling processes, thus minimizing agro-waste, adding economic value to our agricultural products and protecting the environment through biodegradation. The accumulation of agro-waste may cause health, safety, environmental, and aesthetic concerns. Thus, this represents a problem that requires safe disposal (Soh-Fong and Sylvester, 2014). Because of this incessant increase in the production of agro-wastes which in turn leads to environmental pollution, agricultural waste management (AWM) for ecological agriculture and sustainable development has become an issue of concern for policymakers (Hai *et al.*, 2010). The organic wastes, especially manure generated by animals, if improperly managed or left untreated can result in significant degradation of soil, water and air quality. Stagnant wastes provide a medium in which flies breed and diseases are transmitted. There is a need to consider these wastes as potential resources rather than considering them as undesirable and unwanted, to avoid contamination of air, water, and land resources, and to avoid transmission of hazardous materials. These problems may be circumvented by utilizing residues to feed domesticated animals thereby producing a less expensive feed (Hussein,

\*Corresponding Author Email: [blissing.onyegeme-okerinta@uniport.edu.ng](mailto:blissing.onyegeme-okerinta@uniport.edu.ng); Tel: +234 (0)803 5201 039

2010). This study focuses on the use of livestock and plants agricultural wastes in the production of sustainable organic feed for Wistar rats and the effect of these organic-formulated feed on the physiology of the experimental animals.

## MATERIALS AND METHODS

The reference feeds were bought from known manufacturers of livestock feed products and stored at 25–30 °C to protect them from spoilage. Analytical chemicals and reagents were purchased from Sigma-Aldrich Chemical Company dealers. Items for formulated feeds were purchased from Choba daily market. The Cassava peels (*manihot esculenta*), rice bran, periwinkle shell and bone meal were all ground to a palatable size and sundried.

*Collection and Preparation of Plant Leaf Material:* Adopting the method of Oko and Agiang, (2011), leaves of Plantain (*Musa paradisiaca*), hospital too far (*Jatropha tajorensis*) and pumpkin leave (*Telfairia occidentalis*) were obtained from the Botanical garden of Plant Science and Biotechnology Department, University of Port Harcourt. The plant materials were identified in the Herbarium unit of the same Department by Dr. Ekeke. The leaves were air-dried at room temperature for about fourteen days. The dried leaves were milled into powder form using an electric-blender and stored in an air-tight container before its usage in the formulation of the diets.

*Preparation of Seeds:* The seeds used in this study include: corn, groundnut, soya bean and they were all purchased from local dealers in Choba market in Obio/Akpo local government area in Rivers State. The seeds were carefully sieved to remove impurity and were dried and grounded into semi powder of moderate sizes palatable to the rats. The grounded seeds were stored awaiting formulation of the feed. The Palm Kernel Cake (PKC) used in this research was purchased from major dealers in already processed form and was likewise stored pending feed formulation.

*Experimental Animal:* A total of 30 weaning rats weighing between 70 to 90g were used. They were acquired from Fluidic Medical Sciences animal farm at Aluu, University of Port Harcourt environment. They were housed in a specially designed wooden/wire gauze animal cage and left to acclimatize for seven (7) days before use and were placed on standard feed and given access to water *ad libitum*. The rats were grouped into six of 5 rats each and fed with different diets. Group 1,2 3, and 4 were fed with corn, Vital, Top and Hybrid feeds respectively while Groups 5 and 6 were fed with FF1 and FF2 feeds respectively.

*Formulation of Feed One (FF1):* The method used by Olowookere (1994) was adopted in the formulation of the three feeds. The feed was composed of ground corn (31%) being the major source of carbohydrate, crayfish meal and groundnut at 5% and 40% respectively serving as the main source of protein (Table 1). Rice bran and PKC were the major sources of crude fibre. Approximately 6% of ground *Musa paradisiaca* (plantain) leaf was added to the feed to serve as a source of vitamins and minerals.

*Formulation of Feed Two (FF2):* The main ingredient for this formulation is sorghum which makes up to 31% of the feed is the major source of carbohydrates, bone meal and soya bean 5% and 40% respectively serving as the main source of calcium and also protein. Rice bran and PKC were the major sources of crude fibre and stones (Table 1). Approximately 6% of the feed consist of ground *Telfairia occidentalis* (pumpkin leaf) which were added to the feed to serve as a source of vitamins and minerals.

*Nutritional composition of the Formulated Feeds:* The proximate composition (Table 1) of the formulated feeds was determined following the modified methods as described by Luciano *et al.*, (2016) and Hanne *et al.*, (2018).

**Table 1:** Composition of Formulated Feed One (FF1) and Two (FF2)

| S/N | Feed Component                | FF1          |           | FF2          |           |
|-----|-------------------------------|--------------|-----------|--------------|-----------|
|     |                               | Quantity (%) | Unit (Kg) | Quantity (%) | Unit (Kg) |
| 1   | Corn                          | 31           | 7.75      | -            | -         |
| 2   | Crab meal                     | 11           | 2.75      | -            | -         |
| 3   | PKC                           | 40           | 10        | -            | -         |
| 4   | Groundnut meal                | 6            | 1.5       | -            | -         |
| 5   | <i>Musa paradisiaca</i> Leaf  | 11           | 2.75      | -            | -         |
| 6   | Rice bran                     | 7            | 1.75      | 7            | 1.75      |
| 7   | Sorghum                       | -            | -         | 31           | 7.75      |
| 8   | Bone Meal                     | -            | -         | 5            | 1.25      |
| 8   | Soybean                       | -            | -         | 40           | 10        |
| 10  | Periwinkle Shell              | -            | -         | 11           | 2.75      |
| 11  | <i>Telfairia occidentalis</i> | -            | -         | 6            | 1.5       |

**Blood Sample Collection and analysis:** The blood sample collection process was in line with methods described by Nwosu *et al.* (2014) considering the health and safety of both collectors and subjects. Blood samples (5ml) for each subject were collected intravenously by venipuncture from the ante-cubital vein in the antecubital fossa of the forearm after thorough sterilization of the site with spirit and swab, using sterile needle and syringe into sample bottles. Serum samples were obtained by centrifuging the clotted blood samples at 500 revolutions per minute for 7 minutes and later collected into legibly labelled serum bottles and kept frozen in a refrigerator. The animals were dissected under anaesthesia and the blood samples were collected by venipuncture into heparinized tubes and EDTA bottles. The organs were also collected and washed in 15ml of 10% ethanol and weighed. Haematological indices- RBC, HB, PCV, WBC, PLC and white blood cell differential were carried out according to the method of Dacie and Lewis (2006) while biochemical plasma levels of protein, ALT, AST, ALP Total Bilirubin, Creatinine and Urea concentration were analysed using methods as outlined in Randox assay kits (Randox Laboratories, Crumlin, County Antrim, England). The determination of activities of markers of oxidative stress - SOD, Catalase, MDA and levels of Glutathione were carried out as described by Usoh *et al.*, (2005).

**Data analysis:** Statistical analysis was performed on the data generated, using Analysis of variance (ANOVA) methods. Descriptive analysis was used to determine the mean and standard error of mean (SEM) values. The level of significance was set at 5% ( $p < 0.05$ ).

## RESULT AND DISCUSSION

The proximate analyses of the three formulated feeds were represented in Table 2. The moisture content of the formulated feed 1 (FF1) is the highest followed by FF2. Food spoilage is one major problem of the mass production of feeds. The moisture content is inversely proportional to the degree of spoilage. The ash content is the total mineral content inherent in the formulated feed. FF2 is seen to have the highest ash content followed by FF1. The crude fibre is essential to the digestibility and movement of food in the gastrointestinal tract (GIT). The value recorded for the two formulated feeds is in line with most fibre contents of standard feeds in the market. The lipid content is highest in FF2, its presence in food aid the transport of certain molecules around the body. They are basic components of body structures. The protein content of FF1 and FF2 was in line with that of other standard feeds. The nutritional composition of the commercial feeds is shown in Table 3.

**Table 2.** Proximate Compositions of the Formulated Feeds

| S/N | Formulated feed | Moisture   | Ash       | Crude fibre | Lipid     | Crude protein | Carbohydrate |
|-----|-----------------|------------|-----------|-------------|-----------|---------------|--------------|
| 1   | FF1             | 8.850±1.35 | 0.70±0.10 | 7.05±0.25   | 3.50±0.50 | 30.00±3.00    | 49.90±5.00   |
| 2   | FF2             | 6.55±0.75  | 1.50±0.20 | 3.25±0.35   | 5.50±1.50 | 22.00±1.00    | 61.20±3.100  |

**Table 3.** Nutritional Composition of Commercial Feed

| S/N | Ingredients             | Vital       | Top         | Hybrid      |
|-----|-------------------------|-------------|-------------|-------------|
| 1   | Crude Protein           | 18%         | 21%         | 22%         |
| 2   | Fat/Oil                 | 10%         | 6%          | 5.1%        |
| 3   | Calcium                 | 1.2%        | 1%          | 1.2%        |
| 4   | Phosphate               | 0.45%       | 0.45%       | 0.45%       |
| 5   | Lysine                  |             | 1%          | 1.3%        |
| 6   | Methionine              |             | 0.50%       | 0.56%       |
| 7   | Crude Fibre             | 12%         |             |             |
| 8   | Salt                    |             | 0.30        |             |
| 9   | Metabolize Energy (min) | 3000kcAL/KG | 2800Kcal/kg | 3000kcAL/KG |

The phytochemical composition of every food item is a determinant of its pharmacological properties as these secondary metabolites exhibit different degrees of therapeutic effects. In this research, the FF1 showed high levels of flavonoids, tannin, and phenols with moderate levels of rasin, and alkaloids (Table 4). Other constituents such as glycosides, steroids, oxalate and terpenoids are found in low concentrations. FF2 exhibited high levels of tannin, saponin, glycosides, phenol and oxalate with moderate levels of rasin, terpenoids, flavonoids and alkaloids. The steroid was observed to be low in FF2.

**Table 4.** Phytochemical Composition of the Formulated Feeds

| S/N | Phytochemical        | FF1 | FF2 |
|-----|----------------------|-----|-----|
| 1   | Alkaloids            | ++  | ++  |
| 2   | Flavonoids           | +++ | ++  |
| 3   | Tannin               | +++ | +++ |
| 4   | Cyanogenic glycoside | +   | +++ |
| 5   | Saponin              | +++ | +++ |
| 6   | Terpenoid            | +   | ++  |
| 7   | Phenol               | +++ | +++ |
| 8   | Steroid              | +   | +   |
| 9   | Oxalate              | +   | +++ |
| 10  | Resin                | ++  | ++  |

Key: + = moderately present; ++ = slightly present; +++ = highly positive; - = absent

**Body Weight of Rats Fed with Various Formulated Feeds:** The body weight is part of the anthropometric measurement that aids us to ascertain the physical state or growth rate of the experimental subject. The trend in weight observed in the rats in the first week (Wk1) showed no significant difference within and between the standard feeds and the formulated feeds (Table 5). The second week (Wk2) showed a growth rate in favour of two of the standard feeds (Top and Hybrid) and as well one of the formulated feed (FF1) showing values of  $110.67 \pm 10.96$ ,  $105.44 \pm 11.30$  and  $102.05 \pm 10.63$  respectively. The third week (Wk3) recorded a boost in the growth rate of FF2 having a value of  $134.38 \pm 4.44$ . Though, FF2 still maintain a lead among the feeds with a value of  $161.80 \pm 4.72$  at the end of the seventh week (Wk7) the Hybrid feed emerge highest at  $184.19 \pm 9.12$  followed by Vital feed and FF2  $171.53 \pm 12.58$  and  $170.01 \pm 5.37$  respectively. While Top feed and FF1 had similar values  $149.42 \pm 9.43$  and  $149.07 \pm 3.96$  respectively, the control group feed with corn only recorded the least value  $99.49 \pm 16.86$ . Two out of the three agro-waste formulated feeds showed metabolic rates similar to those of commercial feeds found in the market.

**Biochemical Parameters of Rats Fed with Various Feed:** The result for biochemical parameters of rats fed with various feed is shown in Table 6. The ALT and AST levels for the FF2 fed Group was significantly higher ( $p < 0.05$ ) when compared to all the groups. Also, the AST level for the Group fed with corn was significantly higher ( $p < 0.05$ ) when compared to the groups fed with commercial Vital, Top and Hybrid feeds ( $4.60 \pm 1.07$  and  $8.40 \pm 1.07$  respectively). Result for ALP showed a significant ( $p < 0.05$ ) increase in groups fed with corn and the test group (FF1)  $186.00 \pm 7.83$  and  $171.80 \pm 6.38$  relative to the positive control Vital, Top and Hybrid feed ( $126.40 \pm 3.95$ ,  $101.80 \pm 4.29$  and  $153.20 \pm 4.38$  groups respectively) with the group fed with Top feed having the lowest value. The Total protein concentrations were shown to be  $37.60 \pm 2.97$  for the group fed with corn. This was significant ( $p < 0.05$ ) compared with the control groups feed with commercial feeds, that is, Vital, Top and Hybrid feeds ( $75.00 \pm 4.32$ ,  $54.40 \pm 2.27$  and  $63.80 \pm 2.31$  respectively) and the test group FF1 but not significant ( $p < 0.05$ ) with the group fed with FF2 diet. There was a significant difference ( $p < 0.05$ ) in the values obtained for Total Bilirubin for Groups fed with Vital, Top and Hybrid feeds ( $7.00 \pm 1.30$ ,  $10.80 \pm 0.86$  and  $6.80 \pm 0.73$ ) when compared with the value obtained for Groups fed with FF1 and FF2 ( $15.00 \pm 1.00$  and  $26.40 \pm 1.72$ ) respectively. Urea and creatinine concentrations of Groups fed with FF2 and corn diets were significantly ( $p < 0.05$ ) higher when compared to the other Groups.

**Lipid Profile Test for Rats Fed with Various Feed:** The lipid profiles over seven weeks of feeding rats with various formulated feeds were as showed in Table 7. Rats fed with corn had the least triglyceride value of  $272.80 \pm 18.81$  when compared to all the groups while the triglyceride value of the Group fed with FF2 diet ( $427.60 \pm 46.01$ ) was significantly higher ( $p < 0.05$ ) when compared to all the groups. The total cholesterol level of the Group fed with Hybrid feed has the highest value  $240.40 \pm 13.65$  and was significantly higher ( $p < 0.05$ ) when compared with the other groups. The Group fed with corn have significantly higher ( $p < 0.05$ ) levels of HDL when compared with Groups fed with the commercial feeds and formulated diets. The Group fed with Hybrid feed had the highest value of LDL  $139.00 \pm 28$  and was significantly higher ( $p < 0.05$ ) when compared with other groups. Groups fed with FF1 and FF2 diets recorded the least value  $34.98 \pm 6.54$  and  $27.62 \pm 3.15$  respectively. Results of the very low-density lipoproteins for all the feeds showed no significant difference ( $p > 0.05$ ) across the groups.

**Oxidative Stress Markers of Rats Fed with Various Feed:** MDA found in the blood or food items are a result of lipid peroxidation, and are one of the major markers of oxidative stress effects on lipids. MDA values obtained for Groups fed with Vital and Top feeds were significantly higher ( $p < 0.05$ ) when compared with other groups. Significantly higher ( $p < 0.05$ ) values of SOD were obtained from the Groups fed with the commercial feed of Vital, Top and Hybrid compared with the Groups fed with corn, FF1 and FF2 diets. Significant ( $p < 0.05$ ) values of Glutathione Peroxidase (GPx) activities were obtained in the Groups fed with corn, Vital, Top and Hybrid feeds compared with the values in the Groups fed with FF1 and FF2 diets. Similarly, significant ( $p < 0.05$ ) values for catalase activity were obtained in the Groups fed with corn, Vital, Top and Hybrid feeds compared with the values in the Groups fed with FF1 and FF2 diets (Table 8). **Haematological Indices of Rats Fed with Various Feed:** The haemoglobin and packed cell volume of the Group feed with corn was significantly lower ( $p < 0.05$ ) compared to the other test groups. However, there were significant increases ( $p < 0.05$ ) in the Hb and PCV values of the Groups fed with commercial Vital, Top and Hybrid feeds when compared to the other test groups. Similarly, the RBC values of the Groups fed with commercial Vital, Top and Hybrid feeds increased significantly ( $p < 0.05$ ) compared to the Groups fed with corn, FF1 and FF2 diets (Table 9). The WBC of the group fed with Vital feed  $7.24 \pm 0.40$  is the highest and is statistically significant ( $p < 0.05$ ) when compared with every other group.

**Table 5.** Body Weight of Rats Fed with Commercial and Formulated Feeds

| S/n | Age (Weeks) | Corn (g)    | Vital (g)    | Top (g)      | Hybrid (g)    | FF1 (g)      | FF2 (g)      |
|-----|-------------|-------------|--------------|--------------|---------------|--------------|--------------|
| 1   | 1           | 58.27±9.012 | 61.85±8.14   | 58.93±10.89  | 65.00±8.50    | 66.12±3.18   | 60.04±9.04   |
| 2   | 2           | 77.05±13.45 | 94.10±12.55  | 110.67±10.96 | 105.44±11.30  | 102.05±10.63 | 83.05±9.91   |
| 3   | 3           | 82.40±14.47 | 114.61±11.53 | 142.66±9.12  | 138.7875±6.49 | 133.67±3.46  | 134.38±4.44  |
| 4   | 4           | 89.28±14.57 | 129.26±13.12 | 154.30±5.90  | 131.71±8.17   | 139.49±3.04  | 161.80±4.72  |
| 5   | 5           | 99.85±15.26 | 150.59±15.99 | 161.40±5.64  | 172.06±12.27  | 155.36±4.41  | 174.23±11.49 |
| 6   | 6           | 91.42±16.08 | 143.87±14.57 | 157.41± 6.13 | 174.16±13.69  | 151.56±1.83  | 165.16±13.18 |
| 7   | 7           | 99.49±16.86 | 171.53±12.58 | 149.42±9.43  | 184.19±9.12   | 149.07±3.96  | 170.01±5.37  |

**KEY:** Data are mean ± Standard Error of Mean (SEM) of four determinations. Values found in the same column represent changes made on the same feed per week while across the period represent weight changes based on the difference in the various feeds administered.

**Table 6.** Biochemical Parameters of rats fed with various feed

| Groups | Feeds      | AST (IU/L)                  | ALT (IU/L)                 | ALP (IU/L)                   | T.P (g/L)                  | T.BILL (µmol/L)             | UREA (mmol/L)              | CREA (µmol/L)               |
|--------|------------|-----------------------------|----------------------------|------------------------------|----------------------------|-----------------------------|----------------------------|-----------------------------|
| 1      | Corn       | 14.40±0.87 <sup>bcg</sup>   | 11.60±0.92 <sup>b</sup>    | 186.00±7.83 <sup>bcdeg</sup> | 37.60±2.97 <sup>bcde</sup> | 16.80±1.06 <sup>bcdeg</sup> | 4.82±0.21 <sup>bcde</sup>  | 76.60±1.74 <sup>bcdeg</sup> |
| 2      | Vital Feed | 4.60±1.07 <sup>adeg</sup>   | 3.60±0.67 <sup>acdeg</sup> | 126.40±3.95 <sup>acde</sup>  | 75.00±4.32 <sup>acg</sup>  | 7.00±1.30 <sup>deg</sup>    | 2.50±0.16 <sup>acdeg</sup> | 52.20±1.42 <sup>deg</sup>   |
| 3      | Top Feed   | 8.40±1.07 <sup>ag</sup>     | 9.20±1.28 <sup>bg</sup>    | 101.80±4.29 <sup>abde</sup>  | 54.40±2.27 <sup>ab</sup>   | 10.80±0.86 <sup>ag</sup>    | 3.76±0.14 <sup>abe</sup>   | 57.80±1.35 <sup>deg</sup>   |
| 4      | Hybrid     | 10.20±0.86 <sup>bg</sup>    | 8.20±1.28 <sup>bg</sup>    | 153.20±4.38 <sup>abdeg</sup> | 63.80±2.31 <sup>ag</sup>   | 6.80±0.73 <sup>deg</sup>    | 3.78±0.19 <sup>abe</sup>   | 55.40±1.20 <sup>ag</sup>    |
| 5      | FF1        | 12.60±0.92 <sup>bg</sup>    | 10.00±1.14 <sup>bg</sup>   | 171.80±6.38 <sup>bcg</sup>   | 67.40±2.42 <sup>ag</sup>   | 15.00±1.00 <sup>bdg</sup>   | 2.98±0.10 <sup>acdeg</sup> | 49.80±1.15 <sup>abcde</sup> |
| 6      | FF2        | 19.20±1.01 <sup>abcde</sup> | 14.80±0.73 <sup>bcde</sup> | 122.40±4.34 <sup>ade</sup>   | 42.40±3.86 <sup>bcde</sup> | 26.40±1.72 <sup>abcde</sup> | 4.42±0.12 <sup>bc</sup>    | 64.80±2.31                  |

**KEY:** Data are represented as mean ± Standard Error of Mean. Values found in a column with superscript letters a,b,c,d,e and g are significantly different (p<0.05) when compared with the group fed with Corn, Vital Feed, Top Feed, Hybrid, FF1 and FF2 respectively. Each group denotes each alphabet from a-g.

**Table 7.** Lipid profile of rats fed with various feeds

| S/N | Groups     | Triglyceride (mg/dL) | Total Cholesterol (mg/dL)      | HDL (mg/dL)                 | LDL (mg/dL)              | VLDL (mg/dL) |
|-----|------------|----------------------|--------------------------------|-----------------------------|--------------------------|--------------|
| 1   | Corn       | 272.80±18.81         | 108.00±5.18 <sup>bd</sup>      | 64.20±1.15 <sup>bd</sup>    | 17.90±5.60 <sup>bd</sup> | 54.56±3.76   |
| 2   | Vital Feed | 372.20±87.95         | 175.80±19.16 <sup>ad</sup>     | 35.80±6.01 <sup>deg</sup>   | 88.80±17.54 <sup>a</sup> | 74.40±17.47  |
| 3   | Top Feed   | 417.20±23.27         | 153.60±9.97 <sup>d</sup>       | 50.00±2.52 <sup>d</sup>     | 41.12±8.98 <sup>d</sup>  | 83.48±4.64   |
| 4   | Hybrid     | 397.80±16.37         | 240.40±13.65 <sup>abcdeg</sup> | 26.80±1.49 <sup>acdeg</sup> | 139.00±28. acdeg         | 82.68±3.90   |
| 5   | FF1        | 370.60±45.19         | 132.00±8.92 <sup>d</sup>       | 52.40±2.52 <sup>bd</sup>    | 34.98±6.54 <sup>d</sup>  | 74.10±9.04   |
| 6   | FF2        | 427.60±46.01         | 130.60±2.06 <sup>d</sup>       | 53.60±4.79 <sup>bd</sup>    | 27.62±3.15 <sup>d</sup>  | 85.52±9.20   |

**KEY:** Data are represented as mean ± Standard Error of Mean. Values found in a column with superscript letters a,b,c,d,e and g are significantly different (p<0.05) when compared with the group fed with Corn, Vital Feed, Top Feed, Hybrid, FF1 and FF2 respectively. Each group denotes each alphabet from a-g.

**Table 8.** Oxidative stress markers of rats fed with various feeds

| S/N | FEED (RAT) | MDA (IU/L)                 | SOD (IU/L)                  | GPX (IU/L)                 | CAT (IU/L)                  |
|-----|------------|----------------------------|-----------------------------|----------------------------|-----------------------------|
| 1   | Corn       | 1.78±0.10 <sup>bcde</sup>  | 17.20±1.65 <sup>bcd</sup>   | 25.60±2.65 <sup>ae</sup>   | 18.80±1.42 <sup>bc</sup>    |
| 2   | Vital Feed | 3.80±0.11 <sup>adeg</sup>  | 34.00±2.88 <sup>acdeg</sup> | 35.80±2.28 <sup>adeg</sup> | 34.40±2.22 <sup>acdeg</sup> |
| 3   | Top Feed   | 3.34±0.19 <sup>deg</sup>   | 25.20±1.65 <sup>abdeg</sup> | 32.20±1.95 <sup>eg</sup>   | 25.60±1.63 <sup>abdeg</sup> |
| 4   | Hybrid     | 2.80±0.12 <sup>abe</sup>   | 29.20±1.06 <sup>deg</sup>   | 26.60±1.74 <sup>deg</sup>  | 22.40±1.28 <sup>deg</sup>   |
| 5   | FF1        | 1.33±0.05 <sup>bcde</sup>  | 17.40±0.50 <sup>bcd</sup>   | 14.60±0.50 <sup>abcd</sup> | 13.20±0.73 <sup>bcd</sup>   |
| 6   | FF2        | 2.62±0.13 <sup>abcde</sup> | 15.00±0.31 <sup>bcd</sup>   | 17.80±1.24 <sup>bcd</sup>  | 13.00±0.31 <sup>bcd</sup>   |

**KEY:** Data are represented as mean ± Standard Error Mean. Values found in a column with superscript letters a,b,c,d,e and g are significantly different (p<0.05) when compared with the group fed with Corn, Vital Feed, Top Feed, Hybrid, FF1 and FF2 respectively. Each group denotes each alphabet from a-g.

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**Table 9.** Haematological indices of rats fed with various feeds

| S/N | Feed       | HB (g/dL)                 | PCV (%)                   | RBC (X10 <sup>6</sup> /L)  | WBC (X10 <sup>3</sup> /L)  |
|-----|------------|---------------------------|---------------------------|----------------------------|----------------------------|
| 1   | Corn       | 12.44±0.19 <sup>bcd</sup> | 36.60±1.20 <sup>bcd</sup> | 2.80±0.15 <sup>bcd</sup>   | 4.10±0.12 <sup>bcd</sup>   |
| 2   | Vital Feed | 15.06±0.15 <sup>ag</sup>  | 51.80±2.26 <sup>ag</sup>  | 5.94±0.28 <sup>acdeg</sup> | 6.40±0.25 <sup>acdeg</sup> |
| 3   | Top Feed   | 14.32±0.29 <sup>ag</sup>  | 47.60±2.13 <sup>ag</sup>  | 4.86±0.12 <sup>abdeg</sup> | 5.50±0.12 <sup>abdeg</sup> |
| 4   | Hybrid     | 14.36±0.30 <sup>ag</sup>  | 47.00±2.00 <sup>ag</sup>  | 4.08±0.07 <sup>abcg</sup>  | 4.86±0.09 <sup>abcg</sup>  |
| 5   | FF1        | 13.74±0.33 <sup>g</sup>   | 43.00±1.78 <sup>a</sup>   | 3.68±0.14 <sup>abce</sup>  | 4.76±0.10 <sup>bce</sup>   |
| 6   | FF2        | 11.78±0.61 <sup>bcd</sup> | 35.40±2.29 <sup>bcd</sup> | 2.24±0.10 <sup>bcd</sup>   | 3.72±0.16 <sup>bcd</sup>   |

**KEY:** Data are represented as mean ± Standard Error Mean. Values found in a column with superscript letters a,b,c,d,e and g are significantly different ( $p < 0.05$ ) when compared with the group fed with Corn, Vital Feed, Top Feed, Hybrid, FF1 and FF2 respectively. Each group denotes each alphabet from a-g.

Bioconversion of agricultural wastes into useful cost-effective by-products is a necessary tool that should be employed to tackle the problems associated with agricultural environmental waste. Agricultural wastes such as Rice bran, palm kernel cake (PKC), some legumes, cereals and even leaves of some plants such as *Musa paradisiacal* (plantain), *Telfairia occidentalis* (pumpkin) and *Jatropha tajorensis* were utilized in this research to formulate feeds that support growth and general metabolism in rats. The proximate compositions of the formulated diets compared favourably with that of commercial feeds such as Vital, Hybrid and Top feeds. The results presented showed that the secondary metabolites present in the feeds consist of alkaloids, flavonoids, steroids, saponins, carbohydrates and tannins. This finding is supported by the report of Ojewole (2010). According to him, the pharmacological relevance of any feed is due to its phytochemical composition. As such the active ingredients present in the formulated feeds under study is highly implicated in its pharmacological property. In the presence of a well-composed and balanced diet and the huge amount of phytochemical substances inherent in the formulated feeds, one could have expected optimal growth and maturation in the experimental rats. However, a slight growth difference was observed between the standard feeds and the formulated feeds the margin was not significant enough to induced ineffectiveness as such variations were also observed among the various standard feeds. The bioavailability of a well-balanced diet is essential to proper growth and development (Hettie *et al.*, 2016). Improper processing of waste agro-products during its utilization as a useful agro-product can limit its bioavailability (Singh *et al.*, 2019). This is the case observed in this research where the same source of protein (soya bean, groundnut and fish meal) used in the standard feeds (Vital, Top and Hybrid) were also utilized as a source of proteins in the formulated feeds and slight observable variations were seen within and between the control groups feed with commercial feeds and the groups fed with formulated feeds. Based on the phytochemical results obtained for the formulated feeds, it was observed that these feeds contain a high level of anti-nutritive factors such as phytates and oxalates. These phytochemical

components can complex or chelate proteins and other food ingredients such as ions (Na, Cl, K, Zn etc) and preventing them from passing through the walls of the intestinal lining into the bloodstream thereby limiting their bioavailability. This point is supported by the observed low plasma total protein level seen in some of the standard feeds as well as some of the formulated feed. Protein is the major source of most immunological fighters and enzymes. Its deficiency can result in several ill-health due to compromised immune system, thereby opening the way for other opportunistic infections. The low protein value observed in the corn-fed group was an indication of nutrition imbalance. This may lead to the rise in AST, ALT and ALP as observed in some of the standard groups. The ALT and AST alongside other markers are used to ascertain the toxicological effect of the feeds on tissues of the body most especially the liver. The significant increase in AST level for the group fed with a corn diet was an indication that the integrity of the liver and/or certain tissue cells are compromised. The ratio of AST to ALT might give an insight as to which organ or tissue is involved. The activities of SOD, CAT and levels of GSH and MDA were elevated significantly in all the Groups fed with Vital, Top, Hybrid feeds and cornmeal. Muller *et al.*, (2006) reported that the levels of these oxidative stress markers will increase with the increasing need to protect the cells against toxic oxidation. A study on oxidative stress in marasmus children conducted by Boşnak *et al*, (2010) demonstrated a significantly higher concentration of plasma MDA in marasmus children Furthermore, superoxide is generated as a by-product of oxygen metabolism and cells may be destroyed if not regulated (Hayyan *et al.*, 2016). Nutrient deficiencies that cannot be measured using anthropological parameters are often measured using the blood, especially haematological indices. A low count of a certain haematological parameter is an indication of malnutrition. Low RBC generally is known as a marker for anaemia (Dacie & Lewis, 2006). The overall presentation of the haematology indices indicated that both the commercial feed, corn diet as well as FF1 formulated diet supported the erythropoietic system and function of the experimental animals. In summary, malnutrition correlates with the

parameters of haematology as most of these parameters are within normal. Corn and FF1 diet compared favourably with Top and Hybrid feeds by significantly increasing the HDL and decreasing the LDL levels of the Rat. This suggests that these feeds especially corn and the FF1 diet may be recommended as a dietary substitute for these animals. FF1 is composed of Palm Kernel Cake (PKC) which is rich in good cholesterol and may be responsible for the increase in HDL recorded. Ibegbulem and Chikezie, (2012) observed the lowering effect of serum profile of rats fed with palm oil and kernel oil-containing diet.

**Conclusion:** The use of livestock and plant agricultural waste in the production of feeds for Wistar rats has proven to be a major avenue to utilizing agricultural waste into a useful product, thus bio-conversion of waste to wealth. It is a new dimension of waste biotransformation into cost-effective replacement for exorbitant commercial rat feeds. Processing of agro-waste products into a useful feed as demonstrated in this study can provide sustainable and bio-available nutritional requirements for experimental animals. The utilization of agro-waste in compounding feed for experimental animals is an innovation that can reintroduce agro-wastes into the environment in a more profitable form as in the case of this study.

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