



Proximate Composition and Metabolizable Energy of Some Commercial Poultry Feeds Available in Abuja, Nigeria

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ABSTRACT: Poultry feeds are prepared to contain all the nutrients in their right proportions necessary for good health, proper growth and egg production of the chicken. This study was undertaken to determine the proximate composition and variations of nutrient in some commercial poultry feeds sold in Abuja, Nigeria. Seven poultry feed brands in their various ratios were subjected to proximate analysis using standard methods. The results of the analysis revealed that the poultry feeds had proximate composition ranging from 6.58 ± 0.02 - 10.88 ± 0.19 % moisture content, 6.03 ± 0.16 - 14.78 ± 0.73 % ash content, 9.98 ± 0.81 - 20.05 ± 0.08 % crude lipid, 3.57 ± 0.11 - 14.77 ± 0.14 % crude fiber, 16.55 ± 0.07 % - 34.01 ± 0.09 % crude protein, 26.28 ± 1.80 % - 48.21 ± 2.07 % carbohydrate and 2971.48 ± 65.44 - 3686.18 ± 29.08 Kcal/kg metabolizable energy. Generally, there were differences in the proximate composition of the poultry feed brands analyzed, however, the poultry feeds have optimum nutrients in their feeds which meet most of the requirements recommended by SON and NRC. The moisture contents in all the feeds were within the recommended value of not more than 12 % while the mean values obtained in crude lipid were all higher than the maximum recommended requirements in poultry feeds.

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Poultry refers to group of birds kept for meat and egg production or reared or hunted for economic value e.g. chickens, turkeys, guinea fowls, pigeons, ducks and geese (also called water fowls) quails, pheasants, ostriches, pigeons and doves (Matanmi, 2011). Poultry industry is one of the most commercialized subsectors in Nigerian agricultural sector and has continued to expand in recent years (Adene and Oguntade, 2006). Nigeria has the second largest chicken population in Africa after South Africa, its poultry industry accounts for about 200 million birds producing 650 000 tonnes of eggs and 290 000 tonnes of poultry meat in 2013 (Sahel, 2015). Poultry feed is any single and multiple materials whether processed, semi-processed or raw, which is intended to be fed directly to poultry (SON,

2018). Feed ration is the amount of feed that is provided to poultry over a period of time. Leeson and Summers (2001) opined that poultry feeds are required to contain certain nutrients such as protein, fat, vitamins, minerals and carbohydrate in their right percentages in starter, grower, layer and finisher rations for various stages of growth. Feed for poultry consists mainly of grains (NRC, 1994). It is made up of mixtures of different feedstuffs such as cereal grains, soybean meal, animal by-product meals, plant protein sources, fats, and vitamin, mineral premixes and feed additives (Mallick *et al.*, 2020). Feed is estimated to account for more than 70 - 80 % of the total cost of production in poultry farming, it represents the major cost of intensive poultry

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production (Gunasekar, 2005; Samuel *et al.*, 2015). Most poultry farmers in Nigeria, depend on commercial feeds for their poultry farms produce. Due to high cost of feed production, some commercial feed manufacturers fail to meet up with the required standards for poultry feeds. Poultry industry in Nigeria is faced with numerous challenges of which feed quality is most notable, however, it has contributed remarkably in shrinking the scourge of unemployment, malnutrition and poverty. The health, growth and reproduction of poultry is determined by the availability of sufficient nutrients, both in quantity and quality regardless of the culture system in which they are raised. In poultry farming, high quality and nutritionally balanced feeds are required for proper growth and development of the chickens. Several researches have been conducted to give insight into proximate composition of commercial poultry feeds available in different parts of Nigeria but so far none has been reported in Abuja, Nigeria. Therefore, this study is aimed at determining the proximate composition of some commercial poultry feeds sold in Abuja, Nigeria to ascertain the quality of the poultry feeds. The results were compared with Standard Organization of Nigeria, SON (2018) and NRC (1994) recommended requirement in feeds.

MATERIALS AND METHODS

Sample Collection: Seven commercial poultry feed brands coded as feeds A, G, H, L, S, T and V in their various rations (starter, grower, finisher and layer) were purchased from their distribution outlets within Abuja, Nigeria. For each ration (starter, grower, finisher and layer) of every feed brand, samples were collected from ten (10) different bags (having the same production batch number) containing the same feed ration. The feed samples were transported in polyethylene bags to the laboratory.

Sample Preparation: Same type of each feed ration from the ten (10) different bags were homogenized to form one composite sample. This was done for all the feed brands. The feed samples were ground using a blender, sieved through 1.0 mm size sieve mesh to obtain a uniform particle size. They were labelled accordingly and stored in pre-washed air tight containers at ambient temperature until required for analysis.

Reagents used for Analysis: All reagents and chemicals used in this study were of analytical grade. Sulphuric acid (95 - 98%, ACS), boric acid (99.5%, ACS), Kjeldahl catalyst and sodium hydroxide pellets (ACS) were products of VWR chemicals BDH. While hydrochloric acid (37%, AR) and petroleum ether

(40 - 60 °C) were manufactured by Loba Chemie Pvt Ltd, India.

Analytical Method: For the proximate analysis of poultry feeds, standard procedures were used. All analysis was done in triplicate and the mean and standard deviation calculated.

Moisture Content Determination: This was determined using the gravimetric method described by AOAC (1990). Two grams (2.0 g) of the feed sample was weighed (W_1) into a pre-weighed crucible (W_0) and dried in an oven for 3 h at 105 °C. The crucible was removed, allowed to cool in a desiccator and weighed. The process of drying, cooling and weighing was repeated until a constant weight (W_2) was obtained. The weight loss due to moisture was obtained by the equation:

$$\% \text{ Moisture} = \frac{W_1 - W_2}{W_1 - W_0} \times 100 \dots 1$$

Where: W_0 = weight of empty crucible (g), W_1 = weight of crucible + undried sample (g); W_2 = weight of crucible + dried sample (g)

Ash Content Determination: The ash content was determined using method described by AOAC (2005). Accurately weighed (W_1) 2.0 g of the dried feed sample was placed into a pre-weighed empty crucible (W_0) and was subjected to ignition in a muffle furnace at 550 °C for four hours. The ash was removed and allowed to cool in a desiccator and weighed (W_2). The percentage ash was calculated using the formula:

$$\text{Ash (\%)} = \frac{W_2 - W_0}{W_1 - W_0} \times 100 \dots 2$$

Where: W_0 = weight of empty crucible (g), W_1 = weight of crucible + sample before ashing (g), W_2 = Weight of crucible + sample after ashing (g)

Crude Lipid Determination: The crude lipid in the feed sample was extracted using soxhlet extraction procedure, given by AOAC (2005) with little modifications. Two grams (2.0 g) dried feed sample was weighed (W_0) into a filter paper, it was folded, tied and the weight of the filter paper and sample taken (W_1). The sample was placed in a soxhlet apparatus and 200 cm³ petroleum ether was added into the extraction flask. The sample was subjected to continuous extraction for about 6 hours after which it was removed from the soxhlet apparatus and dried in the oven at 105°C for about 2 h to be completely free from the solvent and moisture. It was allowed to cool in a desiccator and reweighed (W_2). The crude lipid

was calculated from the weight difference in the sample after extraction.

$$\text{Crude lipid (\%)} = \frac{W_1 - W_2}{W_0} \times 100 \dots 3$$

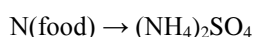
Where: W_0 = weight of sample (g), W_1 = weight of filter paper + sample before extraction (g), W_2 = weight of filter paper + sample after extraction (g)

Crude Fiber Determination: For the crude fibre determination, the AOAC (2005) method was used. Two grams (2.0 g) of lipid extracted feed sample was weighed (W_0) into a 250 cm³ conical flask, 200 cm³ of 0.1275 M H₂SO₄ acid under reflux for 30 minutes, washed several times with hot water until it was acid free. The residue was again subjected to the same treatment using 200 cm³ of 0.313 M NaOH solution, washed thoroughly with hot water until it was base free. After the thermal treatment, the mixture was filtered through Whatman filter paper No 42. The residue was scrapped into the crucible and dried in an oven at 105 °C, cooled in a desiccator and weighed (W_1). The dry residue was incinerated in a muffle furnace at 550 °C for 2 hrs. It was finally allowed to cool in a desiccator and weighed again (W_2).

$$\text{Crude fibre (\%)} = \frac{W_1 - W_2}{W_0} \times 100 \dots 4$$

Where: W_0 = weight of sample (g), W_1 = weight of residue (g), W_2 = weight of ash sample (g)

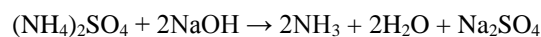
Crude Protein Determination: The crude protein of the sample was determined using the method described by AOAC (2007) and Chang (2010). Exactly 2.0 g of defatted sample was weighed into a digestion flask. This was followed up with the addition of a tablet of Kjeldahl catalyst and 25 cm³ concentrated sulphuric acid. The mixture was digested on a heating mantle in the fume cupboard. The heating was firstly carried out on low heat until frothing subsides, then it was increased with occasional shaking for about two hours until a clear pale green colour solution was obtained. Digestion converts any nitrogen in the food (other than that which is in the form of nitrates or nitrites) into ammonia and other organic matter to CO₂ and H₂O. Ammonia gas is not liberated in an acid solution because the ammonia is in the form of the ammonium ion (NH₄⁺) which binds to the sulphate ion (SO₄²⁻) and thus remains in solution.



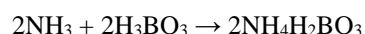
The digest was allowed to cool, filtered into a 100 cm³ volumetric flask and made up to the mark with distilled water. A blank was carried along the same process.

IGWEMMAR, N. C; KOLAWOLE, S. A; OMONIYI, A O; BWAI, D. M; FAGBOHUN, A. A; FALAYI, O. E.

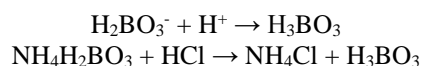
Distillation was done with Markham distillation apparatus. The Markham distillation apparatus was steamed for about 15 minutes before it was used. Under the condenser, 100 cm³ conical flask containing 10 ml of 4 % boric acid and two drops of mixed indicator was placed, such that the condenser tip is under the liquid. 10 cm³ of the digest was pipette into the body of the apparatus via a small funnel aperture followed by addition of 10 cm³ of 40 % NaOH solution.



The mixture was steamed through for about 5 - 7 minutes to collect enough ammonium sulphate (about 25 cm³). The sodium hydroxide converted the ammonium sulphate into ammonia gas which was liberated from the solution and moves out of the distillation flask to the receiving flask.



The ammonium borate formed is titrated directly with 0.1 N HCl. The titre value which is the volume of acid used was recorded.



The concentration of hydrogen ion (in moles) required to reach the end-point is equivalent to the concentration of nitrogen that was in the original food. The nitrogen content of the sample was calculated using the formula:

$$\text{N (\%)} = \frac{V_s - V_b \times N_{\text{acid}} \times 0.01401 \times 100}{W \times 10 \text{ (volume of sample (ml))}} \times 100 \dots 5$$

Where, V_s = titre value of acid (cm³), N_{acid} = normality of acid, V_b = Vol of blank, W = original weight of sample used (g)

The percentage crude protein was obtained by multiplying percentage nitrogen by a conversion factor of 6.25.

$$\text{Crude protein (\%)} = \text{N (\%)} \times \text{conversion factor } 6.25$$

Carbohydrate Determination: Carbohydrate was estimated by subtraction of the percentages of all the other food contents from 100 % (FAO/WHO, 1998). It was calculated using the formula:

$$\text{Carbohydrate (\%)} = 100 \% - (\% \text{ crude protein} + \% \text{ crude lipid} + \% \text{ crude fibre} + \% \text{ ash} + \% \text{ moisture}) \dots 6$$

Metabolizable Energy (ME) Determination: This was calculated with modified Atwater equation (AAFCO, 1997).

$$ME \text{ (Kcal/kg)} = 10 \times (3.5 \times \% \text{ crude protein} + 8.5 \times \% \text{ crude lipid} + 3.5 \times \% \text{ NFE}) \dots\dots 7$$

Total carbohydrate content was approximated as the value for Nitrogen free extract (NFE)

Statistical Analysis: Results were expressed as the mean of triplicates \pm standard deviation (SD). The data were analyzed by one-way analysis of variance (ANOVA) ($p < 0.05$) to check the significant difference existing among the poultry feeds. All statistical calculations were performed using SPSS version 23.0.

RESULTS AND DISCUSSION

The results of proximate composition of the poultry feed brands are presented in Figures 1 – 7. The highest moisture content value was observed in Feed S finisher ($10.88 \pm 0.19 \%$), while the lowest was found in Feed T layer ($6.58 \pm 0.02 \%$). There were variations in the moisture contents among the feed rations. The mean moisture contents in starter, grower, finisher and layer feed rations are $8.96 \pm 1.18 \%$, $8.75 \pm 1.39 \%$, $9.22 \pm 1.00 \%$ and $8.04 \pm 1.17 \%$ respectively (Figure 1).

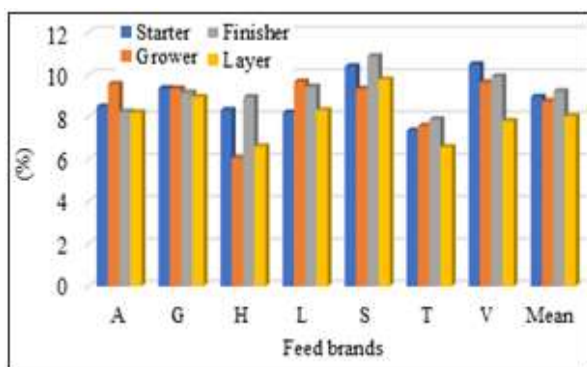


Fig 1: Moisture content (%) of the poultry feed samples

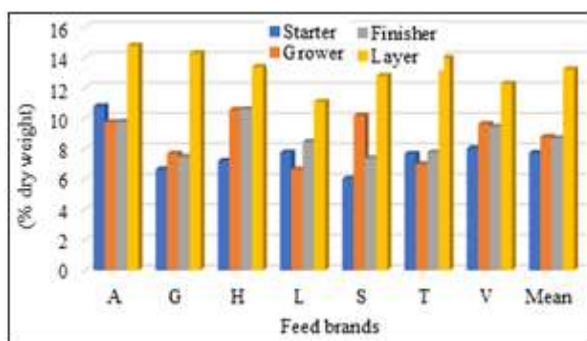


Fig 2: Ash content (% dry weight) in the poultry feed samples

Also, the mean of ash contents (dry weight) in the feed rations were found to be $7.73 \pm 1.52 \%$ in starter, $8.77 \pm 1.62 \%$ in grower, $8.69 \pm 1.26 \%$ in finisher and $13.22 \pm 1.28 \%$ in layer. Generally, the layer feeds of all the feed brands gave high ash content with the highest value observed in Feed A layer ration ($14.78 \pm 0.73 \%$) whereas starter rations had low values except in Feed A. The lowest ash content in the starter ration was found in Feed S brand ($6.03 \pm 0.16 \%$) while the grower and layer rations of Feed L brand gave the lowest ash content of $6.64 \pm 0.17 \%$ and $11.08 \pm 0.75 \%$ respectively (Figure 2). The ash contents in the feed brands were found to be in the order of Feed A > Feed H > Feed V > Feed S > Feed T > Feed G > Feed L.

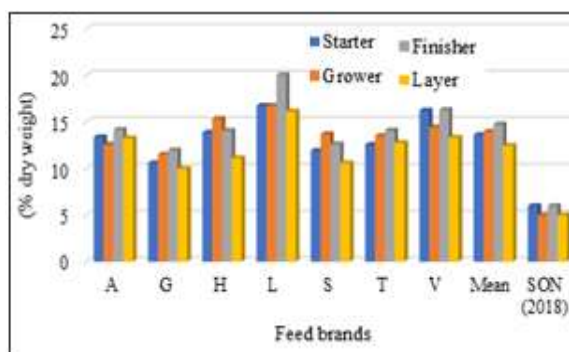


Fig 3: Crude lipid content (% dry weight) in the poultry feed samples

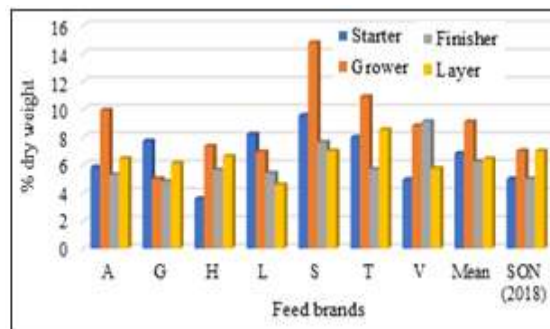


Fig 4: Crude fibre content (% dry weight) in the poultry feed samples

The feed brands recorded crude lipid contents in the order of Feed L > Feed V > Feed H > Feed A > Feed T > Feed S > Feed G (Figure 3). Overall, the lowest crude lipid value of $9.98 \pm 0.81 \%$ was recorded in layer feed ration of Feed G while the finisher of Feed L has the highest value of $20.05 \pm 0.08 \%$. Figure 4 presents the percentage crude fiber (dry weight) in the analyzed poultry feeds. The lowest crude fiber content of $3.57 \pm 0.11 \%$ was observed in starter ration of Feed H while grower ration of Feed S gave the highest value of $14.77 \pm 0.14 \%$ (Figure 4). Generally, the contents of crude fiber in the feed brands are in the order of

Feed S > Feed T > Feed V > Feed A > Feed L > Feed H > Feed G.

recorded mean metabolizable energy in the order of finisher > starter > grower > layer (Figure 7).

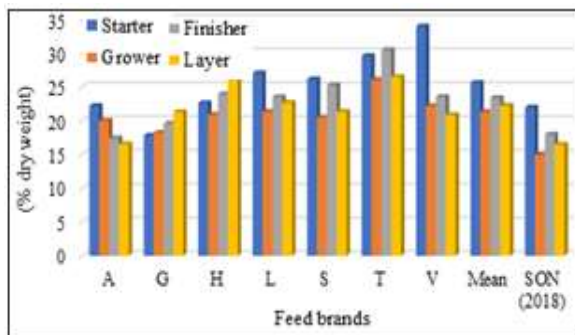


Fig 5: Crude protein content (% dry weight) in the poultry feed samples

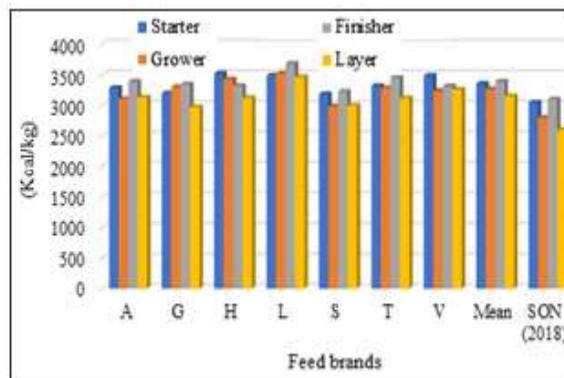


Fig 7: Metabolizable Energy (Kcal/kg) in the poultry feed samples

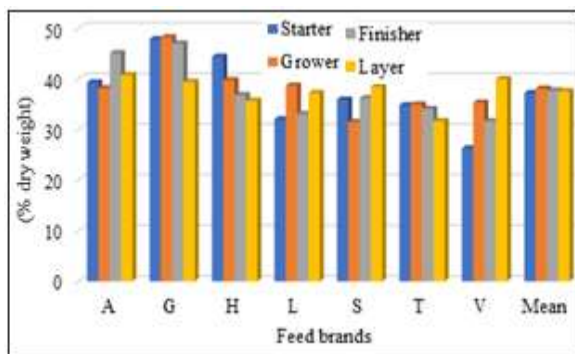


Fig 6: Carbohydrate content (% dry weight) in the poultry feed samples

Also, the mean of crude protein in the feed rations revealed 25.66 ± 5.32 % for starter, 21.34 ± 2.43 % for grower, 23.42 ± 4.18 % for finisher and 22.27 ± 3.49 % for layer (Figure 5). The analyzed feed brands recorded crude protein contents in the order of Feed T > Feed V > Feed L > Feed H > Feed S > Feed G > Feed A. Overall, the lowest crude protein value of 16.55 ± 0.07 % was recorded in layer feed ration of Feed A while the starter of Feed V has the highest value of 34.01 ± 0.09 %. The mean of carbohydrate contents in the feed rations are 37.21 ± 7.33 % (starter), 38.07 ± 5.27 % (grower), 37.69 ± 5.99 % (finisher) and 37.58 ± 3.12 % (layer). The highest and lowest carbohydrate content in the feeds were observed in grower feed ration of Feed G (48.21 ± 2.07 %) and starter ration of Feed V (26.28 ± 1.80 %). Furthermore, the carbohydrate content in the various feed brands follow the order of Feed G > Feed A > Feed H > Feed S > Feed L > Feed T > Feed V (Figure 6). The metabolizable energy of the poultry feed rations are as presented in Figure 7 with values ranging from 3186.34 - 3524.85 Kcal/kg, 2984.78 - 3523.06 Kcal/kg, 3225.32 - 3686.18 Kcal/kg and 2971.48 - 3467.90 Kcal/kg for starter, grower, finisher and layer feed rations respectively. The poultry feed rations

Moisture content is related to the quality and shelf life of food. Ogunmola *et al.* (2013) opined that moisture improves the rate at which absorption takes place within the digestive system and influences the rate at which enzyme activities takes place on the food. From the results (Figure 1), it was found that the moisture contents in the different feed brands varied from 6.58 ± 0.02 to 10.88 ± 0.19 % dry weight. All the feed samples were below the 12 % maximum moisture content requirement in poultry feeds (SON, 2018). New (1987) and Nielsen (2010) reported that high moisture content in feeds affect the shelf life making it unsuitable for long storage since it can easily be infested by insects and encourages the growth of fungi. The moisture content in this study agrees with 8.52 - 10.44 % obtained in Vakili *et al.* (2015). In studies published by Bukar and Saeed (2014), Bukar and Saeed (2015), Dewa and Tikau (2019), Hasan *et al.* (2022) and Ofori *et al.* (2019), higher moisture contents were observed in the poultry feeds in the ranges of $4.98 \pm 0.158 - 11.33 \pm 4.48$ %, $3.81 - 15.97$ %, $0.17 \pm 0.13 - 36.31 \pm 0.38$ %, $6.13 \pm 0.28 - 11.02 \pm 1.52$ % and $7.84 - 11.8$ % respectively, whereas Ogbemor *et al.* (2021) and Okafor and Ezebuo (2014) reported lower moisture content in poultry feeds. The results of the feed moisture contents were observed to be statistically significant at $p < 0.05$.

The ash content (dry weight) in the different feed brands was observed to generally range from 6.03 ± 0.16 % to 14.78 ± 0.73 % (Figure 2). The ash content indicates the mineral content in the poultry diet needed in specific amounts for muscle contraction, blood clotting, egg shell formation, stronger bone and enzymes activation (“Basic poultry nutrition,” n.d). The mean values of the poultry feed rations in this study were found to be 7.73 ± 1.52 % (starter), 8.77 ± 1.62 % (grower), 8.69 ± 1.26 % (finisher) and 13.22 ± 1.28 % (layer) (Figure 2). In previous studies,

IGWEMMAR, N. C; KOLAWOLE, S. A; OMONIYI, A O; BWAI, D. M; FAGBOHUN, A. A; FALAYI, O. E.

Bukar and Saeed (2014), Bukar and Saeed (2015) and Ofori *et al.* (2019) reported high ash content in poultry feeds in the ranges of $9.59 \pm 2.95 - 20.47 \pm 12.67$ %, $6.84 - 35.56$ % and $5.46 - 22.06$ % respectively. On the contrary, Dewa and Tikau (2019), Hasan *et al.* (2022), Ogbemor *et al.* (2021), Ojabo and Wunduga (2020), Okafor and Ezebuo (2014) and Vakili *et al.* (2015) obtained lower ash contents in poultry feeds than the present study ranging from $8.05 \pm 0.57 - 12.28 \pm 0.41$ %, $8.81 \pm 0.03 - 8.97 \pm 0.05$ %, $3.69 \pm 0.32 - 4.99 \pm 0.33$ %, $7.31 - 12.76$ %, $1.90 - 2.00$ % and $4.01 - 6.70$ % respectively. In a study by Ofori *et al.* (2006), it was reported that low ash content of the feed pre-disposes birds to diseases and poor egg shell formation. The study revealed a statistically significant difference between the ash contents of the feeds at $p < 0.05$.

The mean levels of crude lipid (dry weight) in starter (13.62 ± 2.23 %), grower (13.98 ± 1.73 %), finisher (14.75 ± 2.71 %) and layer (12.45 ± 2.10 %) feed rations were all higher than SON (2018) recommended maximum crude lipid values of 6.00 %, 5.00 %, 6.00 % and 5.00 % for starter, grower, finisher and layer rations respectively (Figure 3). This suggests that excess fat was incorporated in the feeds to enhance energy. Lipid component in poultry feed helps to increase overall energy concentration and in turn improve productivity and feed efficiency (NRC, 1994). Baiao and Lara (2005) and Ravindran (2013) reported that fat in poultry diet increases palatability of feed and enhances the absorption of fat soluble vitamins A, D, E and K. Bukar and Saeed (2014), Bukar and Saeed (2015), Dewa and Tikau (2019), Hasan *et al.* (2022), Ofori *et al.* (2019), Ogbemor *et al.* (2021), Ojabo and Wunduga (2020) and Okafor and Ezebuo (2014) in their various studies reported lower levels of crude lipid in poultry feeds than the present study. The crude lipid results revealed a statistically significant difference at $p < 0.05$.

The crude fibre content (% dry weight) in the different feed brands ranged between $3.57 \pm 0.11 - 14.77 \pm 0.14$ % (Figure 4). The present result is higher than $3.53 \pm 0.04 - 8.45 \pm 0.16$ %, $5.27 - 10.39$ %, $4.3 - 9.0$ % and $2.89 - 6.60$ % crude fibre contents published in Ogbemor *et al.* (2021), Ojabo and Wunduga (2020), Okafor and Ezebuo (2014) and Vakili *et al.* (2015) respectively whereas $3.41 \pm 0.17 - 15.90 \pm 6.46$ % and $1.70 - 38.75$ % observed in Bukar and Saeed (2014) and Bukar and Saeed (2015) respectively were higher crude fibre contents. The mean values of the starter, grower and finisher rations of the feed brands exceeded the SON (2018) crude fibre maximum recommended limit of 5.00 %, 7.00 % and 5.00 % respectively except the layer ration (Figure 4). Feed brands H and V starter ration, Feeds G and L grower

ration and Feed G finisher ration also gave crude fibre contents lower than maximum recommended values.

Protein is the major constituent and cost component of feed (Elmasoer and Russ, 2013; Perween *et al.*, 2016). Protein in the feed provides essential amino-acids, it plays an important role in the growth, egg production, immunity and in many other biological functions (Esmail, 2016). Overall, the crude protein content (dry weight) in the different feed brands ranged between 16.55 ± 0.07 % and 34.01 ± 0.09 % (Figure 5). The mean values obtained for starter, grower, finisher and layer rations were above the SON (2018) recommended minimum crude protein values of 22.00 %, 15.00 %, 18.00 % and 16.50 % respectively (Figure 5). Similarly, the starter and layer rations gave higher value than 23 % (starter) and 15 % (layer) stipulated by NRC (1994). The starter ration gave the highest crude protein mean value of 25.66 ± 5.32 % whereas the lowest mean value of 22.27 ± 3.49 % was found in layer ration. Several researchers have reported crude protein in poultry feeds. Bukar and Saeed (2014), Dewa and Tikau (2019), Hasan *et al.* (2022), Ofori *et al.* (2019), Ojabo and Wunduga (2020), Okafor and Ezebuo (2014) and Vakili *et al.* (2015) in their studies, observed lower crude protein than this study ranging from $16.44 \pm 11.29 - 24.26 \pm 0.46$ %, $10.66 \pm 0.76 - 20.16 \pm 1.75$ g/100g, $13.89 \pm 0.46 - 14.04 \pm 0.03$ %, $16.15 - 20.97$ %, $19.46 - 24.31$ %, $20 - 22$ % and $19.40 - 24.21$ % respectively while Ogbemor *et al.* (2021) recorded higher crude protein of 36.50 ± 0.92 % - 70.92 ± 0.51 %. Bukar and Saeed (2015) reported a crude protein (2.80 - 34.56 %) similar to the present study. The results of crude protein showed a statistically significant difference at $p < 0.05$.

Carbohydrates are important sources of energy for poultry. They form part of energy yielding nutrients (carbohydrates, fats and protein) which are oxidised in the course of metabolism to provide energy needed for maintenance and body tissue building (NRC, 1994; Kryger, 2010). The carbohydrate content (% dry weight) in the different feed brands ranged from $26.28 \pm 1.80 - 48.21 \pm 2.07$ % (Figure 6). Carbohydrate content in poultry feeds has been evaluated by many researchers. Ogbemor *et al.* (2021) and Ojabo and Wunduga (2020) observed carbohydrate contents similar to the present study in the ranges of $3.65 - 37.83$ % and $39.06 - 48.95$ % respectively. Furthermore, Bukar and Saeed (2014), Bukar and Saeed (2015), Dewa and Tikau (2019), Ofori *et al.* (2019) and Okafor and Ezebuo (2014) obtained high carbohydrate content in poultry feeds in the ranges of $39.67 \pm 10.68 - 50.70 \pm 21.63$ %, $15.73 - 78.90$ %, $34.65 \pm 0.77 - 68.94 \pm 0.58$ g/100g, $53.73 - 61.81$ % and $49.3 - 55.2$ %

respectively. The results of carbohydrate content revealed that there was no statistically significant difference between the means of the feed samples ($p > 0.05$).

Metabolizable energy is the energy that remains after accounting for the important losses (Warwick & Baines, 2000). Livesey (2001) described metabolizable energy as the amount of energy available for total (whole body) heat production at nitrogen and energy balance. The metabolizable energy in the analyzed feed brands ranged between 2971.48 ± 65.44 Kcal/kg and 3686.18 ± 29.08 Kcal/kg (Figure 7). This study's result is similar to $1984.40 - 3339.60$ Kcal/kg and $2801.14 - 3026.9$ Kcal/kg metabolizable energy values published in Dewa and Tikau (2019) and Ojabo and Wunduga (2020) respectively. On the contrary, Bukar and Saeed (2015) observed slightly higher metabolizable energy value of $1737.30 - 4622.70$ kcal/kg. The mean metabolizable energy of all the feed rations exceeded the SON (2018) recommended minimum requirements of 3050 Kcal/kg, 2800 Kcal/kg, 3100 Kcal/kg and 2600 Kcal/kg for starter, grower, finisher and layer respectively (Figure 7). Furthermore, the mean metabolizable energy observed in starter (3357.73 ± 143.54 Kcal/kg) and layer (3153.16 ± 168.99 Kcal/kg) were above the recommended values of 3200 kcal/kg and 2900 kcal/kg for starter and layer rations as stipulated by NRC (1994). The metabolizable energy results are statistically significant ($p < 0.05$).

Conclusion: The demand for quality feed to meet the nutritional requirements of poultry for efficiency and high productivity is of great importance. This study revealed differences in the proximate composition and metabolizable energy of poultry feed brands available in Abuja. The feeds have optimum nutrients that meet most of the recommended requirements except crude lipid which recorded higher values suggesting excessive lipid incorporation into the poultry diets to boost energy. However, the feeds are not negatively implicated and can be used by poultry farmers.

REFERENCES

- AAFCO (1997). Association of American Feed Control Officials. Official Publication, Atlanta, GA, USA.
- Adene, DF; Oguntade, AE (2006). The structure and importance of the commercial and village-based poultry systems in Nigeria. FAO, United States Department of Agriculture. International Egg and Poultry Report.
- AOAC (1990). Official Methods of Analysis of the Association of Analytical Chemists. 15th ed. Washington, DC, pp: 223-225, 992-995.
- AOAC (2005). Official Methods of Analysis of the Association of Analytical Chemists International, 18th ed. Gathersburg, MD.
- AOAC International (2007). Official Methods of Analysis, 18th ed. Current through revision 2, 2007 (On-line).
- Baião, NC; Lara, LJC (2005). Oil and fat in broiler nutrition. *Braz. J. Poult. Sci.*, 7(3): 129-141.
- Basic poultry nutrition. (n.d). <https://poultry.extension.org/articles/feeds-and-feeding-of-poultry/basic-poultry-nutrition/>
- Bukar, H; Saeed, MD (2014). Proximate analysis and concentration of some heavy metals in selected poultry feeds in Kano Metropolis, Nigeria. *Bayero J. Pure Appl. Sci.* 7(1): 75-79.
- Bukar, H; Saeed, MD (2015). Proximate and heavy metals analysis of selected poultry feeds from Kano Metropolis. *J. Chem. Pharm. Res.* 7(1): 16-24.
- Chang, SKC (2010). Protein analysis. In: Nielsen, SS (ed). *Food analysis*, Springer, New York. Pp. 135-146.
- Dewa, UA; Tikau, F (2019). Proximate and elemental analysis of some selected commercial poultry feeds in Nigeria. *Caliphate J. Sci. Tech.* 2: 148-153.
- Elmasoeur, A; Russ, N (2013). Ghana Poultry Report Annual. Global Agricultural Information Network. Accra, Ghana.
- Esmail, S (2016). Understanding protein requirement. *World Poult.* 32(9): 13-16.
- FAO/WHO (1998). Carbohydrates in human nutrition: Report of a joint FAO/WHO expert consultation, Rome. 14-18 April 1997. FAO Food and Nutrition paper 66 Rome: FAO.
- FAO, Food and Agricultural Organisation (2013). Poultry development review. Rome, Italy.
- Gunasekar, KR (2005). Formulating feed for broiler performance. Avitech Animal Health Pvt. Ltd., India.

- Hasan, MS; Al Basherah, M; Jahan, F; Hossain, A; Waliullah, M; Islam, MB (2022). Proximate composition of some commercially available fish and poultry feeds sold in the market of Bangladesh *Int. J. Biosci.* 20(4): 1-8.
- Kryger, KN; Thomsen, KA; Whyte, MA; Dissing, M (2010). Smallholder poultry production-livelihoods, food security and sociocultural significance. *Smallholder Poultry Production Paper*, (4).
- Leeson, S; Summers, JD (2005) Commercial Poultry Nutrition, 3rd ed., Nottingham University Press, UK, 398.
- Livesey, G (2001). A perspective on food energy standards for nutrition labelling. *Br. J. Nutr.* 85(3): 271-287.
- Mallick, P; Muduli, K; Biswal, JN; Pumwa, J (2020). Broiler poultry feed cost optimization using linear programming technique. *J. Oper. Strat.Plann.*, 3(1): 31-57.
- Matanmi, IO (2011). A Foray into Poultry Nutrition. Inaugural Lecture Series 243. Obafemi Awolowo University Press Limited, Nigeria.
- New, MB (1987). Feed and feeding of fish and shrimp - A manual on the preparation and presentation of compound feeds for shrimp and fish in aquaculture, FAO, Rome. Vol. 275. ADCP/REP/87/26.
- Nielsen, SS (2010). United States government regulations and international standards related to food analysis. In *Food Analysis*, Springer, Boston, MA. pp. 15-33.
- NRC, National Research Council (1994). Nutrient requirements of poultry, 9th revised edition. National Academy Press, Washington, D.C.
- Ofori, H; Amoah, F; Arah, I; Krampah, EK (2019). Proximate analysis and metabolizable energy of poultry feeds. *ARPJ. Eng. Appl. Sci.* 14(5): 1026-1032.
- Ogbebor, AS; Imoni, AA; Ohiorenoya, OR (2021). Fungal composition and proximate analysis of poultry feeds sold in Benin City, Nigeria. *Afr. J. Health, Saf. Env.* 2(2): 109-115.
- Ogunmola, OO; Taiwo, OF; Ayankoso, AS (2013). The nutritive value of the meat quality of locally breed chicken, exotic chicken and turkey. *IOSR J. Appl. Chem.* 3(6): 46-50.
- Ojabo, LD; Wunduga, M (2020). Proximate Analysis of Selected Commercial Broiler Feeds in Makurdi Metropolis, North-Central Nigeria. Merit Research, *J. Agric. Soil Sci.* 8(2): 21-24.
- Okafor, IN; Ezebuo, FC (2014). Proximate analysis and antinutrient composition of poultry feed containing two replacement levels of *Mucuna pruriens* for soy bean meal. *World Appl. Sci. J.* 32(2): 201-206.
- Perween, S; Kumar, K; Chandramoni, SK; Singh, PK; Kumar, M; Dey, A (2016). Effect of feeding different dietary levels of energy and protein on growth performance and immune status of Vanaraja chicken in the tropic. *Vet. World.* 9(8): 893-899.
- Ravindran, V. (2013). Poultry feed availability and nutrition in developing countries. Poultry development review, 2: 60-63.
- Sahel (2015). An assessment of the Nigerian poultry sector. Sahel Capital Newsletter, 11(2).
- Samuel, OO; Olusegun, AO; Adebimpe, OA; Akinbowale, TT (2015). Optimized nutrients diet formulation of broiler poultry rations in Nigeria using linear programming. *J. Nutr. Food Sci.* 14(2).
- SON, Standard Organization of Nigeria (2018). Nigerian Industrial Standard: Standard for Poultry Feeds, NIS 259:2018.
- Vakili, R; Torshizi, ME; Yaghobzadeh, MM; Khadivi, H (2015). Determination of Chemical Composition and Physical Feed Quality with Different Processing Parameters in Broiler Feed Mill Factories. In *Biological Forum*. Research Trend. Vol. 7, No. 1, p. 1098.
- Warwick, PM; Baines, J (2000). Point of view: Energy factors for food labelling and other purposes should be derived in a consistent fashion for all food components. *Br. J. Nutr.* 84(6): 897-902.