

## Quality evaluation of pigs fed poultry by-products

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### Abstract

*Effect of consuming solely poultry-by-products by grower pigs, instead of conventional feeds was the focus of this study. Thirty-six Large White male pigs of 6 weeks 5.7 – 7.5kg were fed Boiled Dead Birds (BDB) (T3), Boiled Hatchery Waste BHW (T2) and conventional pig food PKC (T1). Thus, there were three treatments with 12 pigs per treatment. The pigs were reared for 10 weeks over which the chemical composition, performance and digestibility studies, carcass and organ function, serum and haematological status, and physico – chemical analysis and palatability were evaluated. The study was arranged as a completely randomized design. Daily weight gain, daily feed intake and body weight gain had highest ( $P<0.05$ ) values of 107.45g, 105.31g and 4513.00g in T1 compared to T2 (37.52g, 63.39g and 1580.00g) and T3 (60.00g, 63.30g and 2520.00g) respectively. Pigs on T3 performed best in physico – chemical evaluation having the lowest ( $P<0.05$ ) for thermal and cold shortening, cooking loss and thaw rigor but highest ( $P<0.05$ ) values for water holding capacity than for T1 and T2. Lymphocyte values and white blood cell were best for T3 while T1 had highest in monophils. The T3 had lowest significant cholesterol value (106.80 mg/dL), than T2 (336.76 mg/dL) and T1 (123.88 mg/dL) while T1 did best ( $P<0.05$ ) in glucose content (84.92 mg/dL), compared to T2 (60.22 md/dL) and T1 (66.63 mg/dL). The T1 had the highest palatability scores ( $P<0.05$ ) for palatability status than T2 and T3. T1 performed best in palatability scores, performance evaluation and carcass and organ characteristics, while T2 and T3 led to higher physico – chemical properties, serum and haematological parameters, which had positive significant effect on the health status of the pigs.*

**Keywords:** Boiled Hatchery Waste (BHW), Boiled Dead Bird (BDB), PKC, Pigs, and Diets.

### Introduction

With the ever increasing human population in Nigeria and the world as a whole and comparing to the virtually static Agriculture productivity, animal protein consumption among Nigeria has worsened in the past few year (Okpor, 1999). Many Nigerians feed on carbohydrate; this is because the average man is not enlightened on the significant of animal protein, which are richer in amino acid and because of the fear of cholesterol and saturated fat, many average income earners, and the wealthy people tends to take more plant protein with fruits, vegetables and carbohydrates foods □ Morrison (1991) noticed that, the deficiency of animal protein in the diet of so

many people is attributed to the low number of livestock and their products, and the activities connected with their production which is not efficient. Animal protein are considered to be complete source of protein because they contain all of the essential amino acid that the body needs to function, because animal sources of protein tend to deliver all the amino acid needed in the body. Studies have shown that high-protein food choices play positive role in health of the people and that by supplementing protein sources like fish; chickens can lower the risk of several diseases and premature death (Belewu, 1986). Animal Protein can be derived from meat (cattle,

## *Quality evaluation of pigs fed poultry by-products*

rabbit, goat, sheep, pig, etc), fish, snail, poultry, eggs and dairy (Heathline, 2017). Previously, the U.S Department of Agriculture (USDA) (2010) talks about more fruits, vegetables and whole grains with modest portion of lean meat and low-fat-diet, and that red meat was still virtually banned, as are whole-fat-milk, cheese, cream, butter and a lesser extent, eggs (Nina, 2015). And that cutting back on fat has clearly meant eating more carbohydrates such as grains, rice, pasta and fruits. During this time, the health of America has become striking worse, with the low-fat, low cholesterol diet recommended by America Heart Association AHA (1995), leading to several diseases, like heart diseases, obesity, diabetics, cancers, joint pains etc.

The United States, however, recommended a limit of 300 mg of cholesterol per day for healthy people, the equivalent of one and half eggs (FDA, 1999) and a single large egg has just less than 200mg of cholesterol, and consumption of 2 – 3 daily over a long period of time has never shown to have more than a minimal impact on serum cholesterol, (Keys, 1952). The body secretes insulin whenever carbohydrates are eaten, if carbohydrates are eaten occasionally, the body has time to recover between the surges of insulin. The fat cells have time to release their stored fat, and the muscles can burn the fat as fuel. If carbohydrates are eaten throughout the day, in meals, snacks, and beverages, then insulin stays elevated in the bloodstream, and the fat remain in a state of contact lockdown, then it accumulates to excess; stored and not burned (Nina 2015).

These observation has raise a big question mark about fat in animal protein (saturated fat) which are numerous in eggs and other animal products; that more consumption of these products can improve the health of humans and drive away sugar in our body

and blood, which is the root of all deadly sickness and diseases. An experiment on pig production was carry out in this study, to examined the effect of animal protein (poultry-by-product) diet, since human and animal are both mammals. Poultry-by-products (Hatchery waste and dead birds) and PKC (conventional feed) were used to feed pigs, the hatchery waste and dead birds are animal protein source and their effect on pig consumption were noticed. Hatchery waste from animal source is high in crude protein and contains substantial amount of energy with values of 23.75% and 4.88 Mcal/kg respectively (Vanderpopuliere *et al.*, 1976), calcium content can be quite high, depending on the proportion of eggshells (Gohl, 1970). This study therefore, considers the effect of feeding poultry-by-products in the diet of pig production.

### **Material and methods**

#### ***Experimental site***

The research was carried out in the piggery unit of the Department of Animal Science at the Teaching and Research Farm of Osun State University, College of Agriculture, Ejigbo, Osun State. The farm is located on latitude 7° 54N and longitude 40° 18E and 4° 54E at an altitude of 426m above the sea level (En Wikipedia. Org/Wiki/Ejigbo, 2011). Ejigbo is located in the middle portion of 35km to the North East of Iwo, 30km from Ogbomosho in the north and about 24km east.

#### ***Experimental animals***

A total number of thirty-six Large White weaned pigs at 10 weeks of age were purchased from a reputable farm. The pen and equipment were cleaned and prepared upon the arrival and they were given anti-stress on arrival. The pigs were sorted into six treatments with 12 pigs per treatment and three replicates of four pigs each. Acclimatization of the pigs to the feed and

pen was done for two weeks and eight weeks for experiment.

***Treatment and experimental design used***

The following dietary treatments were employed. The pigs were allotted to the Treatment 1: Palm Kernel Cake (PKC), Treatment 2: Boiled Hatchery Waste (BHW), Treatment 3: Boiled Dead Birds (BDB). The pigs were raised under intensive system management. All daily routine management were carried out such as supply of clean water, feeding, washing of the pen, all appropriate record was taken and kept.

***Blood samples collection***

At the termination of the experiment, 5mL syringe, needles, blood collection bottles, mini cooler, disposable hand gloves, cotton wool and methylated spirit were used for blood sample collection. Blood was safely collected from a clinically healthy pig after weight was taken. 5ml of blood was collected from each pig through the thigh and jugular vein using hypodermic needle and syringe. 5ml of blood was collected for serum analysis and 2ml of blood for haematological analysis in each treatment and replicate respectively. Blood sample were released into the sample bottles containing Ethylene Diametracetic Acid (EDTA) anti-coagulant and the bottles were shaken to ensure proper mixing of the blood with the EDTA acid and to prevent coagulation. The remaining 2ml of blood were released into some other bottles without anti-coagulant to harvest serum. The EDTA bottle containing blood sample was kept in an ice-pack and was taken to the physiology laboratory at University of Ibadan for the analysis.

The PCV which is also known as haemocrit (HCT) of each pigs were analyzed or measured by centrifugation of blood in heparinized capillary tube (with one end scaled) using haematocrit centrifuge and it was measured with the haematocrit ruler.

The RBC is determined using manual haemocytometer. WBC were counted using a small amount of blood which was accurately diluted with 2% Acetic acid which destroys the non-nucleated Acetic acid which destroys the non-nucleated erythrocyte and makes closely visible the nucleic of the leucocytes.

***Physico-chemical analysis***

The parameters measured from the analysis includes cold shortening of meat, water holding capacity of meat, cooking loss and thermal shortening of pig meat.

***Water holding capacity***

Water holding capacity of meat samples was determined with press method as slightly modified by Suzuki *et al.* (1991). An approximately 1g of meat sample was placed between two 9cm whitman No1 filter papers (Model C. Caver Inc, Wabash, USA). The meat samples were then pressed between two 10.2 x 10.2 cm<sup>2</sup> plexi glasses at about 35.2 kg/cm<sup>3</sup> absolute pressure for one minute using a vice. The meat sample was removed and oven dried at 105 °C for 24 hours to determine the moisture content. The amount of water released from the meat sample was measured indirectly by measuring the area of filter paper wetted paper wetted relative to the area of pressed meat samples. Thus water holding capacity was calculated as follows:

$$WHC = \frac{100 - (Aw - Am) \times 9.4}{Wm \times Mc}$$

Where: Aw = Area of meat samples (cm<sup>2</sup>)

Wm = Weight of meat samples (g)

Mc = Moisture content of meat samples (%)

9.47 = a constant factor

***Cold loss and cold shortening of meat***

Cold loss of meat was measured by taking the weight of meat sample and was wrapped in polythene bags and chilled at 4°C for 24 hours. The meat samples were removed, reweighed and the difference in weight will be expressed in g/100g according to Tenin *et al.* (2000).

## Quality evaluation of pigs fed poultry by-products

Thus:

Cold loss =  $\frac{\text{Initial weight of meat} - \text{Final weight of meat} \times 100}{\text{Initial weight of meat}}$

Cold shortening of meat samples was measured with the same meat sample for determining cold loss.

### Cooking loss and thermal shortening

Cooking loss was measured by taking a known weight meat samples, wrapped in air tight polythene bags and cooked in water in pre-heated pressure cooking pot for 20 minutes at an adjustable Pifeo Japan Electric Hot Model (NO ECP 2002), until the center of meat samples was heated to 72°C (Malgorzata *et al.*, 2005). Meat samples were removed from the pot and were allowed to equilibrate to room temperature. The meat samples were reweighed and the difference in weight recorded as percentage cooking loss as follows:

Cooking loss =  $\frac{\text{Initial weight of meat} - \text{Final weight of meat} \times 100}{\text{Initial weight of meat}}$

Thermal shortening measurement was determined with the same meat samples used for measuring cooking less meat samples. The lengths of meat samples were re-measured after cooking for 20 minutes and cooling to room temperature, the difference in length was expressed as thermal shortening following the modified method of (Malgorzata *et al.*, 2005).

Thus:

Thermal shortening =  $\frac{\text{Initial length of meat} - \text{Final length of meat} \times 100}{\text{Initial length of meat}}$

Thus:

Thermal shortening =  $\frac{\text{Initial length of meat} - \text{Final length of meat} \times 100}{\text{Initial length of meat}}$

Initial length of meat

### Proximate composition

Samples were analyzed chemically according to the official methods of analysis described by the Association of Official Analytical Chemist (AOAC., 2005). All analysis was carried out in duplicate.

### Palatability status

A total number of forty trained panellists were selected comprising of adults between ages of 20 - 45. The panellists were randomly allocated to the three treatments. The panellists were made to rate each of the three replicates of the pork samples on a colourless plate under a white florescent light, each bite was accomplished with biscuits bite to erase the previous mouth taste. The panellists rated the samples on tenderness, colour, flavour, juiciness and overall acceptability.

### Digestibility study

The digestibility was conducted during the last week of the experiment three pigs per treatment were randomly selected and kept in a metabolic cage for digestibility studies. Faecal samples was collected daily, oven dried and taken to the laboratory for proximate composition to determine the nutrient composition in the feed according to (AOAC, 2005).

### Growth performance

Parameters that were measured under this study include daily feed intake, weekly feed intake, weekly weight changes, daily weight changes, feed conversion ratio etc.

### Initial weight

The initial weight of the pigs was taken before allocating them into treatments and thereafter data on their body weight, weekly feed consumed, changes in the body weight and the number of mortality were collected. The weight gains and feed efficient ratio were determined on a weekly basis as follows;

### Feed intake (g)

A known quantity of feed was given to the pigs and the leftover was measured to determine both the daily feed intake and weekly feed intake.

Feed intake per bird =  $\frac{\text{Feed supplied} - \text{left over}}{\text{Number of pigs per replicate}}$

**Weight gain**

The initial body weight of the pigs and also subsequently body weight on a weekly basis were taken.

$$\text{Weight gain} = \text{Final weight} - \text{initial weight}$$

**Feed Conversion Ratio (FCR)**

The FCR of each groups of pigs were determined by calculation the ratio of feed intake to the weight gain.

$$\text{FCR} = \frac{\text{Total Feed Intake (g)}}{\text{Total weight gain (g)}}$$

**Carcass evaluation**

After 10 weeks of experiment, six pigs per treatment were selected for carcass yield measurement. Pigs were randomly picked,

weighted and fasted overnight, Pigs were sacrificed by rendering them unconscious, slitting the throat, ensuring complete bleeding by prolonged horizontal position. Then placed in a scalded in a temperature of 58 - 60°C s. Scraping of hair on carcass and eviscerated was done. Carcass cut parts and organs weight was taken. The carcass weights were the head, legs, shanks, and all prima cut and viscera to determine the percentage of carcass weight. The head, neck, trotters, spare ribs, shank, heart, back, liver, spleen, trachea, fat kidney, lungs, testes and intestine.

**Results and Discussion**

**Table 1 Proximate Composition of Experimental Diets**

Treatment	T1 (PKC)	T2 (BHW)	T3 (BDB)
Crude protein (%)	11.65 <sup>b</sup>	13.63 <sup>b</sup>	17.28 <sup>a</sup>
Ash (%)	2.72 <sup>b</sup>	16.02 <sup>a</sup>	0.58 <sup>c</sup>
Ether extract (%)	3.09 <sup>a</sup>	1.84	2.67 <sup>b</sup>
Crude fibre (%)	6.29 <sup>a</sup>	0.07 <sup>b</sup>	0.02 <sup>c</sup>
Dry matter (%)	53.18 <sup>a</sup>	36.16 <sup>b</sup>	24.95 <sup>c</sup>
Moisture content(%)	46.60 <sup>c</sup>	63.72 <sup>b</sup>	74.99 <sup>a</sup>
NFE	76.25 <sup>ab</sup>	68.44	79.45 <sup>a</sup>

Mean on the same row with different superscription are significantly different (P<0.05)

T1 =PKC-Palm kernel cake, T2= BHW-Hatchery by product and T3= BDB – Poultry- by-product.

**Table 2: Performance of Pigs fed Poultry - by-products in their diet.**

PARAMETERS	T1(PKC)	T2(BHW)	T3(BDB)	SEM
Crude protein (%)	84.87 <sup>a</sup>	54.30 <sup>c</sup>	67.34 <sup>b</sup>	6.31
Crude fibre (%)	70.19 <sup>b</sup>	79.30 <sup>a</sup>	79.89 <sup>a</sup>	3.14
Ether extract (%)	70.04 <sup>b</sup>	87.27 <sup>a</sup>	86.16 <sup>a</sup>	5.57
Dry matter(%)	90.67 <sup>b</sup>	90.62 <sup>b</sup>	90.84 <sup>a</sup>	0.21
NFE (%)	46.87 <sup>c</sup>	59.40 <sup>b</sup>	65.62 <sup>a</sup>	5.40

Mean on the same row with different superscription are significantly different (P<0.05)

**Table 3: Apparent Digestibility (%) of Nutrients of Pigs fed Poultry- by-product in their diet.**

Treatments	T1 (PKC)	T2 (BHW)	T3 (BDB)	SEM
Initial body weight (g)	7520.00	5760.00	6600.00	1093.49
Final body weight (g)	12030.00 <sup>a</sup>	7340.00 <sup>a</sup>	9120.00 <sup>b</sup>	1467.36
Body weight gain (g)	4513.00 <sup>a</sup>	1580.00 <sup>c</sup>	2520.00 <sup>b</sup>	1367.36
Daily body weight (g)	107.45 <sup>a</sup>	37.52 <sup>c</sup>	60.00 <sup>b</sup>	5.65
Daily feed intake (g)	105.31 <sup>a</sup>	63.30 <sup>b</sup>	63.60 <sup>b</sup>	5.40
Feed conversion ratio	0.98 <sup>c</sup>	1.68 <sup>a</sup>	1.06 <sup>b</sup>	0.12

Means on the same row with different superscription are significantly different (P<0.05)

### Quality evaluation of pigs fed poultry by-products

**Table 4: Serum biochemistry parameters of pigs fed Poultry- by-products in their diet.**

	T1(PKC)	T2(BHW)	T3(BDB)	SEM
Glucose (mg/dl)	84.92 <sup>a</sup>	60.22 <sup>a</sup>	66.63 <sup>b</sup>	5.22
Ast (u/l)	13.64	11.50	14.09	3.64
Alt (u/l)	2.48 <sup>c</sup>	3.68 <sup>a</sup>	4.24 <sup>a</sup>	0.25
Cholesterol (mg/dl)	123.88 <sup>b</sup>	336.76 <sup>a</sup>	106.80 <sup>c</sup>	58.76
Total Protein (g/dl)	9.28 <sup>b</sup>	7.73 <sup>c</sup>	13.37 <sup>a</sup>	0.68
Albumin (g/dl)	5.32 <sup>a</sup>	3.96 <sup>b</sup>	5.40 <sup>a</sup>	0.83
Creatinine (mg/dl)	4.99 <sup>a</sup>	1.83 <sup>b</sup>	1.50 <sup>c</sup>	1.03
Urea (g/dl)	44.0 <sup>b</sup>	55.38 <sup>a</sup>	52.32 <sup>a</sup>	9.54

<sup>a,b,c</sup> means on the same row are significantly different (P < 0.05).

**Table 5: Haematological parameters of pigs fed Poultry- by-product in their diet.**

	T1(PKC)	T2(BHW)	T3(BDB)	SEM
PCV %	35.40 <sup>b</sup>	36.50 <sup>b</sup>	38.00 <sup>a</sup>	0.63
Hb (g/dl)	11.80	12.10	12.60	0.15
Rbc (10 <sup>6</sup> /ul)	11.23	11.34	11.81	0.33
Wbc (10 <sup>3</sup> /ul)	6.17 <sup>b</sup>	9.50 <sup>a</sup>	9.75 <sup>a</sup>	185.78
Lymp %	66.00 <sup>b</sup>	68.50 <sup>ab</sup>	70.00 <sup>a</sup>	1.46
Neutro %	26.00	30.33	26.67	1.84
Mono %	3.00 <sup>a</sup>	1.67 <sup>b</sup>	1.67 <sup>b</sup>	0.27
Eosino %	2.33	2.00	2.33	0.54
Platelet×(10 <sup>3</sup> /ul)	61.90 <sup>c</sup>	543.33 <sup>a</sup>	316.70 <sup>ab</sup>	132.60

<sup>a,b,c</sup> means on the same row are significantly different (P < 0.05)

**Table 6: Carcass Characteristics of Pigs fed poultry-by-products in their diet.**

PARAMETERS	T1	T2	T3	SEM
TREATMENTS	(PKC)	(HBW)	(BDB)	
Fasted weight (g)	14.67 <sup>a</sup>	76.67 <sup>b</sup>	10.10 <sup>ab</sup>	1520.00
Bled weight (g)	13.80 <sup>a</sup>	10.33 <sup>ab</sup>	9.87 <sup>b</sup>	1530.00
Rib (g)	4167.00 <sup>a</sup>	1983.33 <sup>c</sup>	2800.00 <sup>b</sup>	541.23
Testes (g)	133.33 <sup>ab</sup>	50.00 <sup>b</sup>	150.00 <sup>a</sup>	19.25
Tail (g)	50.00	50.00	50.00	0.00
Head (g)	2000.00 <sup>a</sup>	1250.00 <sup>b</sup>	1550.00 <sup>ab</sup>	194.36
Right hind thigh (g)	1333.00 <sup>a</sup>	700.00 <sup>b</sup>	1000.00 <sup>ab</sup>	200.92
Left hind thigh (g)	1383.00 <sup>a</sup>	700.00 <sup>b</sup>	1017.00 <sup>ab</sup>	191.97
Left hind leg (g)	150.00 <sup>a</sup>	83.33 <sup>b</sup>	100.00 <sup>ab</sup>	19.25
Left thigh	1267.00 <sup>a</sup>	616.67 <sup>b</sup>	816.67 <sup>ab</sup>	120.19
Right fore shoulder (g)	1017.00 <sup>a</sup>	600.00 <sup>b</sup>	816.67 <sup>ab</sup>	122.09
Right leg (g)	150.00 <sup>a</sup>	83.33 <sup>b</sup>	100.00 <sup>ab</sup>	25.46
Right shoulder (g)	866.67 <sup>a</sup>	366.67 <sup>b</sup>	733.33 <sup>ab</sup>	147.19
Left fore shoulder (g)	1017.00 <sup>a</sup>	550.00 <sup>b</sup>	833.33 <sup>ab</sup>	159.57
Left leg (g)	116.67 <sup>ab</sup>	83.33 <sup>ab</sup>	216.67 <sup>a</sup>	83.33
Left shoulder (g)	900.00 <sup>a</sup>	466.67	733.33 <sup>ab</sup>	146.88
Caecum weight (g)	194.37 <sup>a</sup>	99.27 <sup>b</sup>	194.47 <sup>a</sup>	64.50
Liver weight (g)	141.87 <sup>c</sup>	183.43 <sup>b</sup>	209.47 <sup>a</sup>	53.60
Lung weight (g)	186.27 <sup>a</sup>	91.27 <sup>c</sup>	122.67 <sup>b</sup>	37.64
Spleen weight (g)	24.37 <sup>a</sup>	12.17 <sup>b</sup>	17.93 <sup>ab</sup>	2.76
Heart (g)	67.13 <sup>a</sup>	36.90 <sup>c</sup>	40.83 <sup>b</sup>	8.60
Kidney weight	58.00 <sup>a</sup>	33.70 <sup>b</sup>	38.43 <sup>b</sup>	4.14
Intestine weight (g)	1982.00 <sup>a</sup>	654.70 <sup>c</sup>	1053.00 <sup>b</sup>	79.11

Mean on the same row with different superscripts are significantly different (P<0.05)

**Table 7: Proximate composition of muscles of the pigs fed poultry-by-products in their diet.**

Parameters	T1 (PKC)	T2 (HBW)	T3 (BDB)	SEM
Crude protein	15.40	15.24	15.58	0.19
Ash	1.00	1.00	1.00	0.01
Ether extract	9.21 <sup>a</sup>	4.12 <sup>b</sup>	4.00 <sup>b</sup>	0.08
Crude fibre	0.01	0.01	0.01	0.00
Moisture	73.81	73.20	72.60	0.16
Dry matter	26.23	27.06	26.41	0.17

\*Subsets on mean are significantly different (p<0.05)

**Table 8: Physico-chemical analysis of pigs fed poultry-by-products in their diet.**

	T1(PKC)	T2(HBW)	T3(BDB)	SEM
Thermal Shortening %	39.14 <sup>a</sup>	31.82 <sup>b</sup>	31.51 <sup>b</sup>	1.70
Cold Shortening %	42.40 <sup>a</sup>	36.37 <sup>b</sup>	38.50 <sup>b</sup>	1.83
Cooking loss %	77.10 <sup>a</sup>	68.61 <sup>b</sup>	68.06 <sup>b</sup>	1.45
Thaw Rigour %	50.77 <sup>a</sup>	53.41 <sup>a</sup>	37.68 <sup>b</sup>	1.74
Water Holding Capacity %	150.80 <sup>b</sup>	161.40 <sup>ab</sup>	196.10 <sup>a</sup>	12.04

<sup>a,b,c</sup> means on the same row are significantly different (P < 0.05)

**Table 9: Palatability Status of pig fed poultry-by-products in their diet.**

Parameters	T1(PKC)	T2(HBW)	T3(BDB)	SEM
Colour	6.00 <sup>a</sup>	4.76 <sup>b</sup>	3.04 <sup>c</sup>	0.42
Flavour	5.31 <sup>b</sup>	6.74 <sup>ab</sup>	7.31 <sup>a</sup>	0.11
Tenderness	6.62 <sup>a</sup>	5.49 <sup>a</sup>	5.79 <sup>c</sup>	0.58
Juiciness	7.29 <sup>a</sup>	5.80 <sup>a</sup>	5.79 <sup>c</sup>	0.46
Texture	6.91 <sup>a</sup>	5.67 <sup>a</sup>	5.22 <sup>c</sup>	0.68
Acceptability	7.02 <sup>b</sup>	5.72 <sup>ab</sup>	5.71 <sup>a</sup>	6.53

\*Subsets on mean are significantly different (p<0.05)

Table 1 shows the proximate composition of the experimental diets. T1 (PKC) was significantly highest in ether extract, crude fibre, dry matter and NFE, while HBW was significantly highest (p<0.05) in ash content with 16.03% while BDB was highest (p<0.05) in protein, moisture and NFE content. The experiment diet given to the pigs had carbohydrate source (PKC) and animal protein source from poultry by – products (BHW and BDB). The PKC was high in fibre and plant fat and dry matter since it is from plant source. The BHW and the BDB were animal protein source having less or no fibre but higher protein content and moisture content. While HBW had a significant higher ash content since egg shell are very rich in mineral especially calcium. Goli (1970), observed that hatchery waste had quite high calcium

content depending on the proportion of egg shells.

Table 2, shows the performance characteristics of the pigs fed poultry-by-product in their diets. T1 performed better in final body weight, body weight gain, daily body weight, daily feed intake and feed conversion ratio. T2 and T3 did not increase in weight in Table 2, meaning that consumption of animal products or poultry -by- products did not affect weight gain in any area. Also the intake was also lower with higher feed conversion ratio compared to T1 (PKC) where the intake is almost doubled that of T2 (HBW) and T3 (BDB), with lower feed conversion ratio. Nina (2015), presents a state where body secrete insulin whenever carbohydrates are eaten. If carbohydrates are eaten only occasionally, the body has time to recover

### *Quality evaluation of pigs fed poultry by-products*

between the surges of insulin. The fat cells have time to release their stored fat and the muscles can burn the fat as fuel. If carbohydrates are eaten throughout the day, however, in meals snacks, and beverage, then insulin stays elevated in blood stream and the fat remains in a state of constant location.

Pennington (1954) also said that the absence of carbohydrate in feed / food would allow fat to flow out of the fat tissue, no longer held as energy. A person would lose weight, not because he /she necessarily eat less but because the absence of insulin was allowing the fat cells to release the fat and the muscles cells to burn it. The same that were fed with poultry-by-products loses fat and thereby loses weight. While those that were fed with PKC added more weight and so performed better.

Table 3 presents the apparent digestibility of nutrients of pigs fed animal protein in their diet. T2 and T3 had the highest digestible nutrients in crude fiber, ether extracts while T3 had the ( $p < 0.05$ ) digestibility values in T3 from dry matter and NFE respectively. It was showed that crude protein was higher digestibility in T1 when they consumed only conventional feed (PKC) mostly carbohydrate. This report agrees with that of Nina 2015. Gustafson and Stern (2003) reported a contrary report that pigs on high level of nutrition deposited both fat and lean at a faster rate than both moderate level of nutrition with both age and weight constant bases.

The report in Table 3 was contrary to that of Len *et al.* (2009) who had increase in fibre level of diet and also reduction of crude protein when maize cob was included in their diet.

Table 4 shows the serum biochemical parameters of pigs fed poultry-by-products in their diets. Glucose was higher in T1 (80.92 mg/dL) than T2 and T3 with 60.22

and 66.63mg/dL respectively. Albumin and creatinine also follows same trend. T2 was significantly higher in cholesterol with 336.76mg than T2 and T3 while total protein, urea and albumin were highest ( $p < 0.05$ ) in T2 and T3. In Table 4, the sugar (glucose) was higher in T1 indicating that the PKC breakdown to more sugar in their body after consumption. Cholesterol that people run away from consuming red meat or meat generally was very low in T3 where pig consumed poultry birds and even in T2 that had the highest cholesterol value of 336.76 mg/dL still fall in the daily cholesterol consumption limit which is 300 mg recommended by United States for healthy people which equivalent to one and half eggs (FDA, 1999). Keys (1952), reported that single large egg has just less than 200mg of cholesterol and that consumption of 2 – 3 daily over a long period of time has never have more than a minimal impact on serum cholesterol.

Table 5 shows that haematological parameters of pigs fed poultry-by-products in their diets. The T3 had the highest PKC, WBC, Lymphocyte while T2 in monocyte with 3.0% respectively. Haematology analysis talks about blood and blood indicate or reflect the state of health of an animal or an individual person. In this study, the poultry-by-products had the best volume of blood (PCV), its WBC which help to fight against disease in the blood and Lymphocyte were higher than T1 (PKC consumed pigs). This shows that when poultry-by products are consumed which are also animal protein sources food, it will affect the blood positively and thereby affecting the health of an animal. Nina (2015) also presented that the consumption of more animal protein in our diet will reduced the attack of diseases like diabetics, heart attack, body pain, obesity and every other chronic disease.

Table 6 shows the carcass characteristics of

pig fed poultry-by products. The T1 was highly significant in all parameters measured which were followed by T3 and then T2, respectively, except for liver weight, just as T1 had the highest values ( $p < 0.05$ ) in performance analysis so it had the highest values too for carcass and organ evaluation. The carcass and organ had highest weight due to accumulation of fat trap in their muscle which was gotten from more consumption of PKC a carbohydrate source feed. T2 and T3 voided out more fat and fibre in digestibility table which means more of the fat was not trapped in their muscles.

Table 7 depicts the proximate composition of muscles of poultry-by-products in their diets. The muscles showed that T1 had the highest significant ( $p < 0.05$ ) values in ether extract and moisture content while others parameters measured were not significantly different ( $p < 0.05$ ). this results indicated that the PKC consumed resulted in a lot of fat deposit in their body, and this is directly in proportion with the results in T2 on performance analysis and also in carcass and organ characteristics measured. The findings however are in line with the findings of (Roberts *et al.*, 1989) for pigs' muscle that were stored using different methods.

Table 8 had the physico-chemical analysis of pig muscles fed poultry-by-products in their diets. T1 had highest ( $p < 0.05$ ) significant value in thermal shortenings, cold shortening, cooking loss, thaw rigour than in T2 and T3. While T3 had the highest value in water holding capacity followed by T2 with T1 having the least value. Good physical muscle would have higher water holding capacity (WHC) and low cooking loss, cold and thermal shortening and thaw rigour. The WHC was lower in PKC because of the high fat accumulation in it muscles, since there is a known relationship between fat and water in animal muscles.

Water holding capacity is the ability of muscle to hold back it water during processing of meat. The T2 and T3 had capacity than T1 showing that their muscles were very good and quality meat products. The report agreed with 42.1 - 62.7% gotten by Fakolade *et al.* (2018), who worked on the thigh muscle of three breeds of cattle (White Fulani, Sokoto Gudali and Red Bororo).

Table 9 shows the palatability status of pigs fed poultry-by-products in their diet. T1 (PKC) performed better in all parameters measured except for flavour ( $p < 0.05$ ) which was followed by T2 and then by T3. Flavour had relationship with the amount of fat content in a muscle, the flavour from T1 smell offensive when cooking was done and so affected the panellist score, but the amount of fat in the muscles as indicated in Table 7 (proximate composition) and Table 6 (carcass and organ characterise), make the muscle of T1 more tender, affecting it tenderness, texture and juiciness, which are key significant instrument to overall acceptability. T1 had the highest overall acceptability than T2 and T3 respectively.

### **Conclusion**

Consumption of poultry-by-products (animal protein) in the diet of pig animals, showed improvement on the apparent digestibility, physico-chemical analysis, haematological and serum parameters, which are strong indicators for good health status of any animal. Though pigs fed PKC did well in performance, palatability status, carcass and organ characteristics. Indicating that, if humans also consumes more animal products or animal protein in their diet, their health status with muscle morphology will be under control.

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*Quality evaluation of pigs fed poultry by-products*

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