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Carcass and Internal Organs Characteristics of Broiler Chickens Fed Soybean Diet

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ABSTRACT

Soybean (Glycine max) is a principal vegetable protein source in the animal feed industry in Nigeria, including the poultry feed industry, but because of the fact that it contains various anti-nutritional factors, the raw full-fat cannot be used in poultry nutrition. The present study was carried out to examine the carcass, and internal organ characteristics of broiler chickens fed a soybean diet. A total of eight hundred and four unsexed one-day-old broiler chickens (Arbor Acre) with an average weight of 45 ± 1.1 g were used in 56 days feeding trial to observe the effect of different processing methods of soybean on broiler chicken carcass and organs characteristics including; liver, spleen, lungs, crop, bile, pancreas, heart, intestine and empty gizzard. There were four dietary treatments (T1-T4), each containing soybean meal as the control diet, dried-boiled soybean, roasted soybean and dried-fermented soybean. Each treatment was replicated three times with 67 broiler chickens per replicate, giving 201 broiler chickens per treatment. The experiment was arranged in a completely randomized design. The starter diet was fed for 4 weeks and the finisher diet for 4 weeks. At the end of the feeding trial, 15 broiler chickens were randomly selected for sampling and collecting the data. The weight of the internal organs and carcass characteristics showed no significant difference in the treatment groups, but the fermented method showed the highest value in the live weight (2075.00 g), eviscerated weight (1532.46 g), and breast weight (483.72 g) compared to other carcass parameters in other treatments including the control diet. It is, therefore, concluded that for optimal broiler growth, the fermented processing method of soybean is recommended.

Keywords: Broilers chicken, Carcass characteristic, Diet, Internal organ, Processed soybean

INTRODUCTION

Soybean is a major source of protein widely used in the diet of broiler chickens (Guo et al., 2020). However, the use of soybean in young chickens is limited and contraindicated because of the anti-nutritional factors (ANF) and content of trypsin inhibitors (TI) and lectins, oligosaccharides, and phytate (Wu et al. 2020). Extrusion has a positive effect on the level of anti-nutrients (for example, by reducing the activity of trypsin inhibitors); however, it improves the digestibility of protein and starch (Konieczka et al., 2014). Several soybean processing techniques that are aimed at increasing the nutritional quality of soybean and other legumes can be accomplished by methods, such as toasting, cooking, extruding, salt treatment, fermentation, germination pressure cooking, cooking, soaking, urea treatment (Ayanwale, 1999; Okagbare and Akpodiete, 2006; Akande and Fabiyi, 2010). These soybean processing techniques uniquely present different opportunities and challenges in both the nutritional profile and nutrient availability of soybean for utilization by broiler chickens.

Different processing methods are used in processing soybean for their different protein products. Processing methods have an impact on the quality of the products, but it all depends on the method used (Araba and Dale, 1990). The heating process has been identified as the only method that affects the protein quality of soybean. Anti-nutritive factor (trypsin inhibitors and lectins) can be rendered inactive when

heating conditions, such as moisture content, heating temperature and heating time are properly used (Araba and Dale, 1990). Using high heating temperature leads to denaturing of the amino acid and protein content of the soya bean (Hurrell, 1990; Parsons et al., 1992). Therefore, the current study aimed to examine the effect of different soybean processing methods on broiler chicken carcass and internal organs characteristics.

MATERIALS AND METHODS

Ethical approval

The experiment was approved by the Federal University of Oye Ekiti (FUOYE) Faculty of Science Research Ethics Committee (RECOM), and reviewed and considered the submitted research protocol and hereby gives ethical approval (FUOYEFSC 201122-REC2022/006) to carry out the research.

Collection and processing of test ingredients

The experiment was conducted at the Federal University Oye Ekiti, animal production and health department, Ikole campus, Nigeria, located on latitude 7.7979^{o}N and longitude 5.3286^{o}E with bimodal rainfall peaks in July and August at the experimental location. The average ambient temperature during the experiment was 24.2^{o}C with high humidity of over 75%. The soybean seeds (Glycine max, East Asia), were procured from a local market in Ikole, Ekiti State, Nigeria. The collected seeds were cleaned by winnowing and hand-picking of stones and debris and were subjected to three processing methods (Akande and Fabiyi, 2010).

Roasting method

Soybean seeds were grilled in a metal saucepan over firewood. Soybean seeds were constantly and continuously stirred using a stir rod to avoid burning while roasting until a golden brown color was achieved. Soybean seeds were later spread on a concrete floor to cool, then ground into a meal referred to as dried roasted soybean (DRS) meal (Akande and Fabiyi, 2010).

Boiled soybean

Dried soybean seed was cooked by bringing water in a metal pot to a boiling point and pouring it in the boiling water for thirty minutes to produce the cooked full-fat and then sun-dried for 4 days and ground to produce the corresponding full-fat soybean designated as dried, boiled soya bean (DBS) meal (Akande and Fabiyi, 2010).

Fermented soybean

The soya beans seed was cooked in water for 30 minutes, left to cool, and then fermented for 48 hours. The soybean was then sieved, sundried for 4 days, and powdered to make dried fermented soybeans (DFS), (Akande and Fabiyi, 2010).

Management of experimental animals

A total of eight hundred and four one-day-old (804) unsexed broiler chickens (Arbor Acre) with an average weight of 45 ± 1.1 g were sourced from a reputable commercial hatchery at Ikole-Ekiti and were randomly allocated to 4 treatments and 3 replicates of 67 broiler chicks per individual cage of (6.5 x 3.2 x 6) ft. Each cage was adjusted with installed nipple drinks and free access water (*ad libitum*) and was raised on a deep litter system with wood shavings as bedding materials and a controlled environment. The feed was given twice daily in the morning (07.00 a.m.) and afternoon (04.00 p.m.). The treatments used in the research were four dietary treatments (T1-T4) with each diet containing T1 (soybean meal) as control diet, T2 (dried-boiled soybean), T3 (roasted soybean) and T4 (dried-fermented soybean) in a completely randomized design. The investigated parameters include growth performance, carcass and internal organ characteristics. The formulated feed with processed soybean at 33.56% in the starter mash diet and finisher mash diets with processed soybean at 30.57% and nutrient composition in the experimental diet are presented in tables 1 and 2, as the feeding was based on just starter and finisher diet and no grower diet was given. Routine vaccination and standard management practices were carried out (Kalam et al., 2021) and a 17-20 hours lightening schedule was observed, the feeding trial lasted for 56 days.

Carcass yield

At the end of the experiment, 15 broiler chickens were randomly selected from each replicate (45 broiler chickens per treatment). The broiler chickens were starved of feed overnight and then slaughtered by severing the jugular vein with a sharp knife and allowing blood to drain for five minutes. Slaughtered chickens were scalded in hot water (about 50^{o}C) for one minute, then de-feathered and eviscerated manually. The live weights and dressed weights were recorded and the internal organ (liver, kidney, heart, gizzard and intestine) were recorded and expressed as a percentage of live weight. The dressing percentage was calculated as the percent of live weight after bleeding and de-feathering. Eviscerated carcass weight was determined after removing blood, feather, shank, head, heart, liver, gizzard, kidney, lung, pancreas, crop, pro-ventricles, and the intestine.

Statistical analysis

For the statistical analysis, analysis of variance (ANOVA) using a general linear model (GLM) was carried out using SAS software (version 2012) on Demand for Academics (ODA, Cary, NC, USA). Moreover, means of treatment were analyzed using Tukey's honestly significant difference test at 5% probability test.

Table 1. Gross composition of starter and finisher experimental diets for the period of four weeks in broiler chickens

Ingredients (%)	Starter (Days 1-28)				Finisher (Days 29-56)			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
Maize	54.96	54.96	54.96	54.96	56.96	56.96	56.96	56.96
Soybean-meal	33.56	-	-	-	30.57	-	-	-
Dried boiled soybean	-	33.56	-	-	-	30.57	-	-
Roasted soybean	-	-	33.56	-	-	-	30.57	-
Dried fermented soybean	-	-	-	33.56	-	-	-	30.57
Wheat offal	8.51	8.51	8.51	8.51	9.15	9.15	9.15	9.15
DCP	1.50	1.50	1.50	1.50	1.70	1.70	1.70	1.70
Limestone	0.30	0.30	0.30	0.30	0.50	0.50	0.50	0.50
Lysine	0.25	0.25	0.25	0.25	0.23	0.23	0.22	0.22
Methionine	0.20	0.20	0.20	0.20	0.18	0.18	0.18	0.18
Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Toxin binder	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Enzyme	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Salt	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Total	100	100	100	100	100	100	100	100

T1: Commercial soybean meal (control), T2: Dried boiled soybean, T3: Dried roasted soybean, T4: Dried fermented soybean, DCP: Dicalcium phosphate, Premix: Vitamin minerals (methionine, lysine, biotin, niacin, folic acid)

Table 2. Nutrient composition of starter and finisher period of experimental diets fed to broiler chickens

Nutrients	Starter (Days 1-28)				Finisher (Days 29-56)			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
ME (KCAL/KG)	2937	2937	2939	2812	2937	2958	2938	2823
Crude protein (%)	21.5	21.54	21.15	23.8	20.45	20.48	20.12	22.54
Crude fibre (%)	6.00	7.80	5.72	6.50	5.80	8.20	7.10	6.30
Ash content (%)	7.65	5.33	6.85	7.23	7.83	5.69	7.26	7.39
Fat content (%)	1.98	2.07	2.27	2.98	2.15	2.23	2.35	3.15
Moisture content (%)	9.74	10.12	10.29	8.5	8.49	8.34	9.69	8.99

T1: Commercial soybean meal (control), T2: Dried boiled soybean, T3: Dried roasted soybean, T4: Dried fermented soybean, ME: Metabolizable energy

RESULTS AND DISCUSSION

Weight and percentage of carcass parameters

The weights of broiler chickens fed processed soybean diets are presented in Tables 3, and the percentage of broiler chicken carcasses are tabulated in Table 4. The live weights of chicken had no significant difference in the entire treatment group ($p > 0.05$). However, broiler chickens fed diet with fermented soybean had the highest live weight (2075 g) and the lowest (1766.67 g) was recorded in broiler chickens fed with roasted soybean meal. Fermented soybean had the best effect on the slaughter weight (1983.33 g). This may be due to the high level of crude protein that fermented soybean contained (51.85%) and with the lowest recorded in broiler chickens fed roasted soybean meal (1708.33 g). Dressed weight had no significant difference in all the treatment groups ($p > 0.05$), but the lowest was recorded in broiler chickens fed dried roasted soybean meal (1624.32 g). The findings of Abu et al. (2015) in broiler chickens are consistent with this finding of where the dressed weight of the broilers expressed as percentage live weights were similar between treatment groups. The were no significant differences ($p > 0.05$) in the eviscerated and wing weights across the treatment group. However, broiler chickens fed DFS had the highest eviscerated weight (1532.46 g), while those fed dried roasted soybean mean meal had the lowest (1299.13 g). The high eviscerated weight might result from an increase in the bioavailability of nutrients (Hotz and Gibson, 2007) and a decrease in the amounts of anti-nutritional agents (Egounlety and Aworh, 2003). Broiler chickens fed DRS had the heaviest wings (94.53 g), whereas the control group had the lightest wings (80.87 g). This finding is in line with the findings of Roberts et al. (1999), who demonstrated that broiler chickens that were fed roasted soybeans had better performance.

There was a significant difference among the groups regarding the weight of the thighs ($p < 0.05$) except for broiler chickens on a control diet (100.03 g) and those fed a dried boiled soybean diet whose weights were similar (100.80 g). This might be attributed to a better processing method that promotes digestibility. The thigh weight in the fermented soybean group showed a significant difference ($p < 0.05$), having the highest thigh weight of 111.92 g. The weight of thigh and breast, which signifies carcass superiority, was higher in DFS, compared to the weight of thigh and breast of broiler chickens fed DBS and the control diet, while broiler chickens fed roasted soybean had the lowest (87.97 g) thigh weight (Medugu et al., 2010). There was no significant difference ($p > 0.05$) in the weight of the drumstick across the treatment groups and the control except for broiler chickens fed a fermented soybean diet.

There was no significant difference ($p > 0.05$) observed on the chicken's back, neck, shank, and head weight across the treatment group. The feather weight for treatments 1-3 showed no significant difference ($p > 0.05$) except for treatment 4 (DFS), which had the highest weight of 56.73 g, compared to other treatment groups. The chicken back of the broiler chickens was weightier (273.46 g) in the fermented diet group, while the chicken back weight was last recorded in broiler chickens fed boiled and roasted soybean, respectively. There was a significant difference ($p < 0.05$) shown in the breast weight across the treatment group with treatment 4 (DFS) which had the highest (483.72 g), compared with those recorded in broiler chicken fed roasted soybean (582.48 g), boiled Soybean (410.25 g), and commercial soybean meal (399.15 g). Studies have shown that the fermentation method of processing soybean can degrade anti-nutritive and allergenic soybean compounds (Dimidi et al., 2019). The neck was also weightier in birds fed the fermented soybean diet, the control had the best shank weight, and the head was weightier in the roasted and fermented soybean diets, respectively, while the feather was found to have more weight in birds fed the fermented soybean diet.

The percentage of the chicken's back, breast, neck, shank, and head were also similar in all the treatment groups and the diets. The percentage of the feather in the live weight was similar in the control (2.13%), and broiler chicken fed boiled soybean (2.16%); however, significantly different ($p < 0.05$), compared to broiler chickens fed roasted (1.90%) and fermented (2.70%).

Table 3. Weight of carcass parameters of broiler chicken fed processed soybean diets for 56 days

Parameters (g)	T1	T2	T3	T4
Live weight	1791.67 ± 222.30	1816.67 ± 116.90	1766.67 ± 125.17	2075.00 ± 267.86
Slaughter weight	1740.00 ± 223.16	1766.67 ± 116.90	1708.33 ± 131.97	1983.33 ± 294.39
Dressed weight	1669.12 ± 233.12	1695.12 ± 85.58	1624.32 ± 123.01	1875.14 ± 257.37
Eviscerated weight	1330.12 ± 211.18	1371.43 ± 57.01	1299.13 ± 99.23	1532.46 ± 210.13
Wing weight	80.87 ± 10.63	86.54 ± 6.76	94.53 ± 28.89	91.97 ± 7.11
Thigh weight	100.03 ± 13.24^{ab}	100.80 ± 12.96^{ab}	87.97 ± 9.62^{b}	111.92 ± 16.58^{a}
Drumstick weight	103.55 ± 19.11	104.73 ± 9.42	103.15 ± 13.81	103.28 ± 15.07
Back weight	244.86 ± 60.65	233.27 ± 13.54	233.39 ± 31.42	273.46 ± 52.91
Breast weight	399.15 ± 68.16^{ab}	410.25 ± 30.84^{ab}	382.48 ± 35.85^{b}	483.72 ± 87.55^{a}
Neck weight	84.87 ± 18.52	89.37 ± 9.66	80.41 ± 12.37	90.33 ± 19.32
Shank weight	47.39 ± 8.37	44.53 ± 5.07	44.64 ± 7.12	43.29 ± 8.50
Head weight	54.89 ± 4.03	56.91 ± 7.32	59.54 ± 12.51	59.15 ± 10.53
Feather weight	38.22 ± 13.74^{b}	39.26 ± 7.19^{b}	33.45 ± 6.24^{b}	56.73 ± 15.75^{a}

[ab]Different superscripts letters across a row are significantly different from each other at $p < 0.05$. T1: Commercial soybean meal (control), T2: Dried boiled soybean, T3: Dried roasted soybean, T4: Dried fermented soybean

Table 4. Weight of carcass in total live weights of broiler chickens fed processed soybean diets for 56 days

Parameters (%)	T1	T2	T3	T4
Dressed	93.04 ± 2.44	93.38 ± 1.79	91.93 ± 2.27	90.34 ± 2.71
Eviscerated	74.01 ± 1.65	75.59 ± 0.88	73.53 ± 0.77	73.83 ± 0.96
Wing	4.53 ± 0.46	4.76 ± 0.14	5.29 ± 1.17	4.47 ± 0.42
Thigh	5.58 ± 0.21	5.56 ± 0.67	4.98 ± 0.48	5.41 ± 0.57
Drumstick	5.75 ± 0.50^{a}	5.76 ± 0.37^{a}	4.76 ± 0.14	4.99 ± 0.54^{b}
Back	13.52 ± 2.07	12.88 ± 1.06	5.56 ± 0.67	13.16 ± 1.61
Breast	22.20 ± 1.56	22.61 ± 1.53	5.76 ± 0.37^{a}	23.23 ± 2.16
Neck	4.71 ± 0.71	4.94 ± 0.67	4.54 ± 0.54	4.34 ± 0.59
Shank	2.59 ± 0.30	2.46 ± 0.29	2.52 ± 0.30	2.10 ± 0.42
Head	3.08 ± 0.21	3.13 ± 0.29	3.35 ± 053	2.86 ± 0.42
Feather	2.13 ± 0.28^{ab}	2.16 ± 0.13^{ab}	1.90 ± 0.14^{b}	2.70 ± 0.22^{a}

[ab]Different superscript letters across a row are significantly different from each other at $p < 0.05$. T1: Commercial soybean meal (control), T2: Dried boiled soybean, T3: Dried roasted soybean, T4: Dried fermented soybean

Table 5. Weight of internal organs of broiler chickens fed processed soybean diets for 56 days

Parameters (g)	T1	T2	T3	T4
Liver weight	33.34 ± 8.66	29.36 ± 2.68	27.70 ± 3.94	33.33 ± 8.23
Spleen weight	1.45 ± 0.59	1.20 ± 0.26	1.19 ± 0.30	2.24 ± 1.31
Lung weight	8.92 ± 1.87	8.42 ± 1.53	8.87 ± 1.30	9.99 ± 1.69
Heart weight	7.75 ± 1.70	9.36 ± 1.63	7.47 ± 0.57	7.99 ± 0.76
Intestine weight	73.96 ± 6.47	72.66 ± 9.84	70.07 ± 7.37	77.38 ± 23.17
Crop weight	12.79 ± 1.41	13.57 ± 2.25	9.98 ± 2.68	14.45 ± 4.84
Bile weight	2.27 ± 0.56	2.10 ± 1.06	2.66 ± 0.67	3.78 ± 2.26
Pancreas weight	3.09 ± 0.47	2.90 ± 0.51	3.30 ± 0.47	3.52 ± 0.60
Empty Gizzard weight	41.39 ± 4.76	40.18 ± 6.82	38.77 ± 1.37	41.01 ± 3.84

T1: Commercial soybean meal (control), T2: Dried boiled soybean, T3: Dried roasted soybean, T4: Dried fermented soybean

Table 6. Weight of internal organs in live weight of broiler chickens fed processed soybean diets for 56 days

Parameters (%)	T1	T2	T3	T4
Liver	1.85 ± 0.13	1.62 ± 0.09	1.57 ± 0.08	1.59 ± 0.09
Spleen	1.45 ± 0.24	1.20 ± 0.11	1.19 ± 0.12	2.24 ± 0.54
Lung	0.50 ± 0.03	0.46 ± 0.03	0.51 ± 0.03	0.48 ± 0.03
Heart	0.43 ± 0.03^{b}	0.51 ± 0.03^{a}	0.42 ± 0.01^{b}	0.39 ± 0.02^{b}
Intestine	4.14 ± 0.09	3.99 ± 0.13	3.98 ± 0.19	3.71 ± 0.34
Crop	0.72 ± 0.04	0.75 ± 0.05	0.56 ± 0.05	0.70 ± 0.08
Bile	0.15 ± 0.01	0.17 ± 0.02	0.15 ± 0.01	0.18 ± 0.05
Pancreas	0.17 ± 0.01	0.16 ± 0.01	0.19 ± 0.01	0.17 ± 0.01
Empty Gizzard	2.33 ± 0.14	2.21± 0.14	2.20 ± 0.07	1.99 ± 0.09

^{ab}Different superscript letters across a row are significantly different from each other at $p < 0.05$. T1: Commercial soybean meal (control), T2: Dried boiled soybean, T3: Dried roasted soybean, T4: Dried fermented soybean

Weight and percentage of internal organs

The weights and percentages of the internal organs of birds fed processed soybean diets were measured and presented in tables 5 and 6. The internal organs measured were the liver, spleen, lungs, heart, intestine, crop, bile, pancreas, and empty gizzard and their weights were similar in all the basal diets. The values of the organs are within the range reported by Ayanwale (2006) on processed soybean. The mean liver weight was the highest in chickens fed dried fermented soya bean (33.33 ± 8.66 g) and in control group (33.34 ± 8.66 g). The weights of the spleen, lung, heart, intestine, crop, bile, and pancreas were higher in broiler chickens fed dried fermented soybean. Broiler chickens fed dried roasted soybean had the least weight of spleen, heart, intestine, crop, and empty gizzard, while broiler chickens fed dried boiled soybean had the lowest lung weight (8.42 ± 1.53 g). The percentage weight of the internal organs in the live weight indicated no significant differences in the percentage of the lung, intestine, crop, bile, pancreas, and empty gizzards across the treatment diets and the control ($p > 0.05$; Table 6). The percentage of heart weight in live weight d in broiler chickens fed Dried boiled soybean differ significantly compared to control and other treatment groups ($p < 0.05$; Table 5). The internal organs of broiler chickens fed processed soybean seed show no significant difference across the treatment group ($p > 0.05$).

CONCLUSION

In conclusion, DFS enhanced live weight, eviscerated weight, breast weight and internal organ characteristics of broiler chicken. It should be recommended for poultry farmers consider soybeans as the protein source by attention that the processed soybean had no deleterious effect in the present study.

DECLARATIONS

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Authors' contribution

Akinsoyinu Oluwadamilola collected the samples and carried out the fieldwork and wrote the first draft. Ekeocha Anthony Henry, Aganga Ademiju Adeolu, Emerue Patrick Chinedu and Akinsoyinu Oluwadamilola Victoria supervised the overall research, and statistical analysis and revised the draft of the manuscript. All authors approved the final version of the manuscript for publication in the present journal.

Competing interests

The authors declare that they have no competing interests.

Ethical consideration

Ethical issues, including plagiarism, consent to publish, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been checked by the authors who command respect in Nigeria by the ethically committed monitory team.

Availability of data and materials

All related data of the published article can be available according to a reasonable request from the corresponding author.

REFERENCES

Abu OA, Olaleru IF, and Omojola AB (2015). Carcass characteristics and meat quality of broilers fed cassava peel and leaf meals as a replacement for maize and soyabean meal. Journal of Agriculture and Veterinary Science, 8(3): 41-46. Available at: https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=2bed7c70a2333fa865c0098c427a016fbe57733a

Akande KE and Fabiyi EF (2010). Effect of processing methods on some antinutritional factors in legume seeds for poultry feeding. International Journal of Poultry Science, *9:* 996-1001. DOI: https://scialert.net/abstract/?doi=ijps.2010.996.1001

Araba M and Dale NM (1990). Evaluation of protein solubility as an indicator of over processing of soyabean meal. Poultry Science, 69(1): 76-83. DOI: https://www.doi.org/10.3382/ps.0690076

Ayanwale BA (1999). Performance and carcass characteristic of broiler chickens fed sodium sesquicarbonate processed soybean diets. Tropical Journal of Animal Science, 2(1): 85-93. Available at: https://www.ajol.info/index.php/tjas/article/view/49653/35982

Ayanwale BA (2006). Growth and characteristics of broiler fed alkali processed Soyabean. Nigerian Journal of Animal Production, 33(1): 40-44. DOI: https://www.doi.org/10.51791/njap.v33i1.2144

Dimidi E, Cox SR, Rossi M, and Whelan K (2019). Fermented foods: Definitions and characteristics, impact on the gut microbiota and effects on gastrointestinal health and disease. Nutrients, 11(8): 1806. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6723656/

Egounlety M and Aworh O (2003). Effect of soaking, dehulling, cooking and fermentation with *Rhizopus oligosporus* on the oligosaccharides, trypsin inhibitor, phytic acid and tannins of soybean (Glycine max merr.), cowpea (Vigna unguiculata l. Walp) and ground bean (Macrotyloma geocarpa harms). Journal of Food Engineering, 56(2-3): 249-254. DOI: https://www.doi.org/10.1016/S0260-8774(02)00262-5

Guo S, Zhang Y, Cheng Q, Xv J, Hou Y, Wu X, Du E, and Ding B (2020). Partial substitution of fermented soybean meal for soybean meal influences the carcass traits and meat quality of broiler chickens. Animals, 10(2): 225. DOI: https://www.doi.org/10.3390/ani10020225

Hotz C and Gibson R (2007). Traditional food-processing and preparation practices to enhance the bioavailability of micronutrients in plant-based diets. The Journal of Nutrition, 137(4): 1097-1100. DOI: https://www.doi.org/10.1093/jn/137.4.1097

Hurrell RF (1990). Influence of the Maillard reaction on nutritional value of foods. In: P. A. Finot, H. U. Aschbacher, R. F. Hurrell, and R. Liardon (Editors), The Maillard reaction in foods processing, human nutrition and physiology. pp. 245-258. DOI: https://www.doi.org/10.1007/978-3-0348-9127-1_27

Kalam M, Alim M, Shano S, Khan Nayem R, Badsha R, Al Mamun A, Hoque A, Tanzin AZ, Ali Khan S, Islam A et al. (2021). Knowledge, attitude, and practices on antimicrobial use and antimicrobial resistance among poultry drug and feed sellers in Bangladesh. Veterinary Sciences, 8(6): 111. DOI: https://www.doi.org/10.3390/vetsci8060111

Konieczka P, Nowicka K, Madar M, Taciak M, and Smulikowska S (2018). Effects of pea extrusion and enzyme and probiotic supplementation on performance, microbiota activity and biofilm formation in the broiler gastrointestinal tract. British Poultry Science. 59(6): 654-62.

Konieczka P, Smulikowska S, Czerwinski J, and Mieczkowska A (2014). Raw vs extruded coloured-flower pea as an ingredient in broiler diets: Effects on performance, ileal digestibility, gut morphology, and intestinal microbialactivity. Journal of Animal Feed Science, 23: 244-252. Available at: https://pdfs.semanticscholar.org/e23a/e2ba3c69797c28cc805616245555d2ecc7ea.pdf

Kuźniacka J, Adamski M, Czarnecki R, and Banaszak M (2014). Results of rearing broiler chickens under various systems. Journal of Agricultural Science, 6(4): 19-25. DOI: https://www.doi.org/10.5539/JAS.V6N4p19

Medugu CI, Kwari ID, Igwebuke JU, Nkama I, Mohammed ID, and Hamaker B (2010). Carcass and blood components of broiler chickens fed sorghum or millet as replacement for maize in the semi arid zone of Nigeria. Agriculture and Biology Journal of North America, 1(3): 326-329. Available at: http://www.scihub.org/ABJNA/PDF/2010/3/1-3-326-329.pdf

Okagbare GO and Akpodiete OJ (2006). Soybean in pre ruminant nutrition: A review. Nigeria Journal of Animal Production, 33(1): 83-86. DOI: https://www.doi.org/10.51791/njap.v33i1.2216

Parsons CM, Hashimoto K, Wedekind KJ, and Baker DH (1992). Soybean protein solubility in potassium hydroxide: An *in vitro* test of *in vivo* protein quality. Journal of Animal Science, 69(7): 2918-2924. DOI: https://www.doi.org/10.2527/1991.6972918x

Qin G, Ter Elst ER, Bosch MW, and Vander Poel AFB (1996). Thermal processing of whole soyabean: Studies inactivation of anti-nutritional factors and effect on lead digestibility in piglets. Animal Feed Science Technology, 57(4): 313-324. DOI: https://www.doi.org/10.1016/0377-8401(95)00863-2

Roberts R K, Pendergrass R, and Hayes R M (1999). Economic analysis of alternative herbicide regimes on Roundup Ready soybeans. Journal of Production Agriculture, 12(3), 449-454. DOI: https://www.doi.org/10.2134/jpa1999.0449

Wu P, Golly MK, Guo Y, Ma H, He R, Luo X, Luo S, Zhang Ch, Zhang L, and Zhu J (2020). Effect of partial replacement of soybean meal with high-temperature fermented soybean meal in antibiotic-growth-promoter-free diets on growth performance, organ weights, serum indexes, intestinal flora and histomorphology of broiler chickens. Animal Feed Science and Technology, 269: 114616. DOI: http://www.doi.org/doi:10.1016/j.anifeedsci.2020.114616