*Nigerian J. Anim, Sci. 2024, 26 (1): 101-110*

# Evaluation of the varying inclusion levels of lysine supplement on the growth performance and carcass yield of broiler finisher chickens

**Yisa, A. G., Edache, J. A., Imoisi, C. O. and Funok, Z.**

*Department of Animal Production, School of Animal Health and Production Technology, Federal College of Animal Health and Production Technology, Vom, Plateau State, Nigeria*

***Corresponding Author:*** *amosgyisa@gmail.com Telephone number: +234803 678 4413*

***Target audience:*** *Animal scientists, Poultry farmers, Feed millers, Researchers*

## Abstract

*This study was conducted to investigate the effects of varying levels of dietary lysine supplement on growth performance and carcass yield of broiler finisher chickens. One hundred and fifty (150) 4 weeks old broiler chickens were divided into 5 groups of 30 birds. Each group was further divided into 3 replicates of 10 birds in a Completely Randomized Design. The 5 groups were randomly assigned to five isocaloric and isonitrogenous diets containing lysine supplement with inclusion levels of 0.125, 0.100 (control), 0.075, 0.050 and 0.025 %. The experimental diets and drinking water were given to the birds ad libitum for a period of 4 weeks (28 days) during which average initial weights, feed intake, weight gains and final weights at the end of the study period were taken. In evaluating carcass yield, two birds with weights closest to the average of each replicate from each treatment were selected, slaughtered, scalded, plucked, eviscerated and dissected. The dressed carcass, carcass components and internal organs were weighed and expressed as percentage of live weights. Statistical analyses of data obtained revealed significant differences ($P < 0.05$) in all growth performance indices between treatments. Also, dressing percentages and proportions of breasts, drumsticks, hearts and gizzards differed significantly ($P < 0.05$) between treatments. It was concluded that reduction of dietary lysine supplement to as low as 25 % of recommended level did not have any adverse effect on growth performance and carcass yield of broiler finisher chickens.*

**Keywords:** Broilers; Growth Performance: Carcass; Lysine supplement

**Description of Problem**

The two major indicators in maximizing performance of broiler species are growth performance and meat yield being the primary purpose for which broilers are raised. Generally, optimum performance for any species is achieved by the plane of nutrition given and the ability of the birds to utilize the feed provided at the highest level such that maximum output in terms of 14 growth and body development is achieved with the least quantity of feed with other management factors being provided to support the task (1).

It is a common knowledge that feed constitutes the greatest and most costly input

in any livestock farm; especially poultry (2; 3). However, for optimum yield in poultry, the diet must contain all necessary feed nutrients which are carbohydrates, proteins, lipids, minerals, vitamins and water in appropriate amounts and right proportions.

For meat birds such as broiler chickens, key amongst these nutrients is protein; for it is the primary nutrient required for muscle building (4; 5; 6). Intact proteins are broken down by hydrolysis during digestion to yield amino acids, which are then utilized in the body to fulfil a variety of functions, which include: structural components of skin, feathers, and muscle, as well as filling important metabolic roles as blood plasma proteins, enzymes, hormones, and immune antibodies which are all individually involved in specific functions in the body (7). These amino acids have been classified as essential and non-essential because the former cannot be synthesized by the body either at all or in amounts not enough to meet physiological needs, while the latter could be synthesized by the body (8). Commercial poultry diets are routinely supplemented with essential amino acids due to the deficiency of these nutrients in most feed ingredients (9). According to (10), some of the advantages of amino acid supplementation include a reduction in the cost of production, an increase in weight gain, optimization of meat yield, a decrease in carcass fat and uniformity in nutrient intake. Amino acid supplementation also helps to conserve resources and reduce waste (nitrogen excretion) through better utilization for protein synthesis (11). Depending on the basal feedstuffs used in diets formulated, methionine and lysine occupy important positions in poultry nutrition and generally ranks as the first and second limiting amino acids (12). It is necessary to note that bird requirements for efficient development are based on amino acids in the diet and not on crude protein (13), but the crude protein and amino acid status of a diet also influence the carcass composition of broilers with increased carcass protein and reduced carcass fat (14). Notably, adverse effects in performance and carcass yield are perfectly possible in this period due to lysine limitation, since its contents in meat are exceptionally high. Besides, breast meat represents around 30 % of total broiler meat and 50 % of total edible protein (15). Amongst all the ingredients used in compounding poultry feed, lysine and methionine are the costliest per unit weight, and since feed 15 accounts for above 70 % of the cost of feeding poultry (16), it became expedient, in order to minimize cost, to consider varying the quantity of lysine supplement given to broilers and to see if the levels of lysine contained in the other ingredients can support optimum growth and development of the birds. Therefore, the effects of graded the levels of dietary lysine supplement on growth performance and carcass yield of broiler finisher chickens was investigated in this study

## Materials and Methods

### Experimental site

The experiment was carried out at the Poultry unit of the Livestock Investigation Division, National Veterinary Research Institute, Vom which is situated in Vwang district, Jos South Local Government Area of Plateau State, Nigeria. It has total land area of 510 km2 with Elevation of approximately 1280 metres above sea level and mean annual rainfall of 131.75 cm and a temperature range of 12°C - 33°C (54f-91f) (17)

**Experimental design and management of birds**

One hundred and fifty (150) day-old unsexed broiler chicks were purchased from a reputable hatchery. They were brooded in coal pot heated house together for 4 weeks on commercial broiler starter diets. At four weeks old, the birds were randomly allotted to 5 dietary treatments of 30 birds. Each treatment was further divided into 3 replicates of 10 birds in Completely Randomized Design and given the experimental diets. The 5 diets which were isocaloric (2780 kclME/kg) and isonitrogenous (21 % Cride Protein) contained 0.125, 0.100 (Control), 0.075, 0.050 and 0.025 % lysine supplement. The birds were managed in a well cleaned and disinfected poultry house in deep litter pens measuring 1.2 (w) x 2.2 (l) x1.2 (h) metres with rice bran as litter material. They were initially weighed at 28 days of age after which feed intake (obtained by subtracting weight of left-over feed from weight of feed given the previous day) and subsequent weights of the birds were taken and recorded on weekly intervals. The birds had free access to feed and water throughout the entire four (4) weeks of the experiment during which data for feed intake and weight gains were taken. All necessary vaccinations and preventive and curative medications were given to the birds in the course of the study.

**Source of test ingredients 16**

The lysine and methionine used were the branded types of L-Lysine and Methionine, while other feed ingredients were obtained from commercial feed stuff vendors within Jos South Local Government Area of Plateau State

**Feed intake and weight data collection**

A known weight of feed was weighed out and given daily. The leftovers after each day's meal were weighed. Feed consumption for each day was obtained by the difference between the weights of total feed given and the leftovers for each day. Average feed consumption per bird per replicate for the day was calculated by dividing the total weight of feed consumed by the number of birds in each replicate. Birds in each replicate were weighed on arrival and subsequently weighed at the end of each week. The average body weight per bird per week was obtained from each replicate by dividing the total body weight in each replicate by the total number of birds in the replicate.

**Determination of carcass characteristics**

The birds were fasted for 18 hours before the final weights at the end of the feeding trail (8 weeks of age) were recorded for all the treatments and replicates. Two birds having their weights closest to the average of each replicate for all the 5 treatments were selected, slaughtered, bled, scalded and plucked. Heads and shanks of each of the birds were severed (cut off), the carcass eviscerated and the dressed carcass weighed. After this, the different meat yielding parts of the carcass (breast, back, wings, thighs, drumsticks), abdominal fat and internal organs (heart, liver, gizzard and spleen) were cut at specific points as described by (18). The carcass and all the cut parts and internal organs were weighed for each of the chickens using a sensitive electronic scale. The weights of the various carcass components were then expressed as percentages of their respective live weights

**Experimental diets**

**Table 1:** Ingredient composition of broiler experimental diets

| | Dietary levels of lysine supplement (%) | | | | |
|---|---|---|---|---|---|
| Ingredients | 0.125 | 0.100 | 0.015 | 0.050 | 0.025 |
| Maize | 49.250 | 49.150 | 49.160 | 49.200 | 49.230 |
| Wheat offal | 7.385 | 7.370 | 7.370 | 7.380 | 7.380 |
| Rice bran | 4.930 | 4.920 | 4.920 | 4.920 | 4.930 |
| Soya bean cake | 34.310 | 34.360 | 34.360 | 34.390 | 34.410 |
| Fish meal | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Bone meal | 1.500 | 1.500 | 1.500 | 1.500 | 1.500 |
| Lime stone | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Salt | 0.250 | 0.250 | 0.250 | 0.250 | 0.250 |
| Premix (BF) | 0.250 | 0.250 | 0.250 | 0.250 | 0.250 |
| Lysine | 0.000 | 0.100 | 0.075 | 0.050 | 0.025 |
| Methionine | 0.100 | 0.100 | 0.100 | 0.100 | 0.100 |
| **Total** | **100.000** | **100.000** | **100.000** | **100.000** | **100.000** |
| M E (kcal/kg) | 2780.761 | 2778.072 | 2778.410 | 2780.691 | 2782.403 |
| Crude protein (%) | 21.042 | 21.051 | 21.051 | 21.069 | 21.082 |
| Crude fibre (%) | 4.790 | 4.791 | 4.793 | 4.793 | 4.796 |
| Ether extract (%) | 4.172 | 4.165 | 4.164 | 4.168 | 4.169 |
| Calcium (%) | 0.934 | 0.933 | 0.938 | 0.938 | 0.938 |
| Phosphorus (%) | 0.750 | 0.750 | 0.749 | 0.750 | 0.750 |
| Lysine (%) | 1.314 | 1.294 | 1.265 | 1.242 | 1.217 |
| Methionine (%) | 0.461 | 0.461 | 0.461 | 0.461 | 0.461 |

Key: M E = Metabolizable Energy

**Statistical analyses**

All data obtained were subjected to One-way Analysis of Variance using SPSS version 25 (19) software package. Where applicable, significant differences between means were determined using the Duncan's option of the same package.

**Results and discussion**

Calculated Metabolizable Energy (ME) values of the test diets (Table 1) ranged from 2780.76 to 2782.40 kcalME/kg slightly below the 2900 to 3200 kcalME/kg recommended by (1, 6, & 20), which may not be a negative factor as broilers have the ability to utilize much lower energy diets (2280 kcalME/kg) without any measurable differences in the amount of energy consumed per unit live weight gain (21).

However, the calculated values for all the other nutrients are within the higher limits of the recommended range for broiler chickens. All the other nutrients are within the ranges recommended by (22). The

**Table 2:** Proximate composition of experimental diets containing graded levels of lysine supplement

| | Dietary levels of lysine supplement (%) | | | | |
|---|---|---|---|---|---|
| Nutrients | 0.125 | 0.100 | 0.075 | 0.050 | 0.025 |
| Moisture | 9.95 | 11.85 | 9.80 | 10.30 | 10.25 |
| Crude protein | 23.02 | 21.29 | 22.29 | 22.43 | 21.84 |
| Crude fibre | 10.70 | 11.10 | 7.40 | 5.77 | 6.50 |
| Lipids | 4.40 | 2.65 | 4.30 | 4.65 | 3.85 |
| Ash | 7.25 | 6.70 | 7.15 | 7.25 | 7.20 |
| Metabolizable Energy | 3100.40 | 2820.65 | 3240.10 | 3370.97 | 3230.45 |
| Nitrogen Free Extract | 43.28 | 43.41 | 46.56 | 49.30 | 47.36 |
| Calcium | 1.05 | 0.78 | 0.85 | 1.12 | 0.80 |
| Phosphorus | 0.10 | 0.08 | 0.08 | 0.09 | 0.09 |

proximate compositions of experimental diets containing graded levels of lysine supplement (Table 2) gives higher level (23.02 %) of crude protein recorded in diet containing 0.025 % lysine and least (21.29 %) recorded in diet containing 0.100 % lysine although across all dietary groups crude protein contents are not far apart. The crude protein levels are slightly higher than the crude protein requirements of broiler finisher chickens of 19 between 20 and 22 % by (20) and (22). Dietary crude fibre (CF) levels were higher than recommended levels of between 5 – 8 % by (22) for broiler chickens on diets containing 0.0125 and 0.100 % lysine supplement. The highest CF level was recorded in diet containing 0.100 % level of lysine and least in diet containing 0.050 % lysine supplement. The fibre levels of the first 2 treatments (0.125 and 0.100 %) are higher than the recommended range of 3 – 7 % for broiler chickens by (23). The reason for this is not clear and probably can be attributed to error during the analysis The other treatments are within the recommended range with levels reducing with decreasing levels of dietary lysine supplement. This finding is in agreement with the study conducted by (24) who reported higher crude fibre with higher levels of lysine inclusion. The levels of lipids/fat in the diets and other nutrients which are Metabolizable Energy, Nitrogen Free Extract, Calcium and Phosphorus are all within recommended ranges for broiler chickens.

**Growth performance**

Table 3 shows the Growth performance of broiler finishers fed diets containing graded levels of dietary lysine. A significantly lower ($P<0.05$) weight was recorded in the final weights of the birds in treatment containing 0.075% of lysine, while no significant difference ($P>0.05$) was recorded across other treatments. Only treatment containing 0.025% of lysine recorded a significantly different value in the feed conversion ratio of the birds. This is not in agreement with the report of (10) that some of the advantages of amino acid

supplementation include a reduction in the cost of production, an increase in weight gain, optimization of meat yield, a decrease in carcass fat and uniformity in nutrient intake.

**Table 3:** Growth performance of broiler finishers fed diets containing graded levels of dietary lysine

| | Dietary levels of lysine supplement (%) | | | | | |
|---|---|---|---|---|---|---|
| Parameters | 0.125 | 0.100 | 0.075 | 0.050 | 0.025 | SEM |
| Initial weights (g) | 890.00 | 890.00 | 836.67 | 868.33 | 733.33 | 32.52$^{NS}$ |
| Final weights (g) | 2220.00$^{a}$ | 2233.33$^{a}$ | 2116.67$^{b}$ | 2223.33$^{a}$ | 2250.00$^{a}$ | 29.90* |
| Weight gains (g) | 1330.00$^{ab}$ | 1343.33$^{ab}$ | 1280.00$^{b}$ | 1355.00$^{ab}$ | 1516.67$^{a}$ | 45.85* |
| Feed intake (g) | 4002.00$^{ab}$ | 4039.67$^{ab}$ | 3961.67$^{ab}$ | 4189.83$^{a}$ | 3911.67$^{b}$ | 57.26* |
| FCR | 3.04$^{b}$ | 3.02b | 3.16b | 3.10b | 2.63$^{a}$ | 0.10* |
| Feed cost (N /kg) | 461.91 | 461.28 | 460.47 | 460.10 | 458.48 | 0.23$^{NS}$ |
| Feed Cost/kg Gain | 1405.51$^{a}$ | 1392.47$^{a}$ | 1453.78$^{a}$ | 1425.35$^{a}$ | 1206.26$^{b}$ | 46.31$^{NS}$ |

$^{a,b,}$ Means in the same row with different superscripts are significantly different (P<0.05)
S E M = Standard Error of Mean, N S = Not Significant (P>0.05), * = Significant (P<0.05)

Table 3 shows the growth performance of the broiler finisher fed diets containing graded levels of lysine supplement. The initial weights of the birds were not significantly different (P>0.05). Also, the final weights, weight gains, feed intake and feed conversion ratio values were not affected (P>0.05) by levels of lysine supplement. The total weight gains divided by the number of days would translate to 47.50, 47.98, 45.71, 48.3, 54.14 g/bird/day for birds fed diets 1 – 5 respectively. Likewise average daily feed intake values would be 142.93, 144.27, 141.49, 139.70 g/bird/day respectively. These values are in agreement with the average weight gains and feed intake values reported by (20). Feed conversion ratio values ranging from 2.62 to 3.16 are slightly higher than the optimum values of between 1.8 to 2.2 reported by (1). The reason for the slightly poorer feed efficiency might be due to low temperatures recorded during the months of July to September as generally animals are known to consume more feed during cooler, compared to warmer periods (25) in order to meet up with the higher energy demands for body functions and maintenance of body temperature within optimum range. Other reasons could be as a result of the genetic quality of the birds which could not be ascertained in this study. Generally, the lower level of dietary lysine did not appear to have any adverse effect on the growth performance of the birds which is not in agreement with report of (15) who stated that "adverse effects in performance and carcass yield are perfectly possible in this period due to lysine limitation, since its contents in meat are exceptionally high". Also, (7) stated that one of the importance of inclusion of amino acid supplement in poultry diets is optimization of meat yield. It is however observed the FCR values of birds on the least

level of lysine supplement (0.025%) were significantly better (P<0.05) than those of the other treatments. The cost of feed per kilogramme decreased as the levels of lysine supplement in the diets were reduced. Subsequently, the feed cost per kilogramme weight gain decreased as levels of lysine supplement was reduced. Noteworthy, is that the birds fed diets with the least level of lysine supplement 22 (0.025 %) recorded significantly less feed cost per unit weight gain compared to the other treatments

In table 4, dressing percentages were significantly higher in birds fed diets containing 0.050 and 0.075 % lysine supplements compared to those fed diets containing higher levels if lysine including the ones fed the control diet (0.100 % lysine). Proportions of drumsticks, heart and gizzard to live body weights were also highest (P<0.05) with birds fed diets containing 0.050 % lysine supplement compared to the other treatments. Again, this contradicts the findings of the last 2 groups of authors (7 & 15) stated above who specified the need for amino acid supplementation to obtain optimum levels of meat yield in broilers.

5.2 Conclusion and application

Lysine inclusion at minimal level of 0.025 % supported growth performance better than 0.125 % and even the ones fed diets that contained the recommended level (0.100 %) of lysine supplement. Feed conversion ratio of birds on the least level of lysine was also better than what was obtained with other dietary treatments giving a better feed efficiency value. Thus, it is concluded that reducing lysine supplement level by as low as 25 % of recommended rates can support comparative or even better growth performance in broiler finisher chickens provided other ingredients used alongside are of good quality. The following applications may be considered:

To obtain optimum growth performance and carcass yield, lysine supplement can be included in in broiler chicken diets at minimal level of 0.025%. This is provided, the other ingredients used to make the feed are of good quality, especially the protein sources.

**Table 4:** Carcass yield of broiler finishers fed diets containing graded levels of lysine supplement

| | Dietary levels of lysine supplement (%) | | | | | |
|---|---|---|---|---|---|---|
| Parameters | 0.125 | 0.100 | 0.075 | 0.050 | 0.025 | SEM |
| Live weights (g) | 2300.00 | 2166.67 | 2233.33 | 2146.00 | 2216.67 | $50.84^{NS}$ |
| Carcass components expressed in % live weight | | | | | | |
| Dressing percentages | $73.68^{b}$ | $75.05^{b}$ | $82.21^{a}$ | $85.01^{a}$ | $77.01^{b}$ | $1.53^{*}$ |
| Necks | 3.75 | 3.68 | 4.03 | 4.23 | 4.64 | $0.29^{NS}$ |
| Backs | 10.23 | 10.53 | 11.15 | 10.52 | 11.63 | $0.30^{NS}$ |
| Breasts | $27.54^{a}$ | $25.79^{ab}$ | $23.66^{b}$ | $26.49^{a}$ | $28.51^{a}$ | 0.76* |
| Wings | 8.30 | 7.85 | 8.34 | 8.25 | 8.71 | $0.28^{NS}$ |
| Thighs | 11.08 | 10.14 | 11.51 | 10.40 | 11.35 | $0.44^{NS}$ |
| Drumsticks | $9.95^{ab}$ | $9.30^{b}$ | $10.53^{ab}$ | $10.90^{a}$ | $11.03^{a}$ | 0.32* |
| Abdominal fat | 0.48 | 0.26 | 0.40 | 0.44 | 0.22 | $0.10^{NS}$ |
| Internal organs (giblets) | | | | | | |
| Heart | $0.49^{ab}$ | $0.49^{ab}$ | $0.46^{b}$ | $0.53^{a}$ | $0.49^{ab}$ | 0.02 * |
| Liver | 2.27 | 2.13 | 2.21 | 2.10 | 2.05 | $0.06^{NS}$ |
| Gizzard | $2.19^{a}$ | $2.19^{a}$ | $2.02^{b}$ | $2.20^{a}$ | $1.87^{b}$ | 0.07* |
| Spleen | 0.13 | 0.12 | 0.19 | 0.11 | 0.14 | $0.02^{NS}$ |

[a,b] Means in the same row with different superscripts are significantly different (P<0.05)

S E M = Standard Error of Means, N S = Not significant (P>0.05), * = Significant (P<0.05)

**REFERENCES**


1. Mandal, A. B., Yadav, A. S., Johri, T. S. and Pathak, N. N. (2004). **Nutrition and Disease Management of Poultry.** First Edition. International Book Distributing Company. Charbagh, Lucknow 226004 U.P. (INDIA).
2. Kpomasse, C. C., Oke, O. E., Houndonougbo, F. M. and Tona, K. (2021). Broiler production in the tropics: A review. *Veterinary Medicine and Science* 7 (3): 831 - 842
3. Saenz, J. A. C. (2022). Feed conversion in broilers: what does it consist of and how to make it efficient? Veterinaria Digital. *Veterinariadigital.com.* (Accessed 27/11 2023)
4. Aduku, A. O. (2004). Animal Nutrition in the Tropics. Feeds and Feeding, Pasture Management, Monogastric and Ruminant Nutrition. Typeset by Davcon Computers and Business Bureau. 11 Baptist Church Road, Samaru, Zaria, Kaduna State.
5. McDonald, I. P., Edwards, R. A., Greenhalgh, J. F. D., Morgan, C. A., Sinclair, L. A. and Wilkinson, R. G. (2011). Animal Nutrition. 7th Edition. Prentice Hall/Pearson Education. ISBN 1408204274, 9781408204276
6. Olomu, J. M. (2011). Monogastric Animal Nutrition. Principles and Practice, Second Edition, ISBN 978-

2692-53-0 St. Jackson Publishing, Benin City, Nigeria.

7. Corzo, A., Fritts, C. A., Kidd, M. T. and Kerr, B. J (2005). Response of broiler chicks to essential and non-essential amino acid supplementation of low crude protein diets. *Animal Feed Science and Technology*, 118: 319-327.
8. Cheeke, P. R (2005). Livestock Feeds and Feeding (3rd Edition). Pearson Prentice Hall. *Upper Saddle River, New Jersey.*
9. Attia, Y. A., AbdEl- Rahman, S. A. and Qota, E. M. A. (2001). Effects of microbial phytase without out on with cell-wall splitting enzymes on the performance of broilers fed marginal levels of dietary protein and metabolizable energy. *Egyptian Poultry Science.* 21(11): 521- 547.
10. Wallis, I. R (1999). Dietary supplements of methionine increase breast meat yield and decrease abdominal fat in growing broiler chickens. *Australian Journal of Experimental Agriculture,* 39:131-141.
11. Eits, R. M., Kwakkel, R. P., Verstegen, M. W. A. and Den Hartog, L. A (2005). Dietary balanced protein in broiler chickens. 1. A flexible and practical tool to predict dose-response curves. *British Poultry Science*, 46 (3): 300-309.
12. Meirelles, H. T., Albuquerque, R., Borgatti, L. M. O., Souza, L. W. O., Meister, N. C. and Lima, F. R. (2003). Performance of broilers fed with different levels of methionine hydroxy analogue and DL-methionine. *Brazilian Journal of Poultry Science*, 5:69-74.
13. Furlan, R. L., Faria-Filho, D. E., Rosa, P. S. and Macari, M (2004). Does low protein diet improve broiler performance under heat stress conditions? *Brazilian Journal of Poultry Science.*6 (2): 71-79.
14. Iyayi, E. A., Aderemi, F. A., Ladele, O. O. and Popoola, A. S (2014). Effects of low protein diets supplemented with amino acids (Methionine or lysine) on performance of broilers. *American Journal of Experimental Agriculture*. 4(5): 525- 531.
15. Junior, L., Alberto, L., Letti, G.V., Soccol, C.R., Junior, L., Alberto, L., Letti, Gilberto V. and Soccol, C.R. (2016). "Development of an L-Lysine Enriched Bran for Animal Nutrition via Submerged Fermentation by *Corynebacterium glutamicum* using Agro-industrial Substrates*"*. *Brazilian Archives of Biology and Technology* 59. ISSN 1516-8913.
16. Abdulrahman, O. I., Olatunde, P. F., Bello, O. G., Ayanda, I. F. and Oyegbami, G. (2023). Poultry Feed Crises in Nigeria: Implication for Poultry Production in Kwara State. *Journal of Agriculture and Environment* 18 (2): 15 – 24
17. National Veterinary Research Institute (NVRI, 2006). Programme of the 80th Anniversary of the National Veterinary Research Institute, Vom. October, 12-18.
18. Hann, G. and Spindler, M. (2002). Method of dissection of turkey carcasses. *Worlds Poultry Science*

*Journal*. 58: 179 – 201.

19. SPSS (2017). Statistical Package for Social Sciences. Pc Version 25. SPSS Inc. 444 N. Michigan Avenue Chicago, United States of America.
20. Oluyemi, J. A. and Roberts, F. A. (2007). Poultry Production in Warm Wet Climates. Macmillan Tropical Agriculture, Horticulture and Applied Ecology Series. Macmillan Press Limited, London and Basingstoke.
21. Farrel, D. J. (2005). Matching poultry production with available feed resources: Issues and constraints. *World's Poultry Science Journal*. 16: 298 – 307.
22. NRC (1994). Nutrient Requirements of Poultry. Ninth Revised Edition. Subcommittee on Poultry Nutrition, Board on Agriculture. National Academy Press, Washington, D C.
23. Poultry World (2012). Fibre plays a supporting role in poultry nutrition. https://www.poultryworld.net (accessed 07/12/2023)
24. Karr-Lilienthal L.K., Bauer L.L.,Utterback P.L., Zinn K.E., Frazier R.L., Parsons C.M. and Fahey G.C., (2006). Chemical composition and nutritional quality of soybean meals prepared by extrudes/expeller processing for use in poultry diets. *Journal of Agricultural Food Chemistry*, 54 (21): 8108- 8114.
25. Bolton, W. and Blair, R. (1986). Poultry Nutrition. Ministry of Agriculture, Fisheries and Food. Reference Book 147. London, UK.