Comparative Analysis of Zootechnical Performance in Broiler Chickens Across Different Technological Rearing Systems

Veronica-Denisa Lungu*, Andreea Ionela Zinca, Ioan Custură, Minodora Tudorache, Andra Dorina Suler, Dumitru Drăgotoiu

Faculty of Animal Productions Engineering and Management, University of Agronomic Sciences and Veterinary Medicine of Bucharest, 011464, 59 Mărăști Blvd, District 1, Bucharest, Romania

Abstract
This study conducts an in-depth investigation into the zootechnical performance of broiler chickens reared under diverse technological systems, against the backdrop of a globally increasing demand for chicken meat. The research addresses how the rearing system, along with factors such as nutrition, farm management, the rearing environment, and genetics, impacts the yield of chicken meat production. By comparing intensive, semi-intensive, and extensive growth systems, the research aims to identify optimal strategies that ensure efficient and sustainable chicken meat production, maximizing yield and quality while also considering animal welfare and environmental sustainability. The analysis encompasses the evaluation of daily weight, feed conversion ratio, and uniformity across different systems, as well as the examination of environmental homogeneity using the Student's t-test to highlight significant differences between batches. The findings offer valuable insights into the impact of the rearing system on zootechnical performance, indicating that the intensive system is characterized by superior yields and a preferential development of the breast. Moreover, the study highlights the significance of the interaction between genetic and nutritional factors and how these elements, together with the choice of rearing system and healthcare practices, contribute to the optimization of production.

Keywords: broiler chickens, feed consumption, mortality, rearing systems, weight gain, zootechnical performance

1. Introduction

In the context of the steadily increasing global demand for chicken meat, the zootechnical performance of broiler chickens emerges as a crucial research theme. This avian species is raised in various technological systems, and understanding the impact of these systems on their performance is fundamental for the poultry industry [1].
The growth of broiler chickens has witnessed significant development over recent decades, becoming a key segment of modern zootechnics. Ensuring the production of quality chicken meat, in large quantities and at reduced costs, represents an ongoing challenge for farmers [2].
The zootechnical performance of broiler chickens is influenced by factors such as nutrition, farm management, the growth environment, and the genetics of the chickens. Choosing an appropriate technological system can significantly affect the yield of chicken meat production. Therefore, research in this area is critical for optimizing production and ensuring the sustainability of the poultry industry [3].
Broiler chickens, also known as meat chickens, are a species of chicken primarily raised for meat production. These chickens are selected to grow rapidly and efficiently in weight so that they can

* Corresponding author: Andreea Ionela Zinca, +40784327893, zinca_andreea20@yahoo.com

be slaughtered and processed within a relatively short time frame [4,5].

Regarding the rearing systems for broiler chickens, they are diverse, with each system presenting its own advantages and disadvantages, and the choice of the appropriate system depends on several factors such as: the size of the farm (large farms may use intensive systems, while small farms may opt for extensive systems), production cost (intensive systems typically incur higher production costs compared to extensive systems), and animal welfare (extensive systems usually provide more space and freedom for broiler chickens, but are also more challenging to manage and may carry higher risks of illness among the chickens) [6,7].

The intensive system is the most commonly used in commercial chicken meat production. Chickens are raised in high-density barns, typically with 8-12 chickens per square meter. They have constant access to food and water and are raised rapidly, reaching a slaughter weight of 2-2.5 kg within 6-7 weeks [8].

The semi-intensive system offers chickens more space than the intensive system, with a density of 4-6 chickens per square meter. Chickens have constant access to food and water, but may also have access to a limited outdoor area [9].

The extensive system provides the chickens with the most space, with a density of 1-2 chickens per square meter. In this system, the birds are raised in open spaces or courtyards, having the opportunity to move freely and access natural food from their environment. Chickens have constant access to an outdoor area and can be fed a diet based on grains and insects. Often, they are fed a combination of natural feed, food scraps, and, sometimes, nutritional supplements. The extensive system is associated with low population densities, reducing stress and improving the overall health status of the birds [10].

2. Materials and methods

This article aims to investigate the zootechnical performance of broiler chickens bred in different technological systems. For the phenotypic characterization of lots, classical statistical methods [11] such as average, variation, standard deviation, average error, and variability coefficient were used. For the study of the homogeneity of the mediums, respectively for testing as statistically significant of the differences observed between the batches, the Student test was used [12].

The research methodology included collecting data on the zootechnical performance of broiler chickens bred in different technological systems, statistical analysis of the data collected, interpretation of the results, and formulation of conclusions.

As main objectives, we have the comparison of growth performance in which the daily weight will be assessed, the conversion of feed, uniformity in different breeding systems, and the identification of the most effective systems, which maximize the yield and quality of the production of chicken meat.

Weightings were conducted on a weekly basis, on the same day and at the same hour (4-6 hours post-feeding), in groups of five birds at ages 1, 7, and 14 days, and subsequently, individually, starting from the age of 21 days. Mortality rates were recorded daily, calculating weekly mortality percentages and for the entire growth period.

The difference between the initial and final weights of the chickens over the period is reported relative to the number of days in the period.

Daily losses were accumulated for each week of the chickens' lives and reported against the initial flock size for that week.

The average daily consumption (g/head/day) and the feed conversion ratio (g feed/g body weight) were calculated.

Regarding the live weight; this characteristic is differentiated by sex and directly influences the quantitative production of meat. The primary goal is to maximize the biological and economic efficiency of the growth process, which involves combining the factors engaged in this process and the capabilities of the chickens.

3. Results and discussion

A similar study in the literature was conducted by N`Dri et al. and investigates the genetic relationships between feed conversion rate, growth curve parameters, and carcass composition in a slow-growing line of chickens, labelled “Label”. It was found that indirect selection for the feed conversion rate is possible through the use of a growth curve and abdominal fat parameters, which does not require breeding offspring in cages [13].

A pertinent article that outlines methods and approaches for assessing the growth of chickens, including weekly weightings and the calculation of growth increments, feed consumption, and other performance indicators, was conducted by Larsen et al., in which they explored the effects of age on growth, feed conversion rates, weights of individual parts, and yields of female turkeys from three different strains. The study was carried out weekly from the ages of 12 to 21 weeks, providing valuable data on growth dynamics and feed usage efficiency in the context of intensive poultry growth [14].

The average daily gain is influenced by two categories of factors: genetic factors that control the potential limits of growth and environmental factors, primarily the nutritional component of the environment and its interaction with the genotype. Thus, favourable environmental conditions can stimulate growth, while unfavourable conditions may delay growth, although to a certain extent, the latter losses can be compensated [15].

A study in the scientific literature by Leclercq, B. examined the effects of dietary protein content on the growth of chickens with either lean or fat genotypes, highlighting how nutritional and genetic factors interact to influence growth performance. It was observed that lower protein contents negatively affected the growth of chickens with lean genotypes but did not have adverse effects on chickens with fat genotypes. Furthermore, the study demonstrated that for both lines, increasing the dietary protein content led to a reduction in feed ratio and abdominal fat deposition relative to live body weight, suggesting that dietary adjustments based on genotype can improve growth efficiency and body composition of chickens [16].

An important indicator of the amount of meat that can be produced from a flock of birds is the uniformity of growth, which is influenced by the cumulative effect of the chicks' weight at the hatch and the rate of growth [17].

A study conducted by Fanatico et al. [18] assessed the impact of genotype and outdoor access on growth rate and yield at slaughter. A slow-growing strain, two medium-growth genotypes, and a commercial fast-growing genotype were reared for periods of 81, 67, and 53 days, respectively. The data indicate significant differences in growth performance and slaughter yield among the genotypes, highlighting how management and genetic selection influence the uniformity of growth and the amount of meat that can be produced.

At the end of the 6th week of the Normal growth system, the 8th week of the Free growth system, and the end of the 11th week of growth, control slaughters were performed on 25% of the population, both to determine slaughtering performance and to establish the chemical composition of the meat, corresponding to each experimental lot.

Therefore, from Table 1, it emerges that the evolution of the average weekly body weight over the entire growth period, namely 6 weeks for the Normal system, 8 weeks for the Free system, and 11 weeks for the Eco and Traditional growth systems. It is noted that the body weight of the chicks increases with age, the minimum weight value among the presented growth systems being 74 g (Traditional system) and the maximum value 121 g (Normal system), at the age of one week.

The weekly body weight progression (Table 1) highlights that, except for the weight at one week of age, the minimum growth value belongs to the Ecosystem in the second week, also presenting the lowest weights throughout the 6, 8, and 11 weeks of growth, compared with the Normal growth system where we have an average increase of approximately 147 g.

Chakam et al. [19] also discovered, after testing 160 male broilers, aged 21 days, in groups of four birds each, measuring weight gain, feed conversion ratio that there was no statistically significant difference between treatment groups for feed consumption.

Another study carried out by Caisin et al. [20] found that supplementing chickens with feed with “Primix-Alfasorb” and “Primx-Bionorm-K” increased the live weight and average daily growth of chicks compared to the control group. The optimum doses for supplements were determined to be 0.2 kg/t for “Primix-Alfasorb” and 0. 2 kg/ t for “Primx-Bionorm-K”.

Table 1. Evolution of Body Weight of Broiler Chickens According to the Normal, Eco, Free, and Traditional Growth System

No	Period	Normal		Eco		Free		Traditional	
		Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
1.	Week 1	121.20	2.71	91.20	1.85	98.8	2.416683	74.8	2.154131
2.	Week 2	332.60	2.71	185.20	1.85	240.8	1.85478	170.8	3.878262
3.	Week 3	725.60	2.32	334.80	2.15	475.2	1.85478	315.6	2.135481
4.	Week 4	1136.40	2.93	504.80	2.42	748	2.000061	520	2.828513
5.	Week 5	1912.80	1.85	815.20	1.85	1032.8	2.154131	736.4	2.925837
6.	Week 6	2395.00	4.31	1050.00	2.45	1411.6	3.31069	976.4	2.315238
7.	Week 7			1405.60	1.72	1405.6	2.727719	1224.4	2.315238
8.	Week 8			1694.80	2.15	2098.4	3.31069	1468.4	2.561328
9.	Week 9			2086.80	2.87			1714.4	3.31069
10.	Week 10			2398.00	3.52			1962	2.000061
11.	Week 11			2632.00	3.03			2212	2.60776

The dynamics of weekly growth increment across all rearing systems are delineated in Table 2. Based on the conducted analyses and calculations, the growth increment was observed to increase with age across all experimental batches up to the sixth week of life, with minor statistically insignificant differences depending on the rearing system. A similar investigation was conducted by Gritsenko et al. in 2023 [21].
Chicks from all rearing variants exhibited very close average increments up to the sixth week for the rearing system, up to the eighth week, and for the Eco and Traditional systems, even up to the eleventh week.

Kuzniacka et al. [22] found that broilers fed with complete feeds and maintained in an intensive system were characterized by a higher fat content expressed as the weight of abdominal fat, as well as a lower average intake of feed mixtures per individual broiler. The research was carried out on 100 broiler chickens of both sexes, raised up to 42 days in an intensive system, as well as in a semi-intensive system. It was observed that the rearing system did not significantly affect the body weight of the chickens at the end of the growth period, meat yield, and muscular content of the carcasses.

Table 2. Weekly Growth Increment of Broilers According to Normal, Eco, Free, and Traditional Rearing Systems

Crt. No	Period	Normal		Eco		Free		Traditional	
		Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
1.	Week 1	82.60	2.71	55.20	2.80	58.8	2.416683	40	3.949804
2.	Week 2	211.40	4.15	94.00	2.68	142	2.828513	96	2.60776
3.	Week 3	393.00	1.34	149.60	0.98	234.4	1.720517	144.8	4.96402
4.	Week 4	410.80	4.32	170.00	1.90	272.8	2.800085	204.4	4.791805
5.	Week 5	776.40	3.25	310.40	1.17	284.8	3.006751	216.4	3.059505
6.	Week 6	482.20	4.50	234.80	2.65	378.8	378.8	240	4.147414
7.	Week 7			355.60	3.54	349.2	4.454347	248	3.949804
8.	Week 8			289.20	1.96	337.6	4.621829	244	4.56084
9.	Week 9			392.00	2.10			246	4.000122
10.	Week 10			311.20	1.20			247.6	3.059505
11.	Week 11			234.00	5.76			250	4.098905

The weekly viability of broilers, as depicted in Table 3, demonstrates satisfactory outcomes, with a uniform mortality rate of 0.4% across all growth systems in the initial week, followed by sporadic occurrences contingent upon the growth systems. Specifically, in the Eco and Traditional systems, a parallel mortality rate of 2.4% was observed in the final week 3.
To maintain the health status of the broilers throughout the experimental phase, vaccinations

mandated by Romanian legislation for the applied growth technology were administered, including against avian pseudo pest, infectious bursal disease, and infectious bronchitis, with broilers being procured disease-free.

Gabal & Azzam also assessed the impacts of aflatoxin-contaminated feed on the immune response of day-old chicks to live attenuated vaccines for Newcastle disease, infectious bronchitis, and infectious bursal disease. Concurrent exposure of chicks to 200 parts per billion of aflatoxin in feed and vaccination against the aforementioned diseases resulted in inadequate protection against subsequent experimental challenges, as evidenced by antibody responses compared with chicks fed aflatoxin-free diets. Mortality rates were higher in chicks fed with 200 ppb of aflatoxin compared to those fed aflatoxin-free diets [23].

A seminal article addressing the primary causes of mortality among broilers, including yolk sac infections, respiratory conditions, coccidiosis, limb issues, ascites, vascular and cardiac events, and sudden death syndrome, was conducted by Zafra et al. This study examined two cohorts of broiler chickens aged between 15 and 30 days, exhibiting respiratory symptoms such as dyspnoea and mortality rates up to 25%. Necropsy findings included severe ascites, right heart hypertrophy, pulmonary congestion, and extensive multifocal granulomatous pneumonia. Histopathological examination revealed chronic multifocal mycotic granulomatous pneumonia. Aspergillus fumigatus was identified through microbiological analysis of lung samples. Following floor disinfection and substrate replacement, no further clinical signs were observed in the farm. The severe chronic granulomatous pneumonia induced by A. fumigatus in the chickens of this study could have led to hypoxia, resulting in pulmonary hypertension, cardiac failure, and ascites [24].

Table 3. Evolution of Chick Mortality Based on the Rearing Systems: Normal, Organic, Free-Range, and Traditional

No	Period	Normal		Eco		Free		Traditional	
		Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
1.	Week 1	0.48	0.02	0.48	0.02	0.404	0.037631	0.428	0.018548
2.	Week 2	0.86	0.02	0.92	0.02	0.844	0.017205	0.852	0.018548
3.	Week 3	1.24	0.01	1.38	0.11	1.296	0.077307	1.248	0.018548
4.	Week 4	1.62	0.03	1.68	0.02	1.6	0.014143	1.652	0.021541
5.	Week 5	2	0.14	2.08	0.10	2.12	0.195965	2.16	0.172052
6.	Week 6	2	0.14	2.04	0.10	2.02	0.135651	2.28	0.162486
7.	Week 7			2.2	0.20	2.08	0.205919	2	0.200006
8.	Week 8			2.44	0.23	2.16	0.132669	2.48	0.185478
9.	Week 9			2.48	0.19			2.44	0.231524
10.	Week 10			2.36	0.25			2.36	0.248201
11.	Week 11			2.48	0.21			2.48	0.205919

Following the evaluation of slaughter performance both on carcass and live weight, the yield recorded similar values across all four growth systems, with the lowest value being in the Traditional growth system, specifically 98%, and on the opposite end, the best yield was found in the Normal growth system with a yield of 76%.

Considering the yield, the Normal system has the highest average yield (76.02%) with a relatively small variation (0.44), suggesting consistent results in this system. The Eco and Free systems have similar average yields (69.07% and 69.57%, respectively), but the Free system shows a greater variation (1.07), indicating potential inconsistency in results. The Traditional system has the lowest average yield (67.26%) but with the smallest variation (0.36), which suggests consistency in the lower yield.

The highest average percentage of breast is observed in the Normal system (29.88%), indicating that this system favours the development of the breast. The Eco system has the lowest average breast weight (16.91%), suggesting that this system may

limit the development of this part of the carcass. The Free and Traditional systems have lower average breast weights compared to the Normal system. Variations are relatively small between systems, all having average thigh weights in the range of 21.80% - 23.07%. This suggests that the growth system has a lesser impact on the development of the thighs.

Differences between systems are minor, with the Eco and Free systems having average wing weights close to the Normal system. The Traditional system presents the highest average wing weight (8.36%), with a very small variation (0.03), indicating consistent wing production in this system.

The Eco system has the highest average back weight (21.89%), followed by the Free and Traditional systems. The Normal system has the lowest average back weight (16.29%), which may indicate a greater allocation of nutrients to other parts of the carcass in this system.

Table 4. Slaughter Performance of Broiler Chickens - Live Weight

No.	Specification	Normal		Eco		Free		Traditional	
		Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
1.	Yield	76.02	0.44	69.07	0.57	69.57	1.07	67.26	0.36
2.	Breast Proportion	29.88	0.78	16.91	0.29	20.00	1.22	18.53	0.33
3.	Thigh Proportion	22.14	1.09	22.33	0.47	21.80	0.53	23.07	0.58
4.	Wing Proportion	7.72	0.23	7.95	0.21	7.88	0.28	8.36	0.03
5.	Back Proportion	16.29	0.58	21.89	0.30	19.89	0.53	17.31	0.09

In terms of yield, the Normal system has the highest average yield (76.02%), followed by the Traditional (67.26%), Free (69.57%) and Eco (69.07%). The standard deviation (S) is relatively small for all systems, indicating a relative homogeneity of performance within each system.

The Normal system has the highest average breast weight (29.88%), followed by the Traditional (18.53%), Free (20.00%) and Eco (16.91%). The standard deviation (S) is greater for the Free and Eco systems, indicating a greater variability of the chest weight in these systems.

Free and Traditional systems have similar average mass weights (21.80% and 23.07%, respectively), followed by Normal (22.14%) and Eco (22.33%).

The standard deviation (S) is relatively small for all systems, indicating a relative homogeneity of the pulp weight.

There are no significant differences between systems in terms of average wing share, with values ranging between 7.72% and 8.36%. The standard deviation (S) is relatively small for all systems, indicating a relative homogeneity of the wing weight.

The traditional system has the highest average share of the back (21.89%), followed by the Normal (16.29%), Free (19.89%) and Eco (17.31%). The standard deviation (S) is relatively small for all systems, indicating a relative homogeneity of the back weight.

Table 5. Slaughter Performance of Broiler Chickens – Carcass

No.	Specification	Normal		Eco		Free		Traditional	
		Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
1.	Yield	76.02	0.44	69.07	0.57	69.57	1.07	67.26	0.36
2.	Breast Proportion	39.32	1.22	24.48	0.48	28.68	1.43	27.56	0.60
3.	Thigh Proportion	29.09	1.28	32.32	0.46	31.33	0.49	34.29	0.73
4.	Wing Proportion	10.16	0.24	11.51	0.34	11.34	0.45	12.43	0.04
5.	Back Proportion	21.43	0.78	31.69	0.26	28.65	1.14	25.73	0.11

The Normal system has the highest average yield (76.02%), followed by the Traditional (67.26%), Eco (69.07%) and Free Range (69.57%).
The variation in yield is the lowest in the Normal system (SD = 0.44) and the highest in a Traditional system (SD = 1.07).
The Normal System has the highest average breast weight (39.32%), followed by the Traditional (27.56%), Free Range (28.68%) and Eco (24.48%).
The variation in chest weight is the lowest in the Traditional system (SD = 0.60) and the highest in Normal system (SD = 1.22).
The traditional system has the highest average percentage of pulps (34.29%), followed by Free Range (31.33%), Eco (32.32%) and Normal (29.09%).
The variation in pulp weight is the smallest in the Free Range system (SD = 0.49) and the highest in Normal system (SD = 1.28).
The traditional system has the highest average share of wings (12.43%), followed by Eco (11.51%), Free Range (11.34%) and Normal (10.16%). The wing weight variation is the smallest in the Normal system (SD = 0.24) and the largest in the Free Range system (SD = 0.45).

4. Conclusions

In conclusion, the zootechnical performances of broiler chickens raised in various growth systems (Normal, Eco, Free, and Traditional), such as the evolution of body weight, weekly growth spurts, mortality rates, and slaughtering performances of the meat chickens in live weight and carcass, were compared to assess the growth performance of broiler chickens in different growth systems.
The study also examines the weight variation of different parts of the meat chickens, such as the breast, thighs, wings, and back, under various growth system conditions.
Firstly, it is observed that the selection of the appropriate growth system is crucial for optimizing production and maximizing the yield of chicken meat. The Normal growth system is distinguished by superior yield and preferential development of the breast, thus offering a significant economic advantage.
On the other hand, the Eco and Traditional growth systems, while presenting lower overall yields, offer benefits related to animal welfare and the potential to meet market requirements for chicken meat produced in more natural and sustainable conditions. The Free growth system, with significant yield variations, underscores the need for careful management and optimization of growth conditions to achieve desired results.
Genetic and nutritional factors also play a crucial role in determining the growth performance of broiler chickens, with the interaction between these factors and the growth system being an essential area of research for improving production efficiency. Furthermore, the study emphasizes the importance of monitoring the health of the chickens through appropriate vaccination practices and managing the risks associated with diseases and adverse environmental conditions.
The Traditional system produces chickens with the highest yield and the largest percentage of pulp but with the lowest share of chest and back. The Normal System seems to produce chickens with the highest breast yield but with the lowest overall yield and the smallest percentage of pulp. The Eco and Free Range systems appear to produce chickens with intermediate characteristics between the Normal and Traditional systems.

References

1. Torok, V., Hughes, R., Mikkelsen, L., Perez-Maldonado, R., Balding, K., Macalpine, R., Percy, N., & Ophel-Keller, K. (2011). Identification and Characterization of Potential Performance-Related Gut Microbiotas in Broiler Chickens across Various Feeding Trials. Applied and Environmental Microbiology, 77, 5868 - 5878. https://doi.org/10.1128/AEM.00165-11
2. El-Deek, A. & El-Sabrout, Karim. (2018). Behaviour and meat quality of chicken under different housing systems. World's Poultry Science Journal. 75. 1-910.1017/S0043933918000946
3. Hutu, Ioan & Sas, Emil & Chesa, Ioan. (2006). Programarea creşterii puilor broileri. 10.13140/RG.2.2.25296.94720
4. Abreu, Lucas & Yanagi Junior, Tadayuki & Bahuti, Marcelo & de Lima, Renato & Lourençoni, Dian & Fassani, Édison. (2019). Performance of broilers submitted to different intensities and duration of thermal stress. DYNA. 86. 131-137. 10.15446/dyna.v86n211.79465
5. Torrey, S., Mohammadigheisar, M., Santos, M., Rothschild, D., Dawson, L., Liu, Z., Kiarie, E., Edwards, A., Mandell, I., Karrow, N., Tulpan, D., & Widowski, T. (2020). In pursuit of a better broiler: growth, efficiency, and mortality of 16 strains of

broiler chickens. Poultry Science, 100. https://doi.org/10.1016/j.psj.2020.12.052
6. Leeson, S., & Summers, J. D. (2005). Commercial poultry nutrition. Nottingham University Press
7. Kuźniacka, J., Adamski, M., Czarnecki, R., & Banaszak, M. (2014). Results of Rearing Broiler Chickens Under Various Systems. The Journal of Agricultural Science, 6(4), 19
8. Rowe, E., Dawkins, M., & Gebhardt-Henrich, S. (2019). A Systematic Review of Precision Livestock Farming in the Poultry Sector: Is Technology Focussed on Improving Bird Welfare? Animals: an Open Access Journal from MDPI, 9. https://doi.org/10.3390/ani9090614
9. Jones, Philip & Niemi, Jarkko & Christensen, Jens & Tranter, Richard & Bennett, Richard. (2018). A review of the financial impact of production diseases in poultry production systems. Animal Production Science. 59. 10.1071/AN18281
10. Newell DG, Elvers KT, Dopfer D, Hansson I, Jones P, James S, Gittins J, Stern NJ, Davies R, Connerton I, Pearson D, Salvat G, Allen VM. Biosecurity-based interventions and strategies to reduce Campylobacter spp. on poultry farms. Appl Environ Microbiol. 2011;77(24):8605-14. doi: 10.1128/AEM.01090-10. Epub 2011 Oct 7. PMID: 21984249; PMCID: PMC3233073
11. Snedecor, G. W., & Cochran, W. G. (1989). Statistical Methods, 8th Edition. Iowa State University Press
12. Fisher, R.A. (1992). Statistical Methods for Research Workers. In: Kotz, S., Johnson, N.L. (eds) Breakthroughs in Statistics. Springer Series in Statistics. Springer, New York, NY. https://doi.org/10.1007/978-1-4612-4380-9_6
13. N'Dri, A., Mignon-Grasteau, S., Sellier, N., Tixier-Boichard, M., & Beaumont, C. (2006). Genetic relationships between feed conversion ratio, growth curve and body composition in slow-growing chickens. British Poultry Science, 47, 273 - 280. https://doi.org/10.1080/00071660600753664
14. Larsen, J., Adams, R., Peng, I., & Stadelman, W. (1986). Growth, feed conversions, and yields of turkey parts of three strains of hen turkeys as influenced by age. Poultry science, 65 11, 2076-81 . https://doi.org/10.3382/PS.0652076
15. Toar W., Pudjihastuti E., Turangan S., Assa G., Sompie F., Rumokoy L. 2022, The Effect Of Supplementation Of Pataanga Succincta Flour In Ration On Indigenous Chickens Meat Production. Scientific Papers. Series D. Animal Science, Vol. LXV, Issue 2, ISSN 2285-5750, 154-157
16. Leclercq, B. (1983). The influence of dietary protein content on the performance of genetically lean or fat growing chickens. British poultry science, 24 4, 581-7 https://doi.org/10.1080/00071668308416778
17. Pogosyan D., Zemnyakov V., Zueva E., Varlamova E. 2020, Use Of Unconventional Feed For Broiler Chickens. Scientific Papers. Series D. Animal Science, Vol. LXIII, Issue 2, ISSN 2285-5750, 124-128
18. Fanatico, A., Pillai, P., Cavitt, L., Owens, C., & Emmert, J. (2005). Evaluation of slower-growing broiler genotypes grown with and without outdoor access: growth performance and carcass yield. Poultry science, 84 8, 1321-7. https://doi.org/10.1093/PS/84.8.1321
19. Chakam, V.P. & Teguia, Alexis & Tchoumboue, J. (2008). Performance Of Finisher Broiler Chickens As Affected By Graded Levels Of Cooked Cowpeas (Vigna unguiculata) In The Grower-Finisher Diet. Bulletin of animal health and production in Africa. Bulletin des santé et production animales en Afrique. 56. 251-258. 10.4314/bahpa.v56i3.43289
20. Caisîn L., Kovalenko A., Bivol L., Grosu N., 2012, Growth and development of broiler chickens under the use of the adsorbents “Primix-Alfasorb” and the probiotics “Primix-Bionorm-K” in mixed fodders. Scientific Papers. Series D. Animal Science, Vol. LV, ISSN-L 2285-5750, 46-52
21. Gritsenko, S., Belookova, O., Rebezov, M., & Vidyakin, Y. (2023). Dynamics of indicators of linear growth and physique indices of marketable young beef poultry depending on live weight at day old. Agrarian science. https://doi.org/10.32634/0869-8155-2023-375-10-68-72
22. Joanna, Kuzniacka., Marek, Adamski., Rafal, Czarnecki., Mirosław, Banaszak. (2014). Results of Rearing Broiler Chickens Under Various Systems. The Journal of Agricultural Science, doi: 10.5539/JAS.V6N4P19
23. Gabal, M., & Azzam, A. (1998). Interaction of aflatoxin in the feed and immunization against selected infectious diseases in poultry. II. Effect on one-day-old layer chicks simultaneously vaccinated against Newcastle disease, infectious bronchitis and infectious bursal disease. Avian pathology: journal of the W.V.P.A, 27 3, 290-5. https://doi.org/10.1080/03079459808419338
24. Zafra, R., Pérez, J., Pérez-Écija, R., Borge, C., Bustamante, R., Carbonero, A., & Tarradas, C. (2008). Concurrent Aspergillosis And Ascites With High Mortality In A Farm Of Growing Broiler Chicken.