

Productivity and Meat Quality of Broiler Chickens Using a Feather Feed Meal

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Abstract

Poultry industry has emerged as the fastest growing segment not only in the livestock sector but also in the agriculture as a whole and the most important challenges for this direction is to enhance bird productivity while remaining economically and environmentally sustainable. One of the biggest hurdles for poultry is the high cost and variation in the quality of feed ingredients.

Dietary specifications and nutritional strategies are core for optimized poultry performance. Increasing the efficiency of broiler feeding is fundamental to sustainable poultry intensification. The potential of feed additive-based nutritional strategies dietary administration of protein organic substances is critically in the light of their role in supporting the sustainable intensification of this crucial livestock sector.

The objective of this study was to investigate the effect of feeding varying levels of feather meal as a protein source on feed intake, body weight, average daily gain, feed conversion ratio and carcass characteristics of broiler chickens.

During the research, broiler chickens "COBB-500" of one-day-old age were used and were divided into 5 groups (one control and four experimental, 20 heads per group). The chickens of the control group (CG) received basic compound feed (BC), while the experimental groups received BC with the addition of various levels of protein meal from feathers. Parameters measured were Feed Intake (FI), Body Weight (BW) and Average Daily Gain (ADG).

Keywords: body weight, broiler chickens, feather meal, feed conversion, meat quality

Introduction

Modern industrial poultry farming uses highly productive hybrid poultry for the production of eggs and meat, which makes high demands on the complete people nutrition. Sustainability approach of broiler production toward feed efficiency lies on understanding dietary formulation approach of amino acids and energy that promote optimal nutrient utilization and minimal nutrient output to environment. The growth demands and body composition changes associated with increased protein gain in current broiler's meat brought also fulfilling by the genetic progress. The main requirements for compound feed for chickens are to fully meet their needs in all nutrients, to obtain more products with high with high feed conversion. Protein sources are the second largest component of practical poultry diets. In poultry nutrition, most attention is given to protein products, due to the importance of protein as a major constituent of the biologically active compounds in the body.

Broilers have high dietary protein requirements, so identification of the optimum protein concentration in broiler diets, for either maximizing broiler performance or profit, requires more knowledge about birds' requirements for protein effects on the birds' growth performance and development. It also requires knowledge about the protein sources available that can be used in poultry diets Beski, Sleman S.M. et al. 2015.

The mainstream commercial poultry industry uses a limited number of ingredients to produce protein; they are limited in distribution and tend to be more expensive than energy sources. Legumes used in animal feed as a source of protein-soybeans, lupins, peas, vetch fodder beans are characterized by a high content of protein, fats and carbohydrates. Compared to cereals (wheat, corn, barley), legumes have two or three times more protein and amino acids, fat and fatty acids, but less carbohydrates. The

concentration of protein in the grain of legumes ranges from 20 to 40%, which determines their value as a protein feed. Soybean seed is the premier protein source used by the poultry industry Andrianova, E.N. et al. 2012, Andrianova, E.N. et al. 2013, Stele, A.L. 2012, Stele, A.L. 2015.

Increasing the efficiency of using protein from feed products depends not only on the balance of the diet in terms of the content of essential nutrients, in particular amino acids, but also on their availability. The protein source used in feed formulation influences the productive performance and the gut microbiota composition of broilers. The benefits of the selected protein on animal growth are related to their inclusion level, digestibility and amino acid profile Beski, Sleman S.M. et al. 2015.

The tightening of requirements for the use of genetically modified soybeans and its complete ban in animal feed in some EU countries stimulate interest in vegetable protein sources, and above all in other protein sources. The problem of studying the use of alternative protein sources has received increasing interest in recent years. On August 2021, Commission Regulation (EU) 2021/1372 repealing the ban on feeding non-ruminant farmed animals with animal-derived protein was published in the Official Journal of the European Union. This implies that in poultry nutrition may be used meat and bone meal (animal protein), blood products (animal protein) and insect-derived protein. This alternative makes it possible to formulate feed with these raw materials including animal protein if their price is favorable when compared to other protein sources <https://nutrinews.com/en/animal-protein-in-poultry-feed/?reload=yes?reload=yes>. The animal industries, including the poultry industry, yield by-products that are also useful sources of protein.

A significant reserve in terms of protein content is represented by feather flour, nutritive value of feathers makes it suitable and inexpensive animal and poultry feed. The main component of feather is keratin, a mechanically durable and chemically unreactive and insoluble protein, which render it difficult to be digested by most proteolytic enzymes. Keratin is resistant to enzymatic digestion by plant, animals and many known microbial proteases due to insoluble nature. Feathers having only 10% parts which is not keratin, rest 90% is resistant to degradation by common peptidases. This resistance is due to constituent amino acid composition and configuration that provide structural rigidity Mazotto A.M., et al. 2011. Feathers are hard waste products, mainly composed of hard β -keratin.

Feathers degradation through keratinolytic microorganisms has been considered as an important method for efficient bioconversion, nutritional enhancement and eco-friendliness. The conversion of the keratin contained in the waste into a form accessible for digestion and assimilation is of great importance when using animal protein and for solving environmental problems. However, feathers are currently utilized on a limited basis as a dietary protein supplement for animal feed because feather meal production is an expensive process, requiring significant amounts of energy.

In recent years, the direction of developing technologies has been actively improving and including enzymatic processing of feathers to increase the availability of its protein. One of the new feather processing technology and ecological one, based on biotechnologies and state-of-the-art physical-mechanical, is a new treatment method development by “Terafix” Ltd. This study was aimed the investigate the nutritional potentials of feather meal, which was produced by new technology and especially as it affects carcass yield and meat quality attributes of broiler chickens.

Materials and Methods

Scientific research was carried out in the Department of Management of livestock products and agri-food safety of the Technical University of Moldova. The studies were carried out in accordance with the methodology adopted when studying the issues of rearing technology, productivity, poultry health and the quality of the products obtained. To achieve the set goal and solve individual problems, standard zootechnical, biochemical and statistical research methods were used.

The material used in this study was 100 broiler chickens with mixed-sex. During growth, the chickens were fed according to the recommendations for rearing the COBB 500 cross Imangulov, I. A. et. al.

2004. The main feed for the control group included such ingredients as wheat, corn, sunflower meal, soybean meal, fishmeal, vegetable oil, premix, maluses. The main compound feed for broiler chickens was used during the rearing period in accordance with nutritional requirements Kalašnicov A., et al. 2003. The chickens were fed according to differentiated periods: starter feed (from 1 to 14 days), grower (from 15 to 35 days) and finisher. The chickens of the control group received the basic compound feed (BCF), while the experimental groups, instead of fishmeal, included different levels of feather meal (FM) in accordance with the experimental scheme (Table 1).

Table 1. Scheme of Experience

Groups	Number of heads	Feeding features
CG	20	Basic compound feed (BCF)
EG ₁	20	BCF + 1,5% feather meal
EG ₂	20	BCF + 2,5% feather meal
EG ₃	20	BCF + 3,5% feather meal
EG ₄	20	BCF + 4,5% feather meal

The experimental feed and water were supplied ad libitum. Routine vaccination and necessary medication schedule as applicable to the experimental location were administered.

Data were collected and recorded on daily basis on the feed offered, left over, feed intake and weekly basis on body weight and flock uniformity. All measurements were in grams (g) except otherwise stated. The growth parameters were estimated as follow:

Initial Weight = Weight of the experimental animals at the start of the feeding period; Average daily feed intake (ADFI) (g/bird/day) = cumulative feed intake / (number of birds x number of days);

Average daily gain (ADG) (g/bird/day) = final weight gain-initial weight/number of days:

Final Weight = Weight of the experimental $\frac{\text{Final weight} - \text{Initial weight}}{\text{No. of feeding days}}$ animals at the end of the feeding period:

After slaughter, the carcasses of broiler chickens were subjected to anatomical and morphological cutting. The organoleptic evaluation of broiler meat and meat broth was carried out by the tasting commission Imangulov, I. A. et. al. 2004.

The data obtained in the course of the research were analyzed statistically by using the method of variation statistics Plohinschi N., 1969.

Results and Discussions

Livestock growth performance can be measured through parameters of feed consumption, body weight gain and feed conversion Hafid H. 1998, Hafid, H. 2006, Hafid, H., et. al. 2010. During the experiment, the chickens of all five groups were kept and fed with the basic combined feed, depending on the age of the chickens, in accordance with the feeding norms Kalašnicov A., et al. 2003, (Table 2). In the starter period, the nutritional value of the feed in terms of the metabolic energy content varied in broiler chickens' groups from 2900.0 to 2920.0 kcal with a protein level of 21.32 to 21.44g; during the growth period, the level of metabolic energy was 2950.0 kcal, and protein from 19.38g to 19.57g and in the final period (finish) the energy concentration was 2980.0 kcal and protein from 18.02g to 18.10g.

Table 2. The structure of combined feed

Ingredients	%
Starter phase	
Corn	49,3
Wheat	12,9
Soy meal	22,2
Sunflower meal	7,1
Fish meal	1,5
Soybean oil	2,5
Premix	2.0
Chalk	2,5
Grower phase	
Corn	50.0
Wheat	15,2
Soy meal	20.0
Sunflower meal	7.0
Fish meal	1.0
Soybean oil	2,3
Premix	2
Chalk	2,5
Finisher phase	
Corn	52.0
Wheat	14,9
Soy meal	18.0
Sunflower meal	7.0
Fish meal	1.0
Soybena oil	2,3
Premix	2.0
Chalk	2,8

One of the most important indicators of the effectiveness of a feed use is the study of its effect on the growth rate of broiler chickens. According to the results of the experiment, it was found out that the dynamics of the body weight of chickens for the entire growing period, at the beginning of the experiment the weight was on average within 48.0-49.5g; in the starter period the body weight of broiler chickens was on average in the control group 287.4g and in the experimental groups the broiler's mass varied between 284.79 and 292.41g, the largest increase was observed in the second group (EG₂-162.7g).

At the end of grower phase the chicks weighed 638.53g in EG₄, with their largest mass from experimental group in EG₂ – 660.07g, while the chickens in CG weighed an average of 661.22g. At the end of the finisher phase period, the chickens of all groups that received the feed protein meal weighed in the range of 1812.5g and 1927.55g. The weight of the chickens in EG₁ was the greatest, followed by the chickens from EG₂, where the weight was 1893.75g, the broilers from CG averaged was 1869.7g, and the chickens from EG₄ weighed the least - 1812.50g. Thus, the mass of chickens in EG₁ feed feather meal in the amount of up to 1.5%, was higher than the control by 57.85g or 3.09% higher than in the control (Table 3).

Table 3. Body weight of broiler chickens, g

Groups	Periods			
	At the beginning of the experiment	Starter phase	Grower phase	Finisher phase
CG	49.0±0.93	287.0±7.37	661.2±16.12	1869.7±44.57
EG ₁	48.5±0.82	292.4±9.06	660.1±16.92	1927.5±39.20
EG ₂	49.5±0.95	292.0±7.57	652.8±16.97	1893.7±28.77
EG ₃	47.0±1.05	285.7±4.31	640.8±12.41	1819.1±36.91
EG ₄	48.0±0.92	284.8±5.33	638.5±17.58	1812.5±27.21

The meat productivity was estimated by means of a control slaughter of 3 heads from each group. The killing output was calculated according to the generally accepted formula (Table 4).

Table 4. Morpho-productive parameters of broiler chickens

Groups	Indicators	The weight of the chicken before slaughter, g	Mass of the half-eviscerated carcass, g
CG	$\bar{X} \pm S_x$	1866.67±176.39	1454.00±165.16
	S±Ss	305.505±124.75	286.061±116.81
	V±Sv	16.366±6.68	19.674±8.03
EG ₁	$\bar{X} \pm S_x$	2060.00±90.74	1620.67±94.63
	S±Ss	157.162±64.17	163.897±66.92
	V±Sv	7.629±3.11	10.113±4.13
EG ₂	$\bar{X} \pm S_x$	1864.3±43.50	1498.33±39.33
	S±Ss	75.341±30.76	68.127±27.82
	V±Sv	4.041±1.65	4.547±1.86
EG ₃	$\bar{X} \pm S_x$	1884.00±27.74	1508.33±47.18
	S±Ss	48.041±19.62	81.709±33.36
	V±Sv	2.549±1.04	5.417±2.21
EG ₄	$\bar{X} \pm S_x$	1896.67±98.38	1496.33±94.81
	S±Ss	170.391±69.58	164.214±67.05
	V±Sv	8.983±3.67	10.974±4.48

When slaughtering chickens, despite the higher carcass weight of chickens from EG₁ and EG₄, the slaughter yield in these groups was lower than in EG₂ by 1.82 and -1.58%, respectively, which indicates a higher growth rate of chickens in the second experimental group (Figure 1). Chickens slaughter showed the superiority of the broilers of the experimental groups, both in body weight before slaughter and in carcass weight and slaughter output. The best results were obtained when the chickens of the second experimental group were slaughtered.

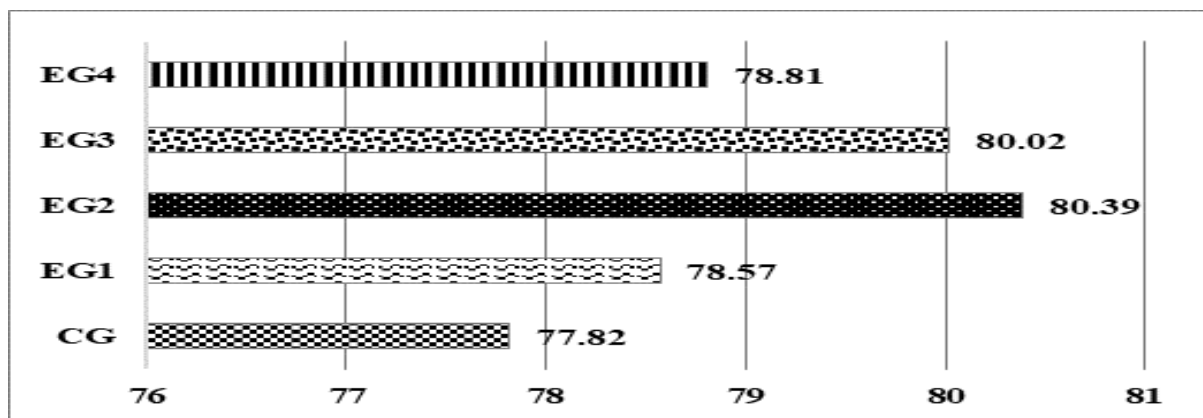


Figure 1. Slaughter yield, %

In order to establish the functional load on the internal organs of the consumed feed flour, the mass of the edible organs, in particular the liver, heart, and the muscular part of the stomach, was determined in the broiler chickens of the experimental and control groups (Table 5).

The mass of the indicated internal organs in almost all experimental groups was greater relative to the control. The established differences are due to the positive effect of the inclusion of feed feather meal in chicken feed.

Table 5. The weight of internal organs of broiler chickens

Groups	Indicators	Heart weight, g	Liver weight, g	Muscular stomach weight, g	Glandular stomach weight, g
CG	$\bar{X} \pm S\bar{x}$	9.33±2.03	39.33±3.76	20.00±4.00	12.00±5.57
	S±Ss	3.512±1.43	6.506±2.66	6.928±2.83	9.643±3.94
	V±Sv	37.627±15.36	16.541±6.75	34.641±14.14	80.363±23.30
EG ₁	$\bar{X} \pm S\bar{x}$	13.33±0.33	47.00±.51	21.66±4.98	29.67±13.30
	S±Ss	0.577±0.24	11.269±4.60	8.62±3.52	23.028±9.40
	V±Sv	4.330±1.77	23.977±9.79	39.792±16.25	77.625±22.51
EG ₂	$\bar{X} \pm S\bar{x}$	11.00±1.73	38.33±3.18	26.66±5.61	33.00±13.05
	S±Ss	3.000±1.22	5.507±2.25	9.71±3.97	22.605±9.23
	V±Sv	27.273±11.14	14.367±5.87	36.422±14.87	68.500±19.86
EG ₃	$\bar{X} \pm S\bar{x}$	11.67±0.88	37.00±3.05	20.66±2.19	16.67±2.03
	S±Ss	1.528±0.62	5.291±2.16	3.79±1.55	3.511±1.43
	V±Sv	13.093±5.35	14.301±5.84	18.319±7.48	21.071±6.11
EG ₄	$\bar{X} \pm S\bar{x}$	13.00±1.15	39.67±6.23	27.66±4.37	19.00±6.11
	S±Ss	2.000±0.82	10.785±4.40	7.57±3.09	10.583±4.32
	V±Sv	15.385±6.28	27.191±11.10	27.368±11.17	55.700±16.15

* $P < 0.1$

The absolute chicken's liver weight in the CG was 1.17 times lower compared to the EG₁, but higher than in EG₂ 1.15 times, in EG₃ 1.36. The mass of the heart and muscular stomach in the groups did not differ significantly.

The meat qualities of broilers are characterized mainly by the degree of development of the pectoral and femoral muscles, which determines the consumer qualities of carcasses. Recently, lean meat of farm animals, including poultry, has been in the greatest market demand. Reducing the level of fat in broiler meat improves its technological characteristics when processed into minced meat and meat semi-

finished products Tutelyan V. A., et. al. 2008. This trend was revealed in the analysis of chicken meat of the 4th and 5th experimental groups.

According to the results of the chemical analysis of poultry meat, it was found out that in those groups where the chickens received feather protein supplement as part of the compound feed, a higher moisture content, a higher protein content were observed, and the amount of fat in the meat in EG₁, EG₂, EG₃ and EG₄ was less in comparison with the control by 0.55%, 0.36%, 0.74% and 0.18%, respectively (Table 6).

The largest amount of protein in the meat of broiler chickens was found in the second experimental group, where the additive was used at a dose of 2.5%. According to this indicator, chickens from the first, third and fourth experimental groups were somewhat inferior to them.

Table 6. Chemical analysis of the broiler chicken's meat of cross Cobb-500

Indicators	Experimental groups				
	CG	EG ₁	EG ₂	EG ₃	EG ₄
Dry substance, %	24.01	23.28	23.67	23.05	22.55
Crude protein, %	18.95	17.94	20.94	20.45	19.39
Crude fat, %	2.69	2.03	2.17	2.11	2.07
Crude ash, %	1.10	1.05	1.03	1.02	1.01
Water retention capacity, %	2.38	2.70	2,37	2.82	2.73
Color intensity, un.	94.17	70.33	68.33	45.00	69.17

It should be noted that difference was also established between the first and fourth experimental groups in favor of the first group. With an increase in the dose of feed feather meal, the protein content in meat decreases, but remains significantly higher than in the meat of chickens from the control group.

The difference found on moisture and protein content in breast meat can be explained by the slow growth rate of the chickens, higher moisture and lower protein content has been reported in fast growing commercial broilers. Reference Muller, S.K. 2018 reported high moisture and low CP content (g/kg) in fast-growing commercial broilers (Ross PM3) than traditional dual-purpose breeds.

Differences in the biochemical processes involved in metabolism between fast and slow growing birds can affect meat composition. The values of humidity and CP content in the breast were in the range specified in Dalle, Z.A., et al 2020, for commercial broilers (Figure 2).

The high content of ethereal extract (EE) in the meat of the breed's breast is consistent with data Choo, Y.-K., et al 2014, which noted a higher fat content in broilers than in traditional dual-purpose breeds. The low EE content and high CP content in chicken breast is an important observation regarding meat quality.

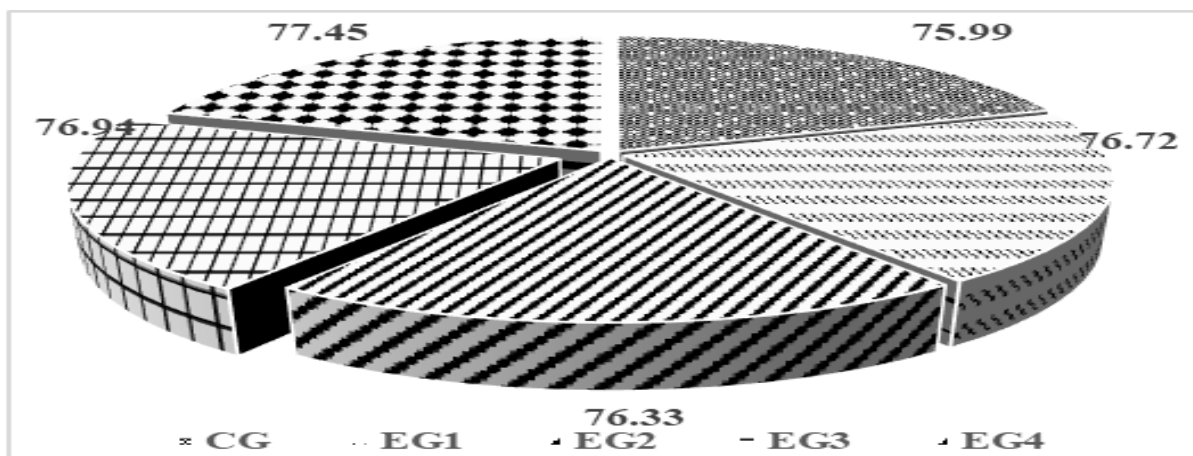


Figure 2. Total humidity of the broiler chicken's meat of cross Cobb-500, %

An important role in assessing the quality of meat belongs to organoleptic indicators-appearance, color, taste, smell and texture. The organoleptic properties of meat are determined by genetic factors (species, breed, phenotype, genotype, type of muscle tissue, etc.); technological factors (microclimate, nutrition, feed composition, weight and age at slaughter, transportation and slaughter conditions), post-slaughter carcass processing (storage temperature, shelf life); culinary factors (method of cooking meat).

The organoleptic evaluation of the broth indicators was carried out according to several indicators, according to color, transparency, taste, aroma, smell and saturation. It was found out that there were no significant differences in organoleptic properties between meat and broth samples in all five experimental groups; according to the results of the points scored, the taste of poultry broth in EG₃ turned out to be the best, followed by EG₁ and EG₄.

Table 7. Organoleptic indicators of meat and broth

Indicators	Groups				
	CG	EG ₁	EG ₂	EG ₃	EG ₄
Broth evaluation					
Colour / Transparency	8.00	8.67	8.33	8.72	8.44
Taste	8.33	8.33	8.33	8.33	8.22
Aroma / Smell	7.56	8.78	8.22	8.76	8.39
Saturation	8.11	8.48	8.22	8.58	8.44
Total	32.00	34.26	33.10	34.39	33.49
Meat taste evaluation					
Type	8.13	8.75	8.31	8.25	8.50
Aroma / Smell	8.25	8.75	8.50	8.44	8.50
Taste	8.00	8.75	8.56	8.75	8.75
Tenderness	8.00	8.75	8.44	8.60	7.75
Juiciness	8.25	8.63	8.50	8.33	8.00
The number of points	40,63	43,63	42,31	42,37	41,5

The meat was judged by taste, smell/aroma, tenderness and juiciness. Chick pectoral muscle samples of EG₁ (pleasant color and uniformity, combined with rich aroma) were highly rated for meat quality, followed by meat samples from EG₃, followed by meat samples from EG₂ (Table 7).

Conclusion

It can be concluded that feather meal is an excellent source of high-quality protein. The easy availability of raw materials for the production of this coma and cost-effective processing methods may make it the most promising protein-rich poultry feed. Considering the price, the effective use of feather meal can certainly increase the amount of meat; therefore, a cost-effective protein-rich feed ingredient.

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