Research Article

A Substitute for Fishmeal in the Diet of Broiler Chicks

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Abstract. The aim of this research was to study the biochemical properties of a new protein-rich feed additive produced by the short-term intense thermal treatment and subsequent enzymatic hydrolysis of the wastes of poultry slaughter and primary processing (feathers and fluff). It was found that this feather-based fermented feed additive contained high amounts of crude protein (86.52%); and the content of easily digestible low-molecular peptides in the additive was 9% higher compared to fishmeal. The amino acid profiles of the additive and fishmeal were compared. The effectiveness of substituting the additive for fishmeal in the diet of broiler chicks was demonstrated by the *in vivo*experiments. The results showed that the digestibility of the dietary nutrients was higher in broilers that were fed the new additive compared to those fed fishmeal, which resulted in higher meat productivity: the average daily weight gains in additive-fed broilers was 3.82% higher ($p < 0.01$) compared to fishmeal-fed control broilers, the dressing was 1.4%higher, the muscle in the carcass was 2.1% higher, and the feed conversion ratio was 3.57%lower. The sensory evaluation scores of the meat and broth were also higher in the additive-fed broilers.

Keywords: feedadditive, feather wastes of poultry slaughter, enzymatic hydrolysis, distribution of molecular peptide weights, digestibility, productive performance in broilers

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1. Introduction

The high productive performance in broiler chicks can be achieved provided the consumption of the reasonable amount of dietary protein. The proteins arenecessary for body growth, *de novo* biosynthesis of enzymes, antibodies, certain hormones, and other compounds involved in the complex metabolic and protective reactions. Theoptimizedproteinnutritionisaprerequisiteforthe management of health condition and productivity in broilers to decrease the production costs and increase the profitability of the commercial broiler production.

Fishmeal is presently a most popular animal protein source in broiler diets worldwide. However, it is expensive and deficient, and often is counterfeited [1]. Therefore, the search for the alternative and effective sources of animal protein for broiler diets is an urgent task.

The keratin- and collagen-containing wastes of poultry slaughter and primary processing (feathers, fluff, inedible offals) can be an effective alternative for fishmeal as the protein source; e.g. the feathers ofchickens contain 85-90% of keratin. However, the digestibility of native keratin for poultry is lower than 16% [2]; it should be preliminary processed to destroy the native structure of the keratin and make it available for the endogenous proteases of the digestive tract in broilers [3, 4]. The prospective technology for this processing is two-stage hydrolysis involving short-termintense thermal treatment and subsequent enzymatic hydrolysis; this technology results in easily digestible protein additives for broilers [5].

The study presented was aimed at the determination of physical and biochemical properties of an additive produced by the two-stage hydrolysis of keratin-containing poultry wastes (feathers and fluff) and its efficiency in diets for broilers as a substitute for fishmeal.

2. Materials and Methods

The production of the protein additive studied involved the two-stage hydrolysis of feathers: 1) the intense thermal treatment (190-metricconverterProductID2000C200^{0}C for 90 min in a specially designed fermenter), and 2) further enzymatic hydrolysis in fermenters (metricconverterProductID5 L5 L each)by protease Novo-Pro D (Novozyme, Denmark) in the dose 15 PU/g for 4 hours.

Protein content in the additive produced was determined according to GOST 32044.1 andGOST 13496.4; contents of moisture, fat, and ash according to GOST 17681; limiting amino acids according to GOST 32195-2013 methods.

The distribution of molecular peptide weights in the additive and in fishmeal was evaluated by the size-exclusion chromatography using chromatograph Varian ProStar HPLC (USA), pump PS210 SDM, autosampler PS410,columnBioSep-SEC-S 2000 7.8×300 mm(Phenomenex, USA). The column was graduated with standard water-soluble proteins and peptides from GE Healthcare (USA), Serva (country-region Germany) and Sigma (country-regionplaceUSA) in the range 450-440,000 Da overlapping its operational range. Theopticaldensitywas detected on flowing detector Varian 335 PDA with photodiode matrix at 190-330 nm with basic wavelength 214 nm. The place50 mM

sodium-phosphate buffer (pH 6.8) was used as an eluent, elution rate 1 mL/min, sample volume 20 μL. The sample preparation involved the dilution by the aforementioned buffer to the concentration of dry matter 1-5 mg/mL and twofold centrifugation at place60,000 g for 40 min.

The trial *in vivo* to determine the efficiency of the additive as a protein source on two treatments of floor-housed broilers (cross Ross-308) from 1 to 38 days of age (3 replicates, 50 birds per treatment in each replicate; 300 birds in total)was performed.The birds were kept on sawdust in similar conditions of management. Thecontroltreatment 1wasfed a diet with fishmeal (crude protein content 67%) as animal protein source balanced according to the recommendations for this cross; in treatment 2 the fishmeal was substituted by the feather-derived additive.

The digestibility and assimilation of dietary nutrientswere determined in a balance trial according to the Institute's manual [6]; anatomic dissection of carcasses and sensory evaluation of meat and broth were performed according to manual [7].

3. Results and Discussion

Physicochemical indices, degree of hydrolysis, and distribution of molecular peptide weights are the main characteristics of a hydrolyzed feed additive. After the two-stage hydrolysis the resulting additive contained 4.57% of moisture, 86.52% of crude protein, 2.25% of crude fat, 20.40% of ash.

The high-molecular proteins (45-130 kDa) were not present in the additive, content of large peptides (up to 30 kDa) was 0.6%. The main amount of peptides (94.6%) was within the range from 0.9 to 10.7 kDa, i.e. the native keratin was successfully hydrolyzed to smaller peptides easily digestible by poultry.

The comparison of the additive with fishmeal revealed that the percentage of high-molecular proteins (over 10 kDa) in the fishmeal was 13.6%, in the additive 3.5%; the percentages of low-molecular peptides (below 5 kDa) were 82.5 and 91.5%, respectively.

The concentrations of limiting amino acids in the fishmeal and in the additive are presented on Figure 1.

The content of cystine in the additive was higher by 4.01% in compare to fishmeal, threonine by 0.87%. The contents of methionine, lysine, and tryptophan in the additive were lower by 1.82; 3.86 and 0.21%, respectively.

The digestibility and assimilation of dietary nutrients from the additive-supplemented diets for broilers determined in the balance trial are presented in Table 1.

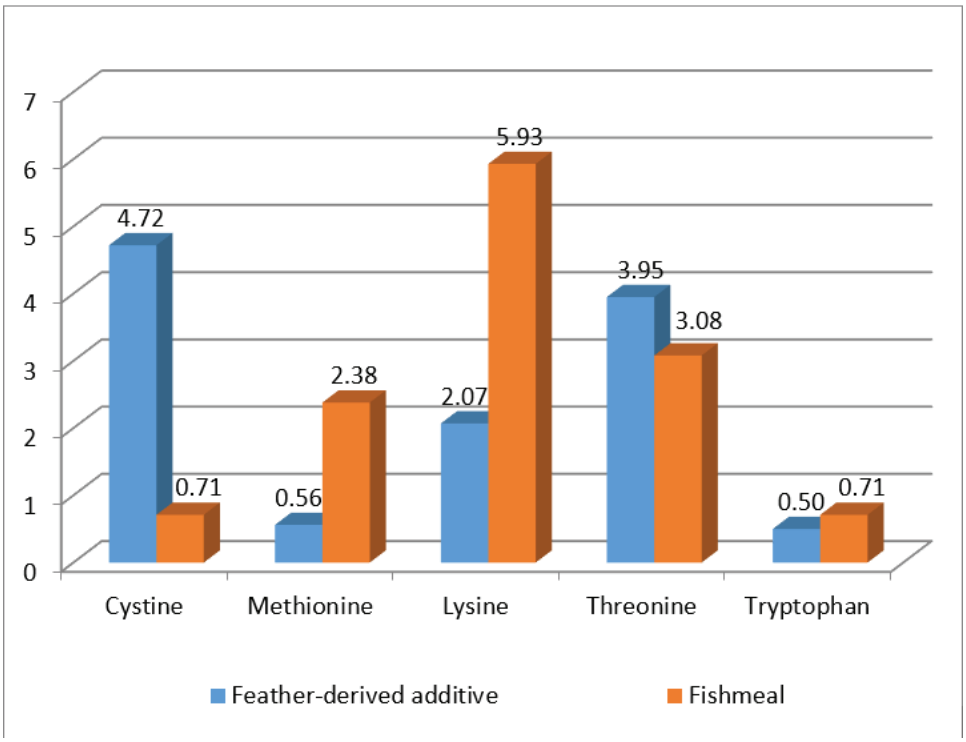

Figure 1: The concentrations of limiting amino acids in the fishmeal and in the additive, %.

TABLE 1: The digestibility and assimilation of dietary nutrients by broilersfed feather-derived additive vs. fishmeal (control), %.

Nutrients	Treatment	
	1 (control)	**2**
Digestibility: dry matter protein fat fiber	74.9 91.1 80.8 10.0	76.1 93.2 83.3 13.0
Assimilation: nitrogen calcium phosphorus	57.7 46.6 29.8	59.2 47.2 31.6

The digestibility of dry matter in the additive-fed treatment 2 was higher by 1.2% in compare to control treatment 1, protein by 2.1%, fat by 2.5%, fiber by 3.0%; the assimilation of dietary nitrogen was higher by 1.5%, calcium by 0.6%, phosphorus by 1.8% in compare to control.

Average indices of the productive performance in broilers and the results of the anatomic dissection of their carcasses are presented in Table 2.

Broilers fed the additive studied had better growth efficiency in compare to control. Average live bodyweight and average daily weigh gains were higher in treatment 2 in compare to control by 3.82 ($P<0.01$) and 3.92%, respectively; feed conversion ratio lower by 3.57%. Mortalitylevelintreatment 2 was 0% whileincontrol 1.3%.

The dressing percentage in treatment 2 was higher by 1.4% in compare to control; the yield of edible part was higher by 1.8% due to the increase in muscle yield by 2.1%.

TABLE 2: The productive performance in broilers fed feather-derived additive vs. fishmeal (control) at 38 days of age (n=150)

	Treatment	
	1 (control)	**2**
Live bodyweight, g (M±m): in average in females in mails	2174.1±20.3 2076.6±24.2 2271.6±28.5	2257.2±15.9** 2164.0±16.8** 2350.4±22.5*
Average daily weight gains, g	56.0	58.2
Mortality, %	1.3	0
Feed conversion ratio, kg/kg	1.68	1.62
Dressing percentage, %	72.4	73.8
Yields of edible carcass parts, % including:muscles skin internal fat	77.4 66.8 9.4 1.19	79.2 68.9 9.1 1.24
The difference with control was significant at: * P<0,05; ** P<0,01.		

The sensory evaluation of breast and thigh meat and broth (taste panel test, 5-score system) revealed the advantage of the products obtained from treatment 2. The average score of the broth in this treatment was 4.80, breast meat 4.68, thigh meat 4.74; the scores of control treatment were lower by 0.15; 0.20 and 0.11, respectively.

4. Conclusions

The two-stage hydrolysis (short-term intense thermal treatment and subsequent enzymatic hydrolysis) of the wastes of poultry slaughter and primary processing (feathers and fluff) resulted in the cleavage of native large keratin molecules into free amino acids and low-molecular peptides easily digestible by poultry.

The *in vivo* trial on broilers revealed that the substitution of the feather-derived additive for fishmeal in diets positively affects digestibility and assimilation of dietary nutrients as well as the productive performance in broilers.

5. Acknowledgements

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