The effectiveness of protein additives based on the wastes of poultry slaughter in diets for broilers

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Abstract. The effectiveness of protein additives based on the wastes of poultry slaughter in diets for broilers (cross Smena-9, 35 birds per treatment, 1-38 days of age) was studied as compared to the traditional diets with fishmeal as an animal protein source. Control treatment 1 was fed diets with fishmeal (FM); in diets for treatments 2 and 3 FM was substituted by fermented feed additive (FFA) and hydrolyzed feed additive (HFA), respectively, produced by the processing of slaughter wastes (feathers, intestines, and blood). The resulting levels of crude protein were similar in all treatments. It was found that the highest growth efficiency was in treatment 2: live bodyweight at 38 days of age was higher by 6.5% in compare to control (p<0.01), average daily weight gain higher by 3.6 g/bird/day; higher digestibility of protein from FFA resulted in feed conversion ratio lower by 1.9% in compare to control. Dressing percentage in this treatment was higher by 0.8% in compare to control, percentage of high-grade carcasses higher by 5.7%; as a result the European production efficiency index (377 points) was higher by 29 points in compare to control.

1. Introduction
The period of rearing in modern broilers is relatively short, usually 35-37 days of age, and the chicks should exhibit their genetically predetermined ability to the fast growth as early as possible. It is also necessary to supply the growing birds with all nutrients (including protein) and energy in the most available dietary forms.

Dietary imbalances are the key reasons of the slowed growth and development, decreased resistibility to different infectious diseases, poor feed efficiency in broilers. The diets for fasts-growing broilers should contain balanced amounts of crude protein (CP), individual amino acids, metabolizable energy, minerals, and vitamins [1]. Dietary CP is the basis of the body growth; it is assumed that the contribution of protein and amino acid nutrition to the resulting productivity in broilers is ca. 20-30% [2].

Fishmeal is presently considered the most effective and hence the most popular animal protein source in diets for broilers [3]; however, it is relatively expensive and its quality often doesn’t fit the
specifications. As a result, the use of the low-value wastes and by-products of poultry slaughter and primary processing in broiler nutrition is presently extensively studied as a step on the way to the waste-free agricultural production, enhancing the food security at the national level [4].

The total yield of secondary products of poultry slaughter and primary processing (feathers, intestines, blood, meat-bone residues of the deboning, etc.) can mount to 25-30% of the initial pre-slaughter live bodyweight. The use of these products in poultry nutrition as protein sources is limited by low digestibility of their native protein, especially by young broilers. E.g., feathers contain 85-88% of protein (primarily keratin) which cannot be digested by animals and poultry in its initial form due to the absence of the respective endogenous enzymes (keratinase, etc.) [5]. Therefore, the preliminary processing of these products is required.

The processing can involve hydrothermal hydrolysis and/or fermentation by proteolytic enzymes. The structural proteins of these products (keratin, collagen, etc.) are resistant to the direct enzymatic hydrolysis and require preliminary partial destruction by hydrothermal hydrolysis [6]. The subsequent fermentation results in small polypeptides and free amino acids easily digestible by broilers. The fermented animal protein is also known as the non-specific growth stimulator in animals and poultry due to the presence of certain unidentified factors [7].

The processing of slaughter wastes is also ecologically important as an instrument of the reduction of the anthropogenic load on the environment and development of the sustainable agriculture [8]. Earlier studies on the use of the processed wastes as protein sources in diets for broilers have evidenced their effectiveness [9].

The aim of the study presented was the comparison of the protein additives derived from the processed poultry slaughter wastes with fishmeal in relation to the productive performance in broilers and to the safety and quality of broiler meat.

2. Materials and methods
The study was performed on three treatments of broilers (cross Smena-9, 35 birds per treatment, 1-38 days of age) housed on the littered floor (sawdust) with similar management conditions. The nutritive value of the diets for all treatments was similar and corresponded to the recommendations of the cross’ producers for the respective age periods.

Control treatment 1 was fed diets with fishmeal (FM, CP 67%); in diets for treatments 2 and 3 FM was substituted by fermented feed additive (FFA) and hydrolyzed feed additive (HFA), respectively. The additives were produced by the processing of slaughter wastes in the natural proportion according to their yields at slaughter (feathers 57.2% by weight, intestines 35.37%, and blood 7.1%) with additional supplementation with ground wheat as an aerator. The HFA was produced by the hydrothermal hydrolysis only; the FFA was additionally fermented by a mixture of proteases.

The FFA contained (%): moisture 4.9; crude protein 26.0%; crude fat 6.6%; crude ash 3.3%; digestibility of crude protein was 66.9%. The HFA contained (%): moisture 7.2; crude protein 76.1%; crude fat 11.7%; crude ash 4.9%; digestibility of crude protein was 95.4%. The biosafety parameters in the experimental batches of the additives fitted the governmentally regulated requirements to feed-grade products.

The basic productivity parameters in broilers were determined at the end of the rearing (38 days of age); the digestibility and retention of dietary nutrients were determined in the balance trial at 28-30 days of age on 3 cockerels from each treatment according to the protocol from [10]. The parameters of biosafety and chemical composition of meat were determined at slaughter in 5 birds from each treatment. The significance of the differences between treatments was assessed by the paired Student’s t-test.

3. Results and discussion
The basic productivity parameters in broilers are presented in table 1 indicating that the highest productive performance was found in treatment 2 fed FFA. Mortality level in all treatments was 0%. Average live bodyweight at 38 days of age in treatment 2 was significantly higher by 6.5% in compare
to control (p<0.05); in females it was higher by 5.2% (p<0.05) while in males by 7.9% (p<0.01). Average daily weight gain was higher by 3.6 g/bird/day (or by 3.8%) in compare to control, feed conversion ratio lower by 1.9%, dressing percentage higher by 0.8%, percentage of high-grade carcasses higher by 5.7%. The European production efficiency factor (EPEF) was higher by 29 points in compare to control.

The productive performance in treatment 3 (fed HFA) was intermediate between control and treatment 2. Average live bodyweight at 38 days of age in this treatment was insignificantly higher by 3.9% in compare to control though lower by 2.5% in compare to treatment 2. Average daily weight gain was higher by 2.1 g/bird/day in compare to control; however, feed conversion ratio was the highest: higher by 1.2% in compare to control and by 3.2% in compare to treatment 2. Dressing percentage and percentage of high-grade carcasses were higher by 0.4 and 2.9% in compare to control. EPEF was higher by 9 points in compare to control though lower by 20 points in compare to treatment 2.

Table 1. The productive performance at 38 days of age in broilers fed different protein additives (n=35).

| Parameter                        | Treatment 1c (FM) | Treatment 2 (FFA) | Treatment 3 (HFA) |
|----------------------------------|-------------------|-------------------|-------------------|
| Average live bodyweight, g       | 2127±37.3         | 2266±37.7b        | 2209±32.8         |
| -""- in males                    | 2282±41.0         | 2401±42.9a        | 2350±22.1         |
| Average daily weight gain, g/bird/day | 54.9              | 58.5              | 57.0              |
| Feed conversion ratio, kg/kg     | 1.61              | 1.58              | 1.63              |
| Eviscerated carcass weight, g    | 1570±27.5         | 1690±28.1         | 1640±24.4         |
| Dressing percentage              | 73.8              | 74.6              | 74.2              |
| Percentage of high-grade carcasses | 88.6              | 94.3              | 91.4              |
| European production efficiency factor | 348               | 377               | 357               |

The differences with control were significant at:

- P<0.05;
- P<0.01.

The results of the balance trial (table 2) evidenced that the digestibility coefficients of dry matter, crude protein, crude fat, and crude fiber in treatments 2 were higher in compare to control by 0.9; 1.2; 2.7 and 1.4%, respectively, in treatment 3 by 0.7; 1.1; 3.2 and 1.0%. The retention coefficients of dietary nitrogen, calcium, and phosphorus were higher in compare to control by 1.5; 1.6 and 0.5%, respectively, in treatment 2 and by 1.3; 1.8 and 1.0 in treatment 3.

Table 2. Coefficients of digestibility and retention of dietary nutrients at 28-30 days of age in broilers fed different protein additives (n=3).

| Coefficients, %          | Treatment 1c (FM) | Treatment 2 (FFA) | Treatment 3 (HFA) |
|--------------------------|-------------------|-------------------|-------------------|
| **Digestibility:** dry matter | 76.2              | 77.1              | 76.9              |
| crude protein            | 92.1              | 93.3              | 93.2              |
| crude fat                | 79.8              | 82.5              | 83.0              |
| crude fiber              | 13.3              | 14.7              | 14.3              |
| **Retention:** nitrogen   | 61.5              | 63.0              | 62.8              |
| calcium                  | 42.7              | 44.3              | 43.2              |
| phosphorus               | 33.9              | 35.7              | 34.9              |

The parameters of biosafety of meat (concentrations of different pollutants) are presented in table 3. The content of lead in meat of all treatments was < 0.01 mg/kg, cadmium < 0.01 mg/kg, arsenic <
0.05 mg/kg, mercury < 0.002 mg/kg; the concentrations of all these pollutants were well below the respective upper allowable thresholds.

The content of hexachlorane (isomeric hexachlorocyclohexanes) was < 0.04 mg/kg, DDT (dichlorodiphenyltrichloroethane) and its metabolites < 0.04 mg/kg; residual concentration of antibiotics (chloramphenicol) < 0.08 μg/kg; i.e. concentrations of all these pollutants were also well below the respective upper allowable thresholds. The concentration of \(^{137}\text{Cs}\) was 2.5-3.7 bq/kg with upper allowable threshold 200 bq/kg.

It can be therefore concluded that meat from all treatments can be regarded as safe and fitting to the governmentally established restrictions on the allowable concentration of different toxins and other pollutants.

### Table 3. Parameters of the biosafety of meat in broilers fed different protein additives (n=5).

| Pollutant                          | Upper allowable threshold | Treatments |
|-----------------------------------|---------------------------|------------|
|                                   |                           | 1с (FM)    | 2 (FFA) | 3 (HFA) |
| Lead, mg/kg                       | 0.5                       | < 0.1      | < 0.1   | < 0.1  |
| Cadmium, mg/kg                    | 0.05                      | < 0.01     | < 0.01  | < 0.01 |
| Arsenic, mg/kg                    | 0.1                       | < 0.05     | < 0.05  | < 0.05 |
| Mercury, mg/kg                    | 0.03                      | < 0.002    | < 0.002 | < 0.002|
| Hexachlorane (α,β,γ), mg/kg       | 0.1                       | < 0.04     | < 0.04  | < 0.04 |
| DDT and its metabolites, mg/kg    | 0.1                       | < 0.04     | < 0.04  | < 0.04 |
| Chloramphenicol, μg /kg           | 0.3                       | < 0.08     | < 0.08  | < 0.08 |
| \(^{137}\text{Cs}, bq/kg\)       | 200                       | < 3.7      | < 2.5   | < 3.1  |

Chemical composition of breast and thigh muscles is presented in table 4. The highest protein content in breast muscles was found in treatment 2 (higher by 0.4 and 0.8%, respectively, in compare to treatments 1 and 3); fat content followed the same pattern (higher by 0.5% in treatment 2 in compare to treatments 1 and 3). Fat content in thigh muscles in treatments 2 and 3 was lower in compare to control by 1.4 and 3.2%, respectively.

### Table 4. The chemical composition of muscles at 38 days of age in broilers fed different protein additives (n=5).

| Treatment | Moisture, % | Fat, % | Protein, % | Ash, % |
|-----------|-------------|--------|------------|--------|
| Breast muscles |             |        |            |        |
| 1с (FM)   | 73.1±7.3    | 1.3±0.2| 24.1±1.9   | 1.35±0.19 |
| 2 (FFA)   | 72.8±7.2    | 1.3±0.2| 24.5±2.0   | 1.30±0.18 |
| 3 (HFA)   | 73.2±7.3    | 1.8±0.3| 23.7±1.9   | 1.22±0.17 |
| Thigh muscles |         |        |            |        |
| 1с (FM)   | 69.7±6.9    | 10.2±1.5| 18.9±2.8   | 1.05±0.15 |
| 2 (FFA)   | 71.1±7.1    | 8.8±1.3| 18.9±2.8   | 1.03±0.15 |
| 3 (HFA)   | 73.2±7.3    | 7.0±1.0| 18.6±2.8   | 1.02±0.15 |

### 4. Conclusion

The comparison of three different sources of animal protein in diets for broilers indicated that the most effective source was the additive produced by the hydrothermal hydrolysis and subsequent fermentation of poultry slaughter wastes (FFA, treatment 2). The productive performance in this treatment was the highest; the EPEF in this treatment was higher by 29 points in compare to control and by 20 points in compare to treatment 3 fed HFA. The meat from all treatments can be regarded as safe and fitting to the governmentally established restrictions on the allowable concentration of different toxins and other pollutants. There were no significant differences between the treatments in the chemical composition of breast and thigh muscles though a trends to higher protein content in
breast muscles (by 0.4% in compare to control) and lower fat content in thigh muscles (by 1.4%) were found in treatment 2.

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