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Nutritivna iskoristivost staroga crnog kruha u hranidbi pilića

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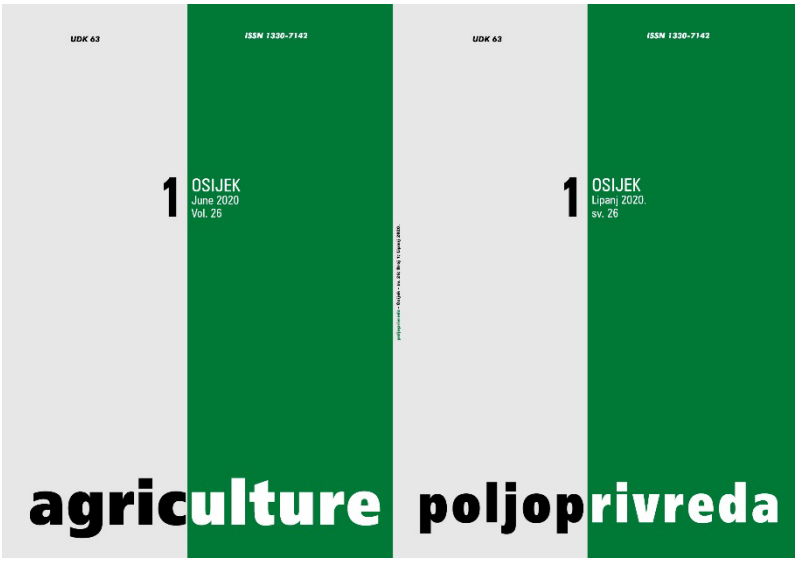

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OLD BROWN BREAD'S NUTRITIONAL USABILITY IN BROILER FEEDS

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SUMMARY

The most important aspect of broiler production is feeding, whose costs represent about 70% of total costs. Thus, the growth of poultry production has been based on a strong consumer demand for products that are cheap, safe, and healthy. That kind of product is old bread, whose return from the store represent a problem for its remediation. For the use of the old bread as a feed, the European Union has promulgated a series of regulations and directives, which order a ban on its utilization without prior treatment. The most common treatments are pelleting and extrusion. In poultry, the upper limit for the use of the old bread in feedstuff is often prescribed and amounts to 15%. The aim of this paper was to determine a possibility to use 5 and 10% old brown pelleted bread in feed mixtures for broilers fattening. The study has shown that the addition of old bread significantly improves broiler production indicators. The best results and a more favorable ratio of omega 6 and omega 3 fatty acids in the chicken muscles were obtained in the group fed with a 10-percent share of old brown bread ($p<0.05$). Such a processed old bread can be used as a new ingredient in animal feed production as a partial replacement for maize component.

Keywords: feeding, old bread, pelleting, usability, remediation

INTRODUCTION

By volume, the broiler chicken industry has occupied the second place in the world, just after pork (Yang and Jiang, 2005). A global production of meat was expected to demonstrate an increase of 1.1 percent in 2017, but a poultry meat output was forecast to rise by 0.9 percent coming to 118 million tons (Bedford et al., 2017). Based on the 2018 USDA forecasts of a 1-percent increase in world broiler production in 2019, a total broiler production in 2019 came close to a record 20 million tons.

In broiler production, feeding is the most important aspect and represents about 70% of total costs. Broiler diets are based on cereals and soybean meal as the major sources of energy and protein, respectively (Catalá-Gregori et al., 2009). Thus, the growth of poultry production has been based on a strong consumer demand for the products that are cheap, safe, and healthy.

The high cost of feed ingredients has drastically reduced a production output in poultry industry, and therefore the animal nutritionists have increased the level of animal protein intake by using the non-conventional feed ingredients (Ayanrinde et al., 2014). Bread waste is a by-product of the bakery industry made of flour, whose main ingredient is a dehulled wheat. The estimated wastage for bakery products ranges from 7 to 10% of its total production (Mena et al., 2011), taking into consideration the estimated global annual production of bread, which amounts to approximately 100 million tons (Melikoglu and Webb, 2013), while the amount of generated waste can reach even 10 million tons per year worldwide. The major factor for bread waste formation is that part of the produced product is left unsold and is returned to the bakery due to a large

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amount of available bakery products assortment, which are produced in excess to fulfil the consumers' demands (Kihlberg et al., 2005). There are limited possibilities for reprocessing bread waste in the bakeries. Some wastes can be used as a replacement of part of flour in sourdough preparation (breadcrumbs) or as animal feed (Pietrzak and Kawa-Rygielska, 2014). Mahmoud (2017) stated that dried bakery products are highly digestible because of their precooked nature and can be incorporated in the poultry diets. A dried bakery product can be an energy source because of its digestible carbohydrate content (starch + sugars) (Catalá-Gregori et al., 2009). It can partially replace the cereals without affecting broiler performance because its basic component is the wheat meal (Damron et al., 1965; Saleh et al., 1996). However, depending on the quality of the initial product and processing conditions, its composition may vary between suppliers (Waldroup et al., 1982).

Subsequent to a return from the market, the old untreated bread is presently used as feed in the Republic of Croatia. However, the EU has brought a series of regulations and directives, which order a ban on its utilization without prior treatment – Food General Law EC 852/2004, Food Hygiene Animal Origin EC 853/2004, Official Central of Animal Origin Food EC 854/2004, Rules for Animal Health 2002/99/EC, Repealing A17 Directive 2004/41/EC and Official Control of Food and Feed EC 882/2004. Furthermore, the Republic of Croatia has its Food Law (Official Gazette, 2015), in which the utilization of non-safe feed, such as an untreated old bread, is not allowed. The aim of this project is to develop a new form of old bread sanitation and an application of the newly developed products as the components in animal feed. A thermal treatment of the old bread, namely the pelleting and extrusion, results in the highly valued components in animal feed, with the properties satisfying both the EU´s and Croatia´s legislations. It is generally accepted that, compared to a mash, the feeding of pellets improves the broiler growth rate, with an increased feed intake (Engberg et al., 2002). An improved feed conversion with pellet feeding is also observed. This may be explained by a higher digestibility of nutrients, since a granulation (a combination of particle size reduction and gelatinization) may expose the feed particles to further enzymatic degradation (Engberg et al., 2002) more efficiently. At the same time, this procedure provides an extra time for preserving the products unchanged, and thereby extends the products usage time (Matin et al., 2018).

In general, the bakery meal is rich in starch because the wheat flour is the main ingredient in all bakery products. Because of this, starch is already thermally processed (cooked), it is highly digestible, and thus of a high nutritive value. As such, the bakery meal is ideal for the diets of young pigs and starter broilers. In poultry, an upper limit of 15% is often prescribed, if only to prevent a loss of performance due to a variability in nutrient content from batch to batch. Based on the abovementioned facts, the aim of this paper is to propose a thermal treatment by the pelleting technology for the unused old brown bread remediation and, subsequent to its usage, for the chicken feeding purposes.

MATERIAL AND METHODS

This investigation has encompassed 360 male single-day broilers (Cobb 500), which were classified by a random selection into three groups with 30 individuals per group. Each group had four repetitions, implying 12 boxes. The first group, the P-0 one, was without an old brown bread addition to the feed, the second group, the P-5 group, was with 5% of the old brown bread added to replace the maize component in the fodder mixture, and the third group, the P-10 group, was with 10% of the old brown bread added to replace the maize component in the fodder mixture. The old bread was thermally treated by pelleting and added to a chicken feed (starter and finisher) in a ratio amounting to 5 and 10%. A nutrition treatment was divided into two phases. In the first phase, at the chicken age ranging from one to 21 days, the chickens consumed the initial feed mixture (starter), and in the second stage, in the age span from 22 to 42 days, the chickens consumed the final feed mixture (finisher), during which the chickens' body mass, fodder mixture conversion, mortality and slaughter indicators were monitored. The old brown bread was previously thermally threated by pelleting to satisfy the Law for its usability in animal feeding. After the pelleting, a chemical analysis of old pelleted brow bread was conducted, figured in Table 1.

Table 1. Chemical analysis of the old brown pelleted bread

Tablica 1. Kemijska analiza staroga crnog peletiranog kruha

Parameter *Pokazatelj*	Old brown pelleted bread *Stari crni peletirani kruh*
Moisture (%) / *Vlaga* (%)	10.18
Crude ash (%) / *Sirovi pepeo* (%)	2.89
Crude protein (%) / *Sirovi proteini* (%)	11.51
Crude fat (%) / *Sirove masti* (%)	0.94
Crude fiber (%) / *Sirova vlakna* (%)	0.70
Calcium (%) / *Kalcij* (%)	0.11
Phosphorus (%) / Fosfor (%)	0.20
Sodium (%) / *Natrij* (%)	0.77
Starch (%) / *Škrob* (%)	63.84

Table 2. figures the feeding recipe mixtures and the feed mixtures chemical analyses.

Table 2. A starter mixture recipe (SMR), a finisher mixture recipe (FMR) with the pelleted brown bread component, and a chemical analysis of the used feed mixtures

Tablica 2. Receptura smjese startera (SMR) i finišera (FMR) s komponentom peletiranog crnoga kruha i kemijska analiza upotrijebljenih krmnih smjesa

Ingredient (%) *Sastojak (%)*	SMR1 (0 %)	SMR2 (5 %)	SMR3 (10 %)	FMR1 (0 %)	FMR2 (5 %)	FMR3 (10 %)
Maize / *Kukuruz*	53.73	49.32	44.91	63.20	58.79	54,47
Dried bread / *Osušeni kruh*	0.00	5.00	10.00	0.00	5.00	10.00
Soybean meal / *Sojina sačma*	37.50	37.00	36.50	29.50	29.00	28.40
Monocalcium phosphate	1.30	1.30	1.30	1.40	1.40	1.40
Oil / *Ulje*	4.00	4.00	4.00	2.50	2.50	2.50
Limestone / *Vapnenac*	1.50	1.50	1.50	1.50	1.50	1.50
Salt / *Sol*	0.35	0.25	0.15	0.35	0.25	0.16
VAM PT1	0.50	0.50	0.50	0.50	0.50	0.50
DL Methionine	0.12	0.13	0.14	0.05	0.06	0.07
Binder / *Vezivo*	1.00	1.00	1.00	1.00	1.00	1.00
Chemical analysis / *Kemijska analiza*						
Moisture (%) / *Vlaga* (%)	10.92	10.83	10.75	11.14	11.06	10.98
Crude ash (%) / *Sirovi pepeo* (%)	6.22	6.18	6.14	5.90	5.86	5.82
Crude protein (%) / *Sirovi proteini* (%)	21.35	21.37	21.39	18.34	18.36	18.34
Crude fat (%) / *Sirove masti* (%)	6.17	6.08	5.99	4.84	4.75	4.66
Crude fiber (%) / *Sirova vlakna* (%)	2.89	2.83	2.78	2.57	2.51	2.45
Calcium (%) / *Kalcij* (%)	1.00	1.00	1.00	0.99	0.99	0.99
Phosphorus (%) / *Fosfor* (%)	0.69	0.69	0.69	0.69	0.68	0.68
Sodium (%) / *Natrij* (%)	0.19	0.18	0.18	0.19	0.19	0.19
Starch (%) / *Škrob* (%)	35.00	32.17	33.38	38.36	38.68	38.35
Metabolizable energy, MJ/kg / *Metabolička energija, MJ/kg*	12.47	12.47	12.47	12.43	12.43	12.44

A vitamin and trace mineral premix provided the following nutrients per 1 kg of diet: vitamin A, 40,000 IU; vitamin D3, 8,000 IU; vitamin E, 10 IU; vitamin K3, 4.0 mg; vitamin B1, 4.0 mg; vitamin B2, 12.0 mg; vitamin B6, 6.0 mg; vitamin B12, 0.02 mg; niacin, 60.0 mg; pantothenic acid, 20 mg; folic acid, 2.0 mg; biotin, 0.02 mg; Fe, 30.0 mg; Zn, 25.0 mg; Mn, 20.0 mg; Cu, 5.0 mg; Se, 0.1 mg / *Vitamin i mineralni premiks u tragovima osigurali su sljedeće hranjive tvari po kg hrane: vitamin A, 40.000 IU; vitamin D3, 8.000 IU; vitamin E, 10 IU; vitamin K3, 4,0 mg; vitamin B1, 4,0 mg; vitamin B2, 12,0 mg; vitamin B6, 6,0 mg; vitamin B12, 0,02 mg; niacin, 60.0 mg; pantotenska kiselina, 20 mg; folna kiselina, 2,0 mg; biotin, 0,02 mg; Fe, 30,0 mg; Zn, 25,0 mg; Mn, 20,0 mg; Cu, 5,0 mg; Se, 0,1 mg*

During the nutrition, the old brown pelleted bread and the used mixtures were analyzed. The analysis included a moisture content (HRN ISO 6496:2001), ash (HRN ISO 5984:2004), fat (HRN ISO 6492:2001—modified by ANKOM XT 15 extraction system guidelines), crude proteins (HRN EN ISO 5983-2:2010), crude fiber (HRN EN ISO 6865:2001—modified by FOSS Fiber Cap manual guidelines), phosphorous (HRN ISO 6491:2001), calcium (RU-5.4.2-11), sodium (HRN ISO 7485:2001) and starch (AOAC-996.11) determination. A metabolizable energy (ME) is calculated according to Jansen (1998). The fatty acid composition is determined according to Pleadin et al. (2014). At the end of investigation, 120 chickens (ten from each experimental unit) were slaughtered. The carcasses' giblets and abdominal fat were collected. The carcasses were chilled at 5°C for 24 hours in a chilling room, and they were subsequently weighed and cut up in commercial parts, which included: breast, drumstick, thighs, back, feet, neck, and wings. A carcass weight (CW) took into account the whole slaughtered chicken (included neck and feet) without head, abdominal fat, and giblets after chilling. A carcass yield (CY) was calculated by the ratio of carcass weight (CW) and body weight at slaughter (BWs), what is represented by the following formula: CY (%) = CW/BWs*100. After slaughter, the composition of all fatty acids in the muscles (*musculus iliotibialis*) of the experimental chickens were determined (10 per each treatment, 30 total). For statistical analysis package (SAS), 9.3 version was used (SAS Institute, Cary, NC, USA, 2001) by applying the GLM procedure, with a significance level amounting to $p \geq 0.05$.

RESULTS AND DISCUSSION

The old pelleted brown bread proved to be a quality and healthy raw material source for a chicken feed mixture preparation. Tables 3 and 4 demonstrate the chicken's production indicator results in the period from one to 21 days and from 22 to 42 days.

Table 3. Chickens' production indicator results in the period from 1 to 21 days

Tablica 3. Proizvodni pokazatelji pilića u razdoblju od 1 do 21 dan

Production indicators *Proizvodni pokazatelji*	Brown bread / *Crni kruh*		
	P-0	P-5	P-10
Body mass (g), 1st day / *Tjelesna masa (g), 1. dan*	39.50 ± 0.29	39.67 ± 0.32	39.69 ± 0.32
Body mass (g), 21th day / *Tjelesna masa (g), 21. dan*	808.86^{b,a} ± 10.53	819.58^{a} ± 10.75	833.74^{a} ± 9.49
Number of chickens, *1st day* / *Broj pilića, 1. dan*	120	120	120
Number of chickens, 21th day / *Broj pilića, 21. dan*	115	117	117
Mortality, % / *Mortalitet, %*	5	2.5	2.5
Conversion, kg/kg / *Konverzija, kg/kg*	1.53	1.58	1.62

a, b, c Mean values within a column having different superscripts are significantly different by a least significant difference test (P<0.05)

Table 4. Chickens' production indicator results in the period from 22 to 42 days

Tablica 4. Proizvodni pokazatelji pilića u razdoblju od 22 do 42 dana

Production indicators *Proizvodni pokazatelji*	Brown bread / *Crni kruh*		
	P-0	P-5	P-10
Body mass (g), 42th day / *Tjelesna masa (g), 42. dan*	2542.81 ± 24.77	2552.98 ± 19.94	2574.32 ± 21.32
Number of chickens, 21th day / *Broj pilića, 21. dan*	115	117	117
Number of chickens, 42th day / *Broj pilića, 42. dan*	112	114	117
Mortality, % / *Mortalitet, %*	2.61	2.56	0
Conversion, kg/kg / *Konverzija, kg/kg*	1.77	1.79	1.79

a, b, c Mean values within a column having different superscripts are significantly different by least significant difference test (p<0.05)

As can be seen from the results, the chicken body mass was uniform. The highest body weight on the 21st day had the chickens fed with a 10-percent share of old brown bread, but compared to the body weight of chickens fed with a 5-percent share of old brown bread in the feed mixture there was no significant difference, while there was a slight difference compared to the body weight of the control group. The control group of chickens fed with standard feed mixture obtained, on the 21st day, the best conversion of feed mixture, while a group of chickens fed with 10% of old brown bread achieved the worst conversion. The chicken groups fed with 5 and 10% of old brown bread had an equal mortality, lower than in the control group. Because of the increased mortality during the first 21 days of research, the chickens' control group fed with standard mixtures had the highest mortality at the end of the study. Chickens fed with 0 and 5% of old brown bread in the second phase of research had a uniform mortality, while a group of chickens fed with a 10-percent share of old brown bread was without mortality. In the second phase of the study, a chickens' group fed with a 10-percent share of old brown bread showed the best conversion. The total conversion has contributed to the benefit of the control group, while the groups of chickens fed with a 5- and 10-percent share of old brown bread have demonstrated the same conversion, but the difference between the groups was not significant.

Table 5 shows statistical values of main chicken body part yield.

Table 5. Statistical values of the main chicken body part yield pertaining to the chicken fed with 0.5 and 10% of old brown bread

Tablica 5. Statističke vrijednosti mase osnovnih dijelova trupa pilića hranjenih s 0,5 i 10% staroga crnog kruha

Parameter *Pokazatelj*	Brown bread / *Crni kruh*		
	P-0	P-5	P-10
Live chickens body mass (g) / *Masa živih pilića (g)*	2580.50 ±180.72	2530.00 ±168.12	2580.25 ±148.47
Carcass weight (g) / *Masa trupa (g)*	1780.25 ± 149.64	1741.25±148.85	1812.75±105.72
Carcass yield (%) / *Randman (%)*	68.94^{b} ± 1.71	68.75^{b} ± 2.06	70.26^{a} ± 1.29
Wings (g) / *Krila (g)*	198.15 ± 15.69	205.30 ± 33.94	200.35 ± 15.99
Drumstick (g) / *Bataci (g)*	233.20^{a} ± 21.92	228.80^{b,a} ± 22.38	242.10^{a} ± 20.22
Thigh (g) / *Zabatci* (g)	322.55 ± 23.77	312.30 ± 30.85	323.15 ± 21.50
Chest (g) / *Prsa (g)*	636.50^{a} ± 70.91	629.75^{b,a} ± 73.37	665.00^{a} ± 48.75
File (g) / *File (g)*	484.85^{b} ± 64.14	480.80^{b} ± 64.92	511.50^{a} ± 44.27
Back (g) / *Leđa (g)*	383.35^{a} ± 31.95	366.60^{b,a} ± 28.48	375.95^{a} ± 30.91
Abdominal fat (g) / *Abdominalna mast (g)*	27.55 ± 8.05	27.79 ± 8.07	26.37 ± 11.48
Stomach (g) / *Želudac (g)*	35.30 ± 7.09	32.75 ± 6.69	33.25 ± 5.78
Liver (g) / *Jetra (g)*	42.35^{b} ± 3.77	44.90^{a} ± 5.11	41.95^{b} ± 5.91

a, b, c Mean values within a column having different superscripts are significantly different by least significant difference test (p<0.05)

A nutritional treatment during the study significantly affected the carcass yield increase of the sacrificed chickens from the group fed with a 10-percent share of old brown bread. Such results are confirmed by Catalá-Gregori et al. (2009), as well as by Ayanrinde et al. (2014). A significantly bigger drumstick, chest, and file mass had a chickens' group fed with a 10-percent share compared to the group with a 5-percent share of old brown bread. The control group had a significantly higher back mass compared to the group fed with a 5-percent share of the old brown bread, while the liver mass was significantly higher in the chickens' group feed with a 55-percent share of old brown bread, compared to the other two groups. The weight of other chicken parts was not significantly different between all chicken groups used in the study.

Table 6. shows the results of fatty acid composition analysis in chicken muscle.

Table 6. Fatty acid composition in the muscles (*musculus iliotibialis*) of the treated chickens (% of total) and the most significant proportions of fatty acid groups

Tablica 6. Sastav masnih kiselina u mišićima (musculus iliotibialis) tretiranih pilića (% od ukupnih) i najznačajniji udjeli skupina masnih kiselina

Fatty acids *Masne kiseline*	Old brown bread (%) / *Stari crni kruh (%)*		
	P-0	P-5	P-10
Caproic 10:0 / *Kapronska 10:0*	0.02	0.02	0.02
Lauric 12:0 / *Laurinska 12:0*	0.26	0.25	0.27
Myristic 14:0 / *Miristinska 14:0*	0.85	0.83	0.86
Pentadecanoic 15:0 / *Pentadekanska 15:0*	0.11	0.10	0.11
Palmitic 16:0 / *Palmitinska 16:0*	22.53	23.07	23.04
Heptadecanoic 17:0 / *Heptadekanska 17:0*	0.27	0.24	0.26
Stearic 18:0 / *Stearinska 18:0*	7.92	7.12	7.22
Behenic 22:0 / *Behenska 22:0*	0.08	0.07	0.08
Lignoceric 24:0 / *Lignocerinska 24:0*	0.02	0.02	0.02
ΣSFA	32.07	31.73	31.88
Myristoleic 14:1 / *Miristoleinska 14:1*	0.14	0.15	0.16
Palmitoleic 16:1/ *Palmitoleinska 16:1*	3.81	4.61	4.66
Oleic 18:1 / *Oleinska 18:1*	39.57	41.49	40.44
Eicosenoic 20:1 / *Eikozenska 20:1*	0.41	0.40	0.41
Nervonic 24:1 / *Neuronska 24:1*	0.01	0.01	0.03
Σ MFA	43.94[a]	46.66[b]	45.70[a,b]
Eicosadienoic 20:2 / *Eikozadienska 20:2*	0.78	0.65	0.74
α-linolenic 18:3n3 / *α-linolenska 18:3n3*	1.11	1.06	1.13
Eicosatrienoic 20:3n3 / *Eikozatrienska 20:3n3*	0.01	0.01	0.01
Eicosapentaenoic 20:5n3 / *Eikozapentaenska 20:5n3*	0.02	0.02	0.02
Docosapentaenoic 22:5n3 / *Dokozapentaenska 22:5n3*	0.05	0.05	0.07
Docosahexaenoic 22:6n3 / *Dokozaheksaenska 22:6n3*	0.04	0.04	0.04
Σ PUFA n3	1.23[a,b]	1.18[b]	1.28[a]
Linoleic 18:2n6 / *Linolna 18:2n6*	20.69	18.56	19.05
γ-linolenic acid 18:3n6 / *γ-linolenska kiselina 18:3n6*	0.24	0.22	0.23
Eicosatrienoic 20:3n6 / Eikozatrienska 20:3n6	0.25	0.23	0.24
Arachidonic acid 20:4n6 / *Arahidonska kiselina 20:4n6*	0.76	0.70	0.79
Σ PUFA n6	21.95[a]	19.71[b]	20.31[b]
Proportions of fatty acid groups / *Omjer grupa masnih kiselina*			
Σ SFA : Σ MFA	0.73	0.68	0.69
Σ PUFA n6 : Σ PUFA n3	17.81[a]	16.68[b]	15.87[c]

[a, b, c] Mean values within a column having different superscripts are significantly different by a least significant difference test ($p<0.05$)

According to Scaife et al. (1994), most fatty acids in chicken muscles are palmitic and stearic acids and the unsaturated oleic and linoleic acids, while the linolenic and arachidonic acids are present in the small amounts, as confirmed by this study. It is known that the fatty acid composition in animal feed can significantly modify the fatty acid composition of meat fats. This is an open way to produce the so-called "functional or healthier food" for humans. In this regard, especially in a human diet, there are the interesting polyunsaturated fatty acids (PUFA), named the omega-3 and omega-6 fatty acids, being very important for the proper functioning of human bloodstream system (Barlow and Pike, 1991). Particularly important is the ratio of omega-6 and omega-3 fatty acids in human portions. Based on the aforementioned facts, the importance of any reduction

in omega-6 and omega-3 fatty acids ratio in humans diet is important. In this regard, the fatty acid composition of thigh chicken meat, subsequent to their feeding with the old brown bread, was investigated. From Table 6, it is evident that the application of the old brown bread in chicken feed mixtures has significantly reduced the ratio of omega-6 and omega-3 fatty acids when compared to the standard feed mixture. It should be emphasized that a very favorable fatty acid content was also found in the muscles of chickens fed with the old bread feed mixtures. Besides, the chicken meat consisted of a decreased omega-6/omega-3 fatty acids ratio in relation to chickens fed with the standard feed mixtures. This fact could be used in a commercial production of this, new product.

The study has circumstantiated that the addition of old bread at both levels significantly improves the broiler production indicators. Subsequent to the collection of all production indicators, the best results were demonstrated by a chicken group fed with a 10-percent share of old brown bread, and a more favorable ratio of omega-6 and omega-3 fatty acids was obtained.

CONCLUSION

The usage of the brown old bread, with a previous thermal processing by pelleting, allows for the replacement of maize component and provides for a high-quality broiler performance. The research has demonstrated that the usage of old bread does not exert a negative impact on the broiler mortality, and there were no significant changes in the slaughter indicators, which renders a feed with a 5- and 10-percent old bread share recommendable. The better broiler performances were observed in feeding them with a 10-percent share of the pelleted old bread. In addition to the other benefits of broiler feeding with the old bread, the chicken meat had a significantly reduced ratio of omega-6/omega-3 fatty acids ($p<0.05$) when compared to the broilers fed with a standard mixture.

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NUTRITIVNA ISKORISTIVOST STAROGA CRNOG KRUHA U HRANIDBI PILIĆA

SAŽETAK

Najvažniji aspekt proizvodnje brojlera jest hranidba, čiji troškovi čine oko 70% ukupnih troškova proizvodnje. Tako se rast peradarske proizvodnje temelji na snažnoj potražnji potrošača za proizvodima koji su jeftini, sigurni i zdravi. Takav je proizvod stari kruh, čije vraćanje iz trgovine predstavlja problem sanacije. Za korištenje staroga kruha kao hrane za životinje Europska unija donijela je niz propisa i smjernica kojima se propisuje zabrana korištenja bez prethodne dorade. Najčešći tretmani su peletiranje i ekstruzija. Kod peradi je često propisana gornja granica za uporabu staroga kruha u hrani za životinje, a ona iznosi 15%. Cilj ovoga rada bio je utvrditi mogućnost korištenja 5 i 10% staroga crnog peletiranog kruha u krmnim smjesama za tov brojlera. Istraživanje je pokazalo da dodavanje staroga kruha značajno poboljšava proizvodne pokazatelje brojlera. Najbolji rezultati i povoljniji omjer omega 6 i omega 3 masnih kiselina u pilećem mišiću dobiveni su u skupini koja se hranila s 10% udjela staroga crnog kruha ($p<0,05$). Takav obrađeni stari kruh može se koristiti kao novi sastojak u proizvodnji hrane za životinje kao djelomična zamjena za kukuruznu komponentu.

Ključne riječi: hranidba, stari kruh, peletiranje, iskoristivost, sanacija

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