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INFLUENCE OF HYDROTHERMIC TREATMENT OF MAIZE ON PERFORMMANCE AND CARCASS YIELD OF BROILERS

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The experiment was performed on 1000 one-day-old Hybro broilers divided into 5 groups. Raw maize was mixed in the diet of the control group, and extruded maize for the experimental group. Different hydrothermic conditions (temperature of 100°C or 120°C for 1.5 or 2.5 minutes) were applied for the treatment of maize.

Extruding contidions (time, temperature) were effective for successful gelatinization of starch and increased amounts of glucose, maltose and maltotriose, without adverse effects on other nutrients in maize grain.

Broilers in the control group had an average daily gain of 27.59 g and a feed: gain ratio of 2.51 kg with carcass yield of 64,86%. The inclusion of extruded maize significantly increased daily gain by 5.1-12.5% and improved feed: gain ratio by 7.6-13.1% with higher carcass yields by 0.5-3,7%.

Key words: poultry, maize, extrusion, performance, carcass yield

INTRODUCTION

In order to achieve the maximal nutritional effect from nutrients contained in grains, the feed industry uses manu different processing methods (Chang and Lii, 1992; Carr, 1991). Their effects lead to changes of form and size of food particles (Wang et al., 1995; Park et al., 1993), taste improvement and increased nutrient digestibility.

The aim of maize extrusion is increase of starch digestibility, which has a complex macromolecular structure, and is poorly utilizable, especially for young animals. Starch grains are made up of highly branched starch molecules that form a sphero - crystal structure with radially oriented "arms" which intersect at the hilum, forming regions of crystalloid structure. Steam heating produces swelling of starch grains, increasing their pressure upon the grain shell. Thus, extrusion is a distinctive way of boiling the grain contents inside its shell (Artz et al., 1990). Under high temperature and pressure, secondary bonds break, altering physical and chemical relations inside the starch grain and disturbing the crystalloid structure (Zheng and Wang, 1994; Takamine et al., 1995). If dried in a short period of time (Liu et al., 1993), starch grains do not reestablish the previous structure, remaining more accessible for enzymatic hydrolysis to glucose (Zuilichem et al., 1990).

Hydrothermic treatment applied to maize grain did not change the basic chemical composition (Puača, 1970; Bekrić et al., 1987; Bekrić et al., 1992; Radosavljević et al., 1992), the greatest contribution of this treatment being formation of readily digestible and available starch, thus increasing energy availability. The advanteges of extruded maize utilization in the nutrition of different animal species have been described (Smoje et al.,1996; Nikolić et al., 1983; Pejić and Kovčić, 1995; Grubić et al., 1987a), while in poultry nutrition data are contradictory (Patterson et al., 1994; Sinovec et al., 1995). The aim of this investigation was to enlucidate the effects of maize grain extruded under different conditions on the performance of broiler chickens.

MATERIALS AND METHODS

The experiment was performed on a thousand one-day-old Hybro broilers divided into 5 groups. Diets were based on standard feed mashes (table 1), composed to fulfill all the requirements of this category. Chickens of the control group were fed with raw maize mixed in the diet, while the experimental groups were fed with maize grain extruded under different conditions (table 2).

Table 1. Composition of complete feeed mashes, %

Ingredient %	Starter		Finisher	
	K	I – IV	K	I – IV
Maize raw	59.0	–	63.0	–
Maize extruded	–	59.0	–	63.0
Soyabean meal solvent	19.8	19.8	13.7	13.7
Sunflower meal solvent	3.0	3.0	5.0	5.0
Alfalfa meal dehy.	2.0	2.0	5.0	5.0
Fish meal	7.0	7.0	4.0	4.0
Fat	3.0	3.0	3.0	3.0
Yeast	3.0	3.0	1.5	1.5
Dicalcium-phosphate	1.0	1.0	1.5	1.5
Limestone, ground	1.0	1.0	0.6	0.6
Iodised salt	0.2	0.2	0.2	0.2
Methionine	0.5	0.5	0.5	0.5
Vitamin-mineral primex	0.5	0.5	0.5	0.5

Table 2. Different conditions for extruding maize

Group	Maize	Temperature °C	Time min
K	raw	–	–
0 – I	extruded	120	2.5
0 – II	extruded	120	1.5
0 – III	extruded	100	1.5
0 – IV	extruded	100	2.5

Chmical analysis for basic nutrient concentration in maize and mash samples was performed by standard analytical methods (AOAC, 1980) using a Tecator system. In raw and extruded maize samples the concentration of glucose, maltose and maltotriose was determined by high pressure liquid chromatography (Anderson et al., 1969), and the absorption index by the method of grain swelling.

During the trial, performance and health status were monitored. At the end, six broilers of both sexes were sacrificed from all groups, chosen by random sampling. Carcass gain was determined by the method "ready for grill".

All data were statistically processed (Snedecor and Cochran 1971) and an appraisal was made of the significance of differences in mean values among the groups of chickens.

RESULTS AND DISCUSSION

Chemical analyses did not reveal significant differences in physical and chemical composition of maize grain processed under different extruding conditions (table 3). The results imply that the process of grain extrusion has no effect on the basic chemical composition of the treated feedstuffs, which is in agreement with previous findings of other authors (Puača, 1970; Bekrić et.al., 1992). Also, the results suggest that replacement of row maize grain by extruded grain in the same quantity does not alter the chemical composition of the mashes (table 4).

The main purpose of maize extrusion is to increase starch digestibility, which is poorly digestible, especially for young animals, due to its complex structure. Breaking of secondary bonds, gelatinization and higher concentrations of siple sugars due to the breaking of starch chains increased digestibility. Our results indicate that glucose concentration was 6.1 - 57.6% higher in treated grains, than in raw maize.The concentrations of maltose and maltotriose were 7.7 - 8.8 and 1.9 - 3.2 times higher, respectively.

Absorption index can be used as a starch dissolution indicator because it is proportional to the number of simple sugars created by the breaking of starch chains under hydrothermal treatment. Although absorption index in our study was increased, no interrelationship with applied times and temperatures or with the increase of simple sugars could be established.

Table 3. Chemical composition of raw and extruded maize

Chemical composition %	Maize raw	Maize extruded			
		120° C 2,5 min	120° C 1,5 min	100° C 1,5 min	100° C 2,5 min
Moisture	10.26	9.11	10.01	9.28	8.90
Ash	1.20	1.12	1.10	1.15	1.13
Crude protein	8.71	8.62	8.50	8.80	8.88
Ehter extract	3.90	4.01	3.95	4.10	4.05
Crude fiber	2.11	2.20	2.17	2.05	2.18
N-free extract	73.82	74.94	74.27	74.62	74.68
Ca	0.01	0.01	0.01	0.01	0.01
P	0.27	0.28	0.26	0.29	0.27
ME. MJ/kg	13.93	14.13	13.99	14.14	14.17
Glucose mg/g DM	3.30	3.05	4.30	4.40	5.20
Maltose mg/g DM	1.00	7.70	8.80	8.20	8.30
Maltotriose mg/g DM	0.30	0.50	0.70	0.90	1.00
Absorption index	1.05	1.18	1.17	1.16	1.18

Table 4. Chemical composition of complete feed mashes, %

Chemical composition %	Starter		Finisher	
	K	I – IV	K	I – IV
Moisture	10.48	10.33 – 10.91	10.71	10.30 – 10.76
Ash	5.82	5.88 – 6.12	5.88	5.53 – 5.95
Crude protein	21.55	21.39 – 21.93	18.39	18.50 – 18.76
Ether extract	5.38	5.25 – 5.92	5.69	5.40 – 5.60
Crude Fiber	4.01	4.29 – 4.83	5.19	5.25 – 5.50
N-free extract	52.76	51.10 – 52.29	54.14	53.86 – 54.73
Ca	1.08	1.10 – 1.16	0.85	0.85 – 0.90
P	0.70	0.70 – 0.73	0.65	0.65 – 0.72
ME, MJ/kg	12.56	12.59 – 12.70	12.56	12.59 – 12.71

Table 5. Body weight of broilers, g

Group	Trial days		
	1st	28th	42nd
K	30. 87 $\pm$ 2.53	847.85 $\pm$ 148.13 ^{a,x}	1671.89 $\pm$ 272.81 ^{x}
0 – I	30.41 $\pm$ 2.66	903.16 $\pm$ 136.73 ^{b,y}	1743.62 $\pm$ 251.65 ^{y}
0 – II	30.88 $\pm$ 2.63	927.60 $\pm$ 128.50 ^{b,y}	1770.16 $\pm$ 239.96 ^{y}
0 – III	30.87 $\pm$ 2.63	879.95 $\pm$ 145.50 ^{c,x}	1751.89 $\pm$ 261.08 ^{a,y}
0 – IV	30.42 $\pm$ 2.74	843.23 $\pm$ 161.17 ^{a,x}	1689.53 $\pm$ 278.90 ^{b,x}

* Values expressed as X$\pm$SD

[a, b, c] Mean values within columns with unlike superscript letters were significantky diferent ($p<0.05$, LSD test)

[x, y, z] Mean values within columns with unlike superscript letters were significantky diferent ($p<0.01$, LSD test)

The average body weight in all experimental groups was maximally equalized at the beginning of the trial, and there were no significant differences (table 5). During the trial significant dirrerences in average body weight due to regime of nutrition became apparent. Although this parameter can be valuable for estimation of feed quality and nutritive value, daily weight gain is more reliable (table 6). Thus, highly significant ($p < 0.01$) differences in daily weight gain in the first period of fattening could be observed between the control and experimental groups. At the end of the trial these differences were significant ($p<0.05$). Our results are similar to the findings of other authors that availability and nutritive value of extruded and non-extruded feed and its influence on performance in the last phase of fattening are almost equal (Sinovec et al., 1995; Smije et al., 1996; Patterson et al., 1994). It can be concluded that young animals achieved better nutrient utilization if fed hydrothermically processed diet. In this period of life extruded feedstuffs represent very important coponent of the diet because incompletely developed enzymatic systems demand special care in diet formulation. Extrusion of grains provides not only gelatinization of starch, but also destruction of non-starch polysaccharides included in cell-wall formmation, allowing more rapid enzymatic digestion of intracellular content. With development of the enzymatic system and its adaptation to the feed, the described effects lose their importance, but still show a positive influence. Regarding the whole trial, it can be concluded that feeding extruded maize gives a higher weight gain than conventional raw grain.

Table 6. Body weight gain of broilers, g

Group	Trial days		
	1st	28th	42nd
K	$27.59 \pm 7.70^{a,x}$	58.55 ± 9.95^{x}	$36.70 \pm 10.45^{a,x}$
0 – I	30.01 ± 6.91^{y}	59.53 ± 10.56^{a}	39.00 ± 9.31^{b}
0 – II	31.03 ± 6.01^{y}	60.03 ± 9.72	40.12 ± 8.31^{y}
0 – III	$29.01 \pm 6.84^{b,x}$	$61.81 \pm 9.91^{b,y}$	38.94 ± 9.62^{y}
0 – IV	28.14 ± 7.11^{x}	59.72 ± 10.23^{a}	37.70 ± 9.32^{x}

[*] Values expressed as $X \pm SD$
[a, b, c] Mean values within columns with unlike superscript letters were significantky diferent ($p<0.05$, LSD test)
[x, y, z] Mean values within columns with unlike superscript letters were significantky diferent ($p<0.01$, LSD test)

Moreover, use of extruded maize resulted in a lower feed intake in the experimental groups than in the control group (table 7). The process of extrusion did not change significantly either the chemical composition of feedstuffs, or the content of gross energy. Thus it could be concluded that breaking starch chains increases digestibility and energy avilability, with a direct effect on feed intake, inversely correlated with energy content in the diet (Jovanović et al., 1995).

Table 7. Feed intake and feed: gain ratio

Trial days	Group K	I	II	III	IV
			Feed intake g		
1 – 28.	66.49	62.91	63.46	65.06	63.00
28 – 42.	145.16	136.23	136.34	142.76	135.62
1 – 42.	92.24	87.04	87.58	90.41	87.00
			Feed: gain ratio kg		
1 – 28.	2.41	2.10	2.05	2.24	2.24
28 – 42.	2.48	2.29	2.27	2.31	2.27
1 – 42.	2.51	2.23	2.18	2.32	2.31

The feed: gain ratio (table 7) is a derivation of daily gain and feed consumption, and at the bottom line is one of the best markers of feed quality and productivity. Usage of hydrothermically treated maize, increased the feed : gain ratio by 7-15% in the first and 7-9% in the second phase of trial. As before, it could be seen that the efficiency of extruded diet and its effects on performance were almost equalized at the end of the trial but at the early stage extruded maize improved feed: gain ratio in young chickens (Sinovec et al., 1995).

Carcass weight was correlated with body weight, and was significantly higher in the experimental groups than in the control group (table 8), which is in accordance with other data (Pavlovski and Mašić, 1991; Bogosavljević-Bogojević, 1994). Generally speaking, it could be concluded that carcass yield depends only on body weight before slaughtering, so that usage of extruded maize, by providing better performance gave more meat.

Table 8. Carcass weight and carcass yield

Group	Body weight g: live	Body weight g: slaughtered	Carcass yield %
K	1683.75 ± 47.87 [x]	1092.08 ± 46.98 [x]	64.86 ± 2.09 [x]
O – I	1778.33 ± 46.97 [y]	1195.67 ± 28.93 [a,y]	67.27 ± 0.73 [a,x]
O – II	1761.67 ± 35.76 [y]	1157.00 ± 54.27 [b,y]	65.65 ± 2.10 [b]
O – III	1754.17 ± 28.03 [y]	1160.50 ± 45.36 [b,y]	66.15 ± 2.09
O – IV	1672.50 ± 33.27 [x]	1090.08 ± 30.17 [x]	65.18 ± 1.04 [y]

[*] Values expressed as X± SD

[a, b, c] Mean values within columns with unlike superscript letters were significantky diferent ($p<0.05$, LSD test)

[x, y, z] Mean values within columns with unlike superscript letters were significantky diferent ($p<0.01$, LSD test)

Regarding all data in our trial, it could be concluded that the extruding conditions (time, temperature) were effective for successful gelatinization of starch, without adverse effects on other nutrients in maize grain. Inclusion of extruded maize in diets for fattening chickens led to better performance and therefore hydrothermically processed feed should be used in broiler nutrition.

REFERENCES

1. *Anderson R., Conway H. F., Pfeiser V. F., Griffin E. L.* 1969. Water absorption and solubility characteristics. Cereal Sci. Today, 14, 4-12.
2. *AOAC* 1980. Official methods of analysis. 14th ed., Washington D. c.
3. *Artz W. E., Warren C., Villota R.* 1990. Twin screw extrusion modification of a com fiber and corn starch extruded blend. J. Food Sci., 55, 746-750.
4. *Bekrić V., Božović I., Polič, Đ.* 1987. Tehnologija termičke obrade zrnastih hraniva ikronizacijom i mogućnosti njene primene u industriji stočne hrane. Krmiva, 29, 101-110.
5. *Bekrić V., Božović I., Radosavljević M.*, 1992. Uporednoispitivanje tehnologija suve ekstruzije i mikronizacije u preradi kukuruznog zrna, kukuruzne klice i endosperma. Zbornik radova "Tehnologija stočne hrane", 25-32.
6. *Bogosavljević-Bogojević S.*, 1994. Uticaj načina gajenja na tovne osobine i kvalitet mesa brojlera teških linijskih hibrida kokoški. Doktorska disertacija, Beograd
7. *Carr M.E.*, 1991. Starch-derived glycol and glycerol glucosides prepared by reactive extrusion processing. J. Appl. Polym. Sci., 42, 45-53.
8. *Chang Y. H. Lii C. Y.* 1992. Preparation of starch phosphates by extrusion J. Food. Sci., 57, 203-205.
9. *Grubić G.* (1987) Uticaj termičke obrade žitarica na efekte iskoriščavanja u mladih goveda. Krmiva, 29, 219-224.
10. *Jovanović N., Sinovec Z., Ivančević, S.* 1995. Ishrana živine u uslovima temperaturnog stresa. Živinarstvo, XXX, 89-98.
11. *Liu H., Lelievre J.* 1993. A model of starch gelatinization linking differential scanning calorimmetry and birefringence measurements. Carbohydro. Polym., 20, 1-5.
12. *Nikolić A.J., Pavličević A., Zeremski D., Bekrić V., Adamović M.* 1983. Uticaj mikronizacije zrna tri osnovna tipa kukuruza na svarljivost hranljivih materija i bilans azota u teladi. Zbornik-radova Poljoprivrednog fakulteta, 56, 27-28.
13. *Park J., Rhee K. S., Kim B. K., Rheee K. C.* 1993. Single - screw extrusion of deffated soy flour, corn starch and raw beef blends. J. Food Sci., 58, 9-20.
14. *Patterson P. H., Acar N., Coleman W. C.* 1994. Feeding value of poultry by-products effect of ensiling poliutry by products as a preservation ethod prior to extrusion. Poulry Sci., 73, 1107-1115.
15. *Pavlovski Z., Mašić B.* 1991. Randman pilića u testovima brojlera 1981-1989. godine. Zbornik radova "Živinarski dani", 9-15.
16. *Pejić N., Kovčić, S.* 1995. Ishrambeni efekti ekstrudiranja. Zbornik radova "Inovacije u stočarstvu", 35-50.
17. *Puača V.* 1970. Uticaj hidrotermičkog tretmana kukuruza vodenom parom i efikasnosti iskoriščavanja. Kriva, 22, 23-32.
18. *Radosavljević M., Bekrić V., Božović I.*, 1992. Komparativno ispitivanje uticaja postupaka mikronizacije i ekstruzije celog zrna i endosperma kukuruza na fizičko-hemijske i funkcionalne karakteristike skroba. Zbornik radova "Tehnologija stočne hrane", 164-170.
19. *Sinovec Z., Savić V., Srđević Ž., Pupavac S.* 1995. Uticaj upotrebe ekstrudiranog kukuruza u smešama za tov brojlera. Živinarstvo, XXX, 35-38.

20. *Smoje I., Ereg D., Sadžakov S., Predin S.* 1996. Novi aspektiproizvodnje i primene ekstrudiranih hraniva. Zbornik radova "Tehnologija proizvodnje u službi kvaliteta", 77-80.

21. *Snedecor W. G., Cocran G. W.* 1971. Statistical Methods. The Iowa state. Univ. Press

22. *Takamine K., Bhatnagar S., Hanna M. A.* 1995. Effect of eggshell on properties of corn starch extudates. Cereal Chem., 72, 385-388.

23. *Wang W., Flores R.A., Huang C. T.* 1995. Physical properties of two biological cushioning materials from wheat and comm starches. Cereal Chem., 72, 38-41.

24. *Zheng X., Wang S. S.* 1994. Shear inducedstarch conversion during extrusion. J. Food. Sci., 59, 1137-1143.

25. *Zuilichem D. J., Rokel G. J., Stolk W., Riet K.* 1990. Modelling of the enzymatic conversion of cracked corn by twin-screw extrusion cooking. J. Food Eng., 12, 13-28.

UTICAJ HIDROTERMIČKOG TRETMANA KUKURUZA NA PROIZVODNE REZULTATE I PRINOS MESA BROJLERA

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SADRŽAJ

Ogled je izveden na 1000 jednodnevnih Hybro brojlera podeljenih u 5 grupa. Za kontrolnu grupu korišćen je sirov kukuruz u smešama, a za ogledne grupe ekstrudiran kukuruz. Za hidrotermičko kondicioniranje kukuruza primenjeni su različiti uslovi (temperatura od 100 ili 120^{0}C u dužini od 1.5 ili 2.5 minuta).

Uslovi ekstrudiranja (vreme, temperatura) bili supovoljni za uspešno odvijanje želatinizacije skroba i većeg prisustva glukoze, maltoze i maltotrioze, bez štetnog dejstva na ostale hranljive materije kukuruza.

Brojleri kontrolne grupe postigli suprosečan dnevni prirast od 27.59 g i konverziju hrane od 2.51 kg uz prinos mesa od 64,86%. Korišćenje ekstrudiranog kukuruza značajno je povećalo dnevni prirast za 5. 1-12.5% i smanjilo konverziju hranu za 7.6-13.1%, uz veći prinos mesa za 0.5-3.7%.

Ključne reči: živina, kukuruz, ekstrudiranje, proizvodni rezultati, prinos mesa.