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Performance of broiler chickens fed compound feeds with various of cereal grains

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Abstract

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Maize and wheat are the main cereal forage crops cultivated at a global scale. They are among preferred forage grains for poultry nutrition. The aim of this study was to evaluate the productive performance of broiler chickens, whose compound feeds contained either maize, or wheat alone and maize +wheat combination. The experiment was performed with 120 day-old male ROSS hybrid chicks reared on the floor for 49 days. The birds were divided into three groups, each one consisting of two subgroups, as follows: group E1 – fed forage with maize and wheat; group E2 – fed forage with wheat and group E3 – forage with maize. The live weight, feed intake, feed conversion and slaughter traits were investigated. By the 49th day of age, the live weight of chickens from groups E1 and E2 fed diet with maize and wheat (35.99%+28%), and only wheat without maize (66%) were the heaviest, 3147.18 g and 3361.32 g, respectively. Chicks from group E3 fed the diet containing only maize (64.12%) without wheat had the lowest average live weight (2587.75 g at $P<0.0001$). Wheat, as a single cereal in broiler compound feeds, and its combination with maize had the most beneficial effect on weight gain and feed conversion over the entire fattening period ($P<0.001$). The improved weight gain of birds fed these diets was accompanied with higher feed intake ($P<0.001$) compared to birds fed forage with maize only. The slaughter yield and the breast with bone cut increased statistically significantly in the wheat-fed groups ($P<0.001$).

Keywords: broiler chickens; wheat; maize; productive performance; slaughter traits

Introduction

Cereals are the main ingredients of poultry compound feeds, constituting approximately 60–80% of their composition (Chadd, 2007). Wheat and maize are two of the most commonly used cereals in Bulgaria. Due to their different chemical and nutritional composition, their proportions in the composition of poultry rations vary.

Maize is the most commonly used cereal crop in industrial poultry rations (Dei, 2017). Its constant and high nutritional value is one of reasons for its widespread use (Slominski, 2011). Maize is the main source of energy in poultry feed worldwide (Ertl and Dale, 1997; Summers, 2001) and its share can be as high as 70% (Summers, 2001; Gehring et al., 2013; Naderinejad et al., 2016). Despite being a source of energy, maize also contains other dietary nutrients including crude protein (CP) and amino acids (AA) (Lilburn et al., 1991; Summers, 2001; Opapeju et al., 2007). The nutritional value of maize is influenced by multiple factors (Summers, 2001; Cowieson,

2005). Varieties, agronomic conditions, pre-harvest and post-harvest soil treatments are considered to be the main factors affecting its nutrients' content (Uribelarrea et al., 2004; Reynolds et al., 2005). Grain phenotypic characteristics - grain filling duration associated with physiological maturity, growth rate and grain moisture content are specific traits of each variety and can affect its nutritional value and thus, broiler growth performance (Seebauer et al., 2010; Prado et al., 2014). The main differences in maize composition include different protein solubility, zein content and amylose:amylopectin ratio (Gehring et al., 2013). Furthermore, the apparent metabolisable energy (AME) value of maize can vary by more than 470 kcal/kg (Cowieson, 2005). Evidence for the impact of different nutritional value of maize on the productive performance of broiler chickens is provided in numerous studies (Lasek et al., 2012; Lathman et al. 2016; Lasek et al. 2020; Melo-Duran et al., 2021; Vargas et al. et al., 2023).

Wheat is the other main ingredient in poultry feed. Its use is increasing over the years due to its profitability and favourable price. However, the physical and chemical composition of wheat is highly variable (Choct et al., 1999). It can provide up to 70% of the metabolisable energy and 35% of protein requirements of broiler chickens. Therefore, variation in wheat quality is expected to be of major importance for chicken growth performance (Gutierrez del Alamo et al., 2008).

In most studies, performance variations in broilers fed different wheat types is attributed to the high variability in chemical composition, in particular the level of non-starch polysaccharides (NSP) (Wiseman, 2000). There are other studies demonstrating that the NSP level and structure in wheat are highly variable (Knudsen, 1997, Pirgozliev et al., 2003, Smeets et al., 2014). The physical characteristics of wheat are also an important criterion that may affect broiler growth performance (Rose et al., 2001, Peron et al., 2006, Carre et al., 2007). For example, whether a grain is hard or soft is of great importance for feed processing and nutritional value (Amerah et al., 2007; Amerah et al., 2015). The wheat protein content is inversely proportional to the starch content (Svihus and Gullord, 2002). Therefore, it is necessary to consider factors other than protein e.g. starch, non-starch polysaccharides (NSP) and to investigate their relationship with broiler growth performance and metabolisable energy (ME). High-yielding varieties with better resistance to diseases are produced (AHDB 2015). Wheat genotype, soil composition, seasonal changes, crop cultivation and agronomic factors have significantly changed wheat composition and quality over the past two decades. Low arabinoxylan cultivars, which have better digestibility and improve broiler growth are now available (Choct and Annison 1992; Pirgozliev et al. 2015).

The aim of this study was to investigate the performance of broiler chickens fed compound feeds containing maize, wheat and their combination.

Material and Methods

The experiment on feeding broiler chickens diets based on maize, wheat or their combination was performed between 12 September and 30 November, 2022, in the Experimental Base of the Agricultural Institute, Stara Zagora. It included 120 day-old male ROSS hybrid chicks reared on floor system for 49 days. The birds were divided into three groups, each one consisting of two subgroups as follows:

group E1 – fed forage with maize and wheat;
group E2 – fed forage with wheat;
group E3 – forage with maize.

Chickens from all groups received balanced, isocaloric and isoprotein feeds according to the requirements of the hybrid and were housed under optimum microclimatic parameters (Table 1). Feed and water were provided ad libitum. The live weight, feed intake and feed conversion ratio were registered. Live weight of broilers was determined by individual weighing at 14, 28 and 49 days of age in the morning, following the same order of groups. On the basis of records, the average daily weight gain was calculated. Feed intake was monitored for the periods 1-14; 15-

28 and 29-49 days of age. Feed conversion ratio was calculated from feed intake and weight gain. After the end of the trial, slaughter analysis was performed on 6 chicks from each group with a live weight close to the group average. The grill weight (carcass without neck and edible offal), breast (with bone and skin), leg (thigh and drumstick), wings, back, edible offal (gizzard, liver, heart), spleen and abdominal fat were determined. On the basis of collected data, the slaughter yield, relative proportions of edible offal and abdominal fat (vs preslaughter live weight) and relative proportions of breast, leg, wings and back (vs grill weight) were calculated.

The statistical analysis of data was done with one-way ANOVA with SPSS (v.19) software. The level of significance among the groups was determined with the LSD-post hoc test at $P<0.05$.

Results and Discussion

The experimental results showed significant effects of cereal grains in compound feed on productive performance of broilers during the different age periods. During the starter period (Table 2), the highest live weight - 322.13 g was achieved by chickens from group E2, which received feed with wheat (57%). The remaining two groups: E1 and E3 demonstrated significantly lower ($P=0.001$) and practically identical average weights, 282.10 g and 282.68 g, respectively. The established trend was preserved until the 28th day, when E2 chickens had the highest live weight -1280.08 g ($P=0.000$), followed by the E1 group fed ration with maize and wheat -1068.95 g and E3 – fed a maize only ration (56.91%) that was with the lowest live weight - 961 g.

Table 1. Composition and nutritive value of the compound feed

Components, %	Compound feed/Groups								
	Starter			Grower			Finisher		
	E1	E2	E3	E1	E2	E3	E1	E2	E3
Wheat	25.440	57.210	-	22.890	59.890	-	28.000	66.080	-
Maize	30.000	-	55.000	36.000	-	56.910	35.920	-	64.120
Soybean meal	35.000	33.000	38.100	31.000	29.000	33.000	24.000	21.500	25.410
Sunflower meal	3.000	3.000	1.000	3.000	3.000	3.000	3.000	3.000	3.000
Sunflower oil	3.000	3.200	2.320	4.000	5.000	4.000	6.000	6.300	4.400
DL - methionine	0.170	0.185	0.160	0.130	0.140	0.120	0.080	0.100	0.065
Lysine	0.240	0.270	0.210	0.130	0.150	0.100	0.090	0.130	0.070
Optimizim	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150	0.150
Salt	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
Limestone	0.500	0.650	0.400	0.440	0.620	0.320	0.490	0.690	0.350
Dicalcium phosphate	2.100	1.930	2.260	1.860	1.650	2.000	1.870	1.650	2.030
Vitamin-mineral premix	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
Contents of the concentrate mixture:									
Metabolizable energy, MJ/kg	12.27	12.27	12.24	12.88	12.87	13.00	13.36	13.37	13.04
Crude protein, %	22.05	22.06	22.04	20.54	20.61	20.71	18.02	18.00	18.01
Crude fiber, %	4.35	4.46	4.05	4.11	4.24	4.06	3.74	3.86	3.65
Lyzine, %	1.44	1.45	1.45	1.23	1.23	1.23	1.01	1.02	1.00
Methionine, %	0.51	0.51	0.51	0.46	0.45	0.46	0.37	0.37	0.37
Calcium , %	1.02	1.02	1.03	0.90	0.90	0.90	0.90	0.90	0.90
Potassium available, %	0.50	0.50	0.50	0.45	0.45	0.45	0.45	0.45	0.45

Table 2. Live weight of broilers (g)

Age, days	Groups			SEM	P-value
	E1	E2	E3		
1 day	38.93	39.05	39.15	0.09	0.350
14 day	282.10[b]	322.13[a]	282.68[b]	8.37	0.001
28 day	1068.95[b]	1280.08[a]	961.00[b]	39.62	0.000
49 day	3147.18[a]	3316.32[a]	2587.75[b]	78.00	0.000

[a-c]- different letters in the row mark statistically significant differences at P<0.05;
E1- maize +wheat; E2-wheat; E3- maize.

At the end of the experiment, feeding maize and wheat (35.92%+28%), as well as wheat alone (66%) had a positive impact on the growth performance of chicks resulting in a significant higher live weight of 3147.18 g and 3361.32 g, respectively. Broilers fed maize (64.12%) only had the lowest live weight - 2587.75 g (P=0.0001).

Although, they consumed less feed during the starter period, chickens from group E2 (Table 3) had the highest weight gain compared to the other groups (361.98 g; P=0.001) and converted the wheat-containing compound feed the most efficiently (1.33 kg/kg; P=0.000). During the next stage of development (15-28 days), significantly higher values of weight gain and feed consumption were again observed in this group (P=0.000), with significant differences in feed conversion compared to E3 chickens, in which feed conversion was less efficient (P=0.000).

At the end of the fattening period (29-49 days), the weight gain and the feed intake remained the highest in chickens from group E1 (maize+wheat) and group E2 (wheat). Totally, for the entire fattening period, feed conversion in groups E1 and E2 was approximately the same, and the differences were small and inconsistent. Chickens from the E3 group converted the dietary nutrients most ineffectively (1.88 kg/kg) compared to groups E1 (1.61 kg/kg) and E2 (1.67 kg/kg).

Wheat has long been used as a base feed for monogastric animals (Javed et al., 2022), but opinions about its influence on the performance of broilers differ. Many years ago, Marion et al. (1984) demonstrated that the newer wheat varieties were utilised at the same extent as maize-based diets when fed to broiler chickens even at the earliest age. According to Rodriguez et al., (2012), the dietary inclusion of wheat and barley reduced growth performance and feed consumption (P<0.05), but did not affect feed conversion compared to a maize-based ration. In the study of Akter et al. (2017), broilers fed wheat-based compound feed had higher feed intake and reduced feed conversion efficiency only in the last week of fattening (25-38 days of age) compared to those fed maize, while growth performance traits were not influenced. Similarly to the results from the present experiment, other authors also found that wheat diet was significantly superior to maize diets when fed to Ross broilers (Kiarie et al., 2014; Razuki et al., 2017; Ghayour-Najafabadi et al., 2018; Yousif et al., 2021). Some studies affirmed that this response may be due to the fact that the Ross hybrid has been selected in Europe for many years and fed mainly diets with wheat as basic cereal grain component, so that the birds became adapted to them and thus, absorption of non-starch polysaccharides (NSP) was not a problem (Razuki et al., 2017; Yousif et al., 2021). These findings do not support earlier studies confirming the negative effect of the NSPs in wheat-based diets (Choct and Annison 1990; Annison 1991) due to their potential ability to increase the viscosity of intestinal contents, causing reduced digestibility of nutrients. These unexpected results have been attributed to the chemical composition of feed components, specifically the NSP content (Wiseman 2000), the amino acid profile of wheat-based diets (Abadi et al. 2014) and the physical characteristics of wheat used in the diets (Gutierrez Del Alamo et

Table 3. Weight gain, feed consumption and feed conversion of broilers (average for the period per 1 chicken)

Items	Groups			SEM	P-value
	E1	E2	E3		
1-14 day					
Weight gain, g	243.17[b]	283.08[a]	243.53[b]	8.37	0.001
Consumption, g	410.64[a]	361.98[b]	414.87[a]	3.93	0.000
Feed conversion, kg/kg	1.76[a]	1.33[b]	1.81[a]	0.07	0.000
15-28 day					
Weight gain, g	786.85[b]	957.95[a]	678.33[c]	33.77	0.000
Consumption, g	880.24[c]	1226.86[a]	1014.90[b]	8.56	0.000
Feed conversion, kg/kg	1.22[b]	1.34[b]	1.61[a]	0.09	0.000
29-49 day					
Weight gain, g	2078.23[a]	2036.24[a]	1626.75[b]	85.00	0.000
Consumption, g	3614.28[b]	3841.02[a]	3116.18[c]	13.56	0.000
Feed conversion, kg/kg	1.86	1.96	1.95	0.16	0.314
1-49 day					
Weight gain, g	3108.25[a]	3277.27[a]	2548.60[b]	78.00	0.000
Consumption, g	4905.16[b]	5429.86[a]	4545.94[c]	16.69	0.000
Feed conversion, kg/kg	1.61[b]	1.67[b]	1.88[a]	0.06	0.003

[a-c]- different letters in the row mark statistically significant differences at P<0.05.

E1- maize +wheat; E2-wheat; E3- maize.

Table 4. Slaughter performance of broiler chickens.

Items	Groups			SEM	P-value
	E1	E2	E3		
Slaughter weight, g	3413.33[a]	3545.00[a]	2882.67[b]	80.77	0.000
Slaughter yield, %	69.40[b]	72.05[a]	68.56[b]	0.68	0.006
Grill, %	2368.67[b]	2554.00[a]	1975.33[c]	60.77	0.000
Breast with bone, %	38.64[a]	39.74[a]	35.10[b]	0.65	0.000
Thighs, %	31.56[a]	30.24[b]	32.57[a]	0.43	0.006
Wings, %	10.55[b]	10.50[b]	11.66[a]	0.18	0.000
Backs, %	19.34[ab]	18.62[b]	20.52[a]	0.50	0.050
Gizzard, %	1.29	1.17	1.30	0.07	0.320
Liver, %	2.08	2.12	2.19	0.12	0.830
Heart, %	0.44	0.49	0.49	0.02	0.299
Abdominal fat, %	0.22	0.22	0.33	0.10	0.658
Spleen, %	0.17	0.12	0.16	0.03	0.352

[a-c]- different letters in the row mark statistically significant differences at P<0.05.

E1- maize +wheat; E2-wheat; E3- maize.

al. 2008). It was further suggested that the rate of starch digestion was an important factor in the productivity of birds (Gutierrez del Alamo et al., 2008, Ball et al., 2013) and may influence blood insulin level, the availability of glucose, and therefore protein accumulation (Weurding, 2002). In addition, rapid starch digestion had a negative effect on feed conversion, while slower digestion improved protein and amino acid digestion efficiency.

At the end of the 49-day experimental period, a slaughter analysis was performed to determine the fattening performance of the broiler chickens (Table 4). The analysis of the results for slaughter weight proved once again the clear differences in favor of feeding wheat-based, as well as wheat+maize based rations – it was the highest in birds from groups E2 (3545.00 g) and E1 (3413.33 g), and statistically significantly different ($P<0.000$) from group E3 - (2882.67 g). Significant differences between the three groups were also found in the weight of the grill ($P<0.000$). Broilers fed wheat-based diet (E2) had the highest grill yield - 72.05% ($P=0.006$), corresponding to the slaughter weight. The inclusion of wheat only in the rations (E2), as well as its combination with maize (E1) increased the relative weight of breast with bone ($P=0.000$), compared to birds fed the ration with maize as the only cereal grain component (E3). At the same time, the share of leg decreased only when wheat was included ($P=0.006$). The remaining parts of the carcass - the wings and the back, which have a minimum content of muscle tissue, had the highest relative share in broiler chickens from group E3, fed maize-based ration. The edible offal involved in the digestion (gizzard and liver) and the relative weights of the heart and spleen were not affected by the dietary cereal grain used. The share of abdominal fat remained practically the same: 0.22-0.33%.

The slaughter analysis results were identical to the conclusions of Saki et al. (2023), who evaluated the effect of maize and wheat gluten, either individually or in combination, on the growth and slaughter performance of broiler chickens and reported significantly better characteristics of the grill, breast, thighs, wings and parts of the digestive system with the participation of wheat gluten. On the other hand, Mateo and Carandang (2006) did not observe significant differences in carcass weight and yield in birds fed either maize- or wheat-based feed.

The inclusion of wheat or maize as the main cereal grain component in broiler feed has changed the weight of digestive organs - increased gizzard weight in birds fed maize-based rations and higher liver weight in wheat-based rations (Ghayour-Najafabadi et al. 2018), which was not confirmed in the present experiment.

Conclusions

The study results allowed concluding that the type of dietary cereal grain was important for the growth and slaughter performance of broiler chickens. Under the conditions of the experiment, wheat as the only cereal grain in broiler compound feed, as well as its combination with maize, had the most beneficial effect on live weight, growth and feed conversion for the entire fattening period ($P<0.001$). Improved weight gain in birds fed these diets was accompanied by higher feed consumption ($P<0.001$) vs that of broilers fed maize only. The slaughter yield and breast with bone cut was significantly increased when wheat was included in the compound feed composition ($P<0.001$). These results are most likely due to the inclusion of a preparation with additional enzymes, as well as the claim of some other studies that the ROSS hybrid may be more adapted to wheat-based diets.

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