Original scientific paper
Journal of Central European Agriculture, 2022, 23(3), p.513-525

DOI: /10.5513/JCEA01/23.3.3611

Effect of herbal and immunomodulatory supplements on growth performance and meat quality in broilers

Влияние на билкови и имуномодулиращи добавки върху растежните способности и качеството на месото при пилета бройлери

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Received: April 14, 2022; accepted: August 5, 2022

ABSTRACT

This study aimed to evaluate the effect of herbal and immunomodulatory die-tary supplements and their combinations on growth performance, slaughter traits and meat quality in male broiler chickens. A total of 210 one-day-old Ross 308 male chickens were randomly distributed after weighing in 7 groups (3 replicates in each, n=10 chickens). Broilers were reared on deep litter until 42 days of age and divided as follows: Group I – control (basal diet without supplements); Group II – supple-mented with 0.2% Immunoßeta; Group III – supplemented with 0.2% garlic powder; Group IV – supplemented with 0.2% herbal mix (0.05% ginger, 0.05% rosemary, 0.05% thyme and 0.05% yarrow); Group V – supplemented with 0.2% Immunoßeta + 0.2% garlic powder; Group VI – supplemented with 0.2% Immunoßeta + 0.2% herbal mix; Group VII – supplemented with 0.2% Immunoßeta + 0.2% garlic powder + 0.2% herbal mix. At the end of the experiment, chickens weighed from 2552±54 g (Group I) to 2689±55 g (Group IV) without statistically significant differences (P>0.05). Feed conversion varied from 1.64 (Group IV) to 1.74 (Group I). Meat pH, water holding ca-pacity, water absorption capacity, and tenderness were not influenced by the dietary supplement type. All supplements used did not show an adverse effect on health, and no mortality was found in the experimental groups. The obtained results show a clear trend towards a positive effect of the used feed additives and their combination mainly on the fattening characteristics of the broiler chickens, evident from the higher values of the two efficiency indices.

Keywords: broilers, herbal additive, garlic powder, immunomodulatory, slaughter traits

РЕЗЮМЕ

Целта на проучването беше да се установи ефекта на някои билкови и имуномодулиращи хранителни добавки поотделно и в комбинация върху растежа, кланичните характеристики и качеството на месото при мъжки пилета бройлери. Общо 210 еднодневни пилета (Ross 308) след претегляне бяха разпределени на случаен принцип в 7 групи (всяка с 3 повторения, n=10 пилета). Бройлерите се отглеждаха върху дълбока постеля до 42-дневна възраст и бяха разделени както следва: Група I – контрола (основна диета без добавки); II група – с добавка на 0,2% Immunoßeta; III група – с добавка на 0,2% чесън на прах; IV група – с добавка на 0,2% билкова комбинация (0,05% джинджифил, 0,05% розмарин, 0,05% мащерка и 0,05% бял равнец); Група V – с добавка на 0,2% Immunoßeta + 0,2% чесън на прах; Група VI – с добавка на 0,2% Immunoßeta + 0,2% билков микс;

VII група – допълнена с 0,2% Immunoßeta + 0,2% чесън на прах + 0,2% билков микс. В края на експеримента пилетата достигнаха жива маса от 2552±54 g (I група) до 2689±55 g (IV група) като не се установиха доказани разлики между различните групи (P>0,05). Конверсията на фураж варираше от 1,64 (IV група) до 1,74 (I група). pH на месото, водозадържащата способност, водопоглъщащата способност и нежността не се повлияха от вида на хранителната добавка. Всички използвани добавки не показаха неблагоприятен ефект върху здравословното състояние, като не беше установена смъртност в експерименталните групи. Получените резултати показват ясна тенденция към положителен ефект на използваните фуражни добавки и тяхното комбиниране основно върху угоителните характеристики на бройлерите, видно от по-високите стойности на двата индекса на ефективност.

Ключови думи: бройлери, билкови добавки, чесън на прах, имуномодулатори, кланични характеристики

INTRODUCTION

The irrational use of antibiotics as growth promoters or for disease prevention in animal farming resulted in a wide prevalence of antimicrobial resistance among microorganisms (Apata, 2009; Furtula et al., 2010; Chang et al., 2015; Mehdi et al., 2018). The ban on the use of antibiotics as growth promoter (AGPs) has (EC No 1831/2003), replaced the AGPs with plant extracts and phytobiotics (Prabakar et al., 2016; Gheisar and Kim, 2018), probiotics, prebiotics and synbiotics (Markowiak and Śliżewska, 2018), as well as immunomodulatory agents (Farag and Alagawany, 2019).

Herbs and herbal extracts have a beneficial effect on gut microbiota inhibiting the development of several pathogens and conditionally pathogenic bacteria – Clostridia, coliform bacteria, Salmonella etc. (Dorman and Deans, 2000; Griggs and Jacob, 2005; Bölükbaşi and Erhan, 2007; Windisch et al., 2008; Frankič et al., 2009; Khan et al., 2012; Gerzilov et al., 2015).

Different hebs like ginger (Zhao et al., 2011; Mohamed et al., 2012; Karangiya et al., 2016), rosemary (Yesilbaq et al., 2011; Alagawany and El-Hack, 2015) thyme (Abdulkarimi et al., 2011; Saki et al., 2014; Arpášová et al., 2018), yarrow (Lewis, 2005; Norouzi et al., 2015), and garlic (Fadlalla et al., 2010; Raeesi et al., 2010; Elagib et al., 2013; Karangiya et al., 2016; Lukanov et al., 2018) are known to have antioxidant, immuno-stimulatory, phytobiotic and/or probiotic activities, improved the health status, production traits and welfare in poultry. Gerzilov et al. (2015) reported that the addition combination of herbal drugs to compound feed of dual-purpose chickens influenced positively their health and growth. This was most probably due to the positive effect of herbal products on microbial colonization of avian gut (Bedford, 2000), stimulation of the digestive system by improvement of digestive glands' function (Langhout, 2000; Gill, 2001) and increase in the bird's appetite (Cabuk et al., 2003), resulting in better feed conversion or increased feed intake and better growth performance.

The utilization of various immunomodulatory agents, e.g., β-glucans and mannan oligosaccharides (MOS) was found to improve birds' performance and health (Chen et al., 2016). Investigations, both *in vitro* and *in vivo*, in animals and humans showed that β-glucans had a probiotic activity (Mitsou et al., 2010; Lam and Cheung, 2013) and immunostimulatory properties, most commonly influencing leukocyte activity (Chae et al., 2006; Volman et al., 2008). Mannan oligosaccharides also exerted probiotic and immuno-stimulatory systemic effects (Spring et al., 2000; Patterson and Burkholder, 2003). Various research reports have documented the use of products on the basis of β-glucans (Guo et al., 2003) and mannan oligosaccharides (Bozkurt et al., 2009).

The aim of the present study was to evaluate the effect of a mix of herbal supplements, garlic powder, and immunomodulatory product Immunoßeta either alone or in combination in broiler's diet on their growth performance, slaughter traits and meat quality.

MATERIAL AND METHODS

Experimental design

The experiment was conducted at Agroecological center, Agricultural University – Plovdiv. One-day-old Ross 308 male broiler chickens (n=210), purchased from a licensed hatchery, were allotted into 7 groups – one control and six experimental. Each group consisted of 3 replicates (n=10), with uniform body weight. Birds were floor reared in 6 m^2 boxes on deep litter. The temperature during the first 3 days of the experiment was 35-32 °C and reduced by 0.4 °C every day to 20-22 °C. Light day duration was on 23 h of light and 1 h of dark. Humidity in the first week was 70-75%, and after the second – 55-65%. The experiment lasted until 42 days of age with strictly observing all requirements for humane treatment of experimental animals and fattening of broiler chickens (Ordinance 20/2012).

Depending on the dietary treatment type, groups were formed as followed:

- Group I –control;
- Group II – supplemented with 0.2% Immunoßeta ;
- Group III –supplemented with 0.2% garlic powder;
- Group IV – supplemented with 0.2% herbal mix (0.05% ginger, 0.05% rosemary, 0.05% thyme and 0.05% yarrow);
- Group V – supplemented with 0.2% Immunoßeta + 0.2% garlic powder;
- Group VI – supplemented with 0.2% Immunoßeta + 0.2% herbal mix;
- Group VII – supplemented with 0.2% Immunoßeta + 0.2% garlic powder + 0.2% herbal mix.

Immunoßeta is a product of Chemifarma S.p.A. – Italy. It is a probiotic and an immunostimulant, derived from selected yeast strains (*Saccharomyces cerevisiae*), contains three major components as active ingredients: 30% β-glucans, 25% mannan oligosaccharides, and 5% nucleotides.

Feeding of broilers was in following stages: starter (from 1st to 7th day), grower (from 8th to 21st day), finisher I (from 22nd to 35th day) and finisher II (from 36th to 42nd day). Nutritional value and composition of compound feed (Table 1) for the respective age differed only with regard to the dietary supplement.

Growth performance

During the experiment, the following traits were monitored:

- Live weight, g – by individual weighing with precision of 0.1 g on days 1, 7, 14, 28, 35 and 42 of age
- Weight gain, g – body weight gain / days number of growth period
- Feed intake, kg/bird – monitored on a weekly basis and for the entire study period
- Feed conversion rate (FCR) – cumulative feed intake (kg) / total weight gain (kg)
- Indices of production efficiency were calculated (Marcu et al., 2013) – European Production Efficiency Factor (EPEF) and European Broiler Index (EBI):

$$EPEF = \frac{viability\ (\%)\ \text{x}\ body\ weight\ (kg)}{age\ (days)\ \text{x}\ FCR}\ \text{x}\ 100$$

$$EBI = \frac{viability\ (\%)\ \text{x}\ average\ daily\ gain\ (g)}{FCR\ \text{x}\ 10}$$

Slaughter analysis

At 42nd days of age, after 12 hours pre-slaughter fasting, 3 birds from each group with body weight closest to the group average value were slaughtered in strict compliance to requirements for the welfare of animals for slaughter at production establishments (Ordinance 20/2012) and requirements for the welfare of animals for slaughter at production establishments. Analysis of carcass weight, slaughter yield, some of the main chicken cuts (breast fillet, breast tenderloin, tight, drumstick, drumette, and wingette with wing tip), and edible offal (heart, liver, and gizzard) was made after 24-hour cold storage at 3 °C. The weight of different cuts and edible offal was determined with precision of 0.01 g with electronic balance OHAUS (Japan).

Table 1. Composition of basal feeds (in %)

	Ingredient	Feeding phase			
		Starter (1-7 day)	Grower (8-21 day)	Finisher I (22-35 day)	Finisher II (36-42 day)
1.	Corn	29.24	28.61	27.31	25.53
2.	Wheat	30.00	35.00	40.00	40.00
3.	Soybean meal, 44%	26.00	19.50	15.00	18.00
4.	Sunflower meal, 34%	4.00	6.00	8.00	8.00
5.	Fish meal, 72%	5.00	4.00	2.00	-
6.	Sunflower oil	2.00	3.60	4.40	5.00
7.	L-Lysine	0.20	0.22	0.22	0.24
8.	DL-Methionine	0.28	0.23	0.16	0.18
9.	L-Threonine	0.06	0.06	0.06	0.07
10.	NaCl	0.15	0.11	0.15	0.18
11.	Sodium bicarbonate	0.10	0.15	0.15	0.16
12.	Calcium carbonate	1.60	1.35	1.40	1.35
13.	Dicalcium phosphate	1.05	0.85	0.83	0.97
14.	VMP *	0.20	0.20	0.20	0.20
15.	Synergen SSF **	0.02	0.02	0.02	0.02
16.	Mycosorb ***	0.10	0.10	0.10	0.10
	Calculated nutrient content				
Metabolizable energy, MJ/kg		12.60	13.30	13.50	13.50
Crude Protein, %		23.20	20.90	18.60	18.40
Crude fiber, %		3.70	3.70	3.80	3.90
Digestible Lisine, %		1.41	1.23	1.04	1.02
Digestible Methionine, %		0.70	0.61	0.48	0.49
Digestible Threonine, %		0.91	0.81	0.71	0.71
Calcium, %		1.10	0.95	0.94	0.94
Available phosphorus, %		0.68	0.45	0.42	0.42

* Vitamin-mineral premix (VMP): Vitamin A – 5000000 IU/kg; Vitamin D3 – 1500000 IU/kg; Cho-line chloride – 150000 mg/kg; Vitamin E – 15000 mg/kg; Niacin amide – 14000 mg/kg; Calcium D- pantothenate – 4500 mg/kg; Vitamin B2 (riboflavin) – 2500 mg/kg; Vitamin B6 – 1500 mg/kg; Vitamin K3 – 1500 mg/kg; Vitamin B1– 1000 mg/kg; Folic Acid – 1000 mg/kg; Vitamin B12 – 13 mg/kg; Bio-tin/D – 1 mg/kg; Manganese oxide – 45000 mg/kg; Zinc oxide – 25000 mg/kg; Ferrous sulphate (monohydrate) – 13000 mg/kg; Copper sulfate (pentahydrate) – 8000 mg/kg; Calcium iodate (anhy-drous) – 500 mg/kg; Sodium selenite – 240 mg/kg

** Synergen SSF (Alltech Inc.) - a product of the solid-state fermentation of Aspergillus niger

***Mycosorb (Alltech Inc.) - mycotoxin binder

Meat quality analysis

By the 24th h post mortem, pH, water holding capacity (WHC), water absorption capacity (WAC), cooking loss (CL), and tenderness (T) were determined on samples from *Musculus pectoralis superficialis (MPS)*, *musculus pectoralis profundus (MPP)* and *Musculus femorotibialis medialis (MFM)*.

Meat pH was measured with portable pH-meter „TESTO 205", with glass electrode, previously calibrated in standard solutions (pH 4.0 and pH 7.0). WHC (%) was measured using the method described by Grau and Hamm (1953) and modified by Zahariev and Pinkas (1979), using samples of approximately 5 g raw meat (initial weight) by the formula:

$$WHC = \frac{A-B}{A}.100$$

where: A – weight of muscle sample before pressing, g; B – weight of muscle samples after pressing, g.

WAC (%) of MPS, MPP, and MFM was determined with physiological saline by the method described by Genchev et al. (2010) and the formula:

$$WAC = \frac{b-a}{a}.100$$

where: a – weight of meat sample before the analysis, g; b – weight of meat sample after 24-hour stay in physiological saline, g.

CL was determined for the three studied muscles on the basis of loss of water from samples after stay at 75-80 °C for 15 min (Petracci and Baeza, 2011).

T (°P) of MPS and MPS was determined with penetrometer RA-1, equipped with a penetration tip. Tenderness values were expressed as degrees of penetration (°P), with 1 °P =0.1 mm.

Statistical analysis

For each trait and each group was applied ANOVA and were calculated mean (m) and standard error of the mean (SEM). A comparative assessment of the groups on each trait was made by Tukey's test at a level of statistical significance α=0.05. Mathematical data processing was performed using the statistical software product IBM SPSS 23 (Aldrich, Conningham, 2016).

Ethical rules

The experimental procedures were approved by Animal Ethic Commission at the Agricultural University–Plovdiv. The slaughtering was made in strict compliance to requirements for the welfare of animals for slaughter at production establishments (Ordinance 20/2012).

RESULTS AND DISCUSSION

In the end of the starter period (7 days of age) the body weight of broilers varied from 183±5 g in Group IV to 194±3 g in Group VII (11 g difference) without statistically significant between-group differences. At 14th days of age, birds from Group III supplemented with 0.2% garlic powder had the highest body weight – 492±11 g, while those given 0.2% Immunoßeta – the lowest (456±10 g). The tendency towards highest average body weight in Group III was preserved up to 35th days of age. At the end of the fattening period (42nd day) the birds fed a diet with herbal mix (Group IV) and with garlic powder (Group III) had the highest weight, whereas the lowest weight was determined in the control group and Group VI supplemented with 0.2% Immunoßeta + 0.2% herbal mix, but the differences were insignificant (*P*>0.05; Table 2).

For the fattening period, FCR of groups was as followed: Group I - 1.74 kg/kg, Group II – 1.67 kg/kg, Group III – 1.72 kg/kg, Group IV – 1.64 kg/kg, Group V – 1.69 kg/kg, Group VI – 1.67 kg/kg and Group VII - 1.70 kg/kg. These values were very close to those reported by the manufacturer of the hybrid – 1.67 kg/kg (Aviagen, 2019).

The results for the beneficial effect of garlic powder added to compound poultry feed was confirmed previously by Onibi et al. (2009), Elagib et al. (2013) and Oleforuh-Okoleh et al. (2014). The positive effect of ginger in the feed on some growth traits in broiler chickens was reported by numerous researchers (Al-Kassie, 2008; Mohamed et al., 2012; Oleforuh-Okoleh et al., 2014; Karangiya et al., 2016). Yesilbag et al. (2011) indicated a more pronounced effect on growth characteristics in broiler supplemented with rosemary oil with the feed, rather than with rosemary plant itself. Thyme and its extracts in the rations of broiler chickens had a positive influence on their growth performance (Al-Kassie, 2009; Al-Mashhadani et al., 2011). Yarrow supplementation influenced positively the growth performance of broiler chickens through stimulation of bile production (Lewis, 2005). Nevertheless, there are also studies that did not confirm any positive effect of above mentioned plants or their mixes on growth traits of broilers (Sarica et al., 2005; Fadlalla et al., 2010; Amouzmehr et al., 2012). The effect of immunomodulator Immunoßeta on broiler chickens growth and layer egg production could be attributed to its positive effect on intestinal mucosa (Bozakova et al., 2016; Gerzilov et al., 2019). This is mostly due to beta-glucans – polysaccharides with prebiotic activity (Mitsou et al., 2010; Lam and Cheung, 2013) and MOS, which stimulate body immune system (Spring et al., 2000; Patterson and Burkholder, 2003; Baurhoo et al., 2007; Corrigan et al., 2012).

During the entire fattening period, no case of death was found out neither in control nor in experimental groups i.e. livability was 100% in all groups. This could be explained with optimum housing conditions and the health impact of tested dietary supplements.

Figure 1 presents data from calculated indices of production efficiency – an economic trait of fattening performance of broilers. The values of both economic parameters are very good in all groups, which are explained by the lack of mortality, the very good weight gain and efficient feed conversion – traits used for their calculation. Yet, Group IV supplemented with herbal mix, is clearly outlined with the highest EPEF and EBI values: 391 and 384 respectively.

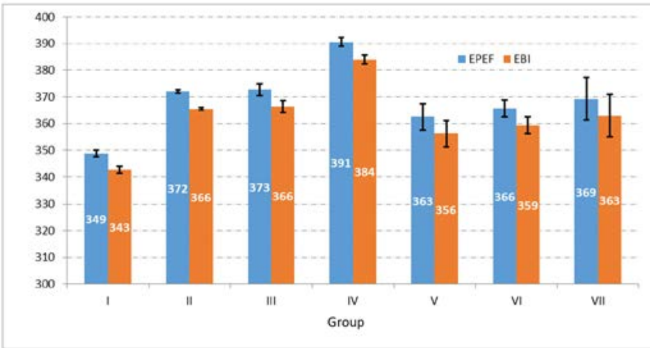

Figure 1. Production efficiency indices (EPEF and EBI)

The lowest EPEF (349) and EBI (343) were detected in controls (Group I). The higher values of economic indices in groups that received Immunoßeta and herbal additives alone or in combination showed their beneficial effect on growth performance, feed conversion and healthy of broiler chickens compared to non-supplemented birds. These results are comparable to previously reported studies (Arczewska-Wlosek and Swiatkiewicz, 2012; Puvača et al., 2015; Pistová et al., 2017).

The slaughter analysis of birds is presented in Table 3. The small number of birds submitted to slaughter analysis did not allow making categorical conclusions about the effect of a given dietary supplement. The values of slaughter traits rather give a general impression about the usefulness of their application in the broiler rations.

Table 2. Average live body weight, g (n=30 in each group)

Age in days	Group							SEM	P-Value
	I m±SEM	II m±SEM	III m±SEM	IV m±SEM	V m±SEM	VI m±SEM	VII m±SEM		
1	44.9±0.7	44.9±0.7	44.9±0.7	44.9±0.7	44.9±0.7	44.8±0.7	44.8±0.7	0.27	1.00
7	191±4	189±4	192±4	183±5	188±5	190±6	194±3	1.74	0.57
14	468±13	456±10	492±11	456±14	466±13	467±14	472±10	9.43	0.36
21	894±20	882±23	943±20	855±30	871±31	853±23	894±23	4.64	0.14
28	1479±33	1476±40	1561±31	1461±50	1473±45	1447±38	1508±33	14.57	0.39
35	2048±38	2043±45	2140±38	2059±50	2038±60	1991±42	2033±39	17.18	0.33
42	2552±53	2602±59	2683±47	2689±54	2569±63	2557±53	2631±43	20.28	0.55

The average carcass weight at 42nd days of age varied from 1730±18.0 g in Group II to 1850±0 g in Group IV. Statistically significant differences were found between Group II vs. all other groups ($P<0.05$) without Group V.

Carcass structure was similar in all seven groups, without visible differences. Broilers from Groups I and V had the highest relative proportion of breast muscle (MPS and MPP): 34.62% and 33.60%, respectively, whereas that of Group II was the lowest - 31.21% ($P<0.05$). Brest fillet (MPS) yield varied from 25.43% in Group II to 28.41% in Group VI ($P<0.05$), and for breast tenderloin (MPS) - from 5.78% in Group II to 6.63% in Group III ($P<0.05$). The relative weight of leg (thigh and drumstick) ranged from 29.4% to 30.5%, in Group V and Group II respectively ($P<0.05$). Edible offal comprised 7.0% in Group I to 7.6% in Group III from body weight of broiler chickens. Similarly, other authors did not demonstrate considerable effect of dietary herbal extracts and mixes on carcass quality, the proportions of cuts and some internal organs in broilers (Halle et al., 2004; Hernandez et al., 2004; Çabuk et al., 2006; Omar et al., 2016).

Physicochemical characteristics of MPS, MPP and MFM including meat pH, WHC WAC, T, CL are presented in Table 4.

The pH_{24} of the three muscles on *post mortem* had the following average values for all groups – 5.37±0.02 for MPS, 5.43±0.02 for MPP, and 5.74±0.06 for MFT. The differences between groups were significant ($P<0.05$). At present, no categorical conclusions on the effect of tested dietary supplements on this trait could be made. Our results were comparable to those of Marinova and Popova (2011), who affirmed that the ultimate value of pH_{24} declined to 5.4-5.8. At this pH, the specific flavour and taste of meat are formed.

Water holding capacity (WHC) of meat is associated with its color and tenderness and is one of the most important functional signs of raw meat (Mir et al., 2017). There were no substantial differences among the different muscle groups ($P>0.05$). Breast muscles showed slightly higher values compared to femoral one: 24.24±1.17% for MPP, 24.05±1.15% for MPS and 22.14±1.11% for MFM.

Water-absorption capacity (WAC) of meat and meat products determines the visual acceptability, weight loss, and cook yield as well as sensory traits on consumption (Warner, 2017). Results allowed affirming that WAC was significantly higher in MFM (21.85±1.17%), compared to MPS (14.0±1.49%) and MPP (17.96±1.49%) ($P<0.05$). The differences between groups confirmed a tendency towards lower values of the trait for the three studied muscles in control group.

Meat tenderness (texture) is perhaps the most important trait for the consumer related to its satisfaction from consumption of poultry meat and meat products (Fletcher, 2002). Other traits are juiciness, flavour and color of meat, determining the final consumer evaluation of meat quality (Wood et al., 1995). T varied within a rather large range for MPS: from 193±13.84 oP in Group IV to 363±22.90 °P in Group V. Average values of tenderness for all groups were considerably lower than respective MPS values (262.0±3.87 oP and 399.57±0.04 °P). Insignificant differences in T values of MPP were identified in the different groups: from 398.20±1.80 °P to 400±0.00 °P. The analysis of the results allowed concluding that dietary supplements had not a consistent effect on the tenderness of MPP and MPS. Due to anatomical features of MFM and specific characteristics of measuring, tenderness of MFM was not tested.

Cooking is widely used in poultry meat processing (Barbantia and Pasquini, 2005). Meat quality traits as tenderness and juiciness are directly influenced by cooking (Küçüközet and Uslu, 2018). Cooking loss (CL, %) values are similar to those of WAC of the three muscles. The highest cooking loss was established for MFM (41.36±0.76%), followed by MPP (37.92±0.61%), and the lowest one was that of MPS (33.24±0.86%). These results did not allow the detection of a certain effect of dietary supplements on this trait.

DOI: /10.5513/JCEA01/23.3.3611

Table 3. Slaughter characteristics

Traits		Group							SEM	P - Value
		I m±SEM	II m±SEM	III m±SEM	IV m±SEM	V m±SEM	VI m±SEM	VII m±SEM		
Live weight	g %	2550±28.9 ^{b}	2541±38.9 ^{b}	2623±37.1 ^{ab}	2703±23.3 ^{a}	2542±31.8 ^{b}	2542±24.0 ^{b}	2643±28.5 ^{ab}	16.64	0.010
Carcass weight	g %	1832±26.0 ^{a}	1730±18.0 ^{b}	1840±22.6 ^{a}	1850±0.00 ^{a}	1765±16.1 ^{ab}	1848±15.9 ^{a}	1847±24.9 ^{a}	11.72	0.002
Slaughter yield	g %	72±0.2 ^{ab}	68±0.4 ^{c}	70±0.8 ^{abc}	68±0.6 ^{c}	69±0.5 ^{bc}	73±0.8 ^{a}	70±0.7 ^{abc}	0.40	0.001
Breast filet	g %	517±9.3 ^{a} 28.18	440±7.6 ^{b} 25.43	485±17.3 ^{ab} 26.36	490±7.6 ^{ab} 26.49	482±17.6 ^{ab} 27.31	525±7.6 ^{a} 28.41	497±12.0 ^{ab} 26.87	6.87	0.005
Breast tenderloin	g %	119±5.3 6.44	100±5.5 5.78	122±4.5 6.63	107±6.4 5.79	111±2.3 6.29	107±1.0 5.79	110±6.5 5.96	2.16	0.091
Tight	g %	317±8.7 17.3	299±6.7 17.3	308±22.1 16.7	317±5.0 17.1	288±3.5 16.3	301±8.3 16.3	309±6.4 16.8	3.94	0.441
Drumstick	g %	235±2.0 12.8	230±7.5 13.2	245±6.1 13.3	247±5.0 13.4	232±6.6 13.1	247±7.0 13.4	243±6.4 13.2	2.46	0.410
Drumette	g %	104±2.6 5.7	106±3.6 6.1	116±12.2 6.3	107±3.1 5.8	102±3.2 5.8	105±3.8 5.7	109±4.9 5.9	2.02	0.632
Wingette with wing tip	g %	89±3.5 4.7	92±5.1 5.3	91±2.4 5.0	94±1.4 5.1	90±3.1 5.1	94±0.6 5.1	98±2.0 5.3	1.11	0.385
Edible offals										
Neck	g %	84±2.3 3.3	83±3.7 3.3	91±0.8 3.5	88±2.8 3.3	82±16.4 3.2	95±5.5 3.7	93±3.0 3.5	2.40	0.812
Gizzard	g %	34±1.5 1.3	38±5.8 1.5	37±3.4 1.4	41±5.2 1.5	38±1.8 1.5	32±4.4 1.2	39±5.6 1.5	1.50	0.704
Liver	g %	49±1.3 ^{ab} 1.9	49±3.2 ^{ab} 1.9	61±4.9 ^{a} 2.2	54±5.3 ^{ab} 2.0	46±3.1 ^{ab} 1.8	42±1.51 ^{b} 1.6	46±2.3 ^{ab} 1.7	1.70	0.029
Heart	g %	12±1.2 0.5	10±0.4 0.4	14±2.0 0.5	13±0.8 0.5	12±0.8 0.5	12±0.6 0.5	12±0.6 0.5	0.40	0.253

Note: $^{a, b, c}$ – means with different letters in the row represent significant differences at $P < 0.05$

DOI: /10.5513/JCEA01/23.3.3611

Table 4. Physicochemical characteristics in the muscle samples at 24th hour

Muscle	Traits	Group							SEM	P - Value
		I m±SEM	II m±SEM	III m±SEM	IV m±SEM	V m±SEM	VI m±SEM	VII m±SEM		
M. pectoralis superficialis	pH_{24}	5.55±0.03 ^{a}	5.46±0.02 ^{b}	5.32±0.01 ^{c}	5.64±0.01 ^{a}	5.29±0.01 ^{c}	5.34±0.02 ^{c}	5.37±0.02 ^{c}	0.02	0
	WHC, %	23.88±2.11 ^{bc}	18.41±0.38 ^{cd}	26.03±0.62 ^{b}	15.90±0.83 ^{d}	32.81±1.78 ^{a}	25.52±0.92 ^{b}	25.82±1.20 ^{b}	1.21	0
	WAC, %	8.64±1.84 ^{bc}	24.67±1.20 ^{ab}	13.88±0.64 ^{b}	15.42±3.14 ^{b}	14.86±0.98 ^{bc}	11.06±2.18 ^{b}	9.50±0.85 ^{b}	1.25	0
	T, °P	221.00±24.54 ^{cd}	312.00±18.58 ^{ab}	255.20±9.17 ^{bcd}	193.00±13.84 ^{d}	363.00±22.90 ^{a}	202.40±17.83 ^{d}	287.60±18.18 ^{abc}	11.77	0
	CL, %	32.16±2.05 ^{abc}	36.08±0.60 ^{ab}	34.39±2.27 ^{ab}	36.36±1.12 ^{a}	30.84±1.81 ^{ab}	38.85±0.53 ^{a}	23.98±4.24 ^{b}	1.22	0.01
M. pectoralis profundus	pH_{24}	5.45±0.01 ^{c}	5.69±0.02 ^{b}	5.38±0.00 ^{ef}	5.84±0.01 ^{a}	5.37±0.01 ^{f}	5.53±0.01 ^{c}	5.43±0.02 ^{de}	0.03	0
	WHC, %	34.20±5.84 ^{a}	21.38±0.89 ^{b}	24.40±1.18 ^{ab}	21.28±0.72 ^{b}	29.22±1.76 ^{ab}	17.81±0.90 ^{b}	21.37±0.97 ^{b}	1.40	0.01
	WAC, %	12.47±0.73	26.96±12.15	12.53±0.78	17.62±2.27	25.68±7.75	17.37±0.89	13.07±1.21	2.17	0.36
	T, °P	398.20±1.80	400.00±0.00	400.00±0.00	398.60±1.40	400.00±0.00	400.00±0.00	400.00±0.00	0.32	0.55
	CL, %	35.80±0.34	38.97±1.00	36.30±1.62	34.28±0.29	41.69±3.40	34.48±0.63	43.93±6.19	1.17	0.17
M. femorotibialis medialis	pH_{24}	5.46±0.02 ^{c}	5.49±0.03 ^{cd}	5.56±0.02 ^{bc}	5.49±0.01 ^{c}	5.52±0.04^{c}	5.71±0.03 ^{ab}	5.74±0.06 ^{a}	0.02	0
	WHC, %	23.21±1.13 ^{abc}	25.81±2.48 ^{ab}	19.63±1.09 ^{bc}	22.50±2.05 ^{abc}	30.67±1.91 ^{a}	15.97±2.98 ^{c}	17.22±1.11 ^{bc}	1.22	0.001
	WAC, %	14.13±2.71 ^{c}	18.47±0.84 ^{bc}	31.50±1.49 ^{ab}	23.98±3.24 ^{ab}	21.90±1.19 ^{bc}	22.76±1.57 ^{abc}	20.22±0.66 ^{bc}	1.26	0.001
	CL, %	34.56±1.27	48.03±5.57	41.98±2.48	41.29±3.01	40.92±2.92	46.16±3.01	36.56±10.15	1.84	0.491

Note: $^{a, b, c, d, e, f}$ – means with different letters in the row represent significant differences at $P<0.05$

CONCLUSIONS

The results from the study allowed recommending the use of dietary supplements 0.2% Immunoßeta, 0.2% garlic powder, and 0.2 % herbal mix (0.05% ginger, 0.05% rosemary, 0.05% thyme, and 0.05% yarrow), either alone or in combination for improvement of fattening performance of broiler chickens and preservation of their vitality. The study confirmed a beneficial effect on the growth performance of broilers when in their rations were added a mix of tested supplements. Regarding the slaughter analysis and the quality of the meat, no significant differences were found depending on the additive used.

ACKNOWLEDGEMENT

The authors acknowledge the financial support of the University Science Fund at Agricultural University – Plovdiv, Grant № 07-15

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