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Effect of different levels of high-protein sunflower meal in compound feeds on broiler's carcass characteristics and meat quality

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Abstract

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The aim of the present study was to evaluate the effect of inclusion of various dietary levels of high-protein sunflower meal (HiSFM) in compound feed for broiler chickens on their carcass characteristics and meat quality. The experiment was conducted with four groups (one control; three experimental), each with 6 128 unsexed day-old Cobb 500 broiler chickens. In the diet of experimental groups, soybean meal (SBM) was replaced with three different levels of HiSFM and in the diet of 3rd experimental group, it replaced entirely the SBM. The chickens were slaughtered at 42 days of age. As carcass characteristics were concerned, no significant differences among the four groups were established, except for "grill" weight which was the highest in control group ($p \leq 0.05$). The substitution of SBM with HiSFM had a negative effect on meat protein content, which was higher in control group than in experimental ones ($p \leq 0.001$). Among meat technological properties, value of pH was lower while water holding capacity (WHC) – better in control group. The consumer panel gave the highest organoleptic score to the second experimental group, whose diet was characterized with a medium level of SBM replacement with HiSFM.

Keywords: sunflower meal; broiler; carcass characteristics; meat quality
Abbreviations: HiSFM – high-protein sunflower meal; SFM – sunflower meal SBM – soybean meal**;** MPM – *M. pectoralis major*; WHC – water holding capacity

Introduction

Soybean meal (SBM) is the main protein source in compound feed for broiler chickens, however its high price urged seeking less expensive alternative feed compounds in order to reduce production costs and improve feed efficiency of broiler chickens. Sunflower meal (SFM) is an alternative to SBM as it is cheaper protein source, which is relatively easily available and could be used in broiler chicken nutrition (Casartelli et al., 2006). On the other hand, the use of SFM would inevitably influence the slaughter traits of broilers and meat quality.

The inclusion of standard SFM in the diet of broiler chickens inhibited their growth due to the high crude fiber content and low dietary level of metabolisable energy (Senkoylu & Dale, 2006; Rezaei & Hafezian, 2007). Also, to maintain the necessary energy density of poultry feeds containing SFM, it is additionally supplemented with fat (Mikulec et al., 2004). This may influence the slaughter traits of birds and meat chemical composition, especially the fatty acid profile (Sheehy et al., 1994; Mossab et al., 2002). The addition of SFM was also reported to have an adverse effect on protein and crude ash percentages of produced chicken and turkey meat (Aregheire, 1998, Jankowski et al., 2011). Contrary to this, Slavica et al. (2006) and Laudadio et al. (2013) found no difference in the chemical composition of poultry meat.

As slaughter traits of broiler chickens were concerned, a number of authors did not report substantial differences between groups fed SBM and different dietary levels of SFM (Malakian, 2010; Araújo et al., 2014; Horvatovic et al., 2015). Unlike them Rehman et al. (2002) and Khan et al. (2006) found out differences in some parameters – as dietary SFM level increased, hot carcass weight increased and dressing percent was improved. With respect to technological properties of meat (pH-value and WHC) Kalmendal et al. (2011) and Laudadio et al. (2013) observed no between-group differences with SFM and SBM. As meat organoleptic parameters were concerned, it was affirmed that the inclusion of SFM in the ration of broiler chickens and turkeys improved the main organoleptic parameters: taste and flavour, juiciness and consistency (Slavica, 2006; Jankowski et al., 2011).

On the basis of analysis of contradictory data, the present study aimed to evaluate the effect of dietary HiSFM on carcass characteristics and meat quality in fattening broiler chickens.

Material and Methods

The experiment was performed in the autumn and winter 2020 in the Experimental Teaching Base of the Faculty of agriculture, Trakia University – Stara Zagora (Bulgaria) with 128 unsexed day-old Cobb 500 chickens. The birds were with uniform body weight and distributed randomly in 4 groups (one control and three experimental) with 30 birds each, in 6 replications. The total duration of the trial was 42 days. The birds were reared in a specially equipped facility under controlled microclimate according to the requirements of the Cobb 500 hybrid (CobbCares, 2018), with constant access to feed and water. The birds from all groups (control, I, II and III experimental) were fed isoenergetic isoprotein compound feeds during the different age periods: starter, grower, finisher I and finisher II (Cobb Cares, 2018). The only difference was the amount of high-protein sunflower meal in the diets of experimental groups, which for experimental group III, replaced entirely the SBM. HiSFM was used as protein ingredients of compound feeds as granules. Compound feeds fed to the control group during all age periods, contained only SBM as only protein source. The experimental design of the study was presented in Table 1.

For evaluation of carcass characteristics, the following poultry cuts were used:

- Bratfertig, g – the cleaned carcass with the neck and by-products (edible offal);
- Grill, g – the cleaned carcass without the neck and by-products (edible offal);
- Breast, g – the breastbone with the superficial and deep pectoral muscles;
- Legs, g – the femur and the tibia (femoro-tibial zone) with muscles attached to them;
- By-products (Edible offal), g – heart, liver, gizzard and spleen.

Meat quality (proximate composition and technological properties) was determined on 24 h *post mortem*, analyzing *M. pectoralis major* (MPM) and thigh muscles. The samples were obtained immediately after slaughtering and carcass cutting and stored in vacuum-packed bags at 0-4°C.

The chemical composition of meat (water, protein, lipids and ash) was determined in line with Bulgarian State Standards (BDS) – BDS 5712:1974, BDS 8549:1992, BDS 9373:1980, BDS 9374:1982. Value of pH on meat was measured with pH meter "Testo 205" (Testo SE & Co. KgaA, Germany). WHC of meat was evaluated by the method of Grau and Hamm (1953). The color of meat was determined by the system CIE L*a*b*. For this purpose, a "Minolta CR-400" colorimetry by Konica Minolta (Osaka, Japan) was used, using an illumination D65 and a 2° observation angle. Cooking loss (%) was determined by roasting a 15 g meat sample at 150°C for 20 min.

For evaluation of organoleptic properties of meat, a consumer panel consisting of 21 people was used. Consumers evaluated the aroma, consistency, juiciness and taste of MPM by a 5-point scoring system with 5 points corresponding to "excellent", and 1 point – to "bad". For this, meat samples of MPM with average weight of 50 g were roasted at 150°C for 20 minutes and offered to consumers at random.

The obtained results were processed with specialised statistical software "Statistica 6" using the descriptive statistics and independent-samples t-test options.

Table 1. Experimental design of the study

Groups *	Periods of development			
	Starter ** 1-8 day	Grower** 9-18 day	Finisher I ** 19-28 day	Finisher II** 29-42 day
C – Control	0%	0%	0%	0%
I – Experimental	5%	8%	10%	10%
II – Experimental	15%	18%	25%	25%
III – Experimental	34.25%	27.27%	27.20%	26.00%

* n = 32 for each group, ** HiSFM participation (%)

Table 2. Carcass characteristics and meat cuts of broilers

Carcass characteristics	Groups*				Significance
	Control (a)	I – Exp. (b)	II – Exp. (c)	III – Exp. (d)	
	$\bar{x} \pm S\bar{x}$	$\bar{x} \pm S\bar{x}$	$\bar{x} \pm S\bar{x}$	$\bar{x} \pm S\bar{x}$	
Bratfertig, g	2093.33±68.96	2085.17±148.21	2058.00±92.39	2023.33±51.66	NS
Grill, g	1980.12±74.95	1966.00±148.79	1942.33±95.20	1894.83±54.64	a:d *
Breast, g	560.00±44.86	571.00±39.24	578.00±13.67	546.33±30.05	NS
Legs, g	504.50±26.73	509.17±25.82	507.50±15.24	472.67±24.01	NS
By-products, g	113.22±10.74	119.17±8.40	115.67±10.93	128.50±10.01	a:d *

*n = 6 for every group; * – p ≤ 0.05, NS – Not Significant

Results and Discussion

Carcass characteristics, presented in Table 2, showed an insignificant trend towards reduction of "bratfertig" and "grill" weights parallelly to increase of dietary level of HiSFM in broilers' ration. For the grill cut, the complete replacement of SBM with HiSFM resulted in statistically significant reduction ($p \leq 0.05$). The differences in the weight of slaughter carcasses could be due to differences in amino acid profile or the biological value of the different protein meals (SFM and SBM) (Rehman et al., 2002).

Statistically significant between-group differences were not present for breast and leg cuts. The lowest weight of these two cuts was observed again in experimental group III. Unlike breast and legs, by-products showed the opposite trend – the increase in the dietary level of HiSFM led to proportional increase in their weight, which, in experimental group III, exceeded statistically significantly that of controls ($p \leq 0.05$).

Data for slaughter traits (except for by-products) of studied broiler chickens agreed with those reported by Araújo et al. (2014) and Horvatovic et al. (2015), affirming lack of consistent differences between experimental (SFM) and control (SBM) groups. Dissimilar to the results of this trial, Salari et al. (2009) found no substantial differences in the weight of edible offal.

The inclusion of HiSFM in the diet of broiler chickens influenced the chemical composition of produced meat (Table 3.) This was most pronounced for breast water content and protein content. Both parameters decreased considerably as the dietary proportion of HiSFM increased, with greatest changes in the second experimental group ($p \leq 0.001$).

The ash content of MPM was higher in all three experimental groups vs controls, with statistically significant differences for experimental groups I ($p \leq 0.05$) and II ($p \leq 0.001$). As to the fat content of MPM, between-group differences were inconsistent.

The water content of thigh muscles did not differ considerably among the groups. The observed trend towards lower protein content of thigh meat was preserved, with substantial difference between experimental group I and the control group ($p \leq 0.05$). Fat content in thigh meat from birds from these two groups was also significantly different ($p \leq 0.001$). The crude ash content of thigh muscles tended to change similarly to that of MPM.

Table 3. Chemical composition of meat from tested broiler chickens at the 24th h *post mortem*, %

Chemical composition	Groups*				Significance
	Control (a)	I – Exp. (b)	II – Exp. (c)	III – Exp. (d)	
	$\bar{x} \pm S\bar{x}$	$\bar{x} \pm S\bar{x}$	$\bar{x} \pm S\bar{x}$	$\bar{x} \pm S\bar{x}$	
M. pectoralis major					
Water, %	73.52±0.49	72.82±0.88	72.56±0.67	72.03±1.02	a:b* ; a:c*** ; a:d***
Protein, %	24.01±0.24	23.17±0.49	22.93±0.38	23.53±0.79	a:b***; a:c***; a:d*
Fat, %	1.31±0.19	1.31±0.13	1.40±0.16	1.21±0.10	NS
Ash, %	1.38±0.12	1.51±0.15	1.64±0.13	1.45±0.99	a:b*; a:c***
Thigh muscles					
Water, %	74.56±0.85	75.05±1.12	74.97±0.96	74.21±0.84	NS
Protein, %	21.00±0.32	20.32±0.48	20.63±0.42	20.83±0.46	a:b**
Fat, %	3.71±0.31	2.72±0.25	3.44±0.27	3.95±0.21	a:b***
Ash, %	1.09±0.11	1.21±0.22	1.20±0.10	1.14±0.04	a:b**; a:c**

*n = 12 for every group; *– p ≤ 0.05, ** – p ≤ 0.01,*** – p ≤ 0.001, NS – Not Significant

To conclude, in our research the replacement of SBM with HiSFM in the rations of broiler chickens had a negative impact on meat protein, water and crude ash percentages. A similar negative effect on meat protein and water content was found out by Aregheire (1998) when 30% of dietary SBM was replaced with SFM. Comparably, Jankowski et al. (2011) also found out an insignificant adverse effect on turkey meat protein and crude ash. Contrary to them, Laudadio et al. (2013) did not affirm any difference in the meat chemical composition in turkeys fed with two kinds of meal – SFM and SBM. In the same experience, no difference in the chemical composition of broiler chicken meat was also reported by Slavica et al. (2006).

Feeding broiler chickens compound feeds containing HiSFM had a significant effect on the technological properties of meat (Table 4).

The analysis of data demonstrated that except for experimental group II, there were no relevant differences in meat pH-value of meat between the other groups in MPM and thigh muscles. In group II, meat pH was the highest and statistically significant vs control chickens: with average value of 5.57 for MPM and 6.00 for thigh muscles.

The WHC of meat tended to be the best in control chickens as compared to all three experimental groups: 21.7% for MPM and 15.18% for thigh meat. Cooking loss percentage as a technological property of meat showed more considerable differences in MPM. Unlike the WHC, cooking loss of MPM in control chickens was statistically significantly greater than in all experimental groups ($p \leq 0.001$), while the lowest loss was noted in the second experimental group. For thigh muscles, differences in cooking loss values among the groups were insignificant.

The investigations of Slavica et al. (2006) did not demonstrate significant differences in abovementioned meat technological properties replacing SBM with SFM. Similar studies with turkey meat, (Jankowski et al. 2011; Laudadio et al. 2013) neither found relevant differences in meat pH, WCH nor colour when SBM in the rations of turkeys was replaced with SFM.

The colour characteristics of MPM were also influenced by dietary replacement of SBM with HiSFM. For them L* values were the lowest in experimental group II, with statistically significant difference vs control group ($p \leq 0.05$). Anadon (2002) found out these low L* values were associated with the measured highest meat pH. The a* colour coordinate did not differ significantly among the groups. However, the b* coordinate value (yellow-blue spectrum) tended to increase parallelly to the dietary proportion of HiSFM in the ration of birds, with statistically significant differences between the control group and experimental groups II and III.

Colour characteristics (L*, a* and b*) of thigh muscles did not differ substantially among the group. There was a trend towards increase in a* and b* values parallel to the dietary level of HiSFM, which made the colour of thigh muscles more saturated. This was in line with data reported by Slavica et al. (2006), affirming that the supplementation

Table 4. Technological properties of meat from broiler chickens at the 24th h *post mortem*

Technological properties	Groups*				Significance
	Control (a)	I – Exp. (b)	II – Exp. (c)	III – Exp. (d)	
	$\bar{x} \pm S\bar{x}$	$\bar{x} \pm S\bar{x}$	$\bar{x} \pm S\bar{x}$	$\bar{x} \pm S\bar{x}$	
M. pectoralis major					
pH	5.48±0.08	5.49±0.05	5.57±0.05	5.53±0.09	a:c **
WHC, %	21.71±2.63	24.89±3.39	21.94±3.73	22.85±3.58	a:b *
Cooking loss, %	37.38±4.10	32.05±2.35	27.27±3.88	30.22±4.56	a:b ***; a:c *** a:d ***
L*	62.59±2.31	61.77±2.84	59.18±3.93	63.10±4.19	a:c *
a*	1.65±1.65	0.70±0.48	1.17±1,11	1.24±1.22	NS
b*	9.63±1.78	8.00±2.25	12.37±2.59	12.72±1.63	a:c **; a:d ***
Thigh muscles					
pH	5.81±0.12	5.76±0.12	6.00±0.24	5.82±0.16	a:c *
WHC, %	15.18±2.29	17.02±2.29	17.99±4.64	19.84±4.93	a:d **
Cooking loss, %	30.28±3.42	30.83±3.42	29.55±3.14	33.49±4.02	NS
L*	54.51±3.33	54.00±3.33	53.78±3.78	56.61±3.99	NS
a*	11.81±2.59	14.13±2.59	12.39±3.16	12.63±4.48	NS
b*	11.92±1.62	11.34±1.62	13.09±1.67	13.06±1.16	NS

*n = 12 for every group; * – $p \leq 0.05$, ** – $p \leq 0.01$,*** – $p \leq 0.001$, NS – Not Significant

Table 5. Organoleptic evaluation (sensory analysis) of meat from broiler chickens at the 24th h *post mortem*

Organoleptic properties	Groups				Significance
	Control (a)	I – Exp. (b)	II – Exp. (c)	III – Exp. (d)	
	$\bar{x} \pm S\bar{x}$	$\bar{x} \pm S\bar{x}$	$\bar{x} \pm S\bar{x}$	$\bar{x} \pm S\bar{x}$	
Aroma	3.90±0.94	3.95±1.28	3.95±1.07	3.95±0.86	NS
Consistency	4.14±0.57	4.00±0.89	4.52±0.51	3.85±0.85	a:c *
Juiciness	3.66±0.66	3.57±0.98	4.47±0.68	3.76±0.99	a:c ***
Taste	3.80±1.12	4.00±1.05	4.33±0.80	3.86±1.01	a:c *

1 – "bad" to 5 – "excellent"; * – $p \leq 0.05$, *** – $p \leq 0.001$, NS – Not Significant

of diets with SFM improved the pigmentation of meat produced from broiler chickens.

To sum up, the addition of HiSFM to the rations of broiler chickens had a more pronounced impact on technological properties of MPM than on thigh muscles. A particular effect was observed on WHC, cooking loss percentage and meat colour characteristics.

Table 5 presents the results from organoleptic evaluation of the meat of broiler chickens on the 24th h post mortem by a panel of 21 consumers.

The data showed no significant differences in meat aroma between groups. For the other 3 evaluated parameters, the meat of birds from experimental group II received the highest scores, statistically significantly different from controls. It could be also noted that except for meat consistency, the scores of meat from control chickens was the lowest among all groups yet significant differences were not recorder. This allowed assuming that the addition of HiSFM to the compound feed of broiler chickens improved partly the organoleptic properties of meat, with best dietary HiSFM level for the second experimental group.

These results were comparable to previously reported data. Slavica (2006) also confirmed that the supplementation with SFM improved the four tested organoleptic properties. Similar results were reported by Jankowski et al. (2011) for turkey breast meat – namely, improved aroma, juiciness and taste of meat as dietary level of SFM increased.

Conclusion

In conclusion, the data from our research show that the partial replacement of SBM with HiSFM had no statistically significant effect on carcass characteristics of broiler chickens. Only the complete replacement of SBM meal with HiSFM had an adverse impact on grill weight. With regard to the chemical composition of breast meat, protein and water content were statistically significantly lower in all experimental groups. On the other hand, the complete substitution of SBM with HiSFM improved substantially cooking loss percentage of MPM, yet value of pH was higher and WHC – weaker. A beneficial effect of dietary HiSFM was noted for the three main organoleptic parameters of meat: aroma, juiciness and taste; the second experimental group received the highest scores by consumers.

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