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Effects of partial substitution of soybean meal with high protein sunflower meal in broiler diets

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Abstract

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A total of 210 one day-old male Ross-308 broiler chicks allotted in 7 dietary treatment groups of 30 birds each, balanced for body weight, were reared to 49 days of age and fed with diets consisting different HiSFM (CP–45.4%) and SBM (CP–46.0%) levels. During the starter period (1-10 d) diets contained HiSFM from 5 to 15% and SBM from 20 to 29.9%; in the grower period (11-24 d) diets contained HiSFM from 10 to 25% and SBM from 5.5 to 20% and finally in the finishing (25-49 d) period – HiSFM was from 15 to 26.5% and SBM was from 0 to 11.3%.

The results showed that at 49 days of age, broilers attained a body weight of 3010±91.9 g (group 5) and 3180±112 g (group 6), with nonsignificant differences among groups (P>0.05). The inclusion of higher dietary HiSFM levels in rations of broiler chickens balanced for L-lysine did not pose risk for the growth performance of birds. The inclusion of HiSFM in broiler diets could provide about or more than half of necessary crude protein during the grower (52.79%) and finisher period (53.55 – 61.70%). Recommended dietary HiSFM level for the starter period is up to 10%, for the grower period – up to 20% and for the finisher period – up to 23%. The replacement of 10% SBM with an equal amount of HiSFM reduces the costs of diets by 3.74% to 4.61% depending on the feeding period.

Keywords: broiler; growth performance; high protein sunflower meal; soybean meal

Introduction

Soybean meal (SBM) and sunflower meal (SFM) are both basic protein sources in poultry nutrition. Due to ideal amino acids profile and digestibility, SBM is considered an excellent protein provider (Mushtaq et al., 2006; Shi et al., 2012; Laudadio et al., 2014; Ditta & King, 2017). It is the most widely used protein source in the formulation of poultry diets, but it is expensive, while SFM is alternative source of protein that is cheaper in formulating poultry rations (Laudadio et al., 2013). SFM has the potential to be a major feed ingredient for poultry in many countries not suitable for extensive soybean cultivation (Senkoylu & Dale, 1999). Compared with SBM, the limitations of using SFM are lower lysine and methionine contents and significant higher fiber content. These limitations can be overcome by supplementing lysine and methionine in SFM-based diets. Availability of amino acids (AA) in SFM is similar to that of AA in SBM and higher than that in rapeseed, cottonseed and other meals. Moreover, SFM generally has fewer antinutritional factors compared with other oilseed meals (Ravindran & Blair, 1992; Waititu et al., 2018). Advanced technological achievements have improved the dehulling process to allow further processing of dehulled SFM to produce a HiSFM whose content may reach 42-48% crude protein (CP) and 8-14% crude fibre (Lević et al., 2005). According to same authors decellulosed sunflower meal containing 44% or even more protein and less than 15% hulls can be more widely used in poultry feeding. Some studies showed that sunflower meal can successfully replace soybean meal (from

50% to 100%) in broiler diets, provided that the diets are supplemented with adequate amounts of lysine and energy (Senkoylu & Dale, 1999; 2006).

The aim of the study was to investigate the effect of gradually increasing levels of HiSFM with simultaneous decreasing levels of SBM in diets for broiler chickens according to their age.

Material and Methods

Birds and housing

The experiment was carried out in the Poultry division at Agricultural University – Plovdiv with 210 Ross-308 male one-day-old chicks allotted in 7 groups of 30 birds (dietary treatments) balanced for body weight. The growth performance and feed consumption were performed according to the group-control principle and lasted up to 49 days of age. The birds from each group were reared in equal condition – into floor pens (floor space 3.50/2.50 m; 0.292 m^2 was allotted for a bird) with wheat straw as bedding material on a concrete floor, with thermostatically controlled heating. Each pen was equipped with two manual drinkers (10 L capacity) and two suspended feeders (25 kg capacity).

Feeding

The broiler feeding was performed according to the Aviagen group's recommendations (Aviagen, 2014). Feed and water were offered *ad libitum*. The diets were prepared *in situ* in the poultry division and were used as mash feed. The starter diets were fed during 1-10 days of age, growing diets were fed during 11-24 days of age and finishing diets during 25-49 days of age. At 10, 24, 35, 42 and 49 days of age feed intake was recorded and live body weight measured with accuracy ± 5 g. Feed conversion ratio (FCR) and financial costs for feeding were calculated.

The diets in the respective nutrition period differed mainly with regard to the content of HiSFM and SBM. The following scheme of partial substitution of SBM with HiSFM in rations was used (Table 1).

The content of CP, crude fat and crude fibre of the main dietary components (corn, wheat, HiSFM and SBM) were determined in an accredited laboratory at the Agricultural University – Plovdiv. The contents of metabolisable energy, crude protein, calcium, available phosphorus, chlorides, the available essential AA – L-lysine, DL-methionine + cysteine, tryptophan, threonine were constant among diets from the respective nutrition period (Table 2).

Statistical analysis

The results were expressed as mean ± SEM. Statistical analyses were performed using SPSS statistical software (SPSS for Windows, version 16.0, 2008, SPSS Inc., and Chicago, USA). Data were analyzed by analysis of variance (ANOVA) and comparisons between treatment groups were performed with the paired Student's t-test. For all statistical procedures performed, a P-value < 0.05 was considered significant.

Results

By the end of the starter period (10 days of age), no statistically significant differences in the body weight of birds

Table 1. Content of HiSFM and SBM (%) in diets according to the group and feeding period

Group	Meal content, %	Period of feeding		
		starter 1-10 day	grower 11-24 day	finisher 25-49 day
1 (control)	HiSFM	5.00	10.00	15.00
	SBM	29.90	20.00	11.30
2	HiSFM	5.00	10.00	20.00
	SBM	29.90	20.00	6.30
3	HiSFM	5.00	15.00	23.00
	SBM	29.90	15.20	3.50
4	HiSFM	10.00	15.00	20.00
	SBM	24.90	15.20	6.30
5	HiSFM	10.00	15.00	23.00
	SBM	24.90	15.20	3.50
6	HiSFM	10.00	20.00	23.00
	SBM	24.90	10.50	3.50
7	HiSFM	15.00	25.00	26.50
	SBM	20.00	5.50	0

Table 2. Ingredients (in %), nutritional content and price (€/t) of diets

Item, %	Starter 1-10 d of age			Grower 11-24 d of age				Finisher 25-49 d of age			
group→	1; 2; 3	4; 5; 6	7	1; 2	3; 4; 5	6	7	1	2; 4	3; 5; 6	7
Ingredients											
Corn, 7.7% CP	29.00	29.00	29.00	30.85	30.85	30.85	30.85	33.00	33.00	33.00	33.00
Wheat, 12.7% CP	28.77	28.70	28.58	31.40	31.17	30.90	30.84	32.32	32.28	32.05	32.03
SBM, 46% CP [a]	29.90	24.90	20.00	20.00	15.20	10.50	5.50	11.30	6.30	3.50	0
HiSFM, 45.4% CP [b]	5.00	10.00	15.00	10.00	15.00	20.00	25.00	15.00	20.00	23.00	26.50
Sunflower oil	3.00	3.00	3.00	4.00	4.00	4.00	4.00	5.00	5.00	5.00	5.00
L-lysine	0.22	0.32	0.40	0.32	0.40	0.40	0.48	0.30	0.39	0.44	0.50
DL-methionine	0.29	0.27	0.25	0.23	0.20	0.18	0.16	0.18	0.16	0.14	0.12
Threonine	0.17	0.17	0.18	0.14	0.14	0.15	0.15	0.13	0.13	0.13	0.13
Sodium chloride	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.20	0.200	0.20	0.20
Bicar Z	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.12	0.12	0.12	0.12
Limestone	1.20	1.20	1.20	0.97	0.95	0.93	0.93	0.9	0.87	0.87	0.85
Dicalcium phosphate	1.55	1.55	1.50	1.20	1.20	1.20	1.20	0.98	0.98	0.98	0.98
Premix Rovimix	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Immunobeta [c]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Synergen –SSF [d]	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Neutox [e]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Cygro [f]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Calculated nutrient content											
Metabolizable energy,MJ/kg	12.50	12.50	12.50	13.00	13.00	13.00	13.00	13.39	13.40	13.39	13.39
Crude protein, %	23.00	23.00	23.00	21.50	21.50	21.50	21.50	19.50	19.50	19.50	19.50
Crude fibre, %	2.90	3.00	3.20	3.80	4.00	4.10	4.30	4.50	4.60	4.70	4.80
Crude fats, %	5.60	6.00	6.40	7.00	7.40	7.80	8.20	8.50	8.90	9.10	9.40
Linoleic acid, %	3.50	3.80	4.10	4.60	4.90	5.20	5.50	5.60	5.90	6.10	6.30
Calcium, %	1.04	1.05	1.04	0.87	0.87	0.87	0.87	0.79	0.79	0.79	0.78
Phosphorus total, %	0.71	0.73	0.74	0.65	0.66	0.68	0.70	0.61	0.63	0.64	0.65
Phosphorus available, %	0.50	0.50	0.50	0.44	0.44	0.44	0.44	0.40	0.40	0.40	0.40
Chlorides, %	0.3	0.31	0.31	0.31	0.31	0.31	0.31	0.29	0.29	0.29	0.29
L-lysine, g	1.38	1.38	1.38	1.26	1.25	1.19	1.18	1.05	1.05	1.06	1.05
DL-methionine, %	0.62	0.63	0.63	0.58	0.57	0.58	0.59	0.53	0.53	0.53	0.53
DL-methionine + cysteine, %	1.05	1.05	1.06	0.98	0.97	0.98	0.99	0.90	0.91	0.90	0.90
Tryptophan, %	0.28	0.27	0.27	0.25	0.24	0.24	0.24	0.22	0.22	0.22	0.21
Threonine, %	0.98	0.97	0.98	0.88	0.88	0.90	0.89	0.80	0.80	0.80	0.80
L-lysine available, %	1.24	1.24	1.24	1.12	1.12	1.05	1.04	0.93	0.93	0.93	0.93
DL-methionine available, %	0.59	0.59	0.59	0.54	0.53	0.54	0.54	0.49	0.49	0.49	0.48
DL-methionine + cysteine available, %	0.95	0.95	0.95	0.87	0.87	0.87	0.87	0.80	0.80	0.80	0.79
Tryptophan available, %	0.25	0.25	0.25	0.22	0.22	0.22	0.22	0.20	0.20	0.20	0.19
Threonine available, %	0.86	0.86	0.86	0.77	0.77	0.77	0.77	0.69	0.69	0.69	0.68
Price											
For 1 ton diet, €/t	370.50	363.5	356.6	349.9	342.9	335.5	328.3	332.9	325.9	321.8	316.5
Difference											
Cheaper vs. First group, %	0	-1.87	-3.74	0	-2.02	-4.12	-6.19	0	-2.12	-3.34	-4.93

[a] Market price of 1 ton SBM – 492 €
[b] Market price of 1 ton HiSFM – 354 €
[c] Immunobeta® – immunomodulator contains active ingredients: 30% β-glucans, 25% mannanoligosaccharides and 5% nucleotides (made in Chemifarma S.p.A. – Italy)
[d] Synergen SSF – product of the solid state fermentation of Aspergillus niger (made in Alltech, USA)
e Neutox – mycotoxin binders (made in Kiotechagil)
[f] Cygro – coccidiostat premix containing 1.0% (10 grams) of Maduramicin Ammonium per kilogram of product. Cygro is effective in prevention and controlling coccidiosis in broiler chickens (made in Zoetis Inc., Australia).

were established – P>0.05. This tendency was preserved at other ages as well. Broilers from group 4 and 5 had a lower body weight but differences were not significant vs the other groups (P>0.05) although they occupied an intermediate position in the order of dietary HiSFM content. By the end of the trial period, birds from groups 2, 6 and 7 had the highest body weight over 3.155 kg, whereas in all other groups it was over 3 kg (Table 3). The comparative analysis showed that at post hatch days 42 and 49 (e.g. the age when broilers attained necessary preslaughter weight), no statistically significant differences between average body weight were found out (P>0.05). The lack of such differences suggested that each individual feeding scheme with specific HiSFM and SBM contents could be used in the practice. In other words, the inclusion of higher levels of HiSFM on the account of lower SBM level did not pose risk for the growth performance of broilers and allowed attaining a high preslaughter live weight at 42 and/or 49 days of age.

The diet fed to group 1 during the three feeding stages (starter-grower-finisher) had the highest CP content provided by SBM: 59.80 – 42.79 – 26.66% respectively and the lowest CP from HiSFM (9.87 – 21.12 – 34.92% respectively, Table 4). In the last two groups (group 6 and 7), whose diet was outlined with highest proportions of HiSFM, CP provided from SBM was 49.80 – 22.47 – 8.26% and that originating from HiSFM: 19.74 – 42.23 – 53.55% for group 6. For group 7, CP coming from SBM was 40.00 – 11.77 – 0.00% while that coming from HiSBM was 29.61 – 52.79 – 61.7%.

The experimental results demonstrated that with strict balancing vs L-lysine, more than 50% of dietary CP could be provided with HiSFM (group 7 during grower and finisher periods, and group 3, 5, 6: during the finisher period), with simultaneous substantial reduction of soybean meal.

For the entire rearing period, FCR varied from 1.726 kg/kg in group 3 to 1.843 kg/kg in group 7 (Table 5). As age advanced, FCR was expectedly increased. Therefore, the best correlation between body weight and FCR should be sought.

In general, this experiment did not show any considerable between-group differences in FCR, which proved once again that every feeding scheme among the seven tested ones, with either higher or lower HiSFM content, could be applied.

The analysis of feeding costs showed that they varied from 1.70 to 1.82 € per bird in the different groups (Figure 1). A more precise criterion were costs for production of 1 kg body weight, which ranged from 0.56 € for group 6 to 0.59 € for groups 1 and 4. Calculations showed that the substitution of 10% SBM with HiSFM reduced the costs of 1 t compound feed by 3.74% (13.80 €/ton) to 4.61% (15.34 €/ton) depending on the feeding period.

Costs for 1 kg weight gain in birds from group 6 were the lowest consequently to the highest preslaughter body weight at 49 days of age and FCR value (more efficient feed conversion compared to groups 4, 5, 7). All this allowed suggesting safe inclusion of higher dietary HiSFM levels (10 – 20 –

Table 3. Growth performance of broiler chickens (mean ± SEM), g

Nutrition period	Age in days	Group						
		1	2	3	4	5	6	7
Starter	1	38.9 ± 0.6	38.9 ± 0.6	38.9 ± 0.6	38.8 ± 0.6	38.8 ± 0.6	38.8 ± 0.6	38.8 ± 0.6
	10	208 ± 8.7	202 ± 7.4	213 ± 8.9	200 ± 7.3	202 ± 6.4	216 ± 7.8	216 ± 8.6
Grower	24	897 ± 43	922 ± 45	905 ± 53	815 ± 35	827±41	898 ± 47	875 ± 46
	35	1886 ± 76	1944 ± 80 [a]	1794 ± 98	1782 ± 66	1693 ± 83 [b]	1834 ± 91	1957 ± 63 [a]
Finisher	42	2473 ± 84	2489 ± 97	2414 ± 96	2388 ± 55	2392 ± 84	2420 ± 90	2479 ± 71
	49	3070 ± 76	3169 ± 99	3040 ± 91	3016 ± 59	3010 ± 92	3180 ± 112	3155 ± 75

Note: Values with different superscript within a line differ significantly at P < 0.05.

Table 4. Provided CP (in %) from SBM and HiSFM in diets

Item	Starter			Grower				Finisher			
Group →	1; 2; 3	4; 5; 6	7	1; 2	3; 4; 5	6	7	1	2; 4	3; 5; 6	7
Content in the diet, %											
SBM	29.90	24.90	20.00	20.00	15.20	10.50	5.50	11.30	6.30	3.50	0
HiSFM	5.00	10.00	15.00	10.00	15.00	20.00	25.00	15.00	20.00	23.00	26.50
Provided protein in % vs. total protein in the diet											
Provided CP from SBM, %	59.80	49.80	40.00	42.79	32.52	22.47	11.77	26.66	14.86	8.26	0
Provided CP from HiSFM, %	9.87	19.74	29.61	21.12	31.67	42.23	52.79	34.92	46.56	53.55	61.70

Table 5. Feed conversion ratio (kg) per 1 kg body gain

Nutrition period	Age in days	Group						
		1	2	3	4	5	6	7
Starter	1-10	1.102	1.104	1.051	1.00	1.120	1.012	1.018
Grower	11-24	1.580	1.576	1.621	1.830	2.016	1.630	1.814
Finisher	25-49	1.831	1.823	1.807	1.795	1.746	1.816	1.883
Total for life	1-49	1.735	1.738	1.726	1.779	1.796	1.748	1.843

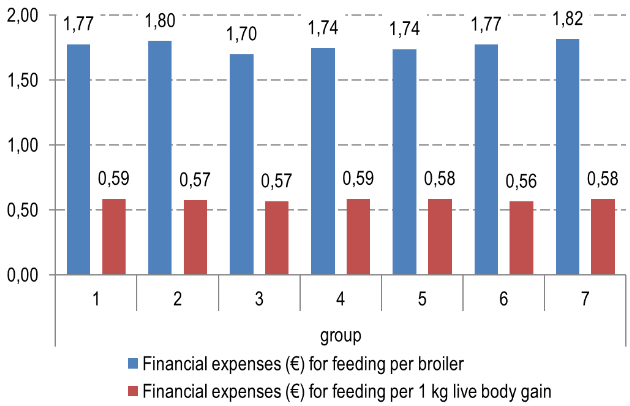

Fig. 1. Feeding costs in euro (€)

23% in starter, grower and finisher rations respectively) with regard to achieving a high performance.

Discussion

A lot of studies for partial or complete replacement of soybean meal with sunflower meal in broiler diets are reported. Long ago Rad and Keshavarz (1976) considered that 50% of soybean meal protein could be replaced with sunflower meal protein with no adverse effect on gain and feed conversion. Substitution of soybean meal protein with sunflower meal even up to the level of 100% seemed to be possible provided that lysine and a rich source of energy are supplemented. In general, sunflower meal has a lower lysine content than soybean meal (NRC, 1994; Corzo et al., 2006; Alagawany et al., 2015). The inclusion of higher levels of high protein sunflower meal in broiler feed requires also addition of higher levels of L-lysine as this amino acid is deficient in sunflower meal (Senkoylu & Dale, 1999). According to Rama Rao et al. (2006) replacement of SBM with SFM up to 67% in starter and 100% in finisher diets did not affect weight gain at 42 days of age. The concentration of HDL cholesterol increased while that of LDL cholesterol decreased with increasing dietary content of SFM (67% of SBM). The concentrations of serum protein and triglycerides were the lowest in groups receiving 100% of SFM. According Waittitu et al. (2018) the high nonphytate phosphorus, low total nonstarch polysaccharides NSP, and high nitrogen-corrected apparent metabolizable energy (AMEn – 1785 kcal kg^{-1}) contents of HiSFM make it an attractive alternative protein source for broiler diets. Also, inclusion of higher levels of HiSFM as a phosphorus source and phytase supplementation in diet increased ileal digestibility of phosphorus, growth performance, and bone traits of the birds (Kim et al., 2019).

During the experiment it was found out that fine particles mainly from HiSFM were stuck to the nasopharynx and the beak of the broilers which had a negative impact on their well-being. In support of this conclusion, Chobanova (2019) having studied the effects of different contents of high-protein sunflower meal in mash diets on the growth performance of broiler chickens reported that poorer productive traits were due to lower feed intake resulting from extremely fine particles (150-300 µm) mainly from high-protein sunflower meal. Although it has been postulated that finer grinding increases substrate availability for enzymatic digestion, there is evidence that coarser grinding but to a more uniform particle size improves the performance of birds (Amerah et al., 2007). The fine particles with diameter up to 600 µm should be avoided at all ages (Waldroup, 1997), but the other hand, particles with size larger than 1000 µm are too big for chicks to be utilised efficiently, as their passage through the gizzard is slower (Lott et al.,1992). Many researchers reported that feed physical form and particle size had a significant impact on broiler growth and feed intake recommending the pelleted rather than the mash form (Choi et al., 1986; Nir et al., 1994; Preston et al., 2000; Dozier et al., 2010; Chewning et al., 2012; Lv et al., 2015; Naderinejad et al., 2016; Mohammadi Ghasem Abadi et al., 2019).

Conclusion

The higher dietary proportions (% in diet) of HiSFM with corresponding reduction of dietary SBM and balancing of L-lysine could be successfully used in feeding broiler chickens. The recommended dietary HiSFM level during the starter period is up to 10%, for the grower period – up to 20%

and for the finisher period – up to 23%. During the grower and finisher periods, HiSFM could provide approximately more than half of necessary dietary crude protein.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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