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Effect of replacing soybean meal with malted chocolate drink's spent grain on productive performance of broilers

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Abstract The results of this study revealed that the soybean meal (SBM) substitution with malted chocolate drink's spent grain (SG) at the levels of 0, 10, 20, 30 and 40% resulted in a decrease in body weight gain (BW gain), average daily gain (ADG) and daily feed intake (DFI) as the percent of SG increased. However, broilers fed 30% SG had BW gain, and ADG and DFI like those of the control group ($p>0.05$) and had a slightly lower feed conversion ratio than the control group but the differences were not statistically significant ($p>0.05$). For carcass composition, the results revealed that the percentage of breast meat in the 20% and 30% SG groups, as well as the percentage of tenderloin in all SG groups were greater than those in the control group ($p<0.05$). Whereas, no differences were found between treatments with regards to whole carcass weight, eviscerated carcass weight and carcass percentage as well as wing, thigh, drumstick and abdominal fat (% of whole carcass weight) ($p>0.05$). Moreover, SG did not significantly affect survival rate and hematological characteristics including PCV, RBC and WBC. In conclusion, SG can be used in broiler diets as a replacement for SBM at the level of 30%.

Keywords: Growth performance, Broiler, Meat quality, Soybean meal, Malt spent grain

Introduction

Using industrial residuals or by-products as animal feed is a cost-effective use of natural resources, which increases economic value and leads to reduce environmental pollution. It also helps to solve the problem of insufficiency of animal feed in the animal production industry. In broiler chicken production, there are some studies on the use of residues from agro-industrial factories as a partial substitute for the original protein feed such as soybean and soybean meal which are normally expensive with the area of cultivation continuously decreasing and leading to lower yields compared to the other competitive crops (Office of Agricultural, 2019). Examples of residues used are rubber seed

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kernels (Somkuna and Srimapon, 2013), palm kernel cake (Niyomdecha, 2015), etc.

Another interesting residual using for broiler feed is malt residue. Because it is quite high (19-30% w/w) in protein (Kieran *et al*., 2016). However, previous studies evaluated the use of malt residue from the brewing industry as a substitute for protein feed in broiler chickens. Denstadli *et al*. (2010) found that brewers' spent grain could be substituted for wheat and soybean meal up to 20 percent without affecting growth and feed efficiency. Moreover, Anjola *et al.* (2016) reported that using brewers' spent grain as a substitute for soybean meal in broiler chickens 4-9-week-old decreased the level of cholesterol in the blood. However, apart from the malt residue from the brewing industry, there was malt residue from the beverage industry. Therefore, this study aimed to evaluate the productive performances, carcass quality, hematology and survival rates of broiler diets using malted chocolate drink's spent grain instead of soybean meal, and to provide guidelines for the use of malt spent grain as an alternative protein source in broiler diets in the future.

Materials and methods

Birds and management

A total of 400 male one-day-old chicks (Ross 308) were randomly allotted to 5 dietary treatment groups included a basal diet without chocolate drink's spent grain (control) consisting of 0, 10, 20, 30, and 40% chocolate drink's spent grain (SG) replacing soybean meal. Each treatment group consisted of 4 replicates with 20 chicks. They were randomly assigned to any of the five treatments in a completely randomized design (CRD) experiment. The diets were formulated to meet the nutrient requirements of the NRC (2001). The diets were composed of starter (1 to 14 d), grower (15 to 28 d), and finisher diets (29 to 42 d). Feed and water were supplied *ad libitum*. The study was carried out at the broiler house, Faculty of Agriculture and Natural Resources, Rajamangala University of Technology Tawan-ok, Chonburi, Thailand.

Growth performance

Gain in weight and feed intake were measured at 1, 14, 28, and 42 d. The mortality was recorded as it occurred. Average daily gain (g/bird), feed conversion rate, and survival rate were calculated.

Hematological technique

Blood samples (3 ml) from the wing vein were randomly collected from each of the 6 birds per treatment. Packed cell volume (PCV) was measured by using microhematocrit capillary tubes centrifuged at 2500 rpm for 5 min. The differential white blood cell (WBC) counts were fixed and stained with Giemsa-Wright's stain. Red blood cell count was determined by using a hemacytometer.

Carcass characteristics

At the end of the experiment (42 d of age), five birds of each replication were bled by cutting the carotid artery. The carcass feathers were removal. The carcasses were dissected to breast, thigh, drumstick, leg, wings, neck, tenderloin, gizzard, heart, spleen, liver, and abdominal fat and weighed. The percentage yield of each part was calculated on the basis of carcass weight.

Statistical analysis

Analysis of Variance (ANOVA) was used for data analysis. The level of significance was reported at $p<0.05$ and the significant differences among the treatment groups were analyzed by Duncan's multiple range test.

Results

Chemical composition

The approximate chemical composition of malted chocolate drink's spent grain is presented in Table 1. The malted chocolate drink's spent grain contained 25.19% DM and 4.71 Cal/g gross energy. The formulation and calculated nutrient level of the diet in the starter, grower, and finisher are presented in Tables 2, 3 and 4.

Growth performance

Body weight and feed intake were measured at the end of starter, grower, and finisher phases. There was no significant difference in day 1 body weight (46.6-47.5 g/bird). In the starter, and grower periods, weight gain and average daily gain in 30% SG (261.4 g and 649.3 g) were higher than 20% SG (224.0 g and 557.6 g); however, the daily feed intake in the starter period was not significantly different, while higher in grower period, as a result the feed conversion ratio in 30% SG was lowest in the starter period (1.23) and not significantly different in grower period. In the finisher period, the weight gain and average daily gain were lower in the 40% SG (844.30 g and 60.31 g) while feed intake (125.96 g/bird) was higher. Therefore, the feed conversion rate was highest in 40% SG (2.10). On the other hand, the 30% SG showed a weight gain, average daily gain, daily feed intake; and the feed conversion rate was not significantly different than 0% SG. Replacing soybean meal with 30% SG led to a non-significant difference in overall weight gain, average daily gain, daily feed intake and feed conversion rate compared to broilers fed 0% SG (1,920.61 g, 45.72 g, 78.88 g, 1.70 versus 1,902.69 g, 45.30 g, 79.28 g, 1.71) (Table 5). Moreover, replacing the SG did not significantly affect survival rate (p>0.05).

Table 1. Chemical analysis of malted chocolate drink's spent grain

Chemical composition	%
Dry matter (DM)1	92.85
	-----%DM-----
Organic matter (OM)1	94.95
Crude protein (CP)1	25.19
Ether extract (EE)1	7.05
Ash1	5.05
Crude fiber (CF)2	18.14
Neutral Detergent Fiber (NDF)2	66.36
Cellulose2	21.05
Hemicellulose2	38.78
	-----Cal/g-----
Gross energy (GE)	4.71

1/ Method of Analysis: Moisture by Hot air oven based on AOAC 930.15; Crude Protein (CP) by Block digestion method based on AOAC 2001.11; Crude Fiber (CF) by on ISO 6865 and AOAC 978.10; Crude Fat by Soxtec based on AOAC 920.39 and Ash by method based on AOAC 942.05

2/ Method of Analysis: Acid detergent fiber (ADF), Neutral detergent fiber (NDF), Acid detergent Lignin (ADL), Cellulose and Hemicellulose based on Georing and Van Soest (1970), Van Soest (1994) and AOAC (2016).

Table 2. Formulation and chemical analysis of the starter diets through -1-2 weeks of age for broiler chickens

Ingredients	Replacement level of SBM with SG, %				
	0	10	20	30	40
Ingredients, kg					
Maize	53.50	53.50	53.50	53.50	52.50
Soybean meal (CP 47%)	30.00	27.00	24.00	21.00	18.00
Dry SG1	0.00	3.00	6.00	9.00	12.00
Rice bran	6.00	6.00	6.00	6.00	7.00
Palm oil	2.00	2.00	2.00	1.50	1.50
Fishmeal (CP 60%)	5.00	5.00	5.00	5.00	5.00
Salt	0.50	0.50	0.50	0.50	0.50
Monocalcium phosphate	0.50	0.50	0.50	0.50	0.50
Lysine	0.00	0.00	0.00	0.50	0.50
Methionine	0.25	0.25	0.25	0.25	0.25
Shell flour	2.00	2.00	2.00	2.00	2.00
Premix	0.25	0.25	0.25	0.25	0.25
Calculated nutrient level					
Gross energy, cal/g	2,986	3,048	3,121	3,170	3,236
Crude protein (%)	22.92	22.26	21.61	21.43	20.81
Crude fiber (%)	4.09	4.42	4.76	5.09	5.50
Calcium (%)	1.02	1.01	1.00	0.99	0.99
Phosphorus (%)	0.45	0.45	0.45	0.45	0.47
Lysine (%)	1.19	1.11	1.03	1.34	1.26
Methionine + cystine (%)	0.93	0.89	0.85	0.82	0.78
Threonine (%)	0.81	0.76	0.71	0.66	0.61
Price/kg, Baht2	14.91	14.46	14.02	13.91	13.44

/1SG = malted chocolate drink’s spent grain; 3.15 Baht/kg
2/ Prices were calculated according the market price in 2018

Table 3. Formulation and chemical analysis of the grower diets through 3 - 4 weeks of age for broiler chickens

Ingredients	Replacement level of SBM with SG, %				
	0	10	20	30	40
Ingredients, kg					
Maize	58.50	58.50	58.25	58.00	57.75
Soybean meal (CP 47%)	28.00	25.20	22.40	19.60	16.80
Dry SG1	0.00	2.80	5.60	8.40	11.20
Rice bran	4.00	4.00	4.00	4.00	4.00
Palm oil	3.00	3.00	3.00	3.00	3.00
Fishmeal (CP 60%)	3.00	3.00	3.00	3.00	3.00
Salt	0.50	0.50	0.50	0.50	0.50
Monocalcium phosphate	0.50	0.50	0.50	0.50	0.50
Lysine	0.00	0.00	0.25	0.50	0.75
Methionine	0.25	0.25	0.25	0.25	0.25
Shell flour	2.00	2.00	2.00	2.00	2.00
Premix	0.25	0.25	0.25	0.25	0.25
Calculated nutrient level					
Gross energy, cal/g	3,078	3,146	3,215	3,285	3,354
Crude protein (%)	20.94	20.33	19.94	19.54	19.14
Crude fiber (%)	3.85	4.16	4.47	4.78	5.08
Calcium (%)	1.01	1.00	1.00	0.99	0.98
Phosphorus (%)	0.38	0.38	0.38	0.38	0.38
Lysine (%)	1.05	0.98	1.10	1.22	1.34
Methionine + cystine (%)	0.87	0.83	0.80	0.76	0.72
Threonine (%)	0.74	0.69	0.64	0.60	0.55
Price/kg, Baht2	14.91	14.91	14.46	14.02	13.91

1/ Price of dry malted chocolate drink's spent grain; 3.15 Baht/kg
2/ Prices were calculated according the market price in 2018

Table 4. Formulation and chemical analysis of the finisher diets through 5 - 6 weeks of age for broiler chickens

Ingredients	Replacement level of SBM with SG, %				
	0	10	20	30	40
Ingredients, kg					
Maize	66.50	66.25	66.15	66.10	66.05
Soybean meal (CP 47%)	21.00	18.90	16.80	14.70	12.60
Dry SG1	0.00	2.10	4.20	6.30	8.40
Rice bran	3.00	3.00	3.00	3.00	3.00
Palm oil	3.00	3.00	3.00	3.00	3.00
Fishmeal (CP 60%)	3.00	3.00	3.00	3.00	3.00
Salt	0.50	0.50	0.50	0.50	0.50
Monocalcium phosphate	0.50	0.50	0.50	0.50	0.50
Lysine	0.00	0.25	0.35	0.40	0.45
Methionine	0.25	0.25	0.25	0.25	0.25
Shell flour	2.00	2.00	2.00	2.00	2.00
Premix	0.25	0.25	0.25	0.25	0.25
Calculated nutrient level					
Gross energy, cal/g	3,161	3,213	3,265	3,316	3,368
Crude protein (%)	18.24	18.00	17.63	17.21	16.80
Crude fiber (%)	3.46	3.69	3.92	4.15	4.39
Calcium (%)	0.99	0.99	0.98	0.98	0.97
Phosphorus (%)	0.39	0.39	0.39	0.39	0.39
Lysine (%)	0.88	1.02	1.04	1.02	1.00
Methionine + cystine (%)	0.80	0.77	0.75	0.72	0.69
Threonine (%)	0.64	0.60	0.57	0.53	0.50
Price/kg, Baht2	14.91	14.91	14.46	14.02	13.91

1/ Price of dry malted chocolate drink's spent grain; 3.15 Baht/kg
2/ Prices were calculated according the market price in 2018

Table 5. Effect of replacing SBM with SG on growth performance of broilers

Parameters	Replacement level of SBM with SG (%)				
	0	10	20	30	40
Body weight, g/bird					
Day 1	46.63±0.43	47.44±1.52	47.50±0.54	46.53±0.54	46.81±1.07
Day 14	291.13±6.50ab	288.75±11.11ab	271.75±2.06b	308.00±24.22a	278.75±13.74b
Day 28	893.05±22.58b	840.16±14.88c	829.41±9.80c	957.36±44.66a	865.16±12.43bc
Day 42	1,949.32±25.87a	1,812.40±33.77b	1,857.64±10.58b	1,967.13±96.67a	1,709.46±45.78c
Starter (Day 1-14)					
Weight gain, g/bird	244.50±6.13ab	241.31±12.37ab	224.06±1.40b	261.48±24.19a	231.94±13.88b
Average daily gain, g/bird	17.47±0.44ab	17.24±0.89ab	16.02±0.12b	18.68±1.73a	16.57±0.99b
Daily feed intake, g/bird	24.29±0.49	23.89±1.16	23.12±0.76	24.44±2.28	23.58±1.87
Feed conversion rate	1.29±0.01b	1.29±0.01b	1.34±0.04a	1.23±0.01c	1.33±0.04a
Grower (Day 15-28)					
Weight gain, g/bird	601.92±16.45b	551.41±7.17d	557.66±11.13cd	649.36±44.73a	586.41±1.58bc
Average daily gain, g/bird	43.00±1.18b	39.39±0.51d	39.84±0.80cd	46.39±3.20a	41.89±0.11bc
Daily feed intake, g/bird	68.77±2.95ab	64.03±2.02bc	63.16±5.59c	71.07±2.80a	71.48±1.52a
Feed conversion rate	1.61±0.06	1.63±0.04	1.59±0.15	1.54±0.07	1.73±0.06
Finisher (Day 29-42)					
Weight gain, g/bird	1,056.27±22.01a	972.24±27.97b	1,028.23±9.15ab	1,009.77±66.42ab	844.30±35.71c
Average daily gain, g/bird	75.45±1.57a	69.45±2.00b	73.45±0.65ab	72.13±4.74ab	60.31±2.55c
Daily feed intake, g/bird	140.86±7.13a	123.25±8.56b	124.88±4.88b	137.24±6.55a	125.96±4.59b
Feed conversion rate	1.88±0.09bc	1.78±0.10bc	1.70±0.06c	1.93±0.20ab	2.10±0.13a
Overall (Day 1-42)					
Weight gain, g/bird	1,902.69±25.62a	1,764.97±33.87b	1,810.14±10.42b	1,920.61±97.11a	1,662.65±46.03c
Average daily gain, g/bird	45.30±0.61a	42.02±0.81b	43.10±0.25b	45.73±2.31a	39.59±1.09c
Daily feed intake, g/bird	79.28±2.46a	71.53±3.51b	71.54±3.45b	78.88±1.61a	74.89±2.41ab
Feed conversion rate	1.71±0.06b	1.66±0.06b	1.62±0.07b	1.70±0.10b	1.86±0.08a
Survival rate, %					
Day 1-14	100.00±0.00	100.00±0.00	100.00±0.00	98.75±2.50	97.50±2.89
Day 15-28	95.00±4.08	100.00±0.00	100.00±0.00	100.00±0.00	96.12±5.02
Day 29-42	97.50±5.00	96.25±4.79	100.00±0.00	98.69±2.63	98.69±2.63
Day 1-42	92.50±2.89	96.25±4.79	100.00±0.00	97.50±5.00	92.50±6.45

a, b, c, d Means in the same row with different letters are significantly different (P <0.05).

Carcass and meat quality

The effect of SG replacement of soybean on the broiler carcasses is presented in Table 6. It is apparent that the different levels of SG in the diet did not result in significant differences in pre slaughter body weight (1699.0-1823.5 g), dressed weight (1602.3-1730.6 g), eviscerated yield (1422.20-1528.95 g), dressing percentage (93.75-97.03), eviscerated percentage (83.12-84.50), wing (8.85-9.03), thigh (14.41-15.29), drumstick (10.68-11.02), leg (4.34-4.68), abdominal fat (1.17-1.46), gizzard (2.35-2.60), heart (0.48-0.56), and spleen (0.11-0.18) (p>0.05). The 20 and 30% SG had affected on the breast and tenderloin (p<0.05). The 30 and 40% SG had highest liver weight (2.29 and 2.30), however the offals was not significantly different from 0% SG (10.40-10.80).

Table 6. Effect of replacing SBM with SG on carcass traits of broilers

Parameters	Replacement level of SBM with SG, %				
	0	10	20	30	40
Pre slaughter body weight (g)	1,786.25±71.40	1,712.00±66.98	1,755.25±71.77	1,823.50±79.37	1,699.00±84.79
Dressed weight (g)	1,730.65±64.81	1,607.35±53.93	1,645.70±71.69	1,715.45±80.38	1,602.35±78.53
Eviscerated yield (g)	1,509.55±72.91	1,422.65±44.29	1,466.00±66.27	1,528.95±68.44	1,422.20±74.76
Dressing percentage	97.03±5.91	93.90±0.74	93.75±0.65	94.07±0.45	94.31±0.22
Eviscerated percentage	84.50±1.54	83.12±0.86	83.51±0.53	83.84±0.21	83.70±0.60
Dressing carcass percentage					
Wing	8.85±0.46	8.97±0.13	8.99±0.28	9.03±0.16	8.90±0.34
Breast	16.97±0.88b	17.39±0.36b	18.66±0.57a	18.49±0.29a	17.09±1.07b
Tenderloin	3.57±0.15c	3.83±0.07b	4.13±0.12a	4.12±0.22a	3.85±0.21b
Thigh	14.52±0.83	14.54±1.04	15.29±0.67	14.82±0.49	14.41±0.96
Drumstick	10.94±0.63	10.83±0.23	10.73±0.52	11.02±0.50	10.68±0.47
Leg	4.56±0.17	4.68±0.14	4.42±0.17	4.34±0.21	4.40±0.15
Abdominal fat	1.17±0.22	1.35±0.30	1.19±0.15	1.34±0.19	1.46±0.15
Offals	10.59±0.33b	11.26±0.24a	10.54±0.42b	10.40±0.05b	10.80±0.61ab
Gizzard	2.44±0.09	2.60±0.10	2.51±0.08	2.35±0.16	2.42±0.17
Heart	0.56±0.05	0.53±0.03	0.55±0.05	0.50±0.06	0.48±0.05
Spleen	0.16±0.03	0.18±0.05	0.15±0.04	0.15±0.04	0.11±0.02
Liver	1.99±0.08c	2.18±0.08ab	2.10±0.16bc	2.29±0.13a	2.30±0.11a

a, b, c Means in the same row with different letters are significantly different (P <0.05).

Hematological values

The effect of the levels of SG in the diet on hematological values is presented in Table 7. The hematlogical parameters including PCV (26.63-28.63 %), RBC ($3.12x10^6$-$3.83x10^6$/ml), WBC ($20.06x10^8$-$24.31x10^8$/ml), heterophil (40.00-44.38 %), eosinophil (10.50-14.75 %), basophil (1.63-2.50 %), monocyte (9.00-13.88 %) and lymphocyte (28.38-35.25 %) were not affected by dietary treatment throughout starter, grower, and finisher periods (p>0.05).

Table 7. Effect of replacing SBM with SG on hematological values of broilers

Parameters	**Replacement level of SBM with SG, %**				
	0	10	20	30	40
PCV (%)	28.63 ±1.38	28.63 ±1.60	27.75 ±1.94	28.13 ±1.55	26.63 ±1.18
RBC (x106/ml)	3.51 ±0.43	3.12 ±0.37	3.19 ±0.60	3.47 ±1.32	3.83 ±0.39
WBC (x108/ml)	21.38 ±7.21	20.06 ±6.17	21.75 ±9.10	22.00 ±4.04	24.31 ±4.62
Heterophil	40.00 ±7.18	42.88 ±4.21	44.38 ±5.12	41.63 ±7.09	43.38 ±7.66
Eosinophil	14.75 ±4.01	13.50 ±2.65	11.13 ±1.65	13.63 ±4.19	10.50 ±2.48
Basophil	1.63 ±0.85	2.25 ±0.50	2.38 ±1.25	2.50 ±1.35	1.88 ±0.48
Monocyte	10.50 ±5.46	13.00 ±7.45	9.63 ±4.03	13.88 ±5.07	9.00 ±4.65
Lymphocyte	33.13 ±9.15	28.38 ±4.61	32.50 ±8.65	28.38 ±2.93	35.25 ±12.98

Discussion

It is well known that the insoluble fiber and non-starch polysaccharides content in the diets containing Brewers' dried grain (BDG) are greater than that in the control diet (0% BDG). Moreover, BDG contains more lignin and cellulose than soy, therefore the total dietary fiber would have been even higher in the BDG diets (Denstadli *et al*. 2010). As in this study, it was found that crude fiber content gradually increased in the malted chocolate drink’s spent grain (SG) based diets while crude protein decreased. In addition, SG contains a relatively high energy content compared to soybean meal (SBM). Therefore, the energy content in SG diet increased with increasing SG levels. As a result, feed intake of the broiler chicken fed SG diets tended to be lower than those of the control group during finisher and overall periods. The result contrasted with some studies of BDG which found that, as the inclusion of BDG increased the chickens did not compensate for the reduced dietary metabolizable energy (ME) levels by increasing their feed consumption (Denstadli *et al*. 2010, Onifade and Babatunde, 1998).

As the levels of SG in the diet increased, it tended to reduce the body weight (BW) gain and average daily gain (ADG) of broilers from the 3rd to 6th week of age. However, BW gain and the ADG of the broilers fed 30% SG substitute for SBM (or 9% of the diet) were similar to those of the control group at the starter, finisher and overall periods, and even greater at the grower period (P<0.05). The potential use of SG in broiler diets seems to be lower than that of BDG. Denstadli *et al.* (2010) reported that BDG at the levels of 30 and 40% in diet (replacing maize and soybean) reduced the BW gain of broilers at 33 d, but BDG at the 10 and 20% levels had a similar performance as that of the control group. Moreover, the study of Aghabeigi *et al*. (2013) showed that BW gain of birds fed a diet with 25% BDG was depressed as compared to other levels at the grower phase which suggested that 20% inclusion of BDG at grower phase and 5% inclusion of BDG at finisher phase support beneficial results on the broilers' performance.

Previous studies revealed that BW gain was not influenced by energy level (Infante-Rodríguez *et al*., 2016; Hu *et al*., 2021). An increased in BW gained the ADG of the 30% SG group which were probably due to the optimal proportion of energy and protein in the diet. Jackson *et al*. (1982) found that BW and feed efficiency improvement with increased dietary energy and protein. However, a significant interaction between energy and protein indicated the importance of a balanced energy, protein ratio to achieve optimal performance. In addition, Dairo *et al.* (2010) reported that broiler chickens fed with a high energy and low protein diet had a similar BW gain compared with normal energy and normal protein (control) group.

A reduction in feed efficiency was expected as fiber increased while protein decreased with increasing levels of SG. Our study showed that the use of SG as a replacement for SBM at 40% (or 12% in the diet) increased the feed conversion rate at all periods and gave a significant increase in the grower and finisher periods compared with the control group (P<0.05). The result supported previous studies with BDG-fed chickens. Lopez and Carmona (1981) revealed that replacing wheat and SBM with BDG for broiler chickens decreased feed efficiency during starter and grower periods when using 20% or more BDG, and finisher period when using 30% or more. In agreement with these findings, Denstadli *et al.* (2010) reported that, FCR was significantly higher in birds fed 30 and 40% BDG compared with birds fed 0, 10, and 20% BDG (P<0.05). In addition, Swain *et al.* (2012) found that the FCR of Vanaraja chicks fed 20% BDG increased significantly (P<0.05) from the 4th to 9th week of age and Aghabeigi *et al*. (2013) found that FCR in broiler chickens fed a diet with 25% BDG was higher than others at the grower phase (P<0.01).

Replacement of SBM with SG at the levels of 0-40 % did not affect carcass yield, carcass percentage and percentage of wing, thigh, drumstick, and abdominal fat relative to carcass yield. However, the present study showed that percentage of breast and tenderloin increased significantly ($P<0.05$) in chicks fed 20 and 30% SG compared to the control group, whereas, the percentage of liver increased significantly ($P<0.05$) at the replacement levels of 10, 30 and 40% SG. These results are similar to the study of Aderolu *et al.* (2007) which showed a significant increase in the weight of liver with inclusion of BDG. But, in contrast, significant differences ($P<0.05$) in eviscerated yield (%) and weight of drumstick, wing, abdominal fat as well as gizzard and thymus were found in chicks fed 10 and 20% BDG replacing maize, SBM and deoiled rice bran compared to the control group (Swain *et al.*, 2012).

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