Received: 07 March 2020 | Revised: 28 May 2020 | Accepted: 19 September 2020

MJVAS Myanmar Journal of Veterinary and Animal Sciences

DOI: 10.1002/0000.21537

ISSN:0000-000X

RESEARCH ARTICLE

Effects of different vegetable protein sources and lighting programs on the performance of broilers

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Abstract

This experiment was conducted to evaluate the effects of different vegetable protein sources and lighting programs on the performance of broilers. A randomized complete design (RCBD) was used with a total of 270 day-old broiler chicks which were randomly assigned to nine treatment groups with five replicates (6 birds per replicate) into 45 pens. From days 3 to 49, equal numbers of chicks were exposed to the experimental treatments in a 3×3 factorial arrangement of three different vegetable protein sources and three different lighting programs. The three different protein sources were Diet 1- soybean meal (SBM), Diet 2- groundnut meal (GNM) and Diet 3- sesame meal (SSM) at 25 % for starter and 20% for grower ration, and three different light regimes were L1-continuous light 23h Light (L):1h Dark (D) control, L2- non-intermittent restricted light 8hL:16hD, and L3- intermittent light 1hL:2hD throughout 24 h. Performances were measured and calculated on weekly basis. On day 49, two birds from each replicate per treatment were randomly sacrificed to determine the crude protein (CP) and crude fat (CF) contents of breast, thigh and drumstick meats. Significant ($P<0.05$) effect on cumulative feed intake, body weight and feed conversion ratio (FCR) were noted among treatments. The treatment 9 (SSM + 1hL:2hD) had highest feed intake, body weight and narrowest FCR when compared to other treatments. No significant treatment ($P<0.05$) effect on the CP contents of breast and thigh meats was noted. Moreover, the CF contents of breast and drumstick meats of all treatments did not differ significantly ($P>0.05$). According to the findings of this study, the combination treatment of sesame meal and intermittent lighting program is the most beneficial among all the treatments.

Keywords:

broilers, performance, vegetable protein sources, lighting programs

1. Introduction

The poultry industry provides high quality food for human consumption. When compare to other commercial livestock industry, broiler industry can provide relatively quick returns on capital investment. Increased consumption of eggs and poultry meat brings substantial benefits to the human population in developing countries. A comparison of chicken meat with other meats shows that it is a healthy meat (FAO, 2014). Broiler meat is contributing a dominant share for meeting protein requirement in human diet (Abro et al., 2012).

The major objective of poultry production is to produce meat and eggs efficiently, at economical rate, which is only possible by using cheaper locally available feed ingredients because the feed alone contribute to 70-75% of the total cost of production (Teguia and Beynen, 2005). The development of poultry industry depends upon the large extent on the availability of feedstuffs that are used or can be made suitable for use in poultry nutrition (Babiker et al., 2009). Therefore, search for alternative vegetable protein sources, which are cheap and locally available, has become an urgent subject to poultry nutritionists.

In Myanmar, the cheaper protein sources like groundnut meal (GNM) and sesame meal (SSM) are used as major protein sources in poultry feed formulation than soybean meal (SBM). But SBM is an extensively used ingredient in poultry diets and is the largest source of protein in poultry in much of the world. These three types of vegetable protein meals can be used as the main sources of proteins in poultry diet. The use of less expensive protein meals could potentially reduce feed costs and gave reasonable performance but only if formulated correctly (Swick, 1999).

Soybean meal is the number-one protein source used in the poultry and livestock industries throughout the world. The protein quality of SBM is high for poultry. The primary type of SBM used in broiler chicken diets is dehulled, solvent-extracted SBM, which contains 48% protein (Penz and Brugali, 2000). When the digestible lysine concentration in SBM is compared to the required amount of lysine for chicks, the amount of digestible lysine in SBM actually exceeds the requirements (Baker, 2000). SBM has an excellent profile of essential amino acids as well as other nutrients including potassium and the vitamins, choline, folic acid, riboflavin, niacin, pantothenic acid and thiamine. However, soybeans contain compounds that inhibit the activity of the proteolytic enzyme trypsin (Read and Haas, 1938). The trypsin inhibitor is inactivated by heat treatment of SBM (NRC, 1994).

Groundnut meal has been used as conventional vegetable protein supplement in the preparation of mixed feeds for various classes of poultry (Naulia and Singh, 2002). GNM is the high-protein solid residue obtained from the extraction of oil from whole or broken groundnuts. GNM is a rich source of protein (45-60%) and can be used in food products (Seifert, 2009). GNM, however, is not balanced in amino acids pattern desirable for poultry. It is deficient in methionine, tryptophan and tyrosine (Singh et al., 1981). Potential aflatoxin contamination is the major problem with GNM (Leeson and Summers, 2001). Its keeping quality is poor as it may develop aflatoxins during storage (Mishra, 1993).

Sesame meal may constitute to be good vegetable protein sources for use in poultry diets in regions where they are readily available and relatively inexpensive. Because the SSM is the residue after pressing the oil from the seed, it is an excellent source of protein ranging from 28.4 % to 52.9 % CP (Kaneko et al., 2002). SSM has a higher content of the methionine than most plant protein supplements. But SSM is very deficient in available lysine, and it also contains high levels of phytic acid which can cause problems with calcium metabolism leading to skeletal disorders (Leeson and Summers, 2001).

Lighting is a powerful exogenous factor in control of many physiological and behavioural processes (Olanrewaju et al., 2006). Light is an important aspect of physical environment for poultry birds. Broiler chickens have usually been kept on a continuous or nearly continuous lighting (CL- 23L:1D) schedule so as to maximize feed intake and growth rate (Campo and Davila, 2002). However, it has been reported that performance of broiler chickens is improved by intermittent lighting (IL) schedules compared with such CL (Savory, 1976; Dorminey and Nakaue, 1977; Cave, 1981; Deaton et al., 1981). Moreover, IL programs have shown increased liveability and decreased leg problems, mortality and incidence of circulatory diseases (Ononiwu et al., 1979; Classen and Riddell, 1989).

Some researchers also observed that an IL schedule significantly increased growth rate (Classen and Riddell, 1989; John et al., 1993; Buyse et al., 1996) and FCR of broilers (Apeldoorn et al., 1999; Ohtani and Leeson, 2000), whereas others indicated that photoperiod treatments had no effect on performance (Renden et al., 1996; Lien et al., 2007; Archer et al., 2009) or that IL reduced the FCR of chickens (Onbasilar et al., 2007). Some researchers showed that CL increased leg problems like tibial dyschondroplasia (Manser, 1996) as well as suppression of developmental stability (Moller et al., 1995). Therefore, the broiler producers must consider several critical factors in the design of a lighting program.

Moreover, very few studies have been done to examine the effect of different lighting schedules by using various vegetable protein sources interaction on the performance of broiler chickens. Therefore, this experiment was intended to investigate the effects of different lighting programs on the performance of broiler and to find most suitable vegetable protein sources that could be used in broiler diets.

2. Materials and methods

2.1 Experimental site, design, animals and management

The experiment was conducted at the University of Veterinary Science, Yezin, Nay Pyi Taw, Myanmar. A randomized complete block design (RCBD) was used in this experiment. A total of 270 day-old broiler chicks were individually weighed and randomly assigned into 9 experimental treatments, comprising a 3×3 factorial arrangement of three different vegetable protein sources and three different light regimes. Each treatment comprised 5 replicates and 6 chicks per replicate. Feed (twice a day: morning and evening by using feeder barrels) and drinking water were supplied ad libitum throughout the experimental period. On day 7, all chicks were vaccinated against Newcastle Disease and Infectious Bronchitis (Live ND+IB) via intraocular route and booster was done on day 21 in the same route of administration. On days 14 and 28, the chicks were vaccinated against Infectious Bursal Disease (IBD) by oral drop.

2.2 Experimental treatments

After determining the chemical composition of soybean meal (SBM), groundnut meal (GNM) and sesame meal (SSM), 3 experimental diets were formulated for chicks. The chicks were provided by three experimental starter diets such as Diet 1- 25% SBM, Diet 2- 25% GNM and Diet 3- 25% SSM from days 1 to 21. From days 22 to 49, the chicks were fed grower diets such as Diet 1- 20% SBM, Diet 2- 20% GNM and Diet 3- 20% SSM. The diets were formulated to maintain a constant ratio of energy and protein to meet the minimum requirements of NRC (1994). The SBM were purchased from local market, Yezin, which is imported from India. The rest of the ingredients were purchased from local market, Yezin. All experimental diets were isocaloric and isonitrogenous. The experimental period lasted for 7 weeks. Respective formulae for each diet are described in Tables 1 and 2.

All the birds were exposed to continuous lighting for the first 3 days. On the fourth day, the three light treatments such as L1- continuous light 23h light (L):1h dark (D) as control; L2- non-intermittent restricted light 8hL:16hD; and L3- intermittent light 1hL:2hD throughout 24 h were provided. Incandescent bulb (60 watt) from 0-21 days and fluorescent lamp from 22-49 days were used as artificial lighting regimes.

The 9 experimental treatments, comprising a 3×3 factorial arrangement of three different vegetable protein sources and three different light programs were T1- SBM + 23hL:1hD, T2- GNM + 23hL:1hD, T3- SSM + 23hL:1hD, T4- SBM + 8hL:16hD, T5- GNM + 8hL:16hD, T6- SSM + 8hL:16hD, T7- SBM + 1hL:2hD, T8 - GNM + 1hL:2hD and T9- SSM + 1hL:2hD respectively.

2.3 Measurements

Feed consumption was recorded daily. The residual feed was collected once daily before the morning feeding, then feed intake was calculated by subtracting the feed refusal from the quantity of feed offered. Body weight of birds was measured individually on a weekly basis. The feed conversion ratio (FCR) was calculated on a weekly basis.

On day 49, two birds from each replicate (10 birds per treatment) were randomly chosen and sacrificed in accordance with the ethical approval. The whole breast, thigh and drumstick meats were dissected and kept at -20̊ C until analysis. For crude protein (CP) content, nitrogen was determined by using Kjeldahl method (Foss 2100 Kjeldahl distillation unit) and calculated as 6.25×N (AOAC, 2005). The muscles were analysed for crude fat (CF) content by using the 2050 Soxtec Auto extraction unit, Foss Tecator. The general principles were according to AOAC (2005).

2.4 Statistical analysis

The data were analyzed according to ANOVA using general linear model (GLM) procedure of SAS® (SAS® institute, 2002) and SPSS 16.0 version (2007). The significant differences among treatments were determined at $P < 0.05$ by Duncan's Multiple Range Test (DMRT).

3. Results

3.1 Mean values of feed intake, body weight and FCR of broiler chickens

The mean values of feed intake, body weight and FCR of broiler chickens affected by different vegetable protein sources and lighting programs are shown in Table 3. There were no significant differences ($P > 0.05$)

Table 1. Composition and calculated nutrient contents of starter ration for broiler chicks (from 1 to 21 days of age)

Ingredients	Diet 1	Diet 2	Diet 3
Maize	53	53.5	55
Rice bran	7	5.5	3.5
Broken rice	5.6	6.6	4.1
Soybean meal	25	-	-
Groundnut meal	-	25	-
Sesame meal	-	-	25
Fish meal	5	6	9
Oyster shell	1	1	1
Dicalcium phosphate	0.2	0.2	0.2
Premix	0.5	0.5	0.5
Lysine	0.1	0.1	0.1
Methionine	0.1	0.1	0.1
Fish oil	2.5	1.5	1.5
Total	100	100	100
Calculated nutrient composition			
ME (kcal/kg)	3113.8	3074.4	3002.4
CP (%)	21.79	21.56	21.03
Energy protein ratio	142.88	142.63	142.76

Table 2. Composition and calculated nutrient contents of grower ration for broiler chicks (from 22 to 49 days of age)

Ingredients	Diet 1	Diet 2	Diet 3
Maize	57	54	56
Rice bran	6	8	5
Broken rice	8.6	8.6	6.6
Soybean meal	20	-	-
Groundnut meal	-	20	-
Sesame meal	-	-	20
Fish meal	4	5	8
Oyster shell	1	1	1
Dicalcium phosphate	0.2	0.2	0.2
Premix	0.5	0.5	0.5
Lysine	0.1	0.1	0.1
Methionine	0.1	0.1	0.1
Fish oil	2.5	2.5	1.5
Total	100	100	100
Calculated nutrient composition			
ME (kcal/kg)	3157.5	3156.8	3101.2
CP (%)	19.30	19.17	19.07
Energy protein ratio	163.58	164.66	162.67

among the feed intake of broilers fed three different dietary treatments. However, there were significant differences (P < 0.001) between the body weight and FCR of broiler chickens fed three different vegetable protein sources. The body weight of broiler fed SSM was significantly highest (P < 0.001) among all treatments, and SBM was significantly higher (P < 0.001) than that of group fed GNM. The FCR of broilers fed SSM and SBM were not significantly different (P > 0.05) but both were significantly better (P < 0.001) than that of group fed GNM. Moreover, the feed consumption, body weight and FCR of broilers were not significantly different (P > 0.05) among three different lighting programs. No significant interaction (P > 0.05) between dietary treatments and lighting programs was observed.

Table 3. Mean values of feed intake, body weight and FCR of broiler chickens affected by three different diets and three different lighting programs

	Dietary treatments (Mean±SEM)			Significant level	Diet× Light[1]
	SBM	GNM	SSM		
Feed intake	3118.86±20.39[a]	3187.86±40.05[a]	3207.75±42.16[a]	NS	
Body weight	1951.31±36.68[b]	1819.57±26.98[c]	2102.71±47.82[a]	***	
FCR	1.61±0.033[b]	1.76±0.027[a]	1.53±0.028[b]	***	NS
	Lighting treatments (Mean±SEM)			Significant level	
	23hrL:1hrD	8hrL:16hrD	1hrL:2hrD		
Feed intake	3142.55±36.28[a]	3156.04±35.56[a]	3215.91±33.28[a]	NS	
Body weight	1934.65±47.61[ab]	1913.51±35.79[ab]	2025.43±55.23[a]	NS	
FCR	1.61±0.037[a]	1.67±0.037[a]	1.60±0.037[a]	NS	

1 : Interaction between diet and light
NS : Not significantly different (P > 0.05)
*** : Significantly different at 0.001% level (P < 0.001)

3.2 Mean values of crude protein and crude fat (%) of breast, thigh and drumstick meats of broiler chickens

There were no significant differences (P > 0.05) in CP and CF (%) of breast, thigh and drumstick meats among different vegetables protein sources and lighting programs (Tables 4 and 5). Significant interaction (P > 0.05) between dietary treatments and lighting programs was not observed.

3.3 Cumulative feed intake

The effect of 9 treatments on cumulative feed intake of broiler chickens is shown in Table 6. The feed intake of broilers treated with T9 had the highest and T4 had the lowest. The feed intake of broilers treated with T9 did not differ significantly (P > 0.05) from that of groups treated with T2, T5, T6 and T7 but was significantly higher (P < 0.05) than that of groups treated with T1, T3, T4 and T8. The feed intake of broilers treated with T2, T5, T6 and T7 did not differ significantly (P > 0.05) from that of groups treated with T1, T3 and T8 but was significantly higher (P < 0.05) than that of group treated with T4. The feed intake of broilers treated with T1, T2, T3, T4, T6, T7 and T8 did not differ significantly (P > 0.05).

3.4 Cumulative feed conversion ratio

The effect of 9 treatments on cumulative FCR of broiler chickens is shown in Table 6. The FCR of broilers treated with T9 did not differ significantly (P > 0.05) from that of group treated with T3 but was significantly narrower (P < 0.05) than that of groups treated with T1, T2, T4, T5, T6, T7 and T8. The FCR of broilers treated with T3 did not differ significantly (P > 0.05) from that of group treated with T6 but was significantly narrower (P < 0.05) than that of groups treated with T1, T2, T4, T5, T7 and T8. The FCR of broilers treated with T6 did not differ significantly (P > 0.05) than that of group treated with T7 but was significantly narrower (P < 0.05) than that of groups treated with T1, T2, T4, T5 and T8. The FCR of broilers treated with T7 did not differ significantly (P>0.05) from that of groups treated with T1 and T4 but was significantly narrower (P < 0.05) than that of groups treated with T2, T5 and T8. The FCR of broilers treated with T8 was significantly narrower (P < 0.05) than that of groups treated with T2 and T5. There was no significant difference (P > 0.05) between the cumulative FCR of broilers treated with T2 and T5.

3.5 Final body weight (on day 49)

The effect of 9 treatments on final body weight of broiler chickens on day 49 is shown in Table 6. The final body weight of broilers treated with T9 had the highest body weight and T5 had the lowest body weight. The final body weight of broilers treated with T9 was significantly higher (P < 0.05) than that of groups treated with T1, T2, T3, T4, T5, T6, T7 and T8. The final body weight of broilers treated with T3 was significantly higher (P < 0.05) than that of groups treated with T1, T2, T4, T5, T6, T7 and T8. The final body weight of broilers treated with T6 was significantly higher (P < 0.05) than that of groups treated with T1, T2, T4, T5, T7 and T8. The final body weight of broilers treated with T7 was significantly higher (P < 0.05) than that of groups treated with T1, T2, T4, T5 and T8. The final body weight of broilers treated with T1 was significantly higher (P < 0.05) than that of groups treated with T2, T4 and T5. The final body weight of broilers treated with T4 was significantly higher (P<0.05) than that of groups treated with T2, T5 and T8. The final body weight of broilers treated with T8 was significantly higher (P < 0.05) than that of groups treated with T2 and T5. The final body weight of broilers fed T2 was significantly higher (P < 0.05) than that of group treated with T5.

Table 4. Mean values of crude protein (%) of breast, thigh and drumstick meats of broiler chickens affected by three different diets and three different lighting programs

Crude protein (%)	Dietary treatments (Mean±SEM)			Significant level	Diet× Light[1]
	SBM	GNM	SSM		
Breast	79.17±0.79[a]	80.34±1.01[a]	80.31±1.17[a]	NS	
Thigh	77.57±0.95[a]	76.29±0.75[a]	75.79±1.33[a]	NS	
Drumstick	76.88±0.89[a]	76.48±0.92[a]	75.61±1.03[a]	NS	
Crude protein (%)	**Lighting treatments (Mean±SEM)**			**Significant level**	NS
	23hrL:1hrD	8hrL:16hrD	1hrL:2hrD		
Breast	79.39±1.28[a]	80.35±0.77[a]	80.07±0.87[a]	NS	
Thigh	77.76±1.09[a]	76.29±1.06[a]	77.76±1.02[a]	NS	
Drumstick	76.10±0.87[a]	76.27±0.69[a]	76.59±1.24[a]	NS	

1 : Interaction between diet and light

NS : Not significantly different (P > 0.05)

Table 5. Mean values of crude fat (%) of breast, thigh and drumstick of broiler chickens affected by three different diets and three different lighting programs

Crude fat (%)	Dietary treatments (Mean±SEM)			Significant level	Diet× Light[1]
	SBM	GNM	SSM		
Breast	6.38±1.49[a]	5.10±0.79[a]	5.75±0.66[a]	NS	
Thigh	8.70±0.86[a]	10.09±1.22[a]	11.92±1.02[a]	NS	
Drumstick	10.03±0.66[a]	10.75±1.56[a]	11.09±0.76[a]	NS	
Crude fat (%)	**Lighting treatments (Mean±SEM)**			**Significant level**	NS
	23hrL:1hrD	8hrL:16hrD	1hrL:2hrD		
Breast	6.26±1.09[a]	5.71±1.14[a]	5.26±1.01[a]	NS	
Thigh	11.47±1.38[a]	9.38±1.29[a]	9.86±1.21[a]	NS	
Drumstick	11.13±1.01[a]	9.96±1.13[a]	10.78±0.92[a]	NS	

1 : Interaction between diet and light

NS : Not significantly different (P > 0.05)

Table 6. Cumulative feed intake, FCR and final body weight (g/bird) of broiler chicks

Treatment	Mean±SEM		
	Cumulative feed intake	Cumulative FCR	Final body weight
T1	3114.33±29.19^{bc}	1.61±0.08^{c}	1942±58.70^{e}
T2	3189.07±75.19^{abc}	1.76±0.04^{a}	1813±72.04^{h}
T3	3124.25±80.51^{bc}	1.53±0.07^{ef}	2049±90.24^{f}
T4	3046.70±20.29^{c}	1.62±0.09^{c}	1886±46.96^{f}
T5	3195.63±74.52^{ab}	1.79±0.03^{a}	1812±22.84^{i}
T6	3173.90±46.34^{abc}	1.56±0.05^{de}	2042±61.86^{c}
T7	3195.63±19.29^{abc}	1.58±0.08^{cd}	2026±69.23^{d}
T8	3127.01±40.47^{bc}	1.71±0.03^{b}	1834±41.77^{g}
T9	3325.09±67.55^{a}	1.51±0.03^{f}	2216±84.81^{a}

$^{a-i}$ Means within a column with no common superscripts differ at P < 0.05.
T1= SBM + 23hL:1hD, T2= GNM + 23hL:1hD, T3= SSM + 23hL:1hD, T4= SBM + 8hL:16hD, T5= GNM + 8hL:16hD
T6= SSM + 8hL:16hD, T7= SBM + 1hL:2hD, T8= GNM + 1hL:2hD, T9= SSM + 1hL:2hD

Table 7. Effect of three different vegetable protein sources and three different lighting programs on crude protein and crude fat contents (%) of breast, thigh and drumstick meats of broiler chickens

Treatment	CP content (Mean ± SEM)			CF content (Mean ± SEM)		
	Breast	Thigh	Drumstick	Breast	Thigh	Drumstick
T1	80.16±0.89^{a}	77.69±0.90^{a}	77.16±1.53^{ab}	6.29±3.19^{a}	9.57±1.48^{ab}	11.06±3.01^{a}
T2	78.79±2.38^{a}	74.05±1.41^{a}	73.63±0.53^{b}	5.98±1.12^{a}	10.56±2.12^{ab}	9.89±1.74^{a}
T3	79.24±3.25^{a}	75.68±2.87^{a}	77.52±1.64^{ab}	6.49±1.07^{a}	14.28±3.21^{a}	12.43±1.85^{a}
T4	78.26±1.72^{a}	75.41±1.77^{a}	76.63±1.57^{ab}	5.58±2.92^{a}	8.17±1.74^{ab}	8.57±3.55^{a}
T5	80.49±0.80^{a}	78.08±1.19^{a}	75.81±1.02^{ab}	5.39±1.63^{a}	10.77±2.46^{ab}	10.22±0.93^{a}
T6	82.30±0.69^{a}	75.41±1.19^{a}	76.37±1.24^{ab}	6.17±1.54^{a}	9.19±2.73^{ab}	11.07±1.02^{a}
T7	79.10±1.77^{a}	79.61±1.81^{a}	76.84±1.05^{ab}	7.28±2.69^{a}	8.37±1.82^{ab}	10.46±0.69^{a}
T8	81.74±1.37^{a}	77.41±1.39^{a}	80.00±2.16^{a}	3.93±1.19^{a}	8.94±1.71^{ab}	12.12±2.62^{a}
T9	79.38±1.39^{a}	76.27±2.07^{a}	72.95±2.04^{b}	4.56±0.73^{a}	12.27±2.20^{ab}	9.76±0.85^{a}

$^{a-b}$ Means within a column with no common superscripts differ at P < 0.05.
T1= SBM + 23hL:1hD, T2= GNM + 23hL:1hD, T3= SSM + 23hL:1hD, T4= SBM + 8hL:16hD, T5= GNM + 8hL:16hD
T6= SSM + 8hL:16hD, T7= SBM + 1hL:2hD, T8= GNM + 1hL:2hD, T9= SSM + 1hL:2hD

3.6 Crude protein and crude fat contents (%) of breast, thigh and drumstick meats of broiler chickens

The CP and CF contents of breast, thigh and drumstick meats of broiler chickens by 9 treatments on day 49 are shown in Table 7. No significant effect of treatments was observed in CP content of breast and thigh meats of broilers. The CP of drumstick meat of broiler chickens by T8 did not differ significantly (P > 0.05) from that of groups by T1, T3, T4, T5, T6 and T7 but it was significantly higher (P > 0.05) than that of groups treated by T2 and T9. The CP content of drumstick meat of broilers by T1, T2, T3, T4, T5, T6, T7 and T9 did not differ significantly (P > 0.05). The CF contents of breast, thigh and drumstick meats were not significantly different (P > 0.05) among all treatments.

4. Discussion

In the present study, the mean values of feed intake were not significant (P > 0.05) difference among three different vegetable protein sources. The result of this study was in agreement with the findings of Costa et al. (2000) who indicated that the feed intake of broilers fed 20% GNM diets was comparable to those fed the same level of SBM diets. Yamauchi et al. (2006) also reported that there was not significant (P > 0.05) difference between the feed intake of broiler chickens fed 20% SBM and SSM diets.

In this study, the FCR of broiler chickens fed SSM diet was superior to that of broiler chickens fed SBM and GNM diets. Rahimi et al. (2013) also observed that SSM would have no detrimental effect on the growth performance with up to 20% dietary SSM. Moreover, GNM-fed broilers had decreased body weight and increased FCR compared to SBM-fed broilers in present study. These observations are similar to the reports by Costa et al. (2000).

Regarding with final body weight, the results from the present study showed that broiler chicks fed SSM had significantly higher final body weight than those fed other diets. The present results are in agreement with the findings of Yasothai et al. (2009) who investigated that the inclusion level of SSM (up to 15%) in broiler ration was found to be advantageous without affecting weight gain. This improvement may be due to the biological functions of SSM to improve growth (Rahimian et al., 2013). The results of this research showed that the broiler chicks fed SBM was in the second place and that of those fed GNM had the lowest body weight. These findings are in close agreements with Ghadg et al. (2009) who indicated that the final body weight of birds fed with GNM alone as vegetable protein source had lowest body weight. Soybean meal as a sole protein source was superior in final body weight than that of GNM (Achi et al., 2007).

Moreover, the mean values of feed intake, body weight and FCR were not significant ($P > 0.05$) difference among three different lighting programs in this study. These observations are similar to reports by Buckland et al. (1976); Ohtani and Leeson (2000); and Li et al. (2010). However, the cumulative feed intake of broiler chickens under intermittent light had significantly higher than that of continuous light and non-intermittent restricted light groups. This is in agreement with the findings of Rahimi et al. (2005) who reported that the lowest value of feed intake was obtained in the non-intermittent restricted light group compared to the continuous or intermittent light groups. Ohtani and Tanaka (1998) observed that IL chickens rushed at feeders and vigorously competitively ate at one time just after the initiation of lighting periods, whereas CL chickens showed little excitement at eating. They also concluded that, in IL chickens, the upper digestive tract might have been empty during the period of darkness, and birds were immediately again ready to eat when lights came on. Buyse and Decuypere (1988) also reported that under IL, chickens eat about 80% of their total feed intake during the light period and eat little during the dark period. This rhythm might exert some influence on intake and digestibility of feed in chickens subjected to IL.

In this experiment, the cumulative FCR of intermittent light was significantly better ($P < 0.001$) than CL and non-intermittent restricted light. Feed to gain ratio of chickens reared under intermittent light was better than the continuous light chickens because of the short meal feeding period, followed by a larger period for digesting the meal. It was in agreement with the findings of Ombasilar et al. (2007). The results are also in line with the findings the Barrot and Pringle (1951), Bean et al. (1962). Buckland et al. (1971), Hooppaw and Goodaman (1972), and Quarles and Kling (1974) observed that the FCR of chick grown under various intermittent light schemes was significantly better than those grown under CL. This result could be due to low physical activity and energy expenditure of the chickens raised under restricted light programs. The reduction of activity during darkness may result in lower heat production and higher feed efficiency (Rahimi et al., 2005).

In the present study, broiler chickens exposure to a non-intermittent restricted light (8hL:16hD) reduced the body weight compared to the other two lighting programs. This finding was in agreement with the results of Abbas et al. (2008). Long dark period in a non-intermittent restricted light, could be a stress and a main factor inducing elevation in corticosterone level. Corticosterone is a key player in increasing pro-inflammatory cytokines. Johnson (1997) reported that pro-inflammatory cytokines, inhibits growth by modulating the intermediary metabolism of carbohydrate, fat and protein substrates. The reduction of live body weight with prolonged exposure to darkness might be due to decreased duration of feed consumption (Renden et al., 1993), which implies that the 8hL:16hD lighting program was not sufficient to allow birds to achieve their growth potential.

Moreover, body weight of chickens reared under intermittent light was higher than the continuous light groups in this experiment. The results of the present study are in accordance with the finding of

Ohtani and Leeson (2000) who reported that the intermittent light (1hL:2hD) chickens showed superior body weight gain than the continuous light. Many studies also reported that the weight gained by the bird when kept under IL was significantly better than on CL (Buckland and Hill, 1970; Buckland et al., 1971; Malone et al., 1980). It might be due to the broilers eat satiation in the light period and then do not expand much energy during dark period in the intermittent lighting program (Ingram and Hatten, 2000).

In this study, the crude protein and crude fat contents of breast, thigh and drumstick meats were not significant (P>0.05) difference between different vegetable protein sources and lighting programs. This is consistent with the finding of Nikolakakis et al. (2014) who reported that meat quality of broilers did not differ between the diets including different levels of SSM (0%, 5%, 10%). However, meat quality under different lighting programs was in contrast with other studies. They mentioned that intermittent lighting was found to enhance protein content of breast meat in 6 week-old broiler chickens when compared with CL because IL promoted the retention of nitrogen (Buyse et al., 1996; Li et al., 2010).

It was noticeable that no interaction was observed between three different vegetable protein sources and three different lighting programs, thus those two main effects were remain independently.

5. Conclusions

The intermittent lighting program enhances the production performance of broiler chickens when compared with continuous or a non-intermittent restricted lighting program. For dietary treatments, sesame meal had better performance than other two vegetable protein meals and it can be used at 20% level without adverse effects on the productive performance of broiler chickens. Moreover, the combination treatment of sesame meal and intermittent lighting schedule improved feed intake, body weight and FCR of broiler chickens. Therefore, it can be concluded that use of the combination of sesame meal diet and intermittent light program (1hL:2hD) is the most beneficial among all the treatments.

Conflict of interest

All authors have approved the submission of this manuscript and do declare that there is no conflict of interest. The manuscript has not been published previously and is not under consideration for publication elsewhere.

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