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Effect of linseed or black cumin meal replacement in laying hen diet on egg production, quality, fatty acid composition and some blood parameters

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Several efforts showed that linseed or black cumin meal is a good supplement for growing laying hen without any adverse effect on organs. One hundred twenty 28-wk-old Hi-sex brown laying hens were randomly classified into 5 equal groups of 6 replicate (4 birds each). The 1st group feeding the basal diet and served as control group (G1). The other four groups (2nd – 5th) feeding the basal diet at 25% replacement of soybean meal (SBM) by linseed meal (LSM), the basal diet at 50% replacement by (LSM), the basal diet at 25% replacement by black cumin meals (BCM) and the basal diet at 50 % replacement by (BCM), respectively till age 12 wks. Feeding hens the replacement by LSM or BCM at the two levels used significantly decreased the egg production by 4%, 11%, 3 and 14%, respectively, compared to the control group. The 3rd and 5th treatment significantly decreased the feed intake by 5% and 8%, respectively, compared to the control group. The 2nd and 3rd treatment significantly increased the egg albumin by 3% and 8%, the yolk % by 8% and 5%, respectively, compared to the control group. Feeding hens the replacement by LSM or BCM at the two levels used significantly decreased the cholesterol level by 13% and 32% or by 28% and 17%, respectively, compared to the control group. The 2nd treatment significantly decreased the albumen by 24%, the globulin by 24%, respectively, compared to the control group. The 2nd, 3rd and 5th treatments significantly decreased the triglycerides by 18%, 24% and 19% respectively, compared to the control group. The 2nd and 5th treatments significantly increased the unsaturated fatty acid of palmitoleic acid by18 and 14% as well as significantly decreased the saturated fatty acid of stearic acid by 14 and 18%, respectively, compared by the control group.

Keywords: Hi-sex brown laying, linseed meal, black cumin meal, egg production, egg quality, egg yolk fatty acid composition and some blood parameters.

INTRODUCTION

Soybean meal is becoming increasingly expensive and the diet price remains the greatest item that limits the profits margin in poultry industry. The search for alternatives is the best strategy to reduce those costs. Linseed meal or (BCM) have potential low-cost protein sources as well as their roles to improve nutritional and health status are underutilized for poultry diets (Al-Jasass and Al-Jasser 2012). Flax, *Linum usitatissimum.* (Linaceae), extensively cultivated in ancient Egypt, where the temple walls had paintings of flowering flax, and mummies were entombed in linen (Sekhri 2011). Linseed meal is one of several forms which contains the highest content of dietary fibers in common forms of linseed (Bassett et al. 2009). Linseed meal contains biologically active substances, such as lignans secoisolariciresinol diglucoside (SDG) which is converted to the mammalian lignans enterodiol and enterolactone as anti-carcinogenic by ruminal microbiota (Gagnon et al. 2009) and linoleic acid, which are believed to provide cardioprotective effects (Prim et al. 2012) in addition to its ability to induce sex hormone binding globulin to act as antioxidants (Wang 2002).

Black cumin seeds, *Nigella sativa L*. belonging to (Ranunculaceae) family, widely grown in the Mediterranean countries (Venkatachallam et al. 2010), that has extensively used for the treatment of asthma, cough, bronchitis, headache, rheumatism, fever, kidney and liver disorders, influenza, eczema, and as a diuretic, lactagogue, carminative and vermifuge (Khattak and Simpson 2008) and has an phenolic profile, antioxidant and diuretic effects (Toma et al. 2015) as well as demonstrates anti- parasitic effects (El Shenawy et al. 2008). Long chain fatty acids and medium chain fatty acids in black cumin seed have been reported to increase oral bioavailability of peptides, antibiotics, and other important therapeutic agents (Ali et al. 2015). Black cumin oil being rich at lenoleic fatty acid (Al-Jasass and Al-Jasser 2012).

Our hypothesis that, the commercial table eggs contain a high proportion of ω-6 polyunsaturated fatty acids (PUFAs) and dietary cholesterol but are poor source of ω-3 fatty acids (Simopoulos and Salem 1992), therefore the properties of hen eggs could be modified in a favorable way by altering the fatty acid composition of yolk lipids through manipulation of laying hen diets (Jiang and Sim 1992) by using some rich sources of ω-3 fatty acids as FSM or BSM (Martínez et al. 2013).

This study aimed to evaluate the effects of soybean meal replacement at 25 and 50% levels by linseed meal or black cumin meals on egg production, egg quality, egg fatty acid composition and some blood parameters in Hi-sex brown laying hens

MATERIALS AND METHODS

This experiment was carried in Nubaria research and production station, National Research Centre and was conducted to study the substitute replacement effect of 25 and 50% levels of SBM by LSM or BSM in laying hens diets. One hundred twenty, 28-weeks old, Hi-sex brown-egg type hens housed in individual wire cages, and divided into 5 equal treatments (groups) of 24 hens, 6 replicates each. All hens were kept under the same managerial hygienic and environmental temperature which ranged from (35–38 ºC) and humidity (40-60%) during over all the experimental intervals 3 periods, 4 weeks each. Also, the lighting schedule was 16 h light: 8h dark/day. Hens received an iso-caloric and iso-nitrogenous (2800 ME Kcal/kg and 18% CP) basal diet (Table 1), balanced to meet requirements of laying hens (NRC, 1994). Flaxseed was grinded and defatted by cold-pressing which contained approximately 10% of flaxseed oil.

The five experimental groups (treatments) were classified as follow: Group 1 basal diet with no replacement and served as (G1), group 2 basal diet with 25% replacement of SBM by LSM (G2), group 3 basal diet with 50% replacement of SBM by LSM (G3), group 4 basal diet with 25% replacement of SBM by BCM (G4) and group 5 basal diet with 50% of (SBM) with BCM (G5).

Feed and water were offered *ad-libitum*. Egg weight (EW) and egg number (EN) were recorded daily. Feed intake (FI) was recorded weekly, while feed conversion ratios (FCR) were calculated. Egg quality parameters were measured using 30 eggs (6 eggs/each group), these involved yolk, albumen, egg shell weight (%). Egg shell thickness was measured in mm using a micrometer. Egg shape index was calculated as egg diameter divided by an egg length. Yolk index was calculated as yolk height divided yolk diameter. Haugh unit was calculated using the calculation chart for rapid conversion of egg weight and albumen height.

Blood samples were collected in tubes from the brachial vein (5 hens /group), and centrifuged at 3000 rpm for 15 minutes to separate clear serum which stored at 20ºC for determination of some blood constituents as aspartate transaminases (AST), alanine transaminase (ALT), total lipids (TL), cholesterol, triglyceride (TG) and total protein by spectrophotometer using available commercial kits. Some of the either of polyunsaturated fatty acids (PUFAs) and saturated fatty acids concentration was determined in egg yolk by using a portion of the yolk which powdered and approximately 10 mg of the powder used for extraction in liquid nitrogen by using chloroform and methanol (Burdge et al. 2000). Data were analyzed using general linear model (GLM) procedure of statistical system (SPSS, 1997). Duncan's Multiple Range Test (1955) was used to separate means when the dietary treatment effect was significant.

RESULTS AND DISCUSSION

Effect of LSM or BSM replacement on hen productive performance

Table (1): Composition of the experimental diets.

Ingredient %	Experimental Treatments				
	Control (T1)	25% Linseed meal (T2)	50% Linseed meal (T3)	25% cumin seed meal (T4)	50% cumin seed meal (T5)
Yellow corn	63.5	58.0	53.3	60.0	58.0
Soybean meal (44%)	20.0	15.0	10.0	15.0	10.0
Linseed meal[1]	-	5.0	10.0	-	-
Black Cumin seed meal[2]	-	-	-	5.0	10.0
Corn glutein meal	5.5	6.5	8.0	6.3	7.4
Wheat bran	1.8	6.3	9.5	4.5	5.4
Di-Ca-Phosphate	1.0	1.0	1.0	1.0	1.0
Limestone	7.5	7.5	7.5	7.5	7.5
Sodium chloride	0.5	0.5	0.5	0.5	0.5
Vit. & Min. mixture[3]	0.2	0.2	0.2	0.2	0.2
Calculated CP	18.05	17.94	18.08	18.08	17.95
ME, kcal/ kg DM	2805	2800	2815	2781	2796

[1-] Linseed meal contain 24 % crude protein; 3960 ME / kg; 0.89 % lysine; 0.44 % methionine; 0.87 % methionine + cysteine ; 0.28 % calcium; 0.55 % available phosphorus; 2.3 % sodium; 6.3 % crude fiber; 35.9 % crude fat; 5.39 % Linoleic acid; 16.8 % Linolenic acid (Ensminger et al, 1990; Vaisey – Genser, 1994).

[2-] Cumin seed meal contain 30.14 % crude protein; 2963 DE / kg ()

[3-]Vit. & Min. mixture: Each kilogram of Vit. & Min. mixture contains: 2000.000 IU Vit. A, 150.000 IU Vita. D, 8.33 g Vit. E, 0.33 g Vit. K, 0.33 g Vit. B1, 1.0 g Vit. B2, 0.33g Vit. B6, 8.33 g Vit.B5, 1.7 mg Vit. B12, 3.33 g Pantothenic acid, 33 mg Biotin, 0.83g Folic acid, 200 g Choline chloride, 11.7 g Zn, 12.5 g Fe, 16.6 mg Se, 16.6 mg Co, 66.7 g Mg and 5 g Mn.

Table (2): Productive performance of laying hens as affected by LSM or BSM containing diets.

Item	Total No. of egg/hen/period	Egg production %	A. egg weight (g)	Egg mass (g)	Feed intake/hen/day (g)	Feed conversion (ratio)
			1st Period			
Control	25.56[a]	85.19[a]	59.55	1519.5[a]	121.4[a]	2.40[ab]
25% Linseed meal	24.78[a]	82.59[a]	61.39	1522.3[a]	121.1[ab]	2.39[ab]
50% Linseed meal	22.50[b]	75.00[b]	62.55	1406.8[b]	113.8[b]	2.42[ab]
25% cumin seed meal	25.44[a]	84.81[a]	60.15	1530.8[a]	117.8[ab]	2.31[b]
50% cumin seed meal	22.17[b]	73.89[b]	62.41	1382.8[b]	116.1[ab]	2.52[a]
Overall mean ± SE	24.09 ± 0.32	80.30 ± 1.06	61.21 ± 0.50	1472.4± 8.12	118.0 ± 1.12	2.41 ± 0.02
			2nd Period			
Control	28.33[a]	94.44[a]	60.33[b]	1706.0[a]	134.3[bc]	2.36[b]
25% Linseed meal	27.00[a]	90.00[a]	63.16[ab]	1704.9[a]	140.6[ab]	2.47[ab]
50% Linseed meal	24.83[b]	82.78[b]	63.08[ab]	1566.8[b]	130.6[cd]	2.51[a]
25% cumin seed meal	27.56[a]	91.85[a]	63.89[a]	1760.3[a]	145.5[a]	2.48[ab]
50% cumin seed meal	23.72[b]	79.07[b]	61.11[ab]	1450.2[b]	124.7[d]	2.58[a]
Overall mean ± SE	26.29 ± 0.38	87.63 ± 1.26	62.32 ± 0.75	1637.6±25.47	135.1 ± 1.63	2.48 ± 0.02

3rd Period						
Control	28.00^{a}	93.33^{a}	63.15^{ab}	1767.2^{a}	148.5^{a}	2.53^{ab}
25% Linseed meal	26.94^{ab}	89.81^{ab}	66.78^{a}	1797.5^{a}	139.3^{ab}	2.33^{c}
50% Linseed meal	25.67^{bc}	85.56^{bc}	64.95^{a}	1668.0^{a}	139.6^{ab}	2.52^{ab}
25% cumin seed meal	26.44^{ab}	88.15^{ab}	66.10^{a}	1747.2^{a}	140.3^{a}	2.41^{bc}
50% cumin seed meal	24.50^{c}	81.67^{c}	60.37^{b}	1479.0^{b}	130.1^{b}	2.65^{a}
Overall mean ± SE	26.31 ± 0.31	87.70 ± 1.04	64.27 ± 0.75	1691.8±28.91	139.6 ± 1.67	2.49 ± 0.03
Whole Period						
Control	81.89^{a}	90.99^{a}	61.04	4992.7^{a}	134.7^{a}	2.43^{b}
25% Linseed meal	78.72^{b}	87.47^{b}	63.83	5024.7^{a}	133.7^{a}	2.40^{b}
50% Linseed meal	73.00^{c}	81.11^{c}	63.57	4641.7^{b}	128.0^{b}	2.49^{b}
25% cumin seed meal	79.44^{b}	88.27^{b}	63.42	5038.3^{a}	134.5^{a}	2.40^{b}
50% cumin seed meal	70.39^{d}	78.21^{d}	61.24	4312.0^{c}	123.6^{b}	2.58^{a}
Overall mean ± SE	76.69 ± 0.85	85.21 ± 0.94	62.62 ± 0.48	4801±0.62.77	130.9 ± 1.05	2.46 ± 0.08

a,b,c,d: In each column means having different superscripts are significantly different ($p<0.05$).

Table (3): Egg quality criteria of laying hens as affected by LSM or BSM containing diets.

Item	A. of Egg Weight	Shell Index %	Yolk index%	Haugh Unit	Yolk Colour	Shell Thickness/ mm	Albumin%	Yolk %	Shell %
1st Period									
Control	62.17	77.94	45.42 a	84.67	4.67	37.33	61.70	26.77 a	11.53
25% Linseed meal	63.67	78.00	44.21 ab	82.83	4.33	40.00	63.70	24.31 b	12.00
50% Linseed meal	60.50	77.05	42.14 b	82.67	4.33	38.33	64.08	24.01 b	11.91
25% cumin seed meal	60.50	77.01	44.64 ab	84.67	5.00	39.17	62.73	24.90 ab	12.37
50% cumin seed meal	59.17	78.83	42.66 ab	81.50	4.83	38.50	61.98	25.58 ab	12.44
Overall mean ± SE	61.2±0.67	77.8±0.38	43.8±0.42	83.3±1.36	4.6±0.23	38.7±0.48	62.8±0.37	25.1±0.36	12.1±0.14
2nd Period									
Control	63.33	78.90	39.52	76.00 a	4.67 a	38.50 b	61.27 b	26.44 a	12.28
25% Linseed meal	64.00	79.42	39.75	70.67 ab	3.67 b	39.17 ab	63.63 a	23.94 b	12.43
50% Linseed meal	66.50	78.36	38.07	65.50 b	2.67 c	38.33 b	62.97 ab	25.16 ab	11.87
25% cumin seed meal	63.50	76.36	39.96	71.00 ab	3.67 b	41.67 a	63.47 a	24.04 b	12.49
50% cumin seed meal	61.33	79.71	41.16	75.67 a	3.67 b	40.17 ab	62.59 ab	25.00 ab	12.41
Overall mean ± SE	63.7±0.90	78.6±0.66	39.7±0.85	71.8±1.27	3.7±0.15	39.6±0.46	62.8±0.33	24.9±0.29	12.3±0.12
3rd Period									
Control	63.00	81.11	37.64	78.17	5.67 a	43.17 a	62.06	25.61	12.33
25% Linseed meal	66.17	80.97	41.58	79.00	5.17 ab	38.33 ab	63.64	24.64	11.72
50% Linseed meal	64.50	80.38	41.14	79.17	4.67 b	36.17 b	62.98	25.48	11.54
25% cumin seed meal	63.33	79.02	39.89	76.50	5.00 ab	39.50 ab	63.23	24.68	12.09

50% cumin seed meal	62.17	82.18	40.98	75.33	4.83^{b}	38.50^{ab}	62.72	24.94	12.34
Overall mean ± SE	63.8±0.68	80.7±0.60	40.3±0.69	77.6±1.24	5.1±0.13	39.1±0.81	62.9±0.27	25.1±0.25	12.0±0.18
Whole Period									
Control	62.83	79.32^{ab}	40.86	79.61	5.00^{a}	39.67	61.68^{b}	26.27^{a}	12.05
25% Linseed meal	64.61	79.46^{ab}	41.85	77.50	4.39^{ab}	39.17	63.66^{a}	24.30^{b}	12.05
50% Linseed meal	63.83	78.60^{ab}	40.45	75.78	3.89^{b}	37.61	63.34^{a}	24.88^{b}	11.77
25% cumin seed meal	62.44	77.46^{b}	41.49	77.39	4.56^{ab}	40.11	63.14^{ab}	24.54^{b}	12.32
50% cumin seed meal	60.89	80.24^{a}	41.60	77.50	4.44^{ab}	39.06	62.43^{ab}	25.17^{ab}	12.40
Overall mean ± SE	62.9±0.59	79.0±0.34	41.2±0.42	77. 6±0.84	4. 5±0.11	39.1±0.40	62.9±0.24	25.0±0.21	12.1±0.12

a, b & c: In each column means having different superscripts are significantly different (p<0.05).

Table (4): Blood parameters criteria of laying hens as affected by LSM or BSM containing diets.

Item	AST	ALT	T. lipids	Cholesterol	T. G.	T. Protein	Albumen	Globulin	A/G ratio
Control	29.33	125.7	951.5	202.3^{a}	223.0^{a}	4.12^{ab}	1.86^{ab}	2.26^{a}	0.82
25% Linseed meal	32.00	122.7	864.4	175.3^{b}	192.0^{b}	3.14^{c}	1.41^{c}	1.73^{b}	0.82
50% Linseed meal	29.67	102.7	913.8	138.0^{d}	176.3^{a}	3.80^{abc}	1.73^{abc}	2.07^{ab}	0.84
25% cumin seed meal	26.00	112.7	856.1	146.7^{cd}	198.7^{ab}	3.50^{bc}	1.57^{bc}	1.93^{ab}	0.81
50% cumin seed meal	29.33	117.0	888.4	167.0^{bc}	189.0^{b}	4.31^{a}	1.99^{a}	2.35^{a}	0.85
Overall mean ± SE	29.27±1.19	116.1±4.40	894.8±17.85	165.9±6.57	195.8^{b} ±5.34	3.78 ±0.14	1.71 ±0.07	2.07±0.02	0.83±0.00

a,b & c: In each column means having different superscripts are significantly different (p<0.05).

Table (5): Fatty acids composition in egg yolk of laying hens as affected by LSM or BSM containing diets

Item	Saturated fatty acid					Unsaturated fatty acid				
	Myristic acid	Palmitic acid	Margaric acid	stearic acid	Arachc acid	Palmitoleic acid	Elaidic acid	Gondoic acid	Linoleic acid (CLA)	α-Linolenic acid
Lipid Numbers	**C14:0**	**C16:0**	**C17:0**	**C18:0**	**C20:0**	**C16:1** (ω−7)	**C18:1** (ω−9)	**C20:1** (ω−9)	**C18:2** (ω−6)	**C18:3** (ω−3)
Control	0.03[c]	28.74[a]	0.24[a]	12.11[a]	0.10	2.57[b]	36.19[d]	0.41[c]	13.48	1.59[c]
25% Linseed meal	0.07[ab]	25.34[b]	0.17[b]	10.47[b]	0.20	3.02[a]	43.18[bc]	0.67[b]	13.67	2.41[b]
50% Linseed meal	0.08[a]	23.60[cd]	0.10[c]	10.82[ab]	0.12	2.83[ab]	46.18[a]	0.92[a]	13.56	3.01[a]
25% cumin seed meal	0.06[b]	25.08[bc]	0.17[b]	11.87[a]	0.10	2.71[ab]	40.93[c]	0.72[b]	13.28	2.32[b]
50% cumin seed meal	0.08[a]	22.59[d]	0.12[bc]	9.99[b]	0.09	2.94[a]	44.11[ab]	0.96[a]	13.69	2.89[a]
Overall mean ± SE	0.06 ±0.01	25.07 ±0.48	0.16 ±0.01	11.05 ±0.24	0.12 ±0.04	2.81 ±0.06	42.12 ±0.78	0.73 ±0.05	13.54 ±0.14	2.44 ±0.11

a,b,c,d: In each column means having different superscripts are significantly different ($p<0.05$).

Birds received the replacement by LSM or BCM at the two levels used significantly decreased the egg production by 3.9%, 10.9%, 3.4 and 14.1% respectively, compared to the control group (Table 2). The 3rd and 5th treatment received the replacement by LSM or BCM at the 50% level significantly decreased the egg mass k/hen by 7% or 13.6% and the feed intake by 5% or 8.2% respectively, compared to the control group (Table 2). The 5th treatment received the replacement by BSM at the 50% level significantly decreased the efficiency of feed conversion by 6.2% compared to the control group (Table 2).

These significant decreasing effects with the replacement by LSM at the two levels used on the productive performance may be attributed to the high dose percent of lignan macromolecule acted as a delivery system of lignans (SDG) in the large intestine (Eeckhaut et al. 2008). In contrast, the low level of adding (Basmacioglu et al. 2003) or replacement (Bean and Leeson 2003) of flaxseed up to 4% to diets did not cause any negative effect on some egg quality criteria such as egg weight, yolk weight, yolk ratio, albumen weight, albumen ratio, shell weight, shell ratio, shell strength or shell thickness, feed intake and feed conversion (Basmacioglu et al. 2003)

While the benefits effects of the replacement by BCM may be due to the rich and diverse chemical composition including amino acids, proteins, carbohydrates, and crude fiber, oils minerals, alkaloids, saponin and others (Khoddami et al. 2011). Similar results showed that supplemented black cumin seed at level of 4% or 5% positively influenced egg production and egg weight (Khan et al. 2013).

Effect of LSM or BSM replacement on hen egg quality

The 3rd treatment received the replacement by LSM at the level of 50% significantly decreased the yolk colour by 22.2% compared to the control group (Table 3). The 2nd and 3rd treatment received the replacement by LSM at the two levels used significantly increased the egg albumin by 3.21% and 7.6%, the yolk % by 7.5% and 5.3% respectively, compared to the control group (Table 3). The 4th treatment received the replacement by BCM at the level of 25% significantly increased the yolk % by 6.6% compared to the control group (Table 3).

These results confirms that colour measurement of egg yolks by sensorial analysis panellists using the Roche colour fan revealed decreasing effect on this parameter which may be attributed to the high-fiber ratio with the two replacement levels used by LSM and BCM which considered a high levels of the replacement (Baeza et al. 2015).

Effect of LSM or BSM replacement on hen blood parameters

The four treatments received the replacement by LSM or BCM at the two levels used significantly decreased the cholesterol level by 13.3% and 31.7% or by 27.5% and 17.4% respectively, compared to the control group (Table 4). The 2nd treatment received the replacement by LSM at the level of 25% significantly decreased the albumen by 23.8%, the globulin by 23.5% respectively, compared to the control group (Table 4). The 2nd, 3rd and 5th treatments received the replacement by LSM at the two levels used and the replacement by BCM at the level of 50% significantly decreased the triglycerides by 17.6%, 24.4% and 18.9 %, respectively compared to the control group (Table 4).

The significant decrease of blood cholesterol, triglycerides, albumen and globulin as feeding diet supplemented with LSM may be attributed to its rich content of fiber, lignans that improving vascular reactivity (Dupasquier et al. 2006), inhibiting the progression of atherosclerosis (Dupasquier et al. 2007) and as promoting the regression of existing atherosclerotic plaques (Francis et al. 2013). In other words the more probable high fiber content is responsible for the cholesterol and triglyceride lowering actions (Harper et al. 2006) as well as triglyceride and high density lipoprotein (Basmacioglu et al. 2003), therefore flaxseed may be regarded as a useful therapeutic additive for reducing hyperlipidemia (Torkan et al. 2015). Similar results showed that the cholesterolemia and tissue lipid modulating properties of chicken eggs could be modified in a favorable way by altering the fatty acid composition of yolk lipids through manipulation of laying hen flaxseed diets (Jiang and Sim 1992). The significant decrease of cholesterol and triglycerides as feeding diet replacement with BCM may be due to the useful agent in improving fatty acids changes in blood by reducing hyperglycemia and an amelioration of associated dyslipidemia (Mohamed et al. 2015). Nigella sativa is an easily available to treat dyslipidemia (Asgary et al. 2015), and it's proposed multiple mechanisms of action may produce better hypolipidemic effects (Ibrahim et al. 2014).

Effect of LSM or BSM replacement on fatty acids composition in hen egg yolk

Birds received the replacement by LSM or BCM at the 2nd ,3rd, 4th and 5th groups significantly increased the egg unsaturated fatty acid of elaidic acid by 44.7, 8.3, 13.1 and 21.9%, the gondoic acid by 63.4, 124.4, 75.6 and 134.2%, the α-linolenic acid by 51.6, 89.3, 45.9 and 81.8% and the only one saturated fatty acid of myrisitic acid by 133, 167, 100 and 167% respectively, compared by the control group as well as significantly decreased the palmitic acid by 11.8, 21.7, 14.8 and 21.4% and the margaric acid by 29.2, 58.3, 29.2 and 50% respectively, compared by the control group (Table 5). The 2nd and 5th treatments received the replacement by LSM at the level of 25% or BCM at the 50% levels significantly increased the unsaturated fatty acid of palmitoleic acid by17.5 and 14.4% as well as significantly decreased the saturated fatty acid of stearic acid by 13.5 and 17.5% respectively, compared by the control group (Table 5).

The improvement of unsaturated fatty acid profile in egg yolk by the replacement by LSM or BCM that showed preferentially selective variety absorption of some fatty acids in egg yolk with LSM or BCM presented in experimental diets may be attributed to the biosynthesis of polyunsaturated fatty acids induced by the reaction of the driving factors in the fatty acid profile in egg yolk (Daley et al. 2010) by eliminate the gondoic acid , and elaidic acid that has ability to lowers HDL cholesterol (Abbey and Nestel 1994) and the longer chain ω-3 fatty acid α-linolenic acid that can only be obtained through diets because the absence of the required 12- and 15-desaturase enzymes makes de novo synthesis from stearic acid impossible and decrease the risk of cancer (Breanne and David 2009) as well as increased the myrisitic acid that acts as a lipid anchor in bio-membranes (Yaws and Carl 2009). The changes of the fatty acid profile in egg yolk at the replacement by LSM or BCM may be due to its antioxidant and anti-inflammatory properties (Seif 2014). The significant decrease in the egg yolk saturated fatty acids of palmitic acid that has hypercholesterolaemic effect if the intake of flaxseed oil is lower than 4.5% of the energy (French et al. 2002) and margaric acid that had ability at the optimum dose to lower insulin and triglycerides (Hansen et al. 1957) as induced by the reaction of the driving factors in the fatty acid profile in egg yolk.

CONCLUSION

In spite of the replacement of SBM by the LSM or BCM at the 25 and 50% level showed significant reduction in most of productive performance and egg quality criteria, while showed significant increase in most of unsaturated fatty acids profile as elaidic acid, gondoic acid, α-linolenic acid and only one saturated fatty acid of myrisitic acid as well as significantly decreased the saturated fatty acids of palmitic acid and the margaric acid in addition to the significant decrease of cholesterol and triglycerides values that confirms the importance of the replacement of SBM by LSM or BCM in improving public health in hen egg production. We recommend further studies using lower than those levels to avoid the high proportion of fiber.

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CONFLICT OF INTEREST

The present study was performed in absence of any conflict of interest.

AUTHOR CONTRIBUTIONS

Magda, M. Abdel Fattah and El Mallah, G. M designed, performed the experiments, the fatty acid profile and data analysis. ElAllawy, Hewida M and Ibrahim, Sh. A. M, performed the egg quality criteria, the blood parameters analysis, reviewed the manuscript and approved the final version.

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