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The Effect of Artichocke Leaves Meal on the Utilization of Dietary Energy for Broiler Chicks

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Abstract: The main target of this study was to evaluate artichoke leaves meal in broiler diets containing different energy levels (the strain requirement and lower energy level). In this study, a total number of 240 unsexed one day old Ross broiler chicks were distributed randomly and divided equally into eight experimental groups (in 3 replicates of 10 each). The experimental groups were 4 levels of artichoke leaves meal (0, 2, 4 and 6% of the diet, mainly of the corn) in each of two diets. The first diet contained the recommended strain requirement of energy (RE), while the second diet contained 200 kcal ME /kg diet lower energy level (LE). All diets were formulated to meet other nutrient requirements of the chicks according to the strain requirement. After 28 days of age all birds fed finisher diets (RE or LE) without artichoke. The chemical analysis of artichoke leaves meal showed that it had good nutritive value. It contains some amino acids, the highest were for the essential amino acids arginine (0.51%) and leucine (0.42%). Artichoke contents of cynarin and total flavonoids were 1.194 and 1.064%. The results of this study showed that, the artichoke leaves meal used in this experiment decreased both BW and BWG, decreased the amount of consumed feed during the 28 days of age, while removing of artichoke increased the feed intake (28-42 days of age), in addition; it deteriorated both the feed conversion values and EPEI as compared with the control (without artichoke). The interaction between diet energy level and artichoke level had no significant effect on broiler performance during the total experimental period. Incorporation of artichoke leaves meal, regardless to energy level, had no significant effects on carcass characteristics except abdominal fat pad (AFP) which was decreased, especially at 4% artichoke when incorporated in low energy diet. The energy level, artichoke level or the interaction had no significant effect on blood constituents, in general at 28 and 42 days of age. It was observed that artichoke increased blood proteins and decreased blood total lipids and blood cholesterol at 28 days of age. Diets containing RE improved the digestibility coefficients ($P \leq 0.05$) of DM, OM, CP, EE, CF and NFE as compared to LE diets. Supplementation of artichoke at 2 and 4% of diet improved the utilization of all the nutrients, significantly except NFE which was improved numerically, compared to the two control groups (without artichoke). Results indicated that LE diets depressed total feed cost/kg BW and improved net revenue and economic efficiency compared to RE diets. Addition of artichoke increased total feed cost/kg BW and decreased net revenue and economic efficiency compared to the control diet. However 4% artichoke when added to LE diet gave the same relative economic efficiency value as that of the RE control diet.

Key words: Artichoke leaves meal, broilers, nutritive value, performance, alternative feedstuffs

Introduction

Artichoke (*Cynara scolymus*) is a herbaceous perennial native to southern Europe, northern Africa and the Canary islands. Artichoke is believed to have several beneficial effects, for example some preparations made from artichokes, encouraged the functioning of liver and kidneys, especially when there is metabolic stress (Pecht, 1996). Water extract of artichoke had some beneficial protective effect against the growth inhibitory effect of ochratoxin A and associated pathomorphological changes (Stoev *et al*., 2002). The recent ban on antibiotics in poultry feed has served to focus much attention on alternative methods of controlling the gastrointestinal microflora, artichoke extract was suggested as alternative option for controlling gastrointestinal microflora (Kleessen *et al*., 2003).

Schutz *et al*. (2004) reported that, the total phenolic contents of approximately 12 g/kg on a dry matter basis in artichoke pomace is a promising source of phenolic compounds that might be recovered and used as natural antioxidants or functional food ingredients. Artichoke leaves extract (ALE) has been used, traditionally, for jaundice and liver insufficiency and it has been suggested as a harmless yet effective treatment option for hypercholesterolaemia (Pittler *et al*., 2005).

In addition to the previous medicinal effects of artichoke, the nutritive value of its wastes or refuse parts was also studied. Gul *et al*. (2001) reported that the nutrient contents and feeding energy value of the silage made of artichoke stalks with leaves (refuse parts) are comparable with other silage. The studies indicated the possibility of using green forage of artichokes in the feeding of rabbits, pigs and poultry as part of a balanced

diet including cereals and other sources of fiber (Farnworth *et al.*, 1993; Bonomi *et al.*, 1994; El-Sayaad *et al.*, 1995; Mesini, 1996 and Bonomi, 2001).

Artichoke leaves extract (ALE) is used, traditionally in gastroenterology mainly because of its strong antidyspeptic actions which are mediated by its choleretic activity in addition; there was a strong ALE-induced increase in total bile acid concentration (Saenz *et al.*, 2002).

Kraft (1997) reported that the increased bile production due to the polyphenols in artichoke leaves extract mixes with and emulsifies fats to support fat digestion and fat metabolism, which may help in better utilization of diet energy. Fat is digested by the combined actions of bile, co lipase and lipase. An inadequacy of any of these facilitators of fat digestion would impair fat utilization (Korgdahi, 1985). Many researchers reported that the specific activity of lipase in chicks decreased during the first six days after hatching and then increased up to 21 days of age (Krogdahl and Sell, 1989; Nitsan *et al.*, 1991 and Uni *et al.*, 1995). Also, several data suggested that the bile secretion into the duodenum in young chicks (less than 3 weeks of age) might be not adequate for efficient fat utilization (Carew *et al.*, 1972 and Katongol and March, 1980). Jin *et al.* (1998) discussed the development of digestive system in post-hatch poultry and concluded that the increase in ME value with age are partly due to increase in dietary fat utilization.

The objective of this study was to evaluate the utilization of dried artichoke leaves meal in rations containing different energy levels and investigate its effect on the performance of growing broiler chicks.

Materials and Methods

The present study was performed at Gizerat El – Sheir poultry research station, El – kanater El – khairia, Animal Production Research Institute. The chemical analysis was conducted at laboratories of Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture, Dokki, Giza, Egypt. In this study, a total number of 240 unsexed one day old Ross broiler chicks were distributed randomly and divided equally into eight experimental groups nearly equal in average live weight. Each group was represented by birds in three replicate pens of 10 chicks each and kept under similar management conditions. The experimental groups were 4 levels of artichoke leaves meal (0, 2, 4 and 6% of the diet, mainly of the corn) in each of two diets. The first diet contained the strain requirement of energy (RE), while the second diet contained 200 kcal ME lower energy level (LE). First experimental diet (RE) contained 23% CP and 3100 kcal ME /Kg during the starter period (0 - 10 days of age), 21% CP and 3200 kcal ME /Kg during the grower period (10-28 days of age) and 19% CP and 3270 kcal ME/Kg during the finisher period (28-42 days of age), while the second experimental diet (LE) contained 23% CP and 2900 kcal ME /Kg during the starter period (0-10 days of age), 21% CP and 3000 kcal ME /Kg during the grower period (10-28 days of age) and 19% CP and 3070 kcal ME /Kg during the finisher period (28-42 days of age). All diets were formulated to meet the other nutrients requirement of the chicks according to the strain requirements. Artificial light was used beside the normal day light to provide 24-hour / day photoperiod. Feed and water were provided *ad libitum*. After 28 days of age the birds fed finisher diets (RE or LE) without artichocke. Composition and calculated analyses of the experimental diets are shown in Table 1, 2 and 3.

Feed consumption and body weight of the birds were recorded. Accordingly, body weight gain, feed conversion ratio (g feed / g gain), and economic efficiency were calculated. The digestibility coefficients of nutrients of the experimental diets were determined using 3 male birds from each treatment at 28 days of age. Faecal nitrogen was determined according to the method outlined by Jakobsen *et al.* (1960), while the urinary organic matter fraction was calculated according to Abou-Raya and Galal (1971). The values of ME were calculated by multiplying the TDN of the diet by the factor 4.185 (Titus, 1971). The proximate analyses of artichoke, feed and dried excreta samples were carried out according to the Association of Official Analytical Chemists (AOAC, 1990). At 28 and 42 days of age, 3 male birds were chosen randomly from each treatment for slaughter test and carcass characteristics. Carcass weights were calculated as a percentage of live body weight. Individual blood samples were taken from jugular vein of 3 male birds within each treatment. Plasma was separated for determination of total protein, albumin, total lipids, cholesterol and liver function enzymes (aspartate aminotransferase, AST and alanine aminotransferase, ALT), which were colorimetrically determined using commercial kits, following the same steps as described by manufactures.

Data from all the response variables were subjected to factorial (4x2) analysis of variance (SAS, 2000). Variables having a significant F-test ($P \leq 0.05$) were compared using Duncan's Multiple Range Test (Duncan, 1955).

Model:

$X_{ijk} = \mu + T_i + F_j + (TF)_{ij} + e_{ijk}$

Where: X_{ijk} = any observation.

μ = Overall mean.

T_i = Artichoke levels (i=1, 2, 3 and 4).

F_j = Energy levels (j=1 and 2).

$(TF)_{ij}$= Interaction between artichoke levels and energy levels

e_{ijk}= Experimental error

Results and Discussion

Chemical composition of artichoke leaves meal: The chemical analysis of artichoke leaves meal (Table 4)

Table 1: Composition and calculated analysis of the starter diets (0-10 days of age)

	RE				LE			
	Artichoke levels				Artichoke levels			
	T1	T2	T3	T4	T5	T6	T7	T8
Ingredients (%)	0%	(2%)	(4%)	(6%)	0%	(2%)	(4%)	(6%)
Yellow corn	48.57	46.40	44.10	41.5	48.57	46.58	44.3	42.00
Soybean meal (38%)	33.99	33.89	33.79	33.89	39.55	39.54	39.33	39.35
Corn gluten meal (60%)	9.16	9.16	9.16	9.16	6.00	6.00	6.00	6.00
Artichoke	--	2.00	4.00	6.00	--	2.00	4.00	6.00
Corn oil	4.21	4.46	4.89	5.40	2.00	2.00	2.50	2.80
Di calcium phosphate	1.66	1.66	1.65	1.64	1.60	1.60	1.60	1.58
Lime stone	1.42	1.42	1.40	1.40	1.41	1.40	1.38	1.38
NaCl	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Premix[1]	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
DL-Methionine	0.21	0.22	0.22	0.22	0.22	0.23	0.23	0.23
L-Lysine HCl	0.18	0.19	0.19	0.19	0.05	0.05	0.06	0.06
Total	100	100	100	100	100	100	100	100
Calculated analysis:								
Crude protein %	23	23	23	23	23	23	23	23
Metabolizable energy (Kcal ME /Kg diet)	3100	3100	3100	3100	2900	2900	2900	2900
Available P%	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Calcium%	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Lysine%	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Methionine%	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Methionine + Cystine %	1.08	1.08	1.07	1.07	1.08	1.08	1.07	1.07

Each 3 kg of Vit. & Min. Mixture contains: Vit. A 12000,000 IU, Vit. D_3 2000,000 IU, Vit. E 10,000 mg, Vit. K_3 2000 mg, Vit. B_1 1000 mg, Vit. B_2 5000 mg, Vit. B_6 1500 mg, Vit. B_{12} 10 mg, Pantothenic acid 10,000 mg, Niacin 30,000 mg, Folic acid 1000 mg, Biotin 50 mg, Choline 300,000 mg, Manganese 60,000 mg, Zinc 50,000 mg, Copper 10,000 mg, Iron 30,000, Iodine 1000 mg, Selenium 100 mg, Cobalt 100 mg, Ca CO_3 to 3,000 gm.

Table 2: Composition and calculated analysis of the grower diets (10-28 days of age)

	RE				LE			
	Artichoke levels				Artichoke levels			
	T1	T2	T3	T4	T5	T6	T7	T8
Ingredients (%)	0%	(2%)	(4%)	(6%)	0%	(2%)	(4%)	(6%)
Yellow corn	50.11	48.11	45.95	43.29	53.18	51.18	48.74	46.23
Soybean meal (38%)	33.75	33.75	33.62	33.75	35.75	35.50	35.55	35.57
Corn gluten meal (60%)	6.00	6.00	6.00	6.00	4.61	4.61	4.61	4.71
Artichoke	--	2.00	4.00	6.00	--	2.00	4.00	6.00
Corn oil	6.37	6.37	6.73	7.27	2.82	3.07	3.47	3.89
Di calcium phosphate	1.67	1.67	1.68	1.66	1.65	1.65	1.65	1.63
Lime stone	1.20	1.20	1.12	1.12	1.14	1.14	1.12	1.11
NaCl	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Premix[1]	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
DL-Methionine	0.21	0.21	0.21	0.22	0.21	0.21	0.22	0.22
L-Lysine HCl	0.09	0.09	0.09	0.09	0.04	0.04	0.04	0.04
Total	100	100	100	100	100	100	100	100
Calculated analysis:								
Crude protein%	21	21	21	21	21	21	21	21
Metabolizable energy (Kcal ME /Kg diet)	3200	3200	3200	3200	3000	3000	3000	3000
Available P%	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Calcium%	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Lysine%	1.27	1.27	1.27	1.27	1.27	1.27	1.27	1.27
Methionine%	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Methionine + Cystine %	0.99	0.99	0.99	0.98	0.99	0.99	0.99	0.98

[1]Each 3 kg of Vit. & Min. Mixture contains: Vit. A 12000,000 IU, Vit. D_3 2000,000 IU, Vit. E 10,000 mg, Vit. k_3 2000 mg, Vit. B_1 1000 mg, Vit. B_2 5000 mg, Vit. B_6 1500 mg, Vit. B_{12} 10 mg, Pantothenic acid 10,000 mg, Niacin 30,000 mg, Folic acid 1000 mg, Biotin 50 mg, Choline 300,000 mg, Manganese 60,000 mg, Zinc 50,000 mg, Copper 10,000 mg, Iron 30,000, Iodine 1000 mg, Selenium 100 mg, Cobalt 100 mg, Ca CO_3 to 3,000 gm.

Table 3: Composition and calculated analysis of the finisher diets, without artichoke (28-42 days of age)

Ingredients (%)	RE T1, T2, T3 and T4	LE T5, T6, T7 and T8
Yellow corn	55.45	59.10
Soybean meal (38%)	30.23	31.23
Corn gluten meal (60%)	4.46	3.45
Artichoke	--	--
Corn oil	6.62	3.00
Di calcium phosphate	1.18	1.17
Lime stone	1.18	1.18
NaCl	0.30	0.30
Premix1	0.30	0.30
DL-Methionine	0.21	0.22
L-Lysine Hcl	0.07	0.05
Total	100	100
Calculated analysis:		
Crude protein%	19	19
Metabolizable energy (Kcal ME /Kg diet)	3270	3070
Available P %	0.35	0.35
Calcium%	0.80	0.80
Lysine %	1.15	1.15
Methionine %	0.57	0.57
Methionine + Cystine %	0.93	0.94

[1]Each 3 kg of Vit. & Min. Mixture contains: Vit. A 12000,000 IU, Vit. D_3 2000,000 IU, Vit. E 10,000 mg, Vit. k_3 2000 mg, Vit. B_1 1000 mg, Vit. B_2 5000 mg, Vit. B_6 1500 mg, Vit. B_{12} 10 mg, Pantothenic acid 10,000 mg, Niacin 30,000 mg, Folic acid 1000 mg, Biotin 50 mg, Choline 300,000 mg, Manganese 60,000 mg, Zinc 50,000 mg, Copper 10,000 mg, Iron 30,000, Iodine 1000 mg, Selenium 100 mg, Cobalt 100 mg, Ca CO_3 to 3,000 gm.

showed that it contained, on air dry basis, 7.7% moisture, 92.3% dry matter (DM), 85.4% organic matter (OM), 9.5% crude protein (CP), 1.5% ether extract (EE), 28.0% crude fiber (CF), 6.9% ash, 46.4% nitrogen free extract (NFE), 3879 kcal/kg determined gross energy, 2484 kcal/kg calculated metabolizable energy (ME), 46.3% NDF, 32.2% ADF, 21.6% cellulose, 14.1% hemicellulose, 10.6% ADL. It contained the following values of minerals (ppm): 22335 K, 5227 Na, 4713 Ca, 1736 Total P, 1478 Mg, 163.2 Fe, 7.7 Mn, 5.6 Zn and 5.2 Cu. Table 5 illustrated that artichoke leaves meal, in addition to the previous nutrients it also contains some amino acids, the highest were for the essential amino acids arginine (0.51%) and leucine (0.42%). Artichoke contents of cynarin and total flavonoids were 1.194 and 1.064% (Table 6).

The value of CP was lower (9.48% vs. 13.0%) and the CF was higher (28.00% vs. 24.2%) than that reported by Bonanno *et al.* (1994). The study of El-Sayaad *et al.* (1995) revealed lower protein content (9.46% vs. 10.27%), higher EE (5.65% vs.1.62%), higher ash (10.33% vs.7.47%), higher CF (37.69%vs. 30.32%) and lower NFE (36.87%vs.50.32), on DM basis. Hussein *et al.* (1999) supported the results of amino acid analysis as they found that methionine was limiting. Artichoke leaves have been found to be a rich source of polyphenolic compounds, with mono - and dicaffeoylquinic acids and flavonoids as the major chemical components (Nichiforescu, 1970; Adzet and Puigmacia, 1985, Dranik *et al.* 1996 and Wagenbreth, 1996).

Growth performance: Table 7 showed that there was no significant difference ($P \leq 0.05$) between birds fed RE diets and those fed LE diets regarding both BW and BWG during starter and grower periods, except during finisher period (28-42 days), where birds fed RE diets gave better BWG ($P \leq 0.05$) value than LE birds. Incorporation of artichoke leaves meal, regardless to energy level, decreased both BW and BWG during starter and grower periods, however there was no significant difference ($P \leq 0.05$) between the control (0% artichoke) and 4% artichoke during the finisher and total experimental periods. The interaction revealed no significant differences ($P \leq 0.05$) between the treatments.

Table 8 represents the amount of consumed feed, feed conversion ratio values and European Production Efficiency Index (EPEI). The amount of consumed feed was higher ($P \leq 0.05$) for LE diets than RE diets during starter period (0-10 days), thereafter (28-42 days of age) the amount of feed consumed was higher for RE diets than LE diets. There was no significant difference ($P \leq 0.05$) between RE diets group and LE diets group during the total experimental period. Incorporation of artichoke leaves meal, regardless to energy level, decreased the amount of feed consumed during the starter period, while removing of artichoke increased the feed intake during finisher period (28-42 days of age). The interaction revealed no significant differences ($P \leq 0.05$) between the treatments during the total experimental period. Feed conversion ratio values were not significantly affected by energy levels or artichoke leaves meal levels during artichocke feeding period (0-28 days). The least difference between the control and the artichoke diet was at 4% artichoke (1.81 vs. 1.95 during the total experimental period, respectively). Feed conversion ratio values were not significantly affected by the interaction during the experimental periods.

European Production Efficiency Index (EPEI) was better for the diets containing RE and those without artichoke compared to LE group and artichoke groups, respectively. However 4% artichoke group gave the nearest values to that of the control.

The previous results showed that, the artichoke leaves meal used in this experiment decreased both BW and BWG, decreased the amount of consumed feed during the 28 days of age (artichoke feeding period), while removing of artichoke increased the feed intake (28-42 days of age), in addition; it deteriorated both the feed conversion values and EPEI as compared with the control (without artichoke).

On the contrary to the results of this study Bonomi (2001) studied the effect of replacing of lucerne meal with meal

Table 4: Chemical composition of artichoke leaves meal on air dry basisOn dry matter basis

Items		On air dry basis (as fed)	On air dry matter basis
Moisture,%		7.7	--
Dry matter (DM),%		92.3	100.0
Organic matter (OM),%		85.4	92.5
Crude protein (CP),%		9.5	10.3
Ether extract (EE),%		1.5	1.6
Crude fiber (CF),%		28.0	30.3
Ash,%		6.9	7.5
Nitrogen free extract (NFE), %		46.4	50.3
Growth energy (determined)[1]		3879.0	4203.0
Calculated ME (kcal/kg)[2]		2484.0	2691.0
Fiber fractions:			
NDF[3]	%	46.3	50.1
ADF[4]	%	32.2	34.8
Cellulose[5]	%	21.6	23.3
Hemi cellulose[6]	%	14.1	15.3
ADL	%	10.6	11.5
Minerals:			
K	ppm	22335.0	24185.0
Na	ppm	5227.0	5660.0
Ca	ppm	4713.0	5103.0
Total P	ppm	1736.0	1880.0
Mg	ppm	1478.0	1600.0
Fepm		163.2	176.7
Mn	ppm	7.7	8.3
Zn	ppm	5.6	6
Cu	ppm	5.2	5.7

[1]It was determined using an adiabatic IKA-Calorimeter C 4000 bomb calorimeter ME[2] = 53 + 38 (% CP + 2.25 x % EE + 1.1 x NFE), Scott *et al.* (1976). NDF[3] (Neutral detergent fiber) = cellulose + hemicellulose + lignin. ADF[4] (Acid detergent fiber) = cellulose + ADL (lignin). Cellulose[5] = ADF-ADL, Hemicellulose[6] = NDF-ADF

Table 5: Amino Acids Composition of Artichoke Leaves Meal (As Air Dry Basis)

Amino acid	%
Arginine	0.51
Histidine	0.23
Isoleucine	0.22
Leucine	0.42
Lysine	0.25
Methionine	0.03
Phenylalanine	0.26
Threonine	0.30
Valine	0.34
Asparatic	1.29
Serine	0.24
Glutamic	0.76
Proline	0.83
Glysine	0.28
Alanine	0.32
Cystein	0.11

from dehydrated artichoke leaves on the performance of different species and concluded that 4% dehydrated artichoke leaves of the total feed improved the growth rate and skin colour of broilers and the egg production of

Table 6: Artichoke Leaves Meal Contents of Cynarin and Total Flavonoids

	(On dry matter basis)	
	Cynarine %	Total favonoids %
Wang *et al.* (2003)	0.924-1.689	----
Our Finding	1.292	1.152

laying hens. Turkeys raised on rates of 4% and 8%, replacing the same rates of lucerne meal, showed enhanced weight increase, and carcass and meat yields. Similarly, meal from dehydrated artichoke leaves fed to guineafowls and ducks at 6% of total feed enhanced weight increase by 12 and 8%, respectively. For rabbits, the substitution of artichoke leaves meal at 5 and 10% of total feed increased weight by 4 and 7%, respectively, after 60 days. Lower rates of artichoke leaves meal had no effect on weight increments. But the results were in agreement with this study in the finding that there were no adverse effects on animal health. The results of this study and the previous studies showed that dehydrated artichoke leaves meal may be comparable or utilized better than other sources of fibre in the diet as reported by Mesini (1996) and it is not utilized as efficiency as the diet corn or soyabean meal. It may gave better results in small ruminant diets as found by Alcicek *et al.* (2000) who suggested the suitability of globe artichoke silage made from artichoke stems with leaves for small ruminant feeding in semi-arid zones.

Therefore, it is suggested to carry out further studies to compare artichoke leaves meal with other sources of fiber in the poultry or small ruminant diets.

Carcass characteristics: Table 9 shows the carcass characteristics values of broiler chicks subjected to different experimental treatments. Using low energy diets resulted in numerically higher values of carcass, liver, gizzard, and lower abdominal fat pad (AFP), when compared with RE diets at 28 and 42 days of age. Incorporation of artichoke leaves meal, regardless to energy level, had no significant effects on carcass characteristics but AFP was decreased, especially at 4% artichoke. The interaction revealed no significant differences ($P \leq 0.05$) between the treatments. It could be concluded that, artichoke decreased AFP when it incorporated in low energy diet.

Bonomi *et al.* (1998) found close dressing percentage values (67.50, 67.91 and 68.82%) due to inclusion of artichoke leaves meal in broiler diets at 0, 2 or 4% of the diets, which were less than those values obtained in this study at 28 days (75.33, 76.00, 74.90 and 72.55% for 0,2,4 and 6% artichoke leaves meal, respectively). The results were supported also by Bonomi *et al.* (1999) who found that when dehydrated artichoke leaf meal was included in mixed feeds of ducks at 6%, in place of dehydrated lucerne meal, an improvement in dressing percentage (6.50%), and depression of abdominal and subcutaneous fat (-25.30%) was observed.

Table 7: Body weight and body weight gain (Mean ± SE) of broiler chicks as affected by different treatments

Treatments			Body weight (g)				Body weight gain (g)				
No	Artichoke levels (%)	Energy levels	IBW	At 10 days	At 28 days	At 42 days	0-10 days	10-28 days	0-28 days	28-42 days	0-42 days
	-	RE	44	163±6	876±20	1954±35	119±6	714±16	832±21	1077^{a}±27	1910±35
	-	LE	44	180±7	902±22	1906±31	136±7	722±17	858±23	1004^{b}± 20	1862±31
	0	-	44	196^{a}±4	966^{a}±17	2032^{a}±25	152^{a}±4	770±16	922^{a}±17	1066^{ab}±22	1988^{a}±25
	2	-	44	168^{b}±9	886^{ab}±32	1903^{bc}±50	123^{b}±8	719±25	842^{ab}±32	1016^{bc}±44	1858^{bc}±50
	4	-	44	160^{b}±10	861^{b}±21	1953^{ab}±39	116^{b}±10	701±18	817^{b}±21	1092^{a}±35	1909^{ab}±39
	6	-	44	162^{b}±10	843^{b}± 28	1833^{c}±36	118^{b}±10	682±18	799^{b}±28	989^{c}±33	1789^{c}±36
1	0	RE	44	197±4	979±29	2068±36	153±4	782±32	934±28	1089±16	2024±36
2	2		44	156±2	860±29	1941±41	112±2	704±27	816±29	1081±54	1897±41
3	4		44	146±5	850±5	2008±38	102±5	704±9	806±5	1158±38	1964±38
4	6		44	153±6	818±16	1799±53	109±6	664±12	774±16	981±57	1755±53
5	0	LE	44	196±9	954±21	1997±23	152±9	758±14	910±21	1043±41	1953±22
6	2		44	179±15	912±61	1864±96	135±15	733±47	868±61	951±50	1820±96
7	4		44	174±16	872±45	1897±57	130±16	698±40	827±45	1026±12	1853±56
8	6		44	170±20	869±54	1867±51	126±20	699±34	825±54	998±48	1823±51

a, b ....= Means in the same column within each factor differently superscripted are significantly different ($P \leq 0.05$)

Table 8: Feed intake and feed conversion ratio (Mean ± SE) of broiler chicks as affected by different treatments

Treatments								Feed conversion ratio					
No	Arti-choke levels (%)	Energy levels	0-10 days	10-28 days	0-28 days	28-42 days	0-42 days	0-10 days	10-28 days	0-28 days	28-42 days	0-42 days	EPEI*
	-	RE	200^{b}±9	1245±23	1445^{b}±21	2237^{a}±37	3683±39	1.70±0.1	1.75±0.0	1.74±0.04	2.09±0.1	1.94±0.0	236
	-	LE	220^{a}±8	1291±15	1511^{a}±15	2156^{b}±30	3668±28	1.65±0.1	1.80±0.0	1.77±0.05	2.16±0.1	1.98±0.0	217
	0	-	238^{a}±4	1280±25	1518±24	2083^{b}±19	3601±28	1.57±0.0	1.67±0.1	1.65±0.04	1.96^{b}±0.0	1.81^{b}±0.0	263
	2	-	197^{b}±11	1257±32	1454±31	2282^{a}±32	3736±31	1.61±0.1	1.76±0.1	1.74± 0.07	2.26^{a}±0.1	2.02^{a}±0.1	222
	4	-	203^{b}±18	1300±39	1503±35	2207^{a}±68	3710±72	1.77±0.1	1.86±0.1	1.85±0.06	2.03^{b}±0.1	1.95^{a}±0.0	223
	6	-	203^{b}±10	1235±12	1439±14	2215^{a}±29	3654±34	1.76±0.1	1.82±0.0	1.81±0.05	2.25^{a}±.09	2.05^{a}±0.0	199
1	0	RE	242^{a}±3	1247±20	1489±18	2110±31	3599±49	1.58±0.1	1.60±0.1	1.60±0.07	1.94 ±0.04	1.78±0.1	277
2	2		184^{b}± 1	1208±7	1392±8	2322±54	3714±57	1.65±0.0	1.72±0.1	1.71±0.05	2.16± 0.13	1.96±0.1	236
3	4		168^{b}±16	1314±86	1482±75	2316±87	3798±119	1.66±0.2	1.87±0.1	1.84±0.08	2.01±0.14	1.94±0.1	230
4	6		208^{ab}±10	1210±6	1418±16	2201±49	3619±38	1.91±.0.1	1.82±0.0	1.83±0.02	2.26±0.13	2.06±0.1	200
5	0	LE	234^{a}±6	1312±41	1547±42	2056±8	3603±40	1.55±0.1	1.73±0.0	1.70±0.03	1.98±0.08	1.85±0.0	249
6	2		209^{ab}±20	1306±51	1515±32	2241±24	3757±31	1.57±0.2	1.80± 0.2	1.76±0.14	2.37±0.12	2.08±0.1	207
7	4		238^{a}± 10	1286±11	1524±2	2098±62	3622±64	1.88±0.2	1.85±0.1	1.85±0.10	2.05±0.04	1.96± 0.0	215
8	6		199^{ab}±19	1260±1	1459±20	2230±41	3689±57	1.61±0.1	1.81±0.1	1.78±0.10	2.25±0.15	2.03±0.1	197

a, b ....= Means in the same column within each factor differently superscripted are significantly different ($P \leq 0.05$)

*EPEI = European Production Efficiency Index = $\frac{\text{Live body weight (kg) x Livability (100-\%mortality)}}{\text{Production period (days) x Feed conversion ratio}} \times 100$

Nutrients utilization: The effect of treatments on the nutrients digestibility coefficient and metabolizable energy are summarized in Table 10. Nutrient digestibility coefficients were affected significantly by energy level, where RE diets improved the metabolizable energe (ME) and digestibility coefficients ($P \leq 0.05$) of dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), crude fiber (CF) and nitrogen free extract (NFE) as compared to LE diets group. Using artichoke at 2 and 4% improved the utilization of all the nutrients, significantly except CP, compared to those of the control group (without artichoke). Same levels improved ME and the utilization of all the nutrients, except CP when added to either RE or LE diets, especially at 4%.

The results were on the same trend with Bonanno *et al* (1994) who incorporated dried artichoke bracts (DAB) in New Zealand White rabbit diets at 15 or 30% for 56 days experimental period and found that only 30% DAB in the diet decreased digestive utilization and energy value of the diet. The obtained improvement in digestibility of lipids (from 4.6 to 6.8%) in chicks fed artichoke supplemented diets may be due to it's stimulating effect on secretion of bile salts. The improvement in the utilization of diet fat and energy was supported by Kraft (1997) who reported that the increased bile production due to the polyphenols in artichoke leaves extract mixes with and emulsifies fats to support fat digestion and fat metabolism, which may help in better utilization of diet energy. Also Speroni *et al*. (2003) reported that, the *Cynara scolymus L*. leaves extracts with high content of phenolic compounds have the major effect on bile flow and liver protection. The improvement effect of bile salt on digestibility of fat reported previously by Gomez and Polin (1976) and Katongole and March (1980) who

Table 9: Effect of treatments on carcass characteristics of the experimental treatments at 28 and 42 days of age

Treatments			At 28 days of age					At 42 days of age				
No	Artichoke levels (%)	Energy levels	Carcass (%)	Liver (%)	Gizzard (%)	Intes-tine (%)	Abdo-minal fat pad (%)	Carcass (%)	Liver (%)	Gizzard (%)	Intes-tine (%)	Abdo-minal fat pad(%)
	-	RE	74.11	2.80	3.37^{b}	8.92	0.78^{a}	72.76	2.30^{b}	2.00	6.78	0.80
	-	LE	75.28	2.93	3.91^{a}	8.53	0.39^{b}	73.74	2.55^{a}	2.20	6.93	0.54
	0	-	75.33	2.79	3.50	8.99	0.65	72.16	2.38	2.49^{a}	6.88	0.94
	2	-	76.00	3.09	3.41	8.15	0.77	74.21	2.36	1.89^{b}	6.45	0.72
	4	-	74.90	2.81	3.81	8.29	0.33	73.57	2.45	2.03^{b}	6.84	0.56
	6	-	72.55	2.76	3.84	9.47	0.60	73.06	2.51	2.00^{b}	7.24	0.47
1	0	RE	74.70	2.79	3.26	8.65	0.58	72.06	2.21	2.48	6.60	0.98
2	2		73.73	2.88	3.07	8.76	0.97	73.04	2.23	1.78	6.57	0.93
3	4		73.97	2.76	3.75	8.77	0.60	74.25	2.26	1.90	6.25	0.64
4	6		74.04	2.78	3.41	9.49	0.97	71.68	2.48	1.84	7.68	0.65
5	0	LE	75.96	2.79	3.73	9.32	0.71	72.25	2.55	2.49	7.16	0.90
6	2		78.26	3.31	3.76	7.53	0.57	75.38	2.48	1.99	6.33	0.50
7	4		75.83	2.86	3.88	7.80	0.06	72.88	2.63	2.17	7.43	0.47
8	6		71.06	2.75	4.28	9.46	0.24	74.44	2.53	2.15	6.80	0.28

a, b ....= Means in the same column within each factor differently superscripted are significantly different ($P \leq 0.05$)

Table 10: Effect of treatments on nutrients digestibility coefficient and ME at 28 days of age

Treatments									
No	Artichoke levels (%)	Energy levels	DM (%)	OM (%)	CP (%)	EE (%)	CF (%)	NFE (%)	ME (kcal/kg diet)
	-	RE	84.5^{a}±0.8	86.7^{a}±0.7	95.9^{a}±2.0	89.8^{a}±0.4	30.5±1.1	89.7^{a}±0.5	3835^{a}±23
	-	LE	80.4^{b}±1.7	82.3^{b}±1.6	91.1^{b}±2.2	88.0^{b}±1.3	30.1±2.0	86.2^{b}±1.7	3616^{b}±46
	0	-	78.1^{b}±1.9	80.6^{b}±1.8	94.0±2.0	85.4^{b}±1.7	25.0^{b}±2.2	84.9^{b}±1.6	3608^{b}±72
	2	-	85.5^{a}±0.5	87.2^{a}±0.6	96.3±0.1	89.6^{a}±0.6	34.3^{a}±1.5	89.0^{a}±0.8	3814^{a}±17
	4	-	86.8^{a}±1.2	88.5^{a}±1.2	89.3±4.4	91.2^{a}±0.9	32.2^{a}±1.9	92.5^{a}±1.8	3806^{a}±57
	6	-	79.5^{b}±1.7	81.9^{b}±1.8	94.4±4.8	89.3^{a}±0.9	29.6^{ab}±1.1	85.5^{b}±1.7	3674^{b}±80
1	0	RE	81.9^{b}±1.0	84.4^{b}±1.0	95.7±0.2	89.1^{ab}±0.6	26.4±1.4	88.0^{b}±0.9	3754^{bc}±35
2	2		86.1^{ab}±0.3	88.0^{ab}±0.3	96.6±0.0	89.3^{ab}±0.9	31.0±0.4	90.5^{ab}±0.6	3828^{abc}±12
3	4		87.2^{a}±1.9	89.0^{a}±1.7	96.2±0.6	90.0^{ab}±1.0	34.6±2.4	91.2^{ab}±1.5	3911^{a}±64
4	6		82.9^{ab}±0.7	85.6^{ab}±0.6	95.1±0.2	90.7^{ab}±0.9	30.0±0.6	89.1^{ab}±0.4	3846^{ab}±13
5	0	LE	74.2^{c}±1.5	76.8^{c}±1.2	92.3±0.5	81.7^{c}±1.3	23.7±5.2	81.7^{c}±1.3	3462^{d}±55
6	2		84.8^{ab}±0.9	86.4^{ab}±0.9	96.1±0.2	89.9^{ab}±0.9	37.7±0.4	87.6^{b}±1.0	3799^{abc}±34
7	4		86.5^{ab}±1.8	87.9^{ab}±1.8	82.3±7.1	92.3^{a}±1.3	29.7±2.3	93.7^{a}±3.6	3702^{c}±33
8	6		76.0^{c}±1.5	78.1^{c}±1.5	93.6±0.4	87.9^{b}±1.0	29.2±2.3	81.9^{c}±1.3	3501^{d}±49

a, b ....= Means in the same column within each factor differently superscripted are significantly different ($P \leq 0.05$)

Table 11: Blood constituents as affected by different treatments at 28 days of age

Treatments										
No	Artichoke levels (%)	Energy levels	Total protein (g/dl)	Albumin (g/dl)	Globulin (g/dl)	A/G ratio	Total lipids (mg/dl)	Chole-sterol (mg/dl)	AST (U/l)	ALT (U/l)
	-	RE	4.29±0.18	1.68±0.06	2.61±0.17	0.67±5.32	775±44	131±8	70^{a}±1.8	16^{a}±0.57
	-	LE	4.64±0.23	1.77±0.07	2.87±0.18	0.63±3.31	709±40	116±7	64^{b}±1.7	14^{b}±0.55
	0	-	4.02±0.21	1.69±0.08	2.34±0.15	0.73±4.05	808±45	135^{ab}±9	68±3.11	16±1.05
	2	-	4.59±0.38	1.73±0.14	2.86±0.31	0.64±8.54	669±38	145^{a}±11	67±1.78	15±0.46
	4	-	4.70±0.24	1.71±0.07	2.99±0.21	0.58±4.39	733±75	111^{b}±12	70±1.12	15±0.85
	6	-	4.55±0.31	1.77±0.05	2.78±0.27	0.67±6.68	757±74	104^{b}±6	62±3.42	13±0.89
1	0	RE	4.04±0.08	1.68±0.10	2.36±0.08	0.71±6.22	853±54	140±17	73±4.47	18±1.56
2	2		4.31±0.28	1.61±0.20	2.71±0.41	0.64±17.8	638±15	163±12	68±1.47	16±0.28
3	4		4.76±0.48	1.75±0.13	3.02±0.41	0.59±7.10	737±127	108±9	70±2.07	16±1.46
4	6		4.05±0.44	1.68±0.06	2.37±0.40	0.75±12.1	870±69	112±7	67±5.95	15±0.63
5	0	LE	4.01±0.46	1.69±0.15	2.31±0.33	0.75±6.34	763±71	129±7	63±2.00	15±0.97
6	2		4.87±0.74	1.86±0.21	3.01±0.55	0.64±6.96	700±78	127±10	66±3.41	14±0.50
7	4		4.63±0.21	1.67±0.10	2.97±0.22	0.57±6.67	729±111	113±25	71±1.33	15±1.05
8	6		5.04±0.21	1.85±0.03	3.19±0.19	0.58±3.11	644±98	96±8	57±0.61	12±1.40

a, b ....= Means in the same column within each factor differently superscripted are significantly different ($P \leq 0.05$)

recorded from 4 to 18% increase in fat digestibility in young chicks fed on diet supplemented with bile salt.

Blood constituents: Results of the blood constituents as affected by different treatments are shown in Table 11

Table 12: Blood constituents as affected by different treatments at 42 days of age

Treatments										
No	Artichoke levels (%)	Energy levels	Total protein (g/dl)	Albumin (g/dl)	Globulin (g/dl)	A/G ratio	Total lipids (mg/dl)	Chole-sterol (mg/dl)	AST (U/l)	ALT (U/l)
	-	RE	4.99±0.30	1.88±0.08	3.11±0.26	0.65±6.17	640±59	105±6	64±2.33	15±0.49
	-	LE	5.09±0.14	1.93±0.13	3.16±0.21	0.69±12.1	579±48	108±6	58±2.46	16±0.64
	0	-	5.20±0.38	1.73±0.08	3.46±0.34	0.52±5.63	616±67	114±9	60±3.72	15±0.85
	2	-	4.96±0.12	1.98±0.25	2.98±0.28	0.76±22.2	692±58	109±6	64±3.19	16±1.16
	4	-	5.05±0.43	1.98±0.15	3.07±0.44	0.73±13.7	622±90	104±5	63±4.83	16±0.67
	6	-	4.96±0.37	1.93±0.09	3.04±0.30	0.66±5.96	508±80	101±11	58±2.40	16±0.61
1	0	RE	5.24±0.82	1.84±0.13	3.40±0.69	0.58±9.36	553±91	107±8	59±3.09	15±1.46
2	2		5.00±0.25	1.66±0.17	3.34±0.20	0.50±6.11	762±35	107±7	66±5.26	15±0.72
3	4		5.02±0.90	2.03±0.21	2.99±0.81	0.77±19.8	763±135	104±10	73±4.74	16±1.05
4	6		4.70±0.60	1.98±0.16	2.72±0.44	0.75±8.12	480±127	103±22	61±2.21	16±1.06
5	0	LE	5.15±0.22	1.63±0.09	3.53±0.29	0.47±6.52	678±102	121±17	61±7.64	16±1.00
6	2		4.92±0.04	2.30±0.44	2.62±0.46	1.02±41.7	621±103	111±11	63±4.70	17±2.30
7	4		5.08±0.36	1.94±0.25	3.14±0.55	0.69±23.0	480±48	103±7	53±0.51	16±1.08
8	6		5.22±0.50	1.87±0.11	3.35±0.41	0.57±5.52	537±121	98±8.0	56±4.18	16±0.87

a, b ....= Means in the same column within each factor differently superscripted are significantly different ($P \leq 0.05$)

Table 13: Input/output analysis and economic efficiency as affected by different treatments

Treatments										
No	Artichoke levels (%)	Energy levels	body weight (kg)	Feed intake/ bird (kg)	Feed cost/ chick (LE)	Feed cost/ kg BW (LE)	Total revenue (LE)[1]	Net revenue (LE)	Economic efficiency (EE)[2]	Relative EE%
	-	RE	1.954	3.683	5.49	2.82	11.73	6.24	1.14	100
	-	LE	1.906	3.668	5.00	2.63	11.44	6.44	1.29	113
	0	-	2.032	3.601	5.17	2.54	12.20	7.03	1.36	100
	2	-	1.903	3.736	5.32	2.80	11.42	6.10	1.15	85
	4	-	1.953	3.710	5.30	2.71	11.72	6.42	1.22	90
	6	-	1.833	3.654	5.20	2.84	11.00	5.81	1.12	82
1	0	RE	2.067	3.599	5.39	2.61	12.41	7.01	1.30	100
2	2		1.941	3.714	5.53	2.85	11.65	6.12	1.11	85
3	4		2.008	3.798	5.65	2.81	12.05	6.40	1.13	87
4	6		1.799	3.619	5.39	2.99	10.79	5.41	1.00	77
5	0	LE	1.997	3.603	4.94	2.47	11.98	7.04	1.42	109
6	2		1.864	3.757	5.11	2.74	11.18	6.07	1.19	92
7	4		1.897	3.622	4.95	2.61	11.38	6.43	1.30	100
8	6		1.867	3.689	5.00	2.68	11.20	6.20	1.24	95

N.B: Total price for feeds was calculated according to the price of different ingredients available in A.R.E. at experimental time; 1- The price was calculated due to the local market which was 6.0 LE/kg live weight; 2- EE = Net revenue/chick (LE) / Total feed cost/chick (LE)

and 12. The energy level, artichoke or the interaction had no significant effect on blood constituents, in general at 28 and 42 days of age. It was observed that using artichoke at 4% of diet resulted in numerically but not significantly ($P \leq 0.05$) increased in blood proteins and decreased blood total lipids and blood cholesterol at 28 days of age, in general.

The results were supported by El-Sayaad *et al.* (1995) who found that incorporation of artichoke bracts (AB) in New Zealand White rabbits diets up to 20%, for 9 weeks, had no significant effect on blood components. The non adverse effect on liver function enzymes (AST and ALT) was supported by Pecht (1996) who reported that a preparation made from artichokes, encourages the functioning of liver and kidneys. The numerical decrease in blood lipids and cholesterol due to artichoke, especially during artichoke feeding period (0-28 days of age) was explained by Pittler *et al.* (2005) who revealed that cynarine (1.5-di-caffeoyl-D-quinic acid), which is the principal active component of artichoke leaves extract (ALE) inhibits the incorporation of 14C-labelled acetate into the non-saponifiable lipid fraction and thus reduce cholesterol biosynthesis or it may have indirect inhibitory effects exerted at the level of HMGCoA reductase, a key enzyme in cholesterol biosynthesis.

Economic efficiency: The economic efficiency of the different formulated diets as affected by different treatments is shown in Table 13. Results indicated that using LE diets lowered total feed cost/kg BW and improved net revenue and economic efficiency compared to RE diets. Addition of artichoke increased total feed cost/kg BW and decreased net revenue and economic efficiency compared to the control diets (without artichoke). However 4% artichoke when added to LE diet gave the same relative economic efficiency value as that of the control (RE).

Conclusion: The presented results indicated that adding artichoke to starter and grower diets at level 4% lead to increase fat and energy utilization especially when diet contain 200 Kcal ME/kg lower than strain requirement.

Consequently, this resulted in economic production. In addition, artichoke had no adverse effect on carcass characteristics and decreased abdominal fat pad.

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