https://dx.doi.org/10.22161/ijeab.51.26 ISSN: 2456-1878

Effect of dietary incremental levels of flaxseed supplementation on productive performance of lactating Damascus goats

Meteab M. I[1], El-Sayed H. M.[2], Abeer.M. EL-Essawy[1], Nassar M.S.[1], El-Bordeny N. E.[2]

[1]Animal and poultry Nutrition Dept., Animal and poultry Divi., Desert Research Center., Mataryia, 11753, Cairo, Egypt.
[2]Animal Production Dept., Fac. of Agric., Ain-Shams Univ., 68 Hadayek Shoubra 11241, Cairo, Egypt.

***Abstract*— *It is believable that supplemental essential fatty acids can change the fatty Acid (FA) composition in the milk. Feeding flaxseed to dairy animals improves milk production and milk quality, resulting in healthier milk for consumer. So, the objective of our study was to evaluate the effect of inclusion of ascending levels of flaxseed in Damascus goat's ration on performance and milk composition. Twenty-four of lactating Damascus goats (39.60 ±0.50 kg weight and 2-3 years old) were divided into three groups (randomly, eight animals each). The basic diet of control group (T1) consisted of 56.67% concentrate feed mixture (CFM) and 33.33% alfalfa hay and supplemented with 10% full fat soya, while the other groups were supplemented with 5% flaxseed + 5% full fat soya (T2) and 10% flaxseed (T3), respectively. Inclusion of higher level of flaxseed (10%) in goat's ration increases dry matter intake (DMI) with the positive effect on digestibility of most nutrients. In addition, rumen fermentation was affected with increased fat supply where levels of total volatile fatty acids (TVFA's) and ammonia-N (NH_3-N) are increased with reduced rumen pH values in animals fed on T3. In this study, significant increase of blood plasma total protein, globulin, albumin, urea and high-density lipoprotein concentration, whereas significant decrease of triglycerides, cholesterol and Low-density lipoprotein concentration in response to higher supplemental fat than T1 and T2. Goats supplemented with higher level of flaxseed recorded higher body weight, milk yield and fat corrected milk (FCM) yield, milk fat, protein and total solid content than the other groups (T1 and T2). In conclusion, higher flaxseed supply in dairy Damascus goat's diets resulted in improved total tract digestibility, feed efficiency and rumen fermentation parameters and milk production, milk composition while reduced blood lipids.*
***Keywords*— Flaxseed, Damascus goat, digestibility, feed intake, milk production.**

I. INTRODUCTION

Recently there has been an interest in using flaxseed in animal rations as it can be used to alter the fatty acid composition of milk products and improve animal performance, therefore, provide functional health benefits for the consumer. Flaxseed is an excellent source of high-quality protein and energy for ruminants **(Neveu *et al*., 2014)**. The oil content in flaxseed ranges between 40% and 45% **(Mohamed, 2013)**. Flaxseed is a great source of essential fatty acids, which contains approximately 50%–70% of α- linolenic acid (ω-3 fatty acids) **(Xu *et al*., 2013)**. So, there has been an increasing interest in use of oilseeds to improve the ruminant dairy products, because of the increasing consumer awareness of food healthiness. Although, **Benchaar *et al*. (2012)** reported that the inclusion of supplemental fat did not decrease or increase the nutrient digestibility, but **Piantoni *et al*. (2013)** found that palmitic acid enhanced the total tract digestibility of NDF, organic matter and CP. **Nawaze and Ali (2016)** suggested that generally fat inclusion in diet increased the milk production clearly compared with control diet while **Gargouri *et al*. (2006)** demonstrated that up to certain level of fat inclusion in diet leads to increased milk production and after that level of milk yield decrease. On the other hand, increasing inclusion level of fats in the diets of the ewes and goats resulted in linear increase of milk fat content **(Casals *et al*., 2006)** whereas, decreased the milk protein in cows and ewes but not in goats **(Nawaz and Ali, 2016)**.

https://dx.doi.org/10.22161/ijeab.51.26 ISSN: 2456-1878

This study aimed to evaluate the effect of increment of flaxseed supply levels (two levels versus control) in Damascus goat's ration on its productive performance during lactation period.

II. MATERIALS AND METHODS

This experiment was conducted at the Mariout Research Station (30 km to Alexandria) and labs of animal nutrition department, Desert Research Center (DRC) , El-Matarya , Cairo, Egypt.

The experimental animals, design and rations

Twenty-four Damascus goats (39.60 ±0.50 kg and 2-3 years) were randomly divided into three groups (eight animals each). All of the experimental groups were fed on 90% basal diet that consisted of 56.67% concentrate feed mixture (CFM) and 33.33% alfalfa hay) and supplemented with one of these supplements:10% full fat soya (T1), 5% flaxseed + 5% full fat soya (T2) or 10% flaxseed (T3), respectively. Three experimental rations were formulated to cover goats requirements according to **(NRC 1981)**. The chemical composition of the feed ingreadents and the experimental rations are presented in Table (1). Complete rations (concentrate + alfalfa) were offered twice daily at 7 am and 4 pm in quantities sufficient to allow free choice access to the ration, and animals have free access to clean fresh water. The animal weighed biweekly befor morning feeding and the orts were determined.

Table 1. Chemical composition of feed ingredients and the experimental rations (% on DM basis).

	feed ingredients				Complete rations		
Items	Flaxseed	Concentrate	Full fat soya	Hay	T1	T2	T3
Dry matter, %	95.93	90.76	93.58	92.66	91.68	91.79	91.91
organic matter, %	96.04	92.47	92.75	87.15	89.88	90.07	90.26
Ash, %	3.96	7.53	7.25	12.85	10.12	9.93	9.74
Crude protein, %	20.06	16.73	37.64	16.28	20.37	19.38	18.40
Ether extract, %	40.24	3.30	16.28	2.19	4.61	5.91	7.21
Crude fiber, %	28.55	13.16	10.23	30.83	20.46	21.43	22.40
Neutral detergent fiber, %	48.43	30.76	31.89	46.31	39.33	40.18	41.03
Acid detergent fiber, %	32.32	14.71	13.65	30.78	21.77	22.76	23.75
Nitrogen Free Extract, %	7.20	59.30	28.60	37.80	44.44	43.35	42.25
Non fiber carbohydrate, %	--	41.68	6.94	22.37	25.57	24.6	23.62

Oilseeds Fatty acids analysis

Fatty acids contents of soybean and linseed were analyzed according to **AOAC, (2000)** using Ultra Gas Chromatographs (Table 2).

Digestibility trials

A digestibility trial was performed at the end of lactation period and samples were taken through 45 days of lactation period. The feces were collected using fecal grab samples method from all doses, three times daily (7.00, 14.00 and 18.00) for three consecutive days. Acid-insoluble ash was used as an internal marker to estimate fecal output and nutrient digestibility. The digestibility coefficient of a given nutrient was calculated according to the following formula **(Van Kulen and Young, 1977):**

$$Digestibililty = 100 - \frac{\%indicator\ in\ the\ feed}{\%\ indicator\ in\ the\ feces}\ x\ \frac{\%\ nutrient\ in\ the\ feces}{\%\ nutrient\ in\ the\ feed}$$

Rumen liquor samples

Rumen liquor samples were randomly collected from four goats within each group using a stomach tube as described by **Khattab *et al*. (2011)** before the morning feeding (zero time), 3 and 6 h after the morning feeding. pH was immediately determined using pH meter (Gallen Kamp pH Stick pH K-120 – B). Then samples were filtered through two layers of sheethcloth, into 25 ml glass bottles with adding few drops of toluene to stop fermentation and 5 ml of paraffin oil just to cover the surface and kept in deep freeze (-18°C) till subsequent analysis.

https://dx.doi.org/10.22161/ijeab.51.26 ISSN: 2456-1878

Table.2: Fatty acids content (% of total) of the experimental oilseeds.

Fatty acid	Oilseeds	
	Flaxseed	Full fat soya
C16:0, Palmitic acid	5.52	13.90
C18:0, Stearic acid	4.90	5.72
C18:1n-9, Oleic acid	19.4	23.6
C18:1n-7, Vaccinic acid	0.74	1.30
C18:2n- 6, Linoleic acid	14.73	50.36
C18:3n-4,	0.20	ND
C18:3n-3, Linolenic acid	53.4	4.53
C20:0, Arachidic acid	0.18	0.40
C20:1n-9, Gadolic acid	0.13	ND
C22:0, Behenic acid	0.15	0.19
Non identified fatty acids	0.65%	ND

ND: not detected

Blood samples

At the end of the experimental trial, blood samples were taken from 4 animals for each group (the same animals were used to get rumen liquor content sample). A sample of 10 ml of blood per animal was withdrawn from the jugular vein before morning feeding. The blood samples were directly collected into vacationer tubes (containing EDTA as an anti-coagulant). The blood plasma was obtained by centrifuging the blood samples soon after collection at 4000 rpm for 15 minutes. Blood plasma was transferred into a clean dried glass vials and then stored in deep freezer at -18º C for subsequent specific chemical analysis.

Milk samples

Daily milk yield (DMY) was individually recorded weekly after colostrum period, up to 12th week of lactation. Doses were kept away from their kids for 12 h (9 pm: 9 am) (overnight), and then one teat was hand milked while the second teat was left for suckled kids. The daily milk yield was determined in two consecutive days the first for left teat and the second for right teat. Consequently, DMY was estimated as an average of the two teats. Milk was multiplied by 4: (2 teats X 2 (two half day) to complete 24 h) **(Alsheikh, 2013).** Milk samples were obtained weekly from each goat for 12 weeks and stored in glass bottles (50 ml) then analyzed to determine milk composition.

Analytical methods

Feedstuffs and fecal analysis

Samples (feeds and feces) were oven-dried (55° C for 72 h), then ground in welly mill fitted with a 1 mm screen (local manufacture). Feeds and fecal samples were subjected to proximate chemical analyses crude protein (CP), crude fiber (CF), ether extract (EE) and Ash according to **AOAC (2000)** while nitrogen free extract (NFE) was calculated by difference. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined in sequential procedures of **Van Soest *et al.* (1991)**, analysis using Ankom^{200} apparatus (Ankom Technology Corp., Fairport, NY) filter bag technique. Non-fiber carbohydrate (NFC) was calculated according to the following formula:

NFC (%) = 100− (%NDF+ %CP + %fat + %ash) (**NRC, 2001**).

Determination of basic rumen fermentation parameters

The pH of rumen liquor was immediately recorded using Gallen Kamp pH Stick pH K-120 – B. quantitative analysis of ammonia concentration was carried out by a modified Nessler's method modified by **Szumacher-Strabel *et al.* (2002)** and total volatile fatty acids (TVF's) were determined by steam distillation according to **Warner (1964)**.

Biochemical analysis of blood plasma

Blood serum samples were analyzed using commercial kits (Human Co. Germany). Total protein, albumin, urea, and creatinine were used as indicators for kidney function, while alanine aminotransferase (ALT) and aspartate aminotransferase (AST) were used as indicators for liver function and lipid profile (triglycerides (TG), cholesterol, high-density lipoprotein (HDL)-cholesterol, low-density lipoprotein (LDL)-cholesterol and total lipids) as indicators for fat mobilization. All measurements were done using Jenway spectrophotometer (UK) and the kits purchased from Human Co. Globulin concentration was calculated by

https://dx.doi.org/10.22161/ijeab.51.26 ISSN: 2456-1878

subtraction of total plasma protein and plasma albumin. The albumin /globulin (A/G) ratio was calculated.

Milk analysis

Milk samples were analyzed for total solids, fat, total protein and lactose by infrared spectrophotometry (Foss 120 Milko-Scan, Foss Electric, Hillerød, Denmark). Solids-not-fat (SNF) was calculated by difference. Fat corrected milk (4% fat) was calculated by using the following equation according to Gaines (1928):

FCM = 0.4 milk yield (gm) + 15 fat yield (gm)

Statistical analysis

Data were statistically analyzed using (**SAS, 2006).** Separation among means was carried out according to Duncan Multiple Range test **(Duncan, 1955).** Data of body weight changes, digestibility and blood parameters were statistically analyzed according to the following model: $Y_{ij} = \mu + T_i + e_{ij}$, Where y_{ij} = represents observation, μ=: the overall mean, T_i = effect of treatment (experimental group), e_{ij}: experimental error. While the data of rumen fermentation parameter and milk production were statistically analyzed according to the following model: $Y_{ij} = \mu + T_i + S + an(t) + S*T + e_{ij}$. Where: Y_{ij}= the observation on the I^{th} treatment, μ = Overall mean, T_i = Effect of the I^{th} treatment, S = Effect of the period, an (t) = Effect of the animal in the treatment and e_{ij}= Random experimental error.

III. RESULTS AND DISCUSSION

Oil seeds fatty acid composition:

Fatty acid (FA) profiles of the two oilseeds are completely different as indicated in Table (2). it is evident that linseed is the richest source of linolenic acid (C18:3n-3) (53.4% of the total fatty acids) followed by oleic (C18:1n-9), linoleic (C18:2n-6), palmitic (C16:0), then stearic acid (C18:0) as (19.4, 14.73, 5.52 and 4.90%, respectively). However, soybean is the richest source of linoleic acid (50.36%) and the rest of FA which are oleic, palmitic, stearic and linolenic acids accounting for formed 23.6, 13.9, 5.72 and 4.53% of the total FA, respectively.

Effect of experimental rations on digestibility and nutritive value

Animals supplemented with the highest level of flaxseed (10%, T3) recorded significant higher digestibility of all nutrients (DM, P=0.019, OM, P=.044, EE, P=0.007, CF, P=0.02 except CP showed non significant differences P=0.45 and nitrogen free extract (P=0.056) compared to 0 and 5% levels (T1 and T2) (table 3). improved digestibility with 10% flaxseed supply may be due to that flaxseeds are small, flat and oval-shaped (2×5 mm), therefore, flaxseed may result in higher possibility of escaping from mastication so, increased passage rate from the rumen and packaging the fat and protein in such a way not to negatively affect rumen function, while promoting feed intake, increase the energy content of the diet and gives a partial protection versus microbial attack or reduces the impact of oil on ruminal microbial or both, leading to negligible effect on the digestion of fibers as well as Improved CP digestibility **(Khorasani *et al*., 1992, Syed *et al*., 2012 and Kim *et al*., 2004)**. In this connection, **Dayani *et al*. (2011)** recorded that feeding flaxseed to ruminants affecting rumen function positively and increase the nutrients availability in the small intestine. Also, **Gonthier *et al*. (2004)** reported an increment of total digestibility of organic matter and fiber with extruded flaxseed supply. In addition, flaxseeds are sources of unsaturated fatty acids which, generally, highly digestible compared to saturated fatty acids **(Palmquist and Mattos, 2006)**. Conversely, **Machmüller *et al*. (2000)** did not find any variations in digestibility when they feed lambs 6.7% flaxseeds, **Wachira *et al*. (2000)** with sheep fed 10.5% flaxseeds and **Paula *et al*. (2014)** with oilseeds in Saanen goat diets.

The reduction in CF digestibility in the animals fed ration of T1and T2 (supplemented with 10 and 5% full fat soybean) compared to the animals fed ration of T3 (supplemented with 10 % flaxseed) may be due to that the fats in full fat soy is not protected and affect negatively on rumen function and cellulolytic bacteria which led to decrease fiber digestion on the contrary for flaxseed the fat is protected as indicated by **Khorasani *et al*. (1992); Syed *et al*. (2012) and Kim *et al*. (2004)**

Improved feed digestibility in the present study resulted in significant enhancement of nutritive value as total digestible nutrients (TDN, P= 0.001 % with 10% flaxseed supplementation (T3). However, digestible crude protein (DCP%) increased (P=0.009) with 10% soybean supplementation. This may be due to that the ration containing 10 % soybean recorded higher CP contents (20.37) compared to the other experimental treatments Table (1)

Table.3: Effect of feeding experimental rations on digestibility of nutrients during the lactation period.

Items	T1	T2	T3	SE	P
Dry matter, %	56.60^{b}	56.12^{b}	61.20^{a}	1.1071	0.019
Organic matter, %	59.18^{b}	60.55^{b}	63.29^{a}	0.9850	0.044
Crude protein, %	79.05	77.9	81.74	0.9545	0.45
Ether extract, %	62.43^{b}	73.02^{b}	82.42^{a}	3.2858	0.007
Crude fiber, %	38.02^{b}	41.36^{b}	49.64^{a}	2.4066	0.02
Neutral detergent fiber, %	31.92^{b}	38.76^{b}	43.68^{a}	2.5424	0.03
Acid detergent fiber, %	32.28^{b}	33.96^{b}	41.42^{a}	2.1368	0.03
Nitrogen free extract, %	60.84	62.12	62.83	1.2821	0.56
Nutritive value					
Digestible crude protein, %	15.85^{a}	14.93^{b}	14.93^{b}	0.1851	0.0094
Total digestible nutrients, %	56.17^{c}	59.55^{b}	64.38^{a}	1.0220	0.0010

^{a} and ^{b}, means with different superscripts in the same row are significant different.

Effect of experimental rations on Feed intake

Results of dry matter intake (DMI) Table (4) showed that supplementation with higher level of flaxseed (T3) resulted in numerically higher dry matter intake (DMI) during the lactation period. This may be attributed to the increment in nutrient digestibility (table 4) which promote rumen discharge consequently force the animal to eat a lot.

Table.4: Effect of feeding experimental rations on feed intake during the lactation period.

Items (g/h/d)	T1	T2	T3
Dry matter intake	2210.62	2213.94	2284.81
Total Digestible Nutrients intake	1241.73	1318.46	1470.91
Crude protein intake	443.18	424.25	417.49
Digestible Crude protein intake	350.34	330.49	341.23

In this connection**, Drouillard *et al*. (2002)** recorded that inclusion of 10% flaxseed in lactating cattle diets led to increase feed intake. However, **Silva-kazama *et al.* (2010)** reported a reduction in dry matter intake when feeding lactating goats on oilseeds and **Benson *et al.* (2001)** attributed this reduction to duodenal availability of fatty acids can decrease feed intake**.**

The goats fed on 10% flaxseeds recorded numerically higher TDN intake compared with the other experimental groups (T1 and T2) in response to increase TDN content for ration of T3 compared to T1 and T2 (table 4). On the other hand, the animals of T1 recorded higher crude protein intake (CPI) and digestible crude protein (DCPI) compared to T2 and T3 as a result of increased CP content for ration T1 (table 1) as well as increase of DCP content for T1 compared to T2 and T3 (table 4).

Effect of experimental rations on rumen fermentation parameters

Concerning ruminal fermentation parameters Table (5) it is clear that 10% supply of flaxseed improved rumen fermentation where total volatile fatty acids (TVFA's) and ammonia concentration increased as a mean value due to the effect of treatment compared to the other groups (T1and T2). These results disagree with the results of **Broudiscou et al. (1994)**, who reported a decrease in total VFA concentration in sheep supplemented with 6% of flaxseed oil in a forage-based diet. Also, in this connection **Ueda et al. (2003)** observed higher ruminal ammonia with flaxseed oil supply to dairy cows, whereas **Doreau et al. (2009)** reported no change in ammonia concentration with flaxseed oil supply in dairy cows. Contradicting with these results, **Ikwuegbu and Sutton, (1982)** and **Broudiscou et al. (1994)** reported a decrement in ammonia concentration in sheep supplemented with different levels of flaxseed oil.

This controversial in results may be due to the level of supplement and it's form (oil or seed), experimental animal, experimental ration or experimental conditions as whole. Regarding the ruminal pH level, it is decreased significantly with higher level of flaxseed supply and this may be related to increased production of TVF'S resulting in decrease in pH value.

Table.5: Effect of feeding experimental rations on rumen fermentation parameters during the lactation period.

Items	T1	T2	T3	mean(time)	SE
			Total volatile fatty acids meq dl^{-1}		
0h	7.95	5.88	9.70	7.84[b]	0.2245
3h	5.38	7.90	8.63	7.3[b]	0.2245
6h	7.23	7.48	12.33	9.01[a]	0.2245
Mean	6.85[b]	7.083[b]	10.22[a]		
			Ammonia concentration, mg dl^{-1}		
0h	5.025	5.3	6.325	5.55	0.1578
3h	4.225	6.4	5.95	5.53	0.1578
6h	4.575	5.65	6.925	5.72	0.1578
Mean	4.61[b]	5.78[b]	6.40[a]		
			pH value		
0h	6.95	6.83	6.77	6.85a	0.0818
3h	6.58	6.55	6.25	6.46b	0.0818
6h	6.68	6.43	6.41	6.51b	0.0818
Mean	6.74[a]	6.61[a]	6.47[b]		

[a] and [b], means with different superscripts in the same row are significant different.

Effect of experimental rations on blood parameters

Blood plasma concentrations of total protein (TP), albumin and globulin (Table 6) were increased significantly (P<0.0001) with higher flaxseed level (T3) compared to the other experimental groups (T1 and T2). This may be due to that T3 recorded the highest CP digestibility (table 3) and the highest DMI and TDNI compared to the other experimental groups (table 4). **Kumar *et al.* (1980)** and **Bush, (1991)** postulated that blood plasma total proteins concentration reflects the nutritional status of the animal and reported a positive correlation between blood total proteins concentration and dietary protein level. Moreover, protein fractions of flaxseed composed of albumin, globulin, glutelin and prolamin where the globulin being the major fraction **(Oomah and Mazza, 1993)**.

Blood plasma levels of lipid profile were mainly affected by flaxseed level. Concentrations of triglycerides (TG), cholesterol, total lipids and low-density lipoproteins (LDL) were decreased significantly (P<0.0001) with increasing the level of flaxseed supply compared with zero flaxseed supply. These may be due to the higher (ω-3) fatty acids concentration in flaxseed compared to soybean seed (53.4 Vs 4.53, Table **2**). In this connection **Harris *et al.* (1997)** found that (ω-3) fatty acids reduce plasma triglyceride levels, by inhibiting the synthesis of low-density lipoprotein and triglycerides in the liver. The present results supported this concept because about 53% of fatty acids content of flaxseeds are α-linolenic acid (ω-3) (table 2) that inhibiting the synthesis of very low-density lipoprotein cholesterol and triglycerides in the liver. Consequently, feeding whole flaxseed increased blood concentrations of (ω-3) fatty acids and decreased the ω-6 fatty acid level in blood **(Petit, 2002)**. It is also possible to attribute the reduction of cholesterol and triglycerides levels to flaxseed CP content, where **Bhathena *et al.* (2002)** found that flaxseed proteins were effective in lowering plasma cholesterol and triacylglycerol levels compared to soybean and casein proteins in obese rats. The gradual increase

https://dx.doi.org/10.22161/ijeab.51.26 *ISSN: 2456-1878*

(P=0.0001) in level of high-density lipoprotein (HDL) in blood plasma of animals fed on rations supplemented with 5 and 10% flaxseed in the current study was matching with the reduction of cholesterol, triglycerides and LDL levels because HDL removes fats and cholesterol from cells including within artery wall and transport it back to the liver for excretion or reutilization **(Peter, 2005).**

Table.6: Effect of feeding experimental rations on some blood plasma parameters during lactation period.

Items	T1	T2	T3	SE	P value	Normal rang
Total protein, g/dl	7.12[c]	7.40[b]	8.52[a]	0.23	<.0001	6.4 -7.8
Albumin, g/dl	4.66[b]	4.59[b]	5.14[a]	0.18	<.0001	2.4 -4.4
Globulin, g/dl	2.45[c]	2.80[b]	3.38[a]	0.25	0.0022	Ne
Urea, mg/dl	39.13[b]	41.21[b]	51.17[a]	3.28	<.0001	15-50
Creatinine, mg/dl	0.84[a]	0.65[b]	0.54[c]	0.07	<.0001	0.9 -1.8
Total lipids, mg/dl	868.0[a]	866.4[a]	745.6[b]	27.6	<.0001	Ne
Cholesterol, mg/dl	210.8[a]	188.6[b]	174.9[c]	5.3	<.0001	150-225
Triglycerides, mg/dl	111.2[a]	99.6[b]	90.5[c]	4.34	<.0001	40-140
High-density lipoprotein, mg/dl	59.7[c]	66.1[b]	73.9[a]	2.74	0.0001	Ne
Low-density lipoprotein, mg/dl	176.1[a]	159.2[b]	141.4[c]	5.18	0.0001	Ne
Aspartate aminotransferase, Units / ml	33.97	34.25	36.47	2.47	0.2281	Up to 40
Alanine aminotransferase, Units / ml	14.94[b]	15.28[a]	15.55[a]	0.15	0.0003	15- 52

a and b mean with different superscripts in the same row are significant different. Normal rang: http://goat-link.com/content/view/204/194/#.XFgUrlwzbIU, ne: not estimated.

Blood urea concentration was increased in animals fed on ration supplemented with 10 % flaxseed compared to the animals fed ration supplemented with zero and 5% flaxseed (Table 6). This increase in urea concentration was supported by the increased CP digestibility (Table 3) as an indicator to improved protein metabolism and improved N utilization with increasing flaxseed level. These results are also supported with higher levels of plasma total protein as an indicator for improved protein metabolism in liver. In this line, **Sharma *e t al.* (1972)** reported lower urea N concentration is usually reported with decreased N digestibility and vice versa.

Regarding creatinine levels, animals fed on T1 recorded significantly higher levels of creatinine than other treatments (T2 and T3), but all values were within the normal range indicating normal renal function. Blood plasma level of aspartate amino transferase (AST) was similar among treatments while flaxseed supply stimulates (P<0.01) blood alanine amino transferase (ALT) activity and its highest level was recorded in goats supplemented with higher level of flaxseed (T3) compared with other treatments although ALT activity lies within the normal range in all treatments. **Nudda *et al*., (2013)** agree with the present findings and they found that inclusion of extruded linseed in dairy goat's diets did not affect renal and hepatic function biomarkers in serum except AST and ALT which tended to differ.

Milk yield, Composition and feed conversion ratio

Data of Table, (8) showed the effect of experimental treatment on milk yield and its composition. Introducing higher level of flaxseed in goats diets (T3) increased milk yield (P<0.01) and improved its composition compared with milk of goats fed T1 or T2 rations. This may be due to increased DM and TDN intake (table 5), improved nutrients digestibility (DM, OM, CP, CF, NDF and ADF) in goats fed on T3 ration (Table 4), leading to increased nutrients availability for milk constitutes synthesis. Similar observations were reported by **Chilliard and Ferlay, (2004)** who generally observed that increase dietary lipids led to increase milk yield, **Gomez-Cortes *et al*. (2009)** in ewes**, Hurtaud *et al*. (2010)** in dairy cows and **Kholif *et al*. (2011)** in dairy buffaloes with flaxseed. Also, higher fat corrected milk (FCM) and fat content% (P<0.01) in milk of T3 fed goats were definitely attributed to high fat content of flaxseed consequently high energy source. Moreover, **Bernard *et al.* (2009); Bionaz *et al.* (2012)** found that fats as dietary supplements encourage the nutrient toward the mammary gland instead of toward fat deposition in the adipose tissue and activate the lipogenic gene expression at mammary gland, leading to an increase of milk fat secretion. Indeed, according to **Zenou and Miron, (2005) and Schwab *et al*. (2006)** increased fiber digestibility in goats fed on T3 diets (table 3) leading to increased milk fat contents. Moreover, use of whole flaxseed as protected fatty acids inside a seed coat did not disturb rumen function so, increased mammary lipogenesis as a result of increased supply of polyunsaturated fatty acid (table 3). **Gargouri *et al.* (2006) and Nudda *et al.* (2013)** consistent with the current results, in sheep Conversely, **Martin *et al.* (2008)** reported decreased FCM yield and fat content on feeding lactating Holstein cows on extruded flaxseed and flaxseed oil diets and they explained these findings by lower DMI and lower digestibility of fiber due to the high level of oil intake. However, **Petit, (2003)** reported no change in milk yield with feeding of (13.3%) whole flaxseed and also **Petit and Cortes, (2010)** when feeding of (72 and 36 g/kg DM) whole flaxseed. Increased milk protein concentration (P<0.01) in T3 fed goats may be due to the increased CP digestibility (table 3) and increase blood total protien and albumin (table 6). **Nudda *et al.* (2013)** agreed with the present results where they reported that flaxseed supplementation to Saanen goats led to increased milk protein concentrations as a result to higher protein availability in the intestine. Milk total solids (TS) were increased (P<0.01) with increased level of flaxseed supply (T3) than the other groups (T1 and T2). This may be due to the increasing content of fat, protein and lactose in milk (table 8). These results agree with **Silva-Kazama *et al.* (2007)** with dairy cows.

Also, increased percentage of solids not fat (SNF) in the same pattern (P<0.05) may be due to increased protein and lactos in milk hence SNF are residual substances after extraction of fat from milk. lactose % results didn't affected in the current study similar to **Miroslava *et al.* (2013)** with goats fed flaxseed. The previous results of the current study indicating general and mostly significant improvement in animal performance (increased DMI, nutrients digestibility, milk yield and all milk macro compounds) with increased supply of flaxseed (T3) so, this improvement associated with the best (P<0.01) feed conversion ratio (FCR) either related to milk yield or to fat corrected milk.

IV. CONCLUSION

In conclusion, flaxseed supplementations in Damascus goat's diets during lactation period, lead to improve total tract digestibility, reduced blood plasma lipids and rumen fermentation. Also, flaxseed increase milk production (milk yield and fat corrected milk yield), milk fat content and protein concentration in milk. Finally, flaxseed inclusion (10%) has beneficial impacts on the fat profile of milk producing healthier dairy products for consumers. Further studies should be conducted to obtain the best inclusion level of flaxseed to get more benefits.

Table.8: Effect of feeding experimental rations on milk production, composition and feed conversion ratio.

Item	T1	T2	T3	SE	P
			Milk production		
Milk yield, g/h/d	1335.7[b]	1300.9[b]	1542.5[a]	136.8757	0.0004
Fat corrected milk, g/h/d	572.1[b]	709.7[b]	1485.9[a]	120.342	<.0001
			Milk composition		
Fat, %	2.52[b]	2.41[b]	3.74[a]	0.163	<.0001
Protein, %	2.67[b]	2.09[c]	3.33[a]	0.1893	<.0002
Total Solids, %	11.68[c]	9.64[b]	12.08[a]	2.2374	0.0002
Solids Not Fat, %	7.28[b]	7.22[b]	8.34[a]	0.3093	0.0292
Lactose, %	4.46	4.21	4.58	0.1842	0.2112
			Feed conversion ratio calculation by		
Milk yield, kg/kg DM	2.088[a]	2.4198[a]	1.632[b]	0.4514	0.0028
Fat corrected milk, kg/kg DM	4.22[a]	4.463[a]	1.70[b]	0.6714	<.0001

[a] and [b] mean with different superscripts in the same row are significant different. Feed Conversion Ratio (FCR) calculation based on DMI.

REFERENCES

[1] **Alsheikh, S., (2013).** Influence of age and live body weight on daily milk yield of Zaraibi and Shami goats in Sinai, Egypt .J. Annals of Agricultural Science.,58 (1):1-3.

[2] **AOAC.**, (**2000).** Official Methods of Analysis, th 17 edition. AOAC, Arlington, VA, USA.

[3] **Benchaar, C., Romero-Pérez, G.A., Chouinard, P.Y., Hassanat, F., Eugene, M., Petit, H.V. and Côrtes, C., (2012).** Supplementation of increasing amounts of linseed oil to dairy cows fed total mixed rations: Effects on digestion, ruminal fermentation characteristics ،protozoal populations, and milk fatty acid composition. J Dairy Sci., 95: 4578–4590.

[4] **Benson, J.A., Reynolds, C.K., Humphries, D.J., Rutter,S.M. and Beever,D.E., (2001)** Effects of abomasal infusion of long-chain fatty acids on intake, feeding behavior and milk production in dairy cows. J. Dairy Sci., 84:1182-1191.

[5] **Bernard, L., Bonnet, M., Leroux, C., Shingfield, K.J. and Chilliard, Y., (2009).** Effect of sunflower-seed oil and linseed oil on tissue lipid metabolism, gene expression, and milk fatty acid secretion in Alpine goats fed maize silage-based diets. J. Dairy Sci.,92: 6083–6094.

[6] **Bhathena, S.J., Ali, A.A., Mohamed, A.I., Hansen, C.T. and Velasquez, M.T., (2002).** Differential effects of dietary flaxseed protein and soy protein on plasma triglyceride and uric acid levels in animal models. J. Nutritional Bio.,13(11): 684-689.

[7] **Bionaz, M., Thering, B.J. and Loor, J.J., (2012).** Fine metabolic regulation in ruminants via nutrient-gene interactions: saturated long-chain fatty acids increase expression of genes involved in lipid metabolism and immune response partly through PPAR-a activation. Br. J Nutr., 107:179–191.

[8] **Broudiscou, L., Pochet, S. and Poncet, C., (1994).** Effect of linseed oil supplementation on feed degradation and microbial synthesis in the rumen of ciliate-free and refaunated sheep. Anim Feed Sci Technol., 49: 189–202.

[9] **Bush, B.M., 1991.** Interpretation of Laboratory Results for Small Animal Clinicians. Oxford Blackwell Scientific Publications, London. pp.515, ref.75.

[10] **Casals, R.G., Caja, G., Pol, M.V., Such, X., Albanell, E., Gargouri, A., Casellas, J., (2006).** Response of lactating dairy ewes to various levels of dietary calcium soaps of fatty acids. J. Anim Feed Sci Technol.,131:312-332.

[11] **Chilliard, Y. and Ferlay, A. (2004).** Dietary lipids and forages interactions on cow and goat milk fatty acid composition and sensory properties. Reprod. Nutr. Dev., 44: 467–492.

[12] **Dayani, O., Dadvar, P. and Afsharmanesh, M., (2011).** Effect of dietary whole cottonseed and crude protein level on blood parameters and performance of fattening lambs. Small Ruminant Research., 97: 48-54.

[13] **Doreau, M., Aurousseau, E. and Martin, C. (2009).** Effects of linseed lipids fed as rolled seeds, extruded seeds or oil on organic matter and crude protein digestion in cows. Anim. Feed Sci. Technol., 150:187–196.

[14] **Drouillard, J. S., Good, E. J., Gordon, C. M., Kessen, T. J., Sulpizio, M. J., Montgomery, S. P. and Sindt, J. J. (2002).** Flaxseed and flaxseed products for cattle: Effects on health, growth performance, carcass quality and sensory attributes. Proc.59th Flax Institute, Fargo, N.D., 72-87.

[15] **Duncan, D.B., (1955).** Multiple range and multiple F tests, Biometrics, 11:(١) 1-42.

[16] **Gargouri, A., Caja, G., Casals, R. and Mezghani, I. (2006).** Lactational evaluation of effects of calcium soap of fatty acids on dairy ewes. J. Small Ruminant Res., 66:1-10.

[17] **Gomez-Cortes, P., Bach, A., Luna, P., Juarez, M. and de la Fuente, M.A. (2009).** Effects of extruded linseed supplementation on n-3 fatty acids and conjugated linoleic acid in milk and cheese from ewes. J. Dairy Sci., 92: 4122–4134.

[18] **Gonthier, C., Mustafa, A.F., Berthiaume, R., Petit, H.V., Martineau, R. and Ouellet, D.R., (2004).** Effects of Feeding Micronized and Extruded Flaxseed on Ruminal Fermentation and Nutrient Utilization by Dairy Cows. J. Dairy Sci., 87, 1854-1863.

[19] **Harris, W.S., Ginsberg, H.N., Arunakul, N., Shachter, N.S., Windsor, S.L. and Adams, M. (1997).** Safety and efficacy of Omacor in severe hypertriglyceridemia. J. Cardiovasc Risk.,4:385-391.

[20] **Hurtaud, C., Faucon, F., Couvreur, S. and Peyraud, J.L. (2010).** Linear relationship between increasing amounts of extruded linseed in dairy cow diet and milk fatty acid composition and butter properties. J. Dairy Sci., 93: 1429–1443.

[21] **Ikwuegbu, O. A. and Sutton, J.D., (1982).** The effect of varying the amount of linseed oil supplementation on rumen metabolism in sheep. Br. J. Nutr., 48:365–375.

[22] **Khattab, H.M., Gado, H.M., Kholif, A.E., Mansour, A.M., and Kholif, A.M. (2011)** The potential of feeding goats sun dried rumen contents with or without bacterial inoculums as replacement for berseem clover and the effects on milk production and animal health. Inter J Dairy Sci., 6: 267-277.

[23] **Kholif, S.M., Morsy, T.A., Abedo, A.A., El-Bordeny, N. and Abdo, M.M., (2011).** Milk production and composition, milk fatty acid profile, nutrients digestibility and blood composition of dairy buffaloes fed crushed flaxseed in early lactation. Egyptian J. Nutr. & Feeds., 14: 385-394.

[24] **Khorasani, G. R., De Boer, G., Robinson, P. H., and Kennelly, J. J., (1992).** Effect of canola fat on ruminal and total tract digestion، plasma hormones, and metabolites in lactating dairy cows. J. Dairy Sci., 75:492–501.

[25] **Kim, C. M, Kim, J. H., Chung, T. Y. and Park, K. K., (2004).** Effects of flaxseed diets on fattening response of

hanwoo cattle: 2. fatty acid composition of serum and adipose tissues. J. Anim. Sci., 17(9): 1246-1254.

[26] Kumar, N., U.B. Singh and D.N. Verma, 1980. Effect of different levels of dietary protein and energy on growth of male buffalo calves. Ind. J. Anim. Sci., 15: 513-517.

[27] **Machmüller, A., Ossowski, D.A. and Kreuzer, M., (2000).** Comparative evaluation of the effects of coconut oil, oilseeds and crystalline fat on methane release, digestion and energy balance in lambs. Anim. Feed Sci. Technol., 85:41–60.

[28] **Martin, J.R., Jouany, J.P., Doreau, M. and Chilliard, Y., (2008).** Methane output and diet digestibility in response to feeding dairy cows crude linseed, extruded linseed, or linseed oil.J.Animal science., 86:2642-2650.

[29] **Miroslava, I., Bohuslav, Č., Luboš,Z., Anna, Š., Kateřina, Š. and Miloslav, Š., (2013).** Effects of flax seed supplementation to lactating goats on milk fatty acid content. Food technology., 2:21-28.

[30] **Mohamed, S. E. E., (2013).** Applying ARIMA to Predict Egypt's Self- Sufficiency Rates of Vegetable Oils During the Period 2011-2010, The 20th Conference of Agricultural Economists, Egypt's Food Security in The Light of International Markets' Risks, The Egyptian Society of Agricultural Economists, October 30-31.

[31] **National Research Council [NRC]., 2001.** Nutrient Requirements of Dairy Cattle. National Academy of Sciences, Washington, DC, USA.

[32] **Nawaz, H. and Ali, M., (2016).** Effect of supplemental fat on dry matter intake, nutrient digestibility, milk yield and milk composition of ruminants. Pak. J Agri. Sci.,53 (1): 271 -275.

[33] **Neveu, C., Baurhoo, B. and Mustafa, k. A., (2014).** Effect of feeding extruded flaxseed with different grains on the performance of dairy cows and milk fatty acid profile. J Dairy Sci., 97:1–9.

[34] **NRC. Nutrient Requirements of Goats., (1981)**. Angora, Dairy، and Meat Goats in Temperate and Tropical Countries. National Academy Press, Washington, DC, USA.

[35] **Nudda,G., Battacone, A., Atzori, S., Dimauro, C., Rassu, S. P. G., Nicolussi, P., Bonelli, P., and Pulina, G., (2013).** Effect of extruded linseed supplementation on blood metabolic profile and milk performance of Saanen goats. J. Animal sci.,7(9): 1464–1471.

[36] **Oomah, B. D. and Mazza, G., (1993).** Flaxseed proteins A review. J.Food Chem., 48: 109-114.

[37] **Palmquist, D.L. and Mattos, W.R.S., (2006).** Metabolismo de lipídeos. In: berchielli, t. T. Nutrição de ruminantes. Jaboticabal: funep, 287-310.

[38] **Paula, A. G., Claudete, R.A., Luciano, S.d.L., Maximiliane, A.Z., Francisco, A.F.M., (2014).** Effect of whole oilseeds feeding on performance and nutritive values of diets of young growing saanen goats. Ciênc. Agrotec, 38: 181-187.

[39] **Peter, P., (2005).** "The good cholesterol "; high-Density Lipoprotein. Circulation.,111 (5): 89–91.

[40] **Petit, H. V., (2002).** Digestion, milk production, milk composition, and blood composition of dairy cows fed whole flaxseed. J. Dairy Sci., 85:1482–1490.

[41] **Petit, H. V., (2003).** Digestion, milk production, milk composition and blood composition of dairy cows fed formaldehyde treated flaxseed or sunflower seed. J. Dairy Sci., 86:2637-2646.

[42] **Petit, H.V. and Cortes, C., (2010).** Milk production and composition, milk fatty acid profile, and blood composition of dairy cows fed whole or ground flaxseed in the first half of lactation. Anim. Feed Sci. Technol., 158: 36- 43.

[43] **Piantoni, P., Lock, A.L. and Allen, M.S., (2013).** Palimitic acid increased yields of milk and milk fat and nutrient digestibility across production level of lactating cows. J. Dairy Sci., 96:7143-7154.

[44] **SAS Institute., (2006).** SAS User's Guide: Statistics. Ver 9.0. SAS Institute, Cary, N.C., USA.

[45] **Schwab, E.C., Schwab, C.G., Shaver, R.D., Girard, C.L., Putnam, D.E. and Whitehouse, N.L., (2006).** Dietary forage and nonfiber carbohydrate contents influence B-vitamin intake, duodenal flow, and apparent ruminal synthesis in lactating dairy cows. Journal of Dairy Science., 89:174–187.

[46] **Sharma, H.R., Ingalls J.R. and Mckirdy, J. A., (1972).** Nutritive value of formaldehyde-treated rapeseed meal for dairy calves. J. Anim. Sci., 52:363 –371.

[47] **Silva-Kazama, D.C., Santos, G.T.D., Branco, A.F., Damasceno, J.C., Kazama, R., Matsushita, M., Horst, J.A., dos Santos, W.B.R. and Petit, H.V., (2007).** Production performance and milk composition of dairy cows fed whole or ground flaxseed with or without monensin. J. Dairy Sci., 90: 2928-2936.

[48] **Silva-Kazama, D.C., Kazama, R., Gagnon, N., Benchaa, C.R., Santos, G.T.D., Zeoula, L.M. and Petit, H.V., (2010).** Milk composition, milk fatty acid profile, digestion, and ruminal fermentation in dairy cows fed whole flaxseed and calcium salts of flaxseed oil. J. Dairy Sci., 93: 3146–3157.

[49] **Syed, A. S., Afshar, M. A., Hasan, F. and Jaber, D., (2012).** Importance essential fatty acids (n-6 and n-3) in animal nutrition: I: Ruminant. J. Annals of Biological Research., 3, 2:1161-1176.

[50] **Szumacher-Strabel,M ., Potkanski, A., Kowalczyk, J., Cieslak, A., Czauderna, M., Gubala, M. and Jedroszkowiak, P., (2002).** The influence of supplemental fat on rumen volatile fatty acid profile, ammonia and pH levels in sheep fed a standard diet. Journal of Animal and Feed Sciences., 11(4): 577-587.

[51] **Ueda, K., Ferlay, A., Chabrot, J., Loor, JJ., Chilliard, Y. and Doreau, M., (2003).** Effect of linseed oil supplementation on ruminal digestion in dairy cows fed diets

with different forage: concentrate ratios. J. Dairy Sci., 86: 3999– 4007.

[52] **Van Keulen, J. and Young, B. A., (1977).** Evaluation of acid insoluble ash as natural marker in ruminant digestibility studies. J. Animal Sci., 44, 2: 282-287.

[53] **Van Soest, P. J., Robertson, J. B. and Lewis, B. A., (1991)**. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysac-charides in relation to animal nutrition. J. Dairy Sci., 74:3583–3597.

[54] **Wachira, A. M., Sinclair, L. A., Wilkinson, R. G., Hallett, K., Enser, M.and Wood, J. D., (2000).** Rumen biohydrogenation of n-3 polyunsaturated fatty acids and their effects on microbial efficiency and nutrient digestibility in sheep. J. Agric. Sci., 135:419–428.

[55] **Warner, A.C.L., (1964).** Production of volatile fatty acids in the rumen: methods of measurement. Nutr. Abstracts and reviews., 34: 339- 352.

[56] **Xu, J., Gao, H., Song, L., Yang, W., Chen, C., Deng, Q., Huang, Q., Yang, J. and Huang, F., (2013).** Flaxseed oil and α-lipoic acid combination ameliorates hepatic oxidative stress and lipid accumulation in comparison to lard. Lipids Health Dis., 1 (12), 58.

[57] **Zenou, A. and Miron, J., (2005).** Milking performance of dairy ewes fed pellets containing soy hulls as starchy grain substitute. Small Ruminant Research., 57: 187–192.