Egyptian Journal of Sheep & Goat Sciences, Vol. 12, No. 2, P: 25-34, August 2017

Effect of Sunflower oil supplementation with or without thyme leaves (*Thymus vulgaris*) on digestibility, milk production and milk fatty acid profile of dairy goats

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ABSTRACT

This work aimed to investigate the effect of sunflower oil supplementation with or without Thyme leaves (*Thymus vulgaris*) in lactating goat's rations on digestibility, milk yield, milk composition and milk fatty acid profile. Eighteen Zaribi goats of round 43 kg live body weight were divided into three similar groups (6 each) for the feeding trial that lasted 90 days. Three experimental rations were formulated, first control (T1) consisted of concentrate feed mixture (CFM) and berseem hay (1:1), second (T2) fed as T1 but supplemented at rate 3% of the total ration with sunflower oil (SO) and third one (T3) was fed as T2 but, supplemented with thyme leaves (*Thymus vulgaris*, THY) at rate 25 g/h/d.

Results showed that most digestibility of nutrients were significantly higher for T3 followed by T2 compared to the control (T1). However, to lesser extent CF digestibility was occurred with diet supplemented either with SO or SO+THY than the control. There was significant ($P<0.05$) increase in TDN value of T3, being 68.35% compared to control (66.39%). The control diet (T1) recorded the highest value of total saturated fatty acid, being 41.54%, while ration (T3) had the highest value of unsaturated fatty acid, being 35.47%. Supplementation with SO alone (T2) or with THY (T3) resulted in higher milk yield compared with control.

In conclusion, results showed that supplementation with sunflower oil and Thyme leaves to lactating goat's rations could increase milk yield and content of unsaturated fatty acids and decrease the saturated fatty acid in milk without any adverse effect on goats' health or lactation performance.

Key words: Thyme, oil supplementation, digestibility, lactating goats, milk fatty acid profile.

INTRODUCTION

Nowadays, it well known that high content of saturated fatty acids (SFA) in ruminant meat or milk can increase the risk of cardiovascular diseases.

Milk composition varies and no ideal composition is optimal for all applications. Hence, opportunities exist for manipulation of milk composition on-farm to improve the human nutritional and physiological properties of milk and milk products, such as enhancing concentration of selenoprotein and/or conjugated linoleic acid (CLA), or improving its composition for more efficient processing into a range of dairy products **(Walker *et al.*, 2004).**

Lipids, in addition to supplying energy to dairy ruminants diet, can modify the fat composition of milk yield **(Chilliard *et al.*, 2000)**. This is of great importance as such feed components give the beneficial effects of some long-chain fatty acids (LCFA) to human health. Essential oils have an active role against several bacteria involved in rumen biohydrogenation. Dietary polyunsaturated fatty acids (PUFA), which undergo in complete ruminal biohydrogenation are considered one of the key sources of cis-9 trans-11 CLA in milk fat. However, the principal source is the endogenous synthesis, in the mammary gland, from the intermediate vaccenic acid that also escapes complete biohydrogenation in the rumen. In recent years, there have been numerous studies on increasing CLA content in milk of dairy cattle using a dietary supplement of vegetable oils rich in C18:2 **(Bell *et al.*, 2006).** Some studies had been carried out on dairy ewes given PUFA-rich oils, such as sunflower oil (SO) or soybean oil.

One of essential oil (EO) with high potential for use in ruminant diet is Thyme leaves (*Thymus vulgaris*). It is a medicinal herb oil (THY) which has beneficial effects in animal nutrition and may include stimulation of appetite and feed intake, improvement of endogenous digestive enzyme secretion, activation of immune response and antibacterial, antiviral, antioxidant functions **(Afshar *et al*., 2012).**

The aim of this study was to investigate the effects of supplementing dairy goats' diet with sunflower oil (SO) rich in C18:2 and thyme (Thymus vulgaris, THY) on milk yield and composition, and milk fatty acids profile.

MATERIALS AND METHODS

This experiment carried out at Sakha, Animal Production Research Station of Animal Production Research Institute, Agriculture Research Center during summer season.

The aim of this study was to evaluate the effect of supplementing sunflower oil (SO) with or without thyme leaves in the diets of dairy goat on milk production, digestibility and milk fat profile.

Experimental rations and animals:

Experimental rations consisted of concentrate feed mixture (CFM) and berseem hay (BH) at rate 1:1. The first group (control) received experimental ration without additives, the 2nd experimental group received experimental ration plus sunflower oil (SO), while the 3rd experimental group received experimental ration plus sunflower oil (SO) and thyme leaves.

Table (1): Chemical composition of CFM, BH and experimental rations (on DM basis, %).

	Chemical composition (%)						
Items	DM(%)	OM	CF	CP	EE	NFE	ASH
BH	88.93	86.43	28.07	11.93	2.06	57.94	13.57
CFM	90.53	91.77	11.12	14.09	2.65	63.91	8.23
T1	89.82	88.83	19.86	13.14	2.35	53.48	11.17
T2	89.73	88.23	20.04	13.13	3.68	51.38	11.77
T3	89.92	88.78	20.09	13.15	3.93	51.61	11.22

* T1: Control ration (CFM + BH), T2:Control ration+sunflower oil, T3:Control ration+ sunflower oil+ thyme leaves

Sunflower oil was added at rate 3% of total ration, while 25 g/h/d of Thyme leaves (THY) was introduced at the time of feeding. Thyme used in the present study contained 55.33% thymol, 3.57% Carvacrol, 13.47% p-Cymene and γ-8.86% Terpinene. Chemical composition of raw materials and different experimental rations are presented in Table (1).

Digestibility trials:-

Three digestibility trials were conducted simultaneously using 3 animals of each treatment group, using acid insoluble ash (AIA) technique as internal marker according to **Van-Keulen and Young (1977)** to determine the digestibility and feeding values of the experimental rations. Fecal grab samples of nearly 100 g were taken from the rectum twice daily at 8 am and 6 pm for 3 days of the experimental period. Representative samples of feed and feces from the whole collection period were prepared for proximate analysis according to **A.O.A.C. (1995).**

Feeding trials:

Eighteen Zaribi goats (averaged 43±1kg) were chosen for the feeding trials and divided into three similar groups (6 each). Animals in all groups housed in barns under open loose system and randomly assigned to receive the three experimental rations, using the randomized complete block design. Rations formulated to meet nutrient requirements of goats **(NRC 1985).** Animals received CFM plus BH at ratio 50:50. The portion of CFM offered to animals in two equal amounts at 8:00 am and 3:00 pm followed by BH. The feeding trials lasted for 90 days. Daily milk yield was recorded and milk sample were collected at first, middle and end of experiment for analysis of milk composition using Milko Scan (model 130 series – type 10900 FOSS electric – Denmark), while fatty acid profile was determined via gas liquid chromatograph (GLC) according to **Farag *et al*. (1986).** Body weight changes individually determined biweekly before morning feeding. Growth of kids was also measured biweekly.

Statistical analysis

Data collected for lactation, digestibility trials and milk were subjected to statistical analysis as one-way analysis of variance using **SAS (1999)** according to the following model:

$Y_{ij} = \mu + T_i + e_{ij}$

where:

Y_{ij}= the observation

μ = Over all mean

T_i = Effect of treatment

e_{ij} = Experimental error

Differences among means were subjected to **Duncan test (1955).**

RESULTS AND DISCUSSION

Digestibility coefficients.

Data respected the daily DM intake, digestibility coefficients and feeding values of the experimental rations present in Table (2). No significant differences noticed among daily feed intake for all experimental groups. In this respect, Chaves *et al*., (2008b) with growing lambs found that addition of THY had no effect on DM intake (DMI). Similar results observed by Cardozo *et al.,* (2006) and Benchaar *et al.,* (2008). However, the effects of EO on DMI might vary due to EO source, type of diet, diet interactions or adaptation of rumen microbial population to EO (Yang *et al*., 2010a). The results showed no significant difference on DM digestibility among goats fed experimental rations. However, the OM digestibility was significantly (P<0.05) increased by 3.22% when goats fed ration T2 compared with those fed control ration (T1), while insignificant difference in OMD was found between T1 and T3. These results are in agreement with the findings of Gonthier *et al*. (2004) who fed diets with flaxseed, which improved total-tract OM digestibility compared with control diet.

Goats fed ration contained SO and THY (T3) showed significant increase in CP digestibility compared to those without THY (T2) and control (T1). This may be due to their effect on improving nitrogen (N) utilization in the rumen. This result agrees with the finding of Zamiri *et al.* (2015). Also, Wallace *et al.*, (2002) suggested that the anti-microbial properties of thymol can be exploited to modulate activities of rumen microbial populations by reducing dietary protein degradation, thereby enhancing rumen N escape, thus potentially increase the protein supply to the post-ruminal tract where the more efficient enzymatic digestion being done in small intestine is in the lower gut.

There were significant decrease (P<0.05) in CF digestibility for both supplemented rations (T2 and T3) compared to the control ration (T1), which had the highest value of CF digestibility. This decrease in CF digestibility may be due to the negative effect of oils on rumen microbes especially celluletic bacteria. Jenkins and Fotouhi (1990) found that depression effect of oilseed was less than oils because of more escaping of oils from rumen fermentation.

On the other hand it could be noticed that, rations T2 and T3 were significantly (P<0.05) higher in EE digestibility than control ration (T1). This probably due to the higher ether extract intake. Similar results were reported by Maia *et al*. (2010).

Digestibility of NFE followed the digestibility of EE among control and tested treatments as well. It showed significant increases (P<0.05) with rations T2 and T3 by 3.37 and 2.49%, respectively compared with control. This increase may be due the effect of adding oils or oilseeds which inhibit the celluletic bacteria in the rumen (Hristov*et al.*, 2008) and simultaneously increase the NFE digestibility.

Table (2):Daily feed intake, digestibility coefficient and feeding values of experimental rations.

	Treatments			
Items	T1	T2	T3	± SE
Daily feed intake (kg DM / h)				
CFM	0.61	0.65	0.64	
BH	0.61	0.65	0.64	
Total DM intake	1.21	1.30	1.28	
Digestibility coefficients				
DM	66.23	67.24	66.33	1.05
OM	67.08^{b}	69.24^{a}	68.12^{ab}	1.01
CP	69.84^{b}	70.90^{b}	72.90^{a}	2.18
CF	67.92^{a}	64.84^{b}	65.25^{b}	2.01
EE	74.11^{b}	77.60^{a}	76.59^{a}	2.23
NFE	74.40^{b}	76.91^{a}	76.25^{a}	0.97
Feeding values on DM basis				
TDN	66.35^{b}	68.12^{a}	68.35^{a}	1.80
DCP	9.17^{b}	9.32^{b}	9.57^{a}	0.21

$^{a,b\ldots c}$: Means of different superscripts in the same row are significantly different(P<0.05) .

On the other hand, data indicates that there was a significant (P<0.05) improvement in the feeding values expressed as TDN for T2 and T3 compared with control, while the improvement in DCP was only significant with T3, but not significant with T2 in comparison with control T1. This improvement may be due to the highest digestion coefficients of all nutrients measured for this group. Moreover, the increase in DCP could be related to the effect of THY supplement, as confirmed by Wallace *et al*. (2002) and Zamiri *et al.* (2015).

Growth performance of kids

Table (3) shows the development of body weight of kids throughout the experimental period. Ration (T3) had higher (P<0.05) birth weight of kids, followed by those born from goats fed T2 ration, and less birth weight was obtained for goats in control group (T1) (P<0.05).

At the end of the experiment, kids in group fed T3, also showed the highest body weight (P<0.05) compared to control (T1) group, and the other tested one (T2), but without significant difference between T1 and T2.

Table (3): Fortnightly growth rate of kids.

Items	Period							
	0	15	30	45	60	75	90	Daily gain (Kg)
T1	3.50^{c}	6.33^{c}	7.33^{b}	8.67^{c}	11.00^{c}	12.33^{c}	13.80^{b}	0.114
T2	4.00^{b}	7.17^{b}	10.33^{a}	12.47^{b}	13.00^{b}	14.00^{b}	15.00^{b}	0.122
T3	4.33^{a}	7.83^{a}	11.83^{a}	14.17^{a}	15.5^{a}	16.33^{a}	17.17^{a}	0.143
±SE	0.02	0.08	0.58	0.833	1.10	0.81	1.50	

$^{a,b..c}$: Means of different superscripts in the same row are significant (P<0.05) different.

These increases might due to the thymol effect, which could cause an increase in rumen propionate production and decrease acetate and methane production without reducing total VFA production in goats' milk, that has a vital role in improving energy metabolism. This also agree with the findings of Calsamiglia *et al*. (2007). In addition, ration (T3) had significant better (P<0.05) average daily gain compared with control and this also may be due to the improvement of utilizing nutrients (Mohammad *et al.,* 2014).

Productive performance of lactating goats:

Data of actual milk yield, milk composition and 4% fat corrected milk (FCM) are presented in Table (4). It was clear that goats fed T3 had significantly higher (P<0.05) milk yield (42%) and 4% FCM (26%) compared with those fed control (T1), but actual milk yield did not differ significantly than that of T2 group. Goats fed diets supplemented with oil or oil plus THY had lesser (P<0.05) fat percentage than control one. Milk fat depression due to fat supplementation to animal' diets, such as oil, might have negative effect on fiber digestion in rumen, thus decreasing acetic and butyric acid production, consequently affect the de novo fat synthesis in mammary gland (Griinari *et al.,* 1998). Meanwhile, the tested rations (T2 and T3) seemed to be insignificantly better in respect of milk protein percentage in comparison with control one (T1). When milk fat and milk protein yields were calculated; goats fed ration contained oil + THY (T3) had the higher (P<0.05) yields compared with those fed ration with only oil (T2) and control group (T1). This may be due to thymol that found in Thyme leaves, which led to increase efficiency of N utilization, as well as increase conversion and availability of nutrients for milk synthesis (Abu Ghazaleh and Holmes, 2007). The current results also agree with those obtained by Johnson *et al*. (1985) who found that there were some active substances in herbs plants, which can affect secretory cells of the mammary gland. Higher (P<0.05) milk lactose percentage was recorded for goats fed ration T3 compared with those fed control ration by 11.86%. No significant differences found between T2 and T1 in lactose percentage. The content of total solids was found to be significantly higher (P<0.05) for T3 compared to control (T1) but non significant difference was observed between T2 and T1 rations. Regarding solid not fat (SNF) percentage, the differences among the dietary treatments were not significant.

Table (4): Daily actual milk, 4% fat corrected milk yields and milk compositions and yields.

Items	T1	T2	T3	±SE
Milk yield (Kg/head)				
Actual Milk yield	0.85^{b}	1.03^{ab}	1.21^{a}	0.14
4% FCM	0.89^{c}	0.99^{b}	1.12^{a}	0.02
Milk composition and its yield				
Fat%	4.35^{a}	3.77^{b}	3.50^{b}	0.08
Fat yield (gm/goat /day)	36.97	38.94	42.35	
Protein%	2.35	2.47	2.60	0.06
Protein yield (gm/goat /day)	19.97	25.51	31.46	
Lactose%	4.72^{b}	4.80^{b}	5.28^{a}	0.07
Total solids%	11.02^{b}	11.27^{ab}	11.69^{a}	0.14
Solids not fat%	6.67	7.50	8.19	0.85

[a,b …c]Means of different superscripts in the same row are significantly different(P<0.05).

Feed efficiency:

Data in Table (5) represent daily feed intake, milk and 4% FCM yields and feed conversion efficiency of goats fed the experimental rations. Animals fed ration (T3), contained SO plus thyme leaves, had the best efficiency, being 1.06 Kg DM/Kg milk yield. When feed efficiency expressed as Kg TDN or DCP per Kg milk yield, values were more efficient with T3, being 0.72 and 0.107 Kg, respectively, compared to control and the other tested ration (T2). Similar trends were observed among treatments regarding the feed conversion efficiency that expressed as DM, TDN and DCP: 4%-FCM.

Table (5): Daily feed intake, milk and 4%fat corrected milk (FCM) yields and feed efficiency.

Items	T1	T2	T3	±SE
Live body weight (Kg)	40.60	43.33	42.83	2.37
Milk yield (Kg/head/day)	0.85^{b}	1.03^{ab}	1.21^{a}	0.14
4%(FCM)yield(Kg/head/day)	0.89	0.99	1.12	.02
Daily feed intake (Kg):				
DM	1.21	1.30	1.28	
TDN	0.803	0.886	0.875	
DCP	0.111	0.121	0.122	
Feed efficiency:				
Kg DM/ Kg milk yield	1.42	1.262	1.058	
Kg TDN/ Kg milk yield	0.940	0.860	0.723	
Kg DCP/ Kg milk yield	0.130	0.117	0.101	
Kg DM/ Kg FCM yield	1.359	1.313	1.143	
Kg TDN/ Kg FCM yield	0.902	0.895	0.781	
Kg DCP/ Kg FCM yield	0.125	0.122	0.109	

$^{a,b\,...c}$: Means of different superscripts in the same row are significant (P<0.05) different.

Fatty acid profile of milk.

Data in Table (6) represent the fatty acid profile of goat's milk. Ration (T3) had less total saturated fatty acids by 28.19% in comparison with control one. This decrease may be due to the altar of essential oils to have antimicrobial properties against different types of microorganisms including bacteria, protozoa, and fungi (Greathead, 2003). These bacteria are involved in ruminal biohydrogenation of unsaturated dietary fatty acids. Pointedly, supplementing with thyme leaves (T3) resulted in decrease of total saturated fatty acids (TS) as mentioned previously.

Supplementation with sunflower oil in ration T2 increased total unsaturated fatty acids (US). This increase may be due to the high content of sunflower oil from oleic (18:1) and linoleic (18:2) acids, being 28% and 62.2%, respectively (Jana Orsavova *et al*., 2015). In ration T3 (with SFO + thyme leaves) the increase in total unsaturated fatty acids reached 35.47% and this agree with the value obtained by Oldemiro et al. (2005). However, the use of EO in addition to THY can compose some active compounds, where mixture of these compounds can cause additive, synergistic or antagonistic antimicrobial properties (Benchaar *et al.*, 2008). Moreover, some of these additives could provide some protection from rumen biohydrogenation. In addition, vegetable oils expose to rumen biohydrogenation. Phenolic compounds such as thymol, carvacrol, and eugenol, which found in thyme leaves, possess high antimicrobial activity due to the presence of a hydroxyl group in the phenolic structure (Dorman and Dean 2000; Ultee *et al*. 2002). Compounds with phenolic structures have a broad spectrum of activities against a variety of both Gram-positive and Gram-negative bacteria (Lambert *et al*. 2001). The mechanism of action by which phenolic compounds are thought to

Table (6). Fatty acid profile of goat's milk as affected by dietary treatments.

rations	Fatty acids (mg/100 g fat)								
	C16:1	C18:1	C18:2	C18:3	T.U. S	C14:0	C16:0	C18:0	C20:0	T. S
T1	1.29[b]	22.37[c]	1.35[c]	0.26[c]	25.27	9.52[a]	17.70[a]	13.65[a]	0.67[a]	41.54
T2	1.41[b]	25.82[b]	3.07[b]	0.44[b]	30.75	8.28[b]	15.71[b]	12.61[b]	0.38[b]	36.98
T3	1.67[a]	28.83[a]	4.3[a]	0.67[a]	35.47	5.42[c]	13.27[c]	10.91[c]	0.23[b]	29.83
±SE	0.005	0.82	0.25	0.009	-----	0.05	0.63	0.13	0.01	----

[a, b, c]…Means with different superscripts in the same row differ significantly ($P<0.05$).

T . S. ------- Total saturated fatty acids.

T. U. S.-------- Total unsaturated fatty acids.

exert their antimicrobial activity is through the disturbance of the cytoplasmic membrane, disrupting the proton motive force, electron flow active transport, and coagulation of cell contents (Burt 2004).

There was an increase in C18:1 content of T3 and T2. This can be a result of partial biohydrogenation of C18:2 and C18:3 FA and the desaturation of C18:0 in the mammary gland (Kennelly, 1996).

From these results, it could be concluded that supplementing goat ration with sunflower oil or sunflower oil plus thyme leaves could increase the feeding values of ration and consequently affect positively goat milk production and kids growth performance.

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تأثيرإضافة زيت عباد الشمس و أوراق الزعتر على معاملات الهضم و الأداء الإنتاجي للماعز الحلابة

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تهدف هذه الدراسة إلى تقييم تأثير إضافة زيت عباد الشمس بدون أو مع أوراق الزعتر إلى علائق الماعز الحلابة على معاملات الهضم والإنتاج و التركيب الكيماوى للبن ومحتواه من الأحماض الدهنية المشبعة والغير مشبعة. تم اختيار ثمانية عشر عنزة حلابة قسمت الى ثلاثة مجموعات متماثلة (ستة بكل مجموعة) وتم تغذية جميع الحيوانات على علف مركز و مواد خشنة بنسبة 1:1 وكانت المواد الخشنة عبارة عن دريس برسيم للمجموعة الأولى (الكنترول) بدون أي إضافات و المجموعة الثانية تتغذى على علف مركز مع إضافة زيت عباد الشمس فقط بنسبة 3% من العليقة والمجموعة الثالثة تم إضافة الزيت بنسبة 3% من العليقة وأوراق الزعتر (25 جرام /راس/ اليوم) الي العلف لتصبح جميع العلائق متساوية فى الطاقة والبروتين وأوضحت النتائج ان استخدام أوراق الزعتر أدى إلى تحسن فى معظم معاملات الهضم و القيمة الغذائية للعلائق التجريبية ولكن أدت إضافة الزيت إلى انخفاض معامل هضم الألياف مقارنة بالكنترول و أيضا إضافة الزيت وأوراق الزعتر أدى إلى زيادة إنتاج اللبن الطبيعى والمعدل الدهن 4%، حيث ارتفع محصول اللبن معنويا فى المعاملة الثالثة (اوراق الزعتر+ الزيت) . المعاملات أدت لاختلافات معنوية فى التركيب الكيماوي الخاص باللبن .أدى إضافة أوراق الزعتر مع زيت عباد الشمس الى زيادة المحتوى من الأحماض الدهنية الغير مشبعة وكانت (35.47%) فى حين ان الكنترول أعطى أعلى نسبة فى الأحماض الدهنية مشبعة كانت (41.83%).

ومن ناحية أخرى أظهرت المجموعة الثالثة أعلى كفاءة غذائية معبرا عنها بكمية المادة الجافة المأكولة و الطاقة والبروتين المأكول لكل كجم لبن طبيعى او لبن معدل الدهن 4% و أوضحت الدراسة ان إضافة زيت عباد الشمس مع أوراق الزعتر فى علائق الماعز الحلابة أدى إلى زيادة المحتوى من الأحماض الدهنية الغير مشبعة ولم يحدث اى تاثير سلبي على صحة الحيوانات او كفاءتها الإنتاجية.