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Original Research Article

Effect of calcium soap of palm oil fatty acids on milk composition, ewe and lamb performance in a crossbred sheep

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ABSTRACT

This study aimed to evaluate the effect of Ca soap of palm oil fatty acids (CSFA), as a protected fat, on milk composition and the performance of both ewes and lambs. Thirty-three crossbred ewes aged 2-3 years and weighed 41-44 kg were allocated in three unequal groups for A, B &C (10, 12 &11 ewes, respectively). Group A was fed a diet free from protected fat and kept as a control. Group B was fed a diet containing 4 % fat and group C was given a diet containing 8 % fat. The ewes were in the last month of pregnancy and the experiment extended till the end of late lactation (4.5 months). Milk composition was tested, and body change in ewes and nursing lambs was traced. Moreover, the effect of fat addition on dry matter intake of ewes was analyzed. Results revealed a decrease in dry matter intake in the late gestation and an increase in early lactation, with no significant differences in the late lactation. The effect followed the amount of fat added. There was no effect on ewe's body weight change or lamb's growth rate from birth to weaning. On milk composition, there was an increase in fat %, higher in group B and total solids%, while percentage of protein was decreased. Concerning fat supplementation, no effect on lactose, urea milk nitrogen, and somatic cell counts was detected. There was a decreased level of solids-not-fat in group B, while group C showed no detectable alterations. In conclusion CSFA supplementation was effective to increase the fat % and yield in milk of sheep especially at the rate of 4% of addition.

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1. Introduction

Incorporation of lipids in rations for dairy animals is often used to increase the energy density and improve lactation and reproductive performance (Funston, 2004). One alternative to increase the supply of polyunsaturated fatty acids to the small intestine is via supplementation with rumen-inert feeds such as calcium salts of fatty acid (Green et al., 2008; Lopes et al., 2009). In general, inclusion of fats in dairy rations is limited to 3% of dry matter intake (Palmquist, 1988). If exceeded, dry matter and fiber digestibilities are reduced (Chalupa et al., 1986). However, if supplementation of fat is done through rumen protected fat, the fat content of the ration can be increased up to 6–7% of the dry matter intake (NRC, 2001). A calcium salt of long chain fatty acids (CSFA) is relatively less degradable in the rumen (Elmeddah et al., 1991) and has the highest intestinal digestibility (Dairy Technical Service Staff, 2002). The importance of fat supplementations in sheep diets has been increased in the recent years as a result of the availability of fat and the favorable results obtained in dairy goats (Morand-Fehr et al., 1991) and cows (Palmquist and Jenkins, 1980).

The response of ewes to CSFA is variable. Sanz Sampelayo et al. (2004) showed that CSFA increased milk production and improved fat and protein yield. Such effects persisted after the supplement withdrawal, while Gargouri et al. (2006) found no significant effect on the milk yield, but significantly increased milk fat content and yield and reduced milk protein content. Milk fat and protein responses were dependent on the dose and lactation phase.

Although milk yield and milk fat and protein contents have been related to preweaning lamb performance (Lynch et al., 1991; Sanz Sampelayo et al., 2004), increasing the long-chain components of milk fat through dietary fat supplementation may increase lamb use of milk energy to improve nursing offspring growth (Casals et al., 1999; Alizadeh et al., 2012). Hernandez et al. (1986) and Casals et al. (1999) found a numerical increase in 4- wk. lamb weight and a more efficient conversion of milk into lamb gain when supplying fat to ewes. However, other researchers found no effect on body weight change of ewes or nursing lambs when ewes were supplemented with rumen-protected lipid (Alba et al., 1997).

In the current study, it was tried to evaluate the effect of supplementing the breeding sheep diets with calcium soap of palm oil fatty acids on lactation, ewes and lambs performance through analyzing or recording feed intake, ewes' body weight change, milk composition, and lambs growth rate till weaning.

2. Materials and methods

2.1. Animals

In the current experiment, 33 four months-pregnant native crossbred (Barki x Rahmani) ewes, aged 2-3 years and weighed 41-44 kg were used and clinically examined to prove to be apparently healthy and free from parasitic infestations. Animals were randomly allocated into three groups; group A (control; 10 ewes), group B (treated; 12 ewes) and group C (treated; 11 ewes). Each group was kept in a separate pen under natural conditions of light and temperature. The duration of the study extended for 4.5 months; one month at the last gestation, 2 months at the early lactation and 1.5 months at the late lactation. The experiment started at December 2013 (the last month in gestation) and ended at April 2014. Animals were weighed at the beginning and monthly to trace the body weight alterations of ewes. Moreover, Lambs born were weighed at birth then every month till weaning to follow up the young's growth rate. The experiment was performed at the Animal Reproduction Research Institute farm, El-Ahram, Giza, Egypt.

2.2. Diets and experimental design

The composition and the kind of the experimental diets follow its respective productive stage. According to the protected fat, three diets were fed; one as a control free from fat supplementation for group A, 4% fat-diet for group B, and 8% fat-diet for group C. The fat added (Magnapac®) composed of calcium soap of palm oil fatty acids and manufactured by Norel, Masr, Egypt. It contains 84% fat and 9% Ca with 44% palmitic acid, 40% oleic acid, 9.5 % linoleic acid, 5 % stearic acid and 1.5% myristic acid. The diets intended to be formulated are 6 in number as shown in table 1.

The control diets (1&4) were formulated to satisfy the requirements mentioned in NRC of sheep (1985), and the diets enriched with fat had higher energy densities in relation to the amount of fat added (2, 3, 5& 6). In the high- energy diets crude protein was also increased to keep the calorie / protein ratios constant as in the control one. The control diets in late gestation and late lactation had 2.17 Mcal/kg DM and the diets with 4% and 8% fat had more dense energy by 9% in the first and 17% in the second. For the early lactation the energy was 2.43 Mcal/kg DM, and the fat supplemented had more energy by 8% in the 4% fat and 15% in the 8% level.

Table 1. The experimental diets intended, energy and crude protein content (on DMB), and the level of protected fat

Stage	Groups	No.	Diet (on DMB) CSFA (%)	ME (Mcal/kg)	CP (%)
Late gestation (1 mo.)	A	1	---	2.17	10.70
	B	2	4%	2.36	11.82
	C	3	8%	2.54	12.89
Early lactation (2 mos.)	A	4	---	2.43	13.40
	B	5	4%	2.62	14.60
	C	6	8%	2.80	15.80
Late lactation (1.5 mos.)	A	1	**As in stage I**		
	B	2			
	C	3			

A = Fat free-control group, B = 4% CSFA group, C = 8% CSFA group

Refer to table 2 for the chemical composition of the ingredients used, and tables 3 & 4 for the physical and chemical composition of the six diets. Ingredients, from which the rations were formulated, were analyzed for chemical composition using the standard methods according to AOAC (1995), Goerings and Van Soest (1970), and Van Soest et al. (1991). Total digestible nutrients and digestible and metabolizable energies were estimated by equations using the chemical analysis according to NRC of dairy cattle (2001). From the mixed diets samples were taken and analyzed for the chemical composition and estimations the same as the ingredients.

Table 2. Chemical composition (%) and energy value (Mcal/kg) of feed ingredients used in the experimental rations

Ingredients	DM	CP	NDF	ADF	Hemi-cellulose	Cellulose	Lignin	Ash	NFC	EE	TDN	DE	ME
	Chemical composition (on DMB)												
Concentrates													
CCM 1*	**91.04**	**14.90**	**32.20**	**19.20**	**13.00**	**13.80**	**5.40**	**10.00**	**37.67**	**5.23**	**68.37**	**3.06**	**2.64**
CCM 2**	**90.24**	**18.50**	**35.80**	**13.40**	**22.40**	**10.20**	**3.20**	**8.20**	**34.80**	**2.70**	**68.93**	**3.14**	**2.72**
Soybean meal	**89.01**	**49.50**	**9.80**	**6.20**	**3.60**	**5.70**	**0.50**	**7.30**	**31.90**	**1.50**	**80.93**	**4.08**	**3.67**
Protected fat	**95.00**	---	----	-----	------	-----	------	**12.50**	**3.50**	**84.00**	**163.50**	**6.85**	**6.46**
Roughages													
Wheat straw	**92.31**	**3.90**	**84.20**	**57.40**	**26.80**	**51.00**	**6.40**	**8.60**	**1.68**	**2.04**	**47.59**	**2.03**	**1.60**
Egyptian clover	**15.25**	**18.30**	**43.48**	**26.86**	**16.62**	**22.19**	**4.67**	**9.30**	**27.08**	**1.84**	**61.42**	**2.81**	**2.38**

DM = dry matter, **CP** = crude protein, **NDF** = nutrient detergent fiber, **ADF** = acid detergent fiber, **NFC** = nonfibrous carbohydrate was calculated according to the equation = **100 – (%NDF+% CP+ % EE+ % ash) NRC of dairy cattle (2001)**, **EE** = ether extract
TDN = Total digestible nutrients was estimated by (NRC of dairy cattle, 2001) software program.
DE = Digestible energy was estimated by (NRC of dairy cattle, 2001) software program.
ME = Metabolizable energy is calculated according to the equation = **DE x 1.01 – 0.45** (NRC of dairy cattle, 2001).
***CCM1**= commercial concentrate mixture of sheep (14% CP, 15% CF, 9% ash, 12% moisture, 2% EE, 65% TDN- fresh basis- Ministry of Agriculture)
****CCM2**= commercial concentrate mixture of cattle (16% CP, 15% CF, 9% ash, 12% moisture, 2% EE, 65% TDN - fresh basis- Ministry of Agriculture)

The diets were composed mainly of sheep commercial concentrate mixture (CCM) potentiated in energy by protected fat, and in crude protein by cattle lactation commercial concentrate mixture and soybean oil meal. The roughage material was wheat straw and Egyptian clover. Because of the large amount of the straw included, especially in the control diets, the mixture could not be pelleted. In addition, the factory of the CCMs was asked to supply the product in a meal form, for the fat tested to be added.

Table 3. Physical and chemical composition of rations (numbered 1, 2&3) mixed for late gestation and late lactation stages

	Diet (% of CSFA) / group		
	1 (0) A	2 (4%) B	3 (8%) C
Physical composition (%) – on DMB			
CCM 1	28.54	----	----
CCM 2	24.45	43.12	26.34
Soybean meal (44%CP)	----	3.84	12.19
Protected fat	----	4.00	8.00
Wheat straw	47.01	49.04	53.47
Egyptian clover	-----	-----	------
Estimated energy values (Mcal/kg,) and chemical composition (%) - on DMB			
Dry matter	91.27	91.46	92.54
Total digestible nutrients	58.92	63.88	68.48
Digestible energy	2.61	2.83	3.04
Metabolizable energy	2.17	2.36	2.54
Crude protein	10.70	11.82	12.89
Ether Extract	3.11	5.57	8.70
Neutral detergent fiber	57.51	57.09	55.63
Acid detergent fiber	35.73	34.15	34.96
Hemicellulose	21.78	22.94	20.67
Cellulose	30.41	29.63	30.64
Lignin	5.32	4.52	4.32
Nonfibrous carbohydrate	19.79	17.03	14.14
Ash	8.89	8.49	8.64

The ingredients; concentrates, wheat straw, and cut berseem; were mixed daily in proportions respective to the group fed and stage of production. The diets were offered two (8 a.m. and 4 p.m.) or three (8 a.m., 1 p.m., and 5p.m.) times daily, according to the amount. The daily feed intake of each group, in the different reproductive stages, was calculated. Animals had free access of clean tap water and salt blocks were constantly available. The concentrates and roughages were offered separate according to the Institute facilities and system followed. The refusal of the wheat straw, if any, will change composition of the rations from that intended but, the change will be on the positive side increasing energy density and protein concentration. The straw was offered to the animal at first, and concentrate mixture after one hour, to decrease the straw refusal.

During lactation periods an individual milk sample was taken monthly for composition analysis from each dam. Ewes were hand- milking after 15 minutes of intramuscular injection of oxytocin hormone. A sample of about 40 ml from fresh milk of each animal was taken and percentages of fat, protein, lactose, urea nitrogen, total solids, and solids not fat were determined by an infrared milk analyzer (Bently-150) according to Teh et al. (1994).

2.3. Statistical analysis

Data were statistically analyzed including the calculation of the mean and standard error according to Snedecor and Cochran (1982) Data were analyzed by two and one-way ANOVA implying a randomized complete block design using Costat computer program to determine significant differences among treatment groups.

Table 4. Physical and chemical composition of rations (numbered 4, 5& 6) mixed for early lactation stage

	Diet (% of CSFA) / group		
	4 (0) A	5 (4%) B	6 (8%) C
Physical composition (%) – on DMB			
CCM 1	59.32	4.91	----
CCM 2	14.56	64.97	55.61
Soybean meal (44%CP)	----	----	6.71
Protected fat	----	4.00	8.00
Wheat straw	19.59	19.59	23.15
Egyptian clover	6.53	6.53	6.53
Estimated energy values (Mcal/kg), and chemical composition (%) - on DMB			
Dry matter	91.37	92.00	91.91
Total digestible nutrients	63.94	68.99	73.68
Digestible energy	2.86	3.08	3.29
Metabolizable energy	2.43	2.62	2.80
Crude protein	13.40	14.60	15.80
Ether Extract	4.00	5.87	8.91
Neutral detergent fiber	43.63	44.15	42.87
Acid detergent fiber	26.32	22.63	22.89
Hemicellulose	17.31	21.52	19.98
Cellulose	21.11	18.75	19.31
Lignin	5.21	3.88	3.58
Nonfibrous carbohydrate	29.50	26.70	23.90
Ash	9.40	8.59	8.63

3. Results and discussion

In this paper the aim was to evaluate calcium soap of palm fatty acid (CSFA), as a concentrated source of energy having an effect on body weight change of ewe and lamb and on milk composition. Many authors tested the effect of CSFA on the reproductive activity of animals, milk yield and composition and used different levels from protected fat ranging from 3% to 9% (Appeddu et al., 2004; Sanz Sampelayo et al., 2004; Titi, 2011). In the present work the CSFA was suggested to be added at the level of 4 % and double the amount 8%. The protected fat was added to the whole diet on DMB and the animals offered the diets according to the management system of the Animal Reproduction Research Institute (ARRI). The concentrates were in a meal form and mixed altogether while straw and berseem were fed separate. To decrease the refusal of wheat straw, it was put infront of the animal before putting the concentrates by a period of one hour. Refusal of tibn in some of the diets changed the concentration of the protected fat on the positive side. Anyway, protected fat added increased the energy density of the diets, and this is the base on which the design depends.

3.1. Chemical composition of really consumed diets

The energy density of diets, due to straw refusal, increased from 2.17Mcal for the intended control to 2.32 in late gestation (LG) and 2.25 in late lactation (LL). In early lactation (EL) increased from 2.43 to 2.46Mcal. For the B groups it increased from 2.36 to 2.59 in late gestation and 2.42 in late lactation, and from 2.62 to 2.65 in early lactation. For the C groups the increase was from 2.54 to 2.96 (LG) and 2.65 (LL), and from 2.80 to 2.85 (EL). Refer to the following table (5) summarizing the energy density in diets, in the three groups, in the three stages.

The fat supplementation proportion also differed after tibn refusal so the 4% level increased to 5.24 & 4.34 in LG and LL, and the 8% level to 11.54 & 8.91 respectively. For the EL stage it was 4.06 for 4% level and 8.25% for the 8% one with no significant difference (Table 6).

Table 5. Energy density, intended and really consumed

Stage	Energy density (Mcal/DM)					
	Intended			After straw refusal		
	A	B	C	A	B	C
Late gestation	2.17	2.36	2.54	2.32	2.59	2.96
Late lactation	2.17	2.36	2.54	2.25	2.42	2.65
Early lactation	2.43	2.62	2.80	2.46	2.65	2.85

Table 6. Energy density, crude protein, and protected fat content (on DMB) of rations according to feed intake in the different stages

Stage of production	Group	ME (Mcal/kg diet)	Crude Protein (%)	Protected fat (%)
Late gestation period (30 days)	A	2.32	12.41	----
	B	2.59	14.25	5.24
	C	2.96	17.00	11.54
Early lactation period (60 days)	A	2.46	13.88	-----
	B	2.65	14.80	4.06
	C	2.85	16.26	8.25
Late lactation period (45 days)	A	2.25	11.58	-----
	B	2.42	12.45	4.34
	C	2.65	14.05	8.91

3.2. Effect of protected fat on dry matter intake

The effect of protected fat supplementation differs according to the stage of feeding. The DMI decreased with a maximum of 15% at 8% level in late gestation and on the reverse it increased with a maximum of also 15% at the 4% level in early lactation stage. In late lactation there was no difference between the control and the two levels of supplementation (Table 7). The decrease or increase in DMI is accompanied by a decrease or increase in concentrate or straw intake. In late lactation the DMI did not get affected by the straw intake which was increased by a maximum of 24% (group C). As the composition of the different diets and energy densities vary from a group to another and from stage to another it is fair to compare and test the effect by calculating the energy intake. In late gestation, early lactation and late lactation the energy intake increased as the level of fat supplementation increased.

Table 7. Dry matter and energy intake in the experimental groups allover the study period

		Dry matter				
Stage	**Group**	**Total**	**Concentrates**	**Straw**	**Berseem**	**Mcal**
Late gestation	A	1268	853	415	---	2.94
	B	1198	801	397	---	3.10
	C	1095	735	360	---	3.24
	Mean	**1187**				
Early lactation	A	1587	1196	264	127	3.90
	B	1820	1363	312	145	4.82
	C	1800	1304	351	145	5.13
	Mean	**1736**				
Late lactation	A	2180	1322	858	---	4.91
	B	2200	1166	1034	---	5.30
	C	2200	1138	1062	---	5.83
	Mean	**2193**				

A= Control group, **B = 4%** protected fat, **C =** 8% protected fat

Generally dry matter intake was the lowest in late gestation, after late gestation DMI increased in the early lactation by about 46% (1736 g) and increased also in late lactation again by about 25% (2193g).

Many authors found no effect on dry matter intake as affected by protected fat supplementation, along the years from 1997 to 2014 as far as references overviewed, Oqla et al.(2004) working on ewes, Rapetti et al. (2002), Sanz Sampelayo et al. (2002), Sanz Sampelayo et al. (2004), and Titi (2011) working on goats, and Duske et al. (2009), Santos et al. (2009), Mudgal et al.(20l2), Singh et al.(2014), and Wina et al.(2014) working on cows. While other six authors found that fat supplementation decreased the dry matter intake, Teh et al. (1994) and Brown-Crowder et al. (2001) working on goats, and Chouinard et al. (1997), Harvatine and Allen (2005), Abu Ghazaleh (2008), and Rodrigues et al. (2014) working on cows. Only Tyagi et al. (2009a) working on cows mentioned an increase in the intake due to fat supplementation.

It was noted that in these studies mentioned, the levels of fat did not reach, anyway, the levels tested in the present one. So most of the papers found no effect or a decreasing one depending on the level and kind of fat added, kind of diet, animal, and reproductive stage tested. The so high levels added in the present study and still the absence of an effect trend, as also concluded from the literature, ask for more research with more defined factors. The reduction of DMI after dietary fat inclusion may be a result of a slowdown of rumen emptying due to a metabolic effect of long chain fatty acids (Chilliard, 1993) or may be due to palatability problem with calcium soaps (Chilliard and Ollier, 1994).

3.3. Effect of protected fat on animal body weight change

Body weight is considered to be a good indicator of the animal's energy status (Randel, 1990). In current study in spite animals consumed more energy, when their diets were supplemented with fat; there was no significant difference in the weight of the ewes among groups along the three stages. In general, the two supplemented groups B &C had the larger weights, especially in the first 120 days postpartum but did not achieve the significant level. The three groups during the stages showed the same trend in their cumulative weight changes. The weight had a steep decrease in late gestation as the animal lambed, a decrease in the first 30 days of lactation, fixed or slightly increased in the rest of the early lactation, and slightly decreased in late lactation.

The cumulative weight change could be extracted from table 8 and found to be – 6.6 kg in control, – 5.5 in 4% fat group and – 3 in the 8% at lambing so fat supplementation decreased the loss in body weight due to lambing. At the time of parturition ewes are faced with high nutrient demands to meet the increase in milk production and during this period the increase in nutrient demand is sharper than the increase in feed intake resulting in loss of body weight, as cited by Oqla et al. (2004) and this agree with our result.

Table 8. Body weight change of ewes in the different stages

Sampling periods	Control		4% CSFA		8% CSFA	
	No.	Mean ±SEM	No.	Mean ±SEM	No.	Mean ±SEM
30 days pre-partum	10	40.90±2.22[a]	12	43.75±2.39[a]	11	41.18±2.16[a]
Parturition	10	34.30±2.23[a]	12	38.25±2.33[a]	11	38.18±1.89[a]
30 days pp	10	34.05±1.74[a]	12	36.33±2.18[a]	11	35.72±1.87[a]
60 days pp	10	34.80±1.70[a]	12	36.33±2.03[a]	11	35.45±1.92[a]
90 days pp	10	34.75±1.64[a]	12	35.71±1.96[a]	11	35.31±1.91[a]

pp= post-partum
Values have the same alphabets and differences are not significant.

In early lactation where there is a nutritional stress on the animal in the high milk secretion, the body weight slightly increased by 0.5kg in the control group it decreased by 1.95 and 2.68 kg in 4% & 8% fat groups pointing to the size of the stress and higher amount of milk secreted. In late lactation the stress decreased and the animal lost 0.4 in the control, 0.9 in 4% where milk was still expected to be high, and 0.1 in the 8% group without an interpretation. The following table (9) is the rate of decrease or increase, expressed in kilogram, in the different stages in the three groups.

Table 9. The rate of the cumulative weight change of ewes in the different stages

Stage	Body weight change (kg)		
	control	4%fat	8%
30 days pre-partum to parturition	- 6.60	- 5.50	- 3.00
Early lactation	+ 0.50	- 1.95	- 2.68
Late lactation	- 0.40	- 0.90	- 0.10

In the present results there was no clear difference among the different groups allover the reproductive stages due to fat supplementation. The same results was recorded by Green et al. (2008) and Costa et al. (2011) on sheep, and Titi (2011) on goat and Naik et al. (2009b), Duske et al. (2009) and Singh et al. (2014) with cow. On the other hand, calcium soaps of fatty acids attenuated the ewe weight loss particularly from lambing to day 25 of lactation (Ghoreishi et al., 2007) and caused much quicker regain of weight (Gowda et al., 2013). The positive effect on weight gain also reported by Oqla et al. (2004) and Titi and Awad (2007), while some found a decrease (Godfrey and Dodson, 2003; Appeddu et al., 2004).

3.4. Body weight change in nursing lambs

The lambs of the three groups were born at nearly the same weight and grew during the suckling period without any significant difference. The birth weight ranged between 3.5 and 3.8 kg and increased in the weight to reach from 16.75 to 19.00 kg at weaning with a daily gain of 115 to 144 grams (Table 10). In spite of the nonsignificant differences between figures the fat supplemented groups had the heavier weaning weight which may be due to increase of both milk production and fat % in milk of treated ewes. In relation to sex males surpassed females by about 12% in weight.

Table 10. Effect of CSFA- Supplementation on lamb's body weight

Month	Group			Sex	
	Control	4%CSFA	8%CSFA	Male	Female
At birth	3.52±0.15[a]	3.83±0.19[a]	3.83±0.22[a]	3.79±0.13[a]	3.70±0.18[a]
1	7.23±0.49[a]	8.02±0.44[a]	8.03±0.48[a]	8.10±0.40[a]	7.48±0.36[a]
2	10.94±0.81[a]	12.08±0.93[a]	12.22±1.19[a]	12.71±0.84[a]	10.90±0.72[a]
3	13.05±0.80[a]	15.45±0.92[a]	15.18±1.46[a]	15.75±1.10[a]	14.06±0.70[a]
At weaning	16.72±0.72[a]	18.06±0.94[a]	18.95±1.49[a]	19.00±1.08[a]	16.98±0.68[a]

Values have the same alphabets and differences are not significant.
Weaning was at 115, 108 & 105 days of age in the three groups respectively.

Similar trends were also reported by Casals et al. (1999), Bottger et al. (2002), Landblom et al. (2003), and Lake et al. (2005) in birth weight and Oqla et al. (2004), Titi (2011) and Titi et al. (2011) in weaning weight and growth rate of lambs. On other hand other authors (Ghoreishi et al., 2007; Abd El-Rahman et al., 2008; Titi and Awad, 2007; Alizadeh et al. 2012) registered heavier weights at birth and weaning as feeding supplemental fat increases energy density in addition improves energetic utilization efficiency (Lammoglia et al., 2000).

3.5. Effect of protected fat on milk composition

3.5.1. Milk fat

In the three groups the fat percentage in the first month is about 5 & 6 in group A & C, while it increased to about 7.5 in B. Supplementation with 4% fat had an effect starting in the first month, while 8% fat had no effect. So it is not a matter of fat level of addition but it is the suitable level for rumen metabolism and milk secretion. In the second month the percentage got doubled and kept fixed in the third in the three groups. The percentage reached a maximum of about 10 in the control group, 14.5 in 4%, and 14 in 8%. Addition of fat increased fat percentage by about 40-45 % with 4% having the higher effect. As an overall mean it is 8.5, 11.9 & 10.7 for the three groups respectively (Table 11). Among all components of milk, fat is the most sensitive to dietary changes. The positive effect on milk fat is not specific to the calcium salts of palm oil as a protected fat but also animal fat, plant oil, processed or whole seeds, have the same effect (Martinez et al., 2013). Fat increase did not differ according to the fat added but on the contrary of Casals et al. (2006) the 4% level had the most significant one compared to the 8%.The positive effect of fat supplementation on milk fat percentage is in agreement with many authors experimented on sheep (Appeddu et al., 2004; Gargouri et al., 2006; Ghoreishi et al., 2007), goats (Chilliard et al., 2003; Sanz Sampelayo et al., 2004 ; Abd El-Rahman et al., 2008; Titi, 2011), and cows (Sirohi et al., 2010; Parnerkar et al., 2011).

Table 11. Milk components, during lactation period, as affected by protected fat addition

Month	Group		
	Control	4% CSFA (B)	8% CSFA (C)
Fat %			
1	5.12±0.29^{Bb}	7.49±0.32^{Ba}	5.92±0.43^{Cb}
2	10.16±0.45^{Ab}	14.61±0.71^{Aa}	13.84±0.53^{Aa}
3	10.27±0.35^{Ab}	13.67±0.76^{Aa}	12.19±0.34^{Ba}
Mean	8.51±0.51^{c}	11.85±0.65^{a}	10.65±0.65^{b}
Protein %			
1	3.04±0.01^{Ba}	3.30±0.46^{Aa}	2.42±0.10^{Ba}
2	3.54±0.09^{Aa}	2.66±0.13^{Aa}	2.78±0.13^{Ba}
3	3.55±0.13^{Aa}	2.89±0.12^{Aa}	3.58±0.14^{Aa}
Mean	3.38±0.077^{a}	2.95±0.17^{b}	2.93±0.11^{b}
Lactose %			
1	3.48±0.08^{Aa}	3.80±0.42^{Aa}	3.47±0.14^{Ba}
2	3.87±0.26^{Aa}	4.37±1.65^{Aa}	2.96±0.24^{Ba}
3	3.58±0.10^{Ab}	2.91±0.11^{Ac}	4.44±0.34^{Aa}
Mean	3.64±0.098^{a}	3.69±0.56^{a}	3.62±0.18^{a}
Milk urea nitrogen (mg/dl)			
1	8.53±0.53^{Cb}	12.84±0.88^{Ca}	14.11±0.59^{Ca}
2	21.45±1.22^{Ba}	22.43±0.81^{Ba}	22.11±0.65^{Ba}
3	35.34±2.2^{Aa}	31.92±1.71^{Aa}	30.33±1.19^{Aa}
Mean	21.77±2.30^{a}	22.40±1.48^{a}	22.18±1.26^{a}
Total solids %			
1	12.85±0.51^{Bb}	16.38±1.05^{Ba}	13.16±0.73^{Bb}
2	17.38±0.59^{Ab}	20.48±0.52^{Aa}	20.07±0.37^{Aa}
3	18.89±0.51^{Aa}	19.77±0.69^{Aa}	20.18±0.77^{Aa}
Mean	16.38±0.59^{b}	18.87±0.53^{a}	17.80±0.68^{a}
Solids not fat %			
1	7.40±0.17^{Aa}	7.96±0.93^{Aa}	6.78±0.16^{Ba}
2	8.25±0.33^{Aa}	6.16±0.27^{Ab}	6.49±0.35^{Ba}
3	8.07±0.23^{Aa}	6.59±0.24^{Ab}	8.81±0.48^{Aa}
Mean	7.91±0.16^{a}	6.91±0.35^{b}	7.37±0.27^{ab}

Values with different superscripts (A, B, C within the columns & a, b, c within the rows) differ significantly from each other.

The higher fat content in milk is a reflection of the greater energy intake due to fat supplementation (Hermansen, 1989) and the increase of fatty acids brought to the mammary gland (Mir et al., 1999; Brown-Crowder et al., 2001). On the other hand some authors found reduction in milk fat due to fat supplementation (Castaneda-Gutierrez et al., 2005); in addition Castro et al. (2009) and Titi et al. (2011) found no effect; a finding might depend on the experimental condition and design.

3.5.2. Milk protein

In our study there was no significant difference among groups and the 4% fat supplementation increased protein percentage slightly in the first month, but decreased it in the second and third months. On the contrary the 8% decreased it in the first and second months but had no effect in the third (Table 11). It is clear from the results that fat addition has no clear trend of effects and nothing could be concluded except that fat may lower the protein percentage depending on the feeding regimen and amount of fat added. As to the effect of the month of lactation protein increased significantly in the second and third months in the control, and in the third in the 8% fat group. No difference was detected in the 4% group.

Some authors found that milk protein is negatively affected by the level of fat and eventually by the addition of protected fat (Appeddu et al., 2004; Gargouri et al., 2006; Zhang et al., 2006). The possible reasons of this reduction are attributed to dilution effects when milk yield is increased, reduction of microbial protein synthesis due to a reduced intake of energy from carbohydrates and changes in glucose metabolism or metabolic utilization of amino acids at the mammary gland (Coppock and Wilks, 1991; Cant et al., 1993 a ,b; Palmquist et al., 1993). While other researchers found an opposite effect with an increase in the milk protein (Sanz Sampelayo et al., 2004; Titi, 2011; Titi et al., 2011; Wadhwa et al., 2012). Titi et al. (2008) stated that increase milk protein in fat treated goats is due to improved energy balance &/or increased availability of rumen nitrogen, which, in turn, enhanced synthesis of protein in the mammary gland. Few authors did not register any effect for fat supplementation (Andrade and Schmidely, 2006; Harvatine and Allen, 2006).

3.5.3. Milk lactose

In the present study the fat addition had a decreasing effect in the third month for the 4% fat level and a nonsignificant decrease in the second for the 8% one. It is conflicting to find slight increase in the second month in the 4% level and in the third in 8% (Table 11). So no clear trend can be concluded, it is decreasing and increasing at the same lactation period, one for a certain level of addition and the other for the second one. The overall means show no effect for fat supplementation on milk lactose. The results of the different studies tracing lactose are conflicting, some found that fat supplementation increases lactose percentage (Duske et al., 2009), some decreases (Alba et al., 1997; Casals et al., 1999) and others found no effect (Appeddu et al., 2004; Tyagi et al., 2009a; Thakur and Shelke, 2010; Naik 2013; Wina et al., 2014).

3.5.4. Milk urea nitrogen

In the first month fat addition significantly increased urea nitrogen and the extent of increase follows the level of addition. In the other two months of lactation there was no effect detected. As to the effect of the months of lactation in control group, the first is the lowest followed by the second and then the third. The same trend was registered in the fat-addition groups. The increase in the second month reached 1.5-2.5 times while the third reached 2.5-4.0 times in the three groups. This result disagrees with Abd El-Rahman et al. (2008) who recorded a significant reduction of milk urea in goats supplemented with protected fat.

3.5.5. Milk total solids

During the first month the highest value for total solids was for the group 4% fat followed by the 8%, and the lowest was that of the control group. The one showed significance is that of 4% fat. In the second month both the 4 & 8% increased the value significantly while the third month showed no significant effect. As a whole for the three months the fat addition groups increased significantly the total solids (Table 11). The increase in total solids seems to be due to the positive effect on fat percentage, as fat addition did not affect the solid not fat or even decreased it as will follow. Changes in total solids content reflected changes in fat content (Chouinard et al., 1998). Titi (2011) found that higher total content for the milk of the 3% fat group was due to significantly higher fat % of milk of this group. Alba et al. (1997) reported that after weaning at 35d postpartum and for the next 5-wk period ewes fed the supplemented diet produced more total solids in milk than did the basal diet. However, reports of no change in total solid content by supplementing protected fat are available by Abd El-Rahman et al. (2008), Naik et al. (2009b), Titi et al. (2011).

3.5.6. Milk solids not fat

There was no effect for fat addition on solids not fat except a decreasing effect found in the second and third months in the 4 % fat (6.16 & 6.5%) compared with 8.25% & 8 % in control and 6.49% & 8.8% in the 8% fat group. There was no difference among the three months in the control and 4%, and low values in the first and second months compared with the third in the 8% level. The overall means for the three months show a decreasing effect for the 4% fat only (Table 11). The previous studies showed that the SNF content of milk was either not altered (Douglas et al., 2004; Abd El-Rahman et al., 2008; Naik et al., 2009b) or increased (Gulati et al., 2003; Mishra et al., 2004; Wadhwa et al., 2012).

General on milk components

Discussing the effect of fat addition on six milk components was much confusing. At a time, the effect was decreasing, increasing or having no effect without any clear trend. So it was found to be too wise to summarize the effect of fat on all the components in one table using plus and minus or (NE) no effect signals (Table 13). The conclusion is on the overall means shown in table (12).

Table 12. Overall means for milk components

Component	Group A	Group B	Group C
Fat %	8.51[c]	11.85[a]	10.65[b]
Protein %	3.38[a]	2.95[b]	2.93[b]
Lactose %	3.64[a]	3.69[a]	3.62[a]
Urea nitrogen (mg/dl)	21.77[a]	22.40[a]	22.18[a]
Total solids %	16.38[b]	18.87[a]	17.80[a]
Solids not fat %	7.91[a]	6.91[b]	7.37[b]

Values with different superscripts within the rows are significantly different.

4. Conclusion

The conclusive results which can be extracted from the current study that the effect of CSFA feeding on dry matter intake of ewes varied from a decrease in late gestation to an increase in early lactation and no difference was in late lactation. The effect followed the amount of fat added which was not more enough to produce change in ewe's body weight. The growth of the suckling lambs until weaning was unchanged reflecting no significant effect on milk production. However, the milk composition was affected by fat supplementation, there was an increase in fat %, with significant value for the 4% CSFA milk, and total solids %, while it decreased protein % as well as the content of solids not fat in the 4%. Other milk constituents were not altered. Globally, CSFA supplementation was effective to increase the fat % and yield of milk in sheep especially at the rate of 4% addition.

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