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Physicochemical and Sensory Characteristics of Processed Cheese Manufactured from the Milk of Goats Supplemented with Sunflower Seed or Sunflower Oil

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ABSTRACT

Oilseed lipids are important sources of unsaturated lipids. Among oilseeds, sunflower, linseed and soybeans seed are used both in farms and experimental work. Moreover, the improvement of unsaturated fatty acids and Conjugated Linoleic Acid (CLA) in milk products is important for human health. The aim of this work was to enhance the fatty acid profile of processed cheese by using milk from goats fed with different additives, namely sunflower seed or sunflower oil. Fifteen lactating goats, in early lactation, were distributed to three groups using complete randomized design for a three months experimental period. The treatments were: (1) control diet consisted of concentrate feed mixture: berseem clover (1:1 dry matter bases), (2) control +50 g/head/d sunflower seed and (3) control +20 mL/head/d sunflower oil. Milk of each treatment was pooled and used in processed cheese manufacturing by acidifying milk with diluted lactic acid until coagulation. Cheese samples were stored at 7°C for 3 months. Results showed that experimental additives increased ($p<0.05$) the total unsaturated fatty acids and CLA in the processed cheese. All additives decreased ($p>0.05$) the total saturated fatty acids and increased ($p<0.05$) the polyunsaturated fatty acids contents of the processed cheese fat. Processed cheese color, flavors and physical properties, such as oil separation melting index and penetrometer reading were not significantly affected ($p>0.05$) by the experimental additives. It may be concluded that sunflower seed or sunflower oil addition to lactating goat rations increased the nutritive value of processed cheese.

Key words: Goat's milk, processed cheese, fatty acids profile

INTRODUCTION

Fats are used in diets for dairy animals to increase energy intake and milk production. Moreover, the fatty acids composition of the produced milk can be manipulated by altering the FA composition of fats in the feed. Dairy foods are an important source of nutrients in the human diet. The nutritional quality of milk depends on its composition, particularly its Fatty Acids (FA) composition. Certain FA have potentially negative effects such as saturated fatty acids, or positive effects such as unsaturated FA on human health. Consumers are demanding dairy products that are richer in mono- and polyunsaturated fatty acids. Feeding oilseeds to lactating dairy animals is one method to change the proportion of unsaturated fatty acids in milk fat with increases as high as 40% (Kim *et al*., 1993), although extensive biohydrogenation occurs normally in the rumen (Palmquist and Jenkins, 1980). Sunflower seed and flaxseed would be a good choice from a consumer viewpoint, as both are rich in polyunsaturated fatty acids, with sunflower being a source

of linoleic acid (66% of the total fatty acids), while flaxseed is rich in linolenic acid (56% of the total fatty acids). Sunflower seeds increase the proportion of unsaturated fatty acids in milk compared to cows fed no supplemental fat (Morsy *et al*., 2015). Processed cheese is an important part of the cheese market. Its market is very progressing. It is a complex system composed of protein, fat, mineral salts and other ingredients. It was found that many variables affect on the properties of processed cheese, such as composition and nature of the initial natural cheese, the nature and amount of the emulsifying agents, the manufacturing procedure and additional factors (Carie *et al.,* 1985). The emulsifier plays a very important role in producing desirable body and texture characteristics and melting and slicing properties in the finished cheese products. In previous studies found that processed cheese spread manufactured from goat's milk fed with plant oils had the highest contents of total unsaturated fatty acids and conjugated linoleic acids (Mohamed *et al*., 2013; Morsy *et al*., 2014). Therefore, the aim of this study was to estimate the nutritional properties of the processed cheese produced from milk of goats supplemented with sunflower seed or sunflower oil.

MATERIALS AND METHODS

Experimental animals and feed analysis: As described by Morsy *et al.* (2015), fifteen lactating Damascus goats in the 3rd or 4th lactating seasons with an average live body weight of 44.8 kg were divided into three equal and similar groups according to their age and weaning weights. Goats were assigned randomly to three dietary treatments: (1) basal diet containing Concentrate Feed Mixture (CFM), berseem clover (*Trifolium alexandrinum*) (1:1 dry matter bases) (control), (2) control diet+50 g/head/day Sunflower Seed (SS) and (3) control diet+20 mL/head/day Sunflower Oil (SO) for 90 days. All rations were formulated to meet the maintenance and production requirements for each animal (NRC, 2007). Chemical analysis of CFM and berseem clover is presented in Table 1. Goats were fed individually with CFM, once daily at 8.00 h, while fresh berseem clover was offered at 10.00 and 16.00 h. The additives (i.e., whole seeds or oil) were mixed with about 100 g of the concentrates before morning feeding at 08.00 h and fed to goats. Drinking water was available at all time. Samples of feed ingredients were analyzed for crude protein, crud fiber, dry matter, ash and ether extract according to methods of AOAC (1997).

Sampling and analysis of milk: Individual milk samples were collected from all animals every two week during the experimental period (three months). The process of milking for goats were occurring twice daily at 8.00 and 16.00 O, clock. Pooled goats milk from each treatment was used in the manufacturing of processed cheese. Samples of milk were analyzed for fat, protein, lactose and total solids using infrared spectrophotometry (Foss 120 Milko-Scan, Foss Electric, Hillerod,

Table 1: Chemical composition (%) of the concentrate feed mixture[1], fresh *Trifolium alexandrinum*, sunflower seeds and the basal diet[2] (on DM basis) adapted from Morsy *et al*. (2015)

Parameters	CFM[1]	*Trifolium alexandrinum*	Sunflower seeds	Basal diet[2]
Dry matter	91.3	13.3	91.6	52.3
Organic matter	89.9	88.2	96.5	89.1
Crude protein	14.2	14.2	21.7	14.2
Ether extract	4.1	2.6	40.3	3.35
Crude fiber	15.3	27.5	22.6	21.4
Nitrogen free- extract	56.4	43.9	11.9	50.2

[1]The CFM consisted of, 25% undecorticated cotton seed meal, 35% wheat bran, 30% corn, 3% rice bran, 3% molasses, 2% limestone, 1% urea and 1% salt (NaCl), [2]The control diet consisted of CFM and fresh *Trifolium alexandrinum* at 1:1 (on DM basis), the same used in Morsy *et al*. (2015)

Denmark) according to AOAC (1997) procedures. The ash content of milk was calculated after heating in a muffle furnace at 550°C for 16 h and the solids not fat content was calculated by difference.

Manufacturing of processed cheese spread: Processed cheese was manufactured by using cheese base, which was prepared by acidifying goats' milk with diluted lactic acid until coagulation. Cheese base was milled and placed into the processing batch type kettle, a pilot machine at National Research Center. The cheese blend was heated using direct injection of steam at pressure of 1.5 bar. The composition of blend was adjusted for fat content using butter and for moisture using skim milk powder. The emulsifying salt (K2211) was added at the optimum level, as calculated by the relative casein according to Meyer (1973). The heating temperature was 85-90°C for different holding times. The hot processed cheese of each treatment was manually filled into glass cups covered with aluminum foil, then rapidly cooled and stored at 7°C for 3 months. The chemical compositions of cheese base and different formulation of processed cheese are shown in Table 2 and 3.

Physical analysis: Penetrometer reading was measured using a penetrometer (Kochler Instrument Co. Inc., USA) as characterized by Gupta and Reuter (1993). The penetration depth was recorded in units of 1/10 mm and in general the greater in the depth of penetration the weaker in the body of cheese. Oil separation was calculated according to the method outlined by Thomas (1973). Meltability of the samples were determined according to the method designed by Olson and Price (1958). Color parameter using a Hunter colorimeter model D2s A-2 (Hunter Assoc. Lab. Inc. VA, USA) according to the directive of user manual. The instrument was first standardized, employing a reference with white surface. As in the Hunter L, a and b tally, where, L: value represents darkness from black (0) to white (100), a: value represents color ranging from red (+) to green (-) and b: value represents color ranging from yellow (+) to blue (-).

Chemical analysis of processed cheese: Processed cheese spread samples were analyzed for total solids, fat, total protein, ash and moisture according to AOAC (1997) and pH value was measured by using a digital pH meter (M4 1150 USA). Fatty acids in processed cheese were determined using methyl esters prepared by base-catalyzed methanolysis of the glycerides (KOH in methanol) according to ISO-IDF. (2002). Fatty acids methyl esters were separated using a Cp-Sil

Table 2: Chemical analysis (%) of the ingredients used in different blends of processed cheese

	Cheese base				
Item	Control	SS	SO	SMP	CB
Total solids	30.50	30.50	30.00	96.00	84.00
Fat	10.50	10.50	10.51	0.99	82.00
Lactose	3.00	3.00	3.00	47.50	-

CB: Cow butter, SMP: Skim milk powder, SS: Sunflower seed group, SO: Sunflower oil group

Table 3: Formulation of the different blends (%) used for manufacturing of processed cheese

Items	Control	SS	SO
Cheese base	66.38	66.38	66.38
Butter	19.92	19.92	19.92
SMP	6.66	6.66	6.66
Emulsifying salts	2.00	2.00	2.00
Salt	1.00	1.00	1.00
Water	4.04	4.04	4.04
Total	100.00	100.00	100.00

SMP: Skim milk powder, SS: Sunflower seed group, SO: Sunflower oil group

88 fused-silica capillary column on a Perkin-Elmer chromatograph (model 8420, Beaconsfield, Perkin Elmer, Beaconsfield, UK) equipped with a flame ionization prospector.

Sensory evaluation of processed cheese: Products were evaluated for aroma, taste, consistency, appearance and overall acceptability by an eleven member panel. The order of testing was randomized. To assist the arbitrators in describing defects, the scores sheet included a list of suggested flavour, consistency and appearance defects. The arbitrators were asked to give an overall score ranging between 1-5, where 5: Excellent, 4: Very good, 3: Good, 2: Fair and 1: Poor.

Statistical analysis: All results were analyzed using the procedure of SAS (2004). Data of milk composition, cheese properties and cheese fatty acid profile were analyzed as a complete randomized design where treatment was the main source of variation. Means were compared using Duncan's multiple rang test of Duncan (1955).

RESULTS AND DISCUSSION

Milk components: As shown in Table 4 the milk fat content and lactose content were higher ($p<0.05$) with SS and SO treatments compared with control. In contrast, there was no significant difference ($p>0.05$) between treatments in milk protein and total solids contents. The higher milk fat and lactose contents for treated goats could be related to the change in ruminal activity with experimental additives. Morsy *et al.* (2012) and Kholif *et al.* (2012, 2015) reported that rumen molar proportions of individual total volatile fatty acids and the acetate to propionate ratio were significantly ($p<0.05$) affected by plant oils additives. Increased milk lactose and fat contents with the SO addition may be due to the increased blood serum glucose concentration and increased rumen fermentation with SO goats (Ollier *et al*., 2009). In addition, Sanz Sampelayo *et al*. (2002) reported a high correlation coefficient ($r = 0.95$) between lactose production and fat supplementation in goats fed isocaloric diets.

Processed cheese composition: Data presented in Table 5 indicate the chemical composition of the processed cheese made from the different treatments. It is obvious that the contents of total solids, fat and ash of the samples under test fall within the standard range given for each component of processed cheese, cheese, processed cheese foods and processed cheese spreads. While, minor differences were observed between the different experimental blends. Have been found no significant differences were observed in chemical composition could be to using either different treatments for the probation of the cheese base. A similar observation was found by Mohamed *et al.* (2013), when added different essential oils on lactating goat's diet and Morsy *et al.* (2014), when supplemented lactating goats ration with flax seeds or flax seeds oil.

Table 4: Milk composition of lactating Damascus goats fed basal diet with sunflower seeds whole (SS) or sunflower seeds oil (SO) Adapted from Morsy *et al*. (2015)

	Diets[1]				
Milk composition (%)	Control	SS	SO	SEM	p-value
Fat	3.96[b]	4.19[a]	4.32[a]	0.050	0.002
Protein	3.16	3.26	3.26	0.027	ns
Lactose	4.65[b]	4.72[ab]	4.96[a]	0.046	0.048
Total solids	12.80	13.00	13.60	1.699	ns
Solids not fat	8.86	8.88	9.30	1.165	ns
Ash	0.88	0.87	0.89	0.094	ns

SEM, standard error of the mean, [1]Diets consisted of concentrate feed mixture and fresh *Trifolium alexandrinum* (1:1; control) or control plus 50 g SS/head/d or Control+20 mL SO/head/d, Means at the same row with different superscripts are significantly ($p<0.05$) differed

Table 5: Chemical composition (%) of processed cheese manufactured from milk of treated goats

Item	Control	SS	SO	SEM	p-value
Total solids	44.11	44.34	44.61	2.12	ns
Fat	22.10	22.40	23.10	2.02	ns
Protein	12.32	12.34	12.35	1.34	ns
Lactose	5.87	6.00	6.10	0.91	ns
Ash	3.97	4.00	3.89	0.54	ns
pH	5.66	5.69	5.70	0.71	ns

SS: Sunflower seeds, SO: Sunflower oil group, ns: Non significant

Table 6: Fatty acids profile (g/100 g fat) of processed cheese from goat's milk fed diets containing sunflower seeds (SS) or sunflower oil (SO)

Item	Control	SS	SO	SEM	p-value
C4.0	1.72	1.41	1.23	0.142	ns
C6.0	1.31^{b}	1.48^{a}	1.51^{a}	0.192	0.050
C8.0	2.55	2.2	2.52	0.261	ns
C10.0	5.98	5.47	5.35	0.485	ns
C12.0	3.66	3.55	3.12	0.291	ns
C14.0	9.97	9.72	9.56	0.841	ns
C14.1	0.11^{b}	0.16^{b}	0.38^{a}	0.021	0.041
C15.0	0.24	0.21	0.29	0.145	ns
C16.0	27.10	26.40	25.90	2.30	ns
C16.1	0.18^{c}	0.29^{b}	0.75^{a}	0.087	0.042
C17.0	0.98^{a}	0.35^{b}	0.33^{b}	0.035	0.005
C18.0	15.20	13.65	12.41	1.06	ns
C18.1N9T	25.37^{b}	29.11^{a}	30.05^{a}	2.910	0.039
C18.1N9C	4.15^{b}	4.41^{a}	4.98^{a}	0.389	0.043
C18:2 *trans*-10, *cis*-12	0.04^{b}	0.08^{a}	0.09^{a}	0.008	0.035
C18:2 *cis*-9, *trans*-11	0.12^{b}	0.14^{a}	0.14^{a}	0.020	0.010
C18.3N3	0.10	0.11	0.12	0.015	ns
C18.3N6	0.31^{b}	0.46^{a}	0.44^{a}	0.037	0.004
C20.0	0.91	0.80	0.83	0.113	ns
TSFA	69.62	65.24	63.05	4.24	ns
TUSFA	30.38^{b}	34.76^{ab}	36.95^{a}	2.83	0.040
MUSFA	29.81^{b}	33.97^{b}	36.16^{a}	3.16	0.043
PUSFA	0.57^{b}	0.79^{a}	0.79^{a}	0.046	0.030
Total CLA	0.16^{b}	0.22^{a}	0.23^{a}	0.017	0.019
N6/N3	3	4.18	3.66	0.207	ns

Each value represents an average of three samples, ^{a,b}Means with different superscripts are significant ($p<0.05$) differed, SEM: Standard error of the means, TSFA: Total saturated fatty acids, TUSFA: Total unsaturated fatty acids, PUSFA: Poly unsaturated fatty acids, CLA: Conjugated linolenic acid

Fatty acids profile in processed cheese: Processed cheese fatty acids profile produced from SS group showed increased ($p<0.05$) content from total Conjugated Linolenic Acid (CLA) and poly unsaturated chain fatty acids but lower ($p>0.05$) in Total Saturated Chain Fatty Acids (TSFA) compared with control. Individually, processed cheese fatty acids with SS group had increased ($p<0.05$) C6, C16:1, C18.1N9T, C18.1N9C and C18.3N6, but decreased ($p>0.05$) in C17 contents compared with control. Regarding the values of fatty acids profile of processed cheese from SO group had increased ($p<0.05$) in total CLA and Total Unsaturated Chain Fatty Acids (TUSFA), but lower ($p>0.05$) in Total Saturated Chain Fatty acids (TSFA) compared with control. While, C6, C14:1, C16:1, C18.1N9T and C18.1N9C have achieved the highest value with SO group (Table 6). These results are in agreement with other studies (Mohamed *et al*., 2013; Morsy *et al.,* 2014), which reported similar changes in processed cheese fat, when processed cheese manufactured from goat's milk fed with plant seeds or plant oils. There have been some studies on increasing CLA content in the milk of dairy animals using a dietary supplementation with sunflower oil or sunflower seeds (Morsy *et al*., 2015; Mohammed *et al*., 2011). Improvement in fat profiles, especially CLA and Unsaturated chain fatty acids in the processed cheese were a result of the use of milk, which had high levels of CLA and Unsaturated chain fatty acids in the manufacture of cheese.

Table 7: Physical properties of processed cheese manufactured using milk of treated goats, fresh and during cold storage

Physical properties	Storage period	Control	SS	SO	SEM	p-value
Penetrometer reading (mm)	Fresh	88	90	93	3.1	ns
	1	80	82	84	2.5	ns
	2	75	80	77	1.9	ns
	3	60	75	64	2.9	ns
Oil separation index	Fresh	34.11	35.66	34.00	3.1	ns
	1	35.70	36.81	35.62	2.4	ns
	2	36.62	37.52	37.60	2.6	ns
	3	39.00	38.95	39.21	1.7	ns
Melting index (mm)	Fresh	80	83	84	2.6	ns
	1	76	80	79	3.8	ns
	2	74	71	74	2.4	ns
	3	60	62	61	2.1	ns

SS: Sunflower group, SO: Sunflower oil group

Table 8: Color properties of processed cheese made using milk of treated goats

Color parameters and storage period	Control	SS	SO	SEM	p-value
L					
Fresh	84.99	85.14	85.08	1.61	ns
1	84.65	84.96	84.95	1.24	ns
2	84.70	84.63	85.16	1.40	ns
3	84.39	84.31	84.55	1.61	ns
a					
Fresh	-2.14	-2.18	-2.11	0.95	ns
1	-2.33	-2.40	-2.30	0.86	ns
2	-2.58	-2.51	-2.46	0.90	ns
3	-2.67	-2.66	-2.69	0.79	ns
b					
Fresh	24.61	24.57	24.60	1.95	ns
1	24.99	24.80	24.81	1.11	ns
2	25.00	24.90	25.00	0.68	ns
3	25.31	25.43	25.7	1.94	ns

L: Lightness (Black (0) to white (100)), a: redness (+) to greenness (-), b: yellowness (+) to blueness (-), SS: Sunflower seeds group, SO: Sunflower Oil group

Table 9: Sensory evaluation of processed cheese manufactured using milk of treated goats

Sensory characteristics	Control (5)	SS (5)	SO (5)	SEM	p-value
Aroma	4	4	4	0.6	ns
Taste	4	4	3	0.4	ns
Consistency	3	4	3	0.1	ns
Appearance	4	3	4	0.3	ns
Overall acceptability	4	4	3	0.4	ns

SS: Sunflower group, SO: Sunflower oil group

Processed cheese physical properties: Processed cheese manufactured from milk of treated goats had no significant difference than other groups in penetrometer reading, oil separation index and melting index (Table 7). The penetrometer reading and melting index were decreased gradually during cold storage until end of 3rd month in sample of all treatments. These results during storage could be related to the interaction between state of protein network and emulsifying salts as well as the changes in chemical composition during storage (Azzam, 2007). But, the oil separation index increased gradually during cold storage (7°C) until 3 months in all treatments. This result is in good agreement with the results of Mohamed *et al.* (2013) and Morsy *et al.* (2014). Moreover, all treatments did not effect on color properties of processed cheese (Table 8). Similar trend were obtained by Morsy *et al.* (2014).

Sensory evaluation: No difference ($p>0.05$) noted in aroma, taste, consistency and appearance, among all treatments (Table 9). Morsy *et al.* (2014) reported that no change in the sensory parameters of processed cheese produced by milk from goats supplemented with flaxseeds or flaxseeds oil.

CONCLUSION

The supplement of sunflower seeds or sunflower oil in the ration of dairy goats can change the milk fat percentage and markedly influenced the fatty acid profile of the milk fat. So processed cheese manufactured by milk from goats fed with sunflower seeds or sunflower oil had the highest contents of unsaturated fatty acids and conjugated linoleic acid with lowest contents of saturated fatty acids.

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