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Nutritional Properties of the Processed Cheese Produced by Milk from Goats Supplemented with Flaxseeds or Flaxseeds Oil

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ABSTRACT

The main objective of this study was to evaluate nutritional properties of the processed cheese produced using milk from goats fed with flax oil or flax seeds. Fifteen lactating Damascus goats, in early lactation, were divided into three groups using complete randomized design for 90-days period. The treatments were (1) Control ration consisted of concentrate feed mixture: Bersem clover (1:1 dry matter bases), (2) Control +50 g head day^{-1} Flax Seeds (FS) and (3) Control +20 mL head day^{-1} Flax Oil (FO). Milk was pooled from each treatment and then used independently for the manufacturing of processed cheese. The total unsaturated fatty acids and Conjugated Linoleic Acids (CLA) in processed cheese were increased ($p<0.05$) with experimental additives. However, poly unsaturated fatty acids contents were insignificant increased ($p>0.05$). On the other hand, the total saturated fatty acids were decreased ($p>0.05$). The results also indicated that the fatty acids profile in processed cheese of FO group was better than FS group. Processed cheese flavors, color and physical properties such as melting index, oil separation and penterometer reading were not significantly affected by the experimental treatments. It is concluded that the addition of flax seed or flax oil to lactating goats ration significantly modified the nutritive value of the processed cheese which may provide benefits to the consumers.

Key words: Flax seed, processed cheese, goat's milk, fatty acids profile

INTRODUCTION

Processed cheese has several technical advantages over natural cheese, including far longer shelf-life, resistance to separating when cooked and a uniform look and physical behavior. It is possible to improve the nutritional value of processed cheese through cooking it from milk rich in unsaturated fatty acids, especially Conjugated Linoleic Acids (CLA). The CLA is best known for its anti-cancer properties, researchers have also found that the cis-9, trans-11 form of CLA can reduce the risk for cardiovascular disease and help fight inflammation in experimental animals (Hughes and Dhiman, 2002). Manipulating the diet of dairy cow is one way to alter the Fatty Acid (FA) profile of milk fat. Health-conscious consumers are demanding milk with higher proportions of healthy FA. From previous study it was found that, the CLA content of milk and meat products from ruminants can be increased through manipulation of the diet, such as grazing on pasture or feeding feed sources rich in linoleic and linolenic acids (Chouinard *et al*., 2001), or feeding fish oil (Abu-Ghazaleh *et al*., 2001, 2003). Flaxseeds are rich sources of linolenic acids 18:3 n-3, as it comprises 50-60% of their total FA content. So the objective of the current study was to investigate

the use of goat's milk produced from animals fed with flaxseeds or flaxseeds oil on composition and properties of processed cheese.

MATERIALS AND METHODS

This study was conducted at Gemazza farm, Animal Production Research Institute, Dokki, Cairo, Egypt and Department of Dariy Science, National Research Centre, Dokki, Cairo, Egypt.

Animals and rations: Fifteen lactating Damascus goats, in the 3rd to 4th lactating seasons and weighting an average 43.4±2 kg were used in this experiment starting after seven days of parturition and extended to 90 days. Goats were divided into three groups, each group contain five animals and were assigned randomly to receive one of three dietary treatments using complete randomized block design. The treatments were (1) Control ration consisted of concentrate feed mixture: Bersem clover (1:1 dry matter bases), (2) Control +50 g head day^{-1} Flax Seeds (FS) and (3) Control +20 mL head Day^{-1} Flax Oil (FO). The experimental additives were mixed with Concentrated Feed Mixture (CFM) for the morning meal. Chemical composition of the ingredients is shown in Table 1. Offered feeds were assessed to cover the maintenance and production requirements for each animal (ARC, 1983). The CFM was offered for each animal individually once daily at 8.00 am, while fresh berseem clover was offered at 10 and 16 h. Drinking water was available at all time.

Feed analysis: Samples of feed ingredient were analyzed for dry matter, ash, crude protein, crud fiber and ether extract according to methods of (AOAC, 2007). Nitrogen-free extract and organic matter were calculated by difference.

Sampling and analysis of milk: Individual milk samples were collected from all animals every month during the experimental period (90 days). The goats were hand milked twice daily at 8 and 16 h. Pooled goats milk from each treatment was used in the manufacture of processed cheese. Milk samples were analyzed for total solids, fat, protein and lactose using infrared spectrophotometry (Foss 120 Milko-Scan, Foss Electric, Hillerod, Denmark) according to AOAC (2007) procedures. The ash content of milk was determined after heating in a muffle furnace at 550°C for 16 h and the solids not fat content was calculated by difference.

Manufacture of processed cheese spread: Processed cheese was manufactured according to the method of Meyer (1973) by using cheese base which was prepared by acidifying goats' milk with

Table 1: Chemical composition (% DM basis) of ingredients used in feeding trial

Items	CFM	Berseem clover
Dry matter	92.8	20.0
Organic matter	90.9	87.9
Protein	14.1	12.8
Fat	4.2	2.5
Crude fiber	15.1	28.2
Ash	9.1	12.1
Nitrogen free extract	57.5	44.4

CFM: Concentrate feed mixture consisted of 35% yellow corn, 25% wheat bran, 23% decorticated cotton seed meal, 15% rice bran, 1.5% ground limestone and 0.5% mineral and vitamin mixture contained 42 ppm Co, 3500 ppm Cu, 20,000 ppm Fe, 12,000 ppm Mn, 12,000 ppm Zn, 1200 ppm I, 3800 IU g^{-1} of vitamin A, 1200 IU g^{-1} of vitamin D and 30 IU g^{-1} of vitamin E

Table 2: Chemical composition (%) of the ingredient used in manufacture of processed cheese

	Cheese base				
Items	Control	FS	FO	CB	SMP
Total solids	30.00	29.99	30.05	84.00	96.00
Fat	10.50	10.50	10.41	82.00	0.99
Lactose	3.00	3.00	3.00	--	47.50
Total nitrogen	76.56	76.54	76.50	--	239.10

CB: Cow butter, SMP: Skim milk powder, FS: Flaxseeds, FO: Flaxseeds oil

Table 3: Formulation of the different blends (%) used in manufacture of processed cheese

Items	Control	FS	FO
Cheese base	66.40	66.40	66.40
Butter	19.92	19.92	19.92
SMP	6.64	6.64	6.64
Emulsifying salts	2.00	2.00	2.00
Water	5.04	5.04	5.04
Total	100.00	100.00	100.00

SMP: Skim milk powder, FS: Flaxseeds, FO: Flaxseeds oil

diluted lactic acid until coagulation. The chemical compositions of cheese base and different formulation of processed cheese are shown in Table 2 and 3. Processed cheese was made locally by a pilot machine at the National Research Center.

Physical analysis: Processed cheese spread penetrometer was measured using a penetrometer (Koch Jer Instrument Co. Inc., USA) as described by Gupta and Reuter (1993). The penetration depth was recorded in units of 0.1 mm, oil separation in mm was determined according to the method outlined by Thomas (1973). Color parameter using a Hunter Lab. Colorimeter Model b25 A-2 (Hunter Assoc. Lab. Inc. Va, USA) according to the instruction of user manual. The Instrument was first standardized using a reference with white surface. As in the Hunter L, a and b scale described lightness black (0) to white (100), redness (+) to greenness (-) and yellowness (+) to blueness (-), respectively were measured.

Chemical analysis of processed cheese spread: Processed cheese spread samples were analyzed for Dry Matter (DM), fat, Total Protein (TP) contents, moisture and ash content according to the AOAC (2007) and pH value was measured by using a digital pH meter (M4 1150 USA). Fatty acids in processed cheese were extracted as described in international standards (ISO, 2001) and determined according to international standards (ISO, 2002) using GC system.

Sensory analysis: The sensory of cheese was evaluated by scoring panel from the staff members of food and dairy department at the National Research Center according to Nelson and Trout (1956).

Statistical analysis: All results were analyzed using the procedure of SAS (2004). Data of milk composition, milk fatty acid profile and cheese properties were analyzed as a complete random design where treatment was the main source of variation. The Duncan's multiple range tests was used to test the significance between means (Duncan, 1955).

RESULTS AND DISCUSSION

Milk composition: The chemical composition of milk used in processed cheese manufacture is shown in Table 4. Milk fat was higher ($p<0.05$) with FS and FO groups compared with control. Also, milk lactose was higher ($p<0.05$) with FO group compared with other treatments. Other milk components were not affected by treatments. The higher milk fat and lactose contents may be due to the change in ruminal activity with experimental additives. Morsy *et al.* (2012) and Kholif *et al.* (2012) reported that rumen molar proportions of individual total volatile fatty acids and the acetate to propionate ratio were significantly ($p<0.05$) affected by essential oils additives. Similar results were obtained by Caroprese *et al.* (2010) who reported that supplementation of flaxseed oil to cows ration had increased the milk fat and lactose contents compared with control.

Chemical composition of processed cheese: The chemical composition of processed cheese was not significantly affected among different groups (Table 5). Similar results were obtained by Mohamed *et al.* (2013).

Fatty acid composition in processed cheese: Table 6 shows the fatty acids profile of processed cheese. It is evident that palmitic (C16:0) proportion was decreased ($p>0.05$) with FS and FO group compared with control. However, palmitoleic (C16:1) proportion were increased ($p<0.05$) with FO group followed by FS group and then control. In the present study the decrease in C16:0 contents in processed cheese may be a positive goal from a human health perspective because high proportions of C16:0 has been associated with human cardiovascular problems (Noakes *et al*., 1996). The fat in processed cheese of FO and FS groups had increased ($p<0.05$) the proportion of linolenic n-3 (C18:3 N-3). Flaxseeds or flaxseeds oil supplemented to goats rations were increased ($p<0.05$) Total Unsaturated Fatty Acids (TUSFA) contents and decreased ($p>0.05$) Total Saturated Fatty Acids (TSFA) contents in processed cheese. The CLA (C18:2 trans-10, cis-12 and C18:2 cis-9, trans-11) proportion was increased ($p<0.05$) with FO group and FS group compared with control. It is known that CLA is important for human health and it is being sold as a panacea that has the capability of reducing or eliminating cancer, preventing heart disease and cardiovascular disease improving immune function and altering body composition to treat obesity or build lean body mass

Table 4: Chemical composition (%) of milk used in processed cheese manufacture

Items	Control	FS	FO	SEM
Fat	3.96^{b}	4.27^{a}	4.37^{a}	0.05
Lactose	3.16^{b}	3.30^{ab}	3.32^{a}	0.07
Protein	4.65	4.84	4.89	0.05
Total solids	12.80	13.40	13.30	0.19
Solid not fat	8.86	9.35	8.96	0.27
Ash	0.88	0.88	0.89	0.01

a, b: Means with different lowercase superscripts in a row differ significantly ($p<0.05$). FS: Flaxseeds group, FO: Flaxseeds oil group

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

Items	Control	FS	FO	SEM
Fat	22.47	22.49	22.50	2.02
Protein	12.25	12.37	12.39	1.34
Lactose	6.00	6.05	5.95	0.91
Ash	3.91	4.01	3.98	0.54
pH	5.76	5.74	5.74	0.71
Total solids	44.06	44.96	44.97	2.12

FS: Flaxseeds group, FO: Flaxseeds oil group

Table 6: Fatty acids (g/100 g fat) in processed cheese manufactured from milk of treated goats

Item	Control	FS	FO	SEM
C4:0	1.70	1.40	1.20	0.49
C6:0	1.24	1.41	1.52	0.24
C8:0	2.60	2.27	2.72	0.19
C10:0	6.66	5.98	5.84	0.41
C12:0	3.20	3.63	3.21	0.51
C14:0	9.97	9.48	9.55	2.70
C14:1	0.16	0.21	0.57	0.19
C15:0	0.32	0.29	0.30	0.07
C16:0	27.43	26.30	25.20	2.11
C16:1	0.24^{c}	0.33^{b}	0.88^{a}	0.21
C17:0	1.11	0.81	0.78	1.95
C18:0	14.40	14.51	13.03	2.15
C18:1N9T	25.80	28.10	28.80	2.37
C18:1N9C	3.77	3.72	4.77	0.27
C18:2 trans-10, cis-12	0.06^{b}	0.09^{a}	0.09^{a}	0.016
C18:2 cis-9, trans-11	0.11^{b}	0.14^{a}	0.15^{a}	0.018
C18:3N3	0.10^{b}	0.13^{a}	0.14^{a}	0.020
C18:3N6	0.28	0.39	0.41	0.12
C20:0	0.85	0.81	0.84	0.42
TSFA	69.48	66.89	64.19	2.11
TUSFA	30.52^{b}	33.11^{a}	35.81^{a}	0.11
MUSFA	29.97	32.36	35.02	0.62
PUSFA	0.55	0.75	0.79	0.12
Total CLA	0.17^{b}	0.23^{a}	0.24^{a}	0.014
N6/N3	2.80	3.00	2.90	0.171

a, b, c: Means with different lowercase superscripts in a row differ significantly ($p<0.05$). FS: Flaxseeds group, FO; Flaxseeds oil group TSFA: Total saturated fatty acids, TUSFA: Total unsaturated fatty acids, MUSFA: Mono unsaturated fatty acids, PUSFA: Poly unsaturated fatty acids, N6/N3: Omega 6 fatty acids/omega 3 fatty acids, CLA: Conjugated linolienic acid

(Whigham *et al*., 2000; Roche *et al*., 2001). Positive changes in fat profiles, especially CLA in the processed cheese were a result of the use of milk which had high levels of CLA in the manufacture of cheese. Flowers *et al*. (2008) and Da Silva *et al*. (2007) found that, when feeding different forms of flaxseed to dairy cows the concentration of n-3 FA and CLA in milk fat increased.

Physical properties of processed cheese: Process spread cheese manufactured by milk from goats supplemented with flaxseeds or flaxseeds oil had no significant difference between groups in penetrometer reading, oil separation index and melting index (Table7). The penetrometer reading and melting index were decreased gradually during cold storage until 3 weeks in all treatments. These differences during storage could be related to the interaction between emulsifying salts and state of protein network as well as the changes in chemical composition during storage (Azzam, 2007). In contrast, the oil separation index increased gradually during cold storage (7°C) until 3 weeks in all treatments. This results is in good agreement with the results of Hussein and Mohamed (2008) and Mohamed *et al*. (2011, 2013). Also it is clear that the various treatments did not affect the color properties of processed cheese (Table 8).

Sensory evaluation: The sensory parameters of cheese were not affected by the treatments (Table 9). These results confirm that the processed cheese product of the treatments had no sensory changes for customers.

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

Physical properties	Control	FS	FO	SEM
Penterometer reading (mm)				
Fresh	98	102	100	5.3
1	90	98	97	4.2
2	76	80	85	4.19
3	66	75	70	4.15
Oil separation index				
Fresh	33.56	35	34.33	2.91
1	35.00	36.60	35.46	2.94
2	36.76	38.20	36.66	1.85
3	38.26	39.44	38.66	2.03
Melting index (mm)				
Fresh	86	88	90	2.12
1	80	82	81	2.09
2	72	70	74	1.81
3	65	60	63	2.00

FS: Flaxseeds group, Fo: Floxseeds oil group

Table 8: Color properties of processed cheese manufacture from milk of treated goats

Color parameters	Control	FS	FO	SEM
L				
Fresh	87.07	87.19	88.93	3.02
1	86.70	86.72	86.96	1.21
2	86.56	86.55	86.68	1.34
3	87.38	88.06	87.15	2.91
a				
Fresh	-2.11	-2.14	-2.16	0.88
1	-2.28	-2.31	-2.25	0.92
2	-2.53	-2.50	-2.43	0.86
3	-2.65	-2.60	-2.63	0.19
b				
Fresh	23.73	23.66	23.70	0.92
1	23.98	23.90	23.91	1.01
2	24.11	24.08	24.09	1.05
3	24.35	24.22	24.19	0.98

L: lightness (Black (0) to white (100)), a: Redness (+) to greenness (-), b: Yellowness (+) to blueness (-), FS: Flaxseeds group, FO: Flaxseeds oil group

Table 9: Sensory evaluation of processed cheese manufacture from milk of treated goats

Sensory characteristics	Control (10)	FS (10)	FO (10)	SEM
Color	8	8	8	0.93
Aroma	7	7	8	0.81
Consistency	8	7	7	0.95
Oiling off	6	6	5	1.01
Taste	9	9	9	1.04
Total	38	37	37	2.34

FS: Flaxseeds group, FO: Flaxseeds oil group

CONCLUSION

This study demonstrated that processed cheese manufactured by milk from goats fed with flaxseed or flaxseed oil had the highest contents of unsaturated fatty acids, conjugated linoleic acid

and omega 3 fatty acid. Therefore use of these additives to dairy animals can improve the health properties of processed cheese and suggesting that its consumption benefits the human health.

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