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Nutritive Value of Processed Cheese Manufactured From Goat's Milk Fed Diet Supplemented With Essential Plant Oils

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Abstract: Given the importance of processed cheese and the attention to its nutritional values, this study examined increasing these values by feeding dairy animals with some essential oils. This in turn changed the profile of fatty acids in milk for the better. Thirty five lactating Damascus goats, in early lactation were divided into seven groups using complete randomized block design for 90-days period. The treatments were (1) Control ration consisted of concentrate feed mixture: berseem clover (1:1 dry matter bases), (2) control ration + 2 ml Cinnamon oil/head/d (3) control ration + 2 Garlic oil ml/head/d, (4) control ration + 2 ml Ginger oil /head/d, (5) control ration + 2 ml Anise oil/head/d, (6) control ration + 2 ml clove oil /head/d, (7) control ration + 2 ml Juniper oil /head/d. Individual milk samples were collected every month during the experimental period for analysis. Pooled goat's milk from each treatment was used in the manufacture of processed cheese. The results demonstrated that milk fat was higher ($P<0.05$) while milk protein was lower ($P<0.05$) for the control group compared with other treatments. Essential oils additives decreased total saturated fatty acids and omega 6: omega 3 ratio and increased mono and poly unsaturated fatty acids contents of processed cheese fat compared with control. Processed cheese flavours, color and physical properties were not significantly affected by milk obtained from experimental treatments. It be concluded that essential oil addition to lactating goats ration improved fat profile of processed cheese.

Key words: Goats · Essential oils · Fatty acids profile · Processed cheese

INTRODUCTION

Goat's milk differs in its composition and characteristics from that of cow's milk. Milk of Goat is richer in fat, smaller in fat globules, higher in short chain fatty acids, Moreover it is easily digested and do not tend to form clusters, It is also higher in casein as a percent of total protein than cow's milk [1]. On the other hand, the animal feed additives can change milk composition according feed composition. Recently, used of some plant extracts with high concentration of secondary metabolites is one of the best candidates as feed additives, where they can enhance milk component and increase nutritive value of milk products. Several studies have examined effects of essential oils (EO) and their active components, on rumen microbial fermentation and it is known that these EO contain active substances may have a positive effect on the rumen activity. Processed cheese is an attractive milky product that enjoys great popularity. It is a product obtained by blending cheeses of different types and maturity with melting salts [2]. Processed cheeses are aromatized by a supply of aroma ingredients of dairy animal as plant origin [3]. The properties of processed cheese spread are greatly influenced by the composition of blend and emulsifying salt used and other ingredients. The aim of this work is to study the feasibility of using Goat's milk obtained from Goats fed diets supplemented with some essential plant oils (Anise, Ginger, clove, Juniper, Garlic and Cinnamon oils) on the production of cheese-base to prepare processed cheese and the properties of resultant processed cheese.

MATERIALS AND METHODS

This study was conducted in Gemaiza farm, Animal Production Research Institute, Dokki, Giza, Egypt and Dariy Science Department, National Research Centre, Dokki, Giza, Egypt.

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Animals and Rations: Thirty five lactating Damascus goats, in the 3rd to 4th lactating seasons and weighting an average 45.4 + 2 kg were used in this experiment starting after 7 days of parturition and extended to 90 days. Goats were divided into seven groups, each group contain five animals and were assigned randomly to receive one of seven dietary treatments using complete randomized block design. The treatments included: (1) control ration consisted of concentrate feed mixture: berseem clover (1:1 dry matter bases), (2) control ration + 2 ml/head/d Cinnamon oil (3) control ration + 2 ml/head/d Garlic oil, (4) control ration + 2 ml/head/d ginger oil, (5) control ration + 2 ml/head/d anise oil, (6) control ration + 2 ml/head/d clove oil, (7) control ration + 2 ml/head/d Juniper oil. The essential oils (EO) 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 [4]. The CFM was offered for each animal individually once daily at 8.00 am, while fresh berseem clover was offered at 10.00 hrs and 16.00hrs. 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 [5]. Neutral detergent fiber (NDF) and Acid detergent fiber (ADF) were determined according to Van Soest *et al.* [6]. 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 8.00 and 16.00 hrs and the milk yield was recorded. Pooled goats milk from each treatment was used in the manufacture of processed cheese. Milk samples were analyzed for total solids, fat, protein, non-protein nitrogen and lactose using infrared spectrophotometry (Foss 120 Milko-Scan, Foss Electric, Hillerod, Denmark) according to AOAC [5] procedures. The ash content of milk was determined after heating in a muffle furnace at 550°C for 16 hour and the solids not fat content was calculated by difference. Fatty acids in milk were extracted as described in international standards ISO [7] and determined according to international standards ISO [8] using GC system.

Table 1: Ingredient and chemical composition of total mixed rations of lactating goats

Ingredient (g/kg)	Control ration
Berseem clover	600
Yellow corn	61
Soybean meal	88
Wheat bran	200
Sunflower meal	20
Urea	5
Calcium carbonate	3
Minerals and Vitamins[a]	23
Chemical composition (g/kg DM)	
Dry matter	901.1
Organic matter	896.6
Crude protein	167
Ether extract	37.1
Crude fiber	234.2
Neutral detergent fiber (NDF)	387
Acid detergent fiber (ADF)	231
NE_L (Mj/kgDM)[b]	6.2

[a]Contained 141 g/kg of Ca, 27 g/kg of P, 65 g/kg of Mg, 14 g/kg of S, 120 g/kg of Na, 6 g/kg of K, 944 mg/kg of Fe, 1613 mg/kg of Zn, 484 mg/kg of Cu,1748mg of Mn, 58mg/kg of I, 51 mg/kg of Co, 13 mg/kg of Se, 248,000 U/kg of vitamin A, 74,000 UI/kg of vitamin D3 and 1656 IU/kg of vitamin E.

[b] Calculated using published values of feed ingredients (ARC, 1983).

Manufacture of Processed Cheese Spread: Processed cheese was manufactured according to the method of Meyer [3] by using cheese base which was prepared by acidifying goats' milk with diluted lactic acid until coagulation. The chemical compositions of cheese base and different formulation of processed cheese are shown in Tables 2 and 3. Processed cheese was made by pilot machine locally at 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 [9]. The Penetration depth was recorded in units of 0.1mm, oil separation in mm was determined according to the method outlined by Thomas [10]. Color parameter using a Hunter Lab. Colorimeter Model b25 A-2 (Hunter Assoc. Lab. Inc. Va, USA) and the instruction of user manual. The Instrument was first standardizing 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 fat content, total nitrogen, soluble nitrogen content as

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

	Cheese base								
Items	Control	Anise	Ginger	Clove	Juniper	Garlic	Cinnamon	CB	SMP
Total solids	29.99	30.00	29.98	29.98	30.01	29.99	30.02	84.00	96.00
Fat	10.50	10.42	10.40	10.45	10.42	10.46	10.40	82.00	0.99
Lactose	3.10	3.00	3.00	2.95	2.95	2.95	3.00	--	47.50
Total nitrogen	76.56	76.50	76.52	76.54	76.65	76.54	76.52	--	239.1

CB: cow butter, SMP: skim milk powder

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

Items	Control	Anise	Ginger	Clove	Juniper	Garlic	Cinnamon
Cheese base	66.40	66.40	66.40	66.40	66.40	66.40	66.40
Butter	19.92	19.92	19.92	19.92	19.92	19.92	19.92
SMP	6.64	6.64	6.64	6.64	6.64	6.64	6.64
Emulsifying salts	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Water	5.04	5.04	5.04	5.04	5.04	5.04	5.04
Total	100	100	100	100	100	100	100

SMP: skim milk powder

described in Ling [11] while, lactose content was calculated by deference. The pH values determined by using (pH meter model Cole-amer Instrument Co., USA).

Statistical Analysis: All results were analyzed using the procedure of SAS computer program [12]. Data of milk fatty acid profile and cheese properties were analyzed as a complete random design where treatment was the main source of variation. Data of milk composition were analyzed as a randomized block design. When a significant F-test was detected (i.e., P< 0.05), treatment means were separated using Duncan's multiple range test was used to test Duncan [13].

RESULTS AND DISCUSSION

Milk Composition: Table 4 shows some chemical composition of Goat's milk fed different essential oils additives. It is clear that milk with Juniper oil had the lowest (P<0.05) content of fat 3.98% whereas control had the highest (P<0.05) content of fat 4.37%. The reduction in milk fat content may be due to the decrease in ruminal acetate proportion with essential oil supplemented goat's ration. Kholif *et al.* [14] 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 which increased the propionate and butyrate proportions and decreased the acetate proportion. Consequently, there was a decrease in the acetate to propionate ratio compared with the control. Milk protein was improved (P<0.05) with goats fed essential oils compared with control. The values of milk protein percent were; 3.15, 3.52, 3.48, 3.57, 3.50, 3.47 and 3.45 % for control, Cinnamon, Garlic, Ginger, Anise, Clove and Juniper treatments, respectively. This improvement of milk protein may be due to lower ruminal ammonia nitrogen and higher microbial protein with goats fed essential oils [14, 15]. Castillejos *et al.* [16] observed a decrease in ruminal ammonia nitrogen concentration with some essential oils supplementation. Lower ammonia nitrogen concentration might be attributed to the action of essential oils additives as regulators in absorbing and releasing ammonia nitrogen in the rumen. These advantages may provide favorable conditions in the rumen for microorganism's activity for best utilization of ruminal ammonia and beneficial conversion into microbial protein. Also, solid not fat was higher with cinnamon oil 0.8% than control. Total solids, ash and lactose contents were not significantly affected by treatments. Similar results were obtained by Spanghero *et al.* [17], who reported that essential oils supplementation to rations had increased the milk protein content while decreased the milk fat content compared with control.

Chemical Composition of Processed Cheese Spread: Chemical composition of processed cheese manufactured from Goat's milk fed essential oils are shown in Table (5). The chemical composition of processed cheese was not significantly affected by essential oils additive. Similar results are obtained by Mohamed *et al.* [18].

Table 4: Composition of Goat's milk with different essential oils (EO) additives

Items	Control	Cinnamon	Garlic	Ginger	Anise	clove	Juniper	±SE
Fat%	4.37[a]	4.17[b]	4.11[bc]	4.15[b]	4.15[b]	4.11[bc]	3.98[c]	0.020
Lactose%	4.82	5.12	5.02	5.03	4.88	4.90	4.85	0.030
Protein%	3.15[b]	3.52[a]	3.48[a]	3.57[a]	3.50[a]	3.47[a]	3.45[a]	0.024
TS%	12.95	13.67	13.48	13.83	13.53	13.48	13.44	0.101
SNF%	8.70[b]	9.50[a]	9.28[ab]	9.43[ab]	9.25[ab]	9.15[abc]	8.96[bc]	0.072
Ash%	0.903	0.902	0.898	0.897	0.903	0.895	0.892	0.002

[a,b,c] Means with different superscripts are significant (P<0.05) difference.

Table 5: Chemical composition of processed cheese manufactured from goat's milk fed essential oils

Items	Control	Cinnamon	Garlic	Ginger	Anise	Clove	Juniper	±SE
Total solids%	44.66	44.79	44.56	44.65	44.5	44.6	44.68	2.35
Fat/DM	50.38	50.23	50.44	50.39	50.56	50.44	50.35	3.56
Fat%	22.49	22.49	22.47	22.49	22.49	22.49	22.49	2.15
Protein%	12.27	12.31	12.28	12.22	12.3	12.25	12.29	1.25
Lactose%	5.95	5.95	5.95	6.0	6.0	5.95	6.0	1.12
Ash%	3.9	4.0	3.8	3.9	3.68	3.88	3.86	1.09
pH	5.76	5.77	5.76	5.76	5.75	5.75	5.76	0.59

Table 6: Fatty acids (g/100g fat) in processed cheese manufacture from Goat's milk fed essential oils

Fatty acids (g/100g FA)	Control	Cinnamon	Garlic	Ginger	Anise	clove	Juniper	±SE
TSFA	73.25	73.19	71.02	66.9	72.96	73.46	69.69	1.078
TUSFA	26.75	26.81	28.98	33.1	27.04	26.54	30.31	0.818
MUSFA	22.81[c]	21.24[c]	28.08[b]	32.22[a]	22.33[c]	20.20[c]	27.34[b]	1.003
PUSFA	3.94[b]	5.57[a]	0.90[c]	0.88[c]	4.71[ab]	6.34[a]	2.97[b]	0.484
N6/N3 ratio	14.5[a]	3.98[d]	9.00[b]	2.52[d]	2.05[d]	6.76[c]	2.46[d]	0.978
Total CLA	0.00[b]	0.37[a]	0.35[a]	0.29[a]	0.00[b]	0.00[b]	0.34[a]	0.033

[a,b,c] Means with different superscripts are significant (P<0.05) difference.

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.

Table 7: Physical properties of processed cheese manufactured from goat's milk fed essential oils fresh and during cold storage

Physical properties	Storage period	Control	Cinnamon	Garlic	Ginger	Anise	Clove	Juniper	±SE
Penterometer reading (mm)	Fresh	192	190	190	192	192	191	193	2.26
	1	189	188	189	190	189	189	188	2.20
	2	180	178	178	179	180	180	179	2.19
	3	169	170	170	171	169	170	171	2.17
Oil separation index	Fresh	33.33	32.66	33.33	33.66	31.66	30.66	30.33	1.02
	1	33.66	33.33	33.66	34.00	33.33	33.00	34.55	1.03
	2	34.66	35.00	35.66	36.00	35.00	34.66	35.00	1.05
	3	36.33	36.66	38.00	38.66	36.66	36.33	38.00	1.10
Melting index (mm)	Fresh	175	176	170	171	170	173	175	2.56
	1	168	170	166	169	168	168	169	2.89
	2	155	156	154	154	153	154	155	2.51
	3	149	152	149	148	149	149	150	2.54

Fatty Acid Composition in Processed Cheese Spread: Data in Table 6 illustrate fatty acid composition in processed cheese manufacture from Goat's milk fed essential oils. Ginger and Juniper oils supplemented to goats rations were decreased total saturated fatty acids (TSFA) and improved total unsaturated fatty acids (TUSFA) contents in process cheese. Mono unsaturated fatty acid (MUSFA) is the highest content in process cheese manufacture from goat's milk containing Ginger oil than other treatments whereas (MUSFA) is the lowest content in process cheese manufacture from goat's milk containing clove oil. There is a significant difference at

Table 8: Color properties of processed cheese manufacture from goat's milk fed essential oils

Color parameters	Storage period	Control	Cinnamon	Garlic	Ginger	Anise	Clove	Juniper	±SE
L	Fresh	89.87	89.89	89.92	89.88	89.89	89.87	89.82	1.02
	1	89.76	89.72	89.76	89.69	89.66	89.71	89.7	1.11
	2	89.59	89.51	89.62	89.5	89.54	89.55	89.61	1.14
	3	89.18	89.06	89.15	89.11	89.1	89.15	89.2	1.13
A	Fresh	-1.86	-1.87	-1.88	-1.87	-1.85	-1.87	-1.89	0.89
	1	-1.92	-1.93	-1.98	-1.95	-1.93	-1.96	-1.95	0.74
	2	-1.98	-2.01	-2.03	-2.06	-1.99	-1.98	-1.98	0.69
	3	-2.22	-2.28	-2.24	-2.29	-2.23	-2.22	-2.19	0.98
B	Fresh	23.93	23.92	23.89	23.9	23.91	23.93	23.9	1.09
	1	23.93	23.96	23.95	23.94	23.95	23.96	23.95	1.08
	2	23.99	23.98	23.99	23.96	23.96	23.99	23.98	1.11
	3	24.15	24.08	24.12	24.16	24.11	24.07	24.09	1.21

L: lightness (Black (0) to white (100)), a: redness (+) to greenness (-), b: yellowness (+) to blueness (-).

(P< 0.05) between all treatments polyunsaturated fatty acids (PUSFA) where the highest content in process cheese manufacture from goat's milk contains clove or Cinnamon oils. On the other hand, process cheese contain Garlic oil had the lowest content of (PUSFA). (C18: 3-N6) / (C18: 3-N3) fatty acids (N6/N3) ratio is the highest in control milk 14.5 followed by Garlic oil 9.0 and Clove oil 6.76 and the lowest with Cinnamon, Ginger, Anise and Juniper oils. Kholif *et al.* [14] reported, that Cinnamon supplementation significantly increased the proportion of N-3 (C18: 3-N3) and N-6 FA, (C18: 3-N6) but significantly decreased the N6/N3 ratio in milk fat and supplementation of essential oils changed the fatty acids profile of the milk fat so that the proportions of unsaturated fatty acid (USFA) were increased and (SFA) were decreased which a good indicator for healthy milk for consumers. Processed cheese fat rich in N3 fatty acids may improve the nutritive value of the human diet [19]. From the same table we indicate that N6/N3 ratio is less than 4 with Cinnamon, Ginger, Anise and Juniper oils. So, these treatments produce a healthy processed cheese for costumers. Conjugated linolenic Acid (CLA) proportion was increased with essential oils treatments and Cinnamon, Garlic, Juniper and Ginger oils treatment had the highest value. It is well documented that conjugated linolenic acid (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, improving immune function and altering body composition to treat obesity or build lean body mass [20].

Physical Properties of Processed Cheese Spread: Table 7 indicate the physical properties of processed cheese manufacture from goat's milk fed essential oils fresh and during cold storage (7°C) for 3 weeks. Process spread cheese manufactured from goat's milk fed Juniper oil had the highest (P>0.05) penetrometer reading (mm) than all treatments whereas process spread cheese manufacture from goat's milk fed on clove oil had the lowest (P>0.05) penetrometer reading (mm) compared with other treatments. The penetrometer reading (mm) decreased gradually during cold storage until 3 weeks in all treatments. The differences in the penetration values 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 [21, 22]. Data in Table 7 indicates the oil separation index in fresh cheese and during cold storage. Also, Table 7 shows that process cheese manufacture from Goat's milk fed Ginger had the highest (P>0.05) oil separation index, whereas the Juniper oil had the lowest (P>0.05) oil separation index in fresh cheese. This means that the curd of process cheese with Ginger is most soft than other treatments and this due to the type of oil. The oil separation index increased gradually during cold storage (7°C) until 3 weeks in all treatments. This result is in agreement with those obtained by Azzam [22], Hussein and Mohamed [23] and Mohamed *et al.* [18].

Data presented in Table 7 illustrates the melting index (mm) of processed cheese fresh and during cold storage (7°C). The process cheese manufactured from Goat's milk fed cinnamon oil had the highest(P>0.05) melting index than other treatments whereas processed cheese from Goat's milk fed Garlic and Anise oils had the lowest(P>0.05) melting index compared with other treatments. Melting index decreased gradually during cold storage (7°C) until 3 weeks in all treatments. These results are in agreement with Mohamed *et al.* [18]. The color properties of processed cheese manufacture from goat's milk fed essential oils are shown in Table 8, when fresh and during cold storage (7°C). It is clear that processed cheese from goat's milk fed Garlic oil had the highest

(P>0.05) lightness than other treatments and the lightness decreased gradually during cold storage (7°C) in all treatments while the intensity of green (α-value) is the highest (P>0.05) in process cheese manufactured from goat's milk fed Anise oil. The same trend of lightness is taken during cold storage (7°C). On the other hand control and process cheesed manufactured from goats milk fed control and clove oil had the highest (P>0.05) yellow than other treatment and it is increased during cold storage (7°C) until 3 weeks.

CONCLUSION

Processed cheese spread manufactured from Goat's milk fed with ginger and Juniper oils had the highest contents of unsaturated fatty acids. Supplementation of Cinnamon, Garlic, Ginger and Juniper oils could be used to improve conjugated linoleic acid and omega3 fatty acids in processed cheese fat. Under the conditions of the present study, these oils supplementation to dairy animals can contribute to improve the health properties of processed cheese and suggesting that its consumption benefits human health.

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