PROPERTIES OF MOZZARELLA CHEESE MADE FROM MILK OF GOATS FED DIETS SUPPLEMENTED WITH CARAWAY OR GARDEN CRESS SEEDS.

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SUMMARY

Nine lactating Baladi goats in early lactation were divided into three groups using 3x3 Latin square design for 30 days period. The control diet (1) consisted of berseem clover (B), as a source of roughage and concentrates (1:1, dry matter basis) (I). The two experimental diets were the same as control diet plus 5 g/d of caraway seeds (*Carum carvi*) (II) or plus 5 g/d of garden cress seeds (*Lepidium sativum)* (III). Individual milk samples were collected at the last three days of each period for analysis. Pooled milk from each period was used in the manufacture of Mozzarella cheese. Cheese samples were stored at refrigerator (4°C) for four weeks. Addition of Caraway and *Lepidium sativum* in the animal diet insignificantly increased milk yield but decreased milk pH value as compared to control milk. Feeding diet on *Lepidium sativum* significantly increased milk fat and decreased milk protein contents. Mozzarella cheese contents of fat and protein showed the same trend but the differences were not significant. Soluble nitrogen, soluble tyrosine and soluble tryptophan of Mozzarella cheese were not affected by treatments, while non protein nitrogen content and total volatile fatty acids (TVFA) were significantly increased by treatments compared to control cheese. Meltability was decreased significantly, and oiling off was significantly increased from milk of goats fed on caraway diet compared to other treatments. Mozzarella cheese flavor and texture were decreased with treated milk compared to control milk. Storage period significantly affected organoleptic properties ($P<0.01$) showing the greatest improvement after four weeks of storage

Keywords: *caraway, Lepidium sativum, goats, milk composition, Mozzarella cheese, storage period.*

INTRODUCTION

Global production of Mozzarella cheese has grown dramatically during the period 1985 to 2000 (Rowney *et al.,* 1999), especially in the United States, where annual production in 1996 was ~1.03 million tonne (Sørensen, 1997). The main impetus for the growth of Mozzarella has been the increased in the popularity of pizza, in which Mozzarella is a main ingredient. The functional attributes of importance in Mozzarella cheese for pizza include the desired degrees of flow and stringiness on baking. These cheeses

best endowed with these characteristics, especially stretchability, are members of the pasta filata group and include Mozzarella, Provolone, and Kashkaval (Fox *et al.*, 2000). In the manufacture of these cheeses, the curd (pH ~5.1 to 5.4) is subjected to a plasticization step towards the end of manufacture during which it is scalded (to ~57°C), kneaded, and stretched in hot (~80°C) water or dilute brine. The conditions of low pH and high temperature limit the aggregation of para-casein and the formation of para-casein fibers of relatively high tensile strength (Kimura *et al.*, 1992; Taneya *et al.*, 1992). These fibers impart stretchability, stringiness, and chewiness to the melted cheese topping when the cheeses are subsequently cooked on pizza (Fox *et al.*, 2000).

The functional attributes of Mozzarella cheese are influenced by many factors, including milk pretreatment, make procedure, manufacturing process, composition and proteolysis (Kindstedt, 1995; Madsen and Qvist, 1998).

Lepidium sativum L, commonly called garden cress, the seeds of which are claimed to possess varied medicinal properties like galactogogue. Also, seeds are useful in hiccup, dysentery, diarrhea and skin diseases caused by impurities and toxins in blood and chronic enlargements of spleen (Nadkarni and Nadkarni, 1954).

The caraway seeds (*Carum carvi L.*) are also used in cheeses and cheese spreads, sauerkraut and salad dressings. Liqueurs, such as Kummel and some schnapps, use caraway seed for their unique flavour. Caraway seeds are also high in protein and fat. The seed and teas made from the seed have an anti-spasmodic action, which soothes the digestive tract and its carminative (gas relieving) action relieves bloating caused by gas and improves the appetite (Laflamme *et al.*, 2008).

The objective of the current study was to investigate the use of milks produced from animals fed caraway seeds or *Lepidium sativum* on composition and properties of Mozzarella cheese.

MATERIALS AND METHODS

Caraway and *Lepidium sativum* seeds were obtained from El Harraz Market, Cairo, Egypt. Composition of Caraway and *Lepidium sativum* seeds are shown in Table 1.

Feeding trial:

Nine lactating Baladi goats in early lactation were divided into three groups for feeding trial using 3x3 Latin square design for 30 day periods. The control diet (I) consisted of Berseem clover (B) as a forage source and a concentrate feed mixture (CFM) fed in equal parts on a dry matter basis. The Berseem clover cut fresh and fed to animals immediately. The two experimental diets used were the same as control diet plus 5 g/d of caraway seeds (*Carum carvi L.*) (II) and control diet plus 5 g/d of garden cress *(Lepidium sativum)* seeds (III). Individual milk samples were collected at the last three days of each

period for analysis. Pooled milk from each period, was used in the manufacture of Mozzarella cheese.

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

Item	CFM	Berseem clover	Garden cress seeds	Caraway seeds
Dry matter	92.7	20.0	95.86	94.60
Organic matter	90.9	87.9	95.35	86.0
Protein	14.1	12.8	22.47	15.1
Fat	4.2	2.5	27.48	6.0
Crude fiber	15.1	28.2	7.01	9.80
Ash	9.1	12.1	4.65	14.0
NFE	57.5	44.4	38.39	55.1

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 mix 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 of vitamin A, 1200 IU/g of vitamin D, and 30 IU/g of vitamin E.

Milk samples, each period, were analyzed for milk fat, total solids (TS), and ash contents and titratable acidity as described by Ling (1963). Total nitrogen (TN) content was determined by Kjeldahl method IDF (1993). Lactose was determined by the method of Nickerson *et al.*, (1976). pH values was measured using digital pH meter (M41150, USA) equipped with glass electrodes.

Cheese manufacture:

Mozzarella cheese manufacture was done as described by Kosikowski (1982). Cheeses were stored at refrigerator (4°C) for four weeks and analyzed when fresh and after four weeks. All cheese samples were analyzed for total nitrogen, and soluble nitrogen (SN) contents by Kjeldahl method (IDF, 1993) as well as for fat, total solids (TS), ash and non protein nitrogen (NPN) contents, sodium chloride and titratable acidity as described by Ling (1963). The soluble tyrosine and tryptophan were determined spectrophotometrically according to the method of Vakaleris and Price (1959). Total phosphorus content was determined colorimetrically by molybedate hydrazine sulphate as described by IDF (1987). Calcium content was determined by the complexometric titration with EDTA as described by Roadsveld and Klomp (1971), while, total volatile fatty acids (TVFA) were determined as described by Kosikowski (1982).

Physical properties:

The Gerber fat test method described by Kindstedt and Fox (1991) was adopted for estimation of free oil in Mozzarella cheese using. Meltabilty was determined by using glass tubes as described by Olson and Price (1958). Rennet coagulation time (RCT) and curdling time (CT) of cheese milk were determined according to Al-Sawaf (1977). The

yield of Mozzarella cheese was calculated according to the formula given by Vandeweghe and Maubois (1987).

Sensory evaluation of cheese:

Cheese samples were judged by a panel taste of 15 staff members of the Dairy Science Department, National Research Center, Egypt. The cheese was scored for appearance (15 points), body and texture (35 points) and flavor (50 points) as suggested by ADSA (1987).

Statistical analysis:

Data were analyzed using the mixed model procedure of Statistical Analysis System (SAS, 1998) to account for effects of treatments and storage period. Complete random block design was applied for milk and cheese data using the following general linear model procedure:

$$Y_{ijk} = \mu + R_i + T_k + e_{ijk}.$$

Where Y_{ijk} is the parameter under analysis of the ijk milk, μ is the overall mean, R_i is the effect due to the storage period, T_k is the effect due to treatment, e_{ijk} is the experimental error for ijk on the observation.

The Duncan's multiple range tests was used to test the significance between means (Duncan, 1955).

RESULTS AND DISCUSSION

Milk yield and composition:

The yield and composition of milk used in mozzarella cheese manufacture is shown in Table 2. Milk yield was not significantly affected by treatment. Milk fat was higher ($P<0.01$) with *Lepidium sativum* compared with other treatments. In contrast, milk protein was lower ($P<0.05$) with *Lepidium sativum* compared with other treatments. Milk pH was significantly lower with experimental treatments compared with control. Other milk parameters were not affected by treatments.

Chemical Composition of Mozzarella cheese:

Data on the composition of the various cheeses are summarized in Table 3. The dry matter (DM) content of Mozzarella cheese made from treated milk (caraway and *Lepidium sativum*) was slightly higher than control milk. Cheese fat content was slightly higher while total protein content was slightly lower with *Lepidium sativum* than other treatments. Ca and P contents in mozzarella cheese were insignificantly higher with *Lepidium sativum* than other treatments. Other cheese constituents were not affected by treatments. The compositions of the DM (fat, protein, ash and salt contents relative to the DM) were not significantly different between the control and treated cheeses. The calcium and phosphorus contents or expressed on DM basis of Mozzarella cheese showed a slightly higher but not significant with caraway milk than other treatments. While, ash and salt contents of Mozzarella cheese were slightly higher with *Lepidium sativum* compared to

other treatments. From the forgoing results one can conclude that the composition of Mozzarella cheese was not affected by treatments.

Table (2): Chemical composition of milk used in Mozzarella manufacture.

Item	Treatments			± SE	Pro. > F
	Control	Caraway seeds	Garden cress seeds		
Milk yield (gm/d)	700.0	770.0	789.8	0.160	0.351
Fat %	2.40^{B}	2.42^{B}	2.62^{A}	0.146	0.009
Total protein %	3.47^{a}	3.39^{a}	3.13^{b}	0.063	0.020
Total solids %	10.65	10.58	10.74	0.194	0.890
Solids not fat %	8.25	8.56	8.12	0.153	0.469
Lactose %	4.17	4.10	4.29	0.123	0.818
Ash %	0.725	0.749	0.710	0.017	0.538
pH	6.77^{A}	6.61^{B}	6.67^{B}	0.021	0.005

^{a,b,} *means with different superscripts are significant (P<0.05) difference.*
^{A,B,} *means with different superscripts are significant (P<0.01) difference.*

Table (3): Effect of experimental treatments on Mozzarella cheese composition.

Item	Treatments			± SE	Pro. > F
	Control	Caraway seeds	Garden cress seeds		
Dry matter %	45.92	46.35	46.79	0.869	0.927
Fat %	10.60	10.00	13.53	1.106	0.233
Fat / DM	23.08	21.58	28.92	2.562	0.224
Total protein %	27.35	27.72	25.80	0.954	0.322
Total protein / DM	59.56	59.81	55.14	1.447	0.193
Ca %	0.594	0.606	0.581	0.008	0.404
Ca*100 / DM	1.29	1.31	1.24	0.033	0.722
P %	0.696	0.719	0.699	0.007	0.493
P*100 / DM	1.52	1.55	1.49	0.031	0.448
Ca / P	0.853	0.843	0.831	0.010	0.812
Ash %	2.80	2.79	2.82	0.015	0.690
Ash*100 / DM	6.10	6.02	6.03	0.124	0.958
Salt %	0.385	0.390	0.403	0.010	0.864
Salt*100 / DM	0.838	0.841	0.841	0.028	0.971

Nitrogenous fractions and TVFA:

Table (4) shows the nitrogenous fractions and TVFA's of Mozzarella cheese. It is evident that soluble nitrogen, non protein nitrogen, soluble tyrosine and soluble tryptophane were not significantly affected by experimental treatments. While, the storage period had highly significant effect on soluble nitrogen, non protein nitrogen, soluble tyrosine and soluble tryptophane contents of Mozzarella cheese. This trend coincided with an increase in the degree of proteolysis (Feeney *et al.*, 2002). The lower levels of intact casein in the cheese reflect the lower protein content and the higher degree of proteolysis

(Feeney *et al.*, 2002). These results are in line with the finding of El-Zoghby (1994) and Di-Matteo et al. (1982) who mentioned that soluble nitrogen gradually increased as time of storage advanced. The TVFA content of Mozzarella cheese was significantly higher with *Lepidium sativum* milk compared with other treatments (Table 3). The TVFA concentration of Mozzarella cheese increased with increasing of fat percent of the original milk used (Table 2). It could be seen that the TVFA content increased with advancing the storage time from 7.19 in fresh cheese to 23.53 ml/100gm cheese at 4th week. El-Abbassy et al. (1991) found similar results with Mozzarella cheese.

Table (4): Effect of experimental treatments and Storage time (weeks) on soluble nitrogen, non protein nitrogen, total volatile fatty acids, soluble tyrosine and soluble tryptophane of Mozzarella cheese.

Item	Treatments			± SE	Pro.> F
	Control	Caraway seeds	Garden cress seeds		
SN (mg/100g)	0.272	0.265	0.271	0.010	0.290
NPN (mg/100g)	0.126^{B}	0.132^{A}	0.130^{A}	0.004	0.007
ST (mg/100g)	27.51	27.51	27.50	4.815	0.650
STr (mg/100g)	18.23	18.24	18.23	3.191	0.787
TVFA (ml 0.1 NaoH/100g)	14.62^{B}	14.37^{B}	15.94^{A}	1.410	0.002
	Storage time (weeks)				
	0	2	4		
SN (mg/100g)	0216^{C}	0.265^{B}	0.326^{A}	0.020	0.0001
NPN (mg/100g)	0.106^{C}	0.127^{B}	0.157^{A}	0.009	0.0001
ST (mg/100g)	3.97^{C}	19.67^{B}	58.88^{A}	8.191	0.0001
STr (mg/100g)	2.18^{C}	13..69^{B}	38.83^{A}	6.231	0.0001
TVFA (ml 0.1 NaoH/100g)	7.19^{C}	14.40^{B}	23.53^{A}	3.140	0.0001

^{A,B} *means with different superscripts are significant (P<0.01) difference.*
SN = Soluble nitrogen, NPN = Non protein nitrogen, ST = Soluble tyrosine, STr = Soluble tryptophane

RCT, CT and cheese yield:

Data in Table (5) show that the cheese rennet coagulation time (RCT) of cheese milk recorded the lowest but not significant value with *Lepidium sativum* followed by caraway and then control. In the other hand, curdling time (CT) was higher but not significant with caraway followed by *Lepidium sativum* milk and then control. The cheese yields non-significantly increased when milk was treated with experimental additives. It is take the same trend of dry matter contents of cheese Table (2).

Acidity and pH:

Table (5) indicates that cheese made from milk produced from goats fed diets supplemented with *Lepidium sativum* showed the highest (P<0.05) acidity than cheese made from control milk, while, cheese made from milk produced from goats fed diets supplemented with caraway seeds milk was recorded the moderate value. The acidity of cheese gradually increased (P<0.01) during storage to reach its maximum after 4 weeks.

On contrast, pH value was not significantly affected by experimental additives, while, it's significantly decreased with storage period to reach the lowest value at 4 weeks. These results are in the line with that reported by Yun et al. (1992) with Mozzarella cheese. Generally, at pH values > ~5.4, it is more difficult to plasticize the curd (Kimura *et al.,* 1992); the curd becomes progressively less smooth and more lumpy with increasing pH. However, curd may be plasticized successfully at a higher pH (e.g., 5.6) and higher colloidal to soluble Ca ratio if the total concentration of Ca is lower than that in curd made by the traditional procedure, e.g., as in directly acidified Mozzarella, where the milk is setting at pH ~5.6 (Kindstedt and Guo, 1997a)., Guinee et al. (2002) found that pH of the cheese increased gradually during storage. The increase in pH during storage was noted by Guo et al. (1997) for full fat in Mozzarella cheeses made using a starter culture.

Table (5): Effect of experimental treatments and Storage time on meltability, oiling off and other properties of Mozzarella cheese.

tem	Treatments			± SE	Pro. > F
	Control	Caraway seeds	Garden cress seeds		
RCT (sec.)	114	104	92	6.668	0.519
CT (sec.)	120.5	140.3	127.0	11.59	0.834
Cheese yield (%)	11.0	11.4	12.1	0.358	0.547
Meltability (mm)	20.62^{a}	17.30^{b}	19.82^{a}	1.808	0.031
Oiling off (%)	71.02	67.31	71.74	3.325	0.108
Acidity (%)	1.005^{b}	1.032^{ab}	1.054^{a}	0.053	0.016
pH	5.22	5.24	5.22	0.016	0.130
	Storage time (weeks)				
	0	2	4		
Meltability (mm)	8.48^{C}	19.86^{B}	28.89^{A}	3.213	0.0001
Oiling off (%)	49.0^{C}	74.9^{B}	85.8^{A}	6.631	0.0001
Acidity (%)	0.684^{C}	1.145^{B}	1.273^{A}	0.105	0.0001
pH	5.30^{A}	5.25^{B}	5.13^{C}	0.031	0.001

^{a,b} *means with different superscripts are significant (P<0.05) difference.*
^{A,B,C} *means with different superscripts are significant (P<0.01) difference.*

Meltability:

Meltability is the capacity of cheese particles to flow together and from a uniform continuous melt. Table (5) shows that the meltability of Mozzarella cheese decreased (P<0.05) with milk produced from goats fed diets supplemented with caraway seeds compared to other milks. Also, meltability of Mozzarella cheese was increased by advanced of storage period from 8.18 at fresh to 28.89 mm at 4 weeks storage. These results are in accordance with those obtained by Yun et al. (1992) and Abd El-Gawad (1998). Furthermore, Patel et al. (1986) found that high cheese had slightly higher meltabilities which attributed to initially higher fat content in cheese milk resulting in cheese with low viscosity or with soft texture thus rendering it more meltable. There was a significant increase ($P<0.05$) in stretchability of pasta filata Mozzarella cheese from 7 to 14 d but no significant change was observed from 14 to 21 d (Kuo and Gunasekaran, 2003).

Proteolysis in Mozzarella cheese is a result of residual coagulant and milk plasmin hydrolyzing (Oberg *et al.*, 1992). Protein breakdown in Mozzarella cheese as a result of residual coagulant and milk plasmin breakdown of α_{s1}-casein and ß-casein (Tunick *et al.*, 1993) reduced cohesiveness and softened the body, thus increasing meltability (Oberg *et al.*, 1992). Accordingly, the effect of aging and tempering on the meltability of both frozen-stored pasta filata and nonpasta filata Mozzarella cheeses might be due to proteolysis of the protein matrix during refrigerated storage.

Oiling off:

The fat oiling off of Mozzarella cheese prepared from different experimental milks is presented in Table (5). It was clear that a direct relation was found between oiling off of cheese and fat content of original milk used in making cheese. Kindstedt (1995) reported that free oil increased with increasing cheese fat on dry matter basis. Storage of cheese for 4 weeks seemed to affect oiling off of Mozzarella cheese. The oiling off was increased from 49 at zero time (fresh) to 85.8 after 4weeks of storage. The amount of free oil released from the cheese increased with increasing storage period for 50 days at 4 °C but little changes were observed after two weeks (Yun *et al.*, 1993).

Organoleptic quality of Mozzarella cheese:

Summary of the sensory scores of Mozzarella cheese made from different experimental milks are showed in Table (6). Significant differences were observed in the appearance score of all cheeses while the scores of flavor and texture were significantly decreased with cheeses made from milks obtained from goats fed diets supplemented with caraway and *Lepidium sativum* compared to control milk. This decrease of flavor and texture may be due to the oil of caraway and *Lepidium sativum*. Also, total score take the same trend of flavor and texture scores. The flavor, texture and total scores were increased

Table (6): Organoleptic properties of Mozzarella cheese made from treated milk through storage time (weeks).

Item	Treatments			± SE	Pro. > F
	Control	Caraway seeds	Garden cress seeds		
Flavor	33.50^{A}	31.33^{B}	32.22^{B}	0.561	0.008
Texture	29.33^{a}	28.00^{b}	27.67^{b}	0.340	0.022
Appearance	10.83	10.33	10.00	0.206	0.325
Total	73.67^{A}	69.67^{B}	69.89^{B}	0.804	0.0003
	Storage time (weeks)				
	0	2	4		
Flavor	29.25^{C}	32.25^{B}	35.13^{A}	1.121	0.0001
Texture	26.88^{B}	27.88^{B}	29.88^{A}	0.693	0.0001
Appearance	11	10	10	0.413	0.109
Total	67.13^{C}	70.13^{B}	75.0^{A}	1.612	0.0001

^{a,b} *means with different superscripts are significant (P<0.05) difference.*
^{A,B,C} *means with different superscripts are significant (P<0.01) difference.*

($P<0.01$) with advanced of storage period of all cheeses. This increase can be attributed the proteolysis of the cheese curd. While, the storage period of Mozzarella cheese had insignificantly decrease on the appearance score. Abd El-Gawad (1998) reported similar results.

CONCLUSION

This study demonstrated that differences in cheese functional properties of Mozzarella cheese such as hardness, melt, and stretch were not affected by milks obtained from lactating goat's fed caraway or garden cress seeds. Also, Mozzarella cheese can be stored for 4 wk at 4°C to obtain good melt and stretch properties of the cheese.

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صفات جبن الموزاريللا المصنع من لبن الماعز المغذاة على علائق مضاف إليها بذور الكراوية أو بذور حب الرشاد

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تم استخدام ٩ حيوانات أنثى ماعز حلابة قسمت إلى ٣ مجموعات بنظام المربع اللاتينى ٣×٣ لمدة ٩٠ يوم (٣٠ يوم / مرحلة). حيث تغذت الحيوانات على العلائق التالية:

١- المجموعة الأولى (المقارنة): علف مركز ٥٠%+ برسيم أخضر ٥٠% (على أساس المادة الجافة %).

٢- المجموعة الثانية: عليقه المقارنة + ٥ جم مطحون بذور الكراوية / رأس/يوم.

٣- المجموعة الثالثة: عليقه المقارنة + ٥ جم مطحون بذور حب الرشاد / رأس/يوم.

وتم تجميع عينات اللبن فى آخر ٣ أيام من كل شهر وتم خلط عينات كل معاملة وتصنيع جبن المزاريللا منها وتم تخزينة لمدة ٤ أسابيع وكانت أهم النتائج المتحصل عليها كما يلى:

١- ارتفع إنتاج اللبن ارتفاعا غير معنويا بإضافة بذور الكراوية وحب الرشاد مقارنة بالمجموعة المقارنة. كما ارتفع دهن اللبن معنويا وانخفض بروتين اللبن غير معنويا بإضافة بذور حب الرشاد لعلائق الماعز الحلاب مقارنة بالمجموعة المقارنة.

٢- ارتفع محتوى جبن الموزاريللا من الدهن ارتفاعا غير معنويا وانخفض بروتين اللبن غير معنويا بإضافة بذور حب الرشاد لعلائق الماعز الحلاب مقارنة بالمجموعة المقارنة.

٣- لم يتأثر محتوى جبن الموزاريللا من النيتروجين الذائب و التيروزين الذائب والتربتوفان الذائب بإضافة بذور الكراوية أو حب الرشاد.

٤- ارتفع محتوى جبن الموزاريللا من النيتروجين غير البروتينى و الأحماض الدهنية الطيارة معنويا بإضافة بذور الكراوية أو حب الرشاد لعلائق الماعز الحلاب مقارنة بالمجموعة المقارنة.

٥- إضافة بذور الكراوية خفضت من المطاطية ومعدل التزييت فى جبن الموزاريللا مقارنة بالمعاملات الأخرى.

٦- فترة التخزين كان لها تأثيرا معنويا على جميع صفات جبن الموزاريللا وأوضحت النتائج أن التخزين لمدة ٤ أسابيع أعطى أقل النتائج.

ومن هذه النتائج يتضح أن إضافة مطحون بذور الكراوية أو حب الرشاد لعلائق الماعز الحلاب لم يكن لها تأثيرا كبيرا على صفات جبن الموزاريللا وأن أفضل فترات التخزين كانت عند ٤ أسابيع للحصول على أفضل صفات لجبن الموزاريللا.