J. Food and Dairy Sci., Mansoura Univ., Vol. 5 (8): 581 - 600, 2014

EFFECT OF USING CROSS - LINKED *B* - CYCLODEXTRIN ON PHYSIOCHEMICAL PROPERTIES OF DOMIATI GOAT'S CHEESE

Ibrahim, A. H. and K.A. Soryal
Department of Animal Breeding, Animal and Poultry Production Division,
Desert Research Center, Matareya, Cairo, Egypt
Correspondent Author: E-mail address (alaa.drc@gmail.com)

ABSTRACT

The present study was carried out to examine the physicochemical and sensory properties in cholesterol-reduced Domiati goat's cheese made by β-cyclodextrin (β-CD).The cholesterol reduction of experimental cheese reached 79.37% when cheese milk was treated with 1% β-CD (Trt A), while 90.09 % when separated cream was treated with 10% β-CD (Trt B).

The total amount of short-chain free fatty acids was significantly lower in both β-CD treated cheeses than in the control cheese during the storage period. Weight/Kg and yield % of cholesterol-reduced cheese treated by β-CD were higher than those produced in control with significant differences ($P < 0.05$) between (Trt B) and other two treatments during storage periods. In cheese treatments (Trt A) and (Trt B) group, a slightly lower amount of free amino acids was produced compared with that in the control, but no significant difference was found between control and (Trt A) group. In addition, the total amount of bitter amino acids was significantly ($P < 0.05$) lower in (Trt B) than in the control and (Trt A) groups throughout storage period. In sensory analysis, results indicated that most of the sensory properties of (Trt B) group cheese could be acceptable to consumers. The present study indicated the possibility of producing cholesterol-reduced Domiati cheese from goat milk by β-CD treatment, which showed similar physicochemical and sensory properties compared to the control cheese during the 8 weeks of ripening period.

Keywords: β-Cyclodextrin, Cholesterol removal, Domiati cheese, Goat cheese.

INTRODUCTION

Domiati cheese is the most popular soft white pickled cheese in Egypt and makes up about 75% of the cheese produced and consumed in that country (Zhang, *et al.,* 2003). Domiati cheese is mainly made from bufflos' milk, cows' milk, or a mixture of both, but it is also made from sheep or goat milk (Abou-Donia, 1986 and Ibrahim *et al.,* 1974).

Goat cheese now is a fashionable commodity in many countries but in Egypt, great numbers of citizens do not prefer it because of its aroma the 'goaty' flavour/odour. Goat milk has a different flavor from cow milk due to certain branched-chain fatty acids (BCFAs) esterified in the triacylglycerol's. These BCFAs are present in very low concentrations compared to the straight chain fatty acids (Ha and Lindsay, 1990; 1991 and 1993). The specific aroma "goaty" flavor of goat cheese has been well identified by different authors (Le Queré *et al.,* 1998; Engel *et al.,* 2002 and Carunchia-Whetstine *et al.,* 2003).

In goat cheeses, this characteristic flavor may be sought after by gourmets, but in whole milk the 'goaty' flavor limits market possibilities in Western societies habituated to the relatively flavorless cow milk. This limitation is particularly important where consumers are allergic or otherwise intolerant to cow milk but not goat milk (Haenlein, 2004).

While there are breeding and production options for reducing goat milk flavor (Chilliard *et al.,* 2003; Fedele *et al.,* 2005 and Park, 2008), many are already applied, and masking 'goaty' flavor with other flavors decreases product options. A different approach is to trap the free fatty acids, including BCFAs, in cyclodextrins (CDs) added to the milk or its products.

There are 3 common CDs, α, β, and γ, respectively, comprising 6, 7, and 8 glucose-molecule rings where the glucoses are linked α (1–4) as in amylose (Young *et al.,* 2012).

The core of these rings is hydrophobic. Substantially hydrophobic molecules of a suitable size, including fatty acids among a host of other compounds, can form inclusion complexes with CDs and thus be rendered nonvolatile (Duchˆene *et al.,* 2003; Del Valle 2004; Szente and Szejtli, 2004 and Astray *et al.,* 2009). Odor is a major component of flavor, so flavor intensity is reduced by rendering a compound nonvolatile.

On the other hand, most consumers are concerned about excessive intakes of cholesterol and fat in their daily diets because of the risk of coronary heart disease (Grundy *et al.,* 1982 and Gurr, 1992). There have been dramatic increases in no, low, and reduced-cholesterol products in the market place (Schroder and Baer, 1990).

Cheese is among the main sources of animal fat and dietary cholesterol. Even though cholesterol is essential for membrane structure, hormone and steroid biosynthesis (Mahann and Escott-Stump, 1996), it has been recognized that its elevated levels in plasma are directly correlated to increased cardiovascular heart diseases (Grundy, 1991).

Today there is a growing interest in the manufacture of cholesterol-reduced dairy products. Many methods for reducing cholesterol in foods have been developed, including blending in vegetable oils (Hariharan et al.,1995 and Krause *et al.,* 2007), extraction by distillation and crystallization (Arul *et al.,* 1988a,b), adsorption with digitonin and saponin (Micich, 1990 and Oh *et al.,* 1998), and removal of cholesterol by supercritical carbon dioxide extraction (Gonzalez-Hierro *et al.,* 1995 and Lim *et al.,* 1998).

Moreover, some methods require high investment and operation costs (Yen and Tsai, 1995 and Kwak *et al.,* 2002). Research studies showed that cholesterol can be removed from milk and dairy products, egg yolk, lard, by using β-cyclodextrin (β-CD) (Yen and Tsai, 1995; Krause *et al.,* 2007; Lee *et al.,* 2007 and Seon *et al.,* 2009).

Beta-cyclodextrins (β-CDs) have been used to effectively remove cholesterol from animal products and improving their nutritional characteristics (Han *et al.,* 2008). Among the studied foods are milk (Alonso *et al.,* 2009; Kim, *et al.,* 2004 and Kwak *et al.,* 2004), butter (Kim, *et al.,* 2006), cream (Han, *et al.,* 2007 and Shim, *et al.,* 2003), cheese (Bae, *et al.,* 2008; Han *et al.,* 2008 and Kim, *et al.,* 2005) .

However, Domiati goat's cheese physiochemical have been reported very few despite their importance. Further no information is available on the effect of cholesterol removal by β -CD with regard to physiochemical and sensory characteristics of Domiati goat's cheese.

The objective of the present study was to more fully explore the potential of CDs to reduce goat cheese cholesterol and flavor intensities during the 8 week storage.

MATERIALS AND METHODS

MATERIALS:

Raw Barki goat's milk was obtained from the animal breeding herd at Maryout-Research Station, Desert Research Center, located at 35km south-west of Alexandria, Egypt. β -CD and cholesterol were purchased from Sigma Chemicals Co. (Sigma-Aldrich Co. LLC. - St. Louis, MO, USA).

Milk treatment:

Milks for Domiati goat's cheese manufacture were prepared for 3 different treatments as:

1)-Control (milk no β-CD treatment).

2)-Treatment A (Trt A): milk treated with 1% β-CD.

3)-Treatment B (Trt B): after cream separation, cream was treated with 10% β-CD, and mixed with skim milk at 680 psi.

Milk for (Trt A) was placed in a 10 L container, and 1.0% (w/v) β-cyclodextrin was added. The mixture was stirred at 800 rpm with a laboratory blender (Explosion Proof Blender 8018- Paul N. Gardner Co., Inc.) in a temperature controlled water bath at 4°C for 10 min. The mixture was centrifuged (Sorvall™ - RC 12BP Plus - Thermo Fisher Scientific Inc.) with 166×g for 10 min (Lee *et al.,* 1999). For (Trt B), raw milk was separated from cream to skim milk. The cream containing 30% milk fat was treated with 10% β-CD (Kwak and Ahn 1999). Then, cream was standardized to 3.7% milk fat for cream cheese milk and mixed with remaining skim milk with homogenized pressure with 680 psi pressure at 70°C (Kwak *et al.,* 2001). Each treatment was centrifuged with 166×g for 10 min at 4°C to remove of β-CD. All treatments were run in triplicate.

Manufacture of Domiati cheese:

White brined Domiati cheese was made from goat's milk (total solids 12.74±0.04 %, total protein 3.4±0.02%, fat 3.7±0.1%, lactose 4.8±0.15%, ash 0.84±0.02% and pH 6.8±0.06). Domiati cheese was made similar to the method of Domiati cheese produced according to (Abou-Donia, 1986) with some modifications as:

The cheese milk was standardized for 3.7% milk fat, and salted with food grad salt at 4% (w/w), then pasteurized at 72°C for 15 s. and cooled to 38°C. Starter culture of *Lactobacillus delbruekii spp. bulgaricus* DSMZ 20080 and *Streptococcus thermophillus* ATCC 19258 was added to the milk (10 kg) in each treatment with the percentage of starter culture (1%, v/v), followed by

$CaCl_2$ 0.03%. Liquid calf rennet (single strength) obtained from local market (Domiat city) was added to the milk at a rate of 1.5 mL kg^{-1} milk and mixed thoroughly. The milk was set at 40 °C to coagulate for 3 h. Curd was scooped into cheese cloth and drained for 1 day in the cooler at 5°C; cheese was taken out of the cheese cloth and weighed. The cheese was cut into small blocks and pickled in the whey solution (6 % salt) in plastic containers kept in the cooler at 4°C for 8 weeks. Samples of cheese were taken for sensory evaluation and chemical analyses when fresh and after 2, 4, 6 and 8 weeks of ripening period. Each batch of cheese making was triplicated.

Cheese yield:

Cheese yield was calculated as the weight of cheese×100/weight of milk. Recovery of components (protein, fat, and milk total solids) was calculated as the weight of the component in the cheese divided by the original weight of the component in the milk expressed as a percentage.

Chemical Composition of Cheese:

Moisture, total solids (TS), Fat, total protein (TP), Ash % content and titratable acidity (TA) were determined according to the method described by Association of Official Analytical Chemists, (AOAC, 1984). Salt content was determined by the Volhard method as described by (Bartels et al.,1987).The amount of salt was calculated according the following equation (1.0ml N/20 $AgNo_3$ solution = 0.002923g NaCl). The pH of cheese sample was measured using a digital pH meter (accumet-model 15).

Extraction and determination of cholesterol:

For the extraction of cholesterol, (1g) of cheese sample was placed in a screw-capped glass tube (15 mm × 180 mm), and 500 µL of 5α-cholestane (1 mg/mL) was added as an internal standard. The sample was saponified at 60°C for 30 min with 5 mL of 2 M ethanolic potassium hydroxide solution. After cooling to room temperature, cholesterol was extracted with 5 mL of hexane. The process was repeated 4 times. The hexane layers were transferred to a round-bottomed flask and dried under vacuum. The extract was re-dissolved in 1 mL of hexane and was stored at −20°C until analysis (Adams *et al.,* 1986).

Total cholesterol was determined on a silica fused capillary column (HP-5, 30 m × 0.32 mm inner diameter×0.25 µm thickness) using Hewlett-Packard 5890A gas chromatograph (Palo Alto, CA) equipped with a flame-ionization detector. The temperatures of the injector and detector were 270 and 300°C, respectively.

The oven temperatures were programmed to increase from 200 to 300°C at 10°C/min and hold for 20 min at 300°C. Nitrogen was used as a carrier gas at a flow rate of 2 mL/min with a split ratio of 1/50. Quantitation of cholesterol was done by comparing the peak areas with a response of an internal standard. Cholesterol determination for the control was averaged with each batch of treatments. The percentage of cholesterol reduction was calculated as follows:

$$\text{Cholesterol reduction} = \left(\frac{\text{amount of cholesterol in } \beta\text{-CD treated cheese milk x 100}}{\text{amount of cholesterol in untreated milk (control)}} \right)$$

Determination of short-chain free fatty acids (FFAs):

Cheese samples (1g) were prepared periodically from the cheeses ripened for 0, 2, 4, 6 and 8 weeks and extracted with diethylether and hexane for 2 h and eluted through a 10 mm i.d. glass column containing neutral alumina as described by (Kwak *et al.,* 1990). A Hewlett-Packard Model 5,880A GC equipped with a flame ionization detector was used. The preparation of FFA was achieved using a 15 m×0.53 mm i.d. Nukol fused-silica capillary column (Supleco Inc., Bellefonte, PA, USA). The GC was operated with helium carrier gas at 37 ml/min, hydrogen gas 37 ml/min, and air at 300 ml/min. The column oven was programmed for an initial holding for 1min at 110 °C, heating to 180 °C for 10 min, and holding for 20 min. Both temperatures for injector and detector were 250°C. All quantitative analyses were done by relating each peak area of individual FFA to the peak area of tridecanoic acid as an internal standard. Each FFA was identified by the retention time of standard.

Analysis of free amino acids (FAAs):

The extraction of free amino acids was carried out as described by (Fresno *et al.,* 1997) .The identification and quantification of amino acids by HPLC techniques were determined according to the method of (Kuchroo and Fox, 1982). The liquid chromatography equipment consisted of a Waters 2690 quaternary pump (Milford, MA, USA) with auto sampler, a Spectra-Physics SP 8792 column heater (San Jose´, CA, USA), a Waters 996 Photodiode array UV/Visible detector, and a software package Millenium 32 chromatography manager as integrator. The column used was a symmetry C18 (5 mm particles; 4.6 × 250 mm; Waters, Mildford, MA, USA) reversed phase type. The temperature was controlled at 50°C. A gradient with two solvents was used to run the sample: solution A comprised 70 mM sodium acetate adjusted to pH 6.55 with acetic acid and added containing 2.5% acetonitrile and solution B was 45% acetonitrile, 40% water and 15% methanol. Before each injection, the column was equilibrated with solvent A for 2 min.

Sensory evaluation:

Samples of Domiati cheese were cut into approximately 5×5 cm pieces and placed on white plates. Samples were tempered at ambient temperature (20±2 °C) and then presented to the panelists in a random order. The cheeses were evaluated by 10 a panel of Desert Research Center; staff research members who are familiar with Domiati cheese .The cheese samples were organoleptically scored using score card for taste & flavor (50 points), body and texture (35 points) and appearance & color 15 points). Panelists were also instructed to report any defects they notice in appearance, texture and flavor (Nelson and Trout, 1981).

Statistical analysis:

Statistical analysis for experimental data was analyzed as completely randomized design. The obtained data were carried out according to the SPSS package (SPSS, 2012). Differences were considered significant at ($P<0.05$).

RESULTS AND DISCUSSION

Table1. Means of cholesterol-reduced goat's milk cheese treated by (β-CD) compared to control goat's cheese.

Component	Control[*1]	Trt A[*2]	Trt B[*3]
Cholesterol removal (%)	-	79.37	90.09
Cholesterol (mg/100 g cheese)	87.9±1.78	18.13±0.47	8.73±0.15

[*1]**Milk was not treated with β-CD.** [*2]**Milk treated with 1% β-CD.**
[*3]**After cream separation, cream was treated with 10% β-CD powder and blended with skim milk.**

Cholesterol removal:

Data presented in Table (1) showed that the cholesterol content of the control goat's milk cheese was 87.9±1.78 mg/100 g. The cholesterol removal of experimental cheese reached 79.37% when cheese milk was treated with 1% β-CD (Trt A), while 90.09 % when separated cream was treated with 10% β-CD powder (Trt B).This result was in full agreement with work conducted by (Kim et al. 2005; 2006; 2008 and Han *et al.,* 2007), they reported the optimum concentration of β-CD to be (10 %, w/v) for cholesterol removal from commercial cream (36% milk fat).

A similar study (Micich, 1990 and Oh *et al.,* 1998) appears that 1% β-CD may be sufficient to remove greater than 80% of cholesterol from milk. These authors have suggested that an excess of β-CD could compete with itself to bind to cholesterol molecules, resulting in reduced cholesterol adsorption. (Oakenfull and Sihdu, 1991) reported that addition of 1% β-CD to milk resulted in a reduction of cholesterol by 77.1% with 10 min of mixing at 4°C. In our laboratory, 90.09% of cholesterol has been successfully removed with 10% β-CD from cream containing 30% milk fat.

Chemical composition of the cheese:

The mean data of chemical composition of cholesterol-reduced goat's milk cheese compared to the control goat's milk cheese during the ripening period are presented in Table 2. The results indicated that cholesterol-reduced goat's milk cheese treated by β-CD revealed higher moisture than control cheese. The moisture content slightly decreased in all cheese types throughout the storage period. The (Trt B) cheese had higher moisture content, 63.25±0.87% than that in the control, 61.11±0.09% and (Trt A) cheese, 62.31±1.25%, with non-significant difference ($P < 0.05$) during the ripening period. All the experimental cheeses were in the range of the Egyptian Standard, (2005) for soft white cheeses.

2

Kwak *et al.,* 2002; Kim *et al.,* 2005, 2008; Han *et al.,* 2007 and Bae *et al.,* 2008), reported that the stirring with β-CD resulted in higher water retention and slower whey drainage in cholesterol-reduced cheese products. Also, the lower fat content of the cholesterol-reduced cheese than the control was expected since more fat would be released due to the smaller size of fat globules resulting from stirring or the fat globules were too small to incorporate within the casein or the protein compound via a fat–protein network.

The present results were in agreement with that of Metzger and Mistry, (1994) they reported that increased the moisture in cheese treatment with β-CD which resulted from slow curd drainage. In addition, β-CD treatment may increase the incorporation of casein or other protein compounds via fat-protein network. Also, homogenization of milk increased cheese moisture, as result of the slow curd drainage in reduced-fat Cheddar cheese.

On the other hand, the Fat/ Dry matter and TP/ Dry matter % were slightly lower in β-CD cheeses treated than in control cheese, and slightly increased during storage period as result of the increased moisture content. Similar results were reported (Fahmy and Hanafy, 1992; Abd-El-Kader *et al.,* 2001, Mehanna *et al.,* 2002 and Salama, 2004). These changes coincided with changes in cheese moisture content obtained by Kandeel *et al.,* (1991) and Ahmed and Abdel–Razig, (1998).

The lower fat content of the cholesterol-reduced cheese than the control might be attainted to the less incorporation with casein via a fat-protein network probably due to modification of casein matrix by β-CD (Kim *et al.,* 2005, 2008 and Han *et al.,* 2007).

Slightly increased in salt contents in all treatment cheese with non-significant difference ($P < 0.05$) was found during the ripening period, because of the diffsion of salt from cheese surfaces into the center where samples were taken for these determinations. These findings of salt content were in harmony with those obtained by (Shehata *et al.,* 2001 and Mehanna *et al.,* 2002).

The pH of the cholesterol-reduced goat's cheese was slightly decreased during the ripening period and lowers than that in the control goat's cheese with significant difference ($P < 0.05$). The obtained results were in agreement with those obtained by Magdoub et al.,(1995), they reported that the decrease in pH values might be attributed to the convert of residual lactose in cheese into lactic acid and free fatty acids developed in the cheese at the end of storage period. Also, the decreased in pH values may be due to the short chain fatty acids which produced in varying quantities as metabolic end product of the probiotic bacteria (Fooks et al.,1999). The pH of all aged cheese was in the normal range of Domiati cheese (Abd El-Salam *et al.,* 1993).

Mehanna *et al.,* 2002 and Elewa *et al.,* 2009, reported that the development of acidity during the refrigeration period as a direct response for converting the residual lactose in cheese into lactic acid by the available micro-flora.

Table 3. Mean cheese yield and recovery of fat, protein and milk total solids % of cholesterol-reduced goat's milk cheese treated by β-CD compared to the control goat's milk cheese during storage period at 4±1°C.

Treatments	Storage period (wk)	Cheese weight/ Kg	Yield %	Fat Recovery%	Protein Recovery%	Solids Recovery%
Control[*1]	Fresh	1.93^{abc}±0.01	19.27^{abc}±0.06	76.20^{ab}±2.40	79.33^{a}±0.89	58.81^{a}±0.29
	2 weeks	1.86^{bcde}±0.02	18.66^{bcde}±0.15	77.16^{a}±2.44	77.72^{a}±1.66	59.15^{a}±1.14
	4 weeks	1.83^{cdef}±0.01	18.30^{cdef}±0.14	77.14^{a}±1.42	77.12^{a}±1.07	58.65^{a}±0.88
	6 weeks	1.80^{def}±0.02	17.97^{def}±0.19	77.05^{a}±1.09	76.61^{a}±1.97	57.85^{a}±1.01
	8 weeks	1.77^{ef}±0.02	17.68^{ef}±0.21	77.28^{a}±1.64	80.79^{a}±0.73	57.31^{a}±0.45
Trt A[*2]	Fresh	1.93^{ab}±0.02	19.33^{ab}±0.15	69.32^{c}±0.67	76.77^{a}±0.61	57.19^{a}±1.46
	2 weeks	1.87^{bcde}±0.01	18.71^{bcde}±0.10	69.97^{c}±0.90	77.61^{a}±1.48	57.40^{a}±3.28
	4 weeks	1.83^{cdef}±0.01	18.31^{cdef}±0.05	71.91^{bc}±0.10	79.34^{a}±1.34	58.48^{a}±3.29
	6 weeks	1.80^{def}±0.01	17.94^{def}±0.04	72.07^{bc}±0.45	78.78^{a}±0.80	57.63^{a}±1.17
	8 weeks	1.76^{f}±0.01	17.61^{f}±0.01	72.81^{bc}±1.67	79.06^{a}±1.06	57.54^{a}±1.40
Trt B[*3]	Fresh	1.99^{a}±0.10	19.87^{a}±1.03	70.51^{c}±3.42	78.90^{a}±5.82	57.27^{a}±2.24
	2 weeks	1.92^{abc}±0.10	19.23^{abc}±0.94	71.38^{c}±3.78	78.05^{a}±3.82	56.50^{a}±1.82
	4 weeks	1.88^{bcd}±0.09	18.81^{bcd}±0.87	72.54^{bc}±3.56	79.48^{a}±3.57	57.44^{a}±2.70
	6 weeks	1.84^{bcdef}±0.08	18.43^{bcdef}±0.84	72.54^{bc}±3.02	78.78^{a}±3.88	56.88^{a}±1.71
	8 weeks	1.81^{def}±0.08	18.09^{def}±0.79	72.84^{bc}±3.06	78.06^{a}±4.39	56.26^{a}±4.01

a.b.c: Means within a column with different letters differ significantly (*P* < 0.05).
[*1] Milk was not treated with β-CD. [*2] Milk treated with 1% β-CD.
[*3] After cream separation, cream was treated with 10% β-CD powder and blended with skim milk.

Data presented in Table (3) showed the mean cheese yield and recovery of fat, protein and milk total solids % of cholesterol-reduced goat's milk cheese treated by β-CD during storage at 4±1°C for 8 wk. The cheese weight/Kg and yield % decreased in all cheese treatments throughout the storage period, which mainly due to losses in moisture content of cheese during ripening (Nasr *et al.,* 1991, El-Neshway *et al.,* 1995, El-Shibiny *et al.,* 1998 and El-Sisey, 2002). On the other hand, (Trt A) and (Trt B) goat's milk cheese weight/Kg and Yield % were slightly higher than those produced in control cheese with significant differences ($P < 0.05$) at the end of the storage periods.

In all cheese, total solids recovery % had similar values among treatments and during storage period.

The fat and protein recovery % slightly increased in all cheese treatments during the storage period with significant differences ($P < 0.05$) in control fresh cheese compared to the reduced evaluated goat's milk cheese groups this could be partially due to a lower fat content in (Trt A) and (Trt B).
The fat recovery % of cholesterol-reduced goat's milk cheese in this study was lower than those of industrial scale cow's milk cheeses (ranging from 85 to 91%).This observation might be resulted from smaller fat globules in goat milk (Phelan, 1981). Protein recovery % of cholesterol-reduced goat's milk cheese was higher than those reported for cow milk cheeses (74–77%). (Abou-Donia, 1986) explained that by the effect of factors such as milk

composition, addition of salt, pasteurization of milk, milk concentration, and addition of starter, affect the yield of Domiati cheese (**Callanan,1991**).

Table 4. Concentration of Volatile short-chain free fatty acids (FFA) in cholesterol-reduced goat's milk cheese treated by β-CD compared to the control goat's milk cheese during storage period at 4±1°C.

Treatments	Storage period (wk.)	Short-chain FFA concentration mg/100g fat				
		C 4	C 6	C 8	C 10	Total
Control[*1]	Fresh	1.85^{d}±0.07	2.85^{g}±0.07	3.10^{fg}±0.01	17.50^{hi}±0.71	25.30^{g}±0.85
	2 weeks	1.95^{d}±0.07	3.10^{f}±0.01	3.25^{f}±0.07	22.00^{ef}±1.41	30.30^{ef}±1.56
	4 weeks	2.15^{c}±0.07	3.40d^{e}±0.01	3.60^{e}±0.01	25.00^{d}±1.41	34.15^{cd}±1.48
	6 weeks	2.45^{b}±0.07	4.25^{b}±0.07	4.15^{c}±0.07	28.50^{b}±0.71	39.35^{b}±0.78
	8 weeks	3.15^{a}±0.07	4.70^{a}±0.14	5.30^{a}±0.14	33.50^{a}±0.71	46.65^{a}±0.35
Trt A[*2]	Fresh	1.45^{f}±0.07	2.35^{ij}±0.07	2.65^{jk}±0.07	13.50^{ik}±0.71	19.95^{i}±0.78
	2 weeks	1.65^{e}±0.07	2.65^{gh}±0.07	2.90^{hi}±0.01	18.50^{gh}±0.71	25.70^{g}±0.85
	4 weeks	1.85^{d}±0.07	3.10^{f}±0.14	3.50^{e}±0.01	22.00^{ef}±1.41	30.45^{ef}±1.48
	6 weeks	1.95^{d}±0.07	3.45^{de}±0.07	4.00^{cd}±0.14	23.00^{de}±1.41	32.40^{de}±1.13
	8 weeks	2.20^{c}±0.00	3.75^{c}±0.07	4.50$_{b}$±0.14	25.00^{c}±1.41	35.45^{c}±1.63
Trt B[*3]	Fresh	1.25^{g}±0.07	2.15^{j}±0.07	2.55^{k}±0.07	13.00^{k}±0.01	18.95^{i}±0.07
	2 weeks	1.40^{f}±0.01	2.55^{hi}±0.07	2.75^{ij}±0.07	15.50^{ij}±0.71	22.20^{h}±0.71
	4 weeks	1.60^{e}±0.01	2.70^{gh}±0.14	2.95^{gh}±0.07	18.50^{gh}±0.71	25.75^{g}±0.92
	6 weeks	1.70^{e}±0.01	3.25^{ef}±0.21	3.45^{e}±0.07	20.50^{fg}±0.71	28.90^{f}±0.42
	8 weeks	1.85^{d}±0.07	3.55^{cd}±0.07	3.85^{d}±0.07	22.00^{ef}±0.01	31.25^{e}±0.07

[a.b.c:] **Means within a column with different letters differ significantly (*P* < 0.05).**
[*1] **Milk was not treated with β-CD.** [*2] **Milk treated with 1% β-CD.**
[*3] **After cream separation, cream was treated with 10% β-CD powder and blended with skim milk.**

Production of Volatile short-chain free fatty acids (FFA):

It is well known that volatile short-chain FFAs (C4 through C10) are primarily responsible for cheese flavours (**Lin and Jeon, 1987**). Therefore, the short-chain FFAs in the cholesterol-reduced cheese were considered to be an important aspect of the present study. The concentration of short-chain FFAs in the control and cholesterol-reduced cheese ripened for 8 weeks is shown in Table 4.

Results indicated that the (Trt A) and (Trt B) cheeses had lower concentration of short-chain FFAs during the storage period. Higher amounts of butyric acid (C4), caproic acid (C6), caprylic acid (C8) and capric acid (C10) were released in control than in (Trt A) and (Trt B) cheeses respectively at the end of storage period.

The release of capric acid (C10) mostly contributed to the increase of total amount of FFAs in all groups. In the control, the amount of total short-chain FFAs increased during storage period from 25.30±0.85 to 46.65±0.35 mg/100g fat, while it increased from 19.95±0.78 to 35.45±1.63 mg/100g for (Trt A) and from18.95±0.07 to 31.25±0.07 mg/100g for (Trt B) cheeses.

The above results indicated that the (Trt B) cheeses ripened might slower than those in other groups control and (Trt A) cheeses. Results were in agreement with the finding by (Kim,et al.,2004).

The total amount of short-chain FFAs was significantly lower in (Trt A) and (Trt B) fresh cheeses than in the control fresh cheese during storage period ($P < 0.05$).

Similar results were reported by (Han *et al.,* 2008). The reason why the short-chain FFA release was lower in experimental cheese could be partially due to a lower fat content in (Trt A) and (Trt B) cheeses as 38.50±1.27 % and 36.36±2.60 % of milk fat, respectively, than in control cheese 39.26±0.57 %.

Production of free amino acids (FAA):

The concentration of free amino acids (FAA) in cholesterol-reduced Domiati cheese by β-CD during storage period at 4°C for 8 weeks was shown in Table 5. The Domiati cheese made by β-CD produced much lower amounts of individual FAAs than the control cheese in all storage periods. Free amino acids increased sharply in all cheese treatments during storage period. Total amount of FAA was 54.32±0.11mg/100g in the control cheese, 51.29±0.15 mg/100g and 44.83±0.07 mg/100g in (Trt A) and (Trt B) cheeses after 8 weeks during storage period respectively.

The statistical analysis indicated that there was significant difference ($P < 0.05$) between control and (Trt B) cheese, while no significant difference ($P < 0.05$) between control and (Trt A) cheeses. On the other hand, the amount of individual amino acids produced, Asp, Glu, thr, Pro, Sys and Lys dominated in all samples and the amount of Asp, Glu and Sys were the highest in all treatments during storage periods respectively.

In addition, the total amount of bitter amino acids was lower in (Trt B) cheese than in the control and (Trt A) cheeses ($P < 0.05$) throughout storage period. The highest concentration was found in the control cheese 14.04±0.01 mg/100g, while the lowest concentration was in (Trt B) cheese as 11.45±0.01 mg/100g cheese.

Results suggested that the cheese treatment (Trt A) kept the amino acid concentration similar to control cheese during ripening period. Also, results indicated that less amount of FAA in the β-CD cheeses was found and it is probably due to the modification of casein matrix by β-CD treatment (Han *et al.,* 2008). Similar results were reported by (Bae *et al.,* 2008 and 2009) in cholesterol-reduced Camembert cheese and feta cheese were showed a slightly lower amount of FAAs in cholesterol-reduced cheese compared with the control cheese, although it was not significantly different ($P < 0.05$).

5

Table 6. Sensory characteristics of cholesterol-reduced goat's milk cheese treated by β-CD compared to the control goat's milk cheese during storage period at 4±1°C.

Treatments	Storage period (wk)	Taste & Flavours (50 points)	Body & text. (35 points)	Appearance & color (15 points)	Total scores %
Control*1	Fresh	38.2^{h}±0.75	28.8^{cde}±1.94	11.5^{abc}±0.55	78.5^{hi}±2.26
	2 weeks	40.7^{fg}±1.03	29.8^{bcd}±1.83	11.7^{abc}±0.82	82.2^{ef}±0.98
	4 weeks	41.2^{efg}±1.47	30.7^{abc}±1.37	11.8^{abc}±0.75	83.7^{de}±2.07
	6 weeks	42.2^{ef}±1.17	31.2^{ab}±1.72	11.8^{abc}±0.75	85.2^{cd}±1.72
	8 weeks	42.7^{de}±1.63	32.0^{a}±1.26	11.8^{abc}±0.41	86.5^{bc}±1.87
Trt A*2	Fresh	40.5^{g}±0.84	26.2^{i}±1.47	10.8^{c}±0.75	77.5^{i}±1.52
	2 weeks	41.0^{fg}±1.26	27.8^{ef}±1.60	11.0^{bc}±0.63	79.8^{gh}±2.14
	4 weeks	41.7^{efg}±1.03	28.2^{de}±0.75	11.2^{abc}±0.75	81.0^{fg}±1.41
	6 weeks	42.2^{ef}±1.17	29.0^{cde}±0.02	11.3^{abc}±0.82	82.5^{ef}±1.05
	8 weeks	44.3^{bc}±1.63	29.8^{bcd}±0.98	11.5^{abc}±1.05	85.7^{cd}±1.63
Trt B*3	fresh	41.3^{efg}±0.52	27.8^{ef}±0.75	11.2^{abc}±0.98	80.3^{fgh}±1.21
	2 weeks	43.8^{cd}±0.75	28.5^{de}±1.38	11.3^{abc}±1.21	83.7^{de}±1.97
	4 weeks	44.7^{abc}±1.37	29.5^{bcde}±1.05	11.5^{abc}±0.55	85.7^{cd}±0.82
	6 weeks	45.3^{ab}±1.51	30.7^{abc}±1.97	12.0^{ab}±0.63	88.0^{ab}±3.16
	8 weeks	45.8^{a}±0.98	31.3^{ab}±1.37	12.2^{a}±0.41	89.3^{a}±1.63

a.b.c: Means in the same column with different letters differ significantly (P < 0.05).
***1 Milk was not treated with β-CD. *2 Milk treated with 1% β-CD.**
***3 After cream separation, cream was treated with 10% β-CD powder and blended with skim milk.**

Sensory evaluation:

The sensory attributes of experimental cholesterol-reduced Domiati cheese stored at 4°C for 8 weeks were shown in Table 6. From 0 to 8 weeks, Taste & Flavours, Body & texture, Appearance & color and Total scores increased steadily in all cheeses throughout storage periods.

For cholesterol-reduced Domiati cheese Taste & Flavours, (Trt A) and (Trt B) cheeses showed a similar increasing trend during storage period, while the flavor development in control did not reach the scores of (Trt A) and (Trt B) cheeses. Results were in agreement with the finding of Kim, *et al.,* (2004).

The larger increase in total and individual amino acids, including bitter amino acids, observed through the ripening period may reflect greater peptidase activity in the cholesterol-reduced cheese . Proteolysis in cheese during ripening results in an increase in peptides, which is directly related to bitterness (Fernandez-Espla and Fox, 1998 and Smit *et al.,* 2000).

Texture characteristics of control cheese was slightly higher than that of the (Trt B) cheese while was significant higher ($P < 0.05$) than that of the (Trt A) cheese. Little significant differences ($P < 0.05$) was found between control and (Trt B) cheese throughout storage periods for Appearance and color.

Total scores in (Trt B) cheese were significantly higher, compared to that of control cheese especially at 8 weeks storage. These data indicated that β-CD-treated (Trt B) cheese may maintain longer the early stage of overall quality of cholesterol-reduced Domiati cheese than other groups.

In conclusion, the present study showed that β-CD-treated (Trt B) cheese was an effective process for cholesterol removal in cheese making. In addition, the ripening during storage may be decelerated in cholesterol-reduced Domiati cheese made from β-CD-treated, which may provide a longer shelf-life like a newly made cheese in chemical and sensory aspects. The present results indicated that most of the sensory properties of (Trt B) β-CD-treated cheese could be acceptable to consumers. In conclusion, the present study indicates the possibility of producing cholesterol-reduced Domiati cheese from goat milk by β-CD treatment, which shows similar physicochemical and sensory properties compared to the control cheese during 8 weeks of ripening.

CONCLUSION

The present study designed to develop a cholesterol reduced cheese by β-CD, and to compare the physicochemical, and sensory properties of regular cheese and β-CD-treated cheeses using β-CD. Approximately 90.09% cholesterol reduction was observed in the cheeses that were treated using β-CD. The amounts of free fatty acids and free amino acids were lower in the cholesterol-reduced cream cheese than in the control throughout storage.

Thus, this study confirmed that cholesterol removal greatly influences the flavor Domiati cheese. Therefore, the present study indicates the possibility to make soft white cheese (Domiati-type) from goat milk with cholesterol reduced and acceptable characteristics.

REFERENCES

Abd El-Salam, M.H., Alichanidis, E., Zerfiridis, G.K. (1993). Domiati and Feta type cheeses. In: 2nd ed. Fox, P.F. editors. Cheese: Chemistry, Physics and Microbiology. Vol. 2: London, UK: Chapman and Hall; p. 301–335.

Abd-El-Kader, Y.I., Mehana M.Y. and Ammar M.A.E. (2001). Study on the effect of adding some spices to Ras cheese curd on the chemical, microbiological and organoleptical properties of the resultant cheese. Proc.the 8th Egyptian Conf. Dairy Sci.&Tech., 317.

Abou-Donia, S.A.(1986). Egyptian Domiati soft white pickled cheese. New Zealand Journal of Dairy Science and Technology, 21, 167–195.

Adams, M. L. Sullivan, D. M., Smith, R. L. and Richer. E. F. (1986). Evaluation of direct saponification method in determination of cholesterol in meats. J. Assoc. Anal. Chem. 69:844–846.

Ahmed, T.K. and Abd El-Razig K.A. (1998). Manufacture of Gibna Beida (white soft cheese) from cows' and goats' milk. Egyptian J. Dairy Sci. 26: 167-174.

Alonso, L., Cuesta, P., Fontecha, J., Juarez, M., and Gilliland, S. E. (2009). Use of β-cyclodextrin to decrease the level of cholesterol in milk fat. Journal of Dairy Science, 92(3), 863–869.

Arul, J., Boudreau, A. Makhlouf, J. Tardif, R. and Bellavia, T. (1988a). Fractionation of anhydrous milk fat by short path distillation. J. Am. Oil Chem. Soc. 65:1642–1646.

Arul, J., Boudreau, A. Makhlouf, J. Tardif, R. and Grenier, B. (1988b). Distribution of cholesterol in milk fat fractions.J.Dairy Res. 55:361–371.

Association of Official Analytical Chemists (1984). Official Methods of Analysis, 14th edn. Horwitz W, ed. Washington, DC: Association of Official Analytical Chemists.

Astray, G., Gonzalez-Barreiro, C., Mejuto, J.C, Rial-Otero, R., Simal-G´andara, J. (2009). A review on the use of cyclodextrins in foods. Food Hydrocoll. 23(7):1631–40.

Bae, H.Y., Kim, S.Y., and Kwak, H.S. (2008). Comparison of cholesterol-reduced Camembert cheese using cross-linked β -cyclodextrin to regular Camembert cheese during storage. Milchwissenschaft. 63(2), 153–156.

Bae H. Y., Kim S Y, Ahn J and Kwak, H. S. (2009). Properties of cholesterol-reduced Feta cheese made by crosslinked β -cyclodextrin. Milchwissenschaft . 64-2 pp. 165-168

Bartels, M, Johnson, E. and Olson, N.F. (1987). Accelerated ripening of Gouda cheese: II. Effect of freeze-shocked *Lactobacillus helveticus* on proteolysis and flavour development, Milchwissenschaft . 42 : 139 -144

Callanan, T. (1991). Recovery of milk constituents in cheese-making. Factors Affecting the Yield of Cheese. IDF Special Issue No. 9301, Square Vergote, Brussels, Belgium.

Carunchia-Whetstine, M.E., Karagul-Yuceer, Y., Avsar, Y.K. and Drake, M.A. (2003). Identification and quantification of character aroma components in fresh chevre-style goat cheese, Food Chem. Toxicol. 68: 2441–2447.

Chilliard, Y., Ferlay A., Rouel J., Lamberet, G. (2003). A review of nutritional and physiological factors affecting goat milk lipid synthesis and lipolysis. J. Dairy Sci. 86(5):1751–70.

Del Valle, E,M,M. (2004). Cyclodextrins and their uses: a review. Process Biochem 39(9):1033–46.

Duchˆene D, Bochot A., Yu, S.C, P´epin, C., Seiller, M. (2003). Cyclodextrins and emulsions. Int J Pharma 266(1–2):85–90.

Egyptian Organization for Standardization and Quality Control (2005). The Egyptian Standard of soft cheese: 1008–2005. Egyptian Organization for Standardization and Quality Control, Cairo, Egypt.

Elewa , N.A.H.,Degheidi, M. A.,Zedan, M. A., Mailam, M.A. (2009). Synergistic effects of inulin and cellulose in UF probiotic white soft cheese. In Egyptian Journal Dairy Science. vol. 37.1 p. 85 - 100.

El-Neshawy, A.A., El-Shafie, N.N. and Abdel Baky, M.A. (1995). Utilization of ultra-filtrated milk in the production of Edam-like cheese. Zagazig J. Agric. Res. 22: 775-787.

El-Shibiny, S., Al-Khamy, A.F., Shahein, N.M. and El-Sheikh, M.M. (1998). Effect of sodium caseinate addition on yield and quality of Edam cheese made by ultrafiltration. Egyptian J. of Dairy Sci., 26: 117 – 130.

El-Sisey, S.A. (2002). Studies on Semi-hard Cheese. Ph.D. Thesis, Fac. of Agric. Menofiya Univ., Egypt.

Engel, E., Lombardot, J.B., Garem, A., Leconte N., Septier, C., Le Queré, J.L. and Salles, C. (2002). Fractionation of the water-soluble extract of a cheese made from goats' milk by filtration methods:behavior of fat and volatile compounds,Int.DairyJ.12:609–619.

Fahmy, M.A. and Hanafy, N.E. (1992). Effcet of addition of green pepper and pickled Domiati cheese slurry on some properties of Domiati cheese. Assiut. J. of Agric. Sci., 23 : 281.

Fedele, V., Rubino, R., Claps, S., Sepe, L., Morone, G. (2005). Seasonal evolution of volatile com- pounds content and aromatic profile in milk and cheese from grazing goat. Small Rumi Res 59(2–3):273–9.

Fernandez-Espla, M. D. and Fox. P. F. (1998). Effect of adding *propiobacterium shermanii* NCDO 853 or *Lactobacillus casei ssp. casei* IFPL 731 on proteolysis and flavor development of Cheddar cheese. J. Agric. Food Chem. 46: 1228-1234.

Fooks, L.J., Fuller, R., Gibson, G.R. (1999). Prebiotics-probiotics and human gut microbiology. International Dairy Journal vol. 9-1 p. 53-61.

Fresno, J. M., Tornadijo, M. E., Carballo, J., Bernardo, A., and Gonza´lez, J. (1997). Proteolytic and lipolytic changes during the ripening of a Spanish craft goat cheese (Armada variety). Journal of the Science of Food and Agriculture, 75, 148–154.

Gonzalez-Hierro, M. T., Ruiz-Sala, P. Alonso, L. and Santamaria, G. (1995). Extraction of ewe's milk cream with supercritical carbon dioxide. Z. Lebensm. Unters. Forsch. 200:297–300.

Grundy, S. M. (1991). Multifactional etiology of hypercholesterolemia: Implications for prevention of coronary heart disease. Arteriosclerosis and Thrombosis, 11, 1619–1635.

Grundy, S. M., Brheimer, D., Blackburn, H., Brown, W. V., Kwiterovich, P. O., Mattson, F. Schonfeld, G. and Weidman, W.H. (1982). Rationales of the diet-heart statement of the American Heart Association. Report of the Nutrition Committee. 65:839A–854A.

Gurr, M. I. (1992). Dietary lipids and coronary heart disease: old evidence, new perspective. Progress. Lipid Res. 31:195–243.

Ha, J.K, Lindsay RC. (1990).Distribution of volatile branched-chain fatty acids in perinephric fats of various red meat species. Lebensm Wiss Technol 23:433–40.

Ha, J.K, Lindsay, RC. (1991).Contributions of cow, sheep, and goat milks to characterizing branched-chain fatty acid and phenolic flavors in varietal cheeses. J Dairy Sci 74(10): 3267–74.

Ha, J.K, Lindsay RC. (1993). Release of volatile branched-chain and other fatty acids from ruminant milk fats by various lipases. J Dairy Sci 76:677–90.

Haenlein, G. F.W. (2004). Goat milk in human nutrition. Small Ruminant Research,51,155-163.

Han, E. M., Kim, S. H., Ahn, J., and Kwak, H. S. (2007). Optimization cholesterol removal from cream using β -cyclodextrin cross-linked with adipic acid. International Journal of Dairy Technology, 60(1), 31–36.

Han, E. M., Kim, S. H., Ahn, J., and Kwak, H. S. (2008). Comparison of cholesterol reduced cream cheese manufactured using crosslinked β -cyclodextrin to regular cream cheese. Asian–Australasian Journal of Animal Sciences, 21(1), 131–137.

Hariharan, K., Soma Kurien, K. and Venkat Rao, S. (1995). Effect of supplementation of milk fat with peanut oil on blood lipids and lipoproteins in infants. Int. J. Food Sci. Nutr. 46:309–317.

Ibrahim, M. K. E., Fahmi, A. H.,Amer, S. N., and Mehriz, A. E. M.(1974). Effect of kind of milk on the percentage distribution of milk constituents and added salt between Domiati cheese and whey. Egyptian Journal of Dairy Science, 2, 143–155.

Kandeel, A.A., Naser, M.M. and Metwally, M.M.K. (1991). Effect of different types of rennet on the manufacture of the Domiati cheese made from goat's milk. Egyptian J. dairy Sci., 19 : 109-116.

Kim, S. H., Ahn, J., and Kwak, H. S. (2004). Crosslinking of β -cyclodextrin on cholesterol removal from milk. Archives of Pharmacal Research, 27(11), 1183–1187.

Kim, S. H., Han, E. M., Ahn, J., and Kwak, H. S. (2005). Effect of crosslinked β - cyclodextrin on quality of cholesterol-reduced cream cheese.Asian–Australasian Journal of Animal Sciences,18(4),584–589.

Kim, J. J., Jung, T. H., Ahn, J., & Kwak, H. S. (2006). Properties of cholesterol-reduced butter made with β -cyclodextrin and added evening primrose oil and phytosterols. Journal of Dairy Science, 89(12), 4503–4510.

Kim, H. Y, Bae, H. Y. and Kwak, H. S. (2008). Development of cholesterol-reduced blue cheese made by crosslinked β -cyclodextrin. Milchwissenschaft. 63 53–56.

Krause, A. J., Lopetcharat, K. and Drake, M. A. (2007). Identification of the characteristics that drive consumer liking of butter. J. Dairy Sci. 90:2091–2102.

Kuchroo, C.N. and Fox, P.F. (1982). Soluble nitrogen in Cheddar cheese: comparison of extraction procedures. Milchwissenschaft . 37:331–335.

Kwak, H. S., Jeon, I. J. and Park, J. (1990). Effects of food grade porcine pancreatic lipase on the production of short-chain fatty acids and its contribution. Korean J. Food Sci. Technol. 22:248–254.

Kwak, H. S., and J. Ahn. (1999). Optimization cholesterol removal in cream using β-cyclodextrin and response surface methodology. J. Food Sci. 64:629–632.

Kwak, H. S., Nam, C. G. and Ahn, J. (2001). Low cholesterol Mozzarella cheese obtained from homogenized and β-cyclodextrin-treated milk. Asian-Aust. J. Anim. Sci. 14 (2): 268 -275.

Kwak H.S, Jung, S., Shim, S.Y. and Ahn J. (2002) Removal of cholesterol from Cheddar cheese by b-cycodextrin. Journal of Agricultural and Food Chemistry 50 7293–7298.

Kwak, H. S., Kim, S. H., Kim, J. H., Choi, H. J., and Kang, J. (2004). Immobilized b-cyclodextrin as a simple and recyclable method for cholesterol removal in milk. Archives of Pharmacal Research, 27(8), 873–877.

Le Queré, J.L., Pierre, A., Riaublanc, A., and Demaizières, D. (1998). Characterization of aroma compounds in the volatile fraction of soft goat cheese during ripening, Lait 78: 279–290.

Lee, S.J., Hwang, J.H., Lee, S., Ahn, J., Kwak, H.S. (2007). Property changes and cholesterol lowering effects in evening primose oil-enriched and cholesterol-reduced yoghurt. Int. J. Dairy Technol. 60:22–30

Lee, D. K., Ahn, J. and Kwak, H. S. (1999). Cholesterol removal from homogenized milk with β-cyclodextrin. J. Dairy Sci. 82:2327–2330.

Lim, S., Jwa, M.K. and Kwak, H.S. (1998). Cholesterol removal from milk fat by supercritical carbon dioxide extraction in coupled with adsorption. Korean J. Food Sci. Technol. 30:574 580.

Lin, J. C. C. and Jeon. I. J. (1987). Effects of commercial food grade enzymes on fatty acid profiles in granular cheese. J. Food Sci. 52:78-81.

Magdoub, M.N., Osman, SH.G. EL- Kenawy, M. M. (1995). Effect of different starter cultures on composition and microbiological quality of Ain shams cheese. In Egyptian Journal of Applied. Science vol. 10, no. 1 p.132 - 141.

Mahann, L. K., and Escott-Stump, S. (1996). Krause's food nutrition and diet therapy (9th ed.) (55pp.). Philadelphia, PA: WB Saunders Co.

Mehanna, N. S., Sharaf, O. M., Ibrahim, G. A. and Tawfik, N. F. (2002). Incorporation and viability of some probiotic bacteria in functional dairy food. I-soft cheese. Egypt. J. Dairy Sci., 30(2):217–229.

Metzger, L. E., and Mistry, V. V. (1994). A new approach using homogenization of cream in the manufacture of reduced fat Cheddar cheese. 1. Manufacture, composition, and yield. J. Dairy Sci. 77:3506–3515.

Micich, T. J. (1990). Behavior of polymer supported digitonin with cholesterol in the absence and presence of butter oil. J. Agric. Food Chem. 38:1839–1843.

Nasr, M.M., El-Sayed, M.M. and El-Samrgy, Y.A. (1991). Acceleration of Edam cheese ripening using acid fungal protease. Nahrung 35: 143 – 148.

Nelson, J.A. and Trout, G.M. (1981): Judging of dairy products, 4th Ed. INC Westport, Academic Press, P. 345-567.

Oakenfull, D. G., and Sihdu, G. S. (1991). Cholesterol reduction. Commonwealth Scientific and Industrial Research Organisation, assignee. Int. Pat. No. WO 91/11114.

Oh, H.I., Chang, E.J. and Kwak. H.S. (1998). Conditions of the removal of cholesterol from milk by treatment with saponin. Korean J. Dairy Sci. 20:253–260.

Park, Y.W. (2008). Goat milk chemistry and nutrition. In: Park Y.W, Haenlein G.F, editors. Handbook of milk of non-bovine mammals. Ames, Iowa: Blackwell Publishing Professional. p. 34–58.

Phelan, J.A., (1981). Standardization of milk for cheese-making at factory level. J. Soc. Dairy Technol. 34, 152–156.

Salama, F.M.M. (2004). Improving the quality of Domiati cheese. Proc. The 9 th Egyptian Conf. for Dairy Sci. & Tech. Egyptian J. Dairy Sci., 385-397.

Schroder, B. G., and Baer, R. J. (1990). Utilization of cholesterol reduced milk fat in fluid milks. Food Technol. (Nov.):145–148.

Seon, K.H., Ahn, J., Kwak, H.S. (2009). The accelerated ripening of cholesterol-reduced Cheddar cheese by cross-linked β -cyclodextrin. J. Dairy Sci. 92:49–57.

Shehata, A. E., EL-Nawawy, M. A., EL-Kenany, Y. M. and Aumara, I. E. (2001). Production of soft cheese with health benefits. In Proc.8th Egyptian conference Dairy Science & Technology p. 635 – 651.

Shim, S. Y., Ahn, J., and Kwak, H. S. (2003). Functional properties of cholesterol removed whipping cream treated by β -cyclodextrin. Journal of Dairy Science, 86(9), 2767–2772.

Smit, G., Verheul, R., Kranenburg, V., Ayad, E., Siezen, R. and Engels, W. (2000). Cheese flavour development by enzymatic conversions of peptides and amino acids, Food Res. International, 33:153-160.

SPSS package (SPSS v.20, 2012). Software package for Social Science For windows .

Szente, L.and Szejtli, J. (2004). Cyclodextrins as food ingredients. Trends Food Sci. Technol. 15(3–4):137–42.

Yen, G.C. and Tsui, L.T. (1995). Cholesterol removal from a lard water mixture with β –cyclodextrin . J. Food Sci. 60:561–564.

Young, O.A, Gupta, R.B, and Sadooghy-Saraby ,S. (2012). Effects of Cyclodextrins on the Flavor of Goat Milk and Its Yogurt. Journal of Food Science . Vol. 77, Nr. 2, 2012.

Zhang, X., Kilmer, R. L. and Mohammad, A. (2003). A descriptive analysis of Egypt and Saudi Arabia who import United States dairy products, mono-graph MGTC 03-8. International Agricultural Trade and Policy Center, Institute of Food and Agricultural Sciences, University of Florida, Gaines- ville, FL.

تـأثير إضـافة البيتـا- سيكلودكسـتران علـى الخـواص الفيزوكيميائيـة للجبن الـدمياطي المصنع من لبن المعز

علاء حامد إبراهيم و كمال اسعد سوريال
شعبة الإنتاج الحيواني والدواجن – قسم تربية الحيوان والدواجن- مركز بحوث الصحراء- القاهرة

أجريـت هذه الدراسـة لمعرفـة تـأثير إضـافة مركـب البيتـا- سيكلودكسـترين علـى الخـواص الفيزوكيميائية والحسية للجبن الطرى الدمياطى المصنع من لبن المـاعز .أوضـحت النتـائج انخفـاض نسـبة الكوليسـترول إلـى ٧٩.٣٧% عنـد معاملـة اللـبن مباشـرة بنسـبة ١% مـن مركـب البيتـا- سيكلودكسترين (المعاملة الأولى) بينما وصلت نسبة الانخفاض إلى أعلى مستوى لها ٩٠.٠٩ % عند فصل القشدة من اللبن ومعاملتها بنسبة ١٠% من مركب البيتا- سيكلودكسترين (المعاملة الثانيـة) ثم اعادة القشدة المعاملة إلى اللبن الفرز بعد تعديل تركيبة والمعاملة بالتجنيس .

أظهـرت النتـائج زيـادة طبيعيـة فـى نسـبة تصـافى الجـبن المعامـل بمركـب البيتـا- سيكلودكسترين حيث سجلت المعاملة الثانية أعلى نسبة تصافى١.٠٣±١٩.٨٩% والمعاملة الأولـى ٠.١٥±١٩.٣٣% بينما اقل نسبة محصول كانت للمعاملة الكونترول ٠.٠٦± ١٩.٢٧ % مع عدم وجود فروق معنوية ($P < 0.05$) بين كل المعاملات خلال فترة التخزين على ٤°م لمدة ثمانية أسابيع.

وأوضحت النتائج أن الجبن المعامل بمركب البيتا- سيكلودكسترين تميز بانخفاض معنوى ($P < 0.05$)فى كمية الأحماض الدهنية الحرة قصيرة السلسلة المسؤولة عن الطعم والرائحة. وكـذلك انخفـاض فـى كميـة الأحمـاض الأمينيـة الكليـة الحـرة للجـبن المعامـل بمركـب البيتـا- سيكلودكسترين عن الجبن الغير معامل مع عدم وجود اختلافات معنوية بين المعاملة الكونترول والمعاملة الأولـى ($P < 0.05$). وكذلك أظهـرت النتـائج انخفـاض معنـوى ($P < 0.05$) فـى الأحماض الأمينية المسببة للطعم المر للمعاملة الثانية عن باقى المعـاملات خـلال فترة التخـزين علـى ٤ °م لمدة ثمانية أسابيع.

وأشارت نتائج التقييم الحسى أن الجبن المصنع من المعاملة الثانية أفضل فى كل خصائص التقييم الحسى. لـذلك فـان هذه الدراسـة أوضـحت إمكانيـة إنتـاج الجبن الـدمياطى مـن لـبن المـاعز مـع انخفاض كبير فى كمية الكوليسترول وإزالة الرائحة الغير مرغوبة لدى المستهلكين بالمعاملة بمركب البيتـــا- سيكلودكســـترين مـــع عـــدم التـــأثير علـــى الخـــواص الفيزوكميائيـــة للجـــبن النـــاتج .

Table 2. Chemical composition of cholesterol-reduced goat's milk cheese treated by β-CD compared to the control goat's milk cheese during the storage period at 4±1°C.

Treatments	Storage Period (wk)	Moisture%	Fat/ Dry matter %	TP/ Dry matter %	Ash/ Dry matter %	Salt/ Dry matter %	pH	Titratable acidity %
Control[*1]	Fresh	61.11^{abc}±0.09	37.63^{abcde}±1.19	36.00^{a}±0.44	9.85^{c}±0.28	4.50^{a}±0.39	6.10^{a}±0.00	0.40^{cd}±0.02
	2 weeks	59.61^{cd}±0.48	37.87^{abcd}±0.50	35.08^{a}±1.40	9.90^{bc}±0.12	4.67^{a}±0.36	5.88^{b}±0.23	0.41^{abcd}±0.02
	4 weeks	59.16^{cd}±0.40	38.20^{abc}±0.56	35.10^{a}±0.79	10.28^{abc}±0.43	4.79^{a}±0.40	5.83^{b}±0.38	0.42^{abcd}±0.01
	6 weeks	58.98^{cd}±0.68	38.68^{ab}±0.60	35.34^{a}±0.68	10.34^{abc}±0.46	4.85^{a}±0.42	5.79^{b}±0.16	0.43^{ab}±0.01
	8 weeks	58.72^{cd}±0.20	39.16^{a}±0.56	37.62^{a}±0.22	10.50^{abc}±0.17	4.96^{a}±0.63	5.80^{b}±0.02	0.43^{a}±0.02
Trt A[*2]	Fresh	62.31^{ab}±1.25	35.23^{e}±1.24	35.84^{a}±1.21	10.35^{abc}±0.36	4.51^{a}±0.15	5.88^{b}±0.16	0.40^{d}±0.02
	2 weeks	60.92^{abcd}±2.36	35.49^{de}±2.38	36.14^{a}±1.63	10.43^{abc}±0.60	4.55^{a}±0.19	5.86^{b}±0.14	0.40^{cd}±0.01
	4 weeks	59.31^{cd}±2.22	35.79^{cde}±1.96	36.27^{a}±1.65	10.43^{abc}±0.64	4.57^{a}±0.25	5.81^{b}±0.03	0.41^{cd}±0.01
	6 weeks	59.06^{cd}±0.93	36.33^{bcde}±0.96	36.50^{a}±1.10	10.51^{abc}±0.31	4.57^{a}±0.14	5.78^{b}±0.02	0.42^{abcd}±0.01
	8 weeks	58.37^{d}±1.01	36.75^{abcde}±0.32	36.68^{a}±0.82	10.57^{abc}±0.29	4.60^{a}±0.07	5.71^{b}±0.06	0.42^{abc}±0.01
Trt B[*3]	Fresh	63.25^{a}±0.87	35.75^{cde}±0.85	36.77^{a}±2.39	10.84^{a}±0.31	4.75^{a}±0.25	5.93^{ab}±0.09	0.39^{d}±0.01
	2 weeks	62.52^{ab}±1.60	36.69^{bcde}±1.60	36.87^{a}±1.53	10.86^{a}±0.61	4.82^{a}±0.17	5.86^{b}±0.13	0.40^{cd}±0.01
	4 weeks	61.10^{abc}±0.13	36.67^{bcde}±0.23	36.93^{a}±0.42	10.80^{ab}±0.29	4.83^{a}±0.10	5.89^{b}±0.04	0.41^{bcd}±0.01
	6 weeks	60.64^{bcd}±1.45	37.04^{abcde}±1.27	36.96^{a}±1.41	10.85^{a}±0.59	4.84^{a}±0.19	5.87^{b}±0.09	0.41^{bcd}±0.02
	8 weeks	60.37^{bcd}±2.41	37.69^{abcde}±2.10	37.09^{a}±2.11	10.97^{a}±0.83	4.87^{a}±0.30	5.80^{b}±0.08	0.42^{abc}±0.01

a.b.c: Means within a column with different letters differ significantly ($P < 0.05$).

[*1]Milk was not treated with β-CD. [*2]Milk treated with 1% β-CD.

[*3]After cream separation, cream was treated with 10% β-CD powder and blended with skim milk.

Table 5.Concentration of free amino acids (FAA) in cholesterol-reduced goat's milk cheese treated by β-CD compared to the control goat's milk cheese during storage period at 4±1°C.

Amino Acids mg/100g	Ripening period (weeks)														
	Control[*1]					Trt A[*2]					Trt B[*3]				
	Fresh	2 weeks	4 weeks	6 weeks	8 weeks	Fresh	2 weeks	4 weeks	6 weeks	8 weeks	Fresh	2 weeks	4 weeks	6 weeks	8 weeks
Aspartic (Asp)	4.25±0.07	4.65±0.07	5.50±0.14	6.90±0.14	8.30±0.14	4.15±0.21	4.75±0.07	5.60±0.28	7.05±0.07	8.08±0.04	3.45±0.07	4.40±0.14	5.30±0.14	6.40±0.14	7.15±0.07
Therionine (Thr)	3.80±0.14	4.45±0.07	5.25±0.07	6.05±0.07	8.00±0.14	3.55±0.21	4.20±0.14	5.50±0.01	6.45±0.07	7.75±0.07	3.20±0.01	3.75±0.07	4.40±0.14	5.30±0.14	6.20±0.14
Serine (Ser)	0.20±0.01	0.27±0.01	0.31±0.01	0.39±0.01	0.42±0.01	0.18±0.01	0.23±0.01	0.27±0.01	0.31±0.01	0.39±0.01	0.18±0.01	0.23±0.01	0.25±0.01	0.29±0.01	0.33±0.01
Glutamic (Glu)	4.40±0.14	4.85±0.07	5.40±0.01	6.10±0.01	7.80±0.01	4.65±0.21	5.05±0.07	5.40±0.00	6.30±0.14	7.37±0.10	4.00±0.14	4.70±0.14	5.35±0.07	6.15±0.07	6.89±0.13
Proline (Pro)	3.35±0.07	3.85±0.07	4.40±0.14	5.05±0.07	5.70±0.01	3.15±0.07	3.85±0.07	4.35±0.07	5.00±0.14	5.35±0.07	3.10±0.01	3.65±0.07	4.15±0.07	4.65±0.07	5.10±0.01
Glycine (Gly)	0.31±0.01	0.45±0.01	0.51±0.01	0.63±0.03	0.71±0.01	0.30±0.01	0.48±0.01	0.52±0.01	0.62±0.02	0.67±0.01	0.28±0.01	0.33±0.01	0.43±0.01	0.50±0.02	0.62±0.01
Alanine (Ala)	0.63±0.01	0.75±0.07	0.93±0.04	1.05±0.07	1.25±0.07	0.65±0.07	0.84±0.01	0.89±0.01	0.95±0.01	1.15±0.07	0.60±0.01	0.64±0.02	0.72±0.01	0.83±0.02	0.95±0.07
Valine (Val)	0.19±0.01	0.23±0.01	0.29±0.01	0.34±0.02	0.50±0.02	0.17±0.01	0.23±0.02	0.29±0.01	0.36±0.01	0.44±0.01	0.17±0.01	0.19±0.01	0.21±0.01	0.28±0.01	0.37±0.01
Methionine (Met)	0.05±0.01	0.06±0.01	0.09±0.01	0.10±0.01	0.14±0.01	0.05±0.01	0.09±0.01	0.10±0.01	0.11±0.01	0.13±0.01	0.05±0.01	0.07±0.01	0.07±0.01	0.08±0.01	0.09±0.01
Iso leucine (Ile)	0.35±0.07	0.39±0.01	0.49±0.01	0.62±0.04	0.83±0.04	0.30±0.01	0.41±0.01	0.53±0.01	0.64±0.02	0.76±0.01	0.33±0.04	0.46±0.01	0.56±0.01	0.62±0.01	0.68±0.04
Leucine(Leu)	0.75±0.07	0.95±0.07	1.15±0.07	1.69±0.06	0.65±0.07	0.85±0.07	1.10±0.01	1.25±0.07	1.55±0.07	0.63±0.04	0.63±0.04	0.63±0.04	0.78±0.04	0.98±0.04	1.25±0.07
Tyrosine (Tyr)	0.51±0.01	0.67±0.03	0.76±0.01	0.97±0.01	1.16±0.01	0.45±0.07	0.65±0.07	0.78±0.04	0.93±0.04	1.06±0.01	0.40±0.01	0.58±0.04	0.63±0.04	0.78±0.04	0.93±0.04
Phenylalanine (Phe)	0.75±0.07	1.25±0.07	1.60±0.14	1.85±0.07	2.07±0.04	0.70±0.14	0.90±0.01	1.15±0.07	1.45±0.07	1.94±0.01	0.65±0.07	0.83±0.04	0.95±0.01	1.15±0.07	1.45±0.07
Lysine (Lys)	3.15±0.07	4.10±0.01	4.95±0.07	5.90±0.14	7.60±0.14	3.05±0.07	4.25±0.07	5.30±0.14	6.15±0.07	7.25±0.07	2.65±0.07	4.10±0.14	4.55±0.07	5.25±0.07	6.40±0.14
Histidene (His)	0.68±0.01	0.81±0.01	1.03±0.04	1.35±0.07	1.70±0.14	0.64±0.07	0.85±0.07	0.95±0.07	1.15±0.07	1.45±0.07	0.60±0.01	0.76±0.01	0.86±0.01	0.98±0.04	1.24±0.01
Argininr (Arg)	0.75±0.07	0.87±0.03	0.97±0.03	1.23±0.04	1.57±0.03	0.68±0.03	0.83±0.04	0.98±0.04	1.20±0.01	1.48±0.04	0.50±0.01	0.75±0.07	0.90±0.07	0.95±0.07	1.15±0.07
Cystine (Sys)	2.75±0.07	3.15±0.07	3.75±0.07	4.20±0.01	4.90±0.01	2.40±0.01	3.00±0.01	3.55±0.07	4.05±0.07	4.49±0.05	2.15±0.07	2.80±0.01	3.30±0.14	3.85±0.07	4.05±0.07
TFAA	26.87^{h}±0.07	31.75^{fh}±0.04	37.36^{d}±0.29	44.14^{a}±0.35	54.32^{a}±0.11	25.71^{k}±0.10	31.43^{fh}±0.25	37.24^{d}±0.30	43.96^{cd}±0.47	51.29^{a}±0.15	22.91^{j}±0.06	28.88^{g}±0.42	33.38^{fg}±0.31	39.02^{de}±0.71	44.83^{c}±0.07
[*4]BAA	6.61^{hi}±0.13	7.91^{gh}±0.17	9.50^{f}±0.37	11.76^{c}±0.16	14.04^{a}±0.01	6.25^{i}±0.07	7.56^{h}±0.08	9.16^{f}±0.33	11.31^{d}±0.01	13.38^{b}±0.01	5.45^{k}±0.07	6.93^{i}±0.17	8.21^{g}±0.16	9.93^{e}±0.28	11.45^{cd}±0.01

a.b.c: Means within a row with different letters differ significantly ($P < 0.05$).

[*1] Milk was not treated with β-CD. [*2] Milk treated with 1% β-CD.

[*3] After cream separation, cream was treated with 10% β-CD powder and blended with skim milk.

[*4] Bitter amino acid: Asp, Tyr, Ile, Leu and Phe.