Minufiya J. Agric. Res. Vol. 34 No. 5:1887-1899 (2009) "http:// agri.menofia.edu.eg/megla.html"

MANUFACTURE OF LOW FAT DOMIATI CHEESE USING FAT MIMETICS

K. M. K. Kebary [1]; R.M. Badawi [1]; S. F. Mahmoud [2] and A. S. El-Sisi [2]

(1) Dep. of Dairy Sci. and Technol., Fac. of Agric., Minufiya Univ., Shibin El-Kom
(2) Dep. of Dairy Res., Food Technol. Res. Institute, Agric. Res. Center, Giza, Egypt.

(Received: Jul. 14, 2009)

ABSTRACT: ***Seven Domiati cheese treatments were made to study the effect of fat replacers on cheese quality. Control cheese was made from buffaloe's milk standardized to 5.0% fat. Another six cheese treatments were made by replacing 20, 40 and 60% of milk fat by either Dairy-Lo® (a protein based fat replacer) or Littesse® (a carbohydrate based fat repalcer) individually. Replacement of milk fat with fat replacers caused a pronounced increase in moisture content and decrease in total calorific values of cheese treatments. Using Dairy-Lo® increased the protein content, while using Littesse increased the total carbohydrate content of cheese treatments. Cheese treatments those made by replacing milk fat with Dairy-Lo® contained higher total volatile fatty acids (TVFA), water soluble nitrogen (WSN) and were more acceptable than corresponding cheese treatments those made by adding Littesse®. Cheese treatment that made by replacing 40% milk fat with Dairy Lo® contained the highest TVFA, WSN and was the most acceptable cheese. Moisture and total nitrogen contents decreased during pickling period, while fat, ash, TVFA, WSN, calorific value, titratable acidity and scores of organoleptic properties increased of all cheese treatments.***

Key Words*: Low fat, Domiati cheese, fat replacers, Dairy-Lo®, Littesse®.*

INTRODUCTION

Domiati cheese is the most popular cheese in Egypt. It could be consumed fresh or after maturation in salted whey. Milk fat plays crucial organoleptic and functional roles in dairy products. It carries, enhances, releases the flavour of other ingredients and interacts with other ingredients to develop texture, colour, flavour perception, flavour stability and the overall sensation of dairy products (Giese, 1996 and De Roos, 1997). Therefore, reduced fat cheeses may exhibited undesirable lack of flavour and a firm rubbery texture. Manufacture of reduced fat cheeses that exhibit the characteristics of traditional full fat cheeses become more popular and one of the priorities of most dairy companies because of health problems associated with high fat intake such as obesity, diabetes, some types of cancer, hypertension, atherosclerosis, liver and heart diseases (Williams, 1985).

Fat replacers is one of the most promising approaches to manufacture reduced fat cheeses and therefore has attracted great attention in the last decade (Bhasharachary and Shah, 2001; Abd El-Hamid *et al.,* 2001; El-Sheikh *et al.,* 2001; Haque and Aryana, 2002; Koca and Metin, 2004; Kavas *et al.,* 2004; Kebary *et al.,* 2006 a and Kebary *et al.,* 2006 b). Many fat repalcers are available commercially and they can be classified as fat based, protein based and carbohydrate based fat repalcers.

In view of the aforementioned the objectives of this study were to evaluate the possibility of making a good quality low fat Domiati cheese using fat mimetics, investigate the effects of using Dairy Lo® (a protein based fat replacer) and Littesse (a carbohydrate based fat replacer) on the quality of low fat Domiati cheese and to monitor the chemical and organoleptic changes during pickling of Domiati cheese.

MATERIALS and METHODS

Cheese making:

Seven Domiati cheese treatments were made. Fresh bulk buffalo's milk (obtained from Farm of the Faculty of Agriculture, Minufiya Univ., Shibin El-Kom, Egypt) was standardized to 5.0% fat (control cheese), 4.0, 3.0 and 2.0% fat. Each of 4.0, 3.0 and 2.0% fat milks was divided into two portions. Dairy Lo® (Parmalat Ingredient Com., Toronto, Canada) was added to one portion of 4.0, 3.0 and 2.0% fat milks at the rate of 1.0, 2.0 and 3.0%, respectively. The other three cheese treatments were made from the second portion of 4.0, 3.0 and 2.0% by adding Littesse® (Danisco cultor America, Inc., Ardsley, NY, USA) at the rate of 1.0, 2.0 and 3.0% in the same order. Littesse® was dispersed in cold milk while Dairy-Lo® was dispersed in heated milk up to 60°C. All milks were pasteurized at 63°C for 60 min, then cooled to 37°C. Calcium chloride and salt were added at the rate of 0.02 and 7%, respectively before renneting. Domiati cheeses were made from all milk batches according to Fahmi and Sharara (1950) and packaged in polyethylene bags, filled with boiled salted whey from the same batch and stored for 8 weeks in the refrigerator at (6 ± 1°C). The whole experiment was duplicated.

Chemical analysis:

Cheeses were sampled at zero day (fresh), 2, 4, 6 and 8 weeks and analyzed for moisture, total nitrogen (TN), fat, ash, soluble nitrogen (SN) and titratable acidity according to Ling (1963). Total volatile fatty acids (TVFA) was determined according to Kosikowski (1966). Carbohydrate was calculated by difference. Total energy was calculated based on conversion factors as follows protein 4 k.cal./gm, carbohydrate 4 k.cal./gm and fat 9 k.cal./gm.

Sensory evaluation:

Cheese samples were evaluated organolepticaly by a regular score panel including the staff members of the Department of Dairy Science and Technology according to the scoring sheet of Abdou *et al.* (1977).

Statistical analysis:

A 2 × 3 factorial design was used to analyses all the data and Newman-Keuls test was followed to make the multiple comparisons (Steel and Torrie, 1980) using Costat program. Significant differences were determined at $p \leq 0.05$.

RESULTS and DISCUSSION

Results presented in Table (1) revealed that moisture content of low fat cheese treatments increased significantly ($p \leq 0.05$) by replacing milk fat with either Dairy-Lo® or Littesse® and this increase was proportional to the rate of replacement. These results might be attributed to the higher water holding capacity of carbohydrate and proteins than that of milk fat. Cheese treatments those made by adding Littesse® contained higher moisture content than those of corresponding cheese treatments made by adding Dairy-Lo®, which means Littesse® was more effective to increase the moisture content than Dairy-Lo® (Tables 1, 5). On the other hand, moisture content of all cheese treatments decreased significantly ($p \leq 0.05$) as pickling period progressed (Tables 1, 5). This decrease might be due the contraction of the curd as a result of developed acidity during pickling period, which helps to expel the whey from the curd. These results are in agreement with those reported by Kebary *et al.* (1996); El-Sheikh *et al.* (2001), Abd El-Kader (2003) and Kebary *et al.* (2006 a, b).

Fat content of cheese decreased significantly ($p \leq 0.05$) as the fat content of milk was reduced (Tables 1, 5). Cheese treatments those were made by adding Dairy-Lo® were not significantly ($p > 0.05$) different from corresponding cheese treatments those made by adding Littesse®, which means that the type of fat did not affected significantly ($p > 0.05$) the fat content of the resultant cheese. These results are in accordance with those reported by Kebary *et al.* (2006 a, b). On the other hand, fat content of all cheese treatments increased ($p \leq 0.05$) during the pickling period (Tables 1, 5), which might be due to the loss of moisture (Kebary *et al.,* 2006 a, b).

Total nitrogen content of all cheese treatments decreased significantly ($p \leq 0.05$) as pickling period progressed (1, 5), which could be attributed to the degradation of proteins into soluble nitrogen compounds and consequently the loss of some these compounds in the pickling solution. These results are in agreement with those reported by El-Abd *et al.* (2003), Kebary *et al.* (2006 a, b).

Table 1

Cheeses treatments those made by adding Dairy-Lo® contained the highest total nitrogen content, which simply because Dairy-Lo® is a protein based fat repalcer. Total nitrogen content of cheese made by adding Dairy-Lo® increased by increasing the amount added of Dairy-Lo®. On the other hand, cheese treatments those made by adding Littesse® were not significantly ($p > 0.05$) different from each other, which means that adding Littesse® did not affect significantly ($p > 0.05$) the total nitrogen content of the resultant cheese (Tables 1, 5).

Total carbohydrates of all cheese treatments increased significantly ($p \leq 0.05$) as the pickling period advanced (Tables 2, 5). This increase could be attributed to the reduction of moisture content (Badawi and Kebary, 1998). Cheese treatments those made by adding Littesse® (a carbohydrate based fat repalcer) contained the highest carbohydrate content and the increase of carbohydrate content was proportional to the replacement rate of fat with carbohydrate (Badawi and Kebary, 1998). On the other hand, cheese treatments those were made by adding Dairy-Lo® were not significantly ($p > 0.05$) different from each other, which means that Dairy-Lo® did not affect significantly ($p > 0.05$) the total carbohydrate content of the resultant cheese (Tables 2, 5).

Ash content of all cheese treatments increased slightly ($p \leq 0.05$) as pickling period proceeded (Tables 2, 5), which might be due to the reduction of moisture content (Badawi and Kebary, 1998). Cheese treatments those made by adding Dairy-Lo® contained higher ash content than corresponding cheese treatments those made by adding Littasse®. These results might be due to the higher ash content of Dairy-Lo® (Badawi and Kebary, 1998).

Ash content increased by increasing the amount added of Dairy-Lo®. On the other hand, cheese treatments those made by adding Littesse® were not significantly ($p > 0.05$) different from each other, which means that Littesse® did not affect significantly ($p > 0.05$) the ash content of the resultant cheese and these cheeses were not significantly different from control cheese (Tables 2, 5).

Calorific values of low fat cheese treatments decreased significantly ($p \leq 0.05$) by reducing the milk fat content and this reduction was proportional to the replacement rate of milk fat with fat replacers (Badawi and Kebary, 1998) (Tables 2, 5). Cheese treatments those made by adding Dairy-Lo® were not significantly ($p > 0.05$) different from corresponding cheese treatments those made by adding Littesse®, which means that the type of fat replacer did not have significant ($p > 0.05$) effect on calorific values of cheese (Tables 2, 5). Calorific values of all cheese treatments increased significantly ($p \leq 0.05$) during pickling period, which might be due to the increase of total solids (Tables 2, 5) (Badawi and Kebary, 1998).

Table 2

Titratable acidity of all cheese treatments increased significantly ($p \leq 0.05$) during pickling period (Tables 3, 5). This increase in titratable acidity might be due to the fermentation of residual lactose in cheese and subsequently development of acidity and / or liberation of fatty acids. These results are in agreement with those reported by Abdou *et al.* (2003), El-Abd *et al.* (2003) and Kebary *et al.* (2006 a, b). Replacement of milk fat with fat repalcers wither Dairy-Lo® or Littesse® caused a slight increase in titratable acidity of cheese, which might be due to the higher moisture content, which stimulate the growth of cheese microflora. Titratable acidity of cheese treatments those made by adding Dairy-Lo® were not significantly ($p > 0.05$) different from corresponding those made by adding Littesse® (Badawi and Kebary, 1998).

Total volatile fatty acids (TVFA) of all cheese treatments increased as pickling period proceeded (Tables 3, 5). These results are in accordance with those reported by Ammar (1999), Mehanna *et al.* (2002), El-Abd *et al.* (2003) and Kebary *et al.* (2006 a, b). Cheese treatments those made by adding Dairy-Lo® contained higher TVFA than corresponding cheese treatments those made by adding Littesse®. Cheese treatment that made by replacing 40% of milk fat with Dairy-Lo® contained the highest TVFA content and was not significantly ($p > 0.05$) different from control cheese treatment (Tables 3, 5).

Water soluble nitrogen (WSN) content of all cheese treatments increased as pickling period advanced (Tables 3, 5). Similar results are reported by El-Abd *et al.* (2003), Abdou *et al.* (2003) and Kebary *et al.* (2006 a, b). Cheese treatments those made by adding Dairy-Lo® contained higher WSN than corresponding cheese treatments those made by adding Littesse® (Tables 3, 5). Cheese made by replacing 40% of milk fat by Dairy-Lo® contained the highest WSN contents followed by control cheese and cheese treatment that made by replacing 20% of milk fat with Dairy-Lo® and those cheese treatments were not significantly different from each other (Tables 3, 5).

Table 3

Total scores of organoleptic properties of all cheese treatments increased significantly ($p \leq 0.05$) as pickling period progressed (Tables 4, 5). These results are in agreement with those reported by Farag *et al.* (1988) and Kebary *et al.* (2006 a, b). These results might be due to protein degradation and fat lipolysis during pickling period and subsequently improvement in flavour, body and texture of cheese. Cheese treatments those made by adding Dairy-Lo® gained higher total scores than corresponding cheese made with Littesse®. Cheese treatment that made by replacing 40% milk fat with Dairy-Lo® was the most acceptable cheese and was not significantly ($p > 0.05$) different from control cheese, which was not significantly ($p > 0.05$) different from cheese treatment that made by replacing 20% milk fat with Dairy-Lo®. Increasing the replacing rate above 40% decreased the scores of organoleptic properties (Tables 4, 5).

Table (4): Effect of fat mimetics and pickling period on the scores of organoleptic properties of low fat Domiati cheese (out of 100).

Cheese samples	Total scores				
	Pickling period (weeks)				
	0	2	4	6	8
C*	82	88	88	87	89
L_1	71	75	78	78	78
L_2	77	79	82	82	82
L_3	69	72	74	76	76
D_1	80	82	86	87	86
D_2	83	88	90	89	91
D_3	75	78	78	79	81

*** See Table (1).**

It could be concluded that replacing of milk fat with fat replacer increased the moisture content and reduced the colorific value of cheese. Cheese treatments those made by replacing milk fat with Dairy-Lo® contained by replacing milk fat with Dairy-Lo® contained higher TVFA and WSN and were more acceptable than corresponding cheese treatments those made by adding Littesse®. Cheese treatment that made by replacing 40% of milk fat was the most acceptable cheese and contained the highest TVFA and WSN. Therefore, it possible to make a good quality low fat Domiati cheese by reducing the fat content up to 40% by using Dairy-Lo®.

Table 5

REFERENCES

Abd El-Hamid, L. B., A. E. Hagrass, R. A. Awad and O. A. Zammar (2001). Physical and sensory properties of low calorie Mozzarella cheese with fat replacers. 8th Egyptian Conf. for Dairy Sci. and Technol., Cairo, pp. 283 – 298.

Abdel-Kader, Y. I. (2003). Changes in the nitrogen fractions of Domiati cheese made with microbial and recombinant rennets during ripening. Egypt. J. of Dairy Science., 31 (1): 111 – 124.

Abdou, S. M., L. B. Abd-El-Hamid, A. H. M. Dawood, A. M. Youssef and G. A. Mahran (1977). Studies on Cephalotyre "Ras" cheese coating. II. Effect on ripening. Egypt. J. Dairy Sci., 5: 191.

Abdou, S. M., M. E. Shenana, S. G. Osman and A. M. Sadek (2003). Production of low-fat Halloumi cheese. Egypt. J. of Dairy Science., 31 (1): 101.

Ammar, El-Tahra, M. A. (1999). Composition and properties of Domiati cheese from cold and frozen stored buffalo milk. Egypt. J. of Dairy Sci., 27 (1): 109.

Badawi, R. M. and K. M. K. Kebary (1998). Influence of fat replacers on the quality of low fat Tallaga cheese. Proc. of the 7th Egypt Conf. for Dairy Sci. and Techn., Cairo, Egypt, 7 – 9 November, pp. 347.

Bhaskaracharya, R. K. and N. P. Shah (2001). Texture and microstructure of skim milk Mozzarella cheeses made using fat replacers. Aust. J. Dairy Techn., 56 (1): 9.

De-Roos, K. B. (1997). How lipids influence food flavour. Food Techn., 51: 60.

El-Abd, M. M., A. M. A. Abd El-Fattah, S. G. Osman and R. S. A. Abd El-Kader (2003). Effect of some lactic acid bacteria on the properties of low salt Domiati cheese. Egypt. J. Dairy Sci., 31 (1): 125.

El-Sheikh, M. M., A. F. Farrag, N. M. Shahein and S. El-Shibiny (2001). Low fat Domiati cheese with particulated whey protein concentrate (PWPC). Egypt. J. of Dairy Sci., 29 (2): 331.

Fahmi, A. H. and H. A. Sharara (1950). Studies on Egyptian "Domiati" cheese. J. Dairy Res., 17: 312.

Farag, S. I., N. A. El-Saify and A. I. Hamed (1988). Microbiological and chemical studies on pickled Domiati cheese treated with some ripening factors. Menofiya J. Agric. Res., 13: 1845.

Giese, J. (1996). Fat, oils and fat replacers. Food Techol., 50 (4): 78.

Haque, Z. U. and K. J. Aryana (2002). Volatiles in low fat cheddar cheese containing commercial fat replacers. Food Sci. and Techn. Res., 8 (2): 188.

Kavas, G., G. Oysun, O. Kinik and H. Uysal (2004). Effect of some fat replacers on chemical, physical and sensory attributes of low-fat white pickled cheese. Food Chem., 88 (3): 381.

Kebary, K. M. K., A. I. Hamed, A. N. Zedan and Amal A. F. Beheary (2006 b). Manufacture of low fat Domiati cheese using Novagel. Egyptian J. Dairy

Sci., 34: 175 – 184.

Kebary, K. M. K., A. I. Hamed, A. N. Zedan and Amal, A. F. El-Beheary (2006 a). Impact of adding Avicel on the quality of low fat Domiati cheese Minufiya J. Agric. Res., 31 (4): 833 – 851.

Kebary, K. M. K., K. M. Kamaly, A. N. Zedan and A. Zaghlol (1996). Accelerated ripening of Domiati cheese by accelase and lipozyme enzymes. Egypt. J. Dairy Sci., 24: 75.

Koca, N. and M. Metin (2004). Texture, melting and sensory properties of low-fat fresh Kashar cheeses produced by using fat replacers. Inter. Dairy J., 14 (4): 365.

Kosikowski, F. V. (1966). Cheese and Fermented Milk Foods. Edward Brothers, Inc., Ann. Arbor., Mich., USA.

Ling, E. R. (1963). A Text Book of Dairy Chemistry. Vol. 2, 3 ed. Chapman & Hall, Ltd., London.

Mehanna, N. M., R. I. H. Al-Ahwal and A. F. Al-Khamy (2002). The use of recombinant chymosin in making Domiati cheese. Egypt. J. Dairy Sci., 30 (2): 191.

Steel, R. G. D. and J. H. Torrie (1980). Principles and Procedures of Statistics. A biometrical approach. 2nd Ed. McGraw-Hill Book Co., New York.

Williams, S. R. (1985). Nutrition and Diet therapy. Times Mirror / Mosluy, College Publishing, St. Louis, Toronto and Stanta Clara.

تصنيع الجبن الدمياطى منخفض الدهن باستخدام بدائل الدهون

خميس محمد كامل كعبارى[١] – رجب محمد بدوى[١] – سامى فاروق محمود[٢] – أحمد صابر السيسى[٢]

(١) قسم علوم وتكنولوجيا الألبان – كلية الزراعة – جامعة المنوفية – شبين الكوم

(٢) معهد بحوث تكنولوجيا الأغذية – مركز البحوث الزراعية – الجيزة

الملخص العربى

أجرى هذا البحث بغرض تصنيع الجبن الدمياطى المنخفض الدهن وذلك باستخدام بدائل الدهن ولذلك صُنّعت سبع معاملات ، حيث صُنّع الكنترول من لبن جاموسى يحتوى على ٥% دهن ، ولقد صُنّعت ست معاملات أخرى استبدل فيها ٢٠ ، ٤٠ ، ٦٠% من دهن اللبن إما باستخدام Dairy-Lo® وهو بديل دهن ذو أصل بروتينى أو باستخدام Littesse® وهو بديل دهن ذو أصل كربوهيدراتى ، ولقد استخدمت هذه البدائل بمفردها . ولقد أوضحت النتائج المتحصل عليها بعد تحليلها إحصائياً ما يلى :

- **أدى استبدال بدائل الدهون إلى زيادة نسبة الرطوبة والحموضة فى الجبن ، بينما أدت إلى خفض كمية الطاقة فى الجبن الناتج .**
- **أدى استبدال دهن اللبن بواسطة Dairy-Lo® إلى زيادة نسبة كلٍ من النيتروجين الكلى والرماد بينما أدى استخدام Littesse® إلى زيادة نسبة الكربوهيدرات .**
- **احتوت العينات التى صُنّعت باستبدال دهن اللبن بواسطة Dairy-Lo® على نسب أعلى من الأحماض الدهنية الطيارة الكلية والنيتروجين الذائب أعلى من تلك للجبن المصنعة باستخدام Littesse® وكذلك كانت أكثر قبولاً .**
- **تناقصت نسبة الرطوبة ونسبة النيتروجين الكلى بتقدم فترة التسوية بينما ازدادت نسب كلٍ من الأحماض الدهنية الطيارة والنيتروجين الذائب والكربوهيدرات والرماد ودرجات التقييم الحسى لكل معاملات الجبن .**
- **احتوت الجبن المصنعة باستبدال ٤٠% من دهن اللبن بواسطة Dairy-Lo® على أعلى نسب لكلٍ من الأحماض الدهنية الطيارة والنيتروجين الذائب وكذلك كانت أكثر المعاملات قبولاً .**

Table (1): Effect of fat mimetics on moisture, fat and total nitrogen during pickling of low fat Domiati cheese.

Cheese samples	Moisture content (%)					Fat content (%)					Total nitrogen content (%)				
	Pickling period (weeks)					Pickling period (weeks)					Pickling period (weeks)				
	0	2	4	6	8	0	2	4	6	8	0	2	4	6	8
C*	57.19	56.04	54.80	53.54	53.00	19.30	20.10	21.70	23.20	23.70	2.30	2.23	2.22	2.18	2.19
L_1	58.63	56.82	55.72	54.59	53.00	14.50	15.70	16.70	17.60	18.80	2.31	2.25	2.19	2.16	2.13
L_2	60.51	59.54	58.23	57.26	56.29	9.90	10.90	12.00	12.90	13.80	2.33	2.27	2.23	2.19	2.15
L_3	62.35	61.15	59.70	58.59	57.65	6.10	7.20	8.40	9.40	10.30	2.35	2.30	2.26	2.21	2.17
D_1	57.35	56.55	55.73	54.37	52.69	14.60	15.80	16.70	17.80	18.80	2.72	2.66	2.62	2.57	2.53
D_2	59.55	58.58	57.52	56.83	55.72	9.95	10.90	12.00	12.80	13.90	2.85	2.80	2.74	2.67	2.61
D_3	61.58	60.71	59.46	58.67	57.87	6.20	7.20	8.50	9.45	10.40	2.97	2.90	2.83	2.77	2.71

C* = Cheese made from 5.0% fat milk.
L_1 = Cheese made from 4.0% fat milk and adding 1.0% Littesse®.
L_2 = Cheese made from 3.0% fat milk and adding 2.0% Littesse®.
L_3 = Cheese made from 2.0% fat milk and adding 3.0% Littesse®.
D_1 = Cheese made from 4.0% fat milk and adding 1.0% Dairly-Lo®.
D_2 = Cheese made from 3.0% fat milk and adding 2.0% Dairly-Lo®.
D_3 = Cheese made from 2.0% fat milk and adding 3.0% Dairly-Lo®.

Table (2): Effect of fat mimetics on total carbohydrate, ash contents and calorific values during pickling of low fat Domiati cheese.

Cheese samples	Total carbohydrate content (%)					Ash content (%)					Calorific values (k.cal / 100 g)				
	Pickling period (weeks)					Pickling period (weeks)					Pickling period (weeks)				
	0	2	4	6	8	0	2	4	6	8	0	2	4	6	8
C*	2.42	3.01	2.54	2.46	2.40	6.42	6.63	6.78	6.83	6.89	242.06	249.82	263.86	274.24	278.78
L_1	6.13	6.46	6.81	7.14	7.68	6.61	6.67	6.80	6.89	6.94	213.94	224.54	233.42	242.08	254.24
L_2	8.06	8.33	8.71	8.94	9.22	6.67	6.75	6.84	6.93	6.98	180.78	189.34	199.72	207.74	215.92
L_3	9.83	10.17	10.62	10.93	11.15	6.73	6.81	6.87	6.99	7.06	154.18	164.16	187.64	184.68	192.66
D_1	4.02	3.91	4.00	4.47	5.31	6.70	6.79	6.88	6.99	7.08	216.80	225.64	233.06	243.56	254.92
D_2	5.55	5.76	5.99	6.23	6.51	6.79	6.92	7.03	7.13	7.24	184.39	192.50	201.00	208.16	217.66
D_3	6.43	6.62	6.89	7.00	7.12	6.87	6.99	7.12	7.23	7.35	157.20	165.20	176.18	183.65	191.12

*** See Table (1).**

Table (3): Effect of fat mimetics on titratable acidity, total volatile fatty acids (TVFA) and soluble nitrogen during pickling of low fat Domiati cheese.

Cheese samples	Titatable acidity					Total volatile fatty acids (TVFA)					Soluble nitrogen				
	Pickling period (weeks)					Pickling period (weeks)					Pickling period (weeks)				
	0	2	4	6	8	0	2	4	6	8	0	2	4	6	8
C*	0.29	0.35	0.38	0.43	0.51	7.3	13.4	16.2	19.7	21.5	0.25	0.40	0.43	0.52	0.660
L_1	0.28	0.36	0.41	0.47	0.52	4.8	7.5	11.7	13.8	14.9	0.22	0.35	0.40	0.44	0.55
L_2	0.29	0.36	0.42	0.48	0.54	5.3	8.6	12.4	14.5	16.0	0.23	0.37	0.43	0.49	0.60
L_3	0.28	0.35	0.43	0.50	0.55	3.7	5.6	7.6	9.10	11.0	0.22	0.33	0.39	0.42	0.52
D_1	0.35	0.41	0.47	0.52	0.53	6.2	9.8	14.1	17.2	18.0	0.24	0.39	0.44	0.50	0.62
D_2	0.35	0.42	0.46	0.50	0.56	7.1	12.5	15.9	20.0	21.7	0.27	0.42	0.47	0.56	0.69
D_3	0.36	0.43	0.48	0.52	0.58	4.8	7.9	11.8	14.0	15.4	0.22	0.36	0.42	0.46	0.57

*** See Table (1).**

Table (5): Statistical analysis of Domiati cheese properties.

Cheese properties	Effect of cheese treatments								Effect of storage period (weeks)					
	Mean squares	Multiple comparisons•							Mean squares	Multiple comparisons•				
		C♦	L_1	L_2	L_3	D_1	D_2	D_3		Fresh	2	4	6	8
Moisture content (%)	43.410*	G	E	C	A	E	D	B	45.585*	A	B	C	D	E
Fat content (%)	229.738*	A	B	C	D	B	C	D	36.712*	E	D	C	B	A
Total nitrogen (%)	0.388*	E	DE	D	D	C	B	A	0.090*	A	B	C	D	E
Total carbohydrate (%)	51.299*	E	C	B	A	DE	D	D	4.468*	D	CD	B	AB	A
Ash content (%)	0.190*	CD	CD	D	D	BC	B	A	0.345*	E	D	C	B	A
Titratable acidity (%)	0.009*	C	BC	ABC	ABC	AB	AB	A	0.110*	E	D	C	B	A
Total volatile fatty acids (TVFA) (1 ml 0.1 NaOH / 100 g cheese)	85.509*	A	E	C	F	B	A	D	298.483*	E	D	C	B	A
Water soluble nitrogen (%)	0.013*	B	D	BC	D	B	A	CD	0.256*	E	D	C	B	A
Total calories (cal/100 g)	10649.240*	A	B	C	D	B	C	D	2944.505*	E	D	C	B	A
Sensory evaluation (total scores)	311.414*	AB	C	C	D	B	A	C	78.286*	D	C	B	AB	A

♦ See Table (1).
* Significant at 0.05 level.
• For each effect the different letters in the same row means the multiple comparisons are different from each other, letter A is the highest mean followed by B, C, … etc.