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FETA CHEESE BASED ON PALM KERNEL OIL MODIFIED PRODUCTS AND SKIM MILK POWDER

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ABSTRACT

Four experimental batches of UF-Feta cheese were made by replacing milk fat with four commercial types of fractionated hydrogenated palm kernel oil to obtain about 40% fat /DM in the final product. A control batch contained anhydrous milk fat with the same fat content was prepared. Resultant cheese batches were pickled for 3 months at refrigerator temperature. Samples were analyzed when fresh and monthly during pickling period to study the effect of this treatment on gross composition, organoleptic properties and storage stability of resultant cheeses. The results showed that replacing milk fat with different modified fats, caused a significant increase in moisture content, while the T.S decreased. Moisture and lactose contents of the cheese decreased, while fat, protein and ash increased as pickling period progressed. Cheese flavour was enhanced in cheese containing different modified fats while the texture of cheese varied widely depending on the melting of the added hydrogenated fractions. Experimental cheese showed whiter colour and better appearance than the control. The results also indicated that replacing milk fat with different modified fats retarded fat oxidation during ripening period. Good quality and storage stability Feta cheese could be obtained by replacing milk fat with different fractionated hydrogenated plam kernel oil.

Key words: *cheese flavour enhancement, feta cheese, functional properties,milk fat substitutes, modified fats, ultrafiltration.*

1. INTRODUCTION

Feta cheese is a special type of white brined Greek cheese which is becoming increasingly popular worldwide. The popularity of this type of cheese is mainly due to its unique flavour and good digestability. The traditional variety of Feta was originally made only from sheep or goat milk by the conventional method. Today, most Feta is made from cow's milk either fresh or recombined using ultrafiltration technique. Thus, Feta is now a generic name for a family of similar cheeses made in many other countries, but lacking too much the typical Greek Feta flavour and digestibility. This may be mainly due to the differences in milk composition between sheep or goat milk and cow's milk. Sheep and goat milk composition differs in many aspects from cow's milk, particularly in milk fat composition. Milk fat of sheep and goat has significantly higher contents of medium chain triglycerides (MCTs) than cow's milk (Ha & Lindsay, 1991 and Haenlein,1996). Thus, sheep and goat cheeses with their normally higher contents of MCTs than cow's milk cheese appear to have a distinct advantage of both flavour and digestibility. Hence, it is claimed that part of the final characteristic flavour of cheese is developed from those components (Harper, 1959 and Haenlein, 1996). On the other hand, MCTs have a superior value in human nutrition because they are easily digested, rapidly absorbed and used directly as a quick energy without deposition as fats in body tissues (Babayan,1981; Kennedy 1991 and Varnam & Sutherland 1994).

Replacing milk fat with vegetable oils in soft cheese manufacture was suggested for providing the desirable qualities of traditional cheese varieties or for developing a new value-added cheese (El-Shibiniy *et al.*, 1983; Fayed *et al.*, 1988;Babayan & Rosenau, 1991 and Kameni & Mbanya, 1995).MCTs are widely distributed in lauric fats such as palm kernel oil (PKO),which is an important precursor for MCTs, because of its bland odour and taste as well as its good stability. PKO is also a versatile oil in terms of its varied functional properties which gives it a potential in many food systems. Moreover, the high fat technology such as selective hydrogenation, fractionation and interestrification, makes it possible to modify PKO giving a series of modified fats with different melting and crystallization characteristics from that of the origin. These new techniques could be tuned to produce fractionated hydrogenated palm kernel oil (FHPKO) tailored- made to suit almost any particular application. Many of these modified fats are commercially available now and are promoted for their utilization. Therefore, the aim of this work was to investigate the possibility of utilizing different types of FHPKO to replace milk fat in Feta cheese composition. The organoleptic properties and storage stability of the resultant cheese were assessed.

2. MATERIALS AND METHODS

2.1. Materials

2.1.1. Palm kernel oil modified fats

Four commercial types of fractionated, hydrogenated and refined palm kernel oil namely; Imco, Kerlo, Kerme and Kerhi were kindly supplied by Loders Croklaan, B.V., Wormerveer, Holland..

2.1.2. Milk fat

Imported anhydrous milkfat (99.8 % fat) from a Belgium origin was used.

2.1.3. Skim Milk powder

Spray dried -low heat - skim milk powder manufactured by Murray Goulburn Co., Australia with chemical composition of 1.25 % fat, 34-36% protein and 4% moisture was used to manufacture Feta cheese.

2.1.4. Stabilizer and emulsifier

A commercial stabilizer/emulsifier blend named Lacta 815 (consists of gelatin, carrageenan and mono- and diglycerides) was obtained from Misr Food Additives Co., Egypt. It was recommended for white soft cheese varieties manufactured by ultrafiltration, specially Feta to improve the water binding capacity in this type of cheese.

2.1.5. Acidulant

Glucono-delta-lactone (GDL) was obtained from Roquette Co., Feres of Lestrem, France.

2.1.6. Rennet

Thermolabile microbial milk clotting enzyme from *Mucor miehei*-strength 1/150 000 - supplied by Gist-brocades, France was used.

2.2. Methods

2.2.1. Preparation of pre-cheese

Skim milk powder was reconstituted at 45°C to give10 % T.S. Reconstituted skim milk was ultrafiltered at 50°C according to Maubois *et al.*, (1971) to ca 4 fold by CARBOSEP module UF-unit (Type 2 S 151 tubular, France) using zirconium oxide membrane with a total area of 6.8 m2. The inlet and outlet pressures were 5 and 3 bar, respectively. The resultant retentate was divided into 5 equal batches. Each of the 4 types of FHPKO was mixed separately with each of the first 4 batches to provide approximately 40 % fat / DM in the final product. Anhydrous milk fat was mixed with the last batch of retentate at the same rate and used to serve as a control. The mixes of all batches were homogenized separately at 60°C under pressure of 250kg/cm using a single stage homogenizer (Rannie, Copenhagen, Denmark). Then, they were pasteurized at 85°C/2 min., cooled rapidly to 5°C and aged at this temperature overnight.

2.2.2. Cheese manufacture

Each batch of retentate was mixed with 0.5% Lacta 815, 2.5% GDL, 0.02% $CaCl_2$ and salted with 3% NaCl followed by the addition of rennet preparation at the rate of 3g/100 kg of retentate. The renneted batches were placed into stainless steel containers and left for coagulation at 40°C. The resultant curd was cut to similar pieces and packaged into 500 ml plastic containers. Preheated salted permeate (6% NaCl) was poured on the cheese before covering the containers. They were then transferred to a refrigerated room (5-8°C) and held at this temperature for 3 months. The experiments were duplicated. The principal steps of the manufacture of Feta cheese from different FHPKO are briefly summarized in Figure (1).

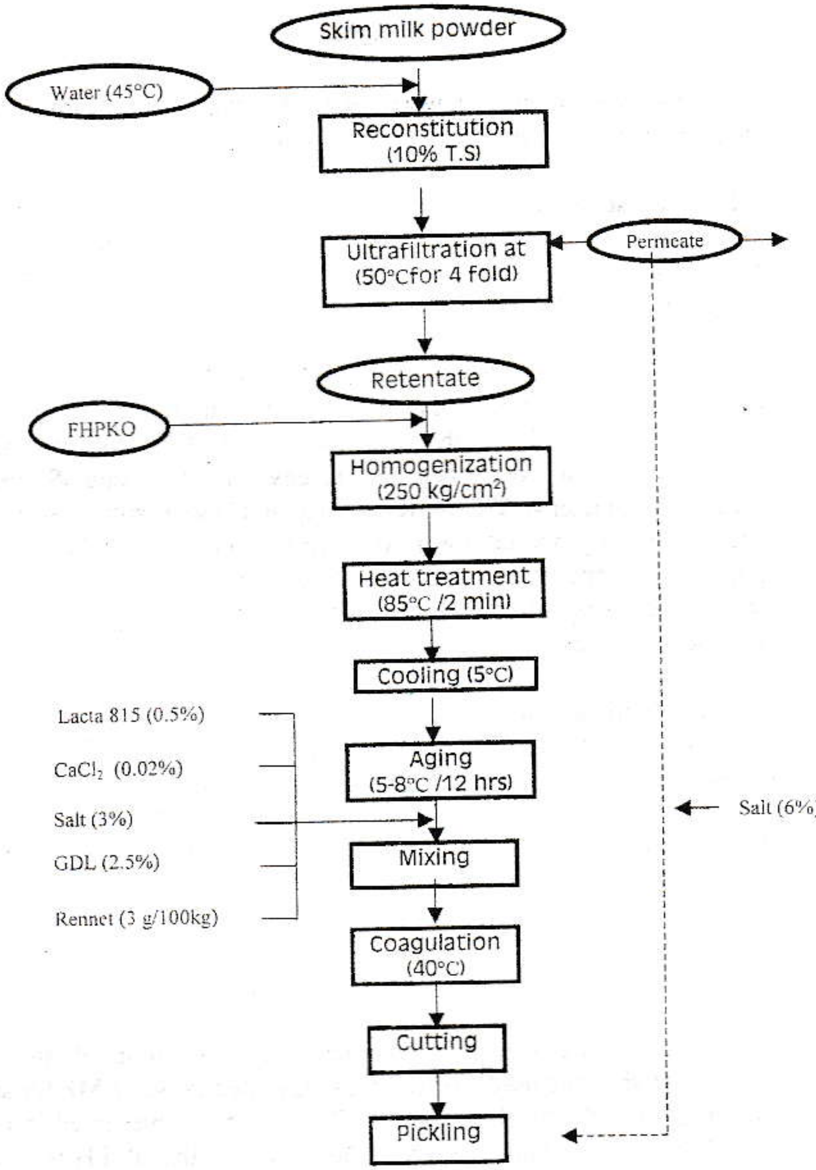

Fig. (1): A simplified diagram for manufacture of UF-Feta cheese from FHPKO and skim milk powder.

Samples of cheese were taken for chemical and organoleptic examinations when fresh and monthly during pickling period.

2.2.3. Cheese and fat analysis

Cheese samples were analysed for moisture, total protein and ash contents according to A.O.A.C. (1990). Fat content according to Ling (1963). Lactose as Nickerson *et al.*, (1975). Melting point (MP), free fatty acids (FFA%), peroxide value (PV) and iodine value (IV) of different fats were determined as described by the A.O.C.S. (1989). Colour of fats was measured using Lovibond Tintometer AF 900 with cell size of 5¼ inch. Thiobarbituric acid value (T.B.A) was estimated at 532 nm as described by Keeny (1971) using Shimadzu spectrophotometer -UV 240-, Kyoto, Japan. Cheese samples were also organoleptically scored for flavour (60 point), body and texture (30 point) and appearance (10 point) by regular score panel chosen from staff members of the Dairy Technology Department, Animal Production Research Institute.

2.2.4. Statistical analysis

Chemical and organoleptic results were statistically analyzed using the General Linear Models (GLM) procedure of SAS. A one-way ANOVA was conducted according to Snedecor and Cochran (1980). Mean comparison was performed with Duncan test at a probability level of ($P<0.05$). All data presented are means of three replicates.

3. RESULTS AND DISCUSSION

Due to the principal role of palm kernel oil modified fats in the present study, the used FHPKO was examined versus AMF for some physical and chemical properties. The results are presented in Table (1). From these results, it could be observed that all FHPKO were characterized by their lower densities in yellow colour than AMF. The yellowish colour in AMF is attributed to the high level of carotenoids present normally in cow's milk fat, while the light colour in FHPKO may be due to the efficiency of bleaching process which was carried out during refining.

FHPKO showed a wide variation in their melting points (MP) and iodine values (IV) among themselves. This is related to the extent of hydrogenation and the limits of fractionation to which each of them was subjected. The results also indicate that free fatty acids (FFA%) and peroxide value (PV) of different FHPKO were comparable to that of AMF. This reflects the good processes which were performed during production of these FHPKO.

Table (1):Some physical and chemical properties of different FHPKO compared with AMF.

Items		FHPKO**			
	AMF*	Imco	Kerlo	Kerme	Kerhi
Colour (Red / Yellow)	1.1/35	1.5/15	1.5/15	1.3/13	1.3/13
Melting point (°C)	32	27	32	35	37
FFA% (as oleic acid)	0.1	0.04	0.07	0.03	0.05
Peroxide value(meq.O_2/kg)	0.7	0.8	0.6	0.4	0.2
Iodine value	31	19	14	11	9

* AMF: Anhydrous milk fat.

** FHPKO: Fractionated hydrogenated palm kernel oil.

3.1. Gross chemical composition of Feta cheese

The changes in chemical composition of Feta cheese made by replacing milk fat with different palm kernel oil hydrogenated fractions are presented in Table (2). These results show that this treatment resulted in a significant ($p<0.05$) increase in moisture content of the resultant cheese. This increase was attributed to the melting of the added hydrogenated fractions. The lower melting fraction, the higher moisture content was in the final product. This may be due to the effect of vegetable fats on curd tension.These findings are in agreement with Hefny (1975), who reported that the use of maize oil in Domiati cheese weakened the formed curd and cheese retained high moisture content . The same trend was observed by Fayed *et al.*, (1988) when they substituted butter fat with palm oil in Domiati cheese making.

The obtained results indicate that moisture contents of various cheeses tended to decrease gradually as pickling period progressed. This decrease may be due to curd contraction as a result of developed

Table (2):Gross chemical composition of Feta cheese as affected by replacing milk fat with different FHPKO during pickling.

Constituents %	Pickling Period (months)	Treatments **				
		Control*	Imco	Kerlo	Kerme	Kerhi
Moisture	0	59.3[e]	61.1[a]	60.9[b]	60.8[c]	60.6[d]
	1	55.2[e]	57.9[a]	57.3[b]	57.1[c]	56.7[d]
	2	53.7[e]	56.8[a]	56.1[b]	55.8[c]	55.3[d]
	3	52.6[e]	56.1[a]	55.2[b]	54.9[c]	54.2[d]
Fat	0	16.5[a]	15.7[e]	15.8[d]	15.9[c]	16.1[b]
	1	19.1[a]	17.8[e]	18.1[d]	18.2[c]	18.6[b]
	2	20.2[a]	18.7[e]	19.1[d]	19.2[c]	19.7[b]
	3	21.5[a]	19.6[e]	20.2[d]	20.4[c]	21.0[b]
Total protein	0	15.1[a]	14.8[d]	15.0[b]	15.0[b]	14.9[c]
	1	15.8[ab]	15.5[e]	15.8[ab]	15.7[c]	15.6[d]
	2	16.2[a]	15.9[de]	16.1[b]	16.0[c]	15.9[de]
	3	16.5[a]	16.1[d]	16.4[b]	16.2[c]	16.2[c]
Lactose	0	5.2[a]	5.0[de]	5.1[bc]	5.1[bc]	5.0[de]
	1	4.1[a]	3.8[d]	4.0[b]	3.9[c]	3.9[c]
	2	2.7[ab]	2.3[e]	2.7[ab]	2.6[c]	2.4[d]
	3	1.2[a]	0.8[d]	1.1[b]	1.1[b]	0.9[c]
Ash	0	2.6[abc]	2.5[de]	2.6[abc]	2.6[abc]	2.5[de]
	1	3.4[abc]	3.2[e]	3.4[abc]	3.3[d]	3.4[abc]
	2	3.7[bc]	3.5[e]	3.8[a]	3.7[bc]	3.6[d]
	3	4.0[b]	3.8[d]	4.1[a]	4.0[b]	3.9[c]

*Feta cheese made with anhydrous milk fat.

**Feta cheese made with different fractionated hydrogenated palm kernel oil.

Mean of three replicates.

Means with the same letter are not significantly different.

acidity during ripening which may help to expel excess of the whey from cheese curd (El-Shibiny *et al.*, 1983 and Salem & Abeid, 1997). The results also indicated that fat content of Feta cheese was significantly ($p<0.05$) affected by replacing milk fat with different FHPKO. It could be noted that FHPKO contained cheese showed lower fat contents than the control. This may be due to the high loss of fat which presumably occurred either at any stage of manufacture or in pickling media throughout the ripening period. These results are in agreement with those reported by Hefny (1975) and Salem & Abeid (1997). The total protein in treated cheese showed a slight decrease as a result of this treatment than that of control. This probably is due to the increase of moisture content. While, lactose and ash contents were not greatly affected by this treatment.

In general, the major constituents of all cheeses included fat, protein and ash contents of all cheeses were gradually increased as pickling period progressed. This would possibly be resulted from the decrease of moisture during pickling. In contrary , lactose was highly decreased as pickling period advanced due to its fermentation. However, lactose did not totally disappear throughout the pickling period that extended up to three months. These results are nearly the same as obtained before by Fayed *et al.*, (1988).

3.2. Organoleptic properties of Feta cheese

The quality of Feta cheese was organoleptically examined throughout the pickling period and the scored results are given in Table (3). It is obvious that replacing milk fat with various FHPKO enhanced the flavour intensity of resultant Feta cheese to be more pronounced than that of the control cheese made from cow's milk fat. Success of FHPKO to develop almost typical original Feta flavour resulted directly from their higher contents of MCTs which are largely responsible for certain characteristic flavour of cheese , particularly Feta type cheese and indirectly from the change of the pattern of flavour released in the mouth. FHPKO have more steeper melting profiles than milk fat which has a gradual melting profile; this is partly a function of the narrow melting range of their component fatty acids, hence they melt readily in the mouth providing a good flavour release and mouthfeel (Harper,1959; Efthymiou & Mattick 1964 ; Ha & Lindsay,1991 and Painter *et al.*,1997).

In respect of the body and texture, the various treatments showed wide variation among themselves in their body and texture. This is due to the wide melting range of different FHPKO (27-37C.).The higher the melting hydrogenated fraction, the higher is the cheese firmness. This is related to the limit of fractionation and the extent of hydrogenation which each of them was performed during process. However, all treatment cheeses fall within the legal standards for Greek Feta cheese established by the National Dairy Committee of

Table (3): Organoleptic properties of Feta cheese as affected by replacing milkfat with different FHPKO during pickling .

Constituents	Pickling Period (months)	Treatments **				
		Control*	Imco	Kerlo	Kerme	Kerhi
Flavour (60)	0	40^{c}	41^{bc}	43^{a}	42^{ab}	41^{bc}
	1	43^{c}	45^{b}	47^{a}	46^{ab}	45^{b}
	2	47^{c}	50^{b}	52^{a}	51^{ab}	51^{ab}
	3	53^{c}	57^{b}	59^{a}	58^{ab}	57^{b}
Body & Texture (30)	0	23^{a}	20^{b}	23^{a}	22^{a}	20^{b}
	1	24^{a}	21^{b}	25^{a}	24^{a}	22^{b}
	2	26^{a}	23^{b}	27^{a}	26^{a}	23^{b}
	3	28^{a}	25^{b}	28^{a}	28^{a}	25^{b}
Appearance (10)	0	5^{b}	8^{a}	8^{a}	9^{a}	9^{a}
	1	6^{b}	8^{a}	9^{a}	9^{a}	9^{a}
	2	7^{b}	9^{a}	9^{a}	9^{a}	10^{a}
	3	7^{b}	9^{a}	9^{a}	9^{a}	10^{a}
Total (100)	0	68^{b}	69^{ab}	74^{a}	73^{ab}	70^{ab}
	1	73^{c}	74^{bc}	81^{a}	79^{ab}	76^{abc}
	2	80^{c}	82^{bc}	88^{a}	86^{ab}	84^{abc}
	3	88^{b}	91^{ab}	96^{a}	95^{a}	92^{ab}

*Feta cheese made with anhydrous milk fat.

**Feta cheese made with different fractionated hydrogenated palm kernel oil.
Mean of three replicates.

Means with the same letter are not significantly different.

Greece as mentioned by Anifantakis (1991). The body and texture characteristics of Feta cheese varied from creamy to crumbly or firm and hard depending on the type of milk used and the method of manufacture, *i.e.,* smooth creamy texture with perhaps internal openings such as so-called Structure Feta cheese or may be closed-structure without any cavities typically as Cast Feta cheese. The cheese is dry, brittle crumbly and/or spreadable, and also it should possess a sliceable body (Nielsen & Trout, 1981 and Kyle & Hickey, 1993). In spite of this wide variation in their textures, all treatment cheeses showed good spreadability. This is due to the quick melt-down characteristics of FHPKO which make their solid fat content curves fall sharply away at room temperature.

Concerning appearance of the resultant cheeses, replacing anhydrous milk fat with different FHPKO resulted in Feta cheeses characterized by whiter and brighter colour than the control which had a yellowish colour. The yellow colour of the control cheese is mainly attributed to the high level of carotene present naturally in cow's milk fat, while the quite white colour of FHPKO cheeses is due to the efficiency of bleaching process which FHPKO were subjected to during refining. For white soft cheese varieties, particularly Feta, the white colour is an important criterion in cheese acceptability. Yellow colour in this type of cheese is considered a disadvantage. Original Feta which is made from sheep milk is normally whiter in colour than similar cheeses made from cow's milk (Mallatou *et al.*, 1993 and Moran & Rajah, 1994). Thus, Feta cheeses made with different FHPKO gained significantly ($p<0.05$) higher scoring points for appearance than the control.

Optimum cheese flavour, body texture and appearance were obtained from experimental cheeses contained FHPKO with middle melting. In general, the overall acceptability of both treatment and control cheeses was considerably improved with progression of pickling period.

3.3. Storage stability of Feta cheese

The changes in peroxide value (PV) and thiobarbituric acid value (TBA) were considered as indices for the storage stability of Feta cheese made by replacing milk fat with different palm kernel oil hydrogenated fractions during pickling period (Figs.2 and 3). The results indicated that the PV and TBA values were increased gradually as pickling period progressed. These values increased slowly during the first two months of pickling, then they increased rapidly toward the end of pickling period. It is obvious from Figure (2) that the PV values for all cheese samples were still increasingly developed and did not reach yet the break down stage till the end of pickling period under storage conditions. The rate of changes in these values was proportional with initial IV of the different FHPKO used for cheese manufacture (IV 9 - 19). The higher the IV fraction, the higher the PV and TBA values development in the final product. These results are in agreement with those reported by Khalifa and Mansour (1988).

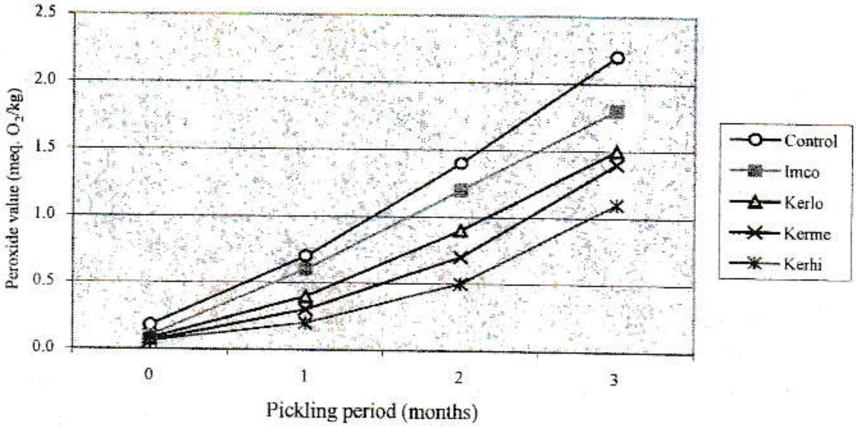

Fig. (2): Peroxide values of Feta cheese made by replacing milkfat with different FHPKO during pickling.

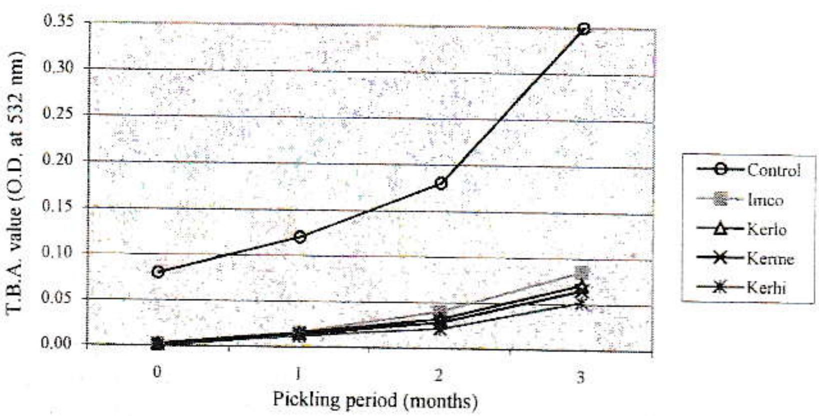

Fig. (3): Thiobarbituric acid values (T.B.A) of Feta cheese made by replacing milkfat with different FHPKO during pickling.

All experimental cheeses showed arelatively lower PV and TBA values than control cheese made with milk fat along the pickling period. This could explained on the basis that, although some FHPKO may have melting points relatively lower than milk fat, they actually have higher level of saturated triglycerides than milk fat, but many are of medium chain triglycerides. Hence, the physical state of any fat does not necessarily indicate the degree of its saturation, but the length of the carbon chains is also an important factor in this respect (Timms, 1985 and Moran & Rajah 1994). Thus, increasing the level of saturated triglycerides in cheese by incorporation of FHPKO led to a retardation of the oxidative changes during storage.

CONCLUSIONS

The foregoing results clearly indicated that the different types of palm kernel oil hydrogenated fractions could be used successfully to replace milk fat in Feta cheese manufacture imparting almost typical Greek Feta flavour coupled with enhancing its storage stability. The resultant cheese may be more favourite than that made from cow's milk fat for consumers who are accustomed to the original Feta flavour and wish the Greek Feta as a cheese option. FHPKO Feta cheese with its higher content of MCTs than cow's milk cheese has a superior value for other people who are restricted by the type of fat they are able to tolerate such as those suffering from various malabsorption syndromes. This cheese is also considered a quick available energy source for premature infants and surgery patients who are requiring caloric`-dense diets. When considering the forms in which these cheeses can be used, their varied texture becomes very important for their use in a wide rang of food applications. For instance, Feta cheese which had a soft creamy-smooth texture can be used for salads, deserts, sandwiches and cooking dishes. Cheese with a semi-hard crumbly texture may be excellent for dressing and snacking. Firm body and hard flaky texture cheese may be suitable as an appetizer particularly when extra salt and some spices or herbs are added. While, cheese with over-firm hard brittle texture, it may be a wonderful for grating over pasta.

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الجبن الفيتا المصنع من منتجات زيت نوى النخيل المعدلة واللبن الفرز المجفف

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ملخص

استهدف هذا البحث دراسة تأثير استخدام منتجات زيت نوى النخيل المعدلة كمصدر للدهن في الجبن الفيتا المصنع بنظام الترشيح الفائق على التركيب الكيماوي والخواص الحسية والثبات أثناء التخزين للجبن الناتج. استبدل دهن اللبن بأربعة أنواع مختلفة من مشتقات زيت نوى النخيل المهدرجة جزئيا بحيث تعطي حوالي ٤٠% دهن/المادة الجافة في المنتج النهائي. خزن الجبن الناتج لمدة ثلاثة شهور على درجة حرارة الثلاجة، وتم تحليل عينات الجبن الطازج والجبن المخزن شهريا خلال فترة التخزين.

أشارت نتائج التحليل إلى أن استبدال دهن اللبن بمشتقات زيت نوى النخيل المهدرجة أدى إلى حدوث ارتفاع معنوي في نسبة الرطوبة مع انخفاض في نسبة الجوامد الكلية في جبن المعاملات عنه في جبن المقارنة سواء في الجبن الطازج أو الجبن المخزن. كما أظهرت جميع عينات الجبن ارتفاعا تدريجيا في نسب كل من الدهن والبروتين الكلي والرماد مع انخفاضا تدريجيا في نسبة كل من الرطوبة وسكر اللاكتوز مع تقدم فترة التخزين.

وأشارت نتائج التحكيم الحسي لعينات الجبن الناتج أن استبدال دهن اللبن بمشتقات زيت نوى النخيل المختلفة أدى إلى زيادة حدة النكهة المميزة لهذا النوع من الجبن عنه في جبن المقارنة. كما أظهرت النتائج وجود اختلافات واسعة بين جبن المعاملات بعضها البعض من حيث القوام والتركيب تبعا لدرجات انصهار مشتقات زيت نوى النخيل المختلفة وقد كان المظهر العام لجبن المعاملات أقرب ما يكون للجبن الفيتا الأصلي عن جبن المقارنة. هذا وقد أدى استبدال دهن اللبن بمشتقات زيت نوى النخيل المختلفة إلى تقليل معدل تطور الأكسدة في جبن المعاملات عنه في جبن المقارنة أثناء التخزين.

والخلاصة أنه يمكن إحلال مشتقات زيت نوى النخيل المعدلة محل دهن اللبن لإنتاج جبن فيتا ذي مواصفات جودة وقوة حفظ أعلى من نظيرها المصنعة باستخدام دهن اللبن البقري.

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