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LIPOLYSIS AND OXIDATIVE STABILITY OF FAT IN ULTRAFILTERD WHITE SOFT CHEESE CONTAINING VEGETABLE OILS

Abd El-Fattah, A.M.
Dairy Science and Technology Department, Faculty of Agriculture, Cairo University.

ABSTRACT

Ultrafiltered white soft cheese containing different vegetable oils was made from buffaloes skim milk retentate homogenized with palm, palm kernel, coconut, shortening and sunflower oils. Control was made by homogenized retentate with buffalo butter oil. Also, three different commercially produced ultrafiltered white soft cheese-containing vegetable oils were procured from Egyptian dairies. Fat was extracted from cheese and analyzed for peroxide value (P.V), thiobarbituric acid (TBA) and acid value (A.V). Total volatile fatty acids (TVFA) and organoleptic properties of cheeses were assessed during storage at 7±1°C for 3 months.

Coconut oil containing cheese showed the highest lipolysis compared to other cheeses. Its TVFA and A.V were 3.81& 0.34; 5.49 & 0.67; 13.11 & 1.34 and 23.25 & 3.04 when fresh,1,2 and 3 months old, respectively. Sunflower oil containing cheese showed the highest oxidation compared to other cheeses. Its P.V and TBA values were 6.23 & 0.017; 9.67 & 0.031; 15.41 & 0.051 and 26.78 & 0.103 when fresh,1,2 and 3 months old, respectively. Palm kernel oil containing cheese showed the lowest lipolysis and oxidation as it had significantly low values for TVFA, A.V, P.V and TBA compared to other cheeses. Commercial cheese samples showed similar trends of variations but with lower values for TVFA, A.V and TBA and higher values for P.V than experimental cheeses. Organoleptically, oily flavour was observed in fresh vegetable oil cheeses especially on the use of sunflower oil. During storage, oily flavour was reduced in all vegetable oil cheese samples except for sunflower oil cheese where oily flavour persisted all through storage.

INTRODUCTION

Vegetable oils are usually preferred for human consumption because they are free from cholesterol, which is highly undesirable in human diet. Also, the use of vegetable oils reduces the production cost of field dairy products. Several investigators (El-Shibiny *et al.*, 1983; Strugnell, 1993 and During *et al.*, 2000) studied the replacement of milk fat with vegetable oils in making different cheeses.

The major problem related to the use of vegetable oils in dairy products is that they are easily oxidized and can form undesirable compounds such as peroxides and aldehydes (During *et al.*, 2000).

Furthermore, primary products of lipid oxidation are odorless and tasteless hydroperoxides, which can be degraded into secondary oxidation products such as carbonyls and hydrocarbon compounds or free radicals (Christensen and Holmer,1996). Free radicals may play a causative role in many diseases including cancer, atherosclerosis, inflammatory diseases, cataracts and aging (Papas, 1999).

The use of different vegetable oils in white soft cheese making was allowed in Egypt. The Egyptian standards (ESO, 2002) for white soft cheese has emphasized that peroxide value (P.V) of the cheese fat should not exceed that of the vegetable oil used.

Several studies had been carried out on fat oxidation of some dairy products e.g. butter, butter oil or samn. However, little information is available on the stability of fats and oils in cheese towards lipolysis and oxidation (Hamed *et al.*, 1987). Therefore, this work has been designed to investigate the effect of milk fat replacement with some vegetable oils on the lipolysis and oxidative stability of white soft cheese made from ultrafiltered milk.

MATERIALS AND METHODS

Materials:

Samples of white soft cheese containing vegetable oil were collected from three different Egyptian companies (A,B,C) which use different sources of vegetable oils. All samples (ten from each company) were kept at 7±1°C for 3 months.

Palm oil was obtained from Misr Gulf Oil Processing Co., Attaka, Suez, Egypt, shortening (100% refined palm oil) and coconut oil were obtained from Savola Sime Egypt Co., Sokhna Rd., Suez, Egypt, palm kernel oil was obtained from Premium, Malizia and sunflower oil was obtained from Arma Food Ind., 10 th of Ramadan city, Egypt.

Fresh buffaloes milk was obtained from the herd of Cairo University. Fresh raw milk was skimmed into skim milk and cream. Cream was churned into butter. Butter was melted at 55°C and the clear butter oil layer was carefully decanted. Skim milk (9.8 % T.S & 0.1% fat) was ultrafiltered (concentration factor 3.5) using Carbo-sep 2s151 ultrafiltration unit at 50°C and inlet and outlet pressure of 5 and 3 bar, respectively.

Experimental procedure:

Butter oil or one each of the vegetable oils mixed with the buffaloes skim milk retentate to give 35% T.S, 18% fat, 10.8% protein and 4.1% lactose in the final product. These mixtures were then homogenized at 70°C and pressure of 150 bar using a homogenizer (Rannie, Denmark).

The homogenized pre-cheese concentrate was heated to 85°C and cold immediately to 40°C, salt was added at the rate of 5% and rennet powder (STAMIX 1150, Denmark) at the rate of 2 g/100 kg, and then dispensed into plastic containers and left to coagulation at 40°C within about 40 – 50 min. The resultant cheeses (pH 6.53 – 6.58) were stored in brine solution at 7±1°C for 3 months and monthly analyzed.

Methods of analysis:

The cheese samples of all treatments were analyzed for total solids, fat, protein and pH according to AOAC (1990). Lactose content was determined according to Barnett and Abd El-Tawab (1957) and total volatile fatty acids (TVFA, expressed as ml 0.1 N NaOH/10 g cheese) were determined according to Kosikowski (1982).

Cheese samples were homogenized with distilled water and centrifuged at 10000 xg for 15min to separate fat layer, then melted at 55°C and the clear oil layer was carefully decanted. Separated fat was immediately analyzed for P.V and A.V (AOAC, 1990) and TBA (Keeney, 1971).

The sensory properties of cheese samples were assessed by 10 panel members of the Dairy Science Department, Faculty of Agriculture, Cairo University for flavour (60), body & texture (30) and appearance (10) as reported by El-Koussy (1966).

Three replicates of each treatment were manufactured and subjected to analysis. Statistical analysis for the obtained data was carried out using the Statistical Analysis System (SAS, 1994).

RESULTS AND DISCUSSION

As shown in Table (1), the type of oil had no significant influence on TVFA of fresh cheeses. During storage, TVFA content significantly increased in all treatments at different rates depending on the oil used. Cheese with coconut oil showed the highest TVFA value followed by that of butter oil. However, no significant differences were found in TVFA values between cheeses made with palm, sunflower oils and shortening. Cheese manufactured with palm kernel oil had the lowest TVFA value. The TVFA of collected cheese samples showed almost the same trend as the experimental cheeses containing the same oils. Our results are partly in agreement with those given by Taha *et al.* (1997) and During *et al.* (2000). The first authors mentioned that Labneh manufactured with olive oil had the highest TVFA value followed by that of corn and sunflower oils. The second authors reported that the lipolysis was positively correlated with cheese ageing and was significantly higher (>2.5-fold) in cheese containing mixed milk fat, sunflower oil and soyabean oil (25:50:25) than control cheese at days 12, 32 and 57.

Table (1): Changes in the TVFA of ultrafiltered white soft cheese containing vegetable oils during storage at 7±1°C

Cheese samples	TVFA (ml 0.1 N NaOH/10 g fat) Storage period, month			
	Fresh	1	2	3
Experimental:				
Butter oil (control)	3.96	4.06	8.13	16.96
Palm oil	3.91	3.98	7.03	12.01
Shortening	3.59	4.74	7.61	13.57
Palm kernel oil	3.97	4.11	6.59	9.13
Coconut oil	3.81	5.49	13.11	23.25
Sunflower oil	4.26	5.19	7.26	12.41
Collected:				
(A) Palm oil	3.42	3.91	6.28	10.17
(B) Palm kernel oil	3.24	3.84	6.11	7.19
(C) Coconut oil	3.68	4.19	9.04	14.12

L.S.D of experimental treatments = 2.732 (P<0.95)

As for A.V, Table (2) shows that the fresh cheeses containing butter oil and coconut oil had the highest A.V, while non-significant differences were found between the A.V of other fresh experimental cheeses. The A.V increased significantly until the end of the storage period. This might be due to the partial activity of lipolytic enzymes. The cheese containing coconut oil gave the highest value, followed by sunflower oil cheese. On the other hand, the cheese containing palm kernel oil recorded the lowest A.V during storage. Collected cheese samples had the same trend of their corresponding experimental cheese samples.

Table (2): Changes in the A.V of ultrafiltered white soft cheese containing vegetable oils during storage at 7±1°C

Cheese samples	Acid value (mg KOH / g oil) Storage period, month			
	Fresh	1	2	3
Experimental:				
Butter oil (control)	0.37	0.47	0.60	1.14
Palm oil	0.17	0.28	0.63	1.28
Shortening	0.12	0.28	0.57	0.95
Palm kernel oil	0.18	0.26	0.37	0.63
Coconut oil	0.34	0.67	1.34	3.04
Sunflower oil	0.10	0.40	1.12	2.58
Collected:				
(A) Palm oil	0.32	0.37	0.55	0.77
(B) Palm kernel oil	0.26	0.31	0.51	0.64
(C) Coconut oil	0.39	0.44	0.73	0.93

L.S.D of experimental treatments = 0.531 (P<0.05)

Results presented in Table (3) indicate that the average P.V of fresh cheeses was affected by the use of different oils. The P.V was 3.04 mEq. Peroxide/ kg oil in fresh cheese containing palm kernel oil where it was 6.23 in cheese containing sunflower oil. This is obviously due to the high levels of polyunsaturated fatty acids in sunflower oil, which are easily oxidized (Anwar *et al.*, 2003). The P.V of fresh commercial cheeses was higher than that of its corresponding experimental cheeses. The P.V increased gradually in different experimental and collected cheese samples with extended storage with higher values in collected samples than corresponding experimental cheese samples. The rate of increase was slow in the first 2 months, which may be considered as the induction period. This may be due to the natural antioxidant originally present in these oils such as vit. E (Zommara and El-Shaer, 2001). Immediately after the end of this induction period, the P.V increased rapidly in all cheeses as a result of progressive and fast oil oxidation. On comparing all cheese samples at the end of storage, sunflower and coconut oil cheeses gave the highest P.V, palm kernel oil cheese gave the lowest P.V, while the P.V of shortening, butter and palm oil cheeses was in between with non-significant differences between these samples. This agrees with data of Anwar *et al.* (2003), who found that the oxidative stability at 110°C for sunflower and palm oils, the induction periods were 3.7and 19.95 h, respectively.

Table (3): Changes in the P.V of ultrafiltered white soft cheese containing vegetable oils during storage at 7±1°C

Cheese samples	Peroxide value (mEq. Peroxide/ kg oil)			
	Storage period, month			
	Fresh	1	2	3
Experimental:				
Butter oil (control)	4.26	5.18	7.33	16.31
Palm oil	3.90	4.59	6.40	14.92
Shortening	4.32	5.07	6.32	14.63
Palm kernel oil	3.04	4.39	5.53	11.35
Coconut oil	5.59	8.24	13.62	23.45
Sunflower oil	6.23	9.67	15.41	26.78
Collected:				
(A) Palm oil	7.60	9.81	14.43	17.60
(B) Palm kernel oil	3.44	6.40	11.25	14.21
(C) Coconut oil	9.31	12.11	16.50	24.42

L.S.D of experimental treatments = 3.104 (P<0.05)

Concerning the TBA value, Table (4) shows a slight increase during the early stages of the induction period followed by a high increase towards its end. Results also indicated that the TBA value was greater in sunflower oil cheese, while it was lower in palm kernel oil cheese than that of the other treatments during storage. Collected cheese samples had a similar trend with higher TBA when fresh, 1 and 2 months old beyond which it was lower than that of their experimental corresponding cheeses. The present data of TBA partly agree with El-Kenawi (1977), who found that the cheese containing different proportions of hydrogenated cotton seed oil showed higher TBA values than the control.

Table (4): Changes in the TBA of ultrafiltered white soft cheese containing vegetable oils during storage at 7±1°C

Cheese samples	TBA (O.D at 532 nm)			
	Storage period, month			
	Fresh	1	2	3
Experimental:				
Butter oil (control)	0.009	0.013	0.024	0.066
Palm oil	0.007	0.014	0.021	0.061
Shortening	0.009	0.014	0.025	0.065
Palm kernel oil	0.007	0.011	0.021	0.051
Coconut oil	0.012	0.023	0.038	0.077
Sunflower oil	0.017	0.031	0.051	0.103
Collected:				
(A) Palm oil	0.013	0.018	0.027	0.053
(B) Palm kernel oil	0.011	0.019	0.023	0.046
(C) Coconut oil	0.021	0.027	0.041	0.067

L.S.D of experimental treatments = 0.0182 (P<0.05)

Replacing milk fat with vegetable oils imparted oily flavour to fresh cheese. The intensity of the oily flavour varies among the oils used and decreased with extended storage. It is worthy to note that none of the cheeses studied was rejected by the taste panel. These results are partly in agreement with El-Shibiny *et al.* (1983) and During *et al.* (2000), who found that fresh cheese containing vegetable oils had an 'oily' flavour that disappeared with ageing. It might be noticed from Table (5) that the fresh and stored cheese samples gained almost similar scores for their appearance and body & texture with no significant differences.

Table (5):Average scores for sensory properties of ultrafiltered white soft cheese containing vegetable oils during storage at 7±1°C

Cheese samples	Storage period, month	Appea-rance (10)	Body & Texture (30)	Flavor (60)	Total (100)
Experimental:					
Butter oil (control)	Fresh	9	25	50	84
	1	9	25	52	86
	2	9	26	53	88
	3	8	25	52	85
Palm oil	Fresh	9	24	45	78
	1	9	24	45	78
	2	9	24	47	80
	3	8	23	45	76
Shortening	Fresh	9	23	43	75
	1	9	23	44	76
	2	9	24	45	78
	3	8	24	44	76
Palm kernel oil	Fresh	9	23	48	80
	1	9	23	48	80
	2	9	24	50	83
	3	8	24	48	80
Coconut oil	Fresh	9	23	46	78
	1	9	23	47	79
	2	9	24	46	79
	3	8	24	44	76
Sunflower oil	Fresh	9	24	40	73
	1	9	24	40	73
	2	9	25	38	72
	3	8	24	36	68
Collected:					
(A) Palm oil	Fresh	8	24	50	82
	1	8	24	50	82
	2	7	22	50	79
	3	7	20	48	75
(B) Palm kernel oil	Fresh	8	24	51	83
	1	8	24	51	83
	2	7	23	50	80
	3	7	22	49	78
(C) Coconut oil	Fresh	8	23	50	81
	1	8	23	50	81
	2	7	21	49	77
	3	7	19	48	73

The scoring of cheese for flavour, showed that cheese made with butter oil (control) was superior and was highly accepted by panelists for its good flavour, body & texture and appearance when fresh and during storage. However, among the vegetable oils used, palm kernel oil was ranked highest scores and was much preferred than other oils as it had slight oily off-flavour and normal body & texture and appearance. On the other hand, sunflower oil cheese samples had a very strong oily off-flavour with highly significant differences when compared with others. Shortening, palm and coconut oils cheeses came intermediate and had some oily off-flavour. These results were related to changes in TVFA, A.V, P.V and TBA levels (Table 1, 2, 3 & 4) of these cheeses.

In general, there was a slight improvement in the organoleptic properties of all samples until 2 months of storage with the exception of sunflower oil cheese, which had oily off-flavour.

Regarding collected cheese samples, as shown in the same Table (5) all samples gained lower scores for their appearance and body & texture and higher scores for their flavour as compared with their corresponding experimental cheese samples, probably due to the existence of flavouring agents in the collected samples.

In conclusion, ultrafiltrated white soft cheese can be made with replacement of milk fat with vegetable oils, preferably palm kernel oil without affecting the oxidative stability of cheese, and lipolysis of palm kernel oil being low. More investigation should be done to prepare mixture of vegetable oils and milk fat with low cost, high oxidative stability, moderate lipolysis, acceptable flavour and fatty acid composition close to 'ideal' recommended for human diets. These could be applied to the production of a range of new more 'healthy' dairy products such as milk, yoghurts and cheeses and so open a new market for the dairy industry.

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التحلل الدهنى وثبات أكسدة دهن الجبن الأبيض الطرى المصنع من مركز الترشيح الفائق للبن المحتوى على زيوت نباتيه

علاء محمد عبد الفتاح ابراهيم

قسم علوم وتكنولوجيا الألبان – كلية الزراعة – جامعة القاهرة

يهدف هذا البحث الى دراسة التحلل الدهنى وثبات أكسدة دهن الجبن الأبيض الطرى المصنع من مركز الترشيح الفائق للبن باستخدام بعض الزيوت النباتية وكذلك لعينات جبن نباتية الدهن تم جمعها من ثلاثة مصانع مختلفه. وصممت معاملات التجربه على أساس استبدال دهن اللبن بالكامل بكل من زيت النخيل، نواة النخيل، جوز الهند، عباد الشمس والشورتنج. وتم خلط كل من دهن اللبن والزيوت النباتية بنسبة ١٨% مع مركز الترشيح الفائق للبن ثم التجانس وتصنيع الجبن الطرى وتخزين الناتج على ٧±١°م لمدة ثلاثة شهور. وقد أجريت التحاليل على الجبن الناتج والدهن المستخلص منه حيث تم استخلاص الدهن من الجبن لتقدير كل من رقم البيروكسيد (P.V) ، والثيوباربتيوريك (TBA) ، رقم الحموضة (A.V) بينما فى الجبن تم تقدير كل من الأحماض الدهنية الطيارة (TVFA) ، الخواص الحسية.

وقد أظهرت النتائج أن الجبن المصنع من زيت جوز الهند حصل على أعلى قيم معنويه للتحلل الدهنى لكل من الـ TVFA ، A.V بينما حصل الجبن المصنع من زيت عباد الشمس على أعلى قيم معنويه لحدوث الأكسدة لكل من الـ P.V ، TBA مقارنة بالمعاملات الأخرى. أما الجبن المصنع من زيت نواة النخيل فقد حصل على أقل القيم معنويا للتحلل الدهنى والأكسدة لكل من الـ TVFA ، A.V ، P.V □ TBA. وقد أخذت عينات الجبن المجمع من المصانع المختلفة نفس الاتجاه مع قيم أقل لكل من الـ TVFA ، A.V ، TBA وقيم أعلى للـ P.V مقارنة بعينات التجربة المصنعة من نفس الزيوت. وحسبا لوحظ وجود طعم زيتى فى عينات الجبن الطازج خاصة المصنعة من زيت عباد الشمس ولكن أثناء التخزين حدث انخفاض فى حدة هذا الطعم لجميع العينات ما عدا الجبن المصنع من زيت عباد الشمس.