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Palm Kernel Oil as a Substitute of Milk Fat in Feta Cheese

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ABSTRACT

Four samples of Feta cheese 5 Kg/each made by substituting buffalo milk fat with palm kernel oil (PKO). The substituting ratios were 25%, 50%, 75% and 100% (PKO) to milk fat (MF). Fat content of the obtained cheese was 40% fat/dry matter. A control batch contained milk fat with the same fat content was prepared. The resultant cheese samples were stored at room temperature for three months. Samples were analyzed monthly during pickling period to investigate the effect of the treatment with (PKO) on cheese yield, gross composition, organoleptic properties and the changes in fatty acids pattern of fat content of the resultant cheese samples. The results showed that substituting of milk fat with different ratios of (PKO) caused a significant increase in moisture content, when compared with the control, while the total solids decreased. Cheese yield of all cheese treatments decreased as pickling period progressed. Moisture content of the cheese decreased, whereas fat, total protein and ash contents increased as pickling period progressed. Cheese flavor was enhanced in cheese containing different ratios of (PKO), while the texture of cheese widely depended on the ratio of (PKO) added. Cheese samples showed a similar color and appearance to the control.The changed occurred in fatty acids pattern of the examined samples showed that the addition of (PKO) as a milk fat substitute at ratios 25%, 50%, 75% and 100%, resulted in an increase in the total medium chain fatty acids of the cheese fat when compared with milk fat. Cheese samples treated with 25% and 50% (PKO) were of the higher score of the acceptability due to the presence of medium chain fatty acids. It could be concluded that the use of (PKO) as buffalo's milk fat substitute succeeded in making Feta cheese of healthy and of acceptance for the consumers..

INTRODUCTION

Vegetable oils were widely used in cheese making, which so called imitation cheese or vegetable oil-based cheese (Ya and Hammond (2000). Trans fatty acids showed an increase in cholesterol levels in blood. It was regarded as a milk factor for increasing coronary heart diseases and others cholesterol. Juttlestad (2004). The increased consumer demand for healthy products has encouraged substitution of milk fat by vegetable oil in dairy products. New verities of cheese have been made by using vegetable oils which so called imitation cheese or vegetable oil- based cheese. (Ya and Hammond 2000).

There are different vegetable oils that can be used to substitute milk fat. In Egypt market, shortening, coco butter substitute, palm oil and coconut oil are the main commercial oils that are used for manufacture of vegetable oil-based cheeses (Karabulut and Turan 2006 and Abd El-Gawad *et al.* 2015). Feta cheese is a special type of white brined cheese. The traditional variety of feta was originally made only from sheep or goat milk. Today, most of feta is made from cows or buffaloes milk using ultrafiltration technique. Because of the leaking of the typical feta flavor which mainly due to the differences in milk composition between sheep or goat milk and cows or buffalos milk, particularly in milk fat composition. Milk fat of sheep and goat has significantly higher contents of medium chain triglycerides than cows and buffaloes milk. (Ha & Lindsay, 1991). Thus, sheep and goat cheeses with their normally higher content of medium chain triglycerides than cows or buffaloes milk cheese appear to have a distinct advantage of both flavor and digestibility. Hence, it is claimed that part of the final characteristics flavor of cheese is developed from those components, (Haper 1959 and Haenlein 1996). On the other hand medium chain triglycerides have distributed in lauric fats such as PKO, which is an important precursor for medium chain triglycerides, because of its bland odor and taste, as well as its good stability, (Abd El- Khair and Abd El-Malek 2001).

The problems faced with the manufacture of buffaloes milk cheese are lack of characteristics of soft body and velvety texture, longer ripening period and lack of typical flavor (Burde and Srinivasan, 1967; Jha and Kanawjia, 1985; Srinivasan and Burde, 1967, and Kanawjia and Singh 1988, 1992). On the other hand, the white color of buffalo milk is one of the typical characteristics of good quality of feta cheese (Sangeev Kumar *et al.* 2014).

Furthermore, Noor lida Habi Mat Diaan *et al.*(2017) reported that PKO which is derived from the flesh of the oil palm fruits' kernel is of high content of lauric acid and has a sharp melting, a charactersiticable for use in confectionery fats. Fractionation of palm oil (PO) into palm stearin (POs) and palm olein (POo), and PKO into palm kernel stearin (PKOs) and palm kernel olein (PKOo) further enhances the usage of POand PKO in foods. PO and POo, due to their high content of oleic acid and natural antioxidant (vitamin E) have excellent oxidative stability, hence, are a superior cooking and frying oil. POs which is available in a wide range of saturation level serves as a good hardstock for trans-free solid fat product formulations. Blending of POs with PKO or PKOo and liquid oils such as super POo, sunflower or soybean oil produces solid fat products such as bakery margarine/shortening, table margarine/spreads, pastry/l aminating fats of excellent functional, textural and storage properties. this investigation was aimed to study the effect of replacing buffalo milk fat by (PKO) to decrease the saturated long chain palmitic acid ($c_{16:0}$) and increase the medium chain louric acid($c_{12:0}$) to obtain more healthy and accepted cheese.

MATERIALS AND METHODS

1-Materials

a- Imported palm kernel oil was purchased from the local market(Al Monz brand, Indonesia).
b- Buffaloes milk was obtained from the Animal Production Research Institute, Mehalet Mousa station, Kafr El Sheikh governorate / Egypt.
c- Rennet : Microbial rennet powder was obtained from Danisco France. SAS.
d- Salt: Commercial fine grade salt was obtained from El-Nasr company – Egypt.

2- Methods

Buffalo's milk was pasteurized at 72 ^{o} C. / 15 Sec., cooled to 50^{o} C., then separated using Alfa – Laval separator to obtain buffalo cream and skim milk. Buffalo's

skim milk was subjected to the ultrafiltration (carbosep-tech-Sep-France) technique to obtain concentrated skim milk 1:4 concentration. MF and PKO were added to the concentration as follow:-

A- Five liters of concentrated skim milk mixed with cream to obtain 40% milk fat /dry matter (Control).

B- The rest of concentrated milk was divided into four parts. Every part was treated with PKO and milk fat at the ratios of 25 % PKO + 75 % milk fat, 50% PKO + 50 % milk fat, 75% PKO + 25 % milk fat and 100 % PKO, to obtain a final pre cheese with 40% fat/dry matter. All samples were homogenized under pressure of 250 Kg/Cm using single stage homogenizer (Rannie, Copenhagen, Denmark.). with fat and then the salt (6%) was added and the rennet was also added at 40°C till the curdling.

Samples were packed in suitable lined with plastic tin containers including salted permeate (8%) sodium chloride and stored at room temperature. The samples were analysed at zero time and then every one month for three months of ripening period. Moisture, Total protein and ash contents were analysed according to A.O.A.C., fat according to Ling (1963). An actual yield of cheese samples was detected by using the following formula:

$$\text{Actual yield} = \frac{\text{Weight of cheese}}{\text{Weight of milk used to make cheese}} \times 100$$

Cheese samples were scored organoleptically for its flavor (60 points), body and texture (20 points) and appearance (10 points), by regular score panel chosen from staff members of dairy Department, Animal production research institute.

Fat was extracted using mixture of chloroform: methanol in the ratio of 2:1 and the solvents was evaporated under water-pump-vacuum at 30°C using rotational evaporator, Shemidt (1975). Gas chromatographic analysis used for detecting the triglycerides fatty acids of the obtained fat, which were converted to the corresponding methyl easter according to Shahin (1977). The determination of the resultant fatty acids methyl esters was carried out using a gas chromatograph, type Hewlett-Packard 5840 A, with double flame ionization detector and multi-level-temperature programmer provided with a HP 5840 A terminal. The conditions of the analysis were as described by Hamzawi and Shahin (1986), Columns used were a 20 inch stainless-steel packed with 10% U.C.W. on chromosorb W.AW, DMCS treated, 80-100 mish (Hewlett-Packard)- carrier gas used was nitrogen.

The condition of injection as follow: Programming temp. 140 - 230 ^{0}C., detection temp. 300 ^{0}C., injection port temp 230 ^{0}C., Carrier gas flow rate (N2) 40 ml/min., hydrogen flow rate 40 ml/min., and air flow rate 300 ml/min.

RESULTS AND DISCUSSION

The yield and losses of Feta cheese

Data presented in Table (1) show that the cheese yield of Feta cheese samples was influenced by replacing milk fat with (PKO). Cheese yield of all cheese treatments decreased by proceeding the pickling period. It decreased rapidly during the first 1 month of pickling followed by gradual decrease during 2 and 3 months. The lowest yield was recorded in the control. The obtained results may be due to the increase in fat content of milk, which leads to reduce the whey synersis from cheese curd. The increase of replacing milk fat ratios by (PKO) leads to increase loss of cheese weight till the end of storage period.

Table 1. Change of yield (%) and loss in weight (%) of Feta cheese by different substitution of PKO during storage period.

Storage period (month)	property	Treatments				
		Control	25 %	50 %	75 %	100 %
Fresh	Yield %	35	35	35	35	35
	Loss %	-	-	-	-	-
1	Yield %	30.7	30.5	30.4	29.7	29.5
	Loss %	12.3	12.9	13.1	15.1	15.7
2	Yield %	27.4	27.1	26.9	26.1	25.9
	Loss %	21.7	22.6	23.1	25.4	26.0
3	Yield %	25.2	24.8	24.5	23.5	23.2
	Loss %	28.0	29.1	30.0	32.9	33.7

Gross chemical composition of feta cheese:-

Changes occurred in the chemical composition of Feta cheese made by replacing milk fat with (PKO) are presented in Table (2). It could be revealed that by treating with (PKO) led to an increase in moisture content of all treated samples. The moisture increase might be attributed to the effect of added vegetable oil, and also to the homogenization effect, which is in agreement with Hefny (1975), Fayed *et al.* (1988), and Zamora *et al.* (2007).

Table 2. Gross chemical composition of Feta cheese made by replacing milk fat with different concentrations of PKO

Constituents	Pickling period / month	Replacing Ratios				
		Control	25 %	50 %	75 %	100 %
Moisture	0	60	60	60	60	60
	1	57	57	57	57.5	57.7
	2	55.2	55	55	56	56.8
	3	53.5	53.7	53.8	55	55.7
Fat	0	16	16	16	16	16
	1	18.9	18.5	18.3	18.1	18
	2	20.3	20	19.9	19.5	19
	3	22	21.5	21	20.7	20.5
Total Protein	0	15	15	15	15	15
	1	15.8	15.5	15.3	15.1	15.1
	2	16.5	16.3	16	15.7	15.6
	3	17	16.6	16.2	16	16
Ash	0	7	7	6.9	6.8	6.8
	1	7.4	7.3	7.2	7.1	7
	2	7.8	7.6	7.6	7.4	7.3
	3	8.2	8	8	7.7	7.6

Data in the same Table indicate that the moisture content of the cheese tended to decrease gradually as the pickling period progressed, which might be due to curd contraction as a result of the developed acidity during ripening, which may help to expel excess of the whey from the cheese curd. These findings agreed with those mentioned by El-Shibiny *et al.* (1983); and Salem & Abeid (1997) and Abd.El-Malek & Abed-El-Khair (2002).

Fat content of the examined samples was also affected by the partial substitution of milk fat with PKO.

The fat content slightly decreased in all treated samples compared with the control cheese, that might be due

to the loss of the fat being occurred at any stage of manufacture or pickling substrate throughout the ripening period. The obtained results came in agreement with those observed by Hefny (1975) and Salem and Abeid (1997).

The total protein in the treated cheese slightly decreased, compared with the control. On the other hand, the total protein gradually increased as the stage of pickling progressed. Ash content, however, was not markedly affected by the treatment, while it was increased in the control cheese and the treated samples as the pickling time progressed.

Generally, the major constituents of all cheese samples including fat, protein and ash contents characterized with gradual increase as the pickling period progressed. This could possibly due to the decrease of moisture content during the pickling period. These results are in agreement with those reported by Fayed et.al. (1988) and Abd.El-Malek & Abed-El-Khair (2002).

Fatty acids content of cheese:-

Table (3) demonstrates the content (%) of the individual triglycerides fatty acids in control and in the other treated with 25%, 50% and 75% and 100% PKO samples during the ripening period. From the results in Table it's clear that the fatty acids profile of PKO varied from that occurred in the milk fat (MF). Louric acid (C_{12}) represented the highest concentration of 48% in the PKO, whereas, palmitic ($C_{16:0}$), Steiaric ($C_{18:0}$) and Oleic ($C_{18:1}$) acids were the predominant fatty acids in milk, (Prateek Kumar & Theekar, 1995, and Ali,2016).

The content of short chain (C_4- C_8) fatty acids in each PKO and MF was 4.9 and 6.75 %, respectively, while the level of medium chain (C_{10}- C_{12}) fatty acids specially lauric (C_{12}) acid were markedly higher in PKO than that of MF, and The proportion of long chain (C_{14} through C_{18}) fatty acids, particularly, palmitic ($C_{16:0}$) and Oleic ($C_{18:1}$) acids were considerably higher in MF than that in PKO (Fox et.al. (1988) and Abed-El-Khair and Abd.El-Malek (2001). And Ali., (2016), concerning the total saturated fatty acids (TSFA) and unsaturated (USFA) fatty acids of PKO.

Concerning the total saturated fatty acids (TSFA) and unsaturated (USFA) fatty acids of PKO, it could be observed that PKO was of the highest content of TSFA (81.80 %), and the lowest content of USFA (18.20%), while the corresponding values in MF were 64.13% and 35.87 %, in the same order.

Table 3. Fatty acid content of feta cheese during ripening period in different substituting ratios for milk fat with palm kernel oil

Fatty Acids %	Milk fat	Palm Kernel oil	Ripening Period and Substitution Ratioes																			
			0					1st Month					2ed Month					3rd month				
			C	25%	50%	75%	100%	C	25%	50%	75%	100%	C	25%	50%	75%	100%	C	25%	50%	75%	100%
C_4	3.16	-	3.16	2	1.6	0.7	-	3.18	2.1	1.7	0.75	-	3.22	2.2	1.8	0.85	-	3.3	2.3	1.85	0.95	-
C_6	2.07	0.6	2.07	1.81	1.2	0.82	0.6	2.00	1.5	1	0.6	0.7	2.1	1.4	0.8	0.45	0.3	2.2	1.5	1	0.5	0.3
C_8	1.52	4.3	1.52	2.30	2.02	3.21	4.3	1.22	2.1	2.1	3.1	4.1	1.12	2	2.2	2.8	4.2	1.00	1.6	2.31	2.7	4.3
C_{10}	1.81	4.6	1.81	2.21	3.2	3.9	4.6	1.6	1.66	2.7	3.3	4.5	1.7	1.7	2.3	2.9	4.6	1.5	1.5	2	2.5	4.6
C_{12}	2.30	48.0	2.30	11.73	25.69	36	48	2.4	12	25.7	36.5	48.1	2.5	12.11	25.8	36.6	48.3	2.6	12.33	26	37.6	48.3
C_{14}	10.13	14.3	10.13	11.2	12.02	13.15	14.3	9.9	10.90	11.8	12.3	14.2	9.00	10.68	11.9	11.9	14.1	8.9	10.2	10.22	11	14
$C_{14:1}$	1.7	-	1.7	1.25	0.9	0.53	-	1.5	1.2	0.7	0.6	-	1.66	1.2	0.8	0.7	-	1.5	1.24	0.8	0.6	-
C_{16}	31.98	8.0	31.98	29	19.6	14.91	8	32	30	20.3	15.1	8.1	32.2	30.1	20.35	15.5	8.2	32.4	30.3	20.9	15.7	8.3
$C_{16:1}$	2.33	-	2.33	1.80	1.27	0.58	-	2.4	1.9	1.3	0.6	-	2.6	2.0	1.35	0.7	-	2.8	2.1	1.35	0.7	-
C_{18}	11.16	2.0	11.16	9.0	6.4	4.4	2	11.8	9.14	6.1	4.45	2.1	12.1	9.21	6.2	4.7	2	12.2	9.3	7	4.8	2
$C_{18:1}$	29.81	16.5	29.81	25.7	24.2	20	16.5	30	25.8	25.1	21	16.7	30.2	25.9	25.2	21.55	17	30.3	26.5	25.25	21.75	17.1
$C_{18:2}$	2.03	1.7	2.03	2	1.9	1.8	1.7	2	1.7	1.5	1.7	1.5	1.6	1.5	1.3	1.35	1.3	1.3	1.13	1.32	1.2	1.1
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
SCFA (C_4-C_8)	6.75	4.9	6.75	6.11	4.82	4.73	4.9	6.4	5.7	4.8	4.45	4.8	6.44	5.6	4.8	4.1	4.5	6.5	5.4	5.16	4.15	4.6
MCFA (C_{10}-C_{12})	4.11	52.60	4.11	13.94	28.89	39.9	52.6	4	13.66	28.4	39.8	52.6	4.2	13.81	28.1	39.5	52.9	4.1	13.83	28	40.1	52.9
LCFA (C_{14}-C_{18})	89.14	42.5	89.14	79.95	66.29	55.37	42.5	89.6	80.64	66.8	55.75	42.6	89.36	80.59	67.1	56.4	42.6	89.4	80.77	66.84	55.75	42.5
TSFA	64.13	81.8	64.13	69.25	71.73	77.09	81.8	64.1	69.4	71.4	76.1	81.8	63.94	69.4	71.35	75.9	81.7	64.1	69.03	71.28	76	81.8
TUSFA	35.87	18.2	35.87	30.75	28.27	22.91	18.2	35.9	30.6	28.6	23.9	18.2	36.06	30.6	28.65	24.1	18.3	35.9	30.97	28.72	24	18.2

SCFA = Short chain fatty acids **LCFA = Long chain fatty acids** **TUFA = Total unsaturated fatty acids**
MCFA = Medium chain fatty acids **TSFA = Total saturated fatty acids**

Levels of medium chain fatty acids (MCFA) in the samples treated with different concentrations of PKO (Table 4) markedly increased as the added PKO increased. It could also be observed that the total saturated fatty acids (TSFA) considerably increased throughout the pickling period in the treated with PKO cheese samples, compared with the control.

The addition of PKO to the treated cheese samples resulted pronounced decrease in the unsaturated fatty acids, compared with that of milk fat, while it showed an increase when compared to TUSFA of PKO.

From the obtained findings and from the results mentioned in the same Table, it could be concluded that the highly scored samples were the samples treated with 25% and 50% of PKO at the 3rd month of ripening period

Organoleptic properties of Feta cheese:-

Table (4) showed the organoleptic properties of Feta cheese samples treated with substitution of milk fat with different concentrations of PKO. It observed that the replacement of milk fat with PKO enhanced the flavor intensity of the resultant cheese, compared with the control cheese made by buffalo's milk fat. The flavor development in the control sample was slightly slower than that of the treated samples.

The higher content of medium chain fatty acids in PKO is responsible for certain characteristic flavor of cheese, particularly Feta cheese, and indirectly from the

change of the pattern of flavor released in the mouth (Harber, 1959; Efthymiou & Mattick 1964; Ha and Lindsay 1991, Painter et.al. 1997, and Abd.El-Malek & Abed-El-Khair 2002).

Table 4. Organoleptic properties of Damietta cheese as affected by replacing milk fat with (PKO)

Constituents	Pickling period / month	Replacing Ratios				
		Control	25 %	50 %	75 %	100 %
Flavor (60)	0	40	42	43	40	40
	1	42	44	45	43	42
	2	48	51	52	50	49
	3	52	56	58	54	53
Body & texture (30)	0	24	23	22	21	20
	1	26	24	24	23	22
	2	27	25	25	24	23
	3	28	27	26	25	24
Appearance (10)	9	9	9	9	8	8
	1	9	9	9	9	9
	2	10	10	10	10	10
	3	10	10	10	10	10
Total (100)	0	73	74	74	69	68
	1	77	77	78	75	73
	2	85	86	87	84	82
	3	90	93	94	89	87

Body and texture of the various treatments of the cheese characterized with marked variation. This difference might be due to the different concentrations of added PKO as a substituted of to milk fat. It could also be observed that as the substitution concentration increased the spreadability of the treated cheese increased. (Nilson & Trout, 1981 and Kyle & Hickey 1993).

Concerning the appearance of the control cheese and the treated samples of cheese, it gained high scoring due to the white color of the buffalo milk used in making the examined cheese (Sangeev Kumar et al. (2014).

From the previously mentioned results, it could be concluded that the substitution of milk fat with PKO in making Feta cheese, the resultant cheese characterized with improved flavor as the period of pickling progressed. The substituting of 50% of milk fat with PKO was the treatment which gained the highest score among the samples.

CONCLUSION

From the previously obtained results, it could be concluded that by using of PKO as a milk fat substitute in different ratios in buffalo milk, an acceptable Feta cheese could be obtained with a safe profile of fatty acids, which is lower in saturated long chain fatty acids and higher levels of medium chain fatty acids, and with acceptable Feta cheese properties.

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إستخدام زيت بذرة النخيل كبديل لدهن اللبن في صناعة الجبن الفيتا

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تم تصنيع خمسة عينات من الجبن الفيتا زنة العينه خمسة كيلو جرامات وذلك عن طريق استبدال دهن اللبن الجاموسى بزيت بذرة النخيل. كانت نسبة الأستبدال ٢٥ % و ٥٠ % و ٧٥ % و ١٠٠%. بالإضافه الى عينة المقارنه. كانت نسبة الدهن فى العينات المصنعه وكذلك عينة المقارنه هى ٤٠ % دهن / ماده جافه.عينات الجبن الناتجه تم تخزينها على درجة حرارة الغرفه لمدة ثلاثة أشهر وحللت العينات كل شهر أثناء فترة التسويه وذلك لبحث تأثير المعامله بزيت بذرة النخيل على تصافى الجين والتركيب الإجمالى والتقييم الحسى وكذلك محتوى الدهن من الأحماض الدهنية المختلفة.أظهرت النتائج أن استبدال دهن اللبن بنسب مختلفه من زيت بذرة النخيل سبب زياده محسوسه فى محتوى الجبن من الرطوبه عند مقارنتها بجبن المقارنه بينما انخفضت الجبن فى محتواها من الجوامد الكليه.محتوى عينات الجبن من الرطوبه انخفض وكذلك تصافى الجبن بينما زاد محتواها من الدهن والبروتين الكلى والرماد كلما زادت فترة التسويه فى جميع المعاملات والكنترول.زادت نكهة الجبن فى العينات التىً عوملت بزيت بذرة النخيل بمستويات مختلفه بينما اعتمد قوام الجبن بشكل كبير على النسب المضافة من زيت بذرة النخيل. وأظهرت عينات الجبن لون متماثل للعينه المقارنه.التغير الحادث فى صورة الأحماض الدهنيه للعينات تحت البحث أظهرت أن إضافة زيت بذرة النخيل كبديل لدهن اللبن عند المستويات ٢٥ % و ٥٠ % و ٧٥ % و ١٠٠ % أدت إلى زياده فى الأحماض الدهنيه متوسطة السلسله عند مقارنتها بمستوياتها فى دهن اللبن.وقدً إستنتج أن إستخدام زيت بذرة التخيل كبديل لدهن اللبن قد نجح فى إنتاج جبن فيتا صحيه ومقبولة كجبن فيتا.