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EVALUATION OF SOME CHEMICAL AND SENSORY PROPERTIES OF PROCESSED CHEESE ANALOGUE WITH SELECTED VEGETABLE OILS

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ABSTRACT

Cheese analogues are cheese-like products with varied compositions and functional properties which produced by partial or whole replacement of milk components, in particular milk fat, by non milk-based components. The purpose of this research was to evaluate the effect of replacement of milk fat in processed cheese with different formulations from olive, corn and sesame oils on some chemical and sensory properties. The results indicated that the peroxide values were not affected by the replacement of milk fat with vegetable oils significantly (P <0.05), while the free fatty acid content was slightly but significantly affected. These two values were significant (P <0.05) increased during the three months of storage. The cholesterol contents in the cheese samples with olive, sesame and corn oils were 86.9, 84%, and 83.1%, respectively lower than those of the whole milk cheese sample. The replacement of milk fat with vegetable oils did not affect the appearance, color and tenderness of the processed cheese samples. The replacement of milk fat with vegetable oil significantly (P <0.05) affected the flavor of the cheese analogue samples.

Keywords: Processed cheese, Cheese analogue, Oils, Oxidation, Cholesterol, Sterols, Sensory properties.

Contribution/ Originality

This study is one of the very few studies which have investigated the influence of the olive and sesame oil on the chemical and sensorial properties of processed cheese analogue.

1. INTRODUCTION

Consumers demand for healthy and nutritionally balanced products has increased lately and this led to the development of number of fat- free or low fat products like cheese. Modern food technologist allows the substitution of highly saturated milk fat with vegetables oils in cheese analogue manufacturing. Cheese analogues are cheese-like products with varied compositions and functional properties which produced by partial or whole replacement of milk components, in particular milk fat, by non milk-based components. This might give new opportunities to control

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elevated serum cholesterol concentration, which is known to be one of the most important risk factors for atherosclerotic vascular diseases [1]. On the other hand, the replaced milk fat with mono-unsaturated fatty acids and/or poly-unsaturated fatty acids has been shown to lower the serum cholesterol level in humans [2]. The reduction of the saturated fatty acids level in processed cheese by substitution of milk fat with emulsified vegetable oil is an option for obtaining cheese with healthier saturated/ unsaturated fat balance [3] in addition, the flavor, texture and shelf-life of such cheeses can be improved [4].

Technologically, the complete elimination of milk fat or using a low fat content (less than 10%) in cheese manufacturing will result in a hard, rubbery and translucent cheese, and poor or diluted cheese flavor [5]. For this reason, fat replacers have been used to stimulate the functional and organoleptic properties of milk fat with a substantial reduction in saturated fatty acids [6].Attempts to use vegetable oils to replace milk fat in the manufacture of cheese have been made, such substitution could be advantageous because the vegetable oils are cholesterol-free, usually cheaper and sometimes more stable and slightly subjected to seasonal variations than milk fat [4]. However, little information is available in literatures about using olive oil, sesame oil and/or corn oil in the processed cheese production and their effect on sensorial and chemical properties of the final product.

The aim of this study was to study the effect of replacement of milk fat with three different sources of oils (olive, sesame and corn) on some sensory and chemical properties of freshly prepared and stored processed cheese.

2. MATERIAL AND METHODS

2.1. Raw Materials

About one hundred and seventy liters of cooled raw cow's milk were obtained from the farm of Faculty of Agriculture-The University of Jordan, Amman. Different oils (extra virgin olive oil (acidity=0.61%, PV= 0.62 (meqO_2/ Kg), corn oil (acidity= 0.41%, PV= 0.6 meqO_2/ Kg)) and sesame oil (acidity (0.39%), PV= 0.54 (meqO_2/Kg)) were purchased from the local markets. Emulsifier composed of sodium diphosphate and sodium polyphosphate (CREMOSAL®), packaging materials (Polyethylene/ polyester combined film) and molding boxes (used for filling and forming processed cheese samples) were purchased from Danish Jordanian Dairy Company-Amman- Jordan.

2.2. Processed Cheese Preparation

One hundred and seventy liters of the obtained milk were skimmed using Alfa Laval milk separator (Italy). One hundred and twenty liters of the skimmed milk were steam heated in a double jacketed container to reach the pasteurization temperature of 72°C. The pasteurized milk were then chilled to 37°C and divided into four portions (30 liters each) for cheese making. Cheese

samples were prepared in the dairy plant at the University of Jordan. The pasteurized skim milk at 37°C was inoculated with 1.68g of Cheddar cheese starter culture (*Lactococcuslactisssplactis* and *Lactococcuslactisspcremoris* in ratio1:1) mixed with six grams of $CaCl_2$ diluted in water. The cultured milk was left for about 30 min at 37°C to develop acidity. After that, rennet was added (according to the supplier) to the inoculated skim milk and left for extra 30 min at 37°C. After clotting of milk was completed (determined by the easy separation of whey from the curds), the curd was cut into slices (1 cm^3 size) and left for 10 min for whey separation. The curd was transferred into a molding pan (30 x 30 x 5 cm) lined with cheese cloth, pressed using sacks of salt and left 30 min for whey drainage. The curd was left warm until its acidity reached value of 0.7-0.8%. The control cheese sample was made from 30 liters of pasteurized whole milk under the same processing conditions of the skimmed milk.

2.3. Processed Cheese Analogue Production

To manufacture the processed cheeses analogues, several trials were made before obtaining good processed cheese that is compatible with the Jordanian Standard [7] for the processed cheese and have smooth and homogeneous structure, and uniform color. The ingredients composition of all processed cheeses in this study are shown in table 1. An amount of 700 g of the previously prepared cheese was cooked indirectly using steam with 70 g of ground commercial cheddar cheese to improve cheese flavor and color. The other ingredients reported in the table were then added to the cooked cheese and mixed thoroughly in a stainless steel pan under stirring and indirect heating using steam until the mass became semi-liquid. The mass transferred to a homogenizer (Silverson Machines Ltd., London, UK) and homogenized effectively until the temperature reached 70-80° C for around 15 min. The mixture was transferred to molding boxes for packaging.

Table-1. Processed cheese formulations using whole cow's milk and skimmed milk with olive oil, sesame oil, and corn oil.

Ingredients	Treatment			
	Reference	(PCHO)	PCHS	PCHC
Cow's whole milk (g)	700	-	-	-
cow's skim milk (g)	-	700	700	700
*Cheddar cheese (g)	70	70	70	70
Oil (g)	-	140	140	140
Salt (g)	10	10	10	10
Emulsifier (g)	30	30	30	30
Potassium Sorbate (g)	1	1	1	1
Water (ml)	50	50	50	50
Safflower (mg)	200	200	200	200

*Cheddar contains: moisture (35.6%), fat in dry matter (52%), salt (1.6%), pH=5.2

Reference: cheese sample from whole milk, PCHO: processed cheese samples with olive oil,

PCHS : processed cheese samples with sesame oil and PCHC : processed cheese samples with corn oil

Hot filling was applied to kill microorganisms which are possibly found on the surface of packaging material and to remove oxygen in order to prevent molds growth and to protect cheese color and flavor. A control natural processed cheese sample was prepared under the same conditions but with the use of cheese prepared from whole pasteurized milk. Samples of freshly prepared cheeses were taken and analyzed within two days for chemical and sensory properties.

Other samples were kept in a refrigerator at 3-4 ºC for 3 months, and then analyzed for chemical and sensory properties. Table 1: Processed cheese formulations using whole cow's milk and skimmed milk with olive oil, sesame oil, and corn oil.

2.4. Chemical Composition

The processed cheese samples were analyzed for moisture, fat and protein following AOAC [8]. All analysis was carried out in triplicate.

2.5. Lipid Extraction

Total lipid extraction was carried out according to the modified Folch method [9].

2.6. Peroxide Value and Free Fatty Acids Content Determination

Peroxide value (melliequivelnt peroxide/ kg fat) and free fatty acids content (expressed as % oleic acid) for the extracted fats were determined as described by AOAC [8]. All analysis were carried out in triplicate.

2.7. Fatty Acids Composition

Fatty acid methyl esters of the fat of the processed cheese samples were prepared according to the method described by Chritopherson and Glass [10]. The prepared methyl esters were analyzed using capillary GLC column (Restek, Rtx-225, USA, cross-bond 50%-cyanopropylmethylpolysiloxane, 60m, 0.25 µm df) immediately after esterification by injection 1µl of the hexane layer through the injection port of the GLC (model GC-2010, shimadzu Inc., Kyoto, Japan). The fatty acids methyl esters (FAMEs) were injected after adjusting the GLC condition; column oven temperature was 70°C, increased to 165°C for 10 min., kept at 185°C for 1 min, then increased to 220°C for 15 min. Injector temperature was 240°C flame ionization detector temperature was 250°C, flow rate 0.8 ml/min He, and split ratio used was 80. The FAMEs were identified using chromatogram of fatty acids standard.

2.8. Cholesterol and Cholesterol Oxidation Products (COPs) Determination

Cold saponification of the extracted fat of the processed cheese samples was carried out according to the method reported by Sander, et al. [11]. The trimethylsilyl derivatives (TMS) of cholesterol and cholesterol oxides were carried out according to the method of Pie, et al. [12].

The derivatized sterols were analyzed using capillary GLC column (Restek, USA, crossbond 5%-diphenyl 95%- dimethyl polysiloxane, 30m, 0.25 mm/D, 0.1 μm df) immediately after trimethylsilylation by injection of 1μl of hexane layer through the injection port of the GLC. The GLC conditions used were; the injector temperature was 280° C, detector temperature was 290° C, the flow rate was 0.8 ml/min, and split ratio was 20%. The cholesterol and COPs peaks were identified compared with the retention time of the reference standards.

2.9. Sensory Analysis

Processed cheese from each treatment was evaluated by 13 trained sensory panelist that are familiar with processed cheese. Careful consideration (experience and health) was taken into consideration in the selection of the evaluator. The sensory evaluators were from both sexes, and from different ages, they were requested to evaluate each sample separately without comparing it with other samples. Panelists were familiarized with the questionnaire form. The samples were evaluated for desirability in appearance, color, tenderness, flavor, and overall acceptability using a 9 hedonic scale test as described by Larmond [13] which ranged from 9 to 1, where 9, 8, 7, 6, 5, 4, 3, 2 and 1 means like extremely, like very much, like moderately, like slightly, neither like nor dislike, dislike slightly, dislike moderately, dislike very much and dislike extremely, respectively. Cheeses of four treatments were given random three digit numbers and served, at approximately 7 ºC, to each sensory evaluator in a tray. Sensory evaluation was carried out in a well lightened room. Each evaluator sat in a separate cabinet for around 30 min to evaluate each of the 5 samples. Pieces of bread and water were used to neutralize the taste between samples.

2.10. Statistical Analysis

Statistical analysis of data was carried out using Statistical Analysis System package [14]. The data obtained were analyzed using a complete randomized design (CRD) to study the effect of treatments on a proximate composition, cholesterol, fat acidity, peroxide and sensory evaluation scores. Multiple comparison of means was performed by using least significant difference (LSD). For all analysis, $\alpha = 0.05$ was the level used for statistical significance.

3. RESULTS AND DISCUSSION

3.1. Chemical Composition of Prepared Cheese Samples

The storage period for 3 months did not change moisture and composition of all cheeses, which simply an indication that cheese samples were properly. The cholesterol content of the processed cheese samples prepared with vegetable oils were about 4.9 mg/100 g compared to 32.3 mg/100 g in the reference cheese sample. This indicate that the replacement of milk fat with vegetable oils decreased the level of cholesterol by 86.9%, 85% when compared to that of the reference

Storage time did not significantly (P >0.05) affect cholesterol contents of all treatments, and this was supported by the level of 7-keto cholesterol content that is generated from the oxidation of cholesterol, since there was no detectable amount of this oxides in all stored samples. The stability of cholesterol in all treatment was due to the fact that effective packaging and storage conditions were applied. These results agreed with those found by Sieber [15] who concluded that formation of COPs in milk and dairy products can only occur under harsh conditions such as the application of high heating temperatures for long period or long storage at high temperatures or harsh storage conditions where the impact of oxygen and light or oxygen and low water activity. These results of the present study agree with those of Tai, et al. [16] who reported that good packaging materials were able to inhibit or reduce the permeation of air and light in to foods and consequently minimize cholesterol oxidation. Also, storage conditions (low temperature and darkness) seem to contribute to inhibition of lipid oxidation of the cheese samples and thus reduce cholesterol oxidation.

Table-2. Effect of formulation and storage time on moisture, fat and protein contents of processed cheese samples

Characteristics	storage time (month)	Reference	PCHO	(PCHS)	(PCHC)
Moisture (%)	0	40.3[a]	39.4[a]	39.5[a]	39.9[a]
	3	40.2[a]	39.07[a]	39.4[a]	39.6[a]
Fat (%) DMB	0	34.7 [a]	33.6 [a]	33.7 [a] 1	33.6 [a]
	3	34.5 [a]	31.9 [a]	33.6 [a]	33.3 [a]
Protein (%)	0	21.67 [a]	22.6 [a]	22.8 [a]	22.3 [a]
	3	21.5 [a]	22.3 [a]	22.9 [a]	22.1 [a]
Cholesterol (mg/ 100g cheese	0	32.3[a]	4.9 0[b]	4.9 [b]	4.70[b]
	3	31.9[a]	4.8[b]	4.8[b]	4.8[b]

Values within the same row with different letters are significant differences (P<0.05) according to LSD.

Reference: cheese sample from whole milk, PCHO: processed cheese samples with olive oil, P PCHS: processed cheese samples with sesame oil and PCHC : processed cheese samples with corn oil

3.2. Peroxide Value (PV)

Peroxide value is used as a measurement of the extent to which oxidative rancidity have occurred during processing or storage of fat or fat-containing foods. Other methods are available but PV is the most widely used. It is evident that PV of all cheese samples at the beginning of storage were not significantly different (p<0.05) and they were below 1 meq O_2/kg (table 3). This indicates the high quality of the milk and oils used in this study. However, PV in cheese samples except the control increased significantly (PV< 0.05) after 3 months of storage, which is in accordance with other studies [17]. The results presented in table 3 show that the lipid oxidation did not occur to a great extent in the processed cheese analogue (PV < 2 meq/kg) during storage for 3 months. The order of oxidation in theses cheese samples after 3 months of storage was PCHO> PCHS > PCHC > Reference.

3.3. Free Fatty Acids Content (FFs)

Free fatty acids content refers to the degree of hydrolytic lipolysis of fat in dairy products [18]. The FFs of the cheese samples significantly ($p< 0.05$) increased during the storage period and no significant difference was found between between them. These results were in line with those of Kavas, et al. [6] who reported that the extent of lipolysis in cheese usually increased during storage. Canceled the degree of lipolysis in all samples was quite similar and similar to those reported by Kesenkas, et al. [18] for kasher cheese and lower than those reported by Tarakci and Kucukoner [19] for kasher cheese and by Franco, et al. [20] for cow milk cheese varieties.

Table-3. Effect of formulation and storage time on fat acidity and peroxide values for the processed cheese samples

Characteristic	Storage period (month)	Reference	PCHO	PCHS	PCHC
Fat acidity %	0	$_{b}0.58^{a}$	$_{b}0.61^{a}$	$_{b}0.59^{a}$	$_{b}0.54^{a}$
	3	$_{a}1.05^{a}$	$_{a}0.99^{a}$	$_{a}0.95^{b}$	$_{a}0.94^{c}$
Peroxide value (meq. O_2/ Kg)	0	$_{b}0.58^{a}$	$_{b}0.62^{a}$	$_{b}0.54^{a}$	$_{b}0.60^{a}$
	3	$_{a}0.60^{c}$	$_{a}1.73^{a}$	$_{a}1.17^{b}$	$_{a}0.69^{c}$

Values within the same column with different subscripts are significantly ($P<0.05$) different according to LSD.
Values within the same row with different superscripts were significant differences ($P<0.05$) according to LSD.
Reference: cheese sample from whole milk, PCHO: processed cheese samples with olive oil, P PCHS : processed cheese samples with sesame oil and PCHC : processed cheese samples with corn oil

3.4. Fatty Acids ProfileFatty Acids Profile

The fatty acid profile of the 4 cheese samples are shown table 4. There was a significant effect for the cheese formulation on the fatty acid profile when compared to that of prepared from whole milk (reference samples). It can be observed a high reduction in the short chain fatty acids (C4:0 - C10:0) in the cheese analogue samples which is due to the replacement of milk fat with the free short chain vegetable oils. However, the presence of low amount of these short chain acids is due to the addition of cheddar cheese. Furthermore, a decrease in the saturated palmitic, myristic and stearic acids was observed in the cheese analogue samples. It has been reported that luaric, myrestic and palmitic acids may contribute to the increase in the blood plasma cholesterol and LDL [21]. Therefore, decreasing the level of these acids in dairy products by replacing milk fat with vegetable oils may reduce the risk of the diseases correlated with the high content of these compounds. Oleic and linoliec acids content was significantly ($P < 0.05$) higher than that of the reference. The oleic acid content in PCHO, PCHS and PCHC samples was 2.8, 1.7, and 1.24 times, higher than that of the reference. Similarly the increase of linoleic was 2.14, 12.38, 15.0 and 7.4 times, respectively higher than that of the reference. These results were expected because the used vegetable oils are rich of unsaturated fatty acids. Among the cheese samples analogue, PCHC samples had the lowest content of stearic (3.93%) and oleic (27.6%); while it had the highest content of linoleic acid (43.7%) (table 4). This is due to the high the content of linoleic acid and the low content of oleic and stearic acids in corn oil. On the other hand, PCHO samples

had the highest oleic (61.5%) and palmitic (19.7%) contents and the lowest one in linoleic acid (6.2%). It has been reported that long chain fatty acids (≥C16:0) have higher perception threshold than short chain fatty acids (C4-C12) and are thought to play a less important role in cheese flavor [18]. Replacement of milk fat by vegetable oils in the processed cheese samples had a significant effect on SFA, MUFA, PUFA, and USFA/SFA ratio. The SFA in the cheese samples analogue significantly($P < 0.05$) decreased, while MUFA, PUFA and USFA/SFA ratio increased when compared to the those of the reference. For example the USFA/SFA ratio of the reference sample was about 5.7 times lower than those found for the cheese samples analogue. The addition of vegetable oils to the processed cheese improves their nutritional value because of their high content of PUFA. Unsaturated fatty acids are healthier than saturated fatty acids because of their positive effect in prevention of cardiovascular disease and cancer [22].

In general no significant effect of storage on fatty acids content, SFA, MUFA, PUFA and USFA/SAF ratio was observed (Table 4). This might be due to the effective packaging and the condition of storage.

Table-4. Fatty acids profile (g/ 100g fatty acids) for different processed cheese samples

Fatty acid	Storage Period (month)	Reference	PCHO	PCHS	PCHC
C4:0	0	1.64^{a*}	0.30^{c}	0.20^{d}	0.47^{b}
	3	1.63^{a}	0.32^{c}	0.21^{d}	0.49^{b}
C6:0	0	1.70^{a}	0.22^{c}	0.23^{c}	0.32^{b}
	3	1.65^{a}	0.26^{c}	0.20^{c}	0.31^{b}
C8:0	0	1.20^{a}	0.30^{b}	0.21^{c}	0.25^{b}
	3	1.15^{a}	0.39^{b}	0.21^{c}	0.23^{c}
C10:0	0	2.60^{a}	0.40^{d}	0.51^{c}	0.76^{b}
	3	2.60^{a}	0.44^{d}	0.50^{c}	0.70^{b}
C12:0	0	3.30^{a}	0.68^{c}	0.76^{b}	0.83^{b}
	3	3.50^{a}	0.78^{b}	0.80^{b}	0.79^{b}
C14:0	0	11.70^{a}	2.30^{bc}	2.07^{c}	2.39^{bc}
	3	11.80^{a}	2.47^{bc}	2.09^{c}	2.10^{c}
C16:0	0	37.31^{a}	19.70^{b}	13.50^{d}	16.04^{c}
	3	37.40^{a}	19.80^{b}	13.76^{d}	16.25^{c}
C16:1	0	2.20^{a}	0.90^{b}	0.41^{d}	0.52^{c}
	3	2.27^{a}	0.90^{b}	0.41^{d}	0.47^{c}
C18:0	0	9.52^{a}	6.06^{c}	6.91^{b}	3.93^{d}
	3	9.95^{a}	6.01^{c}	6.90^{b}	3.70^{d}
C18:1	0	22.30^{d}	61.53^{a}	37.88^{b}	27.60^{c}
	3	22.70^{d}	61.00^{a}	37.6^{b}	27.15^{c}
C18:2	0	2.89^{d}	6.20^{c}	35.92^{b}	43.70^{a}
	3	2.90^{d}	6.40^{c}	35.90^{b}	43.65^{a}
SFA	0	70.01^{a}	30.54^{b}	30.54^{b}	25.63^{c}
	3	70.67^{a}	31.13^{b}	31.13^{b}	25.24^{c}
MUFA	0	25.36^{c}	63.09^{a}	63.09^{a}	28.49^{b}
	3	25.92^{c}	62.50^{a}	62.50^{a}	28.00^{b}
POFA	0	3.30^{c}	6.25^{b}	6.25^{b}	44.49^{a}
	3	3.33^{c}	6.49^{b}	6.49^{b}	44.45^{a}
Unsaturated / Saturated fatty acids	0	0.42^{c}	2.27^{b}	2.27^{b}	2.80^{a}
	3	0.42^{c}	2.20^{b}	2.20^{b}	2.80^{b}

Values within the same raw with different subscripts are significantly ($P<0.05$) different according to LSD.
Reference: cheese sample from whole milk, PCHO: processed cheese samples with olive oil, PCHS: processed cheese samples with sesame oil and PCHC : processed cheese samples with corn oil
SFA: saturated fatty acids, MUFA: monounsaturated fatty acids, PUFA: polyunsaturated fatty acids

3.5. Sensory Evaluation

Table 5 shows the mean values of sensory scores awarded for different processed cheese samples, using 9-hedonic scale test. It is evident that there was no significant effect of the fat

replacement of milk fat with corn, sesame and olive oils on the appearance, color and tenderness of freshly prepared processed cheese analogue. The panelist liked slightly the color and appearance of all prepared cheese samples, while they neither liked nor disliked the tenderness. The flavor scores, which refers to the combination of taste and odor of the cheese samples indicate that the panelist significantly preferred the cheese sample made of whole milk (Like moderately) followed by those prepared with corn oil (like slightly). On the other hand, they disliked the cheese sampled prepared with olive oil. This result was in line of those of Strugnell [23] who reported that cheese made with olive oil was rejected cheese that cheese made from olive oil, was rejected because of such taints. The higher flavor scores of the cheese samples made from whole milk might be due to the fact that milk fat is an important contributor to milk flavor, since it contains the short chain triglycerides that give pleasant flavor to the dairy products [23].

The overall acceptability scores showed similar trend to that observed for flavor, since cheese samples prepared from whole milk had the highest scores (Like moderately), while those prepared with olive and sesame had the lowest scores (neither like nor dislike). This result indicates that the panelist judgment on the cheeses samples based on its flavor rather than on its color, appearance and tenderness. The lower flavor scores of cheese sample prepared with olive and sesame oils is due to the fact that these two oils are crude oils. Therefore, the naturally occurring flavor compounds in these oils affected negatively the flavor of the cheeses prepared with them. The flavor of PCHO can be improved by using refined olive oil or adding flavor enhancers like butter flavor. Storage for three months did not significantly affect the examined sensory attributes. The insignificant effect of storage on the flavor might be due to the existence of low level of the free fatty acids and peroxide, which are the main contributors for the rancid flavor of the fat [24].

Table-5. Effect of formulation and storage time on sensory evaluation scores for the Processed cheese samples

Characteristics	Time of storage (month)	PCHS	PCHO	PCHC	Reference
Appearance	0	6.0^{a}	6.37^{a}	5.77^{a}	6.54^{a}
	3	6.2^{a}	6.77^{a}	5.92^{a}	6.62^{a}
Color	0	6.31^{a}	6.69^{a}	6.54^{a}	6.55^{a}
	3	6.46^{a}	6.62^{a}	6.46^{a}	6.59^{a}
Tenderness	0	5.69^{a}	5.69^{a}	5.85^{a}	5.54^{a}
	3	5.77^{a}	5.31^{a}	5.45^{a}	5.62^{a}
Flavor	0	4.54^{c}	5.48^{c}	6.20^{b}	7.77^{a}
	3	5.07^{c}	5.54^{bc}	6.07^{b}	7.46^{a}
Overall acceptability	0	5.31^{c}	5.62^{c}	6.77^{b}	7.77^{a}
	3	5.38^{c}	5.55^{c}	6.38^{b}	7.62^{a}

Means are the average of 13 readings

Values within the same row with different superscripts denote significant differences ($P<0.05$) according to LSD.

Reference: cheese sample from whole milk, PCHO: processed cheese samples with olive oil, PCHS : processed cheese samples with sesame oil and PCHC: processed cheese samples with corn oil

4. CONCUSION

Replacement of milk fat by vegetable oils in processed cheese manufacturing enhanced their health values by increasing unsaturated/ saturated fatty acids ratio and decreasing their cholesterol contents. Furthermore, replacement of milk fat by vegetable oils in processed cheese did not affect the color, appearance, tenderness of cheese of all treatments. Storage of the processed cheese at 3-4 ^{o}C and proper selection of packaging materials that provide barrier properties against the transmission of oxygen and light was found to be effective in minimizing the adverse effect on the processed cheese products and retaining reasonable shelf life of the products. However, the replacement of milk fat with vegetable oils affected negatively the flavor of the prepared cheese samples when compared to that made from whole milk.

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