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Manufacture of Processed Cheese Spread from Camel Cheese Based: Evaluation of Cheese Characteristics

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Abstract

In this study, an acceptable cheese was produced by blending a camel cheese based (made from camel milk retentate) with Ras cheese. Whole camel milk was concentrated by ultrafiltration, and fermented with yoghurt starter culture and rennet to get the cheese based (camel cheese based). Five experimental processed cheese treatments were prepared to contain 0% (control), 25, 50, 75, and 100% of camel cheese based. Cheese spreads were stored for three months at 5±1°C, and the gross chemical composition, color parameters, meltability, microstructure, and sensory attributes were analyzed. The most preferable trial of processed cheese spreads was obtained through the addition of camel cheese based to Ras cheese with 25 and 50%. The results confirmed that cheese treatment made by the supplementation of camel cheese based at the rate of at least 50% tempted to have hardness texture similar to the control cheese. The substitution of young and aged Ras cheese with camel cheese based caused a further decrease in the meltability. Total color difference values increased with the decrease in the concentration of camel cheese based in cheese samples. Processed cheese spread prepared from camel cheese based (25 and 50%) could be used as an extender in processed cheese spread, but 75 and 100% (camel cheese based) were likely unsuitable due to the coarse mouth feel and the low scores of organoleptic properties.

Keywords

Camel Milk, Retentate, Cheese Base, Processed Cheese Spreads, Microstructure, Color, Meltability

1. Introduction

Processed cheese is a dairy product made from different types of cheese, it is usually manufactured from fresh cheese and ripened cheese, with added ingredients such as emulsifiers, salts, flavors and colors. [1] Processed cheeses are considered the most dairy products that having a high consumption pattern by high sectors of the population. Processed cheese can be made either from a simple basic net of ingredients consisting of cheese, water, and melting salts or from a complicated blend of ingredients along with extraordinary types of proteins, fat, gums, stabilizers, flavorings, humectants, and other minerals. The main component of processed cheese is casein, the colloid system of which substantially relies upon at the calcium ions in the micelles surface, the polypeptide chains, and another phosphate group therein. In recent years, the consumers have tended to eat low-fat, healthy foods that provide adequate nutritional value and do not harm their health. So, there is an increasing demand for low-fat dairy products such as reduced- or low-fat processed cheeses which entered the marketplace. The fat content can be replaced by water, protein or other additives not traditionally found in cheese, such as gums, stabilizers, soy proteins, soy fibers, maltodextrine, modified starch, and humectants. [2, 3] Camel milk is a balanced diet contains all the essential nutrients necessary to meet the needs of the human body and is concerned by the consumer particularly in the desert areas, so the interest in it has recently increased by dairy manufacturers and researchers; however it is unsuitable for the processing of different dairy products. Recently, many efforts have been made to improve the dairy products manufactured from camel milk especially some types of cheese**.** Camel milk cheese is characterized by its nutritional and therapeutic properties, so it is preferred by the consumer but the production of camel cheese faced many problems. Researchers and manufacturers found that the most difficulties facing the cheese industry from camel milk are the weak curd and low yield. [4] The use of membrane technology as a processing and separation method in food industry has gained wide application. Membrane separations can be used either as alternatives to conventional techniques or as novel technology for processing new ingredients and foods. Membrane separations are considered green technologies. In many cases, membrane processes are more advantageous than traditional technologies. [5] The concentration of milk components by ultrafiltration (UF) enables the recovery of all milk proteins, which in traditional methods of cheese production are generally lost with the whey. Products acquired from UF retentates are characterized by a higher recovery of milk proteins, a higher biological value of protein, and lower cost of production as compared to cheeses obtained with the traditional methods. The utility of UF retentate as a raw material for processing is therefore beneficial for both food processors and consumers. Some of the research had been pronounced almost about the usage of ultrafiltration to processed cheese production. Some of them envisage evaporation of water from highly concentrated retentates to obtain products with a composition similar to that of natural hard cheeses used for processing. There have been some studies on the using of UF milk retentate in processed cheese. The application of UF retentate as a raw material for subsequent incorporation into processed cheese products as a partial or whole replacement for natural cheese has been shown to be feasible. [6, 7] Other studies reported that milk was concentrated only by UF to different levels, and the retentates milk was used for processed cheese manufacture by using ripening agent to accelerating flavor development. [7] Also, protein preparations obtained by drying milk or whey UF retentates, such as milk protein concentrate (MPC) or whey protein concentrate (WPC) were successfully used for processed cheese production. [8] Kycia [9] confirmed that a developed cheese base can successfully replace the young rennet cheese in processed cheese spread production. Purna [10] produced processed cheese by using the same natural cheese at different ages, and concluded that a discount in intact casein in natural cheese caused reduced viscosity and firmness and improved meltability of the processed cheese. Cheese based yields greater than 16 to 18% might be expected from conventional cheese-making processes. Mixtures of 80% based curd and 20% aged Cheddar cheese produced desirable flavored processed cheese. The body of the processed cheese became overly firm, however that of the processed cheese food was acceptable. The present study aimed to investigate the utilization of camel's milk retentate in the manufacture of low fat processed cheese spread. The chemical, physicochemical, textural, microstructure and organoleptic characteristics of the processed cheese manufactured with different types and quantities of ingredients were determined.

2. Materials and Methods

2.1. Materials

Ras cheese; young (1 month) and aged (3 months) were made according to the method reported by Hofi et al. [11] at the Department of Food Science, Faculty of Agriculture, Zagazig University, Zagazig, Egypt. Commercial JOHA emulsifying salts S_9 (E452 sodium polyphosphate, E339 sodium orthophosphate) were obtained from BK-Ladenburg corp., Gmbh, Germany. Table salt was obtained from the local market. Camel milk was obtained from Matrouh Station Deseret Research Center. Rennet Hannilase$^{@}$ TL 2300 granulaste NB microbial rennet and Freeze-dried FD-DVS YF-L812$^{®}$ starter cultures containing: *Lactobacillus delbrueckii* ssp *bulgaricus* and *Streptococcus thermophilus* were purchased from Chr. Hansen's Lab., Copenhagen, Denmark by Misr Food Additives (MIFAD), Egypt.

2.2. Methods

2.2.1. Camel Cheese Based Production

Raw camel milk (TS, 11.69%; protein, 2.81%; fat, 3.4%; lactose, 4.41%; ash, 0.81%, and pH 6.69) was heated at 50±1°C and submitted to ultrafiltration directly using Carbo-sep, the Tech. Sep UF fitted with 2s 151 (Model tubular) membrane type mineral (Zerconium oxide), support with a membrane surface area of 6.8 m^2. The unit was operated with an inlet pressure of 5 bars and outlet pressure of 3 bars. The retentate was pasteurized (72°C/15 s), cooled down to 42±2°C, inoculated with 0.03% yoghurt culture, and incubated at 42±2°C until its pH reached 5.1-5.2. After that, the rennet (1mL/kg) was added. The obtained cheese base was cooled down in ice water and stored at 5±1°C until processing. The whey was removed from camel milk cheese (fermented retentate) by cloth cheese (fine-mesh filters, made of cotton cloth) in order to reduce the moisture content of the fermented retentate, and the resultant was called a camel cheese based.

2.2.2. Manufacture of Low Fat Processed Cheese Spread

Low fat processed cheese spread was prepared by replacing young Ras cheese by cheese base (fermented camel milk retentate) at levels of 25, 50, 75, and 100%. In addition, control low fat processed cheese spread was made using aged and young Ras cheese. The analysis of raw material, the composition, and percentage of ingredients used in the formula for all patches of low fat processed cheese spread are given in Tables 1 and 2. Citric acid was added to adjust the pH of the products to 5.8, and 3% emulsifying salts (S_9) were added. Specifications of the cooking machine are mentioned by Meyer [12], and the processing was carried out in the Dairy Technology Unit, Food Science Department, Faculty of Agriculture, Zagazig University. The ingredients were mixed for about 1 min before processing. The mixture was cooked for 10 min at 80-85°C using indirect steam at a pressure of 1.5-2.0 kg/cm^2. The melted processed cheese spread analogue of the different treatments was poured into wide mouth glass jars (120g) sealed with sterilized aluminum foil and capped directly after filling. The obtained processed cheese spread was stored at 5±1°C for 3 months. Samples were taken and subjected to the different analyses when fresh and after 1, 2, and 3 months of storage.

Table 1. *Chemical composition (%) of the raw materials used in low fat processed cheese spread production.*

parameter	Property of raw material			
	Young Ras cheese	Aged Ras cheese	Camel cheese based	Permeate
Dry matter	61.73±2.44^a	63.45±2.02^a	20.52±1.05^b	8.0±0.17^c
Fat	27.1±1.07^a	28.3±0.85^b	8.5±0.85^c	0.5±0.09^d
Protein	24.9±1.10^a	25.3±0.86^a	7.30±0.96^b	1.6±0.07^c
Ash	3.82±0.41^a	4.19±0.21^a	1.70±0.26^b	0.58±0.07^c
NaCl	3.09±0.20^a	3.6±0.39^b	ND	ND
Lactose	2.28±0.15^c	1.39±0.06^d	3.80±0.39^b	5.30±0.32^a

Mean (±SD). Values with small letters in the same row having different superscripts differ significantly ($p \leq 0.05$).
ND, not detected

2.3. Chemical Analysis

Low fat processed cheese spread samples were analyzed for moisture, acidity, and ash contents as mentioned by Chemists Horwitz. [13] Fat, total and soluble nitrogen contents. [14] The total carbohydrates were calculated by variations as represented by Ceirwyn. [15]

2.4. Physicochemical Properties

pH values were measured by using a digital pH meter (HANNA), combined with a glass electrode (Electric Instruments Limited). Meltability of cheese samples was determined. [16] Briefly, the cheese samples were taken using a No.10 cork borer. The cylindrical sample was placed on a Whatman No. 42 filter paper and heated in an atmospheric oven at 100°C for 10 min. The area of the melted discs was measured with a Digital planimeter (PLACOM, S06071 S06440, Japan). The meltability was expressed as the percentage variations between the zone of melted and original discs.

2.5. Color Analysis Cheese

MiniScan portable colorimeter (Hunter Associates Laboratory Inc., Reston, VA) used for measured color. Color measurements were made using the Commission Internationale de l'Éclairage. [17] L*, a*, and b* values using illuminant D65. The L* value is an indicator of luminosity (the degree of lightness from black to white). The a* value is an indicator of green (-) and red (+), whereas b* is an indicator of blue (-) and yellow (+). Because combining a* and b* gives a better indication of color than their individual values, we calculated hue angle as the inverse tangent of the ratio b*/a* [18]. The petri dish was placed directly on the colorimeter sensor. The color intensity (C), the hue angle (hab), and total color difference (ΔE) in comparison to an untreated control were calculated, where hab = 0° for red hue and hab° = 90° for a yellow hue, and the results were expressed as: $C = (a^{*2} + b^{*2})^{0.5}$; hab = arctan (b*/a*); $\Delta E = [(L - L0)^2 + (a - a0)^2 + (b - b0)^2]^{0.5}$. The color was expressed as a whiteness index (WI) based on the formula [19]: $WI = 100 - [(100-L^*)^2 + a^{*2} + b^{*2}]^{0.5}$, where L0, a0 and b0 were the L, a, and b values of the reference sample which is here the control samples.

2.6. Texture Profile Analysis of Processed Cheese Spread

Texture profile measurements of cheese samples were carried out according to Bourne [20] with the universal testing machine (Cometech, B type, Taiwan) provided with software. Back extrusion cell with 35 mm diameter compression disc was used.

2.7. Scanning Electron Microscopy

Processed cheese samples were examined using the scanning electron microscope (SEM, FEI company, Netherlands) Model Quanta 250 FEG (Field Emission Gun) attached with EDX Unit (Energy Dispersive X-ray Analyses), with accelerating voltage 10 K. V. The samples were kept refrigerated until used for SEM analysis. Samples were freeze-fructured in liquid nitrogen to approximately 1-mm pieces and these pieces were then mounted on aluminum stubs and scanned under low vacuum condition with pressure champers of 60 Pas. At least four images of typical structures at 1000×magnification were recorded, magnification14x up to 1000000 and resolution for Gun. 1n) by the Egyptian Mineral Resource Authority, Central Laboratories Sector, Dokki, Giza, Egypt according to Karami, Ehsani. [21]

2.8. Sensory Evaluation

Samples of low fat processed cheese spread were sensory scored by 8-10 panelists according to the scheme of Meyer [12] for outer appearance (20 points), body & texture (40 points), aroma and flavor (40 points). The course of scoring for each sample was repeated three times, and all collected data were statistically analyzed by SPSS using liner Model

(GLM). Duncan's multiple ranges were used to separate among means at $p \leq 0.05$.

2.9. Statistical Analysis

The data were analyzed by the one-way ANOVA test according to the appropriate experimental designs, and reported as (means ± standard deviations), which were separated by Duncan's New Multiple Range Test at $p \leq 0.05$ [22] and least significant difference (LSD) test using SPSS computer program, version 16.0 (SPSS Inc., Chicago, IL, USA).

3. Results and Discussion

3.1. Gross Chemical Composition of Processed Cheese

Table 2 shows the physicochemical composition of control and experimental low processed cheese spreads. All processed cheeses did not differ in respect of the contents of dry matter (22.76-30.96%), fat (8.25-11.90%), and fat in dry matter (34.36-38.42%) because of the standardization of cheese mixtures earlier than processing. Replacing young Ras cheese with cheese base resulted in processed cheese exhibiting comparable protein content to control cheese. Up to 100% of young Ras cheese was successfully replaced with cheese base without any significant drops in protein content as compared to control cheese. [9] The results revealed that the pH of the experimental cheeses with the addition of 25-100% of cheese based was lower than the pH of control cheese. Marchesseau, Gastaldi [23] reported that the small changes in pH and ionic composition and strength induced substantial modification during cheese processing, and consequently had an important repercussion on the final structure of the network that was formed with dissociated caseins.

Table 2. *Formulation of ingredients and chemical composition of low fat processed cheese spread as affected by replacing Ras cheese with camel cheese based.*

	Treatments				
	C	T1	T2	T3	T4
Ingredients (kg):					
Young Ras cheese	12.4	0.95	0.00	0.00	0.00
Aged Ras cheese	24.60	22.60	21.50	20.90	0.00
Camel cheese based	0.00	19.60	64.50	70.00	97.00
Emulsifying salt S_9	3.00	3.00	3.00	3.00	0.00
Permeate	60.00	45.30	11.00	6.10	0.00
Total	100.00	100.00	100.00	100.00	100.00
Chemical composition:					
Moisture,%	69.09 ± 2.32^{a}	69.30 ± 1.60^{a}	69.39 ± 0.20^{a}	69.04 ± 0.56^{a}	77.25 ± 1.84^{a}
Dry matter,%	30.91 ± 1.46^{a}	30.70 ± 1.94^{a}	30.61 ± 2.58^{a}	30.96 ± 2.12^{a}	22.76 ± 2.80^{b}
Fat,%	10.62 ± 0.50^{b}	10.86 ± 1.52^{b}	11.62 ± 0.54^{ab}	11.90 ± 1.08^{ab}	8.25 ± 0.58^{c}
Fat/DM,%	34.36 ± 2.64^{c}	35.38 ± 1.98^{c}	37.97 ± 2.60^{bc}	38.42 ± 1.06^{ab}	36.23 ± 2.90^{a}
Protein,%	9.31 ± 1.08^{a}	9.75 ± 0.38^{a}	10.92 ± 1.24^{a}	11.24 ± 1.54^{a}	8.24 ± 1.00^{b}
Lactose,%	3.80 ± 1.02^{a}	3.68 ± 0.90^{a}	3.33 ± 0.81^{a}	3.27 ± 0.83^{a}	3.69 ± 0.20^{a}
Ash,%	7.17 ± 0.18^{a}	6.41 ± 0.52^{a}	4.73 ± 0.38^{b}	4.56 ± 0.16^{b}	2.58 ± 0.18^{bc}
Soluble nitrogen,%	0.41 ± 0.60^{a}	0.34 ± 0.06^{b}	0.29 ± 0.04^{c}	0.22 ± 0.04^{d}	0.19 ± 0.04^{d}
pH value	5.73 ± 1.56^{a}	5.68 ± 0.90^{a}	5.65 ± 0.78^{a}	5.62 ± 0.52^{a}	5.59 ± 0.56^{a}

Mean (±SD). Values with small letters in the same row having different superscripts differ significantly ($p \leq 0.05$).
C: 100% Ras cheese (control), T1:75% Ras cheese + 25% camel cheese based, T2:50% Ras cheese + 50% camel cheese based, T3: 25% Ras cheese + 75% camel cheese based, T4= 100% camel cheese based.

3.2. Textural Characteristics of Low Fat Processed Cheese Spread

The outcomes of texture profile parameters (including hardness, adhesiveness, cohesiveness, springiness, gumminess, and chewiness) of low fat processed cheese spread are demonstrated in Table (3). The outcomes showed that the incorporation of cheese based to low fat processed cheese spread caused significant changes in their textural parameters. Generally, it was shown that increasing cheese based addition contributes to lower the measured textural parameters compared with those obtained for control cheese. Adhesiveness is described to imitate as the stickness of the sample in the mouth throughout mastication (from slippery to sticky), However, it was found out that the experimental cheeses containing 25% of cheese based had a slight difference in comparison to control cheese in respect to hardness, springiness, cohesiveness, gumminess, and elasticity. The fact that replacing young Ras cheese with cheese based does not vary the texture of the processed cheese affords the real possibility of using cheese base as a substitute of the young Ras cheese utilized in processed cheese manufacture. When the supplement of cheese based in the formulation was at lower 50 or 75%, the values of springiness differed significantly from control cheese. However, hardness, gumminess, adhesiveness, and cohesiveness decreased with the increase in cheese bases addition. Processed cheeses with the highest supplement of cheese based (100%) possessed the lowest values in all measured structural parameters. The decrease in hardness is accredited to early variation in the texture which is associated to the proteolysis of casein network, increasing protein hydration (soluble nitrogen%, Table 2) and solubilization of colloidal calcium phosphate. [24] Consequently, the substitutions of aged cheese (3 months) with ripen cheese base resulted in processed cheese with low hardness values. It is well known that aged Ras cheese might cause a decrease in the firmness and elasticity but increases spreadability in processed cheese possess hydrolysed proteins and that intensified proteolysis. [9, 25] The variations in hardness of the processed cheese under study should be related partially to its moisture content.

3.3. Meltability of Low Fat Processed Cheese Spread

Meltability of processed cheese as affected by replacing mature Ras cheese by camel cheese based when fresh and during storage at 5±1°C is presented in Table 3. The consequences showed that increasing protein content of processed cheese resulted in lower meltability. The substitution of young and aged Ras cheese with camel cheese based caused a further decrease in meltability. It may seems that these results contradict the study of Ernstrom, Sutherland [26], who found that the supplement of a cheese based made from an ultrafiltration retentate to processed cheese blend decreased the meltability of the resultant product. The meltability was closely and positively correlated with the textural characteristic of cohesiveness in the experimental processed cheese. It was much less closely correlated with other textural characteristics. It can be predicted that meltability is correlated to the state of the casein in cheese, i.e., the degree of acidification of the curd during manufacturing and gradation of proteolysis during curing. In addition, other factors may be important in determining the extent of emulsification and subsequent melting properties of processed cheeses. [9, 27, 28]

Table 3. *Texture profile analysis and meltability of low fat processed cheese spread as affected by replacing Ras cheese by camel cheese based during storage period at 5±1°C.*

	Treatments					
	control	T1	T2	T3	T4	
Texture profile:						
Hardness (N)	2.50±0.36^{a}	2.10±0.24^{ab}	1.90±0.38^{b}	1.80±0.98^{b}	0.70±0.06^{c}	
Adhesiveness (mj)	5.63±1.01^{a}	4.52±0.80^{b}	2.71±1.42^{c}	2.64±0.78^{c}	1.05±0.12^{d}	
Cohesiveness (Ratio)	0.79±0.16^{a}	0.74±0.06^{a}	0.72±0.14^{a}	0.69±0.22^{a}	0.25±0.08^{b}	
Springiness (mm)	12.48±1.00^{b}	13.50±1.70^{ab}	14.50±2.50^{a}	14.55±1.94^{a}	15.07±0.76^{a}	
Gumminess (N)	4.30±0.58^{a}	3.70±1.16^{b}	3.20±0.44^{b}	2.40±0.52^{c}	0.40±0.20^{d}	
Chewiness (mj)	28.04±2.06^{b}	31.09±1.94^{a}	26.14±2.00^{c}	16.26±2.02^{d}	5.58±0.94^{e}	
Meltability*:						
Storage period (months)						Means of storage period
Fresh	22.10±1.04^{b}	24.70±3.10^{a}	21.70±2.32^{b}	19.30±1.88^{c}	3.60±0.38^{d}	18.28±7.84^{A}
1	20.30±1.88^{a}	21.50±2.50^{a}	17.20±1.68^{b}	16.80±1.64^{b}	3.20±0.10^{c}	15.80±6.81^{B}
2	18.52±0.84^{b}	20.11±0.42^{a}	16.25±0.70^{c}	15.24±1.28^{d}	2.96±0.52^{e}	14.61±6.29^{C}
3	17.50±0.80^{a}	18.10±0.90^{a}	15.30±1.00^{b}	14.50±0.80^{c}	2.70±0.82^{d}	13.62±5.82^{D}
Means of treatments	19.60±0.52^{b}	21.10±2.66^{a}	17.61±2.65^{c}	16.46±2.01^{d}	3.12±0.41^{e}	15.58±6.80

Mean (±SE). Values with small letters in the same row and values with capital letters in the column having different superscripts differ significantly (p ≤ 0.05).
[*] Expressed as the percentage difference between the area of the melted and the original disc of cheese sample.
C: 100% Ras cheese (control), T1:75% Ras cheese + 25% camel cheese based, T2:50% Ras cheese + 50% camel cheese based, T3: 25% Ras cheese + 75% camel cheese based, T4= 100% camel cheese based.

3.4. Color of Low Fat Processed Cheese Spread

The color attributes of processed cheese as affected by replacing mature Ras cheese by camel cheese based were compared (Table 4). It was observed that the lightness value (L*) diminished (P<0.05), specified that the cheese became lightness color when replacing mature Ras cheese by camel cheese based is one of the reasons for such effect. In addition, the reduction in the darkeness value of low fat processed cheese spread as affected by replacing aged Ras cheese by camel cheese based can be accredited to the reduction of lactose in cheese base (lactose content of cheese base was 3.8%) which might did not allow the Maillard's reaction during cheese processing. The lightness of the product was increased by increasing levels of cheese base during storage. For all samples, the parameter b* is presented by positive values (Table 4). The results indicated that the b* values were significantly (P<0.05) reduced when camel cheese based levels increased. Thus, the use of cheese base had an opposite effect on the color of cheese as compared to the control. The variations in the parameter a* of samples containing cheese base is shown in Table 4. The greenness of cheese was increased as a result of accretion in the levels of camel cheese based utilized in the resultant product. This observation was in agreement with the results obtained by other researchers who used immature raw materials for processing. [7, 25] Color intensities of these cheeses varied and could be described as white, pale, and yellow-orange. The yellow-orange color may be due to that the used Ras cheese containing annatto. Among the processed cheeses, control had the most orange color compared with T1 as shown by having the highest a* value (P < 0.05) and more yellow in appearance (i.e., highest b* value), these were made with the supplement of Ras cheese (with annatto colorant). In contrast, cheese T4 was made with 100% camel retentate had the lowest yellow color intensity (b* = 6.7 to 27.22), with a similar degree of redness as cheese T4 (mean a* value of -2.15 associated with control cheese). As expected, L* values were the highest (P < 0.05) for the cheese T4. Hue angle values for cheeses control and T1 were not significantly different and ranged from 83.57 to 84.17°, which is within the expected values of 40 to 90° transition from orange to yellow. Cheese T4 had a lower ($P < 0.05$) hue angle of -65.65 to -84.05°. Although when colors are close to neutral, small differences can reason a large variation in the calculated hue angle. [18] Cheese made from 100% camel cheese based (T4) had similar low a* (-2.15 ± 0.2, indicating a slight green tinge) and b* values (6.7 ± 2), indicating a slight yellow color. Control cheeses, T1, T2, and T3 with the addition of Ras cheese had the highest a* and b* values, respectively. The whiteness index, which accounted for the lightness of the product, was calculated based on the L*, a* and b* values. The whiteness index was affected by an interaction between camel retentate and Ras cheese which has been added (Table 2). A significant decrease in the whiteness index was detected for cheese containing Ras cheese as the amount addition of processed cheese. For cheese containing Ras cheese, a significant decrease in the whiteness index was obtained with 75 and 100% Ras cheese in comparison with 100% camel cheese based (Table 4). Whiteness values (WI*) were increased in T4, T3, T2 as a result of added camel cheese based (100, 75, 50%, respectively) compared with control and T1. Total color difference values (ΔE) increased with the decrease of camel cheese based concentration in cheeses.

3.5. Microstructure of Low Fat Processed Cheese Spread

Figure 1 shows the main structure of cheese, it indicated the interaction between casein particles and small fat globules, which were largely embedded in casein aggregates with whey forming with cheese base T1, T2, T3 and T4 comparable with control (c) large fat globules strong interaction between casein particles. These structures may have been accountable for the loss of cheese meltability.

The protein matrix in camel cheese based became more ragged, less homogenous, and contained numerous small holes and cracks. These results are in agreement with the finding of Mistry, Hassan [29], who observed the fat globules of various sizes embedded in the continuous protein network. However, a porous structure with relatively large pores was noted in the control cheese, more compact protein masses were also observed in cheeses made from the concentrated milk. The structural matrix of spread processed cheese is a cross-linked casein-calcium phosphate network in which fat globules are physically entrapped; the protein matrix is elastic when the casein is largely intact. [30]

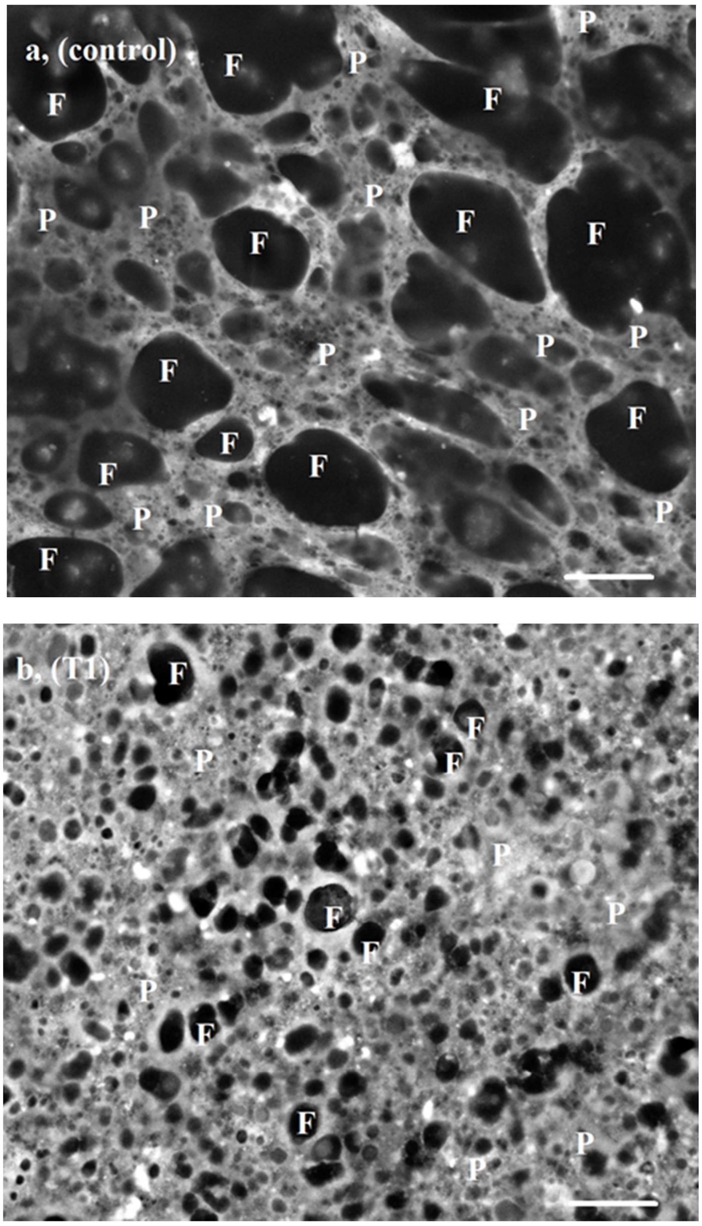
Table 4. *Color properties of low fat processed cheese spread as affected by replacing Ras cheese with camel cheese based during storage period at 5±1°C.*

Color values	Storage period (months)	Treatments					Means of storage period
		control	T1	T2	T3	T4	
L*	Fresh	65.14±1.82^{b}	66.37±2.28^{b}	66.37±2.8^{b}	79.39±2.29^{a}	79.39±2.32^{a}	71.33±6.88^{C}
	1	73.16±1.81^{c}	75.61±2.72^{b}	80.52±2.32^{a}	80.98±3.24^{a}	81.13±1.54^{a}	78.27±3.54^{B}
	3	76.22±1.14^{c}	79.35±1.98^{b}	80.14±2.92^{ab}	81.24±0.22^{ab}	81.37±2.52^{a}	79.66±2.12^{A}
	Means of treatments	71.51±5.00^{d}	73.78±5.78^{c}	75.67±7.07^{b}	80.53±1.31^{a}	80.63±1.33^{a}	76.42±5.84
a*	Fresh	2.78±0.26^{a}	2.63±0.24^{a}	-1.08±0.06^{b}	-2.51±0.08^{c}	-2.75±0.40^{d}	-0.19±2.52^{B}
	1	3.01±0.48^{a}	2.71±0.92^{a}	-1.37±0.64^{b}	-2.19±0.34^{c}	-2.38±0.04^{c}	-0.04±2.49^{B}
	3	3.33±0.16^{a}	2.87±0.12^{b}	-1.18±0.30^{c}	-1.73±0.42^{d}	-1.86±0.50^{d}	0.28±2.40^{A}
	Means of treatments	3.04±0.28^{a}	2.74±0.26^{b}	-1.21±0.22^{c}	-2.14±0.36^{d}	-2.33±0.40^{d}	0.018±2.42
b*	Fresh	27.22±0.28^{a}	23.35±0.94^{b}	19.55±0.86^{c}	12.22±1.72^{d}	6.07±0.08^{e}	17.68±7.91^{B}
	1	25.93±3.14^{a}	20.61±2.5^{b}	19.26±1.8^{b}	16.03±1.34^{c}	10.7±2.68^{d}	18.51±5.32^{A}
	3	23.81±2.26^{a}	19.25±1.78^{b}	18.65±2.58^{b}	17.35±1.94^{b}	14.85±3.66^{c}	18.78±3.22^{A}
	Means of treatments	25.65±1.78^{a}	21.07±1.98^{b}	19.15±0.91^{c}	15.20±2.41^{d}	10.54±3.97^{e}	18.32±5.69
C*	Fresh	27.36±0.10^{a}	23.50±1.82^{b}	19.58±1.12^{c}	12.48±2.18^{d}	6.66±0.42^{e}	17.92±7.76^{B}
	1	26.10±0.82^{a}	20.79±2.28^{b}	19.31±1.9^{c}	16.18±0.34^{d}	10.96±0.80^{e}	18.67±5.23^{AB}
	3	24.04±1.26^{a}	19.46±4.20^{b}	18.69±2.36^{b}	17.44±0.50b^{c}	14.97±5.16^{c}	18.92±3.37^{A}
	Means of treatments	25.33±1.50^{a}	21.25±2.19^{b}	19.19±0.90^{c}	15.37±2.30^{d}	10.86±3.83^{e}	18.50±5.63
h_{ab}°	Fresh	84.17±1.84^{a}	83.57±2.64^{a}	-86.84±3.46^{d}	-78.40±4.30^{c}	-65.65±2.58^{b}	-12.63±81.86^{A}
	1	83.38±2.80^{a}	82.51±2.52^{a}	-85.93±5.14^{c}	-82.22±1.78^{b}	-80.81±0.88^{b}	-16.61±84.17^{B}
	3	82.04±1.36^{a}	81.52±2.40^{a}	-86.38±0.86^{b}	-84.31±3.90^{b}	-84.05±2.80^{b}	-18.24±84.54^{C}
	Means of treatments	83.19±1.29^{a}	82.53±1.41^{a}	-86.38±1.61^{d}	-81.64±3.01^{c}	-76.84±8.56^{b}	-15.82±81.65
WI*	Fresh	55.68±2.64^{d}	58.97±3.22^{c}	61.09±1.90^{c}	75.91±1.58^{b}	78.34±2.18^{a}	65.99±9.66^{C}
	1	62.56±2.62^{e}	67.95±3.18^{d}	72.57±2.42^{c}	75.03±1.34^{b}	78.18±0.46^{a}	71.26±5.76^{B}
	3	66.18±1.64^{d}	71.62±1.34^{c}	72.73±2.30^{c}	74.39±1.62^{b}	76.10±0.60^{a}	72.20±3.55^{A}
	Means of treatments	61.47±4.72^{e}	66.18±5.75^{d}	68.79±5.85^{c}	75.11±0.93^{b}	77.54±1.23^{a}	69.82±7.20
ΔE	Fresh	0.00	4.06±0.12^{d}	8.67±0.84^{c}	21.36±2.22^{b}	26.10±0.88^{a}	12.04±10.40^{A}
	1	8.12±0.94^{e}	5.87±0.18^{d}	10.86±3.67^{c}	13.65±2.58^{b}	18.02±0.66^{a}	11.30±4.49^{B}
	3	3.74±0.54^{e}	5.55±0.72^{d}	7.90±1.30^{c}	9.62±2.42^{b}	11.56±2.90^{a}	7.67±2.99^{C}
	Means of treatments	3.95±3.53^{e}	5.16±0.86^{d}	9.14±1.66^{c}	14.87±5.27^{b}	18.56±6.36^{a}	10.34±6.89

Mean (±SE). Values with small letters in the same row and values with capital letters in the column having different superscripts differ significantly ($p \leq 0.05$). The L* value is an indicator of luminosity (the degree of lightness from black to white). a* value is an indicator of green (–) and red (+), whereas b* is an indicator of blue (–) and yellow (+).

C: 100% Ras cheese (control), T1:75% Ras cheese + 25% camel cheese based, T2:50% Ras cheese + 50% camel cheese based, T3: 25% Ras cheese + 75% camel cheese based, T4= 100% camel cheese based.

Figure 1 a. shows the image of microstructural of the traditional processed cheese spread (control, c) and its analogues with 25-100% (T1-T4) camel cheese based with the same magnification 100x. Protein matrix is visible with various forms and sizes open spaces representing. The fat globules gaps were extracted during samples preparation of analysis. Image A, the image of control processed cheese sample made from Ras cheese, revealed on an open network of aggregated proteins where the walls of the protein matrix are relatively solid with smaller aggregates have been joined together directly by the stranded of fibrous protein material. SEM micrographs showed a uniform distribution of fat globules throughout the protein matrixes of all samples, but fat globules in cheese from camel cheese based were not imbedded in the protein aggregates as they were in control one. The density of the protein network increases and pore sized decreases in processed cheese spread fortified by camel cheese based compared with control one with the decrease in pH. Low fat processed cheese spread made with camel milk protein showed a protein matrix to be composed of relatively uniform small particle Figure 1: b, c, d, e (T1, T2, T3, and T4). These differences in structure and hardness may be related to differing ionic conditions, especially ionic calcium and phosphate during cheese processing. [31] Thus, processed cheese spread fortified with camel cheese based consisted of a uniform dispersion of protein particles and fat globules interrupted only by occasional it by the SEM. Fat globules in T1 and T2 (Figure 1: b and c) in both types of processed cheese spreads were dispersed throughout the matrix, but did not appear to interact with protein aggregate in the matrix as they are in control cheese spread. In cheese spread T3 and T4 (Figure 1: d and e) revealed larger aggregates apparent by coarse structure of the increase the appearance fat globules (fat gaps) and protein matrix these account for the rough flavors of those cheeses which had fewer scores than other cheeses.



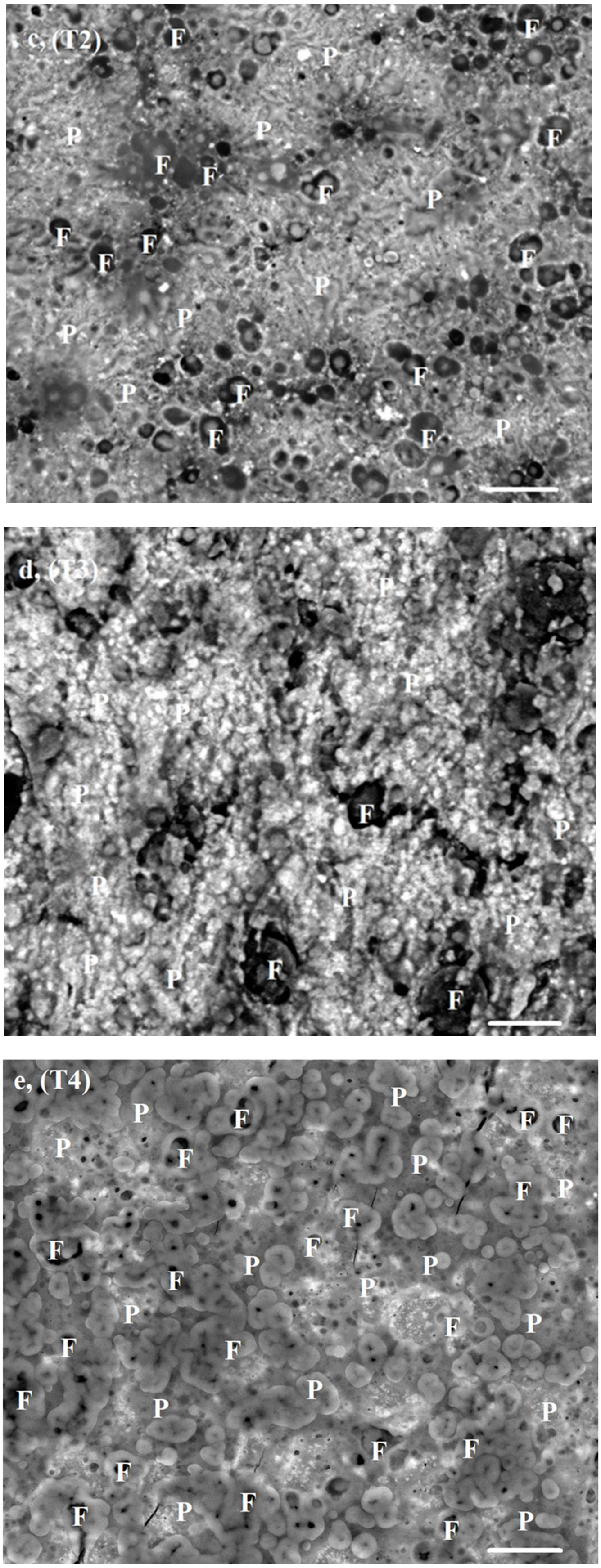


Figure 1. *SEM micrographs of low fat processed cheese spread as affected by replacing Ras cheese by camel cheese based. a (control): 100% Ras cheese; b (T1):75% Ras cheese + 25% camel cheese based; c (T2):50% Ras cheese + 50% camel cheese based; d (T3): 25% Ras cheese + 75% camel cheese based; e (T4): 100% camel cheese based. P, protein; F, fat gap; bar, 100μm; Magnification, 1000x.*

3.6. Sensory Evaluation

Results of the sensory evaluation showed that the processed cheese spreads containing 25% of camel cheese based had taste, flavor, and color similar to those of the control cheese (Table 5). Higher addition of cheese based caused a decrease in hardness, which had an effect on the spreadability of the final product. The supplement of camel cheese based at a higher level (75%) gave a product with the slightly weaker intensity of cheese flavor in contrast to the control cheese. This was perhaps due to the use of small amounts of extra-aged cheese in the blend. The addition of 100% camel cheese based exhibited the lowest score in flavor, appearance, and body & texture. In addition, it could be observed from the foregoing results that processed cheese can be done by substitution Ras cheese with camel cheese based 25% or 50%. While, 75% camel cheese based had good appearance and flavor, this will improve the texture. This observation is in agreement with the results reported by other literature. [7, 25] The cheese base serves to provide body and texture, as well as flavor, body and texture, are generally achieved with young cheese and flavor with aged cheese. Therefore, a blend of young and aged cheese is required. [32-34] Extravagant amounts of young cheese will lead to poor flavor, whereas extravagant amounts of aged cheese will produce a poor body. The age of cheese is an important factor because it determines the extent of proteolysis and flavor. For optimum functional features, such as melting, the amount and structural features of the proteins are critical. With the progress in cheese ages, proteins hydrolyze into smaller proteins and peptides with a reduced interaction among these shorter proteins. Consequently, process cheese produced from such aged cheese is less elastic and may be crumbly [35] and have extreme meltability. [36] It is important for processed cheese manufacturers to be able to select a cheese based with the preferred degree of proteolysis and prominently, according to commercial manufacturers, to be able to control proteolysis.

Table 5. *Organoleptic properties of low fat processed cheese spread as affected by replacing Ras cheese by camel cheese based during storage period at 5±1°C.*

parameters	Storage period (months)	Treatments					Means of storage period
		control	T1	T2	T3	T4	
Appearance (20)	Fresh	19±1.00^{ab}	19.42±1.84^{a}	18.29±1.58^{ab}	17.51±2.52^{b}	15.29±2.08^{c}	17.90±1.70^{A}
	1	18.52±2.54^{a}	18.92±1.84^{a}	18.22±1.84^{a}	17.70±2.40^{a}	14.35±2.20^{b}	17.54±1.94^{AB}
	2	18.06±0.88^{a}	18.78±3.06^{a}	17.83±1.16^{a}	16.82±2.64^{a}	13.11±1.72^{b}	16.92±2.25^{BC}
	3	17.53±2.56^{a}	17.88±2.76^{a}	17.13±1.76^{a}	16.20±1.90^{a}	12.95±3.40^{b}	16.33±2.14^{C}
	Means of treatments	18.27±0.99^{a}	18.75±1.19^{a}	17.87±0.84^{ab}	17.06±1.19^{b}	13.93±1.44^{c}	17.18±2.06
Body & Texture (40)	Fresh	39.15±1.80^{a}	39.03±1.06^{a}	38.76±2.52^{a}	37.25±4.50^{a}	33.93±4.86^{b}	37.62±2.47^{A}
	1	38.57±2.14^{a}	38.22±1.94^{a}	37.97±4.94^{a}	36.80±3.60^{a}	32.94±3.88^{b}	36.90±2.59^{AB}
	2	37.92±3.34^{a}	37.02±3.04^{a}	36.63±20.76^{a}	35.77±3.04^{a}	32.09±1.68^{a}	35.88±4.90^{AB}
	3	37.41±2.32^{a}	36.9±3.30^{ab}	36.05±1.10^{ab}	35.00±1.00^{b}	31.05±1.60^{c}	35.28±2.50^{B}
	Means of treatments	38.26±1.26^{a}	37.79±1.40^{a}	37.35±5.12^{a}	36.20±1.68^{a}	32.50±1.80^{b}	36.42±3.32
Flavor (40)	Fresh	39.50±1.00^{a}	38.70±0.40^{a}	38.16±1.82^{a}	37.60±4.20^{a}	30.52±3.24^{b}	36.89±3.53^{A}
	1	39.02±1.04^{a}	38.16±1.82^{a}	37.68±2.86^{a}	36.90±3.30^{a}	30.03±1.56^{b}	36.35±3.49^{A}
	2	38.80±3.10^{a}	37.88±3.26^{ab}	37.04±2.08^{ab}	36.20±1.90^{b}	28.5±2.70^{c}	35.68±3.98^{A}
	3	38.00±2.00^{a}	37.01±2.25^{a}	36.92±3.34^{a}	35.81±3.12^{a}	28.00±1.00^{a}	35.15±5.69^{A}
	Means of treatments	38.83±1.01^{a}	37.93±4.81^{a}	37.45±1.22^{a}	36.62±1.55^{a}	29.26±1.47^{b}	36.02±4.21
Total (100)	Fresh	97.65±3.80^{a}	97.15±3.30^{a}	95.21±5.92^{a}	92.36±11.22^{a}	79.74±10.18^{b}	92.42±7.55^{A}
	1	96.11±5.72^{a}	95.30±5.60^{a}	93.87±9.74^{a}	91.40±9.30^{a}	77.32±7.64^{b}	90.80±7.89^{AB}
	2	94.78±5.56^{a}	93.68±6.36^{a}	91.50±26.00^{a}	88.79±7.58^{a}	73.70±6.10^{b}	88.49±9.73^{AB}
	3	92.94±6.88^{a}	91.79±28.08^{a}	90.10±6.20^{a}	87.01±6.02^{a}	72.00±6.00^{b}	86.76±9.82^{B}
	Means of treatments	95.37±2.99^{a}	94.48±6.78^{ab}	92.67±6.53^{ab}	89.89±4.33^{b}	75.69±4.54^{c}	89.62±8.86

Mean (±SE). Values with small letters in the same row and values with capital letters in the column having different superscripts differ significantly ($p \leq 0.05$).
C: 100% Ras cheese (control), T1:75% Ras cheese + 25% camel cheese based, T2:50% Ras cheese + 50% camel cheese based, T3: 25% Ras cheese + 75% camel cheese based, T4= 100% camel cheese based.

4. Conclusion

In this work, camel cheese based (made from camel milk retentate) was mixed with Ras cheese for the production of an acceptable cheese. Low fat processed cheese spread was prepared by replacing young Ras cheese by cheese base (fermented camel milk retentate) at levels of 25, 50, 75, and 100%. It can be concluded that low fat processed cheese spread with good meltability, desired body, and texture characteristics, and improved spreadability can be prepared by using camel milk retentate (camel cheese based) at least 25-50%. It has been shown that the cheese base can successfully replace the Ras cheese in low fat processed cheese spread production from camel milk retentate. Further investigations are recommended to evaluate the nutritional aspects of the resultant processed cheese spread.

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