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Improving of Low-Fat Ras Cheese Properties with Adding Sesame Hulls

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Abstract This study aimed to improve the properties of low-fat Ras cheese via the application by adding sesame hulls. Ras cheese were made from cow's milk standardized to skim milk (T5), 1% (T4), 1.5% (T3), 2% (T2) and 3% fat (control) (T1) with adding zero % (T1) control, 1% (T2), 1.5% (T3), 2% (T4) and 3% (T5) sesame hulls respectively . Control cheese and their treatments were stored for four months at (13±2oC and humidity 85%). The chemical composition, microbiological and organoleptic properties were determined in cheese and its treatments months. The obtained results reveal that both contents of the dry matter (DM), protein (total nitrogen, TN x 6.38), salt, ash, titratable acidity (TA) and vitamin (A) contents of cheese increased as the fat content of cheesemilk decreased and increased ratio sesame hulls. The adding of sesame hulls associated with an increase in the DM, protein, fat/DM, salt, ash, TA, and vitamin (A) contents of cheese, those also raised gradually along the ripening period for four months. The water-soluble nitrogen (WSN/TN), shilovich ripening index (SRI), and PH value contents of cheese decreased as the fat content of cheesemilk was reduced and increased of ratio sesame hulls. An increase in total volatile fatty acids (TVFA) contents occurred of cheese decreased as the fat content of cheesemilk was reduced and increased ratio sesame hulls. Adding of sesame hulls lead to the increase in antioxidants activity and fiber contents of cheese increased as the fat content of cheesemilk decreased and increased of ratio sesame hulls, as well as mineral contents (K, Ca, Fe, P, Zn, Mg, Cu, Mn) increasing of ratio sesame hulls with increasing. Hardness values increased gradually while each of Springiness and Cohesiveness values decreased when reducing the fat content of cheesemilk and increased ratio sesame hulls. Microbiological analysis of Ras cheese revealed that the total bacterial count increased until the second month, then decreased at the end period storage. However, mold and yeasts were not detected during the first months then slightly detected at the end of the storage period meanwhile, the coliforms were not detected. Ras cheese containing 1%, 1.5%, 2%, and 3% sesame hulls was acceptable and of good flavor, color, body and texture, and appearance, while the most acceptable cheese treatments were cheese made by adding 1-1.5% sesame hulls. Finally, a palatable low-fat Ras cheese could successfully be made from low-fat milk using sesame hulls between 1% - 1.5%.

Keywords: *low-fat Ras cheese, sesame hulls, antioxidant activity, vitamin (A), sensory attributes*

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1. Introduction

Ras cheese is one of the most popular hard cheese in Egypt which is known as "Romi cheese". It's similar to the Greek cheese "KeFalotyri" [1]. It is produced from cow's milk or a mixture of cow's and buffalo's milk. Milk fat plays a vital role in the quality, acceptability of cheese and gives the cheese satisfying characteristic texture. Therefore, the reduction of fat cheese produces undesirable properties such as lack of flavor and hard dry body.

Ras cheese is known as the most popular hard cheese in Egypt. This cheese is normally marketed after 4-6 months of ripening. There is a great interest in recent years for the manufacture of low-fat dairy products, particularly reduced-fat cheese to meet consumer demand. Consumers wish to reduce their dietary fat intake for numerous health benefits, without sacrificing the desirable textural and flavor attributes of cheese. Lipids play a vital role in the functional and sensory properties of food products. Lipids play a vital role in the functional and sensory properties of food products by carrying, enhance, and release other flavors and ingredients [2], and also its interaction with other ingredients to develop the texture, flavor, generation perception, stability, and the overall sensation of foods [3]. Reduction in the cheese fat content tends to develop the hard, dry body, and low flavor cheeses as fat cheese types play a marvelous role in the overall quality and acceptability of cheeses. The value of milk fat has been put in doubt on grounds of health considerations [4]. Milk fat has been identified as hypercholesterolemia because it contains cholesterol and is primarily saturated [5].

Moreover, high fat intake is associated with increased risk for obesity, some types of cancer, liver, and heart diseases [6,7]. Besides, because of the awareness of the adverse effects of excessive dietary fat intake, many consumers are modifying their dietary habits [8,9].

Technically, milk fat plays several important functions in cheese making affecting cheese firmness, adhesiveness, mouthfeel, and also an important flavor ingredient whose partial or total removal causes major sensory problems [9,10] Besides its significant partnership in the formation of the consistency of the products, the buttery flavor associated with milk fat contributes to the richness of cheese flavor and it plays crucial roles in developing the flavor perception, flavor stability, flavor generation and the overall sensation of dairy products [3,7,11,12,13]. Whereas the majority of flavor components are dissolved to some extent in the lipid phases of food, fat governs to release the flavor slowly in the mouth and to result in a pleasant aftertaste [14,15]. That means, as the fat provides mouthfeel and richness, it serves also as a reservoir of flavor. Thereby, removing any significant amount of fat (above 25%) from a product changes the flavor profile, in dairy products. [15,16,17].

Some technical trials depending on the modification of some processing steps of cheese making for some varieties of semi-hard or hard cheeses other than Ras cheese were described by [18,19,20], but of the most problems facing the manufacture of low-fat cheese are the shortage of characteristic flavor and suitable body and texture [11], and although [21] reported that the addition of whey protein concentrate improved slightly the sensory properties of low-fat Ras cheese but it's the resultant cheese was lacking the typical body & texture and flavor of good quality Ras cheese.

Sesame *(Sesamumindicum* L.*)* is an oilseed herbaceous crop of the Pedaliaceae family. [22,23,24]. The world production of sesame seeds reached (3.7 million tons) in 2007, Asia, and Africa produced 2.40 and 1.15 million tons accounting for 64% and 31% respectively, of the total seed supply [25]. Sesame *(Sesmumindicum* L.*)* is considered as one of the oldest crops in the world. Archeological records indicate that it has been used in India for more than 5000 years [26]. Sesame oil is very stable because it contains many antioxidants such as sesamin, sesamolin, and sesamol [27]. Hence, it has a long shelf life and can be blended with less stable vegetable oils to improve their stability and longevity [27,28].

The sesame chemical composition is shown that the seed is an important source of oil (50-60%), protein (18-25%) and carbohydrates (16-18%) [29]. Its seed contains about 42-54% quality oil, 22-25% protein, 20-25% carbohydrates, and 4-6% ash [30,31,32]. The oil fraction shows remarkable stability to oxidation due to the presence of antioxidants (sesamol, sesamolin, and sesamin) together with tocopherols [33,34]. Sesame (Sesameumindicum L.) seed is one of the important oilseed crops in the world. It is not only a good source of edible oil but also widely used in baked goods and confectionery products [35,36,37]. The quantity and quality of the oil contained in the seed have been depending on ecological genetics and physiological factors such as climate, soil type, cultivars, and maturity of plant respectively [37,38]. On the other hand, Sesame seed is contenting s approximately 50 percent oil (out of which 35% is monounsaturated fatty acids and 44% polyunsaturated fatty acids) and 45 percent meal (out of which 20% is protein) [39,40]. And it could be considered Sesame seeds are an excellent source of copper and calcium. It is rich in phosphorous, iron, magnesium, manganese, zinc, and vitamin B1. And also many medical properties and health benefits of sesame may be attributed to its mildly laxative, emollient, and demulcent [41].

Some approaches can be used in the cheese-making process to improve the texture of low-fat cheeses, being one example of the addition of microparticulate whey proteins as fat replacers [42].

So the main objective of this study was to determine the effect of sesame hulls on the properties of low-fat Ras cheese.

2. Materials and Methods

2.1. Materials

Fresh cow'smilk was obtained from the herd of faculty of Agricultural, Cairo University. Sesame hulls were obtained from the Field Crops Research Institute, Agricultural Research Center, Giza, Egypt. Pure Yoghurt starter cultures of *Streptococcus. thermophilus* (EMCC1043) and *lactobacillus delbrueckii subsp. bulgaricus (EMCC1102)* were obtained from Cairo MIRCEN Culture Collection Center, Faculty of Agric., Ain Shams University. Rennet powder was obtained from CHR. Hansen's Lab. Denmark. A good grade table salt (Nacl) was obtained from the local market. Liquid precoating from farmacheese Company as a gift. The composition of dairy ingredients used is presented in Table 1.

2.2. Methods

2.2.1. Preparing of Sesame Hulls

Sesame seeds was heated without reaching to roasting degree, after that crushed to obtained (red Tehana), roistering to obtained sesame hulls by adding salted water gradually mechanically.

Table 1. Chemical composition of milk and sesame hulls used in the manufacture of Ras cheese

Constituents	Full fatcow's milk	Skim Cow's milk	Sesame hulls
Dry matter (DM) %	11.84	8.76	68.86
Fat %	3.0	0.1	0.10
Protein %	4.24	3.44	17.70
Lactose or Carbohydrate*	3.85	4.63	47.85
Ash	0.75	0.59	3.210
PH value	6.67	6.67	ND
Acidity %	0.165	0.165	ND
Total antioxidant activity **(DPPH) %	ND	ND	69.50
Fiber	ND	ND	8.73

*: Calculated by difference – TC% = [100- (protein + ash + fat + moisture)]
**: Reduction percent reduction of antioxidant activity of DPPH
DPPH: 2, 2 diphenyl-1-picrichydrazyl.
ND: not determined.

2.2.2. Ras Cheese Manufacturing

Ras cheese was made from cow's milk standardized by cow's skim milk to 3% fat, 2% fat, 1.5% fat, 1% fat and zero% fat for control (Treatment 1), Treatment 2 (T2), Treatment 3 (T3), Treatment 4 (T4) and Treatment 5 (T5) respectively.

T1 (control): Ras cheese manufactured from 3% fat cow's milk+zero% sesame hulls.

T2: Ras cheese manufactured from 2% fat cow's milk + 1% sesame hulls.

T3: Ras cheese manufactured from 1.5% fat cow's milk + 1.5% sesame hulls.

T4: Ras cheese manufactured from 1% fat cow's milk + 2% sesame hulls.

T5: Ras cheese manufactured from zero% fat cow's milk +3% sesame hulls.

Ras cheese was manufactured as described by [43] and enacted by [44]. The milk was heated to 72°C/15sec. and immediately cooled to 32°C. Than 1% of each *Streptococcus. thermophilus* (EMCC1043) and *lactobacillus delbrueckii subsp. bulgaricus* (EMCC1102) were added and left until the acidity reached to 0.19-0.20%. Rennet powder was added to the milk the curd becomes firm during 25-30 min. The curd was cut into cubes using vertically and horizontally knives, stirring and heated gradually to reach 45°C in 15min and held at this temperature unit acidity reached to 0.14%. About 2/3 (two-third) of the whey was drained, 1.5% table salt was added, left for 15min after that whey was completely drained then add sesame hulls as follows: (T1): as a control without any addition, (T2): by adding 1% sesame hulls, (T3): by adding 1.5% sesame hulls, (T4): by adding 2% sesame hulls and (T5): by adding 3% sesame hulls. The cheese was allowed to ripen under controlled (about85%) relative humidity and condition at temperature (13±2°C).

2.2.3. Chemical Analysis

Milk and cheese samples were chemically analyzed at zero, 1, 2, 3, 4months for titratable acidity (TA), dry matter (DM), fat (F), total nitrogen (TN), salt and water-soluble nitrogen(WSN) contents according to [45], whereas ash, vitamin (A) and fiber contents were determined as given in [46]. The pH of samples was measured using pH meter with a combined electrode, HANNA HI8014 (HANNA, Instrument, Portugal). The total volatile fatty acids (TVFA) in cheese samples were determined by the method of [47]. Values were expressed as ml of 0.1 N NaOH/100g. Shilovich ripening index (SRI) was tested according to [48]. The mineral contents were determined by using the Atomic Absorption spectrophotometer as described in [46]. The antioxidant activity was determined by the2, 2-diphenyl-1-picrylhydrazyl (DPPH) from Sigma-Aldrich (Steinheim, Germany) method of [49].

2.2.4. Microbiological Examination

Cheese samples were determined for the total bacterial count (TBC), Mold and yeast (M&Y) and coliforms according to [50].

Texture profile analysis (TPA):

Cheese samples were done using a Universal Testing Machine (TMS-Pro) equipped with (250Ibf) Ioad cell and connected to a computer programmed with Texture Pro ™ texture analysis software (program, DEVTPA withhold) [82].

2.2.5. Organoleptic Quality

All cheese samples were evaluated during ripening periods for the appearance, flavor and body and texture according to the scoring sheet of [51] by the staff members of Dairy Science Department, Food Technology Institute Agriculture Research Center, and Giza, Egypt.

2.2.6. Statistical Analysis

All results were evaluated statistically analyzed using the general model program [52]. The difference among means was tested using [53] multiple range test. Also, the correlation coefficient analysis was done between the different parameters.

3. Results and Discussion

3.1. Gross Composition

Data in Table 2 reveal that, the contents of dry matter (DM), protein (TN x 6.38), salt and ash of cheese increased proportionally as the fat content of starting cheesemilk decreased and/or as the ripening period prolonged (p<0.001), i.e. The relatively high level of fat allowed the resultant Ras cheese to hold more moisture and *vice versa*. Similar findings.

Table 2. Effect of sesame hulls on chemical composition of low-fat Ras cheese during ripening period (RP)

Product / Property	Storage (months)	T1 (Control)	T2	T3	T4	T5
Dry matter % (DM)	Fresh	59.41^{e,e}	60.30^{dc,e}	61.52^{cb,e}	62.65^{ba,e}	63.51^{a,e}
	1	61.47^{e,d}	62.63^{dc,d}	63.47^{cb,d}	64.03^{ba,d}	64.12^{a,d}
	2	63.92^{e,c}	64.13^{dc,c}	65.21^{cb,c}	65.80^{ba,c}	66.11^{a,c}
	3	65.75^{e,b}	66.43^{dc,b}	67.57^{cb,b}	68.82^{ba,b}	69.51^{a,b}
	4	67.29^{e,a}	68.43^{dc,a}	68.92^{cb,a}	69.53^{ba,a}	69.92^{a,a}
Fat/dry matter % (F/DM)	Fresh	34.68^{a,e}	23.88^{b,e}	18.47^{c,e}	12.32^{d,e}	9.94^{e,e}
	1	36.32^{a,d}	25.17^{b,d}	19.59^{c,d}	13.19^{d,d}	10.67^{e,d}
	2	36.37^{a,c}	25.29^{b,c}	20.30^{c,c}	13.66^{d,c}	11.05^{e,c}
	3	36.55^{a,b}	25.40^{b,b}	21.06^{c,b}	14.13^{d,b}	11.65^{e,b}

Property \ Product	Storage (months)	T1 (Control)	T2	T3	T4	T5
	4	$36.84^{a,a}$	$25.95^{b,a}$	$21.35^{c,a}$	$14.29^{d,a}$	$12.07^{e,a}$
Protein % (total nitrogen x 6.38)	Fresh	$28.26^{e,e}$	$30.30^{d,e}$	$32.35^{c,e}$	$34.38^{b,e}$	$36.39^{a,e}$
	1	$32.62^{e,d}$	$35.02^{d,d}$	$37.32^{c,d}$	$39.74^{b,d}$	$41.36^{a,d}$
	2	$33.30^{e,c}$	$35.73^{d,c}$	$38.02^{c,c}$	$40.51^{b,c}$	$43.07^{a,c}$
	3	$34.19^{e,b}$	$36.67^{d,b}$	$39.04^{c,b}$	$41.66^{b,b}$	$44.19^{a,b}$
	4	$34.71^{e,a}$	$37.26^{d,a}$	$39.68^{c,a}$	$42.30^{b,a}$	$45.42^{a,a}$
Salt %	Fresh	$3.29^{e,e}$	$3.52^{dc,e}$	$3.54^{cb,e}$	$3.58^{ba,e}$	$3.61^{a,e}$
	1	$3.71^{e,d}$	$4.02^{dc,d}$	$4.11^{cb,d}$	$4.20^{ba,d}$	$4.31^{a,d}$
	2	$3.82^{e,c}$	$4.15^{dc,c}$	$4.30^{cb,c}$	$4.50^{ba,c}$	$4.61^{a,c}$
	3	$3.96^{e,b}$	$4.44^{dc,b}$	$4.52^{cb,b}$	$4.62^{ba,b}$	$4.77^{a,b}$
	4	$4.13^{e,a}$	$4.74^{dc,a}$	$4.89^{cb,a}$	$5.04^{ba,a}$	$5.14^{a,a}$
Ash %	Fresh	$8.26^{e,e}$	$9.53^{dc,e}$	$9.67^{cb,e}$	$9.77^{ba,e}$	$9.90^{a,e}$
	1	$8.38^{e,d}$	$9.60^{dc,d}$	$9.73^{cb,d}$	$9.83^{ba,d}$	$9.92^{a,d}$
	2	$9.10^{e,c}$	$9.63^{dc,c}$	$9.82^{cb,c}$	$9.90^{ba,c}$	$9.96^{a,c}$
	3	$9.50^{e,b}$	$9.67^{dc,b}$	$9.88^{cb,b}$	$9.92^{ba,b}$	$9.97^{a,b}$
	4	$9.60^{e,a}$	$9.86^{dc,a}$	$9.90^{cb,a}$	$9.95^{ba,a}$	$9.99^{a,a}$

The means with the same letter did not significantly differ (P<0.001).
T1 (control): Ras cheese manufactured from 3% fat cow's milk + zero% sesame hulls.
T2 : Ras cheese manufactured from 2% fat cow's milk + 1% sesame hulls.
T3 : Ras cheese manufactured from 1.5% fat cow's milk + 1.5% sesame hulls.
T4 : Ras cheese manufactured from 1% fat cow's milk + 2% sesame hulls.
T5 : Ras cheese manufactured from zero% fat cow's milk +3% sesame hulls.

Table 3. Effect of sesame hulls on ripening indices of low-fat Ras cheese during ripening period (RP)

Property \ Product*	Storage (months)	T1 (Control)	T2	T3	T4	T5
WSN**/TN %	Fresh	$5.12^{a,e}$	$4.69^{b,e}$	$4.14^{c,e}$	$3.71^{d,e}$	$3.21^{e,e}$
	1	$10.54^{a,d}$	$9.47^{b,d}$	$8.20^{c,d}$	$7.38^{d,d}$	$6.10^{e,d}$
	2	$13.21^{a,c}$	$11.78^{b,c}$	$10.40^{c,c}$	$9.29^{d,c}$	$8.17^{e,c}$
	3	$18.28^{a,b}$	$16.34^{b,b}$	$14.21^{c,b}$	$12.55^{d,b}$	$10.23^{e,b}$
	4	$19.11^{a,a}$	$17.12^{b,a}$	$14.95^{c,a}$	$13.27^{d,a}$	$11.88^{e,a}$
TVFA***	Fresh	$11.25^{e,e}$	$12.20^{d,e}$	$13.13^{c,e}$	$14.06^{b,e}$	$14.61^{a,e}$
	1	$28.95^{e,d}$	$31.06^{d,d}$	$33.52^{c,d}$	$35.90^{b,d}$	$37.30^{a,d}$
	2	$39.05^{e,c}$	$42.46^{d,c}$	$45.82^{c,c}$	$49.07^{b,c}$	$50.99^{a,c}$
	3	$51.65^{e,b}$	$55.35^{d,b}$	$59.73^{c,b}$	$63.97^{b,b}$	$66.47^{a,b}$
	4	$60.07^{e,a}$	$65.29^{d,a}$	$70.46^{c,a}$	$75.46^{b,a}$	$78.41^{a,a}$
SRI****	Fresh	$20.00^{a,e}$	$18.00^{b,e}$	$17.00^{c,e}$	$15.00^{d,e}$	$13.00^{e,e}$
	1	$67.00^{a,d}$	$60.00^{b,d}$	$58.00^{c,d}$	$54.00^{d,d}$	$50.00^{e,d}$
	2	$86.00^{a,c}$	$84.00^{b,c}$	$77.00^{c,c}$	$73.00^{d,c}$	$69.00^{e,c}$
	3	$105.00^{a,b}$	$102.00^{b,b}$	$92.00^{c,b}$	$88.00^{d,b}$	$84.00^{e,b}$
	4	$120.00^{a,a}$	$114.00^{b,a}$	$107.00^{c,a}$	$103.00^{d,a}$	$99.00^{e,a}$

The means with the same letter did not significantly differ (P<0.001).
*: See Table 2. **: Water soluble nitrogen% (WSN)/TN， ***: Total volatile fatty acids (ml 0.1N NaOH/ 100g cheese) (TVFA).
****: Shilovich ripening index (SRI).

Were reported by [8,13,54,55,56,57]. These results could be attributed to that the fat present in milk, reduced the whey syneresis from cheese curd due to the elimination of whey from it through its thinnest capillaries in which the fat globules are situated. That, because of the great number of globules, which hindered the whey flow [58]. Besides, [59,60] reported that, increasing fat content might increase the number of interstices within the network which are occupied by fat globules thus leading to the increased impediment of whey drainage. The use of different levels of sesame hulls during the ripening period there were differences in dry matter (DM) content among all treatments including control treatment, which contained the lowest dry matter (DM) with the lowest content of protein, salt and ash. The fat decreased while dry matter (DM), protein, salt and ash increased the resultant Ras cheese. The highest contents of dry matter (DM), protein, salt and ash in Ras cheese with sesame hulls are mainly due to the higher ratio in sesame hulls. These results are in agreement with those obtained by [61,62].

3.2. Ripening Indices

A reduction rate in all ripening indices, expressed as water-soluble nitrogen (WSN/TN), total volatile fatty acid (TVFA) and shilovich ripening index (SRI) contents in Table 3 of Ras cheese with sesame hulls were recorded among the descending levels of the fat content with sesame hulls ($p<0.001$). This indicates, that reducing the fat content of cheese milk led to delay the proteolysis rate and hence a decrease in the WSNreleased during cheese ripening ($p<0.001$). On the other hand, WSN decreased in Ras cheese made from sesame hulls at a different ratio. This might be due to the higher of sesame hulls in treated Ras cheese which caused higher protein decomposition than control [63,64]. The effect of different ratios of sesame hulls on total volatile fatty acid (TVFA) during the ripening period is shown in Table 3. Data indicated that there were slight differences ($p<0.001$) among Ras cheese treatments in Table 3. Treatments with zero%, 1%, 1.5%, 2% and 3% sesame hulls contained the highest TVFA, followed by an increased content of sesame hulls. Total volatile fatty acid (TVFA) content increased significantly ($p<0.001$) asthe ripening period proceeded. This could be attributed to the lipolysis activity of lactic acid bacteria. These results are following those reported by [65,66].

Thewater-soluble nitrogen (WSN) content and shilovich ripening index (SRI) in Table 3 of Ras cheese with sesame hulls followed similar trends of variations during ripening being gradually increased. This trend can be attributed to cheese proteolysis. Comparing the WSN content of cheese from different treatment revealed that cheese with sesame hulls had the highestWSN while the other treatments and control had nearly the same WSN content without any significant differences between them. However, differences were found in SRI between treatments as cheese containing 1% sesame hulls had significantly higher SRI than other treatments. While the differences between other treatments and control in SRI was not significant. These results are following those reported by [21,67,68].

3.3. Titratable Acidity% (TA) and PH Value

Results also showed that the Ras cheese treatments exhibited were relative to higher acidity than the control in Table 4. During the ripening period, the acidity of all treatments increased, but the rat of acidity development was slower in cheese. A similar finding was reported by [69]. The trend of the changes in PH values of all treatments was opposite to that of acidity, which may lead to more lactic acid production as a result of microorganisms' metabolism [70,71].

Table 4. Effect of sesame hulls on titratable acidity % (TA) and PH value of low-fat Ras cheese during ripening period (RP)

Property \ Product*	Storage (months)	T1 (Control)	T2	T3	T4	T5
TA %	Fresh	$0.75^{e,e}$	$0.80^{d,e}$	$0.82^{c,e}$	$0.83^{b,e}$	$0.85^{a,e}$
	1	$1.32^{e,d}$	$1.35^{d,d}$	$1.40^{c,d}$	$1.42^{b,d}$	$1.45^{a,d}$
	2	$1.47^{e,c}$	$1.51^{d,c}$	$1.53^{c,c}$	$1.55^{b,c}$	$1.57^{a,c}$
	3	$1.58^{e,b}$	$1.60^{d,b}$	$1.62^{c,b}$	$1.64^{b,b}$	$1.66^{a,b}$
	4	$1.66^{e,a}$	$1.70^{d,a}$	$1.73^{c,a}$	$1.76^{b,a}$	$1.79^{a,a}$
PH value	Fresh	$5.59^{a,a}$	$5.42^{b,a}$	$5.30^{c,a}$	$5.19^{d,a}$	$5.10^{e,a}$
	1	$5.54^{a,b}$	$5.37^{b,b}$	$5.25^{c,b}$	$5.14^{d,b}$	$5.05^{e,b}$
	2	$5.50^{a,c}$	$5.35^{b,c}$	$5.21^{c,c}$	$5.12^{d,c}$	$5.03^{e,c}$
	3	$5.46^{a,d}$	$5.30^{b,d}$	$5.18^{c,d}$	$5.10^{d,d}$	$4.95^{e,d}$
	4	$5.41^{a,e}$	$5.20^{b,e}$	$5.11^{c,e}$	$5.06^{d,e}$	$4.87^{e,e}$

The means with the same letter did not significantly differ ($P<0.001$).
*: See Table 2. **: Titratable acidity % (TA).

Table 5. Effect of sesame hulls on microbiological properties (log cfu/ml) of low-fat Ras cheese during ripening period (RP)

Property \ Product*	Storage (months)	T1 (Control)	T2	T3	T4	T5
Total bacterial count (cfu/gm x 10^6)	Fresh	$7.70^{e,a}$	$7.91^{d,c}$	$7.94^{c,c}$	$7.96^{b,c}$	$7.98^{a,c}$
	1	$7.51^{e,b}$	$7.95^{d,b}$	$7.99^{c,b}$	$8.01^{b,b}$	$8.03^{a,b}$
	2	$7.40^{e,c}$	$8.01^{d,a}$	$8.02^{c,a}$	$8.05^{b,a}$	$8.08^{a,a}$
	3	$7.32^{e,d}$	$7.84^{d,d}$	$7.88^{c,d}$	$7.90^{b,d}$	$7.91^{a,d}$
	4	$7.12^{e,e}$	$7.71^{d,e}$	$7.75^{c,e}$	$7.77^{b,e}$	$7.80^{a,e}$
Mold& yeast (cfu/gm x 10^1)	Fresh	ND	ND	ND	ND	ND
	1	ND	ND	ND	ND	ND
	2	ND	ND	ND	ND	ND
	3	3.93	4.00	4.19	4.30	4.43
	4	4.49	4.37	4.50	4.61	4.68
Coliform (cfu/gm x 10^1)	Fresh	ND	ND	ND	ND	ND
	1	ND	ND	ND	ND	ND
	2	ND	ND	ND	ND	ND
	3	ND	ND	ND	ND	ND
	4	ND	ND	ND	ND	ND

The means with the same letter did not significantly differ ($P<0.001$).
*: See Table 2. ND: not detected.

3.4. Microbiological Properties

Results in Table 5 showed the total bacterial count in Ras cheese treatments. It could be observed that the total count of control. T4(2%) and T5(3%) showed higher total bacterial, while they reached their maximum counts at 2 months of the ripening period, and decreased at the end of the ripening period. This decrease could be attributed to the developed acidity. These results are in agreement with those reported by [72].

Counts of mold and yeast recorded in Ras cheese treatments are presented in Table 5. It could be seen that the molds and yeasts were not detected at fresh, 1, and 2 months for all treatments. An increase in mold and yeast counts in control cheese was observed at the three months to four months. While, at higher concentrations of sesame hulls (T5), the mold and yeast count were slightly increased in all treatments during the ripening period and this might be due to the acidity development and accumulation of lactic acid [73]. It could also be observed from Table 5 that either the control or the treated with sesame hulls Ras cheese were completely free from coliforms while fresh or during the ripening period.

3.5. Mineral Contents (ppm) (mg/kg)

Treatments made with sesame hulls showed different mineral contents, compared to control (T1) in Table 6. Adding sesame hulls to cow's skim and low milk was accompanied by a high level of potassium, calcium, magnesium, iron, zinc, copper and manganese in the resultant cheese, it could also be noticed that the iron content of fortified Rascheese with sesame hulls varied between 14.86- 34.14 (in fresh) and 16.28- 62.85 (in 4 months) ppm (mg/kg), compared to 10.22 (in fresh) and 12.14 (in 4 months) ppm (mg/kg) in control (T1) treatment. These results are following those reported by [66] and agreement with reported by [74] Ohba and Iio (2000), who stated that beverage, prepared using sesame hulls had the same calcium contents milk with a high level of iron (3-times than of milk). All elements were increased with increasing sesame hulls content in milk.

3.6. Texture Profile Analysis (TPA)

Results in Table 7 showed the Changes in textural parameters of Ras cheese during the ripening period. Hardness values increased gradually during the treatments as a result of the decrease in the fat content of cheesemilk was reduced and increased ratio sesame hulls and Hardness decreased during the ripening period. That means that fat

Content was an important factor to decrease the hardness of Ras cheese. The results agree with [75,76], mention that reduction of fat increases the hardness of Ras cheese. Springiness values decreased during the treatments also decreased during the ripening period. These agree with [75,77] was found a negative correlation between Springiness and hardness of Ras cheese Cohesiveness was affected by the fat content, cheese made from full-fat milk had higher Cohesiveness value and decrease by decrease the fat content of cheesemilk was reduced and increased of ratio sesame hulls. Results agree with [78,79].

3.7. Total Antioxidant Activity (DPPH), Fiber (%) and Vitamin (A)

Results are given in Table 8 show that the total antioxidant activity, fiber and vitamin (A), total antioxidant activity (DPPH, free radical screening capacity) of Ras cheese without sesame hulls (control) (T1) exhibited low total antioxidant activity, compared to treatments supplemented with sesame hulls. Sesame hulls can be considered as rich natural material of the total antioxidant. The increase in total antioxidant was more pronounced as the level of sesame hulls increased.

Regarding data in Table 8. The total antioxidant activity increased from 34.00 % for treatment without sesame hulls (control) (T1) up to 85.30 % for treatment made with sesame hulls (T5) (3%). These results are a line with those of [80] who found increasing total antioxidant activity percentage for sesame hulls. The highest content of fiber in Ras cheese with sesame hulls is mainly due to the higher ratio in sesame hulls, compared to control (T1) in Table 8. These results are in agreement with those obtained by [61,62]. Table 8 Ras cheese made with sesame hulls higher vitamin (A). Control (T1) cheese without sesame hulls showed the lowest vitamin (A) content among all treatments. Increasing the ratio of sesame hulls added resulted in a higher value of vitamin (A), being highest in (T5) 3% sesame hulls treatment. Similar observations were reported by [66].

3.8. Organoleptic Quality

The sensory evaluation of Ras cheese made with sesame hulls is shown in Table 9. The flavor of resultant cheese enhanced and became more preferable to panelists with adding 1% (T2)-1.5% (T3) sesame hulls into cow's low-fat milk compared to control (T1). At 3% (T5) the panelists started to detect the flavor of sesame hulls in the product. The body and texture of resultant cheese were improved and the cheese showed more ability to spread with adding sesame hulls into cow's low fat milk. Treatments with up to1% (T2)-1.5% (T3) sesame hulls were firm enough and body and texture with no defects. While with higher sesame hulls ratios, the body started to be more firm which was more obvious with 3% (T5) sesame hulls. Addition of sesame hulls into cow's low, and skim milk led to the slight yellow color of resultant cheese and this becomes more obvious within increasing the ratio added. Generally, the appearance of the final product was affected by the ingredients used in the manufacture of cheese. Total scores of all Ras cheese treatments were satisfactory and acceptable butadding sesame hulls into low-fat milk up to1% (T2)-1.5% (T3) provided the best organoleptic quality compared to the control. Increasing the ratio of sesame hulls additional above that affected significantly the quality characteristics.

Storage of cheese up to four months slightly provided the total quality attributes and this effect was more marked in cheese samples at the end of the ripening period. These findings are in agreement with those of [81].

Table 6. Effect of sesame hulls on mineral contents (ppm) (mg/kg) of low-fat Ras cheese during ripening period (RP) (Fresh and 4 months).

Mineral contents (ppm) (mg/kg)	Storage (months)	Cheese treatments*				
		T1 (Control)	T2	T3	T4	T5
Na	Fresh	1148.04	1259.12	1513.58	1540.14	1626.25
	4	1311.11	1430.05	1626.85	1655.79	1724.42
K	Fresh	2770.69	7019.79	17978.92	43508.95	53097.21
	4	9151.41	21185.44	25590.52	85512.56	119737.59
Ca	Fresh	1542.68	1580.36	1724.64	1805.60	2097.91
	4	1869.94	2218.24	2456.99	2641.7	2882.30
P	Fresh	103.06	109.63	115.91	121.11	125.93
	4	110.00	119.20	124.35	128.45	132.55
Mg	Fresh	167.33	171.86	239.73	337.84	353.96
	4	207.40	307.49	491.10	524.54	748.69
Fe	Fresh	10.22	14.86	21.60	29.61	34.14
	4	12.14	16.28	50.03	50.31	62.85
Zn	Fresh	274.40	320.30	345.78	397.01	436.31
	4	303.34	342.56	386.63	414.74	452.83
Cu	Fresh	8.75	13.24	21.53	40.99	49.11
	4	9.69	19.39	69.57	82.90	92.16
Mn	Fresh	8.83	26.71	32.50	58.19	88.26
	4	10.32	29.04	98.17	99.87	136.10

*: See Table 2.

Table 7. Effect of sesame hulls on texture profile analysis of low-fat Ras cheese during ripening period (RP)

Product* / Property	Storage (months)	T1 (Control)	T2	T3	T4	T5
Hardness (N)	Fresh	$50.2^{e,a}$	$55.6^{dc,a}$	$57.1^{cb,a}$	$59.1^{b,a}$	$62.7^{a,a}$
	1	$34.9^{e,b}$	$37.7^{dc,b}$	$38.6^{cb,b}$	$50.1^{b,b}$	$49.3^{a,b}$
	2	$32.0^{e,c}$	$36.1^{dc,c}$	$37.4^{cb,c}$	$40.7^{b,c}$	$47.2^{a,c}$
	3	$26.3^{e,d}$	$32.2^{dc,d}$	$33.4^{cb,d}$	$37.2^{b,d}$	$45.2^{a,d}$
	4	$24.0^{e,e}$	$30.4^{dc,e}$	$30.7^{cb,e}$	$30.9^{b,e}$	$43.4^{a,e}$
Springiness (mm)	Fresh	$7.48^{a,a}$	$6.94^{b,a}$	$6.86^{cb,a}$	$6.71^{dc,a}$	$4.00^{e,a}$
	1	$7.04^{a,b}$	$6.80^{b,b}$	$6.38^{cb,b}$	$5.57^{dc,b}$	$3.96^{e,b}$
	2	$6.92^{a,c}$	$6.70^{b,c}$	$5.94^{cb,c}$	$4.70^{dc,c}$	$3.70^{e,c}$
	3	$6.84^{a,d}$	$6.65^{b,d}$	$5.91^{cb,d}$	$4.63^{dc,d}$	$3.10^{e,d}$
	4	$6.80^{a,e}$	$6.47^{b,e}$	$5.13^{cb,e}$	$4.26^{dc,e}$	$2.41^{e,e}$
Cohesiveness (ratio)	Fresh	$0.71^{a,e}$	$0.68^{b,e}$	$0.66^{cb,e}$	$0.43^{d,e}$	$0.37^{e,e}$
	1	$0.80^{a,d}$	$0.78^{b,d}$	$0.69^{cb,d}$	$0.68^{d,d}$	$0.49^{e,d}$
	2	$0.85^{a,c}$	$0.83^{b,c}$	$0.76^{cb,c}$	$0.72^{d,c}$	$0.69^{e,c}$
	3	$0.91^{a,b}$	$0.90^{b,b}$	$0.82^{cb,b}$	$0.77^{d,b}$	$0.74^{e,b}$
	4	$0.99^{a,a}$	$0.91^{b,a}$	$0.85^{cb,a}$	$0.82^{d,a}$	$0.78^{e,a}$
Gumminess (N)	Fresh	$35.64^{b,a}$	$37.8^{a,a}$	$37.69^{a,a}$	$25.41^{c,d}$	$23.20^{d,e}$
	1	$27.92^{b,b}$	$29.41^{a,c}$	$26.63^{a,d}$	$34.07^{c,a}$	$24.16^{d,d}$
	2	$27.20^{b,c}$	$29.96^{a,b}$	$28.42^{a,b}$	$29.30^{c,b}$	$32.57^{d,c}$
	3	$23.93^{b,d}$	$28.98^{a,d}$	$27.39^{a,c}$	$28.64^{c,c}$	$33.45^{d,b}$
	4	$23.76^{b,e}$	$27.66^{a,e}$	$26.10^{a,e}$	$25.34^{c,e}$	$33.85^{d,a}$

*: See Table 2.

Table 8. Effect of sesame hulls on total antioxidant activity, fiber (%) and vitamin A (Iu) of low-fat Ras cheese during ripening period (RP) (Fresh and 4 months)

Property	Storage (months)	Cheese treatments*				
		T1 (Control)	T2	T3	T4	T5
Total antioxidant activity%(DPPH)%**	Fresh	34.00	69.50	70.00	82.10	85.30
	4	34.90	69.80	70.30	82.42	85.78
Fiber %	Fresh	0.94	16.26	17.56	22.25	22.31
	4	12.72	14.91	15.82	30.1	33.13
Vitamin A (Iu)	Fresh	0.30	0.150	0.280	0.370	0.460
	4	0.50	0.170	0.300	0.400	0.490

*: See Table 2. **: Reduction percent reduction of antioxidant activity of DPPH.
DPPH: 2,2 diphenyl-1-picrichydrazyl.

Table 9. Effect of sesame hulls on organoleptic properties scores of low-fat Ras cheese during ripening period (RP)

Storage (months)	Cheese treatments*				
	T1 (Control)	**T2**	**T3**	**T4**	**T5**
Flavour (out of 50 points)					
Fresh	$43^{a,b}$	$42^{a,b}$	$44^{a,b}$	$40^{a,c}$	$36^{a,d}$
1	$43^{a,b}$	$45^{a,b}$	$44^{a,b}$	$40^{a,c}$	$37^{ea,d}$
2	$45^{a,b}$	$45^{a,b}$	$45^{a,b}$	$38^{a,c}$	$37^{a,d}$
3	$48^{a,a}$	$45^{a,b}$	$48^{a,a}$	$38^{a,c}$	$36^{a,d}$
4	$48^{a,a}$	$47^{a,a}$	$48^{a,a}$	$39^{a,c}$	$36^{a,d}$
Body and texture (out of 40 points)					
Fresh	$37^{a,a}$	$35^{a,b}$	$35^{a,b}$	$34^{a,b}$	$30^{a,c}$
1	$37^{a,a}$	$36^{a,a}$	$36^{a,a}$	$34^{a,b}$	$30^{a,c}$
2	$38^{a,a}$	$36^{a,a}$	$37^{a,a}$	$35^{a,b}$	$29^{a,c}$
3	$38^{a,a}$	$37^{a,a}$	$38^{a,a}$	$36^{a,a}$	$27^{a,d}$
4	$38^{a,a}$	$38^{a,a}$	$38^{a,a}$	$36^{a,a}$	$27^{a,d}$
Appearance (out of 10 points)					
Fresh	$9^{a,a}$	$7^{a,b}$	$9^{a,a}$	$7^{a,b}$	$5^{a,d}$
1	$9^{a,a}$	$8^{a,a}$	$9^{a,a}$	$7^{a,b}$	$5^{a,d}$
2	$9^{a,a}$	$9^{a,a}$	$9^{a,a}$	$7^{a,b}$	$6^{a,c}$
3	$9^{a,a}$	$9^{a,a}$	$9^{a,a}$	$7^{a,b}$	$6^{a,c}$
4	$9^{a,a}$	$9^{a,a}$	$9^{a,a}$	$7^{a,b}$	$6^{a,c}$
Total score (out of 100 points)					
Fresh	$89^{a,a}$	$84^{a,a}$	$88^{a,a}$	$81^{a,b}$	$71^{a,c}$
1	$89^{a,a}$	$89^{a,a}$	$89^{a,a}$	$81^{a,b}$	$72^{a,c}$
2	$92^{a,a}$	$90^{a,a}$	$91^{a,a}$	$80^{a,b}$	$72^{a,c}$
3	$95^{a,a}$	$91^{a,a}$	$95^{a,a}$	$81^{a,b}$	$69^{a,c}$
4	$95^{a,a}$	$94^{a,a}$	$95^{a,a}$	$82^{a,b}$	$69^{a,c}$

The means with the same letter did not significantly differ (P<0.001).
*: See Table 2.

4. Conclusion

Finally, the foregoing results led evidently to conclude that, a palatable low-fat Ras cheese could successfully be made from low-fat milk with adding sesame hulls. Ras cheese can be produced by adding sesame hulls up to 1.5% into cow's low milk without any significant difference. Incorporation and with adding of sesame hulls into low and skim milk like cheese exhibited several nutritional advantages. Antioxidant and vitamin (A) levels were increased of liver functions and blood profile, mineral and fiber level increased of bone health, and obesity. It could be concluded, that sesame hulls can be used as an ingredient in marking functional cheese with improved health benefits. Also, using sesame hulls gave the product expect improvement physicochemical, texture properties, and sensory properties special flavor and natural color without the need to add industrial color in the manufacture of Ras cheese.

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