



## Research Article

### Effect of Addition of Sesame Seeds on Physiochemical Quality of Mudaffara Cheese during Storage

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#### Abstract

This study was designed to evaluate the effect of some additives (black cumin and sesame seed), preservation method (with or without whey) and storage period on physiochemical properties of Mudaffara cheese. Mudaffara cheese was prepared from fresh cow's milk by the known traditional methods using the commonly used black cumin as a control in addition sesame seed was introduced as a new additive. The cheese was divided into four portions and treated as follows: two portions were stored in whey (cheese with black cumin and cheese with sesame) and the other two portions were stored without whey; for 7 weeks. All cheese samples were stored in plastic bags at the refrigerator temperature (8°C) and were subjected to weekly examination during the storage. During the first 4 weeks, the two types of cheese stored without whey were significantly ( $P < 0.001$ ) higher in total solids, protein and fat content compared to the whey stored samples. The acidity and the ash content of sesame flavored cheese that was stored without whey were significantly ( $P < 0.001$ ) higher than the other three types of cheese. During the second month, the cheese in the whey revealed non-significant ( $P > 0.05$ ) variations in protein, fat and ash content, which could be due to the variations of the added additive. However, the acidity was higher ( $P < 0.05$ ) in Mudaffara cheese flavored with sesame than that flavored with black cumin. This would influence the ripening and maturation of Mudaffara cheese.

**Keywords:** Black cumin; Cheese; Mudaffara; Physiochemical; Sesame; Storage

#### Introduction

Like most dairy products, cheese is a rich source of minerals, protein, vitamin, fat and carbohydrate [1]. Also cheese is a rich source

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of essential nutrients; in particular proteins, bioactive peptides, amino acids, fat, fatty acids, vitamins and minerals [2]. Moreover, the quality of cheese depends on a variety of factors like raw milk composition, technological parameters, bacteria species, storage, transportation and delivery conditions [3].

The two main types of cheese in Sudan include Sudanese white cheese (*Gibna bayda*), which is the most popular type of cheese and Braided semi hard cheese; Mudaffara cheese [4,5]. Mudaffara cheese is made from non-pasteurized raw whole milk, partially skimmed or a mixture of skim milk and whole cows, sheep or goat's milk [6]. Mudaffara cheese production in Sudan is a small business, and a standard procedure is adopted by the different producers for its production [7].

The range of titratable acidity, pH, fat, protein total solids and ash contents of Mudaffara cheese were 0.29-0.69%, 3.29-4.30, 6.02-20%, 28.29-31.92%, 53.63, 63.83% and 5.40-7.29% [6]. During ripening of Mudaffara cheese, the weight of the cheese, its moisture content and total solids showed variations [8]. The means for fat, protein, total solids, ash and acidity content of Mudaffara cheese made using chymosin were  $17.2 \pm 2.13$ ,  $21.49 \pm 2.53\%$ ,  $51.89 \pm 12.25\%$ ,  $10.96 \pm 9.32\%$  and  $0.48 \pm 0.06\%$ , respectively [9].

A spice is a dried seed, fruit, root, bark or flower of a plant or a herb used in small quantities for flavor, color or as a preservative [10]. Black cumin would be useful for fermented milk because black cumin as spice have significant effect as preservative [11]. Sesame seed, a rich source of protein, is one of the first crops processed for oil production. Its non-culinary application includes its use as an ingredient in soap, cosmetics, lubricants and medicines [12]. The sesame protein isolate exhibited high oil and water absorption capacities, and could be employed in the formulations of food products such as doughnut, pancakes and baked food products and as food thickener [13]. Hence this study was designed with the objectives of comparing Mudaffara cheese manufactured using two different additives as flavor: black cumin (*Nigella sativa*) and sesame seed (*Sesamum indicum*). It is also meant to investigate the effect of preservation method (whey and duration) and storage period on the chemical composition of Mudaffara cheese.

#### Materials and Methods

##### Source of milk

The fresh cow's milk (raw material) used in the processing of Mudaffara cheese in this experiment was obtained from a local farm in Khartoum North during the period of June-August 2013.

##### Sources of spices, salt, starter cultures and rennet

Black cumin (*Nigella sativa*), sesame seed (*Sesamum indicum*) and sodium chloride (NaCl) were obtained from the local market. The starter culture was supplied by Premier Food Product Dairy Factory, Khartoum North (Sudan). Rennet sticks (Christen Hansen's laboratories-Copenhagen, Denmark) was used (1 stick coagulate 50 kg milk).

## Manufacturing mudaffara cheese

The sesame seed was roasted at first and left to cool down, and then it was analyzed to obtain the chemical composition.

The milk was first filtered from impurities and was divided into two parts; 13 liters each; for the two different flavoring additives (black cumin and sesame seed). Then the milk was heated to 40° C and 1% of starter culture was added to develop the acidity. The rennet powder (1%) was added after it was dissolved in a glass of tap water and stirred for 2-3 minutes in order to ensure uniform distribution of the rennet. The milk was left undisturbed to settle and to coagulate into a curd.

After coagulation (about 40 minutes), the whey was allowed to drain from the curd and cut into slices during which more whey draining was occurred. The curd was then taken to the incubator (40° C) and left for 1.5 hours until the required elasticity and acidity (0.54-0.60%) were reached. During this period, every half an hour, inflatable was measured by dipping a small piece of curd into hot water, then holding it in hands, kneading and pulling to form a cord of 2 meters long. If the curd breaks before reaching this length, ripening is considered incomplete. When the curd became smooth paste that showed satisfactory stretching to a rope of more than 4 meters long and elastic, the curd was cut into strips. Then 4-5 pieces were taken at a time and put in the hot water (65-75°C) for 3-5 minutes using wooden paddles until the curd turned into smooth. After that the additives (Black cumin or roasted sesame seeds) were added to the hot paste before braiding. The curd was then hand worked and pulled to form a long rope which was then braided, washed by immersing into cold water.

The two types of cheese were taken after the cooking process and put in steel buckets. All the braided cheeses were immersed into sterilized salted whey (3%) for salting (12 hours).

## Chemical analysis of milk and cheeses

The chemical composition of milk was determined before heat treatment using the Lactoscan milk analyzer (Milkotronic LTD, Europe), while the chemical compositions of the cheeses were determined weekly for 7 weeks.

The total solids content was determined according to the modified method of AOAC [14]. The protein content was determined by the Kjeldahl method and the fat content was determined by the Gerber method [14]. The ash content and the titratable acidity were determined according to AOAC method [14].

## Statistical Analysis

The data of the present study were analyzed using the SPSS (Statistical Package for Social Sciences) microcomputer programmer. Means were separated using LSD.

## Results and Discussion

### Chemical composition of milk

The milk used for cheese manufacturing contained 9.5% solids non-fat, 4.2% fat, 3.3% protein and 5.07% lactose. The density was 1.033 gm/cm<sup>3</sup>. The chemical composition of the additives (black cumin and sesame seed) used are shown in table 1.

Additives	Dry matter	Fat	Crude protein	Crude fiber	Ash
Black cumin	94.45	19.12	31.34	26.32	2.70
Sesame	98.04	29.87	31.20	6.12	2.98

**Table 1:** Chemical composition (%) of black cumin and sesame seeds used for flavoring Mudaffara cheese.

## Chemical in Mudaffara Cheese during the Storage Period

### Total solids

Data showed that the total solids content of Mudaffara cheese was higher at day 0 and day 28, the total solids content were 61.69±0.12% and 54.11± 0.05%, respectively. Table 2 showed that there was slight decrease in the total solids of Mudaffara cheese during storage. Similarly the total solids content of Mudaffara cheese was found to range between 53.63 and 63.83 [6]. The total solids content of Mudaffara cheese steadily increased to 53.61% at day 14 before decreasing at day 21 and then increased to 58.45% at the end of storage [9]. Similar decrease in total solids content of the cheeses during storage was reported [15-18]. The reason might be due to degradation of total protein and decrease in fat content during the storage period [15].

Parameters	Storage Period			
	Day 0	Day 7	Day 14	Day 21
Total Solids (%)	61.69±0.12 <sup>a</sup>	60.50±0.12 <sup>b</sup>	58.78±0.12 <sup>c</sup>	56.15±0.12 <sup>d</sup>
Protein (%)	30.47±0.31 <sup>a</sup>	27.90±0.31 <sup>b</sup>	26.26±0.31 <sup>c</sup>	25.83±0.31 <sup>c</sup>
Fat (%)	22.00±0.28 <sup>a</sup>	21.57±0.28 <sup>a</sup>	19.17±0.28 <sup>b</sup>	19.25±0.28 <sup>b</sup>
Ash (%)	4.17±0.06 <sup>a</sup>	4.08±0.06 <sup>a</sup>	2.94±0.06 <sup>b</sup>	2.91±0.06 <sup>b</sup>
Acidity (%)	0.46±0.29 <sup>c</sup>	0.53±0.29 <sup>c</sup>	0.79±0.29 <sup>b</sup>	1.30±0.29 <sup>a</sup>

**Table 2:** Effect of storage period on the chemical composition of Mudaffara chesses. a,b,c,d means value within the same row with different superscripts letters are significantly different at P<0.001.

The cheese samples flavored with both additives kept without whey showed significantly (P<0.001) higher values for the total solids content (59.67±0.12%) compared with the samples kept in the whey were 58.52±0.12% and 58.97±0.12, respectively as shown in tables 3 & 4. It was observed from the result in table 3 that there was a decrease in the total solids content of the cheese stored in the whey. After day 21, there was significant different (P<0.001) in the cheeses stored in the whey.

The total solids content of Mudaffara cheese ranged between 54.24±0.23% to 61.69±0.23% (Table 4), which was lower than that reported for Mudaffara cheese [6-9], processed cheese [17] and Sudanese white cheese [18,19-21].

The present result showed significant (P<0.001) difference between the samples stored in the whey and those stored without whey. The decrease in total solids content was due to the degradation of protein, dissolution of salt in whey or adsorption of whey by curd [22]. The increase in the total solids content of the cheese flavored with sesame kept in whey at day 21 (Table 4) might be attributed to the higher protein and fat content in sesame seed [12-23]. The data in Table 1 also confirmed this fact.

Parameters	C	Cw	S	Sw
Total solids (%)	59.67±0.12 <sup>a</sup>	58.52±.12 <sup>c</sup>	59.67±0.12 <sup>a</sup>	58.97±0.12 <sup>b</sup>
Protein (%)	29.53±0.31 <sup>a</sup>	25.68±0.31 <sup>b</sup>	28.94±0.31 <sup>a</sup>	26.32±0.31 <sup>b</sup>
Fat (%)	22.5±0.28 <sup>b</sup>	17.75±0.28 <sup>c</sup>	23.58±0.28 <sup>a</sup>	18.33±0.28 <sup>c</sup>
Ash (%)	4.50±0.06 <sup>a</sup>	3.73±0.06 <sup>b</sup>	4.47±.06 <sup>a</sup>	3.97±0.06 <sup>b</sup>
Acidity (%)	0.78±0.29 <sup>b</sup>	0.69±0.29 <sup>b</sup>	0.88±0.29 <sup>a</sup>	0.73±0.29 <sup>b</sup>

**Table 3:** Effect of preservation methods and type of additives on chemical composition of Mudaffara cheese.

C=Mudaffara cheese flavored with black cumin kept without whey.  
 Cw = Mudaffara cheese flavored with black cumin kept with whey.  
 S = Mudaffara cheese flavored with sesame seed kept without whey.  
 Sw =Mudaffara cheese flavored with sesame seed kept with whey.

The total solids content of Mudaffara cheese stored in the refrigerator and flavored by the two different additives and stored in the whey or without whey were found to decrease significantly ( $P<0.001$ ) during the storage (Table 3). The total solids content of Sudanese white cheese stored at refrigerator temperature were significantly ( $P<0.001$ ) lower than those stored at the room temperature [24].

### Protein content

The highest value of protein content of Mudaffara cheeses was found at day 0 (30.47±0.31%), however the protein content decrease significantly ( $P<0.001$ ) during storage as shown in table 2.

High significant ( $P<0.001$ ) mean values in protein content were found for Mudaffara cheese flavored by black cumin and sesame seed that kept without whey (29.53±0.31% and 28.94±0.31%, respectively) compared to those kept in the whey (25.68±0.31% and 26.32±0.31%, respectively) as shown in table 3. This might be because sesame seed, a rich source of protein [12-23]. Table 1 also illustrated high protein content in sesame seed compared to black cumin.

After 21 days of storage, the protein content of cheese flavored with black cumin was significantly ( $P<0.001$ ) higher than that flavored with sesame seed. Table 4 showed that the Mudaffara cheeses kept without whey had higher values in protein content compared to that kept in its whey. The increase in protein content could probably be due to decrease in the moisture content of the cheese [25]. However, the nitrogen content were slightly affected by moisture contents of the cheese [26].

The protein content of Mudaffara cheese ranged between 23.32±0.62% and 31.76±0.62%, which agreed with that reported previously [6]. Also the protein content was higher (21.49±2.53%) in Mudaffara cheese made with chymosin [9]. Higher values were found than those reported for Sudanese white cheese [17-20]. The present study showed that all types of cheese stored in the refrigerator had shown a significant ( $P<0.001$ ) decrease in the protein content during the storage. Similarly it was reported that the protein content of Sudanese white cheese decreased during storage at cold temperature [5-15]. The decrease in protein content during pickling was a direct result of protein degradation leading to the formation of water-soluble compounds, some of which were lost in pickling. The reduction in protein content till day 21 was possibly due to the activity of proteolytic microorganisms leading to protein degradation [9]. Also significant decrease of protein content was reported previously during the storage of Sudanese white cheese [15]. This results were in agreement with the findings mentioned that the protein of processed cheese tend to decrease during the storage period [17]. Variations in the protein content of Mudaffara cheese stored at room and refrigerator were in line with the pervious reports showing that the protein content of the cheese samples stored at room temperature were higher than those stored at the refrigerator temperature [18-24]. This might be because the amino acid would continue to decrease during storage of the processed cheese depending on the storage duration and temperature [27]. The low storage temperature delays the ripening of cheese as a result of its effect on the number and activity of lactic acid bacteria and proteolytic organism and consequently lowering the rate of protein decomposition [28].

### Fat content

Data describing the change that occur in the fat content of Mudaffara cheese samples stored with or without whey throughout the storage period were illustrated in table 5.

The fat values of Mudaffara cheese were significantly ( $P<0.001$ ) higher at the beginning of the storage period (day 0, 7 and 28 that revealed 22.00±0.28%, 21.57±0.28%, and 14.83±0.31% respectively), compared with those obtained at day 42 and 49 (12.00±0.31% and 11.67±0.31%, respectively) as shown in table 3. The increase in fat content of Mudaffara cheese till day 21 might be due to high moisture loss during the storage, but the decrease in fat content at end of storage period may be attributed to breakdown of fat by microorganisms and loss from cheese [9].

Parameters	Total Solids				Protein			
	With whey		Without whey		With whey		Without whey	
	Cumin	Sesame	Cumin	Sesame	Cumin	Sesame	Cumin	Sesame
Day 0	61.69±0.23	61.69±0.23	61.69±0.23	61.69±0.23	28.99±0.62	29.74±0.62	31.76±0.62	31.41±0.62
Day 7	60.22±0.23	60.30±0.23	60.69±0.23	60.78±0.23	26.08±0.62	27.20±0.62	28.90±0.62	29.40±0.62
Day 14	57.93±0.23	58.29±0.23	59.30±0.23	59.61±0.23	24.08±0.62	24.99±0.62	29.69±0.62	26.28±0.62
Day 21	54.24±0.23	59.61±0.23	56.99±0.23	57.77±0.23	23.56±0.62	23.32±0.62	27.75±0.62	28.67±0.62
Day 28	54.12±0.07	54.09±0.07	D	D	22.33±0.44	22.67±0.44	D	D
Day 35	53.38±0.07	53.19±0.07	D	D	20.67±0.44	20.67±0.44	D	D
Day 42	52.36±0.07	52.21±0.07	D	D	23.33±0.44	23.33±0.44	D	D
Day 49	52.00±0.07	52.00±0.07	D	D	23.66±0.44	23.67±0.44	D	D
Level of sig.	***							

**Table 4:** Effect of preservation methods and additives type on the total solid and protein contents of Mudaffara cheese during storage.

\*\*\*= significant different at  $P<0.001$ .

Parameters Storage	With Whey		Without Whey	
	Cumin	Sesame	Cumin	Sesame
Day 0	20.67±0.57	22.33±0.57	22.33±.57	22.67±0.57
Day 7	19.00±0.57	19.33±0.57	24.00±0.57	24.67±0.57
Day 14	16.67±0.57	17.33±0.57	20.00±0.57	22.67±0.57
Day 21	14.67±0.57	14.33±0.57	23.67±0.57	24.33±0.57
Day 28	15.00±0.44	14.67±0.44	D	D
Day 35	14.33±0.44	13.00±0.44	D	D
Day 42	11.67±0.44	12.33±0.44	D	D
Day 49	11.00±0.44	12.33±0.44	D	D
Level of significant	***			

**Table 5:** Change in fat content of cumin and sesame Mudaffara cheeses kept in or without whey during the storage.

a,b,c,d means value within the same columns and rows with different superscripts letters are significantly different at P<0.001

D = cheese deteriorated.

\*\*\*=significant different at P<0.001.

The highest value of fat content was found in Mudaffara cheese stored without whey flavored with both sesame (23.58±0.28%) and black cumin (22.5±0.28%) compared to the cheese that kept in the whey (17.75±0.28% and 18.33±0.28%, respectively) as shown in tables 3 & 5. Moreover the data showed significant (P<0.001) differences. The cheese flavored with sesame had higher values of fat content (Tables 3 & 5). This could be due to the higher fat content in sesame seed as shown in table 1 and as stated in previous reports [12-23]. The fat content of the cheese kept with whey was significantly (P<0.001) lower compared to that kept without whey during the storage period (Table 5). However there was no significant (P>0.05) variation between the cheeses stored with whey after day 21 (Tables 3 & 5). This conclusion was previously claimed by Abdalla who stated that when the cheese was stored in the whey, the fat leakage in the brine solution resulted in a decrease of fat content [22].

The fat content ranged between 14.33±0.57% to 24.67±0.57%, which was higher than that reported previously [6]. Similarly a fat content in the range of 22.22-28.61% for Sudanese Mudaffara cheese collected from Khartoum markets was found [29]. Some fat must have leaked from curd into the brine solution, which partially might explain the decrease in fat content in curd during storage [22]. Also the decrease in fat content during storage period was probably due to lipolytic activity of microorganisms on fat [15-18].

### Ash content

The ash content of Mudaffara cheese was significantly (P<0.001) higher at day 0 and 7; it revealed 4.17±0.06% and 4.08±0.06%, respectively (Table 2). However, significantly (P<0.01) lower value was obtained at day 35 (2.93±0.06%). The ash content was significantly (P<0.001) lower in Mudaffara cheeses flavored with black cumin and sesame seed stored in the whey (3.73±0.06% and 3.97±0.06%, respectively). However there was no significant (P>0.05) variation after day 21 of storage between cheeses stored with whey. This study showed a decrease in ash content during storage. However higher values were reported (5.40-7.29%) for the ash content of Mudaffara cheese [6]. Also the ash content in Mudaffara cheese prepared by *Solanum dubium* extract was higher (11.92±9.2%) than that (10.96±9.32)

made using chymosin [9]. The ash content in curd and whey was very much affected by diffusion of salt from curd into whey [22].

The ash content was significantly (P<0.001) higher in Mudaffara cheese stored without whey compared with cheeses stored in whey (Tables 2 & 6). This might be due to total solids in Mudaffara cheese stored without whey had high total solids. During pickling the ash content followed a similar trend to the total solids [22].

The present study showed that the ash content of Mudaffara cheese ranged between 2.30±0.13 and 5.27±0.13%, respectively (Table 6), which was lower than that reported previously [6-18,19]. The ash content of white cheese decrease and remained constant throughout the storage period [30].

### Acidity content

The acidity showed sharp increase in cheese at day 21 (1.30±0.29%), which was continued throughout the rest of storage. It was significantly (P<0.001) lower at day 0 and 7 (0.46±0.29% and 0.53±0.29%, respectively). The acidity was significantly (P<0.001) higher in sesame Mudaffara cheeses compared to black cumin cheeses (Tables 3 & 6), which will influence repining of cheese and its early maturation. This might be due to the high value of the fat in sesame seed (Table 1), supported the previous reports stating that sesame seed contain high fat content [12,13]. The result supported earlier study which found that braided cheese sample containing 3.5% black cumin recorded the highest titratable acidity (1.52%), while control sample (0.0% black cumin) showed the lowest (0.74%) [7]. the acidity was found in a range between 0.44±0.06% and 1.57±0.06%, which was higher than that reported in a previous study [6]. The data in Tables 2 & 6 revealed an increase in the lactic acid level of Mudaffara cheese during storage. High acidity content in the product is related to the presence of lactic acid as a result of the fermentation [31]. Storage period significantly (P≤0.05) affected titratable acidity of braided cheese as the titratable acidity increased gradually till the end of the storage period [7]. Similarly the titratable acidity is significantly (P<0.05) affected by the storage period, increasing gradually until day 21 (0.57±0.16%), then decreased at the end of the storage period (0.50±0.09%) [9]. the increase in acidity during storage period was mainly due to lactic acid bacteria [16,26,32]. The storage temperatures activate the natural microflora of raw milk to develop acidity as the result of lactose fermentation [33].

After 21 days of storage, the cheese samples stored without whey were deteriorated, the acidity content was significant (P<0.05) higher in Mudaffara cheese flavored with sesame (1.50±0.03%) compared to cheese flavored with black cumin (1.46±0.03%). Moreover Farah and El Zubeir reported that the panelist showed a high affinity for Mudaffara cheese made from sesame and recommended that processing and consumption of braided (Mudaffara) cheese flavored with sesame seed have to be promoted [34].

### Conclusion

This study concluded that there is a possibility of using the sesame seed in addition to the commonly used black cumin in Mudaffara cheese. Mudaffara cheese flavored with black cumin and sesame seed revealed more or less similar compositional content. Thus the Braided (Mudaffara) cheese industry is a practical way to save the milk and to give a product with high nutritional value with a long shelf life if there was a proper storage conditions. Hence it was recommended that processing and consumption of Braided (Mudaffara) cheese flavored with sesame seed should be practiced at large scale as it will improve the repining of cheese.

Parameters	Ash				Acidity			
	With whey		Without whey		With whey		Without whey	
	Cumin	Sesame	Cumin	Sesame	Cumin	Sesame	Cumin	Sesame
Day 0	3.73±0.13	3.97±0.13	4.50±0.13	4.47±0.13	0.45±0.06	0.44±0.06	0.46±0.06	0.49±0.06
Day 7	3.23±0.13	2.77±0.13	5.07±0.13	5.27±0.13	0.49±0.06	0.49±0.06	0.53±0.06	0.61±0.06
Day 14	2.78±0.13	2.80±0.13	3.10±0.13	3.10±0.13	0.80±0.06	0.77±0.06	0.77±0.06	0.84±0.06
Day 21	2.70±0.13	2.30±0.13	3.53±0.13	3.10±0.13	1.04±0.06	1.23±0.06	1.35±0.06	1.57±0.06
Day 28	3.23 ±0.08	3.17±0.08	D	D	0.69 ±0.04	0.71 ±0.04	D	D
Day 35	2.87 ±0.08	3.00 ±0.08	D	D	0.79 ±0.04	0.87 ±0.04	D	D
Day 42	3.00 ±0.08	3.07 ±0.08	D	D	1.17 ±0.04	1.27 ±0.04	D	D
Day 49	3.17 ±0.08	3.47 ±0.08	D	D	1.27 ±0.04	1.27 ±0.04	D	D
Level of significant	***							

**Table 6:** Effect of storage methods and additives type on ash and acidity of Mudaffara cheese during storage.

a,b,c,d means value within the same columns and rows with different superscripts letters are significantly different at P<0.001. D = cheese deteriorated. \*\*\*= significant different at P<0.001.

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