

Microstructure of industrially produced reduced and low fat Turkish white cheese as influenced by the homogenization of cream

By A.D. Karaman^{a*}, M. Benli^b and A.S. Akalin^c

^aAdnan Menderes University, Faculty of Agriculture, Department of Food Engineering, Aydın, Turkey

^bAnkara University, Faculty of Science, Department of Biology, Ankara, Turkey

^cEge University, Faculty of Agriculture, Department of Dairy Technology, Izmir, Turkey

*Corresponding author: demet.karaman@adu.edu.tr

RESUMEN

Microestructura de quesos blancos turcos bajos en grasa producidos industrialmente, influencia de la homogenización de la crema.

Se estudia la microestructura y distribución de los glóbulos de grasa de quesos blancos turcos bajos en grasa. Quesos con reducida y baja cantidad en grasa fueron fabricados conteniendo entre el 1,5% y 0,75% de grasa de leche, respectivamente, y con cremas homogeneizadas y no homogeneizadas, en una planta de lácteos. Las cremas homogeneizadas y no homogeneizadas y el suero de los quesos se analizaron para determinar la distribución de los glóbulos de grasa y también se analizaron las características de la microestructura de muestras de queso. De acuerdo con los resultados, la homogeneización de la crema reduce el tamaño de los glóbulos de grasa, mostrando un gran número de partículas de grasa dispersa en la matriz de caseína que mejoró la lubricación de la microestructura del queso. De acuerdo con las micrografías de la grasa que no se elimina, estas exhiben una matriz más amplia en la que hay pocos glóbulos de grasa en comparación con las micrografías de las muestras desgrasadas. La homogeneización de la crema produce pequeños glóbulos de grasa y el suero resultante contiene glóbulos de grasa no incrustados. Estos resultados son importantes para los procesadores de productos lácteos, y muestran la utilidad de la homogeneización de crema como una herramienta del procesamiento a nivel industrial.

PALABRAS CLAVE: Crema homogeneizada – Microestructura – Queso blanco – Reducción de grasa

SUMMARY

Microstructure of industrially produced reduced and low fat Turkish white cheese as influenced by the homogenization of cream.

The microstructure and fat globule distribution of reduced and low fat Turkish white cheese were evaluated. Reduced and low fat cheeses were manufactured from 1.5% and 0.75% fat milk respectively which were standardized unhomogenized and homogenized cream in a dairy plant. Homogenized and non-homogenized creams and cheese whey were analyzed for fat globule distribution and cheese samples were also analyzed for microstructure characteristics. According to the results, the homogenization of cream decreased the size of fat globules; and showed that a large number of fat particles were dispersed in the in matrix and improved the lubrication of cheese microstructure. According to the micrographs for the fat, which was not removed, they

exhibited a more extended matrix with a few small fat globules compared to the defatted micrographs. Homogenization of cream produces small fat globules and unclustered fat globules were found in the resulting whey. These results are important for dairy processors for using cream homogenization as a processing tool at the industrial level.

KEY-WORDS: Fat reduction – Homogenized cream – Microstructure – White cheese.

1. INTRODUCTION

The homogenization of milk or cream decreases the fat globule size and homogenization has been used in the cheese industry especially to increase yield and rate of lipid hydrolysis (Madadlou *et al.*, 2007; Rudan *et al.*, 1998). However, the homogenization of milk adversely affects the structure of rennet gel and milk proteins in commercial practice and the concept of homogenizing only the cream portion of cheese milk was studied. Recently there have been many reports on the use of cream homogenization as a processing tool to enhance the properties of different types of cheese (Madadlou *et al.*, 2007; Rudan *et al.*, 1998; Poduval and Mistry, 1999; Metzger and Mistry, 1994; 1995).

Turkish white cheese is a brined cheese variety which is the most commonly consumed cheese in Turkey (Temelli *et al.*, 2006). It is made from heat-treated milk ripened slowly to improve flavor (Akın *et al.*, 2003). In this study, the homogenization of cream was used as a processing tool at the industrial level, in order to reduce the ripening time for economic reasons.

The arrangement of casein particles, fat globules, dispersed water and mineral components on the micron scale is known as the microstructure of cheese (Ong *et al.*, 2011). The microstructure is not a static concept; but evolves throughout the cheese processing steps (Pereira *et al.*, 2009). Also, the microstructure of cheese significantly affects its final product processing characteristics, flavor and also textural properties (Noronha *et al.*, 2008). Every cheese variety has different characteristic structural features that represent the chemical and biochemical changes in the cheese (Madadlou *et al.*, 2005).

Accordingly, the microstructure of white cheese (Madadlou *et al.*, 2005; 2006; Lobato-Calleros *et al.*, 2007; McMahon *et al.*, 2009; Karami *et al.*, 2008; 2009; Akalin and Karaman, 2010; Ozer *et al.*, 2003) and the microstructure of various cheeses produced by homogenized cream (Madadlou *et al.*, 2007; Rudan *et al.*, 1998; Poduval and Mistry, 1999; Metzger and Mistry, 1994; 1995) have been studied by many researchers. However, no information is available on the effect of cream homogenization on the microstructural properties of reduced and low fat Turkish white cheese. Therefore, the objective of this research was to investigate the effect of cream homogenization on the microstructure properties of reduced and low fat Turkish white cheeses at the 1st day of ripening.

2. MATERIALS AND METHODS

2.1. Milk and cheese

Raw cows' milk containing 3.45% milk fat was obtained from and processed at the Pinar Dairy Products Company, Izmir, Turkey. Four different

kinds of cheese from reduced-fat milk (CRF, HRF, CLF, and HLF) were prepared according to Figure 1. Then, the milk was pasteurized at 74 °C for 15 s in a HTST system and cooled to 33 °C. The milk was inoculated by a sachet of direct-to-vat single culture containing *Lactobacillus casei* ssp. *Casei* and 0.5% reactivated Redi-set mixed culture containing *Lactococcus lacti* sssp. *Lactis* and *L. lactis* ssp. *Cremoris* (DaniscoCo., Langebrogade 1, Copenhagen, Denmark), and then supplemented with a CaCl₂ solution (0.02% w/v). It was held at 33 °C for approximately 15 min for starter maturation (until pH 6.30) and then the liquid calf rennet (Ecoren 200, Maysa, Istanbul, Turkey) was added. The curd was allowed to set for 65-75 min and following coagulation, the curd was cut into approximately 1 cm³ cubes with vertical and horizontal knives. After being cut, the curd was left to settle for 30 min. The curd was then mixed for 15 min to facilitate whey expulsion and transferred into the blocking machine. Following this procedure, the curds were molded in the polyethylene (PE) blocks (300 g) and the whey was moved on the conveyor. The cheeses in PE blocks were left in a cooling room (+ 4 °C) until the pH dropped to 4.75. Then,

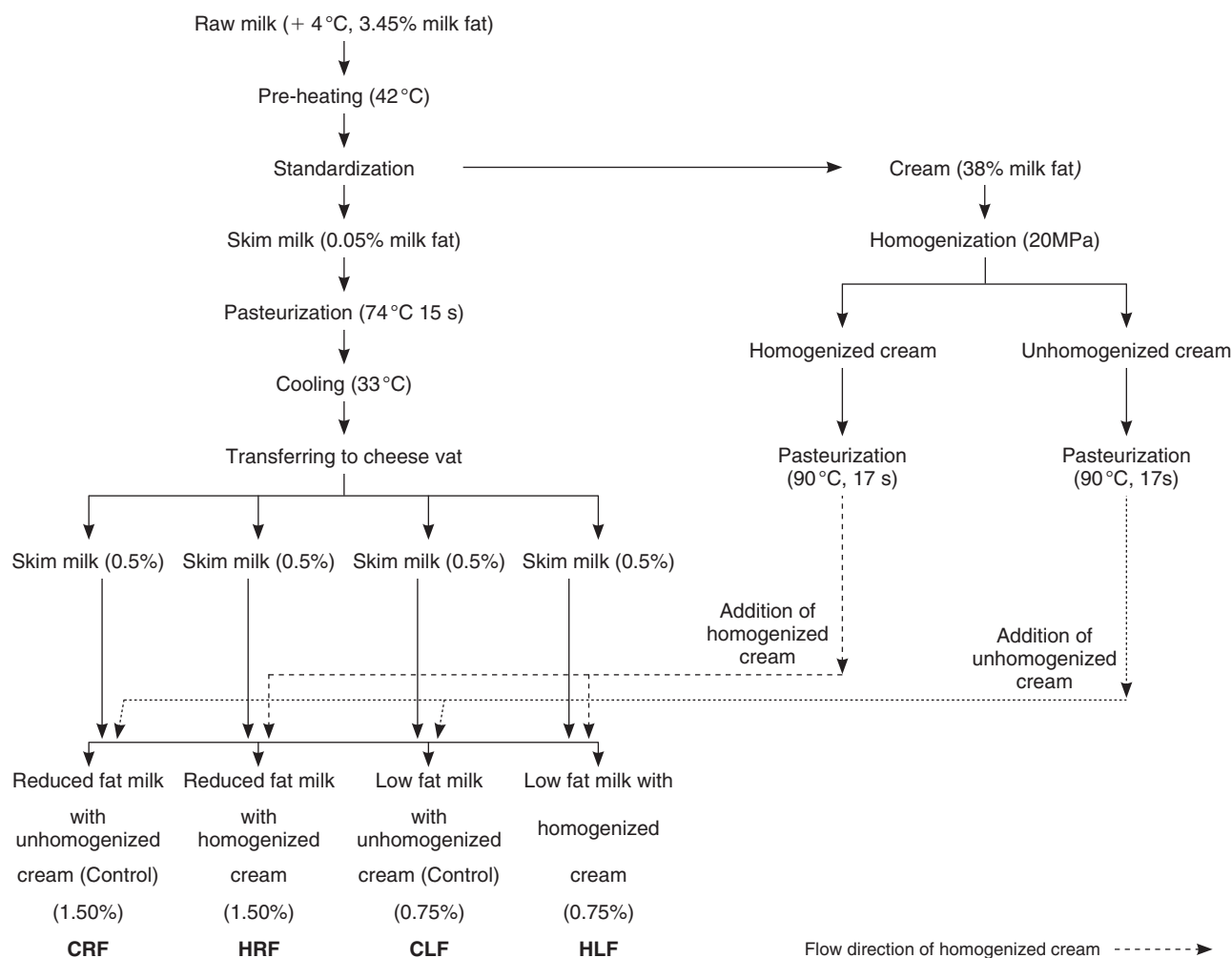


Figure 1
Flow sheet for the preparation of cheese milks.

the cheese blocks were covered with a brine solution (15% brine NaCl, w/v, 15 °C) for 300 min and stored at 4 ± 2 °C for approximately 500 min. The cheese blocks were removed from the PE blocks. Subsequently, the cheese blocks were packaged in the vacuum sealed plastic pouch (BK3550, Cryovac, Sealed Air Corporation, U.K.) and stored at 4 ± 2 °C at Pinar Dairy Company, Izmir, Turkey.

2.2. Chemical analyses

Dry matter, fat and protein contents were determined in the cheese whey obtained from the reduced and low fat treatments (Anonymous, 1994).

2.3. Fat Globule Distribution

The fat globules of reduced and low fat whey, homogenized and unhomogenized cream samples were viewed and photographed using an Olympus Light Microscope attached to a camera (CX21FS1, Olympus Optical Co., Tokyo, Japan) using a modified method by Metzger and Mistry (1995).

2.4. Microstructure

The cheese samples were prepared for scanning electron microscopy (SEM) at the 1st day of ripening following a modified method by Hayat (1981) and Khosrowshahi *et al.* (2006). Micrographs of normal and defatted samples were selected for presentation at a magnification of 2500 or 3000 x.

2.5. Statistical analysis

An experimental design was conducted to evaluate the influence of cream homogenization on the chemical characteristics of reduced and low fat white cheese whey. One way analysis of variance for the data of chemical analyses was carried out. Significant means were compared using the Duncan test on the level of $P < 0.05$. All the statistical analyses were conducted using the SPSS (Version 11.0) commercial statistical package (Kocabas *et al.*, 1998; Dinkci *et al.*, 2011).

3. RESULTS AND DISCUSSION

3.1. Composition of cheese whey

The average composition of the whey obtained from the reduced and low-fat Turkish white cheese from different treatments is given in Table 1.

Whey from the homogenized treatments has lower fat content than their corresponding controls ($P < 0.05$). In other words, fat transition to the whey was greater with CLF and CRF than with the HLF and HRF, respectively. So, it can be said fat loss in cheese manufacturing was decreased by homogenization of the cream.

As expected, homogenization of the cream significantly reduced the size of fat globules in Turkish white cheese milk. The difference between the homogenized treatment and the controls was likely to come from the fat particle clustering that occurred in the homogenized treatments. However, fat losses to the whey were of the same ratio (0.02%) between low fat treatments (CLF and HLF) and reduced fat treatments (CRF and HRF), respectively.

Rudan *et al.* (1998) reported that whey obtained from homogenized milk has a higher fat content than the control while whey from the mixture of homogenized cream and milk has a lower fat content than the control. Similar to our results, the authors reported that homogenization of cream decreased the fat loss to the whey for reduced fat Mozzarella cheese.

As seen in Table 1, there was no significant difference in the dry matter between whey samples obtained from controls or whey from homogenized treatments ($P > 0.05$). However, the levels of dry matter content of the homogenized treatment cheese whey became gradually lower than the control. A similar decrease was obtained in the cheddar cheese whey which was produced with homogenized cream compared to the control by Nair *et al.* (2000).

On the other hand, the protein content of homogenized cream reduced fat whey was higher than the control ($P < 0.05$). Similar to other reports (Nair *et al.*, 2000; Rudan *et al.*, 1998) there were no differences between the protein contents of whey from HLF and CRF.

Table 1
Compositions of whey

Treatment ^a	CLF	HLF	CRF	HRF
Dry matter, %	5.96 ± 0.01A	5.88 ± 0.00B	5.97 ± 0.05A	5.89 ± 0.01B
Fat, %	0.05 ± 0.01B	0.03 ± 0.01C	0.07 ± 0.01A	0.05 ± 0.00B
Protein, %	1.43 ± 0.18C	1.70 ± 0.27C	2.41 ± 0.09B	2.95 ± 0.45A

^a CRF: Reduced-fat white cheese whey manufactured from nonhomogenized cream containing 1.5% milk fat. HRF: Reduced-fat white cheese whey manufactured from homogenized cream containing 1.5% milk fat. CLF: Low-fat white cheese whey manufactured from nonhomogenized cream containing 0.75% milk fat. HLF: Low-fat white cheese whey manufactured from homogenized cream containing 0.75% milk fat. A, B, C: Means in the same row bearing a common superscript differ significantly ($P < 0.05$).

This type of whey composition of homogenized treatments is related to the compositions of cheeses with the homogenization of cream. The homogenization treatment of reduced and low fat cheeses resulted in a higher fat content, dry matter and free fatty acid (FFA) compared to the controls (1st day not shown, in Karaman, 2007).

3.2. Fat Globule Distribution

Fat globules in the homogenized and unhomogenized creams are shown Figures 3a and 3b. The control cream had larger fat globules, but the homogenized cream had small fat globules. Additionally, homogenized cream has clustered fat globules despite the fact that the other one hasn't. According to Figs. 3a and b, homogenized cream has different size fat globules; unhomogenized cream has approximately smaller sizes. So, an important feature of the photos is that the fat globules decreased drastically in size due to homogenization.

It was also determined that fat globules have uniformly, unclustered and irregular distribution. Figures 4 and 5 shows whey from cheeses made from CRF, HRF and CLF, HLF respectively. The fat globules in all cases were unclustered but the globules in the whey from the cheese from unhomogenized cream (CRF, CLF) were larger than the homogenized cream (HRF, HLF). The presence of tiny unclustered fat globules in the cheeses (Figures 6a, b, c, d) and whey (Figure 4b, 5b) is evidenced.

According to Metzger and Mistry (1995) the control cream of reduced fat Mozzarella cheese contained fat globules which were unclustered and large, but homogenized cream had fat globules which were small and clustered. Similar to our results, same researchers obtained an unclustered fat globule distribution in whey from Mozzarella cheese made with the control and homogenized cream.

The homogenization of cream or milk reduced the size of fat globules and made important changes in the milk fat globule membrane (Rudman *et al.*, 1998; Nair *et al.*, 2000). So, before cream homogenization, the fat globule sizes were distributed uniformly in the cheese milk (Figure 2). After homogenization their sizes were decreased in the cream (Figure 3b) and also in the whey (Figure 4b, 5b).

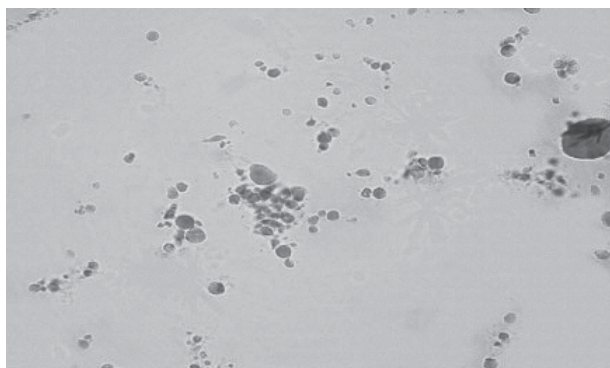


Figure 2
Fat globule distribution in whole milk.

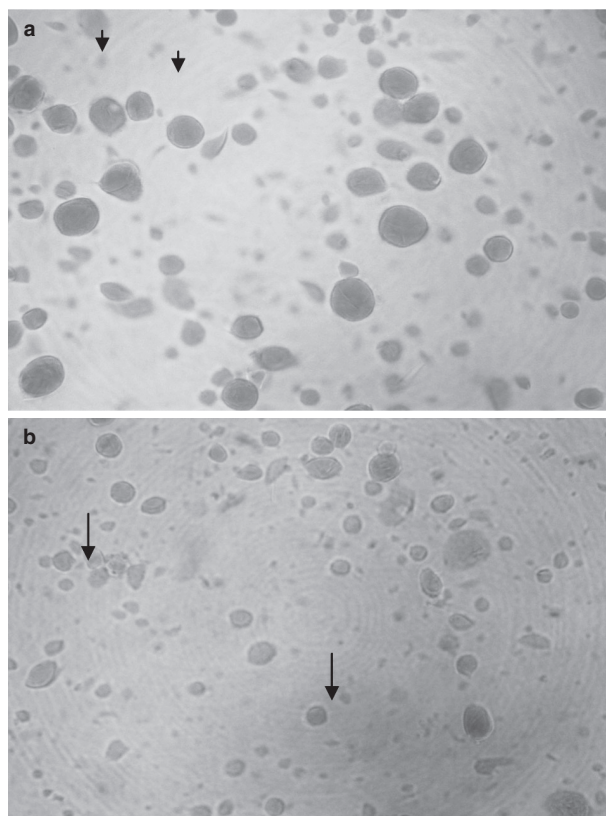


Figure 3
Fat globule distribution in **a)** the control cream
b) homogenized cream.

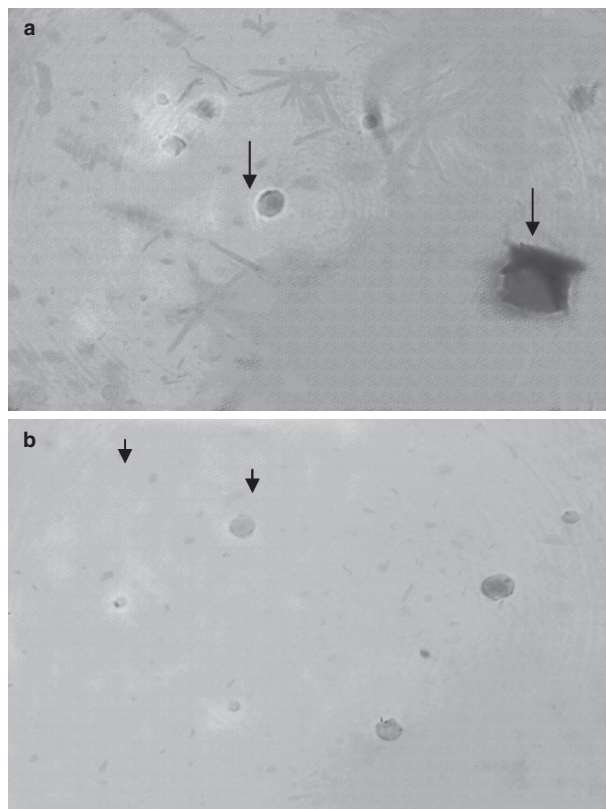


Figure 4
Fat globule distribution in **a)** the control skim milk standardized to 1.5% fat with unhomogenized cream **b)** the control skim milk standardized to 1.5% with homogenized cream.

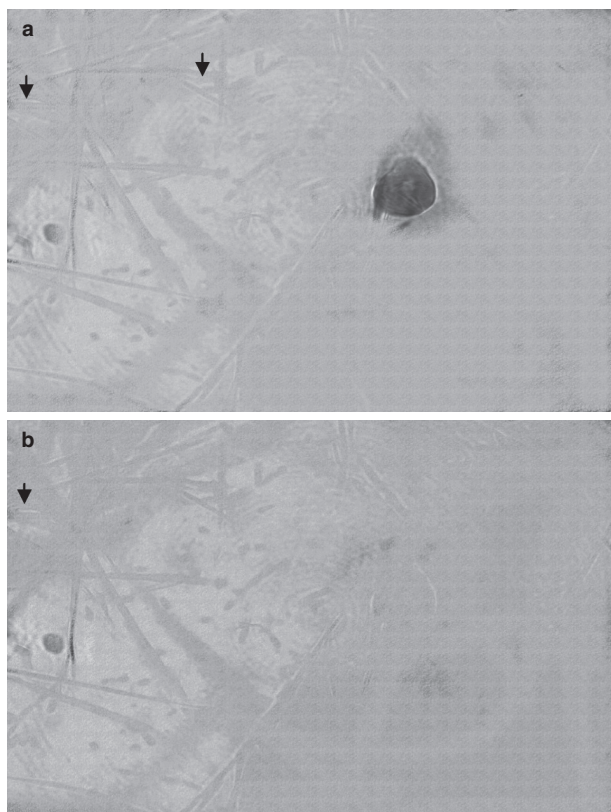


Figure 5

Fat globule distribution in **a)** the control skim milk standardized to 0.75% fat with unhomogenized cream **b)** the control skim milk standardized to 0.75% fat with homogenized cream.

3.3. Microstructure

The differences between reduced and low fat Turkish white cheeses manufactured from homogenized and non-homogenized cream could be visually observed in images obtained by defatted and normal SEM (Figure 6).

In the micrographs of the defatted samples, the microstructure of reduced and low fat control cheeses showed a dense fibrous protein matrix interspread with irregular surfaced cavities of different sizes. This compactness of the network indicates a removal of fat and serum during serum preparation. Therefore, the control cheese possibly has a denser microstructure with larger protein compared with the homogenized treatments. In other words, verifying the data in Table 1, fat loss to the whey was decreased by the homogenization of cream. In cheeses from homogenized cream (Figures 6a, 6c), large numbers of fat particles were dispersed in the casein matrix. In these samples, the protein matrix was dispersed with a large number of small fat globules. Subsequently, small fat globules in the protein matrix improve the lubrication of homogenized cream cheeses. There were also very few small and irregularly shaped cavities. So, homogenization of the cream in reduced and low fat white cheeses resulted in smaller, more dispersed fat globules in the cheese and caused a slightly softer structure. This type structure of homogenized treatments corroborated

the extensive elastic characteristic which was described by the consumer taste panel and the textural analysis, especially for hardness. The homogenization treatment of reduced and low fat cheeses resulted in a lower hardness compared to the controls (1st day of dates 2.84, 2.98, 3.02, 3.22 for HRF, CRF, HLF, CLF, respectively, all data not shown, in Karaman, 2007). Similar results were also reported by Madadlou *et al.* (2007); Metzger and Mistry (1994); Metzger and Mistry (1995) for white cheese and cheddar cheese, respectively.

On the other hand, the protein matrix in the control cheese of low fat cheese (Figure 6b1) was dispersed with less fat than that in the reduced fat cheese (Figure 6b). This may be explained by a decreased fat content or increased protein contents that lead to a hard and crumbly cheese. Similar results were obtained by Metzger and Mistry (1995) for reduced fat cheddar cheese manufactured from homogenized cream or milk Emmons *et al.* (1980).

Madadlou *et al.* (2007) also reported that cream homogenization had a significant influence on the microstructure of the low fat Iranian white cheese. Similar to our results, same researchers reported from the micrographs of the cheeses of homogenized treatments that a large number of small fat particles was embedded in the casein matrix, improving the lubrication of these cheeses.

In the micrographs of normal cheeses (fat not removed), all samples exhibited a more extended matrix with few small fat globules compared to the defatted micrographs (Figure 6c, c1, d, d1). Similar to our results, the differences between the defatted and normal micrographs of Turkish white cheeses were observed by Akalın and Karaman (2010).

4. CONCLUSIONS

The study indicated that cream homogenization had major effects on the microstructure and fat globule distribution of reduced and low fat Turkish white cheeses. Defatted scanning electron microscopy demonstrated that homogenization of the cream decreased the size of fat globules and showed a large number of fat particles were dispersed in the casein matrix. According to the fat not removed micrographs, they have exhibited a more extended matrix with few small fat globules compared to the defatted micrographs. Homogenization of the cream produces small fat globules and unclustered fat globules in the resulting whey. These findings are important for using cream homogenization as a processing tool at the industrial level.

ACKNOWLEDGMENTS

The authors thank the Pinar Dairy Products Company, İzmir, Turkey; Turkish Scientific and Technological Research Council (TUBİTAK) Ankara and Ege University Scientific Research Fund, İzmir, Turkey for funding this project.

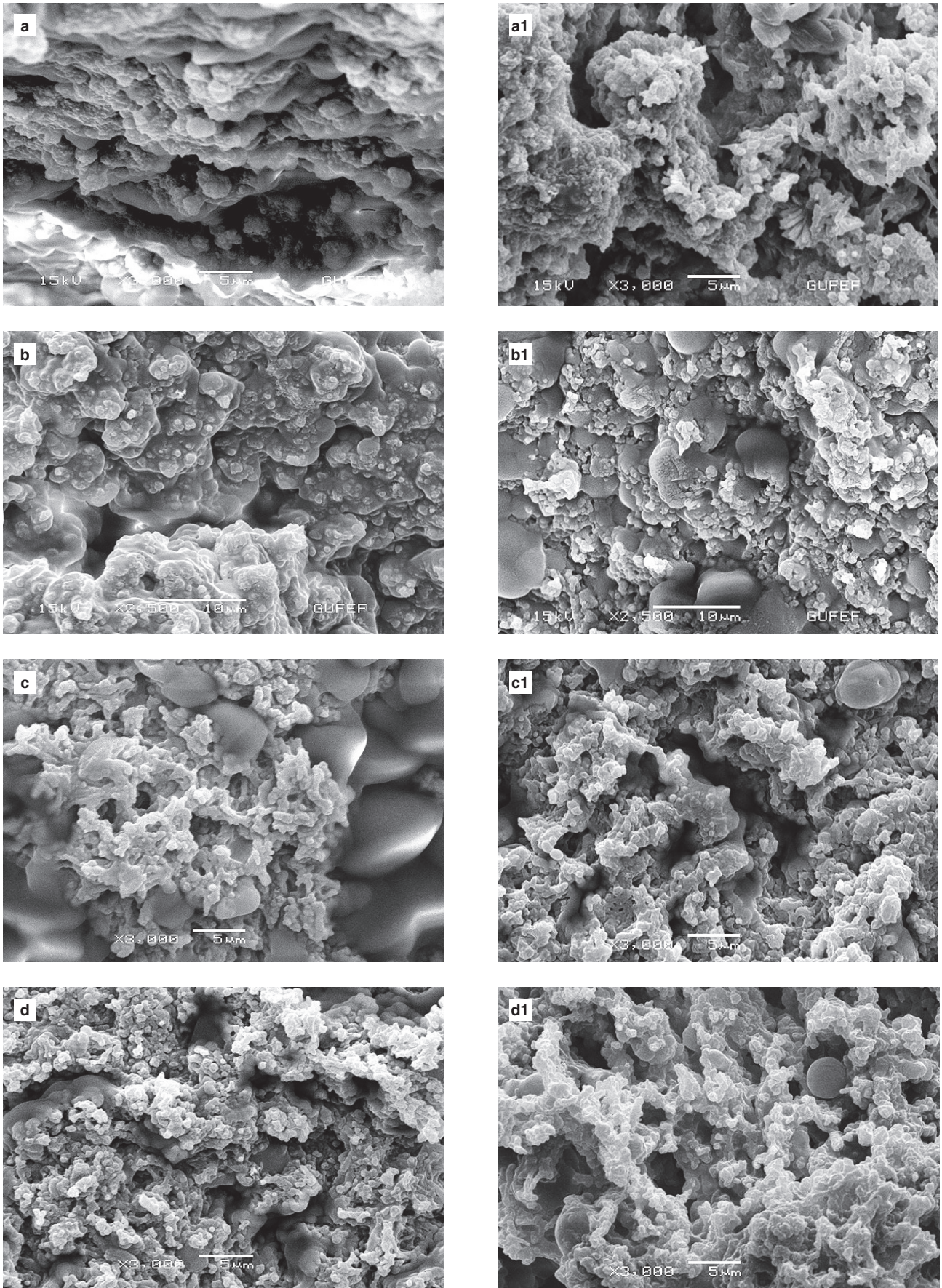


Figure 6

Scanning electron micrographs of reduced fat (**a, c**), reduced fat control (**a1, c1**), low fat (**b, d**) and low fat control (**b1, d1**) Turkish white cheeses. The micrographs show appearances of defatted samples **a, a1, b, b1** and normal samples **c, c1, d, d1**.

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Recibido: 7/10/11
Aceptado: 24/1/12