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Manufacture of pickled and un-pickled high fat soft cheese using olive and sunflower oleogels

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ABSTRACT

The aim of this study was the use of construction unsaturated oil in the manufacture of soft cheese. Oleogels were made from olive oil (OO) or sunflower oil (SO) and bee wax (BW). They were used as fat replacer in the manufacture of pickled or un-pickled soft cheese. Using oleogels slightly decreased the pH values but had no effect on the moisture and fat contents of soft cheese. Cheese made with oleogels exhibited higher values for the texture parameters namely: hardness, springiness, gumminess and chewiness but slightly lower cohesiveness than cheese made with milk fat. Scanning electron micrographs displayed oleogels showed a compact network with small uniform fat droplets embedded in the protein matrix. Sensory evaluation indicated that soft cheese of acceptable quality can be made with the oleogels.

Key words: soft cheese, organogel, bee wax, texture analysis, microstructural

Introduction

White soft cheese is a generic name for one of the most popular cheese in Egypt. It is made either by enzymatic or acidic coagulation of fresh milk or recombined skim milk powder with vegetable oils and stored at room or low temperature with or without brine and it is consumed either fresh or after pickling for few months. The Egyptian dairy industry produce about 149.012 thousand ton per year (CAPMS, 2016).

Consumers, generally prefer consuming fat-rich foods since fats greatly contribute to the palatability (mouth feel) and eating pleasure of foods. Therefore, the food industry incorporates fats from different sources in their products to improve flavor, texture, color, and tenderness of the final product. Over the last few decades, much attention has been focused on eliminating unhealthy fats from our diets (Acevedo *et al*., 2011).

Fat replacers, have been frequently used to replace natural fats in cheese with the objective of reducing the caloric value (Romeih *et al.*, 2002). While the use of fat replacers can be an effective way to create a low-fat cheese products, there are problems that arise in the cheese formulation and they don't develop the desirable characteristics of cheese. On the other hand, direct substitution of saturated fats with liquid oils composed of MUFAS and PUFAS does not lead to food products with comparable textural attributes (Youssef & Barbut, 2009; Zetzl *et al*. 2012).

Recently, a new approach called "organogelation" have been developed in order to prepare hard but healthier products from liquid oil. Organogels are defined as 3-dimensional networks of an organic phase produced by adding some organogelators into the liquid phase. Using liquid oils as the organic phase, the products is generally called oleogel. Oleogels have the advantage that the fatty acid of the used oil is kept unchanged, and therefore, no trans and fatty acids can be developed in the product which is one of the major problem in hydrogenated oils (Toro-Vazquez *et al*., 2007; Marangoni & Garti 2011; Co & Marangoni 2012).

Out of the used crystalline oleogelators, waxes have proven to be the most efficient ones able to produce, even at low concentrations (as low as 0.5 wt %), well-formed network with strong oil-binding properties (Abdallah *et al.,* 2000; Patel *et al*., 2013). Several studies have already been reported for wax crystallization in liquid oil such as candelilla wax in safflower oil (Toro-Vazquez *et al.,* 2007), rice bran wax in olive oil (Dassanayake *et al.,* 2009), sunflower wax in milk fat (Kanya *et al*. 2007), plant waxes and animal waxes in soybean oil (Hwang *et al.,* 2013), beeswax and sunflower wax in olive oil (Yılmaz and Öğütcü, 2014a), and beeswax in hazelnut oil (Yılmaz and Öğütcü, 2014b).

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On the present paper, endeavors were made for the use of oleogels prepared from olive and sunflower oils with bee wax in the manufacture of pickled and un-pickled soft cheese, and evaluate its phisco-chemical and sensory properties.

Materials and Methods

Materials

Fresh skim milk was obtained from Dairy Science Department, Faculty of Agriculture, Cairo University, Egypt. Skimmed milk powder (SMP) Valio skimmed milk powder (Finland) was obtained from Master Trade Company, Egypt. Lacta–825 as stabilizer was obtained from Misr Food Additives (MIFAD) Company, Egypt. Freeze dried starter culture (FD-DVS YC-X11) containing *Lactobacillus delbrueckii* ssp. *bulgaricus* and *Streptococcus thermophiles* was obtained from Chr. Hansen A/S, DK-2970 Horsholm, Denmark. Olive oil (OO) and sunflower oil (SO) were purchased from local market. Beewax (BW) was obtained from apiary in Faculty of Agriculture, Cairo University, Egypt. Sodium chloride (dry fine grade table salt) was obtained from the Egyptian Salt & Minerals Company (EMISAL), Egypt. Pure fine Calcium chloride ($CaCl_2$) was obtained from El-Nasr Pharmaceutical Chemicals Co., Cairo, Egypt. Microbial rennet powder (Reniplus 2000 IMCU) was obtained from Caglio Star, (Proquiga, Spain). Shortening (Palm oil) was obtained from MIGOP Company, Suez, Egypt.

Preparation of olive and sunflower organogels

Olive and sunflower organogels were mixed separately with beewax (93:7 w/w) as described by Yılmaz & Öğütcü (2014a). Briefly the weighed amount of the oil was placed in a glass beaker and heated in a water bath set to 80 ^{0}C. The beewax was completely melted, added to the beaker contents, the mixture was stirred for 5 min., left overnight at room temperature to allow the setting of the formed oleogel and then stored in the refrigerator (5 ±1^{0}C) until used.

Analysis of fatty acids

The extraction of total lipids was carried out by the method of Bligh and Dyer (1959), using chloroform and methanol in a ratio of 1:2. The methyl esters of the fatty acids were analyzed using the method of IUPAC (2000), and quantified by gas-liquid chromatography (HP 6890 GC cpillary) equipped with a flame ionization detector (FID) using a 60m x 0.32mm x DB-23 capillary column. The fatty acid profiles of all fats, shown in Table (1).

Table 1: Fatty acid composition (%) of the different fat using in soft cheese making

Fatty acid	Fresh cream	Shortening	Olive oleogel	Sunflower oleogel
Saturated fatty acids				
Butyric ($C_{4:0}$)	4.10	0.0	0.0	0.0
Caproic ($C_{6:0}$)	2.13	0.0	0.0	0.0
Caprylic ($C_{8:0}$)	2.21	0.0	0.0	0.0
Capric ($C_{10:0}$)	2.84	0.0	0.0	0.0
Lauric ($C_{12:0}$)	3.44	0.17	0.0	0.0
Myristic ($C_{14:0}$)	18.13	1.03	0.0	0.06
Palmitic ($C_{16:0}$)	23.96	46.47	13.90	6.14
Margaric ($C_{17:0}$)	0.71	0.10	0.03	0.04
Stearic ($C_{18:0}$)	11.37	4.63	2.26	2.91
Arachidic ($C_{20:0}$)	0.26	0.39	0.35	0.2
Unsaturated fatty acids				
Titradeceneic ($C_{14:1}$)	1.2	0.0	0.0	0.0
Palmitoleic ($C_{16:1}$)	1.8	0.18	0.98	0.10
Oleic ($C_{18:1}$)	22.91	37.55	65.01	28.16
Linoleic ($C_{18:2}$)	2.02	8.89	13.70	60.84
Linolenic ($C_{18:3}$)	0.4	0.18	2.34	0.13
Gadoleic ($C_{20:1}$)	ND	0.14	0.40	0.36

Cheese manufacture:

Soft cheese was made by using the non-traditional method according to El-Alfy *et al.,* (2010). Fresh skim milk was supplemented with 10% SMP, and different batches of the fortified milk were recombined with 21% fat from the different source. Stabilizer (0.3%) and salt (2%) were added to the recombined milk, heated (72 ^{0}C / 15 sec), then cold to 40 – 42 ^{0}C and add Ca Cl_2 (0.01%). Starter culture (1%) was added to the prepared cheese base, incubate at 40 – 42 ^{0}C for 30 min, and the rennet powder (0.015%) dissolved in small amount of water was added, packed in 1 Kg plastic containers and left to complete coagulation. The prepared cheeses were divided into two groups, brine (4% salt) was added to the first group (pickled cheese) and the second was stored without brine (un-pickled). Eight treatments were made as follow:

1- Cheese with milk fat; pickled (C_1) and un-pickled (C_3)
2- Cheese with shortening; pickled (C_2) and un-pickled (C_4)
3- Cheese with olive oleogel; ; pickled (T_1) and un-pickled (T_3)
4- Cheese with sunflower oleogel; pickled (T_2) and un-pickled (T_4)

All cheese samples were stored at 5±1^{0}C for 6 weeks and analyzed after 1 and 6 weeks. Three replicates were done for each treatment.

Analytical methods

The moisture and total nitrogen (TN) contents of cheese were determined according to AOAC (2007), and the fat contents according to BSI (1989). The pH values of cheese samples were measured using electric pH meter "HANNA" with combined glass electrode (Electric Instruments Limited) according to the methods of BSI (1989). Lactose contents for cheese samples were determined according to the method reported by Lawrence (1968).

Scanning electron microscopy

Cheese samples were prepared for scanning electron microscopy (SEM) following the method of Brooker and Wells (1984). The samples were scanned using, SEM Model Quanta 250 FEG (Field Emission Gun) scanning electron microscope attached with EDX Unit (Energy Dispersive X-ray Analyses) was used, with accelerating voltage of 30 KV., magnitication of l4x up and to 1000000 resolution.

Texture profile analysis (TPA)

Texture profile analysis of cheese cubes (2×2×2 cm) was done using a Universal Testing Machine (TMS-Pro) equipped with 1000 N (250 lbf) load cell and connected to a computer programmed with Texture Pro^{TM} texture analysis software (program, DEV TPA withhold). Calculation were done as described by Bourne (1994) to obtain the texture profile parameters.

Sensory evaluation:

Samples of the cheeses were organoleptically evaluated by eleven judges from staff member of Dairy Technology Department, Food Tech. Res. Institute. A nine-point hedonic scale sheet (9=like extremely and 1=dislike extremely) was used to evaluate flavor, body & texture, color & appearance and overall acceptability as described by Piggott (1984).

Statistical analysis

The data obtained (mean of three replicates) were statistical analyzed according to statistical analyses system user’s guide (SAS, 2004). Analysis of variance (ANOVA) and Duncan's multiple comparison procedure were used to compare the means. A probability of $p \leq 0.05$ was used to establish statistical significance.

Results and Discussion

Compositional analysis

Data displayed in Table 2 reveal that, the standardization of the moisture and fat in the cheese base led to gain non-significant ($p > 0.05$) difference in these measures of fresh cheese of all treatments. Although the un-pickled cheese contained slightly higher protein and lactose content than the pickled cheese, statistical analysis revealed no significant differences between the two groups. During storage, a slight decrease was found in the moisture contents of cheese from the different treatments except for pickled cheese made with milk fat (C_1). As the moisture decreased, the total protein and fat contents increased while the lactose content decreased. Replacement of milk fat with oleogels had no significant effect on the pH value ($p > 0.05$) of either pickled or un-pickled cheese samples. Also, the control cheese made with milk fat (C1, C3) had the lowest pH value after 6 week storage compared to other treatments. Generally, prolonging the cold storage caused a significant decrease ($p < 0.05$) in the pH value of all cheese which can be explained by lactose hydrolysis and development of acidity. The data agree with Abd El-Aziz *et al.* (2012) and Bermer *et al*. (2016).

Table 2: Chemical composition of pickled and un-pickled soft cheese made with different vegetable organogels during storage at 5±1^{0}C for 6 weeks

Cold storage period (weeks)	Treatments							
	Pickled soft cheese				Un-Pickled soft cheese			
	C1	**C2**	**T1**	**T2**	**C3**	**C4**	**T3**	**T4**
	Moisture (%)							
1	61.46 ^{b,a,b}	61.37 ^{b,a,a}	61.42 ^{b,a,a}	61.44 ^{b,a,a}	60.95^{a,a,b}	60.90 ^{a,a,a}	60.98 ^{a,a,a}	61.02 ^{a,a,a}
6	61.54 ^{b,a,a}	60.89 ^{b,a,b}	60.97^{b,a,b}	61.07 ^{b,a,b}	60.71^{a,a,a}	60.49 ^{a,a,b}	60.60 ^{a,a,b}	60.72 ^{a,a,b}
	Fat (%)							
1	22.10 ^{b,a,b}	22.31 ^{b,a,a}	22.25 ^{b,a,a}	22.24 ^{b,a,a}	22.43 ^{a,a,b}	22.62 ^{a,a,a}	22.52 ^{a,a,a}	22.50 ^{a,a,a}
6	21.96 ^{b,a,a}	22.61 ^{b,a,b}	22.53^{b,a,b}	22.17 ^{b,a,b}	22.51^{a,a,a}	22.93 ^{a,a,b}	22.76 ^{a,a,b}	22.68 ^{a,a,b}
	Protein (%)							
1	7.13 ^{a,a,a}	7.07 ^{a,a,b}	7.01 ^{a,a,b}	6.94 ^{a,a,b}	7.22 ^{a,a,a}	7.19 ^{a,a,b}	7.13 ^{a,a,ab}	7.08 ^{a,a,b}
6	7.02 ^{a,a,b}	7.21 ^{a,a,a}	7.16 ^{a,a,a}	7.06 ^{a,a,a}	6.98 ^{a,a,b}	7.33 ^{a,a,a}	7.29 ^{a,a,a}	7.19 ^{a,a,a}
	Lactose (%)							
1	5.46 ^{a,a,a}	5.49 ^{a,a,a}	5.69 ^{a,a,a}	5.73 ^{a,a,a}	5.49 ^{a,a,a}	5.57 ^{a,a,a}	5.70 ^{a,a,a}	5.71 ^{a,a,a}
6	4.32 ^{a,a,b}	4.38 ^{a,a,b}	4.43 ^{a,a,b}	4.38 ^{a,a,b}	4.23 ^{a,a,b}	4.25 ^{a,a,b}	4.34 ^{a,a,b}	4.27 ^{a,a,b}
	pH							
1	6.49 ^{b,a,a}	6.43 ^{b,ab,a}	6.40 ^{b,b,a}	6.40^{b,b,a}	6.56^{a,a,a}	6.52 ^{a,ab,a}	6.50 ^{a,b,a}	6.50 ^{a,b,a}
6	5.74 ^{b,b,b}	5.85 ^{b,a,b}	5.92 ^{b,a,b}	5.80 ^{b,a,b}	5.80^{a,b,b}	5.96 ^{a,a,b}	5.93 ^{a,a,b}	5.90 ^{a,a,b}

The letters before comma possess the factor of pickled. While those after comma possess the factor of the type of fat, storage period, respectively. The means with the same letter at any position were not significant (P>0.05)

Texture profile analysis

Table (3) shows that, cheese made with the oleogels exhibited significantly higher values ($p < 0.05$) for all texture parameters namely hardness, springiness, gumminess and chewiness, i.e. the texture becomes harder, more gummy and chewy as the oleogels were used instead of milk fat, but the cohesiveness values were generally decreased. This finding are supported by those reported for cream cheese by Bermer *et al.* (2016). Several studies have indicated a relationship between lipid globule sizes and the strength and meltability of the cheese (Lopez *et al*., 2007 and Noronha *et al*., 2008). The small fat globule sizes resulted in firmer cheese products due to their interactions with protein and inclusion within the cheese matrix (Noronha *et al.,* 2008).

Table 3: Texture attributes of pickled and un-pickled soft cheese made with different vegetable organogels during storage at 5±1⁰C for 6 weeks

Cold storage period (weeks)	Treatments							
	Pickled soft cheese				Un-Pickled soft cheese			
	C1	C2	T1	T2	C3	C4	T3	T4
	Hardness (N)							
1	$0.3^{b,b,b}$	$0.8^{b,a,b}$	$1.0^{b,a,b}$	$0.9^{b,a,b}$	$0.3^{a,b,b}$	$1.0^{a,a,b}$	$1.2^{a,a,b}$	$1.1^{a,a,b}$
6	$0.3^{b,b,a}$	$1.0^{b,a,a}$	$2.1^{b,a,a}$	$1.0^{b,a,a}$	$0.6^{a,b,a}$	$2.5^{a,a,a}$	$2.5^{a,a,a}$	$2.3^{a,a,a}$
	Cohesiveness							
1	$0.83^{a,a,b}$	$0.76^{a,b,b}$	$0.73^{a,b,b}$	$0.80^{a,b,b}$	$0.72^{b,a,b}$	$0.71^{b,b,b}$	$0.69^{b,b,b}$	$0.71^{b,b,b}$
6	$0.93^{a,a,a}$	$0.90^{a,b,a}$	$0.73^{a,b,a}$	$0.67^{a,b,a}$	$0.73^{b,a,a}$	$0.63^{b,b,b}$	$0.67^{b,b,b}$	$0.65^{b,b,b}$
	Springiness (mm)							
1	$2.5^{b,b,b}$	$4.02^{b,a,b}$	$3.90^{b,a,b}$	$3.93^{b,a,b}$	$3.83^{a,b,b}$	$3.97^{a,a,b}$	$4.22^{a,a,b}$	$4.05^{a,a,b}$
6	$4.51^{b,b,a}$	$5.41^{b,a,a}$	$5.23^{b,a,a}$	$5.45^{b,a,a}$	$5.47^{a,b,a}$	$4.98^{a,a,a}$	$4.60^{a,a,a}$	$5.48^{a,a,a}$
	Gumminess (N)							
1	$0.2^{b,b,b}$	$0.5^{b,ab,b}$	$0.8^{b,a,b}$	$0.7^{b,a,b}$	$0.3^{b,b}$	$0.9^{a,a,b}$	$0.8^{a,a,b}$	$0.7^{a,ab,b}$
6	$0.4^{b,b,a}$	$0.7^{b,ab,a}$	$1.6^{b,a,a}$	$0.9^{b,a,a}$	$0.4^{a,b,a}$	$2.0^{a,a,a}$	$1.9^{a,a,a}$	$1.8^{a,ab,a}$
	Chewiness (N.mm)							
1	$0.61^{b,b,b}$	$2.19^{b,b,b}$	$3.24^{b,a,b}$	$2.80^{b,a,b}$	$1.09^{a,b,b}$	$3.59^{a,a,b}$	$3.57^{a,a,b}$	$3.66^{a,a,b}$
6	$1.86^{b,b,a}$	$2.91^{b,b,a}$	$8.10^{b,a,a}$	$4.34^{b,a,a}$	$2.37^{a,b,a}$	$9.81^{a,a,a}$	$8.75^{a,a,a}$	$9.66^{a,a,a}$

The letters before comma possess the factor of pickled. While those after comma possess the factor of the type of oil, storage period, respectively. The means with the same letter at any position were not significant (P>0.05).

Microstructure analysis

Differences between cheese samples after one week of the ripening period could be visually observed in images obtained by scanning electron microscopy (fig. 1). Figure clearly demonstrates similar structural network for the pickled and un-pickled cheeses. The morphology and distribution of the fat globules in the cheese matrix appeared to be similar both types of cheese samples. Both control and olegels cheese samples exhibited numerous small lipid globules embedded in continuous protein matrix. Also cheese made with shortening exhibited more compact structure compared with that made with milk fat or oleogels. Furthermore, it has been proposed that sodium chloride in the serum phase of pickled cheese would promote solubilization of caseins and increased protein to water interactions, so the protein matrix becomes more hydrate and puffiness, occupying an increased area of cheese matrix, becoming more continuous and homogeneous in appearance principally SW cheese. These results were in agreement with data reported by Pastorino *et al.* (2003) and Bemer *et al.* (2016).

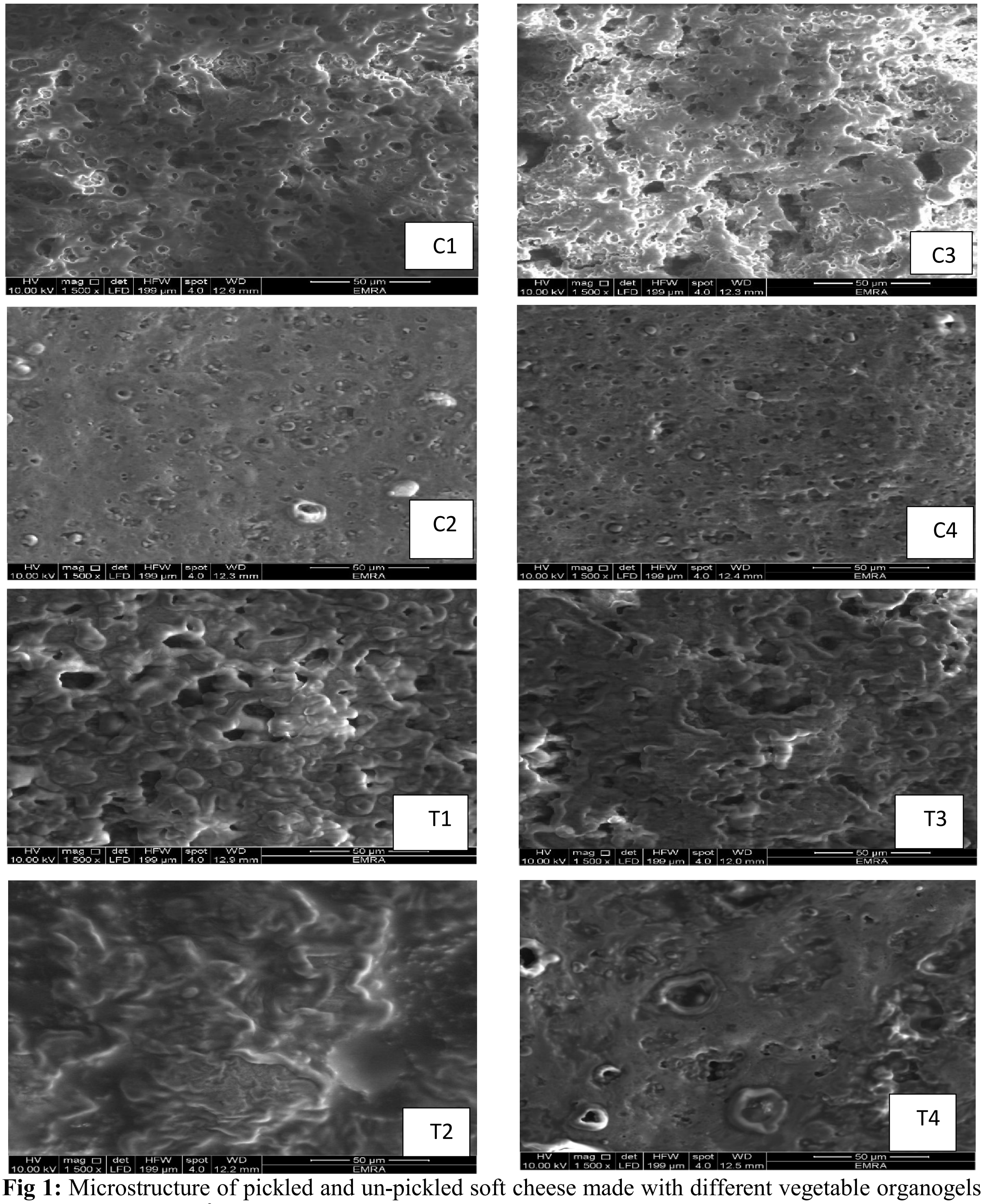

Fig 1: Microstructure of pickled and un-pickled soft cheese made with different vegetable organogels storage at 5±1^{0}C for one week

Sensory analysis

In order to gain the consumer realization of the oleogel cheese samples either made by OW or SW in comparison with milk fat or shortening, hedonic tests were accomplished for flavor, appearance & color, texture attributes and overall acceptability (Table 4). The flavor and appearance & color scores given to the control either pickled or un-pickled were significantly higher ($p < 0.05$) than that given to oleogel cheese samples. Whereas the oleogel cheese got higher scores for body & texture than the control. This finding was reversal of the results seen in the textural analysis, which indicated that the oleogel cheese had higher values than cheese made with milk fat but had similar hardness values to the cheese containing shortening. The sensory attributes scores of un-pickled cheese were not significantly improved ($p < 0.05$) by extended storage for 6 weeks. However, the overall acceptability scores indicate that consumers may have a slight positive perception for the developed oleogels for the attributes of color and flavor, except texture. Hence, more studies are needed to improve appearance (mostly color), flavor properties of the wax oleogels to make them highly acceptable replacers to milk fat and shortening in cheese making. The data agree with Abd El-Aziz *et al.* (2012) and Bermer *et al.* (2016).

Table 4: Sensory attributes of pickled and un-pickled soft cheese made with different vegetable organogels during storage at 5±1^{0}C for 6 weeks

Cold storage period (weeks)	Treatments							
	Pickled soft cheese				Un-Pickled soft cheese			
	C1	C2	T1	T2	C3	C4	T3	T4
	Flavor							
1	$8.00^{b,a,b}$	$7.80^{b,b,b}$	$7.78^{b,b,b}$	$7.83^{b,ab,a}$	$8.40^{a,a,a}$	$8.00^{a,b,a}$	$8.02^{a,b,a}$	$8.10^{a,ab,a}$
6	$8.10^{a,a,a}$	$7.78^{a,b,b}$	$7.80^{a,b,b}$	$8.00^{a,ab,a}$	$7.90^{b,a,b}$	$7.62^{b,b,b}$	$7.46^{b,b,b}$	$7.83^{b,ab,b}$
	Color & appearance							
1	$8.10^{a,a,a}$	$8.00^{a,a,a}$	$7.86^{a,a,a}$	$7.92^{a,a,a}$	$8.15^{a,a,a}$	$8.00^{a,a,a}$	$7.92^{a,b,a}$	$7.95^{a,b,a}$
6	$7.60^{a,a,b}$	$7.61^{a,a,b}$	$7.48^{a,b,b}$	$7.55^{a,b,b}$	$7.69^{a,a,b}$	$7.72^{a,a,b}$	$7.59^{a,b,b}$	$7.60^{a,b,b}$
	Body & Texture							
1	$7.42^{b,b,a}$	$7.76^{b,a,b}$	$7.95^{b,a,b}$	$7.75^{b,a,b}$	$7.65^{a,b,b}$	$7.96^{a,a,b}$	$8.10^{a,a,b}$	$7.89^{a,a,b}$
6	$6.94^{b,b,b}$	$8.10^{b,a,a}$	$8.22^{b,a,a}$	$8.14^{b,a,a}$	$7.30^{a,b,a}$	$8.15^{a,a,a}$	$8.27^{a,a,a}$	$8.21^{a,a,a}$
	Overall acceptability							
1	$8.14^{b,a,a}$	$7.75^{b,b,a}$	$7.79^{b,b,a}$	$7.81^{b,ab,a}$	$8.25^{a,a,a}$	$7.90^{a,b,a}$	$7.94^{a,b,a}$	$8.11^{a,ab,a}$
6	$7.26^{b,a,b}$	$7.13^{b,b,b}$	$7.23^{b,b,b}$	$7.30^{b,ab,b}$	$7.40^{a,a,b}$	$7.22^{a,b,b}$	$7.33^{a,b,b}$	$7.34^{a,ab,b}$

The letters before comma possess the factor of pickled. While those after comma possess the factor of the type of oil, storage period, respectively. The means with the same letter at any position were not significant (P>0.05)

Conclusion

Structured oil system (oleogel or oleogelation) can be used in development of new dairy products successfully improved both physical and nutritional properties, i.e. pickled and un-pickled soft cheese of acceptable quality can be made by replacing the saturated milk fat or shortening with the more healthy olive and sunflower oleogels.

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