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Effect of Emulsifying Salts on Texture and Sensory Properties of Reduced Fat Kaymak

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A R T I C L E I N F O

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A B S T R A C T

Kaymak is a traditional Turkish dairy product with high fat and moisture, and low protein content. According to the Turkish Food Codex, Kaymak must contain at least 60% milk fat. Obesity is one of the most important health problems of our era, and there have been many initiatives to reduce the fat content of ready-to eat consumer products. In this study, the effect of emulsifying salts (trisodium citrate, disodium phosphate and tetrasodium pyrophosphate) on texture and sensory properties of reduced fat Kaymak (30% fat) was investigated. Emulsifying salts were used in the manufacture at two different concentrations (5 and 10 m*M*) and a reduced fat Kaymak without emulsifying salts was used as control. Manufacturing reduced fat Kaymak with 10 m*M* trisodium citrate and 5 m*M* tetrasodium pyrophosphate increased Kaymak hardness. Samples manufactured with 10 m*M* trisodium citrate exhibited the highest sensory quality, while Kaymaks manufactured with 10 m*M* tetrasodium pyrophosphate received lowest sensory scores. In conclusion, 10 m*M* trisodium citrate successfully improved textural and sensory properties of reduced fat Kaymak.

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Introduction

Kaymak or Kajmak is a traditional dairy product produced in Balkans, Middle East and Central Asia. Traditionally, Kaymak is manufactured from buffalo milk in the west and central regions of Turkey; however, today commercial production is mainly carried out from bovine milk (Cakmakci and Hayaloglu, 2011). Kaymak is not churned or whipped, it is generally produced with separation of cream to over 60% fat and heating (~90°C for 2 min). Thus, it is distinguished from similar high fat dairy products (e.g. whipped cream) in terms of composition and texture. Textural properties of Kaymak (e.g. hardness, consistency) primarily comes from the high fat content of the product as it only contains small amount of protein (<2%). According to the Turkish Food Codex, Kaymak must contain at least 60% milk fat. Many studies were conducted to reduce fat content in various dairy products with the main objective to combat obesity, and a large variety of reduced and low fat dairy products can be found in the market. However, reducing the fat content of Kaymak is challenging as milk fat constitutes most of the solids in the product. Moreover, currently it is not permissible to market a product as Kaymak if it contains less than 60% milk fat.

Emulsifying salts (ES) has been widely used in processed cheese industry to obtain the desired texture of the final product (Kapoor and Metzger, 2008). Contrary to their name, ES do not have emulsifying properties; the main purpose ES to chelate calcium and modify/liberate caseins, which act as an emulsifier due to their separated hydrophilic and hydrophobic regions (Guinee et al., 2004; Mizuno and Lucey, 2005). Even though all various types of emulsifying salt follow similar mechanism, they do not have similar effect on textural properties (Brickley et al., 2008; Chen and Liu, 2012). The new created protein network is affected by many interactions such as calcium bridges, hydrophobic interactions, hydrogen bridges and calcium phosphate complexes (Bunka et al., 2014).

Sodium salts of citrate and phosphate constitute of an important part of emulsifying salts. The most important and industrially most widely used member of citrate salts is trisodium citrate (TSC) (Lucey et al., 2011). Citrates increase the mobility and hydration ability of caseins by dissolving colloidal calcium bound to caseins (Mizuno and Lucey, 2005). Trisodium citrate do not create new interactions between caseins and has no creaming effect.

Citrate salts, especially TSC, are generally preferred in the production of block type and sliced process cheese manufacture (Lucey et al., 2011). It has been reported that the use of low amounts of TSC in yogurt production increases the hardness of yogurt gel (Ozcan-Yılsay et al., 2007). Phosphate salts are obtained from phosphoric acid and generally divided into two categories; single phosphates and polymeric phosphates. Another name for single phosphates is orthophosphates, and the most widely studied and used member of this group is disodium phosphate (DSP) (Lucey et al., 2011). Similar to TSC, DSP is widely used in the block type process cheese manufacture, where softer structure and meltability are desired (Kapoor and Metzger, 2008). Disodium phosphate has the ability to interact, albeit slightly, among caseins and increases the viscosity in systems containing small amount of protein (Mizuno and Lucey, 2005). Tetrasodium pyrophosphate (TSPP) is the most important member of the short chain polyphosphates. Tetrasodium pyrophosphate, like other emulsifying salts, dissolves colloidal calcium and increases the mobility of caseins. In addition, TSPP is known to lead to new interactions between caseins through calcium bridges (Mizuno and Lucey, 2007; Lu et al., 2008). Tetrasodium pyrophosphate has a high degree of creaming effect, thus it is utilized especially where hard texture desired or in the production of high moisture containing processed cheese.

As expected, majority of studies on emulsifying salts were conducted on processed cheeses (Caric et al., 1985; Deshwal et al., 2023; Kapoor and Metzger, 2008). Several important studies have been carried out examining ES in model systems created with milk proteins and acid gels (e.g. yogurt) (Garcia et al., 2023; Mizuno and Lucey, 2005; Ozcan-Yılsay et al., 2007; Ozcan et al., 2008). There are no studies examining the use of different emulsified salts in Kaymak or similar high fat, high moisture and low protein content dairy products. This study is the first in the literature to examine the effects of various emulsifying salts on the texture and sensory characteristic of reduced fat Kaymak.

Materials and Methods

Kaymak Manufacture

Reduced fat Kaymak manufacture was carried out with 3 independent trials over 5 month periods. Direct reduction of fat content led to weak, semi-solid gels with phase separation. Thus, to compensate the large loss of total solids with fat reduction, reduce fat Kaymak samples were fortified with rennet casein. In the production of rennet casein, non-fat milk was pasteurized (72°C 2 min) and cooled to 8°C, then milk was preacidified to pH 5.5 by using 20% citric acid. Chymosin (*BioRen*® Premium 95LH300, 290 international milk clotting units (IMCU)/mL, Biokim & Wenda Kimya San. ve Tic. A. S., Izmir, Turkey) and $CaCl_2$ (30%) were added at the rate of 2 g and 3 g for 5 L of milk, respectively. The temperature of the milk was raised to 30° C and waited (~2 h) to obtain the coagulum. The coagulum was then cut, drained and transferred into cheese cloth and pressed for 12 h. In the manufacture of reduce fat Kaymak, fresh dairy cream (40% milk fat) and obtained rennet casein was mixed with TSC, DSP, TSPP at 5 and 10 m*M* levels and then mixture was blended at 4°C for 10 min (Thermomix®,Vorwerk, Istanbul, Turkey). One reduced fat Kaymak sample was manufactured in the same procedure without ES (control). After blending, 80 g reduced fat Kaymak samples were transferred into polypropylene containers (diameter 118.5mm, height 47.5mm), closed with a lid and stored at 4°C. Kaymak samples used in this study is given at Table 1. Analyses were performed at 1, 14 and 30 d.

Compositional Analysis

Milk and Kaymak samples were analyzed for protein (total percentage N × 6.38; Kjeldahl method; method 991.20; AOAC, 2000), total solids (method 990.19; AOAC, 2000), fat (method 2000.18; AOAC, 2000), ash (method 945.46; AOAC, 2000), pH (Inlab® solid pro; Mettler Toledo, Columbus, OH), and salt (method 975.20, AOAC, 2000) on the day of manufacture.

Textural Analysis

The textural properties of Kaymak samples were monitored with a texture analyzer (TA.XTPlus; Texture Technologies Corp., Scarsdale, NY, USA). Kaymak samples were transferred into containers and 75% of the containers were filled. Uniaxial compression was performed onto Kaymak samples at 4-6°C. A 35 mm cylindrical probe was used and penetration depth was 5 mm with test speed of 1 mm/s. Analyses were done in triplicate. Analyses were performed at 1, 14 and 30 d of storage.

Sensory Analysis

Kaymak flavor and texture attributes were analyzed with 8 trained panelists (3 male, 5 female). A 0-9 points (0 extremely dislike, 9 extremely like) hedonic scale was used to evaluate consistency, flavor, smoothness, spreadability and overall score for Kaymak samples. Samples were given a random 3-digit number and evaluated at 4°C at 30 d of storage.

Table 1. The type and concentration of emulsifying salts used in the manufacture of experimental Kaymak samples

Sample number	Sample name	ES[1] used	ES concentration
1	ES-free	-	-
2	DSP5	DSP[2]	5 mM
3	DSP10	DSP	10 mM
4	TSC5	TSC[3]	5 mM
5	TSC10	TSC	10 mM
6	TSPP5	TSPP[4]	5 mM
7	TSPP10	TSPP	10 mM

[1] Emulsifying salt; [2] Disodium phosphate; [3] Trisodium citrate; [4] Tetrasodium pyrophosphate

Experimental Design and Statistical Analysis

Three independent replicated trials of Kaymak manufacture was carried out over 5 months. In each trial, 3 emulsifying salts (DSP, TSC, TSPP) were used at 2 levels of (5 and 10 m*M*) to manufacture reduced fat Kaymak samples. One reduced fat Kaymak was manufactured without ES as control. A split-plot design was employed to analyze the effects of the ES and storage time on the physical, chemical and sensory properties of reduced fat Kaymak samples. Kaymak manufacture time was considered as the blocking factor and ES was analyzed as discontinuous variable in whole-plot factor. The storage time and the interaction of the ES with the storage time were considered as variables for the sub-plot factor. The interaction of ES and manufacture time was considered as the error term. Statistical analysis is performed with JMP (13.0 version; SAS Institute Inc., Cary, NC, USA). The data were analyzed by analysis of variance (ANOVA), and the statistical difference is determined at the P<0.05 level with the help of the Tukey-HSD multiple comparison test. Pearson correlation coefficients were estimated between various responses.

Results and Discussion

Composition

The composition of Kaymak samples are given in Table 2. Reduced fat Kaymak samples contained 30% milk fat, which is around 50% fat reduction compared to Turkish codex standard. Milk fat is the major component of Kaymak, and 50% reduction in milk fat caused a significant decrease in the total solid content, as expected. Addition of rennet casein increased the protein content of reduced fat Kaymak samples to 3.6%, which was nearly 2-fold increase compared to regular fat Kaymak (~2%). The pH values of reduced fat Kaymak samples are given in Figure 1. The pH values of commercial regular fat Kaymak depends on the season of production; however, it is close to the pH values of milk as it is directly produced from fresh cream. Incorporation of rennet casein (pH ~ 5.2) in fresh cream in the manufacture of reduced fat Kaymak caused lower the initial pH values. Even though various concentration and types of ES used in the production of reduced fat Kaymak, the buffering created by ES did not significantly (P>0.05) increase the pH values compared to control, thus all reduced fat Kaymak samples exhibited similar pH during 30 d storage. All Kaymak samples had <1% salt, and no difference was observed in the salt levels. The salt content of Kaymak samples were analyzed with titrimetric method based on chloride level, as ES do not have clorine as anion, no difference was observed in the salt content.

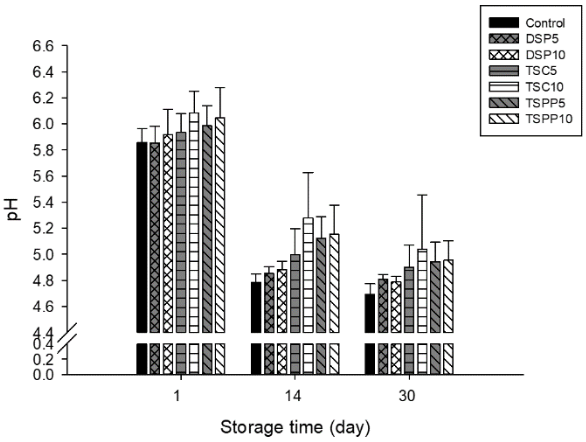

Figure 1. pH of Kaymak samples for control (■), DSP5 (▩), DSP10 (▩), TSC5(▤), TSC10 (▤), TSPP5 (▧), and TSPP10 (▧) at 1, 14, and 30 d of storage. An asterisk (*) indicates significant (P<0.05) difference from control at the indicated storage time point.

Kaymak Texture

Hardness values of Kaymak samples are given in Figure 2a. In most dairy products, protein-protein interactions are the main forces affecting the texture. Kaymak is a very low protein containing product, and the texture is primarily come from solid nature of milk fat at refrigeration temperature. Reduced fat Kaymak manufactured with 10m*M* TSC had the highest hardness during storage. Mizuno and Lucey, (2005) investigated various ES on turbidity and calcium phosphate and protein interaction in casein micelles. They reported that TSC had the highest calcium chelation and dispersion of casein micelles. In low protein product like Kaymak, high dispersion of casein micelles with TSC may have created better protein distribution, which might have caused more continuous protein matrix, leading to higher hardness in TSC10 samples. Ozcan-Yilsay et al., (2007) investigated the effect of various concentrations of TSC on the rheological properties of yogurt. Similarly, they reported that highest storage modulus (G′) in yogurt was observed with yogurts manufactured with 10-20 m*M* TSC. On the other hand, they also reported that yogurt gels manufactured with 5 m*M* TSC exhibited lower G′ values compared to gels manufactured with 10 m*M* TSC. We also observed that TSC5 Kaymak sample had lower hardness values compared to TSC10 one day after manufacture.

Table 2. Composition and pH values of reduced fat Kaymak samples at 1 d of storage.[1]

	pH	Total Solids (%)	Fat (%)	Protein (%)	Salt (%)
Control	5.9 ± 0.1^{a}	37.0 ± 0.3^{a}	30.3 ± 0.3^{a}	3.6 ± 0.2^{a}	0.0 ± 0.0^{a}
DSP5	5.9 ± 0.1^{a}	37.4 ± 0.2^{a}	30.0 ± 0.1^{a}	3.6 ± 0.1^{a}	0.1 ± 0.0^{a}
DSP10	5.9 ± 0.2^{a}	37.4 ± 0.4^{a}	30.2 ± 0.3^{a}	3.6 ± 0.0^{a}	0.1 ± 0.0^{a}
TSC5	5.9 ± 0.1^{a}	37.3 ± 0.4^{a}	30.0 ± 0.1^{a}	3.6 ± 0.2^{a}	0.1 ± 0.0^{a}
TSC10	6.1 ± 0.2^{a}	37.5 ± 0.3^{a}	30.1 ± 0.2^{a}	3.6 ± 0.1^{a}	0.1 ± 0.0^{a}
TSPP5	6.0 ± 0.2^{a}	37.5 ± 0.2^{a}	30.2 ± 0.5^{a}	3.6 ± 0.0^{a}	0.1 ± 0.0^{a}
TSPP10	6.0 ± 0.2^{a}	37.6 ± 0.3^{a}	29.8 ± 0.3^{a}	3.6 ± 0.1^{a}	0.1 ± 0.0^{a}

[1] Values are means (n = 3) ± standard deviations; [a–b]Means within a row with different lowercase superscripts differ (P<0.05).

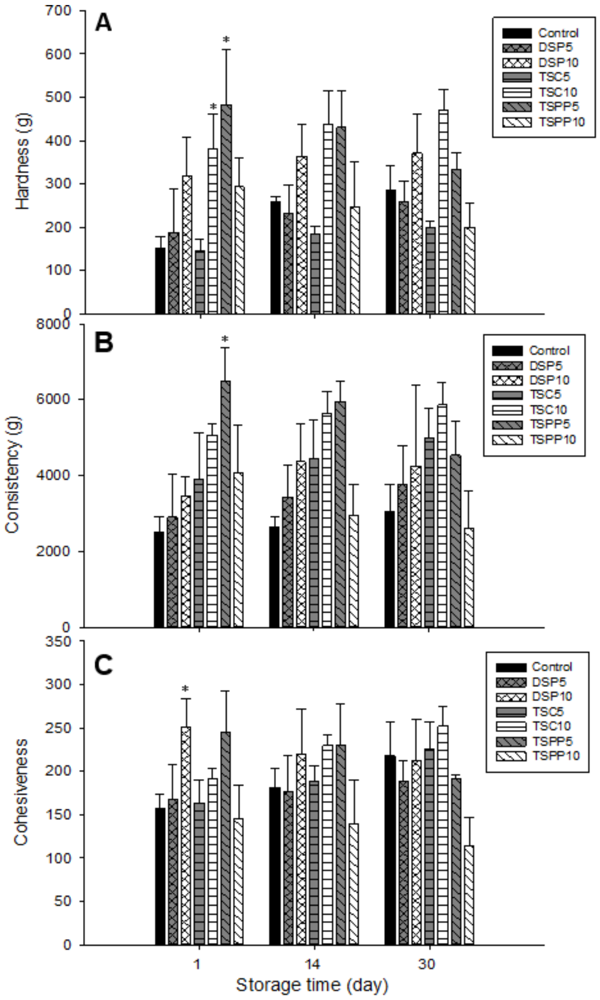

Figure 2. Hardness (a), consistency (b) and cohesiveness (c) of Kaymak samples for control ( ), DSP5 ( ), DSP10 ( ), TSC5( ), TSC10 ( ), TSPP5 ( ), and TSPP10 ( ) at 1, 14, and 30 d of storage. An asterisk (*) indicates significant (P<0.05) difference from control at the indicated storage time point.

TSPP5 sample increased the hardness of reduced fat Kaymak compared to control at 1 d of storage. Mizuno and Lucey, (2005) reported that TSPP was effective on solubilizing colloidal calcium phosphate (CCP) and liberating caseins, also it can create calcium casein complexes. In another study, Mizuno and Lucey, (2007) investigated the effect of phosphate salts on milk proteins. They reported that gels with highest breaking force were formed with the utilization of 6.7 m*M* TSPP. They also reported that no gel formation was observed when TSPP was added ≤2.9 or ≥10.5m*M*. We observed a similar trend, while TSPP5 increased the Kaymak hardness, TSPP10 sample did not affect the hardness during storage. Ozcan et al., (2008) also reported that using high levels of TSPP (≥0.125%) significantly decreased G′ values. On the other hand, Cunha and Viotto, (2010) reported that TSPP created harder texture compared to TSC in Requeijao cremoso processed cheese spread. Tetrasodium pyrophosphate has the ability to create new casein-casein interactions and they may create stronger gels in high protein environment. Requeijao cremoso cheeses had much higher protein content (10%) compared to reduced fat Kaymak (%3.6), which could be the reason TSPP did not create harder Kaymak gels compared to TSC in our study.

Reduced fat Kaymak samples manufactured with DSP at any level did not influence the Kaymak hardness. Mizuno and Lucey, (2005) reported that DSP did not affect the turbidity and soluble Ca and Pi levels in reconstituted milk protein concentrate solution (5% wt/wt), indicating that DSP has lowest ability to disperse casein micelles. Solubilized calcium was possible to create new interactions between caseins (Bunka et al., 2008). Relatively lower calcium dispersion properties of DSP compared to TSC and TSPP might be responsible for lower formation of calcium bridges between caseins. Also low casein dispersion ability of DSP might not have created a continuous protein matrix, resulting in no significant changes in Kaymak hardness.

pH values is an important factor affecting the protein network and influencing the final texture of dairy products. As the pH value approaches to the isoelectric pH of caseins hydrophobic interactions increase due to reduction in electrostatic repulsion (Lucey et al., 2003). The pH values of control sample significantly (P<0.05) decreased during storage. We have found a negative correlation (R^2 = -0.91, P<0.05) between pH values and Kaymak hardness, i.e. as the pH values decreased, hardness of control was increased. Thus, even though TSC10 and TSPP5 samples exhibited significantly higher hardness compared to control at 1 d of storage, no difference was observed at 14 and 30 d of storage. The pH values of TSC5 and TSC10 samples were also negatively correlated (R^2 = -0.70, P<0.05, R^2 = -0.71, P<0.05, respectively) with hardness. No significant correlation was observed between pH values and Kaymak samples manufactured with DSP and TSPP.

Consistency of reduced fat Kaymak samples during 30 d of storage is given in Figure 2b. Manufacturing reduced fat Kaymak with 5 mM of TSPP resulted in an immediate increase in consistency compared to control. Consistency of control negatively correlated with pH values, (R^2 = -0.67, P<0.05) and as pH values decreased with storage consistency of control sample increased. No significant differences were observed in consistency among Kaymak samples at 14 and 30 d of storage.

No significant difference was observed between control and reduced fat Kaymak samples manufactured with ES. TSPP10 sample exhibited lowest cohesiveness during storage. At 30 d of storage, TSC10 sample showed significantly higher cohesiveness compared to TSPP10. The cohesiveness of TSC10 was negatively correlated with pH values, the cohesiveness increased with decreasing pH values.

Sensory Analysis

Sensory texture and flavor scores are shown at Table 3. Emulsifying salt and the concentration of ES used significantly (p < 0.05) influenced the sensory properties. Kaymak samples manufactured with TSC (TSC10 and TSC5) exhibited the highest scores in sensory analysis. TSC10 received higher consistency, flavor, smoothness, spreadability and overall scores compared to control and all reduced fat Kaymak manufactured with DSP and TSPP. Samples manufactured with DSP5, TSPP5 and TSPP10 had significantly (P<0.05) lower scores in textural and flavor attributes compared to control.

Table 3. Sensory scores (on a 0-9 point scale) for reduced fat Kaymak samples at 30 d of storage.[1]

	Consistency	Flavour	Smoothness	Spreadability	Overall
Control	4.7 ± 0.2[e]	5.5 ± 0.1[b]	4.3 ± 0.4[b]	4.5 ± 0.4[c]	4.7 ± 0.4[c]
DSP5	5.1 ± 0.1[d]	5.1 ± 0.2[c]	4.1 ± 0.4[b]	5.3 ± 0.1[b]	4.0 ± 0.1[de]
DSP10	5.6 ± 0.3[c]	4.6 ± 0.3[d]	3.1 ± 0.1[c]	4.9 ± 0.1[bc]	4.2 ± 0.3[cd]
TSC5	6.3 ± 0.2[b]	6.3 ± 0.1[a]	4.3 ± 0.3[b]	4.5 ± 0.5[c]	5.7 ± 0.2[b]
TSC10	7.2 ± 0.3[a]	6.6 ± 0.2[a]	5.7 ± 0.5[a]	6.5 ± 0.3[a]	6.5 ± 0.4[a]
TSPP5	3.5 ± 0.1[f]	3.8 ± 0.2[e]	2.5 ± 0.1[c]	3.5 ± 0.1[d]	3.2 ± 0.1[e]
TSPP10	2.7 ± 0.1[g]	2.4 ± 0.1[f]	2.5 ± 0.1[c]	2.2 ± 0.2[e]	2.1 ± 0.2[f]

[1] Values are means (n = 3) ± standard deviations; [a–b]Means within a row with different lowercase superscripts differ (P<0.05).

Among the ES studied, TSPP10 received the worst sensory scores in all parameters. The textural properties of Kaymak samples influenced the sensory scores. Overall sensory scores were correlated with firmness (R^2 = 0.48, P<0.05), consistency (R^2 = 0.60, P<0.05) and cohesiveness (R^2 = 0.83, P<0.05). Cunha and Viotto, (2010) investigated the effect of various ES on Requeijao cremoso processed cheese spread. They also reported that textural properties directly influenced the sensory properties. On the other hand, they reported that TSPP exhibited similar sensory properties to TSC. The differences in the amount of ES used and especially high protein content of Requeijao cremoso cheese compared to Kaymak should be responsible for observing different behavior between TSC and TSPP in this study.

Conclusions

Utilization of ES in the manufacture of reduced fat Kaymak significantly affected textural and sensory properties. Emulsifying salts at various concentration resulted in different textural properties, thus not only the used ES type, but also the concentration of the ES caused distinctive effect on textural properties. Utilization of TSC at 10 m*M* level improved the textural and sensory properties of reduced fat Kaymak compared to control. However, products lower than 60% milk fat cannot be commercially sold as Kaymak due to the legal limitations. On the other hand, a reduced fat product with similar textural and sensory properties to Kaymak can be successfully manufactured by using TSC at 10 m*M* level.

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Conflict of Interest

The authors declared that there is no conflict of interest.

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