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Effect of Whey Protein Concentrate and Cornstarch on Chemical, Rheological and Sensorial Properties of White Feta Cheese

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Abstract This study examined the effect of Whey Protein Concentrate and Cornstarch on the chemical, rheological, and sensorial properties of Feta cheese. Four combinations were tested: C (control; no additive), A (1.5% cornstarch), B (1.5% whey protein concentrate), AB (0.75% cornstarch and 0.75% whey protein concentrate).Sampling was done on 3, 7, 14, 28 days after production and sensory testing was performed 28 day after production. All treatments exhibited significant differences in sensory (flavor, appearance, texture, overallacceptance), chemical (acidity, pH, dry matter, lactic and acetic acid content), and rheological properties ($p < 0.05$). Results showed positive effects from these two components on cheese properties. The addition of either Cornstarch Whey Protein Concentrate or a mixture of them increased dry matter in the cheese samples. The addition of Whey Protein Concentrate increased lactic and acetic acid and softness. The mixture of Whey Protein Concentrate and Cornstarch scored the highest grade on the sensorial evaluation.

Keywords: *Whey protein concentrate, Cornstarch, feta cheese, rheological properties*

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1. Introduction

White feta cheese is a soft cheese. It has an acidic and salty taste and 18%-20% fat [1,5]. Whey Protein Concentrate is a food product produced by eliminating the lactose and salt in whey. The US Food and Drug Administration defines whey concentrate as obtained by separating the non-protein components from the whey so that the final product after drying contains at least 25% protein. The amount of lactose should not exceed 60% and it is generally recognized as safe [17].

When Whey Proteins are heated, they aggregate and gelatinize under suitable conditions and display various performance properties similar to fat, such as emulsification, water absorption, viscosity, and adherence [18]. These determine rheological and structural network properties and define the water retention capacity of the protein gel in this substance. It is possible to increase the food value and quality of this product with the addition of Whey Protein Concentrate, especially if it improves the taste. Whey Protein Concentrate has been substituted for fat in ice cream [19], for albumen protein in cake [21], and as a stabilizer for cornmeal bakery products [16]. It has been used with starch sources, such as Cornstarch, to improve the properties and quality of food products [2,8].

This research examined the effect of Whey Protein Concentrate and Cornstarch on the chemical and rheological properties of white Feta cheese.

2. Materials and Methods

2.1. Cheese Production

The milk used in this research was first cooled to 4°C. After microfiltration, fat standardization (3% to 4.5%), pasteurization (72°C for 12 s), ultra-filtration (APV, Denmark), the retentate was moved to the culture tank. Then, 2% starter culture was added (Y 532 LYO and DM LYO 230. Hansen, Denmark). The Cornstarch (Sigma-Aldrich, Germany) and WPC40 (Alacen, New zealand) were pasteurized separately and then added. After bringing the contents of the tank to 32°C, rennet was added (Sangyo, Japan). In the sealing process,2.5% to 3% (wt) salt was poured onto parchment paper which was placed over the surface of the cheese and covered with aluminum foil. Then the tank was closed and heat sealed. After that The pre-cheese incubated at the 40°C to complete coagulation within 30 min. At this point the containers were removed from the incubator and kept at refrigerator temperature (5°C).

2.2. Method

Acidity was expressed as %lactic acid and was determined by titration of water solution of 10g processed cheese with NaOH at 0.1N (Merck, Germany)using phenolphthalein (Merck, Germany) as indicator, pH was

measured by pH-meter (Knick766, Germany) with glass electrode (pH electrode Sensoret, Garden Grove, CA, USA) at 20 ± 2ºC; according to Iranian national standard no. 2852 [10].

Dry matter content was determined by evaporation method according to Iranian national standard no. 1753.

The HPLC system (Shimadzu LC-64) was used to determine organic acid. This system was equipped with an ultraviolet indicator (Shimadzu SPD-6AV), column oven (CTO-6A), controller system (SCL-6A), and computer analyzer chromotropic (CR4A). One ion exclusion separator column, (shimadzo model SCR-44 10H) 7.9 x 300 mm in size was used in the oven at 70°C; each sample was injected into the injection port. The ultraviolet indicator was adjusted to 214 nm. The mobile phase was isocratic and 0.009 N dilute sulfuric acid was used. The solution was passed through filters under a 0.145 µ vacuum and then exhausted under vacuum for 20 min. The mobile phase speed was 0.7 mm/min, chart speed was 5 mm/min. The method recommended by the manufacturer was used to determine the percentage of recovered organic acid.

Uniaxial compression, the simplest fundamental test, was done by the universal Experiment Machine HTE (Hounfield test, UK S-series Bench UTM model H 5k-S, Redhill, Equipment Ltd).This machine was equipped with loadcell of 500N. To do the experiment, a flat piston with 49 mm diameter was connected to machines forwarding front. Cheese pieces were cut into cylinders of 25 mm diameter and 10 mm height in 5°C. To prevent losing their moisture quickly, they were put in airtight containers and potted. In order to provide a balance between sample conditions to get ready for test, samples were kept for three hours at room temperature before test. The samples were pressed in uniaxial way with forwarding speed of 50 mm/min. The Shear stress (σ) was calculated by dividing the force at the shear point on the deformation curve of the first area of the sample and the secant modulus of Elasticity (E) at the shear point.

Sensorial assessment was done by a 10 member group of trained panelists according to the hedonic method and according to Iranian national standard no.4983. Sensory evaluation was carried out with scoring test by ten trained panelists who are the members of Food Engineering Department. The panelists were selected on the basis of their interest in sensory evaluation of cheeses. The cheeses were evaluated for appearance, flavour, texture and overall acceptability using a score from 1 to 5. Panelists were also requested to tick the defects on the panel scale in order to determine the reasons of decrease in scores.

3. Results and Conclusion

3.1. Acidity and pH

The acidity of the samples increased and the pH decreased during the 28 days production process. The results showed that the control sample had the lowest acidity and highest pH and the sample with 1.5% Whey Protein Concentrate had the highest acidity and lowest pH. There was a significant difference between the cheese samples ($p < 0.05$) (Table 1 and Table 2). Since the Whey Protein Concentrate was obtained by separating the non-protein from the whey, samples with whey protein had more lactose and their acidity increased during storage. The decrease in pH during days after production was attributed to the increase in lactic acid production due to the activity of starter culture [6,9,11].

Table 1. Tests of significant differences in acidity of the cheese samples (in basis of Lactic Acid)

	3 days	7 days	14 days	28 days
Control	0.42^{Dbc}	0.44^{Dd}	0.51^{Bd}	0.56^{Ad}
Cheese with 1.5% corn starch	0.41^{Cc}	0.45^{BCc}	0.53^{ABc}	0.63^{Ac}
Cheese with 1.5% whey protein	0.64^{Da}	0.72^{Ca}	0.76^{Ba}	0.82^{Aa}
Cheese with 0.75% corn starch and 0.75% whey protein	0.52^{Db}	0.58^{Cb}	0.60^{Bb}	0.66

Small shared letters indicate no significant differences in each column and Large shared letters indicate no significant difference in each row.

Table 2. Tests of significant differences in pH of the cheese samples

	3days	7days	14days	28days
Control	6.32^{Aa}	6.32^{Bb}	6.24^{Ca}	6.14^{Da}
Cheese with 1.5% corn starch	6.32^{Ba}	6.32^{Ba}	6.24^{Ca}	5.97^{Dc}
Cheese with 1.5% whey protein concentrate	5.33^{Ab}	5.28^{Bc}	5.22^{Cd}	5.15^{Dd}
Cheese with 0.75% corn starch and 0.75% whey protein concentrate	6.24^{Aa}	6.19^{Bb}	6.11^{Cc}	6.02^{Db}

Small shared letters indicate no significant differences in each column and Large shared letters indicate no significant difference in each row

3.2. Dry Matter

In the initial days of production, the highest amount of dry matter was recorded for the sample that contained 1.5% Cornstarch and the control sample had the lowest amount.There was a significant difference between cheese samples ($p < 0.05$) (Figure 1). At the end of production, again, the sample with 1.5% Cornstarch had the most dry matter and the control had lowest dry matter (Figure 1). Sant Eve et al had showed in study of effects of dry matter, and salt on cheese properties. They found that an increase in dry matter increased stiffness (texture mechanical and taste test) and elasticity. An increase in salt decreased stiffness (texture mechanical test) [22].

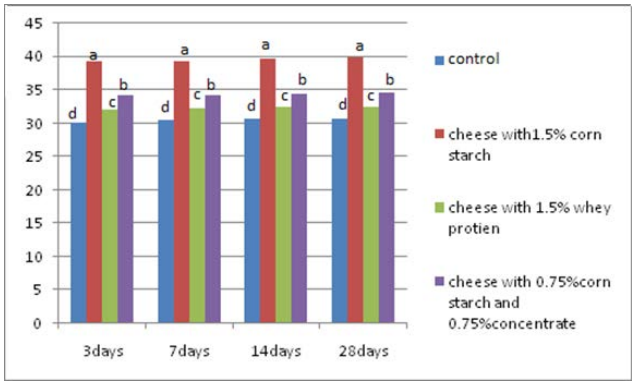

Figure 1. compare dry matter amount in cheese samples (in basis of percent). Small shared letters indicate no significant differences in each column

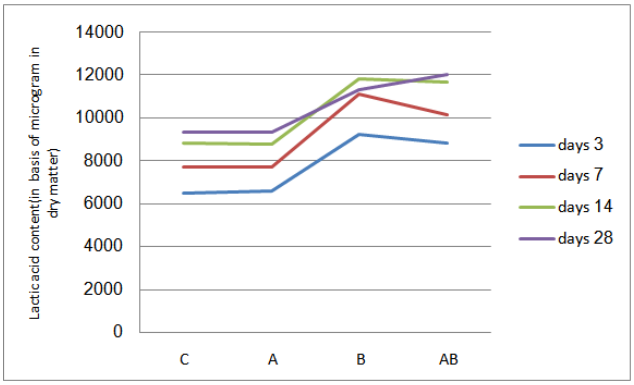

Figure 2. Changes in lactic acid content of cheese samples. c:control, A:with 1.5% cornstarch, B:with 1.5% whey protein concentrate, AB:with 0,75% cornstarch and 0.75%whey protein concentrate

3.2. Organic Acid (Acetic Acid and Lactic Acid)

Organic acid production increased during production ($p < 0.05$) (Figure 2 and Figure 3). Lactic acid is the most abundant organic acid in all type of cheese [12]. Lactic acid increased in the sample containing 1.5% Whey Protein Concentrate 3 days after production from 9200 µg in the dry matter to 11300 µg at 28 days after production. This sample contained the highest amount of acid. As, Acetic acid in this sample after 28 days had increased from 225 µg in dry matter to 245 µg. Overall, there was a significant difference between the cheese samples ($p < 0.05$) (Table 3 and Table 4). Increased Acetic acid content was stable but Lactic acid trend had fluctuation .The Lactose is converted into lactic acid during cheese making by the starter culture [3].

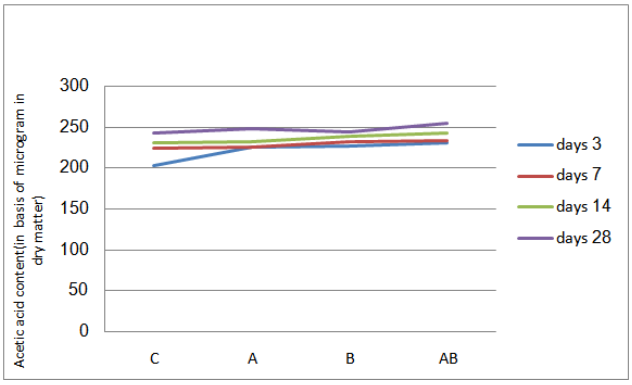

Figure 3. Changes in Acetic acid content of cheese samples. c:control, A:with 1.5% cornstarch, B:with 1.5% whey protein concentrate, AB:with 0,75% cornstarch and 0.75%whey protein concentrate

Table 3. Lactic acid amount in cheese samples (in basis of microgram in dry matter)

	3days	7days	14days	28days
Control	6492.5^{Dd}	7706^{Cc}	8817^{Bc}	9349.5Ac
Cheese with 1.5% corn starch	6608^{Dc}	7692^{Cc}	8780^{Bd}	9365^{Ac}
Cheese with 1.5% whey protein concentrate	9202.5^{Da}	11105^{Ca}	11829^{Ba}	11328^{Ab}
Cheese with 0.75 % corn starch and 0.75 % whey protein concentrate	8801.5^{Db}	10122.5^{Cb}	11682.5^{Bb}	12015^{Aa}

Small shared letters indicate no significant differences in each column and Large shared letters indicate no significant difference in each row

Table 4. Acetic acid amount in cheese samples (in basis of microgram in dry matter)

	3days	7days	14days	28days
Control	202^{Dc}	224^{Ba}	230.5^{Ba}	243^{Ab}
Cheese with 1.5% corn starch	224.5^{Bb}	225.5^{Ba}	232^{ABa}	248^{Aab}
Cheese with 1.5% whey protein concentrate	226.5^{Dab}	231.5^{Ca}	238^{Ba}	244.5^{Aab}
Cheese with 0.75 % corn starch and 0.75 % whey protein concentrate	230.5^{Ca}	233.5^{Ca}	242.5^{Ba}	254.5^{Aa}

Small shared letters indicate no significant differences in each column and Large shared letters indicate no significant difference in each row

Table 5. shear stress of chesse sample by survey test of texture according to single press (in basis of kpa)

	3days	7days	14days	28days
Control	17.3^{Da}	25.14^{Ca}	37.07^{Bb}	46.58^{Ac}
Cheese with 1.5% corn starch	15.23^{Db}	24.64^{Cb}	42.57^{Ba}	69.19^{Ab}
Cheese with 1.5% whey protein concentrate	7.36^{Dd}	11.55^{Cd}	19.88^{Bd}	26.22^{Ad}
Cheese with 0.75 % corn starch and 0.75 % whey protein concentrate	12.99^{Dc}	22.71^{Cc}	36.07^{Bc}	72.29^{Aa}

Small shared letters indicate no significant differences in each column and Large shared letters indicate no significant difference in each row

Table 6. elastic young module E, of cheese sample by survey test of texture according to single shaft press method (in basis of kpa)

	3days	7days	14days	28days
Control	34.18^{Da}	51.34^{Ca}	74.27^{Bb}	94.26^{Ac}
Cheese with 1.5% corn starch	31.12^{Db}	49.18^{Cb}	86.14^{Ba}	101.18^{Ab}
Cheese with 1.5% whey protein concentrate	14.13^{Dd}	26.08^{Cd}	39.20^{Bd}	54.20^{Ad}
Cheese with 0.75 % corn starch and 0.75 % whey protein concentrate	26.16^{Dc}	45.32^{Cc}	73.60^{Bc}	144.11^{Aa}

Small shared letters indicate no significant differences in each column and Large shared letters indicate no significant difference in each row

3.3. Texture

The texture survey was done using a single shaft press 28 days after production. There was a significant difference in texture between the cheese samples ($p < 0.05$) (Table 5 and Table 6).

The Shear stress and secant modulus of Elasticity increased for all samples by 28 days after production. The maximum Shear stress and secant modulus of Elasticity was recorded for the sample with 0.75% Cornstarch and 0.75% Whey Protein Concentrate. The sample with 1.5% Whey Protein Concentrate had the lowest Shear stress and secant modulus of Elasticity. Stress in the Shear point is directly related to cheese stiffness. The more stress at the Shear point, the more stiffness, and vice versa. Similar to stress at the Shear point, the greater the secant modulus of Elasticity, the greater the stiffness of the cheese. Therefore, according to the results of the texture test, the sample with 1.5% Whey Protein Concentrate, the samples with 0.75% Cornstarch and 0.75%Whey Protein Concentrate, and the sample with 1.5% Cornstarch had the highest to lowest amounts of softness. Brigheti et al examined the taste, texture, and rheological properties of 18 cream cheese samples with different amounts of fat and assessed the softness using a penetration test. They found that a decrease in fat or increase in the protein surface enhanced softness of the cheese texture [4]. In another study, Sheriaber et al reported that using less than 0.5% whey protein increased humidity and efficiency [23]. Several studies have shown that using corn starch as an imitation of casein, improves the rheological properties [7,16]. Noronha et al found that Increasing the amount of starch in the cheese texture from soft and delicate leather-like changes and decreased water flow [20].

3.4. Sensory Evaluation

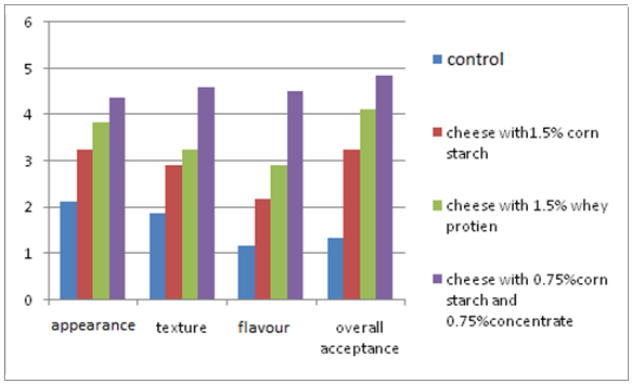

Figure 4. comparing panelists s scores (scores between 0-5)

Sensory evaluation showed that the sample containing 0.75% Cornstarch and 0.75% Whey Protein Concentrate had highest score (Figure 4). Zalazar et al studied the effect of Dairy-Lo (a fat substitute made from whey protein) on the rheological and sensory characteristics of low-fat soft cheese. They found that the best rheological properties observed for the whey protein composition after 30 days [24]. Koca et al showed that textural and sensory properties of low-fat keshar cheese produced with a combination of Dairy-Lo (a fat substitute made from whey protein) in 90-day storage period studied and observed the stiffness, gum Mode and resinous composition containing Whey Protein samples were lower. These results indicate that the use of compounds based on Whey Protein Concentrate can improve textural and sensory properties of cheese [13]. Meshgi Aghazadeh et al studied using Cornstarch and gelatin (0.5 to 1%) to produced non-fat yogurt and sample with 1% Cornstarch had the worst score in sensorial evaluation (taste and smell) [2].

3.5. Statistical Analysis

All assays (except sensorial test) were carried out in triplicate, and results were expressed as mean values with standard deviations. Statistical analyses were performed using SPSS (Version 8.0) software. Comparisons were accomplished by Two-way ANOVA followed by Duncan test, and $p < 0.05$ was considered significant. All figures were done using Excel software.

3.6. Conclusion

The results of this research showed the positive effect of adding Whey Protein Concentrate and Cornstarch on the sensorial, rheological, and Physicochemical properties of cheese. Adding Cornstarch alone or in combination with Whey Protein Concentrate increased dry matter content in the cheese samples. The addition of Whey Protein Concentrate increased the Acetic and Lactic acid and the softness of the cheese samples. Cheese samples with a mixture of Whey Protein Concentrate and Cornstarch had best panelists scores.

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