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Study on textural and color characteristics of UF-white cheese containing caffeine

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ABSTRACT

For various reasons such as increasing awareness, reducing fatigue, increasing energy and reducing tiredness, caffeine consumption is popular among consumers as a drink and also as an additive. In addition, the consumption of caffeine causes weight loss by reducing appetite, and for this reason, its use in the formulation of food supplements has been considered. Therefore, the consumption of ultrafiltrated (UF) cheese containing caffeine, in addition to being a very good source of nutrients and useful substances needed by the body, increases energy and reduces fatigue, which makes a person more energetic. In this study, caffeine with different concentrations of 0 (control sample), 0.2, 0.4 and 0.6% was added to UF white cheese and the color changes (L*, a* and b* indices) and textural properties (hardness, cohesiveness, adhesiveness, gumminess and springiness) of the product were studied during 45 days of storage in the refrigerator. The results of color evolution showed that the L* index decreased with the increase of caffeine concentration ($p< 0.05$) and passing the storage period ($p< 0.001$). In addition, no significant effect was observed by adding caffeine to UF-cheese on a* and b* indices, but the storage time caused a significant decrease ($p< 0.01$) in both parameters. The degree of hardness, cohesiveness and gumminess of the UF-cheeses decreased significantly with the increase of caffeine concentration from 0.2 to 0.6% and with the passage of storage time ($p< 0.01$). Adhesiveness and springiness values also decreased with increasing caffeine concentration and storage time, but these changes were not significant ($p> 0.05$). Based on color and texture quality, there were no significant differences between control and sample containing 0.4% caffeine. Therefore, by using the concentration of 0.4% caffeine, it is possible to produce an energizing and invigorating UF-cheese.

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1-Introduction

Inadequate health care and insufficient nutrition are one of the main causes of many chronic diseases and deaths around the world. So far, many researches by nutritional science experts have been devoted to the study of prevention of chronic diseases, including metabolic syndrome, osteoporosis, dementia and digestive disorders. Based on the research, making changes in the diet may be one of the ways to prevent the onset of chronic diseases [1, 2]. Dairy products are among the most nutritious and known essential food items in the diet, which have many health benefits for consumers and are an excellent source of beneficial nutritional components and a balanced diet. The beneficial effects of dairy products are due to the presence of proteins, minerals, vitamins, lipids, carbohydrates and also the presence of bioactive peptides, probiotics and prebiotics, which are beneficial for health [3, 4]. In fact, whole milk is naturally rich in minerals (calcium, potassium, magnesium, phosphorus, selenium, and zinc), vitamins (riboflavin, thiamin, A, B12), protein, carbohydrates and fat [5]. Consumption of dairy products can be considered as an effective source in absorbing calcium and other nutrients due to its high absorption speed, availability and low price [6].

Cheese is a protein dairy product rich in calcium, which is produced in a wide range of different flavors and forms all over the world. This product is obtained by coagulation of milk (whole milk, semi-fat milk or fat-free milk), and with the help of coagulating agents or rennet [7]. Cheese is rich in essential nutrients such as proteins, lipids, vitamins and minerals, and due to the high concentration of essential amino acids in it, it helps the growth and development of the human body [8, 9]. The amount of lactose in cheese is low due to the conversion of lactose into lactic acid by the metabolism of lactic acid bacteria during the production and fermentation of cheese, so the consumption of cheese in patients with lactose intolerance is not prohibited [10, 11]. Cheese is classified based on different characteristics such as production and ripening conditions, type of milk, fermentation, fat content, etc.

Ultrafiltrated (UF) cheese is one of the most popular cheeses produced in Iran, which is produced by ultrafiltration method and thru the milk concentration. The most important kind of cheese in Iran produced by this way is Iranian white cheese. This cheese has relatively a spreadable texture, and has a soft and uniform texture, without eye cheeses. The softness and special mouthfeel of this cheese are related to the proteolysis reactions [12]. During the process of producing UF cheese, due to the low amount of heat applied to the milk, its nutritional components are better preserved, which increases the nutritional value of this cheese. The amount of dry matter and salt in UF cheese is 35-40% and 2-3%, respectively, its ripening period is very short and its maximum storage time is 60 days. Preservation of cheese protein, which leads to an increase in the yield of cheese production, an increase in the nutritional value of cheese, and saving energy and manpower, is one of the advantages of cheese production using the UF method [13, 14].

Caffeine, (1,3,7-tri-methyl xanthine), is an alkaloid from the family of methylxanthines and a stimulant of the central nervous system, which is naturally present in some foods such as tea, coffee, and cocoa beans. The rate of absorption of caffeine after consumption is very high and it increases alertness, reduces fatigue, increases energy, reduces drowsiness and increases concentration. Caffeine increases alertness by reducing brain adenosine. However, consuming too much caffeine will have harmful effects such as increased heart rate, anxiety, digestive disorder, shortness of breath and restlessness [15]. Caffeine is used in foods and beverages as an additive and stimulant of the nervous system in standard amounts. The permissible amount of caffeine use in people and at different ages is different, but the maximum permissible amount of daily intake of caffeine in adults is reported to be 400 mg [16]. Nowadays, the consumption of caffeine as a drink and also as an additive has attracted a lot of attention among consumers and food industries. On the other hand, cheese is one of the most popular dairy products among consumers, which is especially consumed as a breakfast meal. Therefore, the use of caffeine in cheese as a popular dairy product, in addition to receiving nutrients and valuable substances in cheese, can cause alertness and increase energy in consumers due to the presence of caffeine. This is while it seems that receiving appropriate amounts of caffeine can reduce osteoporosis by increasing bone density, especially in women [17]. Although various researches have been

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conducted in the field of using caffeine in different foods, no research has been done in the field of caffeinated cheese production.

Pimpley et al. [18] used green coffee extract powder to produce a functional yogurt. Yogurt enriched with 0.5% of the mentioned powder had suitable pH (4.7), acidity, antioxidant properties (due to the presence of polyphenols and alkaloids) and color and had minimal syneresis or water loss. Also, the enriched product had good taste, texture and other sensory characteristics during 14 days of storage at 4 °C and therefore it was suggested as a functional food. Niimi et al [19], using sugar, salt, monosodium glutamate, lactic acid and caffeine as 5 main flavors of food, investigated the possibility of simulating the taste of cheddar cheese. Based on the sensory results, these researchers reported that by using the combination of sugar, salt, monosodium glutamate, lactic acid and caffeine with the amounts of 0.3, 0.5, 0.11, 0.11 and 0.08% respectively, it is possible to obtain a taste similar to the characteristics of the taste of cheddar cheese. Tan and Korel [20] compared the chemical, physical, microbial and sensory characteristics of yogurt containing different levels of instant coffee powder (0.5, 0.7 and 0.9%) after one day of production with the control sample. During 15 days of storage in the refrigerator (5-7°C), the pH value decreased and the acidity increased significantly in all the examined samples. The yogurt sample containing 0.5% coffee and 5% sugar had more sensory acceptance among panelists and consumers.

This research was aimed at the possibility of producing UF cheese containing caffeine with different concentrations (0.2, 0.4 and 0.6%) and to investigate some characteristics of the produced cheese in comparison with commercial UF cheese (as control sample, without caffeine) during 45 days at 4 °C.

2-Materials and methods

2-1- Materials

The UF cheese samples were produced in Pegah Khuzestan factory. CHOOZIT 230 mesophilic starter powders (containing a mixture of *Lactococcus lactis* subsp. *cremoris* and *Lactococcus lactis* subsp. *lactis*) and Yo-Mix 532 thermophilic starter (containing *Streptococcus thermophilus* and *Lactobacillus delbrooki* subsp. *bulgaricus*) was purchased from Germany's Danisko Company. Microbial rent with commercial name of Chey-Max from Denmark's Christian Hansen Company and caffeine with a molecular weight of 194.20 g/mol was purchased and used from Merck, Germany.

2-2- Production of UF cheese samples containing caffeine

UF cheese samples were prepared in Pegah dairy factory of Khuzestan according to the method of Danesh et al. [14]. After performing the microbial and chemical tests, the milk was transferred to storage tanks and pumped to the plate pasteurizer at a temperature of 5 °C. After preheating and reaching the temperature of the milk to about 50 °C, the separation of milk fat was done by the milk cream separator. Then, milk with standard fat was processed by bactofugation in two stages to eliminate more than 99% of bacteria. The milk was then transferred to the pasteurized milk storage tanks for and then the temperature of the milk reached 50 °C in the plate heat exchangers for the purpose of the concentration process. In the next step, by passing through the ultrafiltration device and through several stages of UF, the milk was divided into two passing parts (permeate) and concentrated part (retentate). Next, caffeine powder was added to the retentate in amounts of 0.2, 0.4, and 0.6%, and then samples were mixed and homogenized. Thereafter, 3% of mixture of the starter culture and cheese rennet was added to retentate and the mixture was poured into 100-gram containers. The appropriate levels of caffeine in this research (4 levels) were selected after conducting preliminary tests and used in the formulation of UF cheese. Then, the samples were put into the coagulation tunnel at 31°C for 25 minutes for the coagulation process. After the coagulation stage, parchment paper was placed on the surface of the cheese to evenly distribute the salt in the cheese, and 3% salt was added to it before sealing. Finally, the produced samples were transferred to a warm room for incubation with a temperature of 37°C and kept until pH of the samples were reached to 4.8. Finally, the UF cheese packs were transported to refrigerated storage (4°C).

2-3- Assessing the color values

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The color of the control UF cheese samples and caffeine-containing UF cheeses was determined using a colorimeter, Minolta CR300 series, Minolta Gamera Co., during 45 days of storage period at 4°C, where a* (a value), b* (b value) and L* (L value) indicate redness, yellowness and whiteness, respectively [21].

2-4- Texture analysis

In order to evaluate the texture characteristics of UF cheese samples such as hardness, cohesiveness, adhesiveness and springiness, texture profile analysis (TPA) was performed according to the method described by Jooyandeh [22], using a texture measuring device (Stable Micro System, model TA.XT.PLUS, made in England), and probe number P5/S. The speed of the probe before, after and during the test was 2, 1, and 1 mm/s, respectively. The probe penetrated up to 50% of the initial height of the cheese samples. In this test, the properties of hardness (N), adhesiveness (N.mm), adhesiveness, springiness (mm), and gumminess (N) of the cheese samples were investigated (Figure 1).

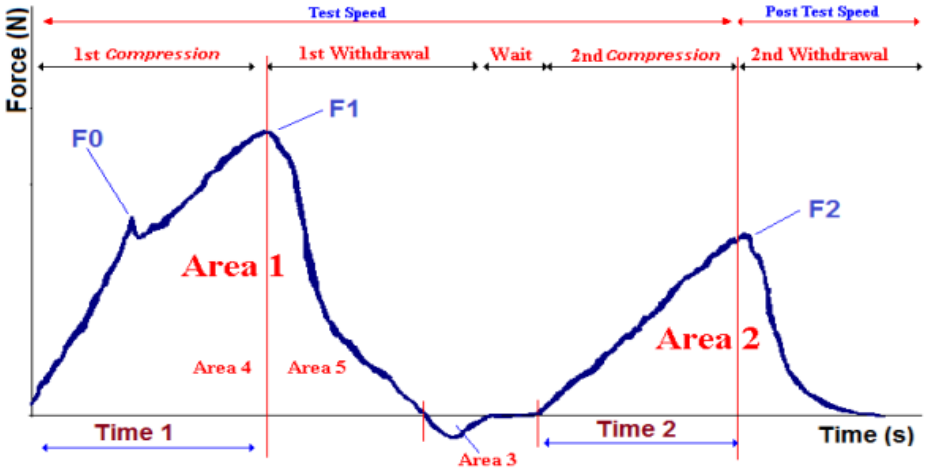

Figure 1. Calculations of texture profile analysis

Hardness is the amount of force required to achieve deformation, and expressed as the maximum force during the first compression period (F_1), with dimensional unit of N, kg or g. Cohesiveness is the ratio of the positive area of the second cycle to the positive area of the first cycle, which indicates the strength of the food's internal bonds (Area2/Area1). Adhesion is the value of the negative area of the first cycle of food compression (Area 3), whose unit is N.mm. Gumminess is the energy required to grind food to prepare for swallowing and it is the product of hardness in cohesiveness, the unit of which is g or N. Springiness is also the distance between the end of the first compression and the beginning of the second compression [22].

2-5- Data Analysis

In this research, caffeine with different concentrations of 0, 0.2, 0.4. 0.6% was added to the ultrafiltrated cheeses and the color and texture characteristics of the cheese samples were compared with each other and with the control sample (plain cheese without caffeine) during 45 days of storage (1, 22 and 45 days). All the cheese treatments were produced in 3 replications and the results were analyzed thru a completely random design by SPSS software (version 20). The mean of the results were compared with the help of Duncan's test at the 5% level [23].

3-Results and discussion

3-1- Color analysis

The color of UF cheese samples containing caffeine was investigated during the storage period. The color parameters indicate the amount of color on the external and internal surface of cheese, among which L* (indicating brightness)

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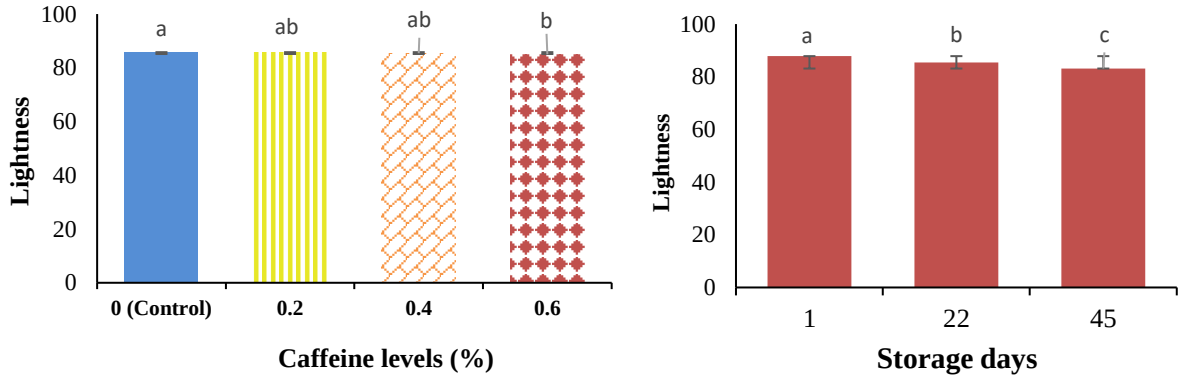
and b* (indicating yellowness) are two important parameters in determining the color of cheese. The research conducted by the scientists' shows that the scattering of light, the uniformity of the molecules and the microstructure are effective factors in the brightness of the food. Colloidal particles, especially calcium phosphate, the accumulation of casein micelles and fat globules are factors that affect the brightness of dairy products such as cheese. The amount of brightness in cheese depends on the number of holes in its casein network structure (porosity), as well as the presence of fat globules [24 and 25]. By passing through the surface layers of cheese, the light is scattered by cheese cavities and fat globules [26 and 27].

The statistical results related to the color values of the cheese samples during the cold storage period are shown in Table 3 and Figure 2. The results showed that the independent variable of caffeine had a significant effect ($p < 0.05$) on the brightness of the cheese samples, but not on the yellowness and redness values ($p > 0.05$). As the amount of caffeine increased, the amount of brightness decreased, but no significant difference was observed between the control sample and samples containing levels of 0.2 and 0.4% caffeine (Figure 2).



(A)

Figure 2. Effect of different concentration of caffeine and impact of storage time on the lightness (L*) of ultrafiltrated cheeses.

According to the results shown in Table 1, there was no significant difference between the L* values of the control sample and the cheese samples containing different concentrations of caffeine on the first and 22nd days of storage period. The L* values of control and cheese samples containing caffeine with different concentrations of 0.2%, 0.4% and 0.6% on the first day were determined as 88.23, 88.05, 87.84 and 87.34, respectively. In the middle of storage, the L* values of the control and cheese samples containing different concentrations of 0.2%, 0.4% and 0.6% caffeine were 85.62, 85.40, 85.34 and 85.30, respectively. As can be seen, at the end of the storage time, the addition of different concentrations of caffeine caused a significant decrease in the color index L*, so that the brightness of the control sample with 83.68 was higher than the sample containing 0.6% caffeine with L* value of 82.42. In addition, the results of the evaluation of the L* index of the cheese samples during the storage period showed that the L* index decreased with the passage of the storage period, and there was a significant difference in this regard between the samples of the UF cheese in the all storage periods ($p>0.001$). Also, a significant difference was observed in terms of the a* and b* indices in the cheese samples with different concentrations of caffeine during 45 days of storage period. However, usually there was no significant difference in terms of a* and b* indices between the cheese samples during the 1st and 22nd days and also the 22nd and 45th days of storage (Table 1).

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Table 1. Color characteristics of ultrafiltrated cheeses containing caffeine with different concentrations during 45 days storage at 4 ◦C

Color Values	Storage Time (Day)	Control	Cheese contains 0.2% caffeine	Cheese contains 0.4% caffeine	Cheese contains 0.6% caffeine
L*	1	88.23±1.11 ^{aA}	88.05±0.06 ^{aA}	87.84±0.36 ^{aA}	87.34±0.47 ^{aA}
	22	85.62± 0.50 ^{aB}	85.40±53 ^{aB}	85.34±47 ^{aB}	85.30±0.72 ^{aB}
	45	83.68±0.32^{aC}	83.34±0.48 ^{abC}	83.15±0.99 ^{abC}	82.42±0.47 ^{bC}
a*	1	–4.49±0.05 ^{aA}	-4.44±0.11^{aA}	-4.45±0.17 ^{aA}	-4.41±0.18 ^{aA}
	22	-4.36±0.18 ^{aAB}	-4.29±0.10 ^{aB}	-4.29±0.10 ^{aAB}	-4.24±0.04 ^{aAB}
	45	-4.23±0.05 ^{aB}	-4.21±0.15 ^{aB}	-4.22±0.08 ^{aB}	-4.15±0. 10 ^{aB}
b*	1	12.54±0.10 ^{aA}	12.41±0.19 ^{aA}	12.43±0.16 ^{aA}	12.38±0.17 ^{aA}
	22	12.33±0.17 ^{aB}	12.28±0.20 ^{aAB}	12.27±0.08 ^{aAB}	12.25±0.09 ^{aAB}
	45	12.25±0.09 ^{aB}	12.19±0.10 ^{aB}	12.17±0.12 ^{bB}	12.14±0.15 ^{aB}

Different small and capital letters indicate significant differences ($p<0.05$) in each row (treatments) and column (days) for each cheese characteristics, respectively.

The decrease in brightness of cheese as a result of adding caffeine powder can be due to the scattering of powder particles in the casein matrix space and the decrease in light reflection due to the decrease of free water droplets in cheese samples [24]. Shaddel and Rajabi-Moghaddam in similar results in the production of instant fruit drink powder containing finely coated caffeine (nanoliposomes coated with chitosan) in order to reduce the bitterness of the product, reported that the use of different concentrations of caffeine had no effect on the a* (red-green) and b* (yellowish-blue) index values of the cheeses [28]. According to the results obtained from this study, unlike caffeine, the storage time variable significantly affected all 3 color parameter of the tested cheese samples ($p < 0.01$) and caused a noticeable decrease in lightness, greenness and yellowness. The values of L* of the cheese samples during the 45-day storage period were in the range of 87.86 (beginning of storage) to 83.15 (end of storage) (Figure 2). The decrease in L* values can be due to the increase in the hydration of proteins and the decrease in free water droplets during the storage period, which causes a decrease in light scattering [25].

3-2- TPA analysis results

Texture profile analysis is a test imitating the act of chewing in two stages. Texture is one of the important factors in the quality of cheese, and this factor along with aroma and taste is one of the important and influential factors in the ability of consumers to accept it. According to Fox et al. [29], the texture of cheese is a combination of sensory and physical properties, which are perceived by the sense of sight, touch, etc. The type of milk, the method of cheese production, the ripening conditions, and the storage conditions are among the effective factors in the texture of the cheese [30 and 31]. Analysis of the texture profile of UF cheese samples containing different concentrations of caffeine is shown in Figure 3 and Table 2.

3-2-1- Evaluation of hardness (firmness)

Hardness is the maximum force required to compress the sample [32]. Table 2 shows the changes in the texture parameters of the control UF cheese and the UF cheese samples containing different concentrations of caffeine during 45 days of storage period at 4 °C. As shown in Figure A-3, the hardness values of cheese samples containing different amounts of caffeine are significantly different from each other ($p < 0.001$) and increasing the concentration of caffeine causes the samples to become softer. However, there was no difference in this regard between the control samples and the cheese sample containing 0.2% caffeine and also the sample containing 0.4% with the sample containing 0.6% caffeine. In addition, the results of the effect of adding different concentrations of caffeine on the hardness values of cheese samples during 45 days in the refrigerator can be seen in Table 2.

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According to the results obtained in Table 2, with the increase of caffeine concentration from 0.2% to 0.6%, and also with the passage of storage time, the cheese hardness decreased. The hardness values of the samples varied from 2.83 N (the sample without caffeine at the beginning of storage) to 1.92 (the sample containing 0.6% caffeine at the end of 45 days of storage). The hardness of control and UF cheese samples containing 0.2, 0.4 and 0.6% on the first day was determined as 2.83, 2.66, 2.56 and 2.53, in the middle of storage, 2.55 , 2.50, 2.40, and 2.32, and at the end of the storage period, 2.28, 2.21, 2.09, and 1.92 newton, respectively. Moisture, is one of the factors affecting the firmness of cheeses; the decrease in the firmness of the cheese samples containing different concentrations of caffeine could be due to the increase of moisture in the cheese samples (results not shown). In fact, high moisture causes interference in the casein network and weakens its colloidal structure, and as a result, the amount of hardness decreases [33 and 34]. According to the research conducted by Fox et al. [29], moisture increases the plasticity of the protein matrix and decreases its elasticity. In fact, with the increase of moisture and the presence of water in the three-dimensional network of the protein, the solidity of the protein network is reduced and the texture of the product becomes soft. Creamer and Olson [35], also by examining the rheological evaluation of the ripening time of Cheddar cheese, stated that during the ripening period of various types of cheese, the protein network has changed from a granular structure to a homogeneous structure, which softens the texture of the cheese. Therefore, the decrease in cheese hardness during the storage period in this research can be due to the breakdown of αs_1 casein into peptides with low molecular weight in cheese and the hydration of the protein network [36]. A decrease in cheese hardness at the end of the storage period has also been reported by other researchers [25, 37]. According to the results of Torabi et al. [25], the softening of the synbiotic processed white cheese treated with microbial transglutaminase enzyme during the ripening period is due to the decrease in pH and as a result the increase in the solubility of micelle calcium phosphate; because this weakens the structural links of the cheese and softens the cheese during the storage period.

3-2-2- Evaluation of cohesiveness

Cohesiveness indicates the strength of the internal bonds in the structure of a material, and also the degree of deformation of a material before crushing; the strength of the internal bonds of casein micelles in cheese indicates its degree of cohesion [38 and 39]. Based on the results obtained from this research, the amount of cohesiveness decreased in UF cheeses with the addition of caffeine concentrations from 0.2 up to 0.6% and also with the passage of storage time (Fig. B-3 and Table 2), the highest level of cohesiveness was observed in the control sample (2.55) and the lowest (2.26) in the sample containing the highest level of caffeine, i.e. 0.6% caffeine. According to Table 2, the evaluation of the degree of cohesiveness in different periods of storage shows that there is no significant difference in terms of consistency between the control and the samples containing 0.2 and 0.4% caffeine. In addition, no difference was observed between cheese samples containing caffeine in all storage periods. By taking a close look at table 2, it can be seen that although the cohesiveness of control cheeses and samples containing 0.2 and 0.4% caffeine decreased significantly with the passage of storage time, but these changes in cheese containing 0.6% was not observed, which could be due to wider proteolysis in this sample. The consistency of cheese texture has an inverse relationship with the proteolysis of cheese, in such a way that with the increase of proteolysis, the cohesiveness decreases. Also, the low pH of cheese curd can affect the decreasing process of cohesiveness due to the gradual decomposition of casein micelles into smaller particles [40-42]. By studying the effect of fermented whey protein concentrate on the texture of Iranian white cheese, Jooyandeh also reported that the amount of cohesiveness in the texture of cheese samples decreased during the storage period, which could be due to the increase in proteolysis [22]. In addition, research shows that during the process of proteolysis, many peptides and amino acids are produced. As a result of the catabolism of these compounds by lactic acid bacteria, amine groups and ammonia are released which causes changes in pH, and therefore causes changes in the texture of cheese and reduces its cohesiveness [43].

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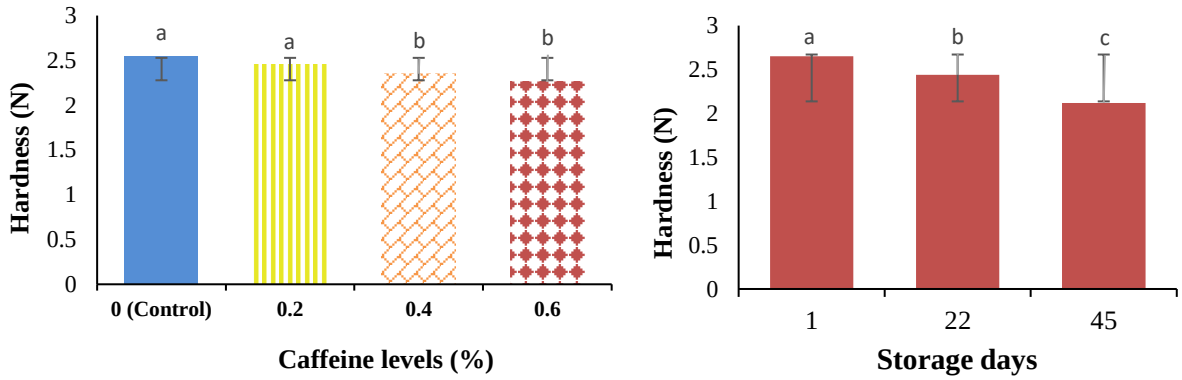
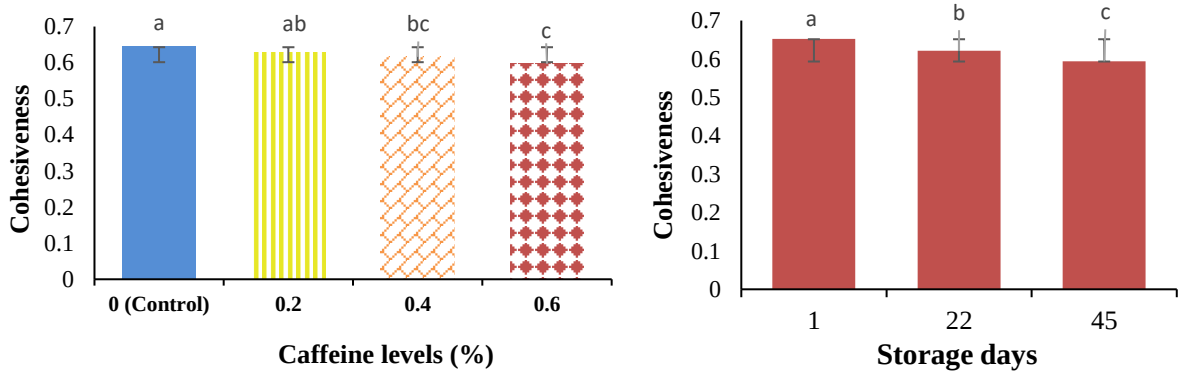


(A)



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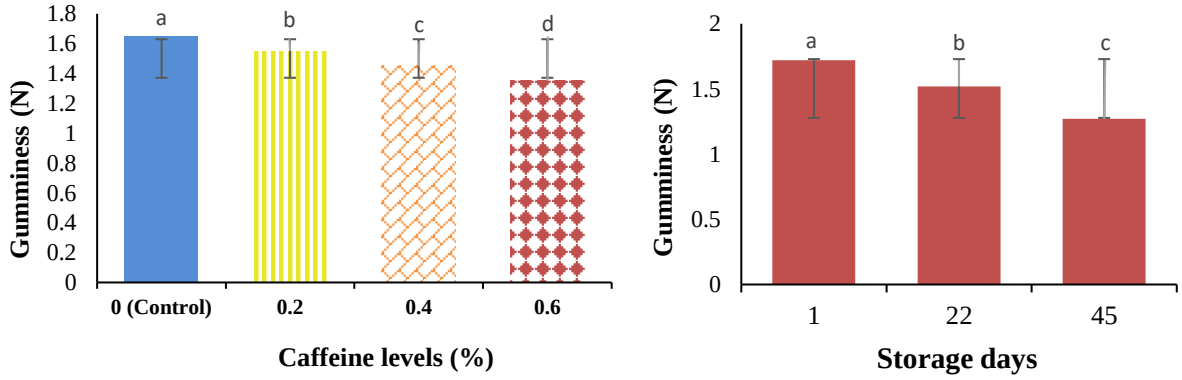

(C)

Figure 3. Effect of different concentration of caffeine and impact of storage time on the texture characteristics of ultrafiltrated cheeses.

3-2-3- Evaluation of gumminess

Gumminess is the amount of energy required to break down a semi-solid food item, to soften and uniform the shape of the food item and prepare it for swallowing, which depends on the hardness and consistency of the food item [44 and 45]. The results of the effect of adding different concentrations of caffeine (0, 0.2, 0.4 and 0.6 percent) and storage period on the cheese gumminess are shown in Figure 3-C and Table 2.

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The obtained results revealed that with the increase in caffeine concentration and with passage of storage time, the amount of gumminess decreased significantly ($p < 0.001$), and this can be attributed to the high proteolytic activity [41]. As it was mentioned, the amount of gumminess depends on the degree of hardness and consistency of the food. Considering the decreasing trend of the hardness of cheese samples containing caffeine during the storage period and the direct relationship between the degree of hardness and gumminess, the reduction of gumminess in cheeses containing caffeine during the storage are expected. According to the results obtained by Goma [46], the decrease in the gumminess content of domiati white cheese (by ultrafiltration method) at the end of the storage period is related to its high proteolytic activity. Although, the increase of gumminess at the beginning of the storage period can also be due to the decrease in the amount of cheese moisture. In addition, Rostamabadi et al. [26] also reported that adding Persian gum to Iranian white cheese in order to replace fat and produce low-fat cheese caused a significant decrease in the cheese gumminess.

3-2-4- Evaluation of adhesiveness and springiness

Adhesiveness is mechanically defined as the necessary work to overcome the adhesion forces between the food and other surfaces. The springiness also refers to the amount of deformation of a sample due to the force applied to it, and after removing the applied force, the sample returns to its original state [32]. According to the results obtained from the TPA of the cheese samples in Table 2, although in general, with the increase of caffeine concentration and passage of storage time, the values of adhesiveness and springiness decreased, but the differences were not significant ($p < 0.05$). Based on the findings of this research, the amount of adhesiveness of cheese samples during the storage period was in the range of -0.337 N.mm (the sample containing 0% caffeine on the first day of storage) to -0.283 (the sample containing 0.6% caffeine on the first day of storage). The springiness of the cheese samples during the storage period was also determined between 8.25 mm (the sample containing 0% caffeine on the first day of storage) and 8.01 mm (the sample containing 0.6% gum at the end of the storage period). According to the results of this research, Torabi et al. [25] also showed that the type of cheese (synbiotic, probiotic and non-probiotic) and the duration of storage had no significant effect on the springiness of the of UF white cheese samples.

4- Conclusion

Caffeine is an alkaloid from the methylxanthines family, which stimulates the central nervous system and increases alertness, increases energy and reduces fatigue after consumption. In addition, due to the other positive properties of its balanced consumption in humans (reduction of appetite, increase in bone density, protection of skin and hair, antioxidant properties, etc.) today, the use of this substance in the food industry has received a lot of attention. Cheese is a popular dairy product among consumers as a breakfast meal, which, in addition to the presence of nutrients, contains very little lactose and does not pose a problem for patients with lactose intolerance. UF cheese has a soft, uniform texture and adequate spreadability, which has a high nutritional value and creates a pleasant mouthfeel when consumed. In this study, the effect of adding caffeine on the color and texture characteristics of UF white cheese was investigated. The results of this research showed that the addition of caffeine with different concentrations to the cheese caused a decrease in the L* index during 45 days of storage period, but did not have effect on the a* and b* values. The evaluation of the texture of UF cheese samples showed that the hardness, cohesiveness and gumminess of the cheese decreased significantly with the increase in caffeine concentration. However, there was no difference in terms of hardness and cohesiveness between the control and the sample containing 0.2% caffeine, and samples containing 0.4% and 0.6% caffeine. Results from the texture analysis also showed that the addition of caffeine to the UF cheeses decreased the adhesiveness and springiness values, but these changes were not significant. In addition, storage time did not have a significant effect on texture parameters except for hardness, adhesiveness and springiness. Based on the results of this research, adding caffeine to UF white cheese improved the texture and softness of the cheese, but due to the decrease in the quality of the color (brightness) of the cheese, the sample containing 0.4% caffeine concentration was identified as the best

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sample. However, it should pay attention to the maximum allowed amount of caffeine consumption per day (400 mg equivalent to a maximum of 100 grams of fortified UF cheese in adults), in the case of other caffeinated beverages are not consumed.

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چکیده

مصرف کافئین به دلایلی مانند افزایش هوشیاری، کاهش خستگی، افزایش انرژی و کاهش خواب–آلودگی، به‌صورت نوشیدنی و هم‌چنین به‌عنوان مواد افزودنی، طرفداران زیادی در میان مصرف کنندگان دارد. به‌علاوه مصرف کافئین با پایین آوردن اشتها سبب کاهش وزن می‌شود و به همین دلیل استفاده از آن در فرمولاسیون مکمل‌های غذایی مورد توجه قرار گرفته است. بنابراین مصرف پنیر فرآپالوده حاوی کافئین، علاوه‌بر این که یک منبع بسیار خوب از مواد مغذی و مفید مورد نیاز بدن است، با افزایش انرژی و کاهش خستگی، سبب نشاط فرد می‌گردد. در این پژوهش کافئین با غلظت‌های مختلف ۰ (نمونهٔ شاهد)، ۰/۲، ۰/٤ و ۰/٦ درصد به پنیر سفید فرآپالوده اضافه شد و تغییرات رنگ (شاخص‌های L*، a* و b*) و خصوصیات بافتی (سختی، پیوستگی، چسبندگی، صمغی و ارتجاعی) محصول در مدت زمان نگهدای ٤٥ روز در یخچال مورد مطالعه قرار گرفت. نتایج حاصل از رنگ سنجی نشان داد که شاخص L* با افزایش میزان کافئین ($p < ۰/۰۵$) و هم‌چنین طی مدت زمان نگهداری ($p < ۰/۰۰۱$) کاهش یافت. به‌علاوه اثر معنی‌داری با افزودن کافئین به پنیر فرآپالایش بر شاخص a* و b* مشاهده نشد اما زمان نگهداری سبب کاهش معنی‌دار هر دو پارامتر شد ($p < ۰/۰۱$). میزان سختی، پیوستگی و صمغی پنیرهای فرآپالوده تولید شده با افزایش میزان غلظت کافئین از ۰/۲ به ۰/٦ درصد و با گذشت زمان نگهداری ($p < ۰/۰۱$)، کاهش معنی‌داری یافت. شاخص چسبندگی و ارتجاعی بودن نیز هرچند به‌طور کلی با افزایش میزان غلظت کافئین و زمان نگهداری روند کاهشی داشت، اما این تغییرات معنی‌دار نشد ($p > ۰/۰۵$). براساس کیفیت رنگ و بافت، اختلاف معنی‌داری میان نمونهٔ شاهد و نمونه حاوی ۰/٤ درصد کافئین مشاهده نگردید. بنابراین با استفاده از غلظت ۰/٤٪ کافئین، می‌توان پنیر فرآپالودهٔ انرژی‌زا و نشاط‌بخش تولید نمود.

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