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Production of spreadable cheese without emulsifying salt: addition of black carrot concentrate

Herstellung von Streichkäse ohne emulgierendes Salz: Zugabe von Schwarzkarottenkonzentrat

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Summary

In this study, spreadable cheeses were produced without the use of melting salt. Cheese samples were produced under negative control, positive control (with 2 % w/w strawberry powder and 3 % w/w sugar) and with the addition of two different percentages of black carrot concentrate (5 % and 10 %). Samples were both packaged with the vacuum and non-vacuum packaging system. Within a 45 days storage period, the physicochemical, textural, and sensorial properties, and the effect of packaging on the sample properties were simultaneously investigated. According to the ascertained results; cheese samples with fruit concentrate were found to be more favourable in terms of sensorial and textural. The addition of fruit concentrate was aimed to make cheese consumption more popular especially among children.

Keywords: spreadable cheese, fruit juice concentrate, black carrot, packing material

Introduction

Processed foods that are widely consumed by the population of many countries are potential sources of high levels of sodium (Buzzo et al., 2014). There is a great concern regarding the excessive intake of dietary sodium, since this mineral has been associated to some chronic coronary disease, such as systemic arterial hypertension (Cruz et al., 2011). In adults, a high-sodium diet not only increases blood pressure (hypertension) but causes vascular and cardiac damage independent of high blood pressure, increases the possibility of a detrimental effect on calcium and bone metabolism, escalates the risk of stomach cancer, and also brings about the severity of asthma. In children, there is a probability of the development of hypertension later in life and a tendency for children to prefer foods with high salt content due to suppressed salt taste receptors (Strazzullo et al., 2009).

Therefore, there is a trend that consumers are beginning to purchase products with reduced salt as a way of caring for their health. However, salt and sodium-containing ingredients are mainly added to processed cheese as emulsifying agents. From the viewpoint of human nutrition, the ideal ratio of calcium and phosphorus absorbed is 1:1. However, in processed cheeses this ratio is usually decreased to 1:1.5–3.0 as a result of the use of phosphate emulsifying salts (Schäffer et al., 2001). Sodium chloride is added to products to enhance flavor, decrease water activity, thus avoiding the multiplication of microorganisms that can cause product spoilage. Therefore, efforts to reduce sodium in processed cheese must involve the modification of one or two ingredients during its formulation and production.

Recently, black or purple carrots have received increased interest as a source of natural food colorants (Kammerer et al., 2004) because of the legal restrictions for synthetic colorants and increasing consumer demand for natural ones. In addition to their colorant features, anthocyanin-rich black carrots have been indicated to exhibit health promoting properties including antioxidant (Kamiloglu et al., 2015), anti-inflammatory (Kamiloglu et al., 2016) and anticancer (Sevimli-Gur et al., 2013) activities.

The main purpose of this study is to investigate the production possibilities of spreadable cheeses without using a melting salt. For this purpose, curd cheese was used. In addition, the choice of packaging materials suitable for cheese is another purpose of this study. In this study, flavoured cheese fortified with black carrot fruit juice concentrate is to be produced for children and adults with given spreadable properties. The effect of these additives and packaging material on the physicochemical, colour and sensory characteristics of spreadable cheese was also investigated during storage. In addition, this study shows that this is the first study to evaluate some chemical and textural properties of spreadable cheese produced without melting salt and by using only curd cheese. Lecithin and carrageenan were added for emulsification and stabilization.

Material and methods

Material

In the production of spreadable cheese samples, curd cheese (protein fraction of the curd cheese consists of 86% casein and 12% whey protein) and pasteurized cream were obtained from Murat Milk and Dairy Products Ind. Trade. Co. Ltd., Sakarya, Turkey. Pasteurized milk, carrageenan and soybean lecithin, strawberry fruit (freeze-dried in a lyophilizer and then powdered) to give flavour to cheese samples, and sugar (crystallized, powdered sugar) were used commercially sold. Black carrot juice concentrate was purchased from Aroma Fruit Juices and Food Ind. Trade. Co. Ltd., Bursa, Turkey.

Polyethylene/polyamide (80µmPE/18µmPA) bags were used for the vacuum packaging parameter of the samples (oxygen permeability:71 mL m^{-2} day^{-1} atm^{-1}(23 °C), water vapour permeability: 3.9g m^{-2} atm^{-1} (37 °C ± 1.1 °C, 90 ± 2% relative humidity)). All the cheeses produced were filled in polypropylene containers. The chemical composition values of raw materials and fruit concentrate used in production are given in Table 1.

Methods

Production of spreadable cheese samples with fruit juice concentrate

After setting the necessary framework for production, the raw materials were placed into the melting unit, and the mixing (4 minutes at 70 °C with 500 rpm mixing speed) and disintegration process was applied. After the mixing and disintegration process, the necessary fruit juice concentrate, taste and aroma substances were added according to the formulated cheese sample. Formed cheese formulation is 56% w/w curd cheese, 18.8% w/w cream, 24.3% v/v pasteurized milk, 0.75% w/w lecithin and 0.15% w/w carrageenan. In addition to the formula, in the positive control group, 2% w/w strawberry powder and 3% w/w sugar were added. In fruit concentrate supplemented samples, 5% and 10% black carrot concentrate were added different from the positive control group. After homogenous mixing, the cheese samples were pasteurized at 70 °C for 2 minutes and the hot cheese mixture in the creamed structure was transferred to the product containers where it is shaped and cooled down in room conditions. Packaging process was carried out using vacuum and non-vacuum packaging materials for each group of cheese samples, which were cooled and stored at +4 °C until the initial analysis.

For 8 groups of cheese (750 grams per group), 6 kilograms of cheese was produced in the required formulation. This amount was divided into two equal parts, half of which was packaged in vacuum packaging and the other half in non-vacuum packaged. Production was separately reserved for each periodic analysis to be performed on days 1, 15, 30 and 45. The cheeses in each group were produced with three replications. 72 kilograms of cheese was produced in total.

The cheese samples indicated by the 'N' code represent non-vacuum packaged samples, while the samples indicated by the 'V' code represent vacuum packaged cheese samples.

Compositional analysis

The pH was measured in samples pre-equilibrated to room temperature by a pH meter (Bante 220, UK), directly into the cheese at three randomly chosen locations. Titratable acidity and ash content were performed according to AOAC 2003. The dry matter ratios in the cheese samples were identified gravimetrically by drying them in specific amounts at 100 ± 2 °C until constant weighing was obtained (IDF, 1982). Water activity was measured by using Aqualab-a_w (Model Series 3TE, Decagon Devices Inc., Pullman, WA) according to the method proposed by

Duggan et al. (2008). The measurements in all analyses were performed in duplicate.

Determination of colour

Surface colour values of the cheese samples were measured using an automatic colorimeter (Lovibond Tintometer RT Series Reflectance, USA). The colour values were recorded as *L*, a** and *b** respectively. *L** value shows 100 lightness / 0 darkness, *a** value + redness / -greenness and *b** value + yellowness / -blue. The colour analyses of the cheese samples were carried out three times.

Determination of antiradical activity

DPPH free-radical scavenging activity was performed, with a slight modification, according to Pyo et al. (2004). For this purpose, 0.16 g mL^{-1} extractions of the samples were prepared and the extracts were diluted in the ratio of 1:10. During the analysis, 200 µL of the diluted sample extract, and 3 mL of (0.025 g L^{-1} in methanol) DPPH (Merck, Germany) solution were added to the test tube. Then, the tubes were incubated for 30 min in dark conditions at room temperature. The absorbance of the samples was measured using an UV-visible spectrophotometer (Shimadzu UV–1240 spectrophotometer, USA) at 517 nm, and methanol was used as the blank. The inhibition percentage was calculated using the following equation:

$$\text{Inhibition (\%)} = (Abs_{control} - Abs_{sample})/Abs_{control} \times 100$$

All analyses were carried out in triplicate.

Determination of total phenolic content

The total amount of phenolic substances in cheese samples prepared with fruit concentrates was determined according to the Folin-Ciocalteau method (Singleton and Rossi, 1965). For analysis, 0.16 g mL^{-1} extractions were prepared and diluted in the ratio of 1:10. 100 µL of diluted sample extracts and 200 µL Folin-Ciocalteau reagent were taken for use, and 2 mL of distilled water was added to the extracts in 3 minutes. After that, 1 ml of 20% sodium carbonate (Na_2CO_3) was added. The prepared tubes were mixed with the vortex and incubated for 1 hour at room temperature and in the dark. Absorbance values were specified at 765 nm. For the results, calibration curves were established using Gallic acid as the standard and the amount of phenolic compound found in the extracts was calculated as mg GAE $100g^{-1}$ dry weight sample. All analyses were carried out three times.

Texture profile analysis

The texture properties of the samples were evaluated using a texture analyzer (Brookfield CT3 (Texture Analyzer, USA) on the 1st, 15th, 30th and 45th day of ripening. Prior to the analysis, the temperature of the samples was brought to room temperature and measurement started afterwards. Single compression (one bite) operation was applied according to the texture profile analysis technique. The test was performed using a stainless-steel cone probe TA15/100.

Analysis conditions: Test speed 1 mm s^{-1}; Target 20.0 mm; trigger load 4.0 g.

The following parameters were observed: hardness and adhesiveness ratio (Genovese et al., 2010). All analyses were carried out two times.

Sensory analysis

A panelist group of 20 people (academicians of the Department of Food Engineering, Sakarya University), who were trained before the sensory evaluation, evaluated the cheese samples in terms of colour, structure and texture, taste and aroma, fruit concentrate, sugar concentration and general acceptability. Each sensory feature was identified using the ‚'hedonic scale" test method and the scoring system applied was between 1–9. Sensory evaluation of cheese samples was carried out 15 days after production.

Statistical analysis

CoStat program (Version 6.45) was used for statistical evaluation. As a result of the research, the correlations of the data obtained were determined and variance analysis was made. The Duncan test was applied to the sources of significant variation. All the data obtained were given as means with their standard deviations. Duncan's Multiple Range Test was also used to separate significant differences between the derived means at the $P < 0.05$ significance level.

Results and discussion

Compositional analysis

As shown in Table 2, it was determined that the fruit juice concentrate (black carrot and frozen strawberry powder) added to the samples had an effect on the pH value while the increased fruit concentration ratio caused a decrease in the pH ($P < 0.05$). Similar results have been reported by Zhang et al. (2011) in the cheese with blueberry additives. At the end of storage the pH values of all cheese samples decreased. The decline in pH values during storage is thought to be due to changes in the number of metabolites resulting from microbial, enzymatic and biochemical activities in the cheese system and consequent changes in the hydrolysis of the components (Bulut-Solak, 2013). It was also determined that there was a significant difference between the vacuum and non-vacuum packaging samples over the pH values during storage ($P < 0.05$).

Titratable acidity showed statistically significant differences depending on the packaging material and the concentrate ratios used ($P < 0.05$). Titratable acidity

TABLE 1: *Chemical composition of raw materials, fruit and concentrate used in production.*

Raw materials	Total dry matter (%)	pH	Fat (%)	Titratable acidity %LA	Protein (%)	Lactose (%)
Curd cheese	22.26±0.54	5.68±0.13	1.45±0.07	0.01±0.00	10.34	5.30
Pasteurized Cream	54.13±1.41	7.23±0.04	45.75±0.35	–	–	–
Pasteurized milk	10.52±0.00	6.54±0.02	3.0±0.00	0.16±0.01	2.84	4.13

			Colour Values			% DPPH radical scavenging activity	Total phenolic mg GAE/100 g
			*L**	*a**	*b**		
Strawberry	93.01±0.40	3.5±0.01	24.80±0.47	+26.19±0.38	+12.04±0.50	71.53±1.66	140.41±3.37
Black carrot concentrate	60.81±0.63	3.8±0.08	0.96±0.02	+0.10±0.03	−0.27±0.06	64.85±2.07	2291.00±3.56

*L**: luminosity, *a**: redness, *b**: yellowness

TABLE 2: *Compositional values of cheese samples.*

Codes	pH		TA (LA %)		TDM (%)		WA		Ash (%)	
	1st day	45th day	1st day	45th day	1st day	45th day	1st day	45th day	1st day	45th day
NC-N	5.29±0.02A^{a}	5.13±0.01A^{b}	0.17±0.00F^{b}	0.24±0.01G^{a}	31.47±0.28G^{a}	30.75±0.06H^{b}	0.977±0.00A^{a}	0.963±0.01AB^{a}	0.59±0.07F^{a}	0.69±0.08BC^{a}
NC-V	5.31±0.07A^{a}	4.55±0.04B^{b}	0.16±0.00F^{b}	0.39±0.00F^{a}	30.44±0.42H^{a}	30.81±0.69H^{a}	0.953±0.01EF^{b}	0.964±0.00AB^{ab}	0.64±0.01EF^{a}	0.61±0.13C^{a}
PC-N	5.35±0.03A^{a}	4.44±0.02CD^{b}	0.14±0.01F^{b}	0.53±0.00D^{a}	34.63±0.28EF^{a}	33.92±0.16G^{b}	0.974±0.01AB^{a}	0.967±0.00A^{a}	0.66±0.08EF^{a}	0.61±0.13C^{a}
PC-V	5.36±0.03A^{a}	4.27±0.01F^{b}	0.26±0.01E^{b}	0.80±0.00B^{a}	33.81±0.25F^{b}	34.65±0.28F^{a}	0.966±0.01ABCDE^{a}	0.960±0.00AB^{a}	0.73±0.02E^{a}	0.61±0.11C^{a}
BC-5-N	4.92±0.01B^{a}	4.53±0.01B^{b}	0.37±0.00C^{b}	0.46±0.01E^{a}	36.34±0.22BC^{a}	34.98±0.30EF^{b}	0.962±0.00BCDEF^{a}	0.963±0.00AB^{a}	0.86±0.02D^{a}	0.81±0.10ABC^{a}
BC-5-V	4.81±0.19C^{a}	4.42±0.01DE^{b}	0.32±0.00D^{b}	0.74±0.01C^{a}	35.08±0.35DE^{b}	36.06±0.10ABC^{a}	0.971±0.00ABC^{a}	0.966±0.00A^{a}	1.00±0.02C^{a}	0.85±0.11ABC^{a}
BC-10-N	4.67±0.01D^{a}	4.45±0.03CD^{b}	0.60±0.00A^{b}	0.72±0.00C^{a}	36.24±0.25BC^{a}	35.14±0.20DEF^{b}	0.959±0.00CDEF^{a}	0.959±0.00AB^{a}	1.11±0.09B^{a}	1.03±0.10AB^{a}
BC-10-V	4.70±0.03D^{a}	4.44±0.04CD^{b}	0.51±0.00B^{b}	0.90±0.00A^{a}	39.37±0.94A^{a}	36.12±0.36AB^{b}	0.968±0.00ABCD^{a}	0.961±0.00AB^{a}	1.21±0.04A^{a}	1.03±0.07AB^{a}

NC-N: negative control non-vacuum packaging, NC-V: negative control vacuum packaging, PC-N: positive control non-vacuum packaging, PC-V: positive control vacuum packaging, BC-5-N: black carrot in 5% concentrate non-vacuum packaging, BC-5-V: black carrot in 5% concentrate vacuum packaging, BC-10-N: black carrot in 10% concentrate non-vacuum packaging, BC-10-V: black carrot in 10% concentrate vacuum packaging; a, b, c: The values indicated by different letters in the same line differs from each other at the level of P <0.05; A, B, C: The values indicated by the different letters in the same column differ from each other at the level of P <0.05; TA: Titratable Acidity, TDM: Total Dry Matter, WA: Water Activity

values increased due to the increased fruit concentration. There was an increase in titratable acidity values of cheese samples at the end of the storage period ($P < 0.05$). Based on the results obtained from the titratable acidity and the packaging material, the N and V coded cheeses were completely different on the first day and at the end of storage.

The amount of dry matter gives an idea about the nutritional value of the cheese and indirectly affects the rheological properties of the cheese. As shown in Table 2, there was also an increase in the total dry matter contents as a result of the increase in fruit juice concentration and ratio added to the samples ($P < 0.05$). Also the applied packaging material was found to have had an effect on the result ($P < 0.05$). Similar studies have indicated that cheese-like products may experience loss of moisture as a result of inadequate packaging (Schar and Bosset, 2002).

The moisture content of cheese reported by Ruiz (2007) for processed cheese spreads had a value of 58.02%. However, Cunha and Viotto (2009) reported a 62.77% and 63.49% moisture value. Therefore, it is concluded that the results obtained depend on the raw material properties and formulation applied.

Water activity values were identified to be close to each other during the storage period and the effect of added fruit concentrate ratio and packaging material was found to be statistically insignificant.

When the ash content was examined (Table 2), it was established that the ash content of the samples during the storage period was statistically insignificant. When the ratio of the fruit juice concentrate added to the cheese samples was compared with the amount of ash, it was established that cheese samples containing 10% black carrot juice concentrate in both packaging materials had a high amount of ash. It was also determined that the ratio of the fruit juice concentrate used in production had a significant effect on the ash content of the produced cheeses ($P < 0.05$), and the packaging material had no effect on the ash content.

Antioxidant activity

Black carrots contain anthocyanins, which is a part of the flavonoid family with antioxidant properties. The lowest content of the antioxidant activity, based on the formulation of the cheese samples, was determined in NC-coded cheese samples. As seen in Table 3, there was a decrease in antioxidant activities ($P < 0.05$) during the storage period of both packaged cheese, and the vacuum packaging application had no direct effect on the preservation of antioxidant activity in cheese samples. The results showed that the highest antioxidant content was identified in cheese containing 10% black carrot juice concentrate ($P < 0.05$).

This finding was in agreement with the results of Han et al. (2011), who suggested that cheese curds with polyphenolic compounds at a concentration of 0.5 mg mL^{-1} showed an effective free radical scavenging activity. The concentration ratio also had a significant effect on the antioxidant activities of the samples ($P < 0.05$). The reduction in antioxidant activity at the end of storage in all cheese samples, produced by the addition of fruit juice concentrate, has been associated with the damage of antioxidant compounds.

Total phenolic content

Many studies have found that total phenolic concentration is positively associated with total antioxidant activity (Rekika et al., 2005). An examination of Table 3 in this study showed that the total content of phenolic material obtained from cheese samples was in parallel with the antioxidant activities of fruit juice concentrates, which was in accordance with the results obtained in similar studies. When the samples of cheese produced by adding black carrot juice concentrate and other samples were compared in terms of total phenolic material content, the highest total phenolic content was found in black carrot-added cheese similar to antioxidant activity. In addition, increasing the total phenolic content with increased juice concentrate content was the expected result. The chemical or enzymatic oxidation of phenolic compounds applied to food increases during various processes or during long-term storage. The reason for the decrease in the total phenolic values during storage is the destruction of these substances in time. The reason for the increases seen during the storage period is the proportional increase in the number of other components that may react with the Folin reagent as the storage time increases (Klimczak et al., 2007). In addition, no significant increase or decrease in the total phenolic content of the samples during storage was observed.

Colour values

The major factors affecting the stability of natural colorants in foods are the concentration of pigments, pH and water activity of food, oxygen, light, metallic ions, enzymes, temperature, and time of processing and storage conditions (Delgado-Vergas et al., 2000). The added black carrot gave a light purple colour to the cheese. As shown

TABLE 3: *The changes in the antioxidant activity and total phenolic content of cheese samples during storage.*

Codes	Antioxidant activity (Inhibition%)				Total phenolic content (mg GA/100 g)			
	1st day	15th day	30th day	45th day	1st day	15th day	30th day	45th day
NC-N	0.00±0.63F^{b}	0.63±0.00G^{a}	0.00±0.77E^{b}	0.00±2.35F^{b}	0.00±0.94E^{b}	1.70±0.48F^{b}	4.96±1.40F^{a}	0.00±2.86F^{b}
NC-V	1.34±0.00F^{a}	0.53±0.75G^{ab}	0.00±0.46E^{b}	0.00±2.05F^{b}	0.00±2.90E^{b}	10.78±4.16EF^{a}	5.32±0.00F^{ab}	3.68±3.31F^{ab}
PC-N	12.50±3.79E^{a}	10.47±0.15E^{a}	0.66±0.00E^{b}	0.00±2.49EF^{b}	6.31±1.27E^{b}	20.26±3.47E^{a}	25.19±2.15E^{a}	19.27±2.16E^{a}
PC-V	15.85±1.26D^{a}	5.07±3.29F^{b}	0.87±1.24E^{b}	2.90±0.00E^{b}	16.93±0.44D^{b}	15.81±0.80E^{b}	45.30±5.34D^{a}	25.23±8.50E^{b}
BC-5-N	67.52±0.47C^{a}	61.73±0.30D^{b}	62.01±0.93D^{b}	56.22±1.76C^{c}	93.92±3.24C^{d}	117.90±0.00D^{b}	106.35±2.44C^{c}	130.10±2.09C^{a}
BC-5-V	75.56±0.47B^{a}	66.70±0.45C^{b}	66.16±0.00C^{b}	46.78±0.44D^{c}	127.01±3.36B^{a}	131.37±5.43C^{a}	105.85±2.04C^{b}	103.36±3.66D^{b}
BC-10-N	87.28±0.00A^{a}	76.00±4.34B^{b}	84.93±0.00A^{a}	77.90±0.73A^{b}	203.36±3.25A^{b}	222.05±5.57A^{a}	181.42±1.21B^{c}	184.06±6.70B^{c}
BC-10-V	85.49±0.95A^{a}	86.89±0.30A^{a}	80.79±0.31B^{b}	72.30±0.44B^{c}	198.63±9.35A^{a}	203.08±8.66B^{a}	202.32±9.95A^{a}	200.37±4.06A^{a}

a, b, c: The values indicated by different letters in the same line differs from each other at the level of P <0.05; A, B, C: The values indicated by the different letters in the same column differ from each other at the level of P <0.05

TABLE 4: *The changes in the colour values of cheese samples during storage.*

Codes	*L**		*a**		*b**	
	1st day	45th day	1st day	45th day	1st day	45th day
NC-N	79.28±0.36B^{b}	80.24±0.03A^{a}	0.08±0.01F^{a}	0.06±0.04E^{a}	7.80±0.03A^{b}	8.01±0.01C^{a}
NC-V	79.88±0.07A^{a}	79.96±0.11A^{a}	0.12±0.02F^{a}	0.06±0.01E^{b}	7.79±0.08A^{a}	7.88±0.04C^{a}
PC-N	72.57±0.09C^{b}	74.49±0.36B^{a}	4.50±0.04E^{a}	2.39±0.06D^{b}	6.02±0.08C^{b}	9.03±0.33A^{a}
PC-V	72.96±0.00C^{b}	74.42±0.21B^{a}	4.66±0.04E^{a}	2.42±0.06D^{b}	6.15±0.02B^{b}	8.51±0.04B^{a}
BC-5-N	46.99±0.13E^{b}	49.39±0.32C^{a}	23.94±0.01C^{a}	21.99±0.10B^{b}	–5.55±0.04E^{b}	–3.88±0.08D^{a}
BC-5-V	47.76±0.25D^{b}	48.71±0.05D^{a}	23.70±0.04D^{a}	21.21±0.04C^{b}	–5.55±0.05E^{b}	–4.73±0.04E^{a}
BC-10-N	36.97±0.25F^{b}	39.02±0.03E^{a}	30.24±0.04B^{a}	27.81±0.31A^{b}	–4.58±0.04D^{a}	–5.38±0.04F^{b}
BC-10-V	35.93±0.16G^{b}	39.01±0.02E^{a}	30.71±0.08A^{a}	27.74±0.17A^{b}	–4.66±0.03D^{a}	–5.44±0.03F^{b}

The values indicated by different letters in the same line differs from each other at the level of P <0.05; A, B, C: The values indicated by the different letters in the same column differ from each other at the level of P <0.05

in Table 4, the highest *L** values were determined in non-black carrot cheese samples (NC code) packaged with both packaging materials on day 45 of storage. The *L** values of black carrot added samples decreased compared to the NC code control cheese samples, and the decrease in the *L** values with the increase in the added fruit concentrates became an expected result. Moreover, the decrease in *L** values and an opposite increase in added concentration was found to be statistically significant (P < 0.05). The increase in *L** during storage is due to the biochemical reactions occurring in the cheese samples, the metabolites formed and the changes in the moisture content at the end of the storage.

*a** value in black carrot added samples was higher than that of control groups. It was determined that the increase in *a** value was statistically significant due to the increase in the ratio of added concentrate (P < 0.05). Also, it was found that the *a** values of cheese samples decreased during the storage period (P < 0.05). It is believed that the reason for this decrease may be due to the biochemical reactions that occur in the structure of cheese and in the added fruit concentrate, resulting in damage to the pigments that provide colour. Similar to Clydesdale (1998), it has also been determined that changes in the pH and in the dry matter has an effect on the colour values of the samples.

When the *b** values of cheese samples were considered, the lowest *b** value was identified in BC coded cheese samples. The Table 4 shows that there has been a similarity between *b** values of samples packaged with vacuum and non-vacuum packaging materials of the same cheese group and the *b** values of samples with both packaging materials did not show a steady increase or decrease during storage.

Evaluation of the Texture Profile

The higher the presence of cross-linkages in the matrix of the product, the harder the processed cheese that can be expected (Kaliappan and Lucey, 2011). Table 5 shows that the hardness values increased in the first 15 days of storage and reached the highest hardness value on the 30th day and later decreased on the 45th day. It was also found that the amount of added carrot juice concentrate had an effect on the hardness, and the hardness value decreased as the ratio increased. This analysis was interpreted as, the increase in hardness detected on the 30th day in cheese samples was as a result of interactions between denatured serum proteins and caseins, and probably due to the strong network structure of casein and denatured serum proteins at certain pH values (the isoelectric point at pH 4.6). Biochemical events occurring in cheese are thought to increase the amount of free water in the medium, increase microbial and enzymatic activities, accelerate maturation and eventually decrease the hardness values of cheese samples (Bulut-Solak, 2013). When statistical analysis results were taken into consideration, it was determined that the addition of fruit juice concentrate changed the hardness values of cheese samples and was found to be significant (P < 0.05). In addition, it was seen that the effect on the hardness value of the packaging material changed throughout the storage period.

TABLE 5: *The changes in the textural properties of cheese samples during storage.*

Codes	Hardness (N)				Adhesive forces (N)			
	1st day	15th day	30th day	45th day	1st day	15th day	30th day	45th day
NC-N	5.06±17.68AB^{c}	5.79±16.26B^{b}	7.95±13.79A^{a}	5.56±16.62A^{b}	-1.52±5.30D^{b}	-1.80±8.49D^{b}	-2.24±4.60F^{c}	-1.16±21.57ABC^{a}
NC-V	5.19±21.21A^{b}	5.37±18.03C^{b}	7.99±10.25A^{a}	5.02±21.57B^{b}	-1.75±2.12E^{c}	-1.48±12.37C^{b}	-2.16±1.41F^{d}	-1.00±10.96AB^{a}
PC-N	4.80±15.56B^{c}	6.21±21.57A^{b}	7.75±12.73A^{a}	3.92±16.97DE^{d}	-1.34±2.83C^{b}	-1.66±1.06D^{c}	-1.86±1.77E^{c}	-0.83±20.15AB^{a}
PC-V	4.73±10.96B^{c}	5.50±15.20BC^{b}	7.26±10.61B^{a}	4.32±21.57CD^{c}	-1.28±3.89BC^{a}	-1.68±4.95D^{b}	-2.38±2.12G^{c}	-1.06±18.03ABC^{a}
BC-5-N	4.08±16.26C^{c}	4.94±21.92D^{b}	5.54±12.37DE^{a}	5.47±12.73A^{a}	-1.20±4.24B^{a}	-1.37±1.06BC^{a}	-1.40±2.47C^{a}	-1.18±35.36ABC^{a}
BC-5-V	3.97±18.03C^{c}	4.47±17.68E^{c}	6.11±15.20C^{a}	5.52±27.58A^{b}	-1.52±0.71D^{a}	-1.31±1.77AB^{a}	-1.52±6.01D^{a}	-1.52±22.63C^{a}
BC-10-N	3.37±21.21D^{b}	4.24±29.34E^{a}	3.95±10.96F^{a}	2.86±14.14F^{b}	-1.01±2.12A^{b}	-1.31±7.42AB^{c}	-1.14±5.30A^{bc}	-0.79±10.61AB^{a}
BC-10-V	4.01±20.86C^{b}	4.49±19.45E^{ab}	4.86±14.50E^{a}	2.42±18.03G^{c}	-1.19±1.06B^{b}	-1.35±4.60BC^{b}	-1.31±3.18BC^{b}	-0.68±21.92A^{a}

a, b, c: The values indicated by different letters in the same line differs from each other at the level of P <0.05; A, B, C: The values indicated by the different letters in the same column differ from each other at the level of P <0.05

TABLE 6: *Table 6. Sensory evaluation of cheese samples.*

Codes	Colour	Consistency and texture	Taste and aroma	Fruit concentration	Sugar concentration	General acceptability
NC-N	6.63±0.52D	6.88±0.35CD	4.63±0.52F	1.00±0.00D	1.00±0.00D	4.75±0.46E
NC-V	7.25±0.46C	5.88±0.35E	5.00±0.53EF	1.25±0.46D	1.13±0.35D	4.63±0.74E
PC-N	6.38±0.52D	6.25±0.46E	5.25±0.46DE	4.50±0.76C	3.50±0.53C	5.38±0.52D
PC-V	6.25±0.46D	6.38±0.74DE	4.63±0.52F	3.63±0.52D	3.88±0.35C	5.75±0.71BCD
BC-5-N	7.13±0.64C	6.38±0.52DE	6.50±0.53B	5.88±0.35AB	5.25±0.46A	6.25±0.46AB
BC-5-V	7.88±0.35B	7.13±0.35BC	6.25±0.46B	4.88±0.64C	4.50±0.53B	6.38±0.52A
BC-10-N	7.38±0.52C	7.50±0.53AB	6.38±0.52B	5.75±0.46B	4.88±0.35AB	6.50±0.53A
BC-10-V	8.13±0.35AB	7.00±0.53BC	6.00±0.53BC	4.75±0.46C	4.63±0.52B	6.25±0.46AB

A, B, C: The values indicated by the different letters in the same column differ from each other at the level of P <0.05

In the case of adhesiveness value, addition of black carrot juice concentrate to the samples decreased the adhesiveness values ($P < 0.05$). It was determined that the value of the adhesiveness obtained by increasing the concentration ratio was further reduced (Table 5). The results showed that there was a significant effect of proteolysis and moisture content in the biochemical events seen in the cheese on the adhesiveness values. The increase in the moisture content was designated by increasing the adhesiveness of the cheese. A shorter length of proteins as a result of proteolysis might lead to the formation of a less compact casein matrix, which is reflected by a decrease in hardness of the processed cheeses and an increase in their adhesiveness. These results and their explanation are in accordance with the works by Acharya and Mistry (2007).

Sensory properties

Sensory evaluation scores of the cheese samples were given in Table 6. The results showed that the highest colour score was in samples with black carrot juice concentration. It was observed that there was an increase in the points given due to the increase in the concentration ratio added in general. PC code cheese got the lowest score. It has been concluded that the addition of fruit juice concentrate is an important parameter to increase the level of colour appreciation of cheese ($P < 0.05$). Black carrot fruit concentrate added samples had a higher structure and texture score than the negative control group ($P < 0.05$) and contributed to the improvement of the structure of cheese samples with added concentrates. When the taste scores were examined, the highest score in the samples was recorded by cheese containing 5% fruit juice concentrate and showed that the non-vacuum packaged samples were more popular. It was determined that the vacuum packaging material had an effect on the taste scores ($P < 0.05$) of the cheese samples and prevented the perception of the present taste. When the general acceptability values of the non-vacuum cheese samples were examined, it was found that the samples obtained by adding the fruit concentrate had a higher acceptability level than the negative and positive control group. In addition, the increase in the added black carrot concentrate ratio did not cause a change in the taste of the fruit and variance analysis revealed that the difference in acceptability scores was not statistically significant.

Conclusion

This study is designed to give a new feature to the newly produced spreadable cheese products in our country. For this purpose, black carrot juice concentrate was added to the curd cheese, which is a commonly consumed dairy product. Another aim of the study was to investigate the changes in the storage period by providing suitable packaging for spreadable cheeses produced by adding concentrate to traditional curd cheese with short shelf life. The evaluation of curd cheese and using natural additives instead of artificial additives gained positive impacts on the production of spreadable cheese. Because the product obtained is flavored, the group of children is expected to attract attention as a consumer. The results show that the use of 5% black carrot concentrate in non-vacuum packaging is most suitable for use in spreadable cheeses and is also the first successful step in the study of producing spreadable cheese using only curd cheese instead of a few kinds of cheese.

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Conflict of interest

The authors declare that they have no conflict of interest.

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