The effects of beetroot powder as a colorant on the color stability and product quality of white compound chocolate and chocolate spread

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Abstract

This study determines the possibility of using spread (SC) and compound chocolate (CC) as delivering agents of betalains, bioactive compounds and coloring agents. Therefore, the effects of various beetroot powder concentrations (0.0-1.00 g/100 g) on SC and CC's quality parameters and the associated visual properties over a 12-week period under accelerated shelf-life conditions were investigated. The hardness and plastic viscosity values of CC significantly increased as the amount of beetroot powder increased (P<0.05), the particle size while melting behavior, water activity, moisture content and sensory properties did not significantly change (P<0.05). The D90 and textural properties (firmness, stickiness, adhesion, work of shear) of the SC samples were significantly affected with the addition of beetroot powder (P<0.05), but no significant differences were observed in moisture content, water activity and some sensory properties (P>0.05). The use of beetroot powder for both groups caused a significant decrease in the samples' color values, and the redness associated with the pigment source also significantly increased (p<0.05). The findings revealed that high concentrations of beetroot powder did not significantly impact CC's color stability to the same extent that it impacted the SC's color stability. This study was made as a preliminary study to produce functional foods.

Keywords: confectionery; beetroot; chocolate spread; color stability; functional foods.

Practical Application: A bioactive feature has been added to the product, which lacks antioxidants. Contrary to most natural colorants, beetroot powder has shown a stable shelf-life. Functional food products with high sensory features were obtained.

1 Introduction

Due to increased awareness of relationships between health and nutrition, functional products have gained importance in recent years (Morato et al., 2015). Global chocolate providers currently supply a range of flavored and colored chocolate and chocolate products (e.g., compound chocolate, chocolate-coated wafers, chocolate chips, etc.). As milk and dark chocolate varieties are not suitable for coloring due to the cocoa powder they contain, white chocolate is suitable to be used for coloring products. White chocolate is used as a carrier for bioactive compounds that have also coloring effect. Even though these products are becoming more popular day by day, a limited amount of research has been performed in this area (Lončarević et al., 2018). As such, this study aimed to address gaps in understanding by investigating the impact of the use of natural colorants in chocolate technology both as pigment sources and coloring agents.

The natural colorant market's main components are carotenoids, anthocyanins, paprika extracts, curcumin, chlorophyll, and Spirulina. In addition to providing visual benefits, natural colorants can also offer a range of multi(functional) bioactive (e.g., antioxidant activity) and technological (e.g., preservative) impacts (Martins et al., 2016). Studies that have examined the multifunctional effects of different pigment sources in confectionery technology have also gained momentum, and the importance of "multi-effect observation" has been emphasized (Otálora et al., 2019).

Betalains are a plant-derived natural pigment that has gained increasing use in recent years as a natural colorant in the food industry (Gengatharan et al., 2015). Beetroot is the most widely used source of betalains (Georgiev et al., 2010). In addition to being a natural colorant, beetroot juice has been reported to reduce the cell mutations caused by the effect of nitrosamines, which are formed from nitrate (Delgado-Vargas et al., 2000). Moreover, thanks to its betalains and other bioactive components, beetroot juice and powder have the potential to prevent degenerative diseases such as blood pressure, cardiovascular diseases, and cancer (Gliszczyńska-Swigło et al., 2006; Clifford et al., 2015).

Beetroot powder, which is the source of betalains, has both coloring and bioactivity effects as a food ingredient. It is important to examine the effects of these and other colorant-containing ingredients on the quality properties of foods before they are used for functional product development purposes, and also to ensure that the visual properties they provide are stable throughout their shelf life. The main aim of this study was to investigate usage possibilities and stability of beetroot powder as a source of betain in white chocolate spread (SC) and compound chocolate (CC) as coloring agent and to determine color stability during accelerated shelf conditions. Also, the effect of the use of beetroot powder on the main quality parameters as physical, physicochemical, thermo-gravimetric, rheological, textural and sensory properties of the samples were investigated by this study.

2 Materials and methods

2.1 Materials

In the production of spread and compound chocolate samples, cocoa butter replacer (Trio30 and Unika44, AAK, Istanbul, Turkey), sugar powder (0.005-0.1 mm) (SMS Kopuz, Istanbul, Turkey), skimmed milk powder (Enka, Konya, Turkey), whey powder (Enka, Konya, Turkey), soy lecithin (Brenntag Chemistry, Istanbul, Turkey), sodium chloride (Salina, Konya, Turkey), polyglycerol polyriconalate (PGPR) (Palsgaard, Zierikzee, Netherlands), hazelnut flavor (Etol Frutarom, Kocaeli, Turkey), ethyl vanillin (Ekin Chemistry, Istanbul, Turkey), anhydrous vegetable fat (Orkide-41, Orkide, Izmir, Turkey), hazelnut puree (Segmen, Giresun, Turkey) and beetroot powder (Dohler, Karaman, Turkey) were used in this study.

2.2 Methods

Production of white compound chocolate and white chocolate spread

Total fat content has effects on many properties of chocolate products, e.g. texture, melting, flow behaviors and even color properties. However other components may also affect these properties, e.g. sugar, milk powder and emulsifiers. Therefore, to minimize component affect in this study, the formulation for all samples was arranged to be 100% complete by beetroot powder. For the production of compound chocolate (Figure 1); sugar powder (450.0 g kg^{-1}), cocoa butter replacer (200.0 g kg^{-1}), whey powder (112.8 g kg^{-1}), skimmed milk powder (130.0 g kg^{-1}), soy lecithin (1.67 g kg^{-1}) were homogenized in the mixer, and subsequently were refined in a 3-roll refiner (Lehmann, Aalen, Germany) to 20 μm.

The refined mass was added to the cocoa butter replacer (100.0 g kg^{-1}), soy lecithin (1.83 g kg^{-1}), PGPR (2.00 g kg^{-1}), hazelnut flavor (1.50 g kg^{-1}), vanillin (0.20 g kg^{-1}). All these components were conched for 6 hours at 60 °C by using a laboratory conche (BSA Scheinder, Angalentechnik, Aachen, Germany). Samples C00, C025, C050, C075 and C100 were prepared by using the components as 1000 g kg^{-1}, 997.5 g kg^{-1}, 995.0 g kg^{-1}, 992.5 g kg^{-1}, 990.0 g kg^{-1}, respectively and then mixed with beetroot powder (0.00 g kg^{-1}, 2.50 g kg^{-1}, 5.00 g kg^{-1}, 7.50 g kg^{-1}, 10.0 g kg^{-1}) for 5 minutes and subsequently molded (diameter: 35.8 mm, depth: 7.3 mm). After 20 min of cooling (Aasted Farum, Denmark) at 5 °C, the process was completed. The samples removed from the cooling tunnel (Aasted, Farum, Denmark) were wrapped in aluminum foil and packed. Samples were stored at temperatures between 15 and 18 °C, and subsequently prevented from light and heat prior to analysis.

For the production of spread chocolate samples; sugar powder (450.0 g kg^{-1}), anhydrous vegetable fat (260.0 g kg^{-1}), whey powder (135.8 g kg^{-1}), skimmed milk powder (120 g kg^{-1}), soy lecithin (2.50 g kg^{-1}), hazelnut puree (30.0 g kg^{-1}), hazelnut flavor (1.50 g kg^{-1}), vanillin (0.20 g kg^{-1}) were used. The spread samples were prepared by using a pilot-scale ball-mill (Alpy, Istanbul, Turkey). Refining-conching time and shaft speeds were 45 minutes and 60 rpm, respectively, at 45 °C. Samples of S00, S025, S050, S075 and S100 were prepared from the components of 1000 g kg^{-1}, 997.5 g kg^{-1}, 995.0 g kg^{-1}, 992.5 g kg^{-1}, 990.0 g kg^{-1} and then each of those components were mixed with beetroot powder of 0.00 g kg^{-1}, 2.50 g kg^{-1}, 5.00 g kg^{-1}, 7.50 g kg^{-1}, 10.0 g kg^{-1}, respectively which were mixed for 5 minutes. Samples were cooled after deposited in 60 mL cups at 12 °C.

Physicochemical analysis

The water activities of the spread and compound chocolates were measured using a Lab-Master a$_w$ (Novasina, Switzerland) according to the method used by Konar (2013). a$_w$ value of each sample was measured in triplicate after a follow-up day of sample preparation. Determination of the moisture content of spread and compound chocolate samples and ingredients were
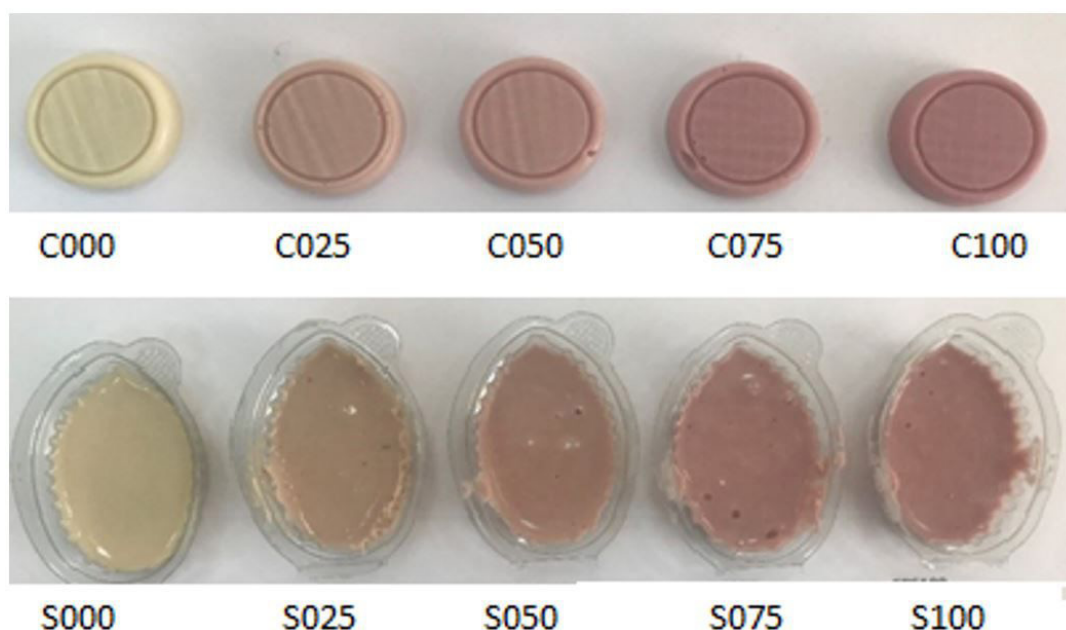

Figure 1. The colored white compound chocolate and chocolate spread samples.

performed using the method previously reported by Lonchampt & Hartel (2006).

Particle size

The particle sizes of the produced spread and compound chocolate samples and ingredients were determined by using micrometers (Mitutoyo, Manufacturing Co. Ltd., Japan, 0.001 mm accuracy) (Toker et al., 2017).

Color and color stability analysis

Color parameters of spread and compound chocolate samples L*: brightness, a*: ± red; -green, and b*: ± yellow; -blue were determined using colorimeters (Chroma Meter CR-400, Konica Minolta, Japan) in the SCI-mode (Specular Component Included). The colorimeter was designed in diffusion illumination 0° viewing angle geometry. Chroma (C*), hue (h°), whiteness index (WI*) values were calculated using the Equations 1, 2 and 3 in the CIELAB system. Spread and compound chocolate samples were stored the day after production at accelerated shelf-life conditions (25 °C and 70% RH) (Subramaniam, 2007). For 7-day periods for 12 weeks, L*, a* and b* values of samples were measured color stability (ΔE) values were calculated by using Equation 4 (Periche et al., 2015);

$$C* = \sqrt{a*^2 + b*^2} \tag{1}$$

$$h° = \arctan(b*/a*) \tag{2}$$

$$WI = 100 - \left[(100 - L)^2 + a^2 + b^2\right]^{1/2} \tag{3}$$

$$\ddot{A}E = \left[\left(\ddot{A}L*\right)^2 + \left(\ddot{A}a*\right)^2 + \left(\ddot{A}b*\right)^2\right]^{1/2} \tag{4}$$

Sensory analysis

Five-point hedonic scale sensory analyses were conducted to identify significant differences between samples. The sensory evaluation test was carried out by panelists. The panel (n= 30) was composed of staff and graduate students from the Department of Food Engineering at Siirt University. The age composition of the panelists was 76.6% (18-25) and 23.4% (30-46) and the gender composition was 43.3% male and 57.7% female. Panelists evaluated the effects of using beetroot powder in various concentrations on the sensory characteristics of spread and compound chocolate samples, as appearance, brightness, color, melting in mouth, sweetness, flavor, taste, intense buying and general acceptance. Between each assessment, panelists were given a cup of water and crackers to consume.

Texture analysis

As a textural parameter, hardness values of the compound chocolate samples were determined using TA-TX plus Texture Analyser (Stable Micro systems, Surrey, UK). During analyses, load cell with 5 kg and 3-point bend ring were used to obtain displacement versus force curve. By using this curve force at peak, necessary for breaking the sample, was calculated. The

trigger force was set to 0.05 N. Pre-test, test and post-test speeds applied during textural measurement were 1 mm/sec, 1 mm/sec and 10 mm/sec, respectively. Hardness values (N) were expressed as the mean value of 5 replicates (Konar, 2013). In the texture analysis of spread samples, the firmness, stickiness, adhesion and work of shear parameters of the samples were determined by using a modified method, which was described previously by McGill & Hartel (2018). According to the analysis, texture parameters of samples were determined by a conical 90° angle probe and texture analyser (TA.HD Plus, Stable Micro System, Godalming, UK) based on shear stress under controlled temperature with a compression force of 55 mm distance and a speed of 3 mm/s.

Melting behavior

Melting behavior of the compound chocolate samples was determined using DSC (TA Q20, USA) according to the method reported by Glicerina et al. (2013). Samples (5 mg) were put into pans with a hermetic lid. The samples were heated from 0.00 to 60.0 °C at 10.0 °C/min in N_2 stream. Onset temperature (Tonset, beginning of the melting), peak temperature (Tpeak), end temperature (Tend, complete melting) and energy required for the complete melting of the samples (ΔH, amount of energy necessary for complete melting) were calculated using thermograms obtained.

Flow behavior

Flow behavior of the melted compound chocolate samples was determined at 40 °C using strain-controlled rheometer (Anton Paar, MCR 302, Austria). Cylindrical probe system was used for the determination of rheological parameters (Toker et al., 2016). Upward and downward shear rate ranged from 0.10 to 50.0 s^{-1} and from 50.0 s^{-1} to 0.10 s^{-1} were applied. For each curve (upward and downward), corresponding parameters of the Casson model were calculated using the following Equation 5:

$$\tau^{0.5} = \tau_0^{0.5} + \eta_{pl} \dot{\gamma}^n \tag{5}$$

where τ is shear stress (Pa), γ is shear rate (s^{-1}), τ_0 is the yield stress (Pa) and η_{pl} is plastic viscosity (Pa s).

Statistical analysis

The measured data were expressed as the mean ± standard deviation. The results were analyzed with analysis of variance (ANOVA). Tukey's test was applied to determine if the effect of beetroot powder on the related parameters of spread and compound chocolates was significant or not at a confidence level of 0.05. The statistical analyses were conducted using the MINITAB 16.0 (Minitab Inc., State College, PA, USA).

3 Results and discussion

3.1 Physicochemical properties

The moisture content is of critical significance for chocolate products as a relationship exists between the amount of moisture and shelf-life of the products and its other main quality parameters such as hardness, viscosity and melting. The moisture value of

these products is expected to be <1.50 g/100 g. This value is determined by process conditions (Konar & Bingol, 2019) and product composition (Afoakwa, 2010). In this study, the moisture values of compound chocolate samples were in the range of 0.77-1.44 g/100 g, which corresponds to the values below the critical level (Table 1). Even though the use of beetroot powder at different levels caused an increase in the moisture content, this increase was not significant (P> 0.05). Moisture content of spread samples were determined at the range of 1.46-2.00 g/100 g (Table 1). Spread samples, similar to compound chocolate, also showed an increase in moisture content when beetroot was used in general. This increase, however, was not significant (P> 0.05). Betaine is a highly polar compound and has a hydrophilic character (Rivoira et al., 2017). The reason for increased moisture content in samples which contain beetroot might be these features of betalains. However, at the stage where this pigment source is added to the sample mass in the process, it is likely that the process of water removal from the structure has been completed (Konar & Bingol, 2019). Therefore, it can be stated that the change in moisture level is a possible result of the affinity of betalains to moisture due to the environmental conditions.

The water activity values of compound chocolate and spread samples showed a narrow change, 0.24-0.25 and 0.30-0.34, respectively (Table 1). The use of beetroot powder did not cause significant change for this parameter (P> 0.05). Chocolate and its derivative products are generally described as a food with low water activity (Nascimento et al., 2012). The water activity of chocolate was generally between 0.4-0.5, but factors such as the raw materials used, the surface area of the materials and particle size, the duration and temperature of the conching may affect the water activity value. Considering the storage period, the target value for water activity can be specified as <0.40 (Konar, 2013).

The D_{90} value obtained from the particle size distribution (a value that is less than 90% of the particle size) is consistent with the value measured by the micrometer (Beckett, 2009). Particle size values above 35 μm cause sandy-sense in the mouth (Schumacher et al., 2009). It is already known that small particles improve the sensory properties of chocolate (Ziegler et al., 2001). In this study, D_{90} values of compound chocolate were determined to be between 30.3 - 33.3 μm (Table 2). The use of beetroot powder did not have a significant effect on this parameter. However, D_{90}

values of spread samples increased significantly with the use of this betalains source (P<0.05). Possible causes of this rise include increased amount of moisture and thus causing agglomeration. However, with the modification of the ball-mill process (time, temperature and rpm), it may be possible to refine the samples containing beetroot powder to have an aimed particle size.

3.2 Textural properties

Textural properties are among the major quality parameters for chocolate and derivative products (Beckett, 2009; Afoakwa, 2010). One of the main textural quality parameters in chocolate is hardness. The hardness of the chocolate samples is indicated by the type and amount of fat used, the type of sugar, the particle size distribution, tempering conditions as well as the temperature of the conching (Afoakwa et al., 2008; Shourideh et al., 2012; Tan & Balasubramanian, 2017). In this study, the hardness properties of the compound chocolate samples were investigated. The hardness of the compound samples varied in the range of 4413-7893 g (Table 1). The addition of beetroot powder caused a significant increase in hardness (p<0.05). However, the increase was not associated with the level of pigment source. Chocolate quality is associated with its textural hardness feature and "snap," which is one of its results. In order to consider a chocolate as a high-quality chocolate, a certain level of hardness is expected (Konar, 2013). Therefore, the obtained result can be considered to be positive. However, it is noteworthy to mention that increase in moisture (though in insignificant amount) and hardness occurred together in the samples.

Firmness, stickiness, adhesion and work of shear properties of spread samples were also determined. The results of these properties were found to be varied between 414-663 g, (-410) - (- 611) g/min, and 349-585 g/min, respectively. Although there were significant differences between the sample groups (P<0.05), a relationship between this difference and the amount of beetroot powder used could not be identified. A reduction in the amount of beetroot used based on the ratios in the control sample composition from all components may be one of the reasons for the obtained results. Some components affect the spread textural properties in various impact and directions. Major components such as fat phase composition and concentration (Manzocco et al., 2014;

Table 1. Physicochemical and textural properties of colored white compound chocolate and chocolate spread.

Sample	Physicochemical		Texture				
	Water activity	Moisture (g/100 g)	Firmness (g)	Stickiness (g)	Adhesion (g/min)	Work of Shear (g.min)	Hardness (g)
C000	0.25 ± 0.029[a]	0.77 ± 0.23[a]	nd	nd	nd	nd	4413 ± 313[c]
C025	0.25 ± 0.01[a]	1.06 ± 0.48[a]	nd	nd	nd	nd	7893 ± 171[a]
C050	0.25 ± 0.02[a]	1.07 ± 0.29[a]	nd	nd	nd	nd	6633 ± 265[b]
C075	0.24 ± 0.01[a]	1.14 ± 0.29[a]	nd	nd	nd	nd	6777 ± 135[b]
C100	0.25 ± 0.02[a]	1.44 ± 0.35[a]	nd	nd	nd	nd	6393 ± 47[b]
S000	0.34 ± 0.02[a]	1.46 ± 0.28[a]	588 ± 87[ab]	-611 ± 76.7[b]	-268 ± 30.7[bc]	480.4 ± 61.0[ab]	nd
S025	0.30 ± 0.01[a]	1.80 ± 0.14[a]	414 ± 2.20[b]	-410 ± 2.70[a]	-182 ± 1.20[a]	349.1 ± 14.5[b]	nd
S050	0.31 ± 0.01[a]	2.00 ± 0.33[a]	663 ± 26.4[a]	-652 ± 39.7[b]	-329 ± 13.1[c]	585.6 ± 15.3[a]	nd
S075	0.30 ± 0.01[a]	1.40 ± 0.53[a]	648 ± 61.6[a]	-588 ± 52.7[ab]	-252 ± 22.5[abc]	575.6 ± 73.4[a]	nd
S100	0.30 ± 0.01[a]	1.80 ± 0.28[a]	516 ± 18.3[ab]	-525 ± 2.60[ab]	-246 ± 22.1[ab]	416.4 ± 30.2[ab]	nd

nd: Not determined. Different superscript lowercase letters show the significant differences for each sample (P<0.05). All experiments were performed in triplicate. All data are represented as means ± standard deviation.

Table 2. Particle size (D_{90}) and color properties of colored white compound chocolate and chocolate spread.

Sample	D_{90} (μm)	CIE-Lab					
		L*	a*	b*	C*	h°	WI
C000	30.3 ± 0.58[a]	74.4 ± 0.6[a]	-5.90 ± 0.10[d]	18.2 ± 0.15[a]	19.2 ± 0.15[a]	-72.0 ± 0.12[e]	68.0 ± 0.42[a]
C025	33.3 ± 1.53[a]	65.9 ± 0.1[b]	3.90 ± 0.20[c]	12.4 ± 0.60[b]	13.0 ± 0.63[b]	72.6 ± 0.38[a]	63.5 ± 0.28[b]
C050	33.0 ± 1.73[a]	65.3 ± 0.5[b]	4.20 ± 0.00[b]	12.6 ± 0.18[b]	13.3 ± 0.19[c]	71.5 ± 0.20[b]	62.9 ± 0.41[b]
C075	31.7 ± 1.15[a]	57.2 ± 0.2[c]	10.77 ± 0.20[b]	9.2 ± 0.05[c]	14.2 ± 0.16[d]	40.7 ± 0.54[c]	54.9 ± 0.20[c]
C100	33.3 ± 1.53[a]	54.9 ± 0.7[d]	12.8 ± 0.10[a]	8.2 ± 0.10[d]	15.3 ± 0.13[d]	32.7 ± 0.16[d]	52.4 ± 0.61[d]
S000	19.0 ± 0.85[c]	68.4 ± 0.16[a]	-2.61 ± 0.11[e]	17.3 ± 0.06[a]	17.5 ± 0.08[a]	-81.4 ± 0.32[e]	63.9 ± 0.12[a]
S025	25.0 ± 1.00[b]	63.5 ± 0.35[b]	2.47 ± 0.33[d]	14.3 ± 0.07[b]	14.5 ± 0.01[b]	80.2 ± 1.34[a]	60.7 ± 0.32[b]
S050	31.7 ± 0.58[a]	60.1 ± 0.33[c]	5.61 ± 0.41[c]	12.1 ± 0.37[c]	13.3 ± 0.32[c]	65.1 ± 1.94[b]	57.9 ± 0.37[c]
S075	30.7 ± 0.58[a]	56.6 ± 0.38[d]	8.95 ± 0.24[b]	10.9 ± 0.13[d]	14.1 ± 0.08[c]	50.7 ± 1.07[c]	54.3 ± 0.38[d]
S100	31.3 ± 2.08[a]	54.2 ± 0.58[e]	10.78 ± 0.37[a]	10.0 ± 0.15[e]	14.7 ± 0.18[d]	42.9 ± 1.39[d]	51.9 ± 0.60[e]

Different superscript lowercase letters show the significant differences for each sample group (*P*<0.05). All experiments were performed in triplicate. All data are represented as means ± standard deviation.

Fayaz et al., 2017) and milk powder level and composition (Sethi & Balasubramanyam, 2018), as well as minor components such as lecithin, have an effect on textural properties of spread. Therefore, it may be useful to study the effects of components for textural properties of spread formulation prepared using pigment sources in future studies.

3.3 Sensory properties

Appearance, aroma, flavor and texture can be specified as the main sensory characteristics for the spread chocolate. The color should also be taken into consideration in spreadable products to meet the consumer acceptance. Therefore, in our study, parameters such as appearance, melting in mouth, sweetness, flavor, taste, buying intense and general acceptance, as well as brightness and color parameters were examined for both compound chocolate and spread samples within the scope of sensory analysis. In the study, a five-point hedonic scale was used, panelists scored these parameters for compound chocolate samples, 4.40-4.80, 4.37-4.93, 4.60-4.80, 4.70-4.80, 4.67-4.77, 4.63-4.73, 4.63-4.77, 4.57-4.70 and 4.33-4.77, respectively. The results of spread samples determined as 4.27-4.83, 4.17-4.77, 4.27-4.70, 4.13-4.67, 4.50, 4.70, 4.13-4.53, 4.37-4.67, 4.304.53 and 4.57-4.80, respectively (Table 3). As all panelists' evaluations were > 4.0 scores, both for compound and spread chocolate, the result can be considered to be positive.

No significant change was determined in using beetroot powder (along with its use in different levels), when it was compared to the control sample, in the sensory properties of brightness, sweetness, flavor, taste, buying intense and general acceptance in compound chocolate samples (P>0.05). For spread samples, however, this was the case only for brightness, sweetness, taste, buying intense and general acceptance (P> 0.05). One of the main objectives of this study is to investigate the possibility of coloring the samples with beetroot powder. It is because of this aim that the level of color appreciation is of particular importance. The highest color liking in the compound samples was acquired for the control sample and the sample containing 1.00 g/100 g beetroot powder (P<0.05). In spread samples, however, the highest rating of all, including control sample, was given to the sample which was prepared by using 1.00g/100 g beetroot powder (P<0.05). Similarly, the highest values for both compound and spread chocolate's appearance likings were

determined for the samples used in the mentioned proportion of pigment sources (P<0.05). This result can be considered as an advantage for the use of compound and spread chocolate as a means of distribution of bioactive compounds. As there was an increase in the level of appreciation of the samples which were prepared with the use of these components at high levels. However, further studies need to examine the concentrations of related bioactive compounds as well as their interactions with other components in the matrix for bioaccessibility and bioactivity. Significant decrease in flavor liking was determined after using a coloring agent in spread samples (p<0.05). Consumers can establish a relationship between aroma and color in confectionery products (Saint-Eve et al., 2011). The reason for the decrease in flavor liking level in spread samples may be that the color of the samples was not associated with its aroma by panelists.

3.4 Flow and melting behaviors

In this study, flow (yield stress and plastic viscosity) and melting (T_{onset}, T_{peak}, T_{end} and Δh) behaviors of compound chocolate samples with different levels of beetroot powder were determined (Table 4). The rheological properties of chocolate have a significant effect on the quality and stability of the end product due to its effect on parameters such as viscosity, consistency and mouth sensation (Glicerina & Romani, 2016). The yield stress and plastic viscosity values of the samples were determined between 1.68-2.02 Pa and 2.09-2.50 Pa.s, respectively. Even though the values of both properties increased with the use of beetroot powder, no significant change was determined (P> 0.05). Chocolate flow properties are affected not only by the process conditions (refining, conching and tempering) but also by the composition (Vavreck, 2004; Schantz & Rohm, 2005). In this study, one of the main reasons for the increase in yield stress and plastic viscosity values may be the higher moisture values in compound chocolate samples compared to the control sample. Servais et al. (2003) underlined that any fluctuation or change in the moisture level of chocolate can cause significant changes in the viscosity value of the sample. At moisture levels below 1.0%, most of the water is bonded and its effect on flow characteristics is negligible. Thickening begins, however, when the chocolate begins to absorb moisture (Wolf, 2017).

Table 3. Sensory properties of colored white compound chocolate and chocolate spread.

Sample	Appearance	Brightness	Color	Melting in mouth	Sweetness	Flavor	Taste	Buying intense	General Acceptance
C000	4.60 ± 0.67[ab]	4.63 ± 0.56[a]	4.73 ± 0.45[a]	4.93 ± 0.25[a]	4.80 ± 0.48[a]	4.80 ± 0.42[a]	4.77 ± 0.43[a]	4.63 ± 0.49[a]	4.73 ± 0.49[a]
C025	4.40 ± 0.72[ab]	4.57 ± 0.50[a]	4.33 ± 0.66[b]	4.90 ± 0.31[a]	4.80 ± 0.48[a]	4.70 ± 0.47[a]	4.77 ± 0.43[a]	4.63 ± 0.56[a]	4.70 ± 0.46[a]
C050	4.53 ± 0.63[ab]	4.63 ± 0.49[a]	4.47 ± 0.57[ab]	4.80 ± 0.41[a]	4.80 ± 0.48[a]	4.70 ± 0.47[a]	4.77 ± 0.43[a]	4.63 ± 0.56[a]	4.70 ± 0.46[a]
C075	4.67 ± 0.48[ab]	4.67 ± 0.48[a]	4.60 ± 0.50[ab]	4.63 ± 0.56[ab]	4.60 ± 0.56[a]	4.70 ± 0.47[a]	4.67 ± 0.48[a]	4.63 ± 0.49[a]	4.63 ± 0.49[a]
C100	4.80 ± 0.41[a]	4.70 ± 0.47[a]	4.77 ± 0.43[a]	4.37 ± 0.67[b]	4.60 ± 0.56[a]	4.70 ± 0.47[a]	4.73 ± 0.45[a]	4.73 ± 0.45[a]	4.767 ± 0.43[a]
S000	4.27 ± 0.72[b]	4.53 ± 0.57[a]	4.57 ± 0.5683[ab]	4.77 ± 0.43[a]	4.70 ± 0.54[a]	4.67 ± 0.48[a]	4.63 ± 0.56[a]	4.47 ± 0.57[a]	4.57 ± 0.57[a]
S025	4.37 ± 0.74[ab]	4.43 ± 0.57[a]	4.37 ± 0.56[b]	4.53 ± 0.68[ab]	4.47 ± 0.73[a]	4.33 ± 0.55[ab]	4.50 ± 0.63[a]	4.13 ± 0.78[a]	4.37 ± 0.56[a]
S050	4.50 ± 0.57[ab]	4.33 ± 0.66[a]	4.47 ± 0.57[ab]	4.47 ± 0.57[ab]	4.43 ± 0.73[a]	4.30 ± 0.75[ab]	4.63 ± 0.67[a]	4.13 ± 0.73[a]	4.47 ± 0.51[a]
S075	4.70 ± 0.46[ab]	4.30 ± 0.65[a]	4.67 ± 0.48[ab]	4.40 ± 0.72[ab]	4.43 ± 0.77[a]	4.33 ± 0.71[ab]	4.70 ± 0.46[a]	4.53 ± 0.51[a]	4.57 ± 0.50[a]
S100	4.83 ± 0.38[a]	4.37 ± .61[a]	4.80 ± 0.41[a]	4.17 ± 0.65[b]	4.27 ± 0.74[a]	4.13 ± 0.73[b]	4.67 ± 0.48[a]	4.33 ± 0.71[a]	4.67 ± 0.48[a]

Different superscript lowercase letters show the significant differences for each sample group ($P<0.05$). All experiments were performed in triplicate. All data are represented as means ± standard deviation. 1= very bad, 2= bad, 3= moderately recognizable, 4= good, 5= very good. Number of panellists (n) was 30.

Table 4. Flow and melting behaviour of colored white compound chocolate.

Sample	Flow Behaviour			Melting Behaviour			
	σ_0 (Pa)	η_{pl} (Pa.s)	R^2	T_{onset} (°C)	T_{peak} (°C)	T_{offset} (°C)	Δh (J/g)
C000	1.68 ± 0.25[a]	2.09 ± 0.01[b]	0.995	21.3 ± 0.38[a]	32.1 ± 0.26[a]	40.8 ± 0.83[a]	35.3 ± 1.55[a]
C025	1.95 ± 0.10[a]	2.50 ± 0.01[a]	0.993	22.0 ± 0.11[a]	32.1 ± 0.16[a]	40.5 ± 0.33[a]	33.1 ± 0.96[a]
C050	1.90 ± 0.03[a]	2.49 ± 0.06[a]	0.993	22.2 ± 0.38[a]	32.1 ± 0.23[a]	41.0 ± 0.64[a]	32.4 ± 0.98[a]
C075	1.89 ± 0.12[a]	2.48 ± 0.12[a]	0.993	21.3 ± 0.85[a]	32.5 ± 0.92[a]	40.5 ± 1.67[a]	34.4 ± 0.44[a]
C100	2.02 ± 0.05[a]	2.40 ± 0.02[a]	0.992	21.1 ± 0.11[a]	32.0 ± 0.06[a]	40.6 ± 0.8[a]	34.2 ± 0.17[a]

Different superscript lowercase letters show the significant differences for each sample group ($P<0.05$). All experiments were performed in triplicate. All data are represented as means ± standard deviation.

Furthermore, the difference in moisture levels, albeit at a non-significant level, did not cause significant changes in compound chocolate melting behavior (P>0.05). Investigating the melting properties of chocolate samples is of great importance in order to learn about in-mouth melting behavior as well as some other physical properties of the fat phase such as hardness and crystallization properties (Braipson-Danthine & Deroanne, 2004). T_{onset}, T_{peak}, T_{end} and Δh values were determined as 21.1-22.2 °C, 32.0-32.5 °C, 40.5-41.0 °C and 32.4-35.3 j/g, respectively. T_{onset} values of the samples obtained by crystallization of different levels of palm stearin/palm kernel olein mixtures under different conditions were determined in the range of 11.5-22.3 °C (Abd-Rashid et al., 2012). Toker et al. (2016) determined the T_{onset}, T_{peak} and T_{end} values for compound chocolate as 21-25 °C, 30.9-33.8 °C and 37.4-42.5 °C, respectively. Therefore, it was determined that the melting behavior characteristics obtained from this study were consistent with the previous studies and that the use of beetroot powder did not cause any negative change on the melting properties of the compound chocolate samples.

3.5 Color properties and stability

Color is one of the purchasing motivations for consumers which affects the perception and attitude towards food (Wu et al., 2013). As one of the aims of this study is a preliminary examination of the use of compound and spread chocolate as a means of distributing pigments that also have bioactive properties, the stability of changes in color properties and the stability of color properties were examined with the use of beetroot powder. In this study, by using CIE-Lab technique, the brightness (L*), a*, b*, chroma (C*) and hue angle (h°) properties and whiteness index (WI),

which is an important color parameter in chocolate and derivative products, were determined (Table 5). With the use of beetroot powder in compound chocolate samples, significant decrease in L* (54.9-74.4), b* (8.20-18.2), C* (13.0-19.2), h° [(-72.0)-32.7] and WI (52.4-68.0) were observed, while the redness (+a*) associated with the pigment source used showed a significant increase [(-5.90)-12.8] (P<0.05). Decreasing in brightness is a disadvantage for chocolate and chocolate products (Konar, 2013). However, the increase in the a* value consistent with the pigment level has been considered a positive indicator for the process stability of this pigment source and the possibility of its use in the compound chocolate matrix. With the use of beetroot powder, L* (54.2-68.4), a* ((-2.61) -10.78), b* (8.20-18.2), C* (13.3-17.5), h° ((-81.4) -80.2) and WI (51.9-63.9) properties of spread samples showed similar changes to the compound chocolate (P <0.05).

It is important that the visual properties gained by the use coloring agent, show stability during the shelf life of the samples. The shelf life of the white chocolate is considered to be around 12 months (Beckett, 2009). White chocolate and its products may show a higher tendency to loss of aroma and color during storage process as they contain a lower level of antioxidant components than other chocolate categories (Stauffer, 2007). All sample groups were stored under accelerated shelf life (ASL) conditions (25 °C/70% RH), prepared for confectionery including chocolate, and their color characteristics were determined for 7-days period of storage under ASL conditions were considered to simulate 1 month of normal storage conditions (Subramaniam, 2007). ΔE values of all sample groups were determined for this aim. (Table 5 and 6). When ΔE value is above 3.0, it is

Table 5. Color stability of white compound chocolate samples in the storage time.

Sample		0	1	2	3	4	5	6	7	8	9	10	11	12
									Storage time (weeks)					
C000	L*	74.4 ± 0.65[bc]	75.5 ± 0.48[a]	73.5 ± 0.51[b]	74.0 ± 0.54[ab]	74.4 ± 0.64[ab]	74.6 ± 0.89[ab]	74.4 ± 0.59[ab]	73.7 ± 0.89[ab]	74.3 ± 0.54[ab]	74.0 ± 0.88[ab]	73.2 ± 0.02[b]	73.2 ± 0.93[b]	73.6 ± 0.66[ab]
	a*	-5.9 ± 0.06[g]	-5.2 ± 0.05[f]	-4.9 ± 0.03[e]	-4.8 ± 0.06[e]	-4.7 ± 0.09[de]	-4.5 ± 0.15[cd]	-4.4 ± 0.08[c]	-4.3 ± 0.11[bc]	-4.2 ± 0.04[ab]	-4.1 ± 0.12[ab]	-4.1 ± 0.06[a]	-4.0 ± 0.11[a]	-4.0 ± 0.06[a]
	b*	18.2 ± 0.17[fg]	18.4 ± 0.11[fg]	18.2 ± 0.28[g]	18.4 ± 0.32[efg]	18.9 ± 0.15[cdef]	18.3 ± 0.29[g]	19.2 ± 0.17[cd]	19.5 ± 0.23[bc]	18.8 ± 0.24[def]	19.1 ± 0.32[cde]	20.3 ± 0.13[a]	20.3 ± 0.37[a]	20.0 ± 0.21[ab]
	ΔE	nd	1.34 ± 0.40[g]	1.42 ± 0.33[efg]	1.29 ± 0.15[g]	1.49 ± 0.13[efg]	1.67 ± 0.14[defg]	1.85 ± 0.03[cdef]	2.30 ± 0.09[cd]	1.89 ± 0.01[cde]	2.18 ± 0.10[cd]	2.99 ± 0.13[a]	3.16 ± 0.14[a]	2.83 ± 0.09[ab]
C025	L*	65.9 ± 0.14[bc]	67.1 ± 0.50[ab]	66.3 ± 0.28[abc]	66.4 ± 0.25[abc]	66.4 ± 0.24[abc]	66.7 ± 0.56[abc]	65.3 ± 0.54[c]	65.8 ± 0.11[bc]	67.4 ± 0.11[a]	66.4 ± 0.48[abc]	65.1 ± 1.19[c]	66. ± 0.45[ab]	66.0 ± 0.76[ab]
	a*	3.90 ± 0.22[ab]	4.02 ± 0.08[a]	3.91 ± 0.17[ab]	3.83 ± 0.08[ab]	3.75 ± 0.10[ab]	4.07 ± 0.09[ab]	3.60 ± 0.12[b]	3.77 ± 0.13[ab]	3.21 ± 0.03[c]	3.08 ± 0.22[c]	3.08 ± 0.22[c]	2.64 ± 0.17[d]	2.89 ± 0.07[cd]
	b*	12.4 ± 0.60[f]	13.05 ± 0.16[ef]	13.2 ± 0.06[def]	13.3 ± 0.072[de]	13.3 ± 0.16[def]	13.4 ± 0.10[de]	13.3 ± 0.16[def]	13.8 ± 0.13[cde]	13.9 ± 0.12[cde]	13.8 ± 0.06[cde]	14.0 ± 0.35[bcd]	15.7 ± 0.13[a]	14.6 ± 0.53[bc]
	ΔE	nd	1.30 ± 0.51[egh]	0.90 ± 0.13[gh]	1.02 ± 0.16[g]	1.16 ± 0.16[efg]	1.21 ± 0.44[efg]	1.62 ± 0.07[def]	1.50 ± 0.12[def]	2.12 ± 0.11[bcd]	1.88 ± 0.40[cde]	2.93 ± 0.12[ab]	3.68 ± 0.26[a]	2.50 ± 0.37[bc]
C050	L*	65.333 ± 0.51[a]	66.1 ± 0.41[a]	65.5 ± 0.43[a]	65.5 ± 0.28[a]	65.5 ± 0.34[a]	66.7 ± 0.39[a]	65.3 ± 1.05[a]	66.6 ± 0.42[a]	67.0 ± 0.87[a]	66.2 ± 0.47[a]	65.4 ± 0.20[a]	67.0 ± 0.14[a]	66.3 ± 1.10[a]
	a*	4.20 ± 0.04[ab]	3.92 ± 0.12[bc]	3.95 ± 0.08[abc]	3.93 ± 0.05[abc]	3.93 ± 0.05[abc]	3.92 ± 0.05[bc]	4.25 ± 0.05[a]	3.68 ± 0.17[c]	4.11 ± 0.14[ab]	3.31 ± 0.16[d]	3.12 ± 0.03[de]	3.29 ± 0.06[d]	2.82 ± 0.01[d]
	b*	12.6 ± 0.19[g]	12.5 ± 0.11[g]	12.9 ± 0.04[fg]	13.1 ± 0.01[f]	13.1 ± 0.01[f]	13.2 ± 0.04[ef]	13.5 ± 0.07[e]	13.6 ± 0.17[de]	14.4 ± 0.15[c]	13.6 ± 0.15[de]	14.0 ± 0.16[d]	15.1 ± 0.11[b]	15.8 ± 0.11[a]
	ΔE	nd	0.86 ± 0.31[def]	0.57 ± 0.03[f]	0.57 ± 0.03[f]	0.63 ± 0.08[ef]	0.78 ± 0.11[ef]	1.67 ± 0.35[cd]	1.44 ± 0.18[cde]	2.25 ± 0.34[bc]	2.23 ± 0.61[bc]	2.00 ± 0.30[bc]	2.71 ± 0.12[b]	3.87 ± 0.15[a]
C075	L*	57.2 ± 0.17[d]	58.5 ± 0.24[e]	58.4 ± 0.20[e]	58.4 ± 0.30[e]	58.4 ± 0.80[e]	59.5 ± 0.24[abc]	58.4 ± 0.63[e]	59.3 ± 0.13[bc]	60.8 ± 0.52[a]	60.3 ± 0.09[ab]	59.1 ± 0.40[bc]	59.4 ± 0.48[bc]	59.3 ± 0.41[bc]
	a*	12.8 ± 0.09[a]	10.8 ± 0.30[b]	10.2 ± 0.12[c]	10.0 ± 0.08[cd]	9.9 ± 0.28[cd]	10.0 ± 0.12[cd]	9.5 ± 0.16[de]	9.7 ± 0.24[cd]	8.3 ± 0.33[gh]	8.1 ± 0.20[h]	8.3 ± 0.19[fgh]	8.9 ± 0.22[ef]	8.8 ± 0.20[fgh]
	b*	8.2 ± 0.10[g]	9.5 ± 0.08[f]	9.6 ± 0.07[ef]	9.7 ± 0.15[ef]	9.7 ± 0.15[ef]	9.9 ± 0.07[e]	10.3 ± 0.16[d]	10.8 ± 0.06[c]	10.3 ± 0.06[d]	10.7 ± 0.04[c]	11.9 ± 0.10[a]	11.3 ± 0.27[b]	11.3 ± 0.08[b]
	ΔE	nd	1.34 ± 0.27[fg]	1.36 ± 0.15[fg]	1.47 ± 0.23[f]	1.69 ± 0.48[ef]	2.51 ± 0.20[de]	2.10 ± 0.40[def]	2.88 ± 0.06[cd]	4.52 ± 0.38[a]	4.30 ± 0.08[a]	4.10 ± 0.34[ab]	3.53 ± 0.4[bc]	3.52 ± 0.39[bc]
C100	L*	54.9 ± 0.70[fg]	56.1 ± 0.23[ef]	55.8 ± 0.67[fg]	56.1 ± 0.26[f]	56.4 ± 0.38[def]	57.2 ± 0.10[cde]	56.4 ± 0.25[def]	57.4 ± 0.23[bcd]	58.6 ± 0.30[a]	58.4 ± 0.23[ab]	56.9 ± 0.34[cde]	58.6 ± 0.42[a]	58.0 ± 0.41[abc]
	a*	12.8 ± 0.09[a]	12.4 ± 0.12[ab]	12.0 ± 0.08[b]	12.0 ± 0.08[b]	12.0 ± 0.24[b]	12.3 ± 0.03[ab]	11.8 ± 0.23[b]	11.8 ± 0.35[b]	10.5 ± 0.30[c]	10.2 ± 0.09[cd]	10.4 ± 0.13[c]	9.9 ± 0.30[cd]	9.7 ± 0.42[d]
	b*	8.2 ± 0.10[f]	8.4 ± 0.06[ef]	8.4 ± 0.1[ef]	8.50 ± 0.05[ef]	8.6 ± 0.12[ef]	8.6 ± 0.07[ef]	9.1 ± 0.11[cd]	9.4 ± 0.05[c]	8.8 ± 0.34[de]	9.5 ± 0.09[c]	10.5 ± 0.22[b]	11.4 ± 0.13[a]	11.4 ± 0.04[a]
	ΔE	nd	1.29 ± 0.19[d]	1.24 ± 0.49[d]	1.48 ± 0.26[c]	1.81 ± 0.37[de]	2.36 ± 0.11[c]	2.03 ± 0.23[d]	2.92 ± 0.30[c]	4.46 ± 0.22[b]	4.57 ± 0.24[a]	3.86 ± 0.28[b]	5.67 ± 0.48[a]	5.63 ± 0.a[b]

nd: Not determined. Different superscript lowercase letters show the significant differences for each sample group due to storage time (P<0.05). All experiments were performed in triplicate. All data are represented as means ± Standard deviation.

Table 6. Color stability of white chocolate spread samples in the storage time.

Sample		0	Storage time (week) 1	2	3	4	5	6	7	8	9	10	11	12
S000	L*	68.4 ± 0.16a	68.6 ± 0.94a	67.4 ± 0.22a	67.9 ± 0.75a	67.0 ± 1.63a	67.4 ± 1.98a	67.8 ± 1.06a	66.8 ± 1.64a	68.1 ± 1.57a	67.1 ± 0.97a	66.7 ± 0.67a	66.8 ± 1.07a	66.2 ± 1.37a
	a*	-2.61 ± 0.11f	-2.44 ± 0.22g	-2.06 ± 0.05f	-1.76 ± 0.02ef	-1.46 ± 0.02de	-1.24 ± 0.11cd	-1.04 ± 0.05ab	-1.21 ± 0.26bcd	-1.05 ± 0.09abc	-1.03 ± 0.10abc	-0.85 ± 0.08a	-0.92 ± 0.07ab	-1.09 ± 0.04abc
	b*	17.3 ± 0.06d	17.7 ± 0.06dc	17.9 ± 0.58de	18.5 ± 0.49bcd	19.1 ± 0.55ab	18.1 ± 0.45cde	19.2 ± 0.22ab	19.1 ± 0.53a	18.1 ± 0.25cde	18.4 ± 0.14cde	19.7 ± 0.28a	19.6 ± 0.40ab	18.2 ± 0.29bcd
	ΔE	nd	0.92 ± 0.20ef	1.36 ± 0.20de	1.72 ± 0.37	2.89 ± 0.35ab	2.45 ± 0.58abcd	2.67 ± 0.08abc	3.11 ± 0.51ab	2.21 ± 0.27bcd	2.44 ± 0.33abcd	3.47 ± 0.32a	3.38 ± 0.19a	2.93 ± 0.85ab
S025	L*	63.5 ± 0.35ab	64.3 ± 0.11a	62.3 ± 0.68bc	61.9 ± 0.46bcd	61.5 ± 0.69cde	61.1 ± 0.76def	60.5 ± 0.75defg	61.1 ± 1.46cdef	62.0 ± 0.81defg	59.9 ± 0.62ef	59.0 ± 0.42f	59.9 ± 0.24def	60.4 ± 0.35cdef
	a*	2.47 ± 0.33g	2.49 ± 0.04g	2.62 ± 0.16g	2.96 ± 0.08fg	3.29 ± 0.12f	3.84 ± 0.32de	4.10 ± 0.26bcd	4.82 ± 0.29a	4.69 ± 0.13ab	4.73 ± 0.14a	4.55 ± 0.10abc	4.04 ± 0.11cd	4.43 ± 0.19abcd
	b*	14.3 ± 0.07ef	14.5 ± 0.07cdef	14.6 ± 0.21cdef	14.8 ± 0.07cde	15.0 ± 0.11bc	14.5 ± 0.19cdef	14.7 ± 0.30cde	15.0 ± 0.16bc	14.1 ± 0.37f	14.4 ± 0.12cdef	15.0 ± 0.15c	15.7 ± 0.10cd	15.4 ± 0.19ab
	ΔE	nd	1.05 ± 0.12e	1.13 ± 0.57e	1.60 ± 0.36	2.14 ± 0.62de	2.64 ± 0.80cde	3.27 ± 0.79bcd	3.39 ± 1.09cd	2.66 ± 0.46cde	4.14 ± 0.59ab	4.81 ± 0.44a	3.99 ± 0.23ab	3.74 ± 0.16abc
S050	L*	60.1 ± 0.34b	60.9 ± 0.92a	59.0 ± 1.06a	58.6 ± 0.72a	58.1 ± 0.41a	58.1 ± 2.14a	57.8 ± 2.00a	58.6 ± 1.41a	59.5 ± 2.28a	58.9 ± 1.66a	58.7 ± 2.01a	59.7 ± 2.63a	60.0 ± 1.46a
	a*	5.61 ± 0.41efg	5.20 ± 0.18ef	6.52 ± 0.23cde	7.27 ± 0.14bcd	8.03 ± 0.26abc	9.12 ± 0.18a	8.56 ± 0.55ab	9.02 ± 0.22ab	7.19 ± 0.79bcd	6.31 ± 0.71defg	6.57 ± 0.17cdef	4.76 ± 1.20g	5.65 ± 0.62efg
	b*	12.1 ± 0.37e	12.5 ± 0.14de	13.0 ± 0.28de	12.7 ± 0.24de	12.4 ± 0.42de	12.4 ± 0.35de	12.7 ± 0.63de	13.6 ± 0.22bcd	12.6 ± 0.77de	13.1 ± 0.52cde	15.0 ± 0.46ab	15.5 ± 0.84a	14.5 ± 0.22abc
	ΔE	nd	1.10 ± 0.73e	1.84 ± 0.47ef	2.37 ± 0.41cde	3.15 ± 0.33abcd	4.36 ± 0.63a	4.14 ± 0.63de	4.15 ± 0.49ab	2.69 ± 0.36bcde	2.16 ± 0.72cde	3.66 ± 0.69bcde	4.23 ± 0.72cde	2.68 ± 0.27bcde
S075	L*	56.6 ± 0.38b	58.1 ± 0.45a	56.3 ± 0.20bc	56.1 ± 0.12bc	56.0 ± 0.12bcd	55.7 ± 0.28bcd	54.4 ± 1.13d	55.5 ± 0.88bcd	57.0 ± 0.590ab	56.2 ± 0.09bc	54.9 ± 0.80cd	55.7 ± 0.27bcd	55.5 ± 0.35bcd
	a*	8.95 ± 0.24de	8.61 ± 0.13e	8.52 ± 0.18e	8.83 ± 0.07de	9.13 ± 0.13de	9.90 ± 0.21cd	10.3 ± 0.44bc	11.4 ± 0.47ab	11.3 ± 0.38ab	11.5 ± 0.45a	12.2 ± 0.26a	11.3 ± 0.41ab	11.4 ± 0.82ab
	b*	11.0 ± 0.13e	11.1 ± 0.11de	11.5 ± 0.09bc	11.4 ± 0.07bcd	11.4 ± 0.05bcd	11.1 ± 0.06de	11.3 ± 0.16bcde	11.2 ± 0.19cde	10.4 ± 0.13f	10.4 ± 0.06f	11.5 ± 0.17bc	11.9 ± 0.16a	11.6 ± 0.08ab
	ΔE	nd	1.48 ± 0.46bcd	0.75 ± 0.02d	0.68 ± 0.11d	0.82 ± 0.13d	1.37 ± 0.09bc	2.71 ± 0.62ab	2.71 ± 0.71ab	2.48 ± 0.28ab	2.65 ± 0.45ab	3.70 ± 0.57a	2.67 ± 0.47abc	2.83 ± 0.75a
S100	L*	54.2 ± 0.58bc	55.7 ± 0.92a	54.6 ± 0.08ab	54.0 ± 0.08ab	53.5 ± 0.25bc	53.7 ± 0.27bc	51.7 ± 0.72cd	51.8 ± 0.05cd	52.0 ± 0.40cd	51.8 ± 0.90cd	50.4 ± 1.26d	51.5 ± 1.03d	51.2 ± 0.56d
	a*	10.8 ± 0.37bcde	10.5 ± 0.12cde	10.08 ± 0.04e	10.2 ± 0.12de	10.3 ± 0.25cde	11.1 ± 0.10abcde	11.5 ± 0.27abcde	12.2 ± 0.12abcd	11.8 ± 1.65abcde	12.3 ± 1.00abc	12.7 ± 1.32ab	13.0 ± 0.53a	12.8 ± 0.50ab
	b*	10.0 ± 0.15ab	10.1 ± 0.05ab	10.5 ± 0.07a	10.4 ± 0.06a	10.3 ± 0.14ab	10.3 ± 0.17ab	10.3 ± 0.09ab	10.1 ± 0.08ab	9.20 ± 0.48c	9.20 ± 0.16c	9.60 ± 0.29bc	10.2 ± 0.38ab	10.5 ± 0.52a
	ΔE	nd	1.56 ± 0.90bcde	0.90 ± 0.09cde	0.74 ± 0.09de	0.94 ± 0.22cde	0.69 ± 0.19de	2.62 ± 0.63abcde	2.75 ± 0.05abcd	2.96 ± 0.56abcde	3.05 ± 1.13abc	4.28 ± 1.66a	3.56 ± 1.00ab	3.68 ± 0.20ab

nd: Not determined. Different superscript lowercase letters show the significant differences for each sample group due to storage time (P<0.05). All experiments were performed in triplicate. All data are represented as means ± Standard deviation.

considered to be a visual color change (Periche et al., 2015). This value was generally lower than 3.16 in 12 weeks storage period under ASL conditions in compound chocolate samples. In the samples containing beetroot powder, lower color stability was observed in the samples with a usage rate of >0.50 g/100 g (p<0.05). In samples containing 0.25 and 0.50 g/100 g beetroot powder, the color stability was found to be maintained under ASL conditions for 12 and 10 weeks, respectively. Some increases and decreases in the color values of both compound chocolate and spread samples were determined during the study (Table 5 and 6). Previous studies also observed some fluctuations in color properties during storage in white chocolate (Jardim et al., 2011). If these changes are considered negligible, the value of ΔE for spread samples for samples containing 0.00 (control), 0.25, 0.50, 0.75 and 1.00 g/100 g beetroot powder is less than 3.0 under ASL conditions for 12, 8, 5, 12 and 9 weeks, respectively. Unlike compound chocolate, higher color stability was determined in spread samples where beetroot powder usage was higher (0.75 and 1.00 g/100 g). Therefore, it can be stated that the product compound is an important factor for color stability. In addition, it is worth to mention that among these sample groups, the samples with the highest moisture content and 0.50 g/100 g beetroot powder has lower color stability. Most natural food colorants may show unstable behavior in process and storage conditions such as moisture, light, oxygen and pH (Wu et al., 2013). It is possible to reach higher color stability both for compound chocolate and spread, especially with the optimization of moisture level and the use of components that improve oxidative stability.

4 Conclusion

Various bioactive compounds have both technological and functional effects on foods. Betalains and beetroot powder, which is the source of this bioactive component, are significant food components with both coloring and bioactivity effects. Before using this and other colorant-containing components in developing functional product, it is important to investigate their effects on the quality properties of foods and also ensure the stability of the visual properties they provide throughout shelf life.

In this study, it was determined that the use of beetroot powder did not cause significant deviations on physico-chemical, texture, flow, melting and sensory properties of the spread and compound chocolate. The sensory evaluation shows that the products that were obtained in this study are determined to be accepted by the consumer. It can be stated that the stability of the visual properties in the spread and compound chocolate samples should be increased. Considering results of sensory analysis and color stability under ASL conditions, 2.50 g kg^{-1} and 7.50 g kg^{-1} beetroot powder may be used to develop compound and spread chocolate, respectively, with improved and stable visual properties. By further studies bioaccesibility and functional properties of spread and compound chocolates including plant-origin bioactive compounds should be investigated.

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