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THE PHYSICAL PROPERTIES, POLYPHENOL CONTENT AND SENSORY CHARACTERISTICS OF WHITE CHOCOLATE ENRICHED WITH BLACK TEA EXTRACT

Ivana Lončarević[1*], Biljana Pajin[1], Jovana Petrović[1], Danica Zarić[2], Vesna Tumbas Šaponjac[1], Aleksandar Fišteš[1], Petar Jovanović[3]

[1]University of Novi Sad, Faculty of Technology Novi Sad, 21000 Novi Sad, Serbia
[2]IHIS Techno Experts d.o.o., Research Development Center, 11000 Belgrade, Serbia
[3]Eugen Chocolate d.o.o., 21412 Gložan, Serbia

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Summary

Chocolate contains a variety of different compounds such as fats, carbohydrates, proteins, vitamins, and minerals. Fat-free cocoa particles are also extremely rich in polyphenols. While dark chocolate is a most powerful source of antioxidants, the content of these components decreases with the reduction in the content of dark cocoa particles in chocolate. White chocolate differs from milk and dark through the absence of fat-free cocoa particles containing antioxidants.
Today's investigations are focused on finding new methods of creating functional confectionery products. Accordingly, in this study white chocolate was enriched with100 g kg^{-1} of encapsulated black tea extract in order to increase its polyphenol content. The addition of encapsulated black tea extract to white chocolate increased the viscosity of enriched chocolate mass to the extent that is acceptable for the production of this kind of product. Total polyphenol content in enriched chocolate was increased over 6 times compared to white chocolate. However, black tea encapsulate contributed to foreign taste of medications in enriched chocolate, making it unacceptable by consumers.

Keywords: white chocolate, encapsulated black tea extract, particle size distribution, rheology, polyphenol content, sensory characteristics

Introduction

Chocolate is a complex rheological system consisting of non-fat particles dispersed in a continuous fat phase primarily composed of cocoa butter (Afoakwa et al., 2009; Zarić et al., 2016). In addition to its own unique flavor and textural properties, chocolate can provide significant amounts of a number of essential nutrients with potential positive impact on human health (Steinberg et al., 2003). Nowadays, research is mostly focused to the polyphenolic fraction of cocoa mainly consisting of flavonoids (Lecumberri et al., 2007). Dark, milk, and white chocolates have different content of cocoa solids (fat free cocoa solids and cocoa butter) and milk fat (Rossini et al., 2011). Dark chocolate contains cocoa liquor, cocoa butter, powdered sugar, and emulsifier lecithin, while, in the case of milk chocolate, the milk powder is added and the content of cocoa solids is lower. White chocolate even doesn't contain fat-free cocoa solids and thus lacks polyphenols (Samsudin, 1996).
Nowadays, many confectionery products have been enriched with bioactive compounds since the market is increasingly searching for functional food that can improve life style (Glaberson, 2011). The bioactive compounds are very sensitive to heat, light, and water, so the encapsulation technique is commonly used in order to improve their stability and to change liquid solutions to powders for easier handling (Tumbas Šaponjac et al., 2016). The acceptability of new type of chocolate by consumers depends primarily on its taste, but also on mouth feeling, which mainly depends on the particle size and the viscosity of the molten chocolate mass. The size of the particles in chocolate is desirable to be 15–30 µm. If particles are bigger, the chocolate will cause a gritty mouth feeling and, on the other hand, smaller particles increase the specific surface area, more liquid phase is needed to cover it, and viscosity increases (Bolenz et al., 2014). Tea polyphenols have a wide range of pharmaceutical properties including antioxidative, antiarteriosclerotic, and anticarcinogenic (Turkmen et al., 2006). In the manufacturing of black tea, a large portion of the catechins are converted to theaflavins and thearubigens, which are responsible for the dark brown color and the taste of black tea. The remaining catechins account for 3–10% in brewed black tea (Hong et al., 2001).
Our previous work involved the production and quality analysis of white chocolate enriched with 60, 80, and 100 g $kg^{-1}$of encapsulated blackberry juice (Loncarevic et al., 2018[a]). This study was designed to examine the impact of encapsulated black tea extract

[*]Corresponding author: ivana.radujko@tf.uns.ac.rs

in amount of 100 g kg^{-1}on particle size distribution, rheological properties, total polyphenol content, and sensory properties of enriched white chocolate.

Materials and methods

Materials

The material used in this work included black tea extract encapsulated in maltodextrins by spray drying technique (Frutarom Etol d.o.o., Slovenia) in the form of black powder (in following text E). The composition of white chocolate is shown in our previous paper (Lončarević et al., 2018)[a], consisting cocoa butter (348.4 g kg^{-1}), powdered sugar (497.6 g kg^{-1}), whole milk powder (149.3 g kg^{-1}), sunflower lecithin (4.5 g kg^{-1}), and vanilla powder (0.2 g kg^{-1}).

Methods

Pre-crystallization of chocolate mass

Chocolate mass was tempered in modified Brabender farinograph where the original kneader is connected with two thermostats (Lauda Ecoline Staredtition E 215 T, Germany), which enables an immediate temperature change in the kneader and in half a minute in chocolate mass (Pajin et al., 2012). First, 120 g of white chocolate was melted in a farinograph kneader at 42 ºC for 30 minutes. Then, chocolate mass was gently stirred at 42 ºC for 60 min, followed by another 60 min at 29.5 ºC. The pre-crystallized chocolate mass was then poured into 50 g plastic mold and cooled in a refrigerator at 5 ºC for 90 minutes.

The same procedure was carried out in order to produce the control sample of white chocolate (in following text W) and chocolate sample enriched with 100 g $kg^{-1}$of encapsulated black tea extract (in following text WE), where the encapsulate was added to melted chocolate after 30 minutes at 42 ºC.

Particle size distribution

The particle size distribution (PSD) of E, W and WE was determined using a laser diffraction particle size analyzer (Mastersizer 2000, Malvern Instruments, UK). The Scirocco dispersion unit was used for dispersing E in the air while Hydro 2000 μP dispersion unit was used for dispersing chocolate in sunflower oil. PSD were described by the volume mean diameter d[4,3], and parameters d(0.1), d(0.5), d(0.9) representing the particle sizes where 10, 50 or 90% of the total particle volume was formed by particles smaller than this size, respectively.

Rheological properties of chocolate mass

Rheological properties of chocolate samples were determined using a rotational rheometer Rheo Stress 600 (Haake, Germany) at the temperature 40 ± 1 ºC (IOCCC, 2000). The shear rate was increased from 0 s^{-1} to 60 s^{-1} during a period of 180 s and then was kept constant for 60 s at max speed of 60 s^{-1} and after that was reduced from 60 s^{-1} to 0 s^{-1}, within 180 s. The obtained flow curves were fitted using Casson model, where the following parameters were obtained: Cason yield stress (Pa) and Casson viscosity (Pas).

Total polyphenol content (TPC)

The total polyphenol content in E was determined spectrophotometrically by a Folin-Ciocalteau method adapted to microscale (González-Molina et al., 2008), while the extraction of polyphenol compounds from W and WE and their determination was performed according to Belščak-Cvitanović et al. (2012) and Belščak-Cvitanović et al. (2015), as described in our previous work (Lončarević et al., 2018)[a].

Sensory analyses

The sensory analyses took place in the Sensory Laboratory of Faculty of Technology Novi Sad, University of Novi Sad, in individual booths, under white light, at room temperature (ISO 8589, 2007). It was performed by a trained sensory panel of 10 staff members from the Faculty of Technology Novi Sad, University of Novi Sad, who had experience in the assessment of chocolates (ISO 8586-1, 1993). During the training sessions, a list of definitions and reference for highest and lowest intensity were developed (ISO 5492, 2008). The sensory characteristics discussed are separated into four groups representing visual (color, glow), textural (hardness, melting rate, graininess), olfactory (cocoa butter aroma and GTE aroma), and gustatory (GTE flavor, cocoa butter flavor, GTE aftertaste) characteristics of chocolate. Panelists evaluated the intensity of each attribute using 15-cm unstructured scale marched on each end with anchors for lowest intensity and highest intensity and they placed a vertical mark on the scales according to their perception of each sensory attribute (ISO 4142, 2002). After that, the ratings were transferred into numbers (1–15) using a ruler. Evaluated attributes, their description, as well as their lowest and highest intensity are listed in Table 1.

Table 1. Description, lowest and highest intensity of evaluated attributes in chocolate samples

Attribute	Description	Lowest Intensity	Highest Intensity
Color	Intensity of black color of chocolate	light (color of white chocolate)	dark (E)
Glow	Intensity of gloss on chocolate surface	matte	Shine
Hardness	Force nedeed to break chocolate sample into two pieces with front teeth	extremly soft	extremly hard
Melting	Length of time to chocolate to melt	quickly	Slowly
Grainines	Sandy texture upon melting	smooth	Gritty
Black tea aroma	Intensity of smell corelated with encapsulate	none	Strong
Cocoa butter aroma	Intensity of smell corelated with coccoa butter	none	Strong
Cocoa butter flavor	The taste of white chocolate	mild	Strong
Black tea flavor	The taste of E	mild	Strong
Sweetness	The taste of table sugar	mild	Strong
Black tea aftertaste	The taste of E in the mouth after swallowing	none	Strong

Results and discussion

PSD od E and chocolate samples

PSD curves of W, E, and WE are presented in Fig. 1.

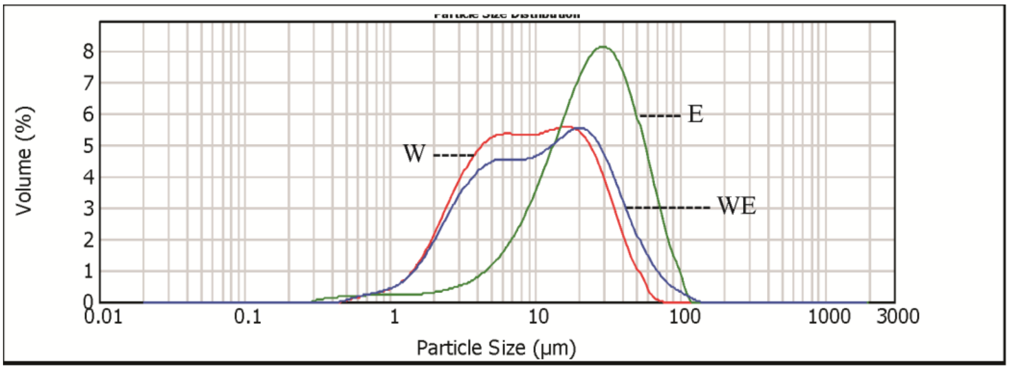

Fig. 1. Particle size distribution of white chocolate (W), encapsulated black tea extract (E) and enriched chocolate with 100 g $kg^{-1}$of E (WE)

White chocolate was milled using five roll mill as seen by multimodal particle size distribution curve. Observing the PSD curve of E, it can be noticed that this powder generally has larger particle sizes comparing to W, however, the largest volume of E consists of particles with diameters in interval 10-30 μm. This indicates that this encapsulate is suitable as supplement in chocolate production since consumers dislike sandy mouth feel, and prefer quickly melting without sticking (Bolenz & Manske, 2013).The PSD parameters are presented in Table 2.

Table 2. Particle size parameters of encapsulated black tea extract (E), white chocolate (W) and enriched chocolates with 100 g kg^{-1} of E (WE)

Particle size parameters (μm)	Sample		
	E	W	WE
d(0.1)	7.41 ± 0.11	2.59 ± 0.04	2.67± 0.06
d(0.5)	24.92 ± 0.07	9.18± 0.06	11.31± 0.13
d(0.9)	58.27 ± 0.14	29.35 ± 0.20	38.32± 0.04
d[4,3] (μm)	30.87 ± 0.09	13.06 ± 0.02	16.91 ± 0.10

Values represent the means (n = 3) ± standard deviation

The addition of 100 g kg^{-1} of E to white chocolate increased all PSD parameters in WE, where the volume mean diameter d[4,3] was increased from 13.06 µm in W to 16.91µm in WE. However, observing that chocolate particles have to be in a size below 30 µm, the addition of E did not increase the mean particle diameter above the acceptable limit.

Rheological properties of molten chocolate samples

The rheology of molten chocolate mass at defined temperature and processing conditions is mainly defined by its ingredient composition, fat content, choice of emulsifier, and particle size distribution (Pajin et al., 2013). Fig. 2 represents the impact of encapsulated black tea extract on rheological properties of enriched chocolate. The both chocolate samples exhibit a thixotropic flow where the addition of encapsulate increases viscosity of white chocolate mass due to a decrease in the free fat phase in the system when the particles of encapsulate were coated by cocoa butter and milk fat.

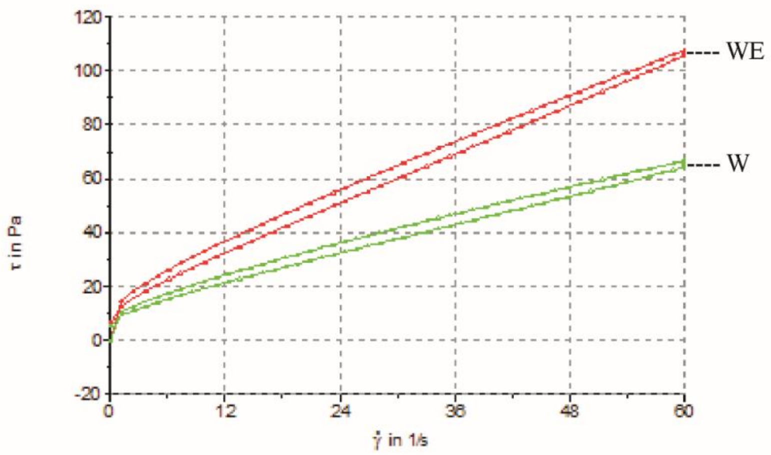

Fig. 2. Flow curves of white chocolate (W) and chocolate with 100 g kg^{-1} of encapsulated black tea extract (WE)

The addition of E to white chocolate increased the values of all rheological parameters in enriched chocolate sample, as shown in Table 3.

Table 3. Rheological parameters of white chocolate (W) and chocolate with 100 g kg^{-1} of encapsulated black tea extract (WE)

Rheological parameters	Sample	
	W	WE
Thixotropic curve area (Pa/s)	144.97 ± 5.00	244.2 ± 7.82
Casson yield stress (Pa)	4.11 ± 0.09	5.26 ± 0.07
Casson viscosity (Pas)	0.63 ± 0.05	1.83 ± 0.04

Values represent the means (n = 3) ± standard deviation

The Casson yield stress of chocolate mass at 40 ºC was increased from 4.11 Pa in white chocolate to 5.26 Pa in enriched chocolate. On the other hand, the addition of encapsulate increased Casson viscosity almost 3 times, from 0.63 Pas to 1.83 Pas. This also led to thixotropic changes within the system with increased value of thixotropic curve area in WE compared to W.

Total polyphenol content

The pure black tea encapsulate contains 1687.64 mg GAE/100g, as shown in Table 4.

Table 4. Total polyphenol contentof black tea encapsulate (E), white chocolate (W) and enriched chocolate (WE)

Sample	E	W	WE
Total polyphenol content (mg GAE/100 g)	1687.64 ± 133.96	40.75 ± 0.96	250.18 ± 4.99

Values represent the means (n = 3) ± standard deviation

The addition of 100 g kg^{-1} of E to white chocolate increased total polyphenol content in enriched chocolate for over 6 times, from 40.75 mg GAE/100 g in W to 250.18 mg GAE/100 g in WE. However, this value is lower compared to total polyphenol content in milk chocolates. Miller et al. (2006) reported that different milk chocolates contain 325-538 mg GAE/100 g. On the other hand, dark chocolate is the reachest source of total polyphenols, originating from dark solids of cocoa beans. Lončarević et al. (2018)[b] showed that dark chocolates made of 58%, 75%, and 88% of cocoa solids contain as much as 1741.98, 1852.72 and 1912.49 mg GAE/100 g, respectively.

Sensory analyses

The sensory characteristics of WC and enriched chocolate with 100 g kg^{-1} of E are shown in Table 5.

Table 5. Sensory characteristics of white chocolate (W) and enriched chocolate with 100 g kg^{-1}of encapsulated black tea extract (WE)

Sensory attribute	W	WE
Color	1.00 ± 0.00	11.26 ± 0.91
Glow	8.03 ± 0.16	7.32 ± 0.28
Hardness	6.28 ± 0.13	6.14 ± 0.23
Melting	13.78 ± 0.15	13.15 ± 0.20
Graininess	1.13 ± 0.08	1.29 ± 0.36
Cocoa butter aroma	13.93 ± 0.09	6.24 ± 0.31
Black tea aroma	1.00 ± 0.00	7.56 ± 1.64
Cocoa butter flavor	14.24 ± 0.09	2.10 ± 0.41
Black tea flavor	1.00 ± 0.00	14.12 ± 0.54
Sweetness	7.87 ± 0.07	2.86 ± 0.35
Black tea aftertaste	1.00 ± 0.00	10.54 ± 0.69

Values represent the means (n = 3) ± standard deviation

The addition of E to white chocolate changed the colour of white chocolate to black, where the gloss on the chocolate surface slightly decreased at the same time. While the hardness and melting of enriched chocolate was not affected, the addition of E caused sandy texture of enriched chocolate. Also, encapsulated black tea extract significantly reduced sweetness of enriched chocolate, but, at the same time, it masked the aroma and flavor of cocoa butter, and contributed to the foreign taste of medications.

Conclusions

The addition of 10 g kg^{-1} of encapsulated black tea extract to white chocolate increased its total polyphenol content over 6 times. The results also showed an increase in particle size distribution and viscosity of chocolate mass at the same time, which did not affect the textural characteristics of enriched chocolate, obtained by sensory analyses. While the addition of black tea encapsulate reduced the sweetness of white chocolate, it also contributed to the unpleasant flavor of enriched chocolate.

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