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Influence of phytosterols addition in the rheology and sensory attributes of dark chocolate

Priscilla Efraim [a*], Gabriela C. Marson[a], Denise C.P. Jardim[b], Aline O. Garcia[b], Katumi Yotsuynagi[b]

[a] *Universidade Estadual de Campinas, Campinas, Brazil (efraim@fea.unicamp.br, gabrielacmarson@gmail.com)*
[b] *Instituto de Tecnologia de Alimentos (ITAL), Campinas, Brazil (djardim@ital.sp.gov.br, alinegarcia@ital.sp.gov.br, katumyot@ital.sp.gov.br*

Abstract

This study evaluated the influence of the application of three types of phytosterols (A- encapsulated pine phytosterol powder; B- oil-based soy phytosterol and C-powder soy phytosterol) in the rheological and sensory properties of dark chocolate. It was observed that the application of phytosterols influenced the rheological properties of the chocolates, mainly the A and C types. On the other hand, the rheological behaviour of the chocolate with B phytosterol was similar to the standard chocolate. In the sensory evaluation, the chocolates with B and C phytosterol showed similar results compared to the standard chocolate in the various attributes tested. Chocolate A presented the lowest acceptance for some of the sensory attributes evaluated.

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Keywords: chocolate, phytosterols, rheological parameters

1. Introduction

Chocolate is a food consumed and enjoyed worldwide by people of varied ages and social classes. It is considered a non-Newtonian fluid, pseudoplastic, and its rheological behavior determines the process conditions adopted industrially [1].

Phytosterols are plant sterols found in vegetables and have proven to be effective in reducing levels of total cholesterol and LDL-cholesterol in humans through inhibition of cholesterol absorption [2]. In a clinical trial with 70 patients with primary hypercholesterolemia, it was shown that consumption of

* Corresponding author. Tel.: +551935213998; fax: +551937431963.
E-mail:efraim@fea.unicamp.br

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chocolate containing 31.5 g of 1.8% of phytosterols was effective in reducing blood LDL-cholesterol and may also reduce the risk of contracting cardiovascular diseases [3].

Studies about the application of phytosterols in chocolate and its influence on sensory characteristics and technological performance are scarce. Thus, this study evaluated the influence of phytosterols in dark chocolate on rheological and sensory properties, in order to obtain products with suitable technological and sensory levels, also providing health benefits.

2. Material and Methods

From a basic formulation containing 55.0% of natural cocoa liquor, 39.9% sugar, 5.0% cocoa butter deodorized and 0.1% of vanilla flavor six samples of chocolate were produced with each type of phytosterol and 6 samples of phytosterol-free chocolate (standard for comparisons), in which the levels of the emulsifiers lecithin and polyglycerol polyricinoleate were varied, as shown in Table 1.

The six experiments were planned so that the total content of emulsifier applied to chocolates was maintained at 0.5% on the total weight of the formulation.

It was used the following commercially available phytosterols in the following amounts:

a. Encapsulated phytosterol powder, obtained from pine, produced by Kerry Ingredients, composed of at least 75% of phytosterols and 25% of Arabic gum (used as cover material in the process of encapsulation) (**named A**), in the quantity of 2.7 g/100g of chocolate;

b. Phytosterol on a lipid basis, obtained from soybean oil, consisting of at least 59% of phytosterols, produced by Cognis (FF 1995) (**named B**), in the quantity of 3.6 g/100g of chocolate;

c. Phytosterol in a powder form obtained from soybean oil, with 100% of free phytosterols, produced by Cognis (FS-M) (**named C**), in the quantity of 2.1 g / 100g of chocolate.

It was defined as the portion of chocolate the amount of 40 g, which were added 0.8 g of free phytosterols (sum of sterols and stanols), as required by the FDA (Food and Drug Administration. Preliminary tests (results not shown) demonstrated not to be technologically feasible to apply higher levels of phytosterols per serving of chocolate.

Table 1. Levels of emulsifiers soy lecithin and polyglycerol polyricinoleate (PGPR) added to the basic formulation of dark chocolate

Test	Soy lecithin [1] (%)	PGPR [2] (%)
1	0.5	0.0
2	0.4	0.1
3	0.3	0.2
4	0.2	0.3
5	0.1	0.4
6	0.0	0.5

[1] Solec CH (Solae)

[2] Grinsted 90 (Danisco Cultor)

The chocolates were produced as shown in Figure 1.

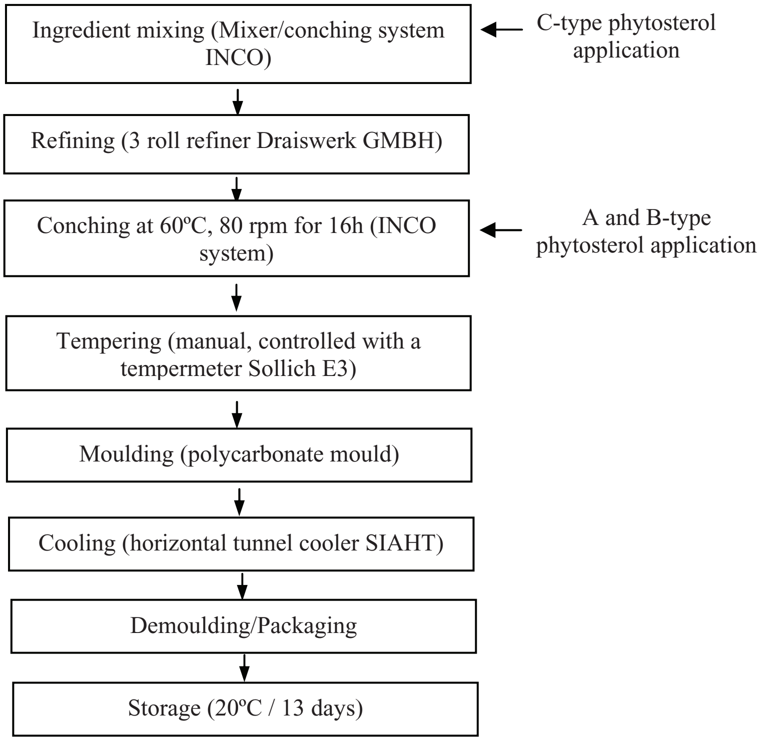


Fig. 1. Flowchart of processing of chocolates with and without phytosterols

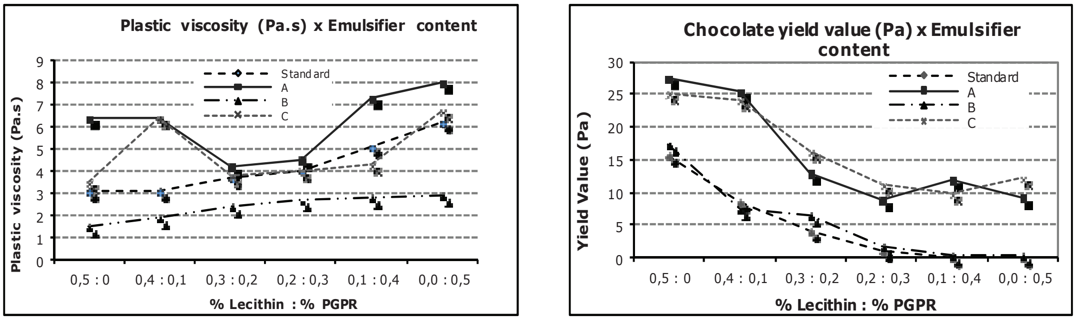
The rheological determinations were performed in a programmable BROOKFIELD RVDV III + rheometer, using a cylindrical spindle S15 [4] coupled to a BROOKFIELD TC 500 bath, for maintaining the temperature at 40 ± 0.5 °C. The measurements were performed in triplicate.

The sensory evaluation consisted of an acceptability test with 60 consumers without restrictions on age, gender and social class [5]. Samples were tested in two sessions, presented in the monadic sequential form according to a balanced block design. It was evaluated: the global acceptability, aroma, flavor, melting in the mouth and the greasy feel in the mouth after consumption, by 9-point hedonic scale (9 = extremely like, 5 = not liked nor disliked and 1 = extremely dislike). It was also evaluated the force required to break the chocolate into the first bite using an ideal scale of 7 points (7 = requires much more strength than I like, 4 = the way I like it = 1 and requires much less force than I like) and purchase intention (5 = definitely would buy, 3 = maybe would/maybe wouldn't buy and 1 = definitely wouldn't buy). The test was conducted in individual booths with fluorescent lighting. Data collection and analysis were performed by the software Compusense Five version 4.8 for sensory evaluation.

For the statistical analysis, data underwent ANOVA and Tukey test to compare means [6].

3. Results and Discussion

The results of the rheological characterization of the chocolates are presented in Figure 2.



(a) (b)

Fig. 2. Casson plastic viscosity and yield value of the chocolates with and without phytosterols after the conching step

The values of Casson plastic viscosity of the B-chocolates were lower compared to those with the phytosterols A and C and also with the Standard, but the rheological behavior of the B-chocolates was similar to that of Standard chocolates. It was observed that increasing the content of soy lecithin and decreasing the percentage of PGPR led to decreased plastic viscosity of Casson and increased levels of PGPR and decreased percentage of lecithin resulted in a reduction of Casson yield value. For the chocolates with the A phytosterol, the higher the content of soy lecithin and the lower the content of PGPR, the smaller the plastic viscosity, and, on the other hand, the higher the content of PGPR and the lower the soy lecithin, the smaller the yield value of chocolates. The A and C-chocolates showed the lower results of plastic viscosity and yield value with the association of the 2 emulsifiers, respectively in the quantity of lecithin:PGPR of 0.3:0.2%; 0.2 :0.3% and 0.1:0.4%.

The chocolates Standard, A, B and C of the test 3 (containing 0.3% of lecithin and 0.2% of PGPR) were sensorially evaluated. The results are presented in Table 2.

Table 2. Results of the sensory evaluation of chocolates by hedonic scale (global acceptability, aroma, flavor, melting in the mouth and greasy feel), ideal scale (force to break the chocolate) and purchase intent

	Chocolates				
	Standard	**A**	**B**	**C**	**M.S.D**
Hedonic scale					
Aroma	7.4 ± 0.8 a	7.0 ± 1.0 a	7.2 ± 1.1 a	7.2 ± 1.1 a	0.53
Flavour	7.5 ± 1.0 a	6.4 ± 1.8 b	7.0 ± 1.6 ab	6.8 ± 1.2 b	0.72
Melting	6.9 ± 0.8 a	6.8 ± 1.5 a	7.3 ± 1.2 a	6.7 ± 1.3 a	0.62
Greasy feel	7.0 ± 1.1 a	6.1 ± 1.9 b	7.1 ± 1.2 a	6.9 ± 1.2 a	0.70
Global acceptability	7.4 ± 1.0 a	6.4 ± 1.6 b	7.0 ± 1.3 a	6.7 ± 1.5 ab	0.65
Purchase Intention	4.1 ± 0.9 a	3.3 ± 1.2 b	4.0 ± 1.1 a	3.7 ± 0.9 a	0.53
Ideal scale					
Force to break the chocolate	5.2 ± 0.9 a	4.9 ± 1.0 a	4.2 ± 0.8 b	5.2 ± 0.8 a	0.43

* Values expressed as mean ± standard deviation.

M.S.D: minimum significant difference at the 5% error level by Tukey test; Samples with equal letter in the same row are not significantly different at a 5% level. In the Table: A= chocolate with encapsulated phytosterol; B= chocolate with oil-based phytosterol; C= chocolate with powdered phytosterol

There was no significant difference between the samples for the acceptability of the aroma and melting; and all of them had averages close to "liked" on the scale used for the evaluation. On the flavor evaluation, the chocolate Standard was the most acceptable, with an average between "liked" and "liked very much," and it did not differ from sample B at a 5% level of significance. Samples A and C were less preferred for flavor than the Standard, and did not differ from sample B. For the sensory attribute "greasy feel," the Standard, B and C samples were better accepted than the sample A. Regarding the global acceptability, the higher averages were obtained for the Standard and B chocolates and the A chocolate had the lowest average. For the purchase intention attribute, chocolates Standard, B and C had the higher positive average, and did not differ among themselves, but were different from the sample A which had the lowest average for this attribute. Concerning the force required to break the chocolate, the sample B was softer than the others, while the samples A and C did not differ from the Standard. This softening effect was possibly caused by the presence of the oil dispersing the phytosterol.

The addition of the oil-based phytosterol (B) did not affect the sensory attributes of dark chocolate and affected positively the plastic viscosity and yield value, reducing their values. On the other hand, the addition of the encapsulated phytosterol (A) affected the sensory acceptability and influenced negatively the plastic viscosity and yield value of the chocolates. The addition of phytosterol in the powder form (C) also influenced negatively the rheological parameters, but did not influence the sensory attributes.

4. Conclusion

It was demonstrated that the different types of phytosterols added to chocolate influenced its sensory properties and its rheological behavior in a different way, but the technological feasibility of the application was also proved. This study will be improved by assessing the shelf-life of the chocolates with the phytosterols and if there is any loss or oxidation of the phytosterols during this period.

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