

## Attempts to improve the functional profile of some artisan chocolate formulas by adding rosehip and carob powder

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**Abstract:** This study deals with designing chocolate formulas under artisanal condition by incorporation in the manufacture recipe carob powder, respectively mixture of carob and rosehip powder, as substitute of cocoa powder. First, six chocolate formulations were prepared by replacing cocoa powder with carob powder at levels of 0% (control sample), 10%, 20%, 30%, 40% and 50% (w/w), then, other three chocolate formulas were prepared with a mixture of carob and rosehip powder as cocoa substitute, i.e. carob 40% and rosehip 10%, carob 30% and rosehip 20% and carob 20% and rosehip 30%. The resulted formulations were investigated versus control sample, in terms of total phenolic content (TP) by Folin-Ciocalteu method, ascorbic acid content (AsAc) by 2,6-dichlorophenolindophenol titrimetric method, and total antioxidant capacity by ferric reducing antioxidant power (FRAP) assay. Regression analyses were performed to correlate TP, respectively TP + AsAc and FRAP value. The results show that by progressively incorporating carob powder into the chocolate formulations, there were incremental increases in the investigated items. Moreover, TP, AsAc and FRAP values were increased more strongly after using carob and rosehip powder mixtures in the recipe. In the case of replacing cocoa powder with 30% rosehip powder and 20% carob, the highest values of antioxidant parameters were recorded. A high positive correlation was detected between TP and FRAP, respectively TP + AsAc and FRAP ( $R^2 > 0.95$ ). These findings support the idea that increased levels of TP and AsAc in chocolate formulas, as a result of the incorporation of carob and rosehip powder, strongly contribute to the increased ferric reducing antioxidant power. The results recommend the use of carob and rosehip powder mixtures to replace up to 50% cocoa, leading to the development of innovative chocolate formulations with improved functional characteristics.

**Key words:** carob powder, rosehip powder, bioactive compounds, total antioxidant capacity, artisan chocolate formulas

### • Introduction

The idea behind this research is that carob powder (*Ceratonia siliqua* L.) and rosehip powder (*Rosa canina* L.) are valuable unconventional materials with a high content of phytochemicals that have the potential to be used as ingredients to improve the functionality of food matrices. Rosehip powder is a rich source of vitamin C, B1, B2, K, carotenoids, pectin, carbohydrates, and organic acids, making it a valuable addition to chocolate. Carob powder, with its superior nutritional benefits compared to cocoa, offers a non-acidic, highly antioxidant, gluten, and lactose-free alternative, particularly suitable for children's nutrition. *Rosa* species pseudo-fruits, notably *Rosa canina* L., are rich in bioactive compounds like vitamin C, phenolics, tannins, tocopherol, lycopene, lutein, zeaxanthin, and other carotenoids, offering a wide range of health benefits including anti-inflammatory, antioxidant, antimicrobial, anti-diabetic, and anticancer properties. Similarly, carob (*Ceratonia siliqua* L.) is a valuable ingredient, packed with sugar, dietary fiber, protein, polyphenolic compounds, and essential minerals. Its cocoa-like flavor and color make it an ideal natural sweetener and cocoa substitute in various food products. This study aims to develop chocolate formulas with enhanced nutritional value and antioxidant function by substituting cocoa powder with carob and rosehip powder.

### • Materials and methods

**Chocolate formulas preparation.** Nine chocolate formulations were prepared in laboratory conditions (Table 1), as follows: C (control sample with 100% cocoa powder), C10 (10% of cocoa powder replace with carob powder), C20 (20% of cocoa powder replace with carob powder); C30 (30% of cocoa powder replace with carob powder), C40 (40% of cocoa powder replace with carob powder), C50 (50% of cocoa powder replace with carob powder), C40R10 (40% of cocoa powder replace with carob powder and 10% with rosehip powder), C30R20 (30% of cocoa powder replace with carob powder and 20% with rosehip powder) and C20R30 (20% of cocoa powder replace with carob powder and 30% with rosehip powder).

**Table 1. The chocolate formulas by incorporation of rosehip and carob powder**

Chocolate formulas	FRAP ( $\mu\text{M Fe}^{2+}/\text{g d.s}$ )	TP (mg GAE/100 g d.s)	AsAc (mg/100 g d.s)
C	26.59±0.21 <sup>ns</sup>	378.71±2.16	n.d
C10	29.91±0.22 <sup>ns</sup>	457.01±2.19 <sup>ns</sup>	3.17±0.12 <sup>*</sup>
C20	33.02±0.25 <sup>ns</sup>	525.35±2.46 <sup>ns</sup>	6.33±0.14 <sup>*</sup>
C30	38.55±0.29 <sup>*</sup>	607.87±3.09 <sup>*</sup>	8.69±0.13 <sup>*</sup>
C40	43.19±0.31 <sup>*</sup>	669.22±3.12 <sup>*</sup>	11.05±0.15 <sup>*</sup>
C50	47.08±0.36 <sup>**</sup>	751.55±3.27 <sup>**</sup>	13.54±0.17 <sup>*</sup>
C40R10	48.75±0.44 <sup>***</sup>	814.41±3.34 <sup>***</sup>	14.02±0.18 <sup>***</sup>
C30R20	50.36±0.49 <sup>***</sup>	863.28±3.47 <sup>***</sup>	16.39±0.22 <sup>***</sup>
C20R30	52.81±0.57 <sup>***</sup>	922.43±3.62 <sup>***</sup>	19.17±0.26 <sup>***</sup>

**Homemade chocolate recipe.** Boiling the water together with the sugar in a small bowl for 6 minutes, until the sugar melts off. Add the butter and stir until the butter melts; turn off the heat, add gradually the dry mixture of milk powder, cocoa, rosehip powder and carob powder and mixed well. Pour the melted chocolate into molds, let it cool and place in the refrigerator for 4 hours. Removed the chocolate from the molds and store in an air tight container at 16-22°C.



### • Results and discussions

Data shown in Table 2 reveal the antioxidant characteristics of rosehip and carob powder used in the chocolate recipe.

**Table 2. Antioxidant characteristics of rosehip and carob powder used in the chocolate recipe**

Antioxidant characteristics	Carob powder (C)	Rosehip powder (R)
TP (mg GAE/100 g d.s)	907.52±2.31	1591.82±3.47 <sup>***</sup>
FRAP ( $\mu\text{M Fe}^{2+}/\text{g d.s}$ )	58.63±1.79	71.76±1.83 <sup>***</sup>
AsAc (mg/100 g d.s)	152.28±1.87	408.34±2.73 <sup>***</sup>

Data in Table 3 present the changes in antioxidant characteristics of chocolate formulas by rosehip and carob powder incorporation in the recipe.

**Table 3. Changes in antioxidant characteristics of chocolate formulas by rosehip and carob powder incorporation in the recipe**

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Data are shown as means, relative to control (C) response recorded in the chocolate formulas. ND – not detected. Statistical differences are shown as follows: ns – non-significant,  $P > 0.05$ ; \* – significant,  $P < 0.05$ ; \*\* – highly significant,  $P < 0.01$ ; \*\*\* – very significant,  $P < 0.001$ .

By adding the carob powder in chocolate formulas, the AsAc content increasing but no significant differences among the chocolate samples (C10-C40). It was found that by addition of rosehip powder in the chocolate samples (C50R10-C20R30) the AsAc increase statistically a very significant. Chemical analysis showed that the addition of rosehip and carob powder in chocolate formulas lead to increase the antioxidant compounds in final product.

A strong positive correlation (the correlation coefficient  $R^2=0.9861$ ) was detected between FRAP values and TP content in chocolate formulas. Moreover, a high correlation (the correlation coefficient  $R^2=0.9862$ ) was noticed between FRAP values and sum of TP content and AsAc content in chocolate formulas.

### • Conclusions

The results showed that adding rosehip powder to chocolate significantly increased its vitamin C and polyphenolic content, enhancing its antioxidant properties. Carob powder can effectively replace cocoa in chocolate production. All samples containing rosehip and carob powder had higher antioxidant compound levels than the control sample. Using locally available rosehips in chocolate production is recommended to diversify chocolate varieties. However, further studies are needed to fully establish chocolate with rosehip and carob powder as functional food.



**Acknowledgement:** The authors acknowledge the technical support and access to the research infrastructure within the Faculty of Food Engineering of the University of Life Sciences "King Mihai I" from Timisoara.