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FORTIFICATION OF BISCUITS WITH CARROT POMACE POWDER IN ORDER TO INCREASE THE NUTRITIONAL VALUE AND ANTIOXIDANT CAPACITY

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Abstract

Carrot pomace powder is stands out by its content in protein, minerals, ß-carotene, vitamin C, B vitamins (vitamin B3, vitamin B6), vitamin E and polyphenols. The aim of this study was to fortify the biscuits with carrot pomace powder, in order to increase their nutritional value and antioxidant capacity. Fortified biscuits have superior sensory qualities and have a complex biochemical composition, being noticed by their protein content (11.22%), total fiber (10.90%), potassium (435.55 mg/100 g), calcium (185.47mg/100 g), magnesium (127.68 mg/100 g), iron (2.26 mg/100 g), zinc (1.72 mg/100 g), total polyphenols (260.75 mg GAE/100 g), β-carotene (1.30 mg/100 g). At the same time, the fortified biscuits with carrot pomace powder have antioxidant capacity: 338.23 mg Trolox/100 g. Due to the addition in the composition of biscuits of dietary fiber with antioxidants, both the increase in nutritional value and the increase in their minimum durability are obtained. The minimum shelf life of fortified biscuits is 25 days. Using differential scanning calorimetry, it was found that fortified biscuits have a lower enthalpy value compared to control biscuits. Thus, it can be concluded that carrot pomace powder delays the starch downgrade (which is equivalent to an increase in shelf life). The fortification of carrot pomace powder biscuits ensures the improvement of their sensory, nutritional quality and microbiological stability.

Key words*: carrot, pomace, powder, biscuits quality, antioxidant capacity.*

INTRODUCTION

Fruit and vegetables are responsible for approximately 22% of food loss and waste along the supply chain. By-products from fruits and vegetables can be capitalized by obtaining flours with a high mineral content, in fibers and bioactive compounds, mainly related to fibers, thus bringing value to the food industry, by creating food products with high nutritional value and antioxidant potential, having beneficial health effects (Santos et al., 2022).

Carrot roots are traditionally used for the preparation of salads and soups, and at the industrial level, to obtain products with high nutritional value, such as juice, carrot concentrate, dry powder, canned carrots (Sharma et al., 2012; Barzee et al., 2019). The yield of carrot juice is quite low, therefore up to 50% of the raw material remains in the form of pomace (Surbhi et al., 2018).

Catana et al. (2019) obtained from carrot waste resulting from the processing of carrots in the form of juice, a functional ingredient like powder that stands out for its mineral content (K: 668.55-704.73 mg/100 g; Ca: 76.85-86.39 mg/100 g; Mg: 27.86-32.56 mg/100 g; Fe: 2.49-2.97 mg/100 g), ash (6.84-7.28%), protein (6.55-6.89%), total sugar (13.65-16.85%), total fiber (47.80-51.67%), vitamin C (13.85-15.63 mg/100 g), β-Carotene (10.70-13.65 mg/100 g), total polyphenols (265.14-295.85 mg/100 g) and have an antioxidant capacity (95.54-103.23 mg Trolox Equivalents/100 g). Sindhu et al. (2016) made an assortment of biscuits with the addition of defatted soy flour and carrot pomace powder and reported that the addition of these functional ingredients caused a significant increase in fiber and β-carotene content of the product.

The biscuits in which 17% defatted soybean flour and 12% carrot pomace powder were

used, have superior sensory qualities and high nutritional value. Also, Aglawe and Bobade (2018) made sweet fried cookies, using in its composition, carrot pomace powder (fortification level 5, 10 and 15%) and defatted soybean flour. Increasing the level of fortification with carrot pomace powder increases the content in protein, ash and total fiber. The sweet fried cookies product made with a 10% fortification level presented superior sensory qualities. Kausar et al. (2018) made a cake fortified with carrot pomace powder (fortification levels (4, 8, 12 and 16%). Fortification of the cake with carrot pomace powder resulted in an increase in ash content (0.42-1.16%), fat (21.43 %-22.64%) and crude fiber (0.2-2.35%). The fortification level of 12% with carrot pomace powder resulted in a cake with superior sensory qualities and high nutritional value.

This paper presents the research undertaken for the fortification of the biscuits with carrot pomace powder, in order to increase their nutritional value and antioxidant capacity.

MATERIALS AND METHODS

Materials

In order to get the product "Biscuits fortified with carrot pomace powder" the following materials were used: whole wheat flour, sugar from coconut flowers, virgin coconut oil (cold pressed), oat flakes, dried fruit, eggs, yogurt, walnut kernels, flax seeds, lemon juice, sodium bicarbonate, natural vanilla and sea salt. The level of fortification with carrot pomace powder was 25% (the reference was made to the amount of whole wheat flour used in the composition of the product).

"Control Biscuits" (C) were not fortified with carrot pomace powder.

Carrot pomace powder was obtained within the Vegetable-Fruit Processing Pilot Experimental Station, from IBA Bucharest (Figure 1).

Figure 1. Carrot pomace powder

The products "Biscuits fortified with carrot pomace powder" and "Control Biscuits" were made in the Cereal and Flour Processing Pilot Experimental Station.

Biscuits-making

The products "Control Biscuits" (C) and "Biscuits fortified with carrot pomace powder" were shaped and their baking was done in a "MONDIAL FORNI-ITALIA" oven for about 27 minutes, at a temperature of 180ºC.

Figures 2 and 3 show these products of "Control Biscuits" (C) and "Biscuits fortified with carrot pomace powder"

Figure 2. "Control biscuits" (C)

Figure 3. Product "Biscuits fortified with carrot pomace powder"

Methods

Statistical Analysis

The biscuits fortified with carrot pomace powder and Control biscuits were analyzed in triplicate. Mean and standard deviation are reported for each analytical parameter studied.

Sensory analysis

The sensory analysis was carried out using the descriptive method and the "Method of comparison with unit score scales" (Burnete et al., 2020).

Instrumental color analysis was performed with a CM-5 colorimeter (Konica Minolta, Japan) equipped with SpectraMagic NX software.

Instrumental texture analysis was performed with Instron Texture Analyzer (model 5944, Illinois Tool Works Inc., USA) equipped with Bluehill 3.13 software.

Physico-chemical analysis

The physico-chemical analysis was carried out using the following methods: ACC 44-15A (moisture content), AOAC 979.09 (protein content), AOAC 963.15 (fat content), AOAC 923.03 (ash content) and AOAC 991.43 (total dietary fiber). The mineral elements were determined by atomic absorption spectrophotometry, after calcination of the samples. β-carotene content was determined by high-performance liquid chromatography Diode-Array Detector (Catană et al., 2020). Energy value (kcal/100 g and kJ/100 g) were calculated according to the Commission Regulation no. 1169/2011 (European Commission, 2011).

Thermal properties

Thermal properties of biscuits were investigated by differential scanning calorimetry (DSC), using DSC 8000 equipment.

The working method included 2 steps: the equilibration step for 1 min at 20°C and the heating step up to 120°C with a heating rate of 10°C/min. Using the thermal analysis program Pyrex Manager, the parameters were calculated: peak temperature (TP) and enthalpy value (ΔH).

Total polyphenol content

Total polyphenol content was performed by Folin-Ciocalteau spectrophotometric method, according to Horszwald and Andlauer (2011), with some modifications (Burnete et al., 2020).

Antioxidant capacity

Antioxidant capacity was performed by DPPH (1,1diphenyl-2-picryl hydrazyl) method, according to Horszwald and Andlauer (2011), with some modifications (Burnete et al., 2020).

Microbiological analysis

Microbiological analysis was performed according to SR ISO 21527-1:2009 (Yeasts and molds) and SR EN ISO 21528-1:2017 method (*Enterobacteriaceae*).

RESULTS AND DISCUSSIONS

Sensory analysis

Following the sensory analysis, it was found that "Biscuits fortified with carrot pomace powder" have a sweet and pleasant, characteristic taste, with natural vanilla aroma, they are well baked and tender. Following the sensory analysis by a panel of 10 tasters, applying the "Comparison method with unitary score scales", the products received the following scores and the qualification "very good": control sample C-20 points, and the product "Biscuits fortified with carrot pomace powder" (Sample-FB), 19.92 points (Figure 4).

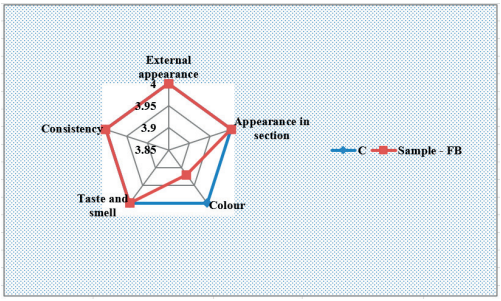

Figure 4. Sensory evaluation of the product "Biscuits fortified with carrot pomace powder" and of the control sample (C)

Textural properties of the products "Biscuits fortified with carrot pomace powder" and "Control biscuits" (C) are presented in Table 1.

Table 1. The textural properties of the product "Biscuits fortified with carrot pomace powder" and the control sample C

Product	Period (days)	Hardness (N)	Brittleness (MPa)
Control (C)	1	2.93 ± 0.10	14.47 ± 1.25
	7	3.99 ± 0.54	16.08 ± 1.41
	14	6.03 ± 1.11	17.95 ± 1.55
	36	7.32 ± 0.46	24.75 ± 1.84
	42	8.19 ± 2.43	28.95 ± 2.12
"Biscuits fortified with carrot pomace powder" (Sample-FB)	1	4.20 ± 0.18	8.08 ± 0.10
	7	6.46 ± 1.15	13.17 ± 0.89
	14	6.71 ± 1.35	16.91 ± 1.48
	36	9.59 ± 0.27	22.38 ± 1.75
	42	11.75± 0,27	23.17 ± 1.78

According to the experimental data we achieved, it causes an increase in hardness and a decrease in brittleness, compared to the control sample (C). Thus, after 42 days from the date of manufacture, the product "Biscuits fortified with carrot pomace powder" recorded values of 11.75 N for hardness and 23.17 MPa for brittleness.

The product "Biscuits fortified with carrot pomace powder" registered a significantly lower value of hardness one day after the date of manufacture (4.20 N), compared to the products "Cookies fortified with raspberry

pomace flour", "Cookies fortified with red currant pomace flour", "Cookies fortified with strawberry pomace flour", which recorded hardness values in the range of 11.88-36.09 N (Tarasevičienė et al., 2021).

Following the instrumental analysis of the color, we found that the fortification of the biscuits with carrot pomace powder causes a darkening of their color, compared to the Control sample (C) (Figure 5). Thus, the product "Biscuits fortified with carrot pomace powder" registered a luminance value (L* = 49.85), lower than that of the Control sample (C). Also, this product recorded the lowest values for the parameters a* (red-green color coordinate) and b* (yellow-blue color coordinate): a* = 9.88 and b*= 18.20.

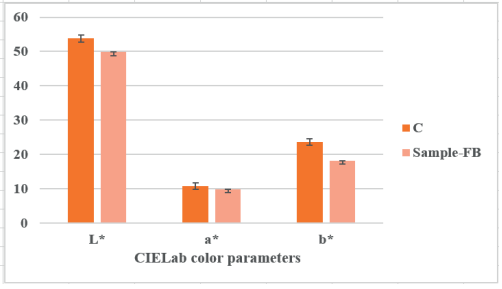

Figure 5. Color parameters of the product "Biscuits fortified with carrot pomace powder" and of the control sample (C)

Physico-chemical analysis

The physico-chemical analysis of the product "Biscuits fortified with carrot pomace powder" is presented in Table 2. Following the physico-chemical analysis, it was found that the fortification of biscuits with carrot pomace powder causes an increase in the content of ash (from 1.86% to 2.25%), fat (from 21.53% to 24.49%), and β-carotene (from 0.02% to 1.30%), in total dietary fiber (from 6.53 to 10.90%) and a decrease in available carbohydrates (from 43.20% to 35.59%).

The product "Biscuits fortified with carrot pomace powder" has a higher protein and fiber content than that reported by *Parveen* et al. (2017) in the case of biscuits fortified with carrot pomace powder (5, 7.5 and 10%) and beetroot pomace powder (1%): protein 7.38-7.95%; crude fiber 3.87-4.17%. Also, at the same time, the biscuits fortified with carrot pomace powder, made in this experimental study, have a significantly lower carbohydrate content (46.49%), compared to that reported by Parveen et al. (2017) in the case of biscuits fortified with carrot and beetroot pomace powder (carbohydrates: 62.09-64.73%).

Table 2. Physico-chemical composition of the product "Biscuits fortified with carrot pomace powder" and of the control sample (C)

Component	C	Sample-FB
Moisture (%)	15.45±0.39	15.64±0.39
Ash (%)	1.86±0.02	2.25±0.02
Protein (%)	11.43±0.10	11.22±0.10
Fat (%)	21.53±0.23	24.49±0.23
Carbohydrates (%)	49.73±0.02	46.49±0.02
Available carbohydrates (%)	43.20±0.01	35.59±0.007
β-carotene (mg/100g)	0.02±0.0003	1.30±0.02
Total dietary fiber (%)	6.53±0.12	10.90±0.20
Energy value (kcal/100g)	425	429
Energy value (kJ/100g)	1778	1788

The high β-carotene content of the product "Biscuits fortified with carrot pomace powder" (1.30 mg/100 g) should be noted. β-carotene (also called pro vitamin A) is a powerful antioxidant that provides protection against numerous conditions, including cancer, arteriosclerosis, cardiovascular disease and ulcers (Knockaert et al., 2012; Syamila et al., 2019). That is why the fortification of food products in general and bakery products in particular with β-carotene from natural sources is of real interest.

Also, the fortification of the biscuits with carrot pomace powder caused an increase in their content in mineral elements. Thus, the product "Biscuits fortified with carrot pomace powder" stands out for its content in mineral elements (Figures 6 and 7): K-445.75 mg/100 g; Ca: 185.47 mg/100 g; Mg: 127.68 mg/100 g; Fe: 2.26 mg/100 g; Zn: 1.72 mg/100 g; Cu: 0.85 mg/100 g.

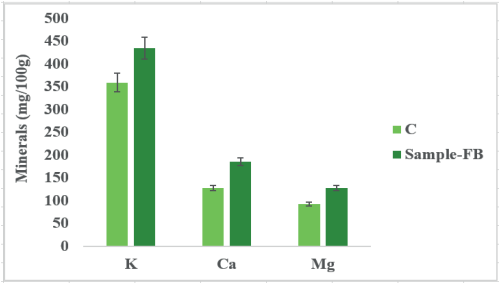

Figure 6. Mineral content (K, Ca and Mg) of the product "Biscuits fortified with carrot pomace powder" and of the control sample (C)

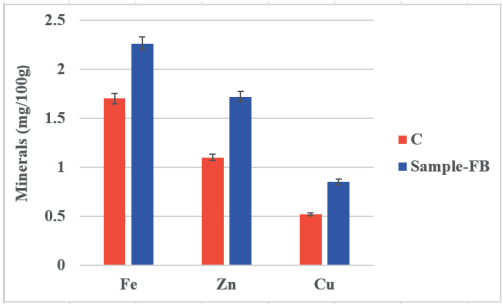

Figure 7. Mineral content (Fe, Zn and Cu) of the product "Biscuits fortified with carrot pomace powder" and of the control sample (C)

The potassium content of the product "Biscuits fortified with carrot pomace powder" is lower than that reported by Catană et al. (2018) in the case of the product "Biscuits with Aronia and cinnamon" (K: 592.16 mg/100 g), and the calcium and magnesium content is higher compared to that reported by these authors (Ca: 158.43 mg/100 g; Mg: 102.90 mg/100 g). At the same time, the iron and zinc content of the "Biscuits with Aronia and cinnamon" product is about 2.5 times and 4.7 times higher, respectively, compared to that of the biscuits fortified with carrot pomace powder, carried out in the framework of the research undertaken in this experimental study.

Thermal properties

The thermal properties of the products "Biscuits Martor" (C) and "Biscuits fortified with carrot pomace powder" were investigated using the differential scanning calorimeter, DSC 8000, 25 days after the date of manufacture. Thus, the peak temperature (TP) and the enthalpy value (ΔH), in the case of the 2 products, are presented in Table 3.

Table 3. Thermal properties of the product "Biscuits fortified with carrot pomace powder" and of the control sample (C)

Product	T_P, °C	ΔH, J/g
Control (C)	56,2	0,78
"Biscuits fortified with carrot pomace powder" (Sample-FB)	55,8	0,60

According to the experimental data we achieved, the fortification of biscuits with pomace powder causes a decrease in the peak temperature and the enthalpy value, compared to biscuits Control (C). Thus, it can be concluded that the fortification of carrot pomace powder delays the degradation of starch, which is equivalent to an increase in the shelf life.

Total polyphenol content

Due to carrot pomace powder fortification and the other ingredients that have a complex biochemical composition (oat flakes, dried fruit, walnut kernels, flax seeds, lemon juice), the product "Biscuits fortified with carrot pomace powder" has a high content of total polyphenols 260.75 mg GAE/100g, about 53% higher than the Control sample (C). In the same time, the total polyphenol content of this product is higher, about 1.4 times higher than that reported by Zlatanović et al. (2019), in the case of cookies fortified with apple pomace flour (fortification level 25%). The product "Biscuits fortified with carrot pomace powder" has a content in total polyphenols, comparable to that reported by Catană et al. (2018), for the "Biscuits with Aronia and ginger" (263.22 mg GAE/100 g).

Biscuits are a product consumed by all categories of consumers, and their fortification in order to increase the nutritional value and bioactive compounds (polyphenols, β-carotene, etc.) is of real interest. Polyphenols represent an important class of phytochemical compounds with multiple effects on human health.

Thus, based on the research undertaken, there are preclinical and clinical evidences, which highlights the fact that diets rich in polyphenols, in the long term, prevent the occurrence of various chronic diseases, such as neurodegenerative diseases, cardiovascular diseases, cancer, diabetes, inflammatory disorders and infectious diseases (Rudrapal et al., 2022).

Antioxidant capacity

Due to the content in bioactive compounds (polyphenols, β-carotene, etc.), the product "Biscuits fortified with carrot pomace powder" has antioxidant capacity: 338.23 mg Trolox/100 g (about 1.4 times more than the control sample).

The product "Biscuits fortified with carrot pomace powder" has an antioxidant capacity comparable to that reported by Catană et al.

(2018), in the case of "Biscuits with Aronia and ginger" (342 mg Trolox/100 g).

Microbiological analysis

The microbiological analysis of the product "Biscuits fortified with carrot pomace powder" and the Control sample (C) is presented in table 4.

Table 4. Microbiological analysis of the product "Biscuits fortified with carrot pomace powder" and of the control sample C

Microbiological indicator	Product			
	Control (C)		"Biscuits fortified with carrot pomace powder" (Sample-FB)	
Yeasts and molds (CFU/g)	24h	< 10	24h	< 10
	10 days	< 10	10 days	< 10
	20 days	< 10	20 days	< 10
	30 days	< 10	30 days	< 10
	40 days	< 10	40 days	< 10
	50 days	-	50 days	< 10
Enterobacteriaceae (CFU/g)	24h	< 10	24h	< 10
	10 days	< 10	10 days	< 10
	20 days	< 10	20 days	< 10
	30 days	< 10	30 days	< 10
	40 days	< 10	40 days	< 10
	50 days	-	50 days	< 10

Following the microbiological analysis of the "Biscuits fortified with carrot pomace powder" product, it was found that it complies with the provisions in force even 50 days after the date of manufacture. The microbiological stability of the product is due to antibacterial activity of carrot pomace powder. Bello et al. (2019) demonstrated that aqueous extract of peel carrot (concentrations 25-200 mg/mL) present bacteristatic action against *S. aureus* and *E. coli*.

Corroborating the results of the microbiological analysis with the sensory results and the results of the instrumental analysis of the texture, the shelf life of the product "Biscuits fortified with carrot pomace powder" was set at 25 days.

CONCLUSIONS

Taking in account the circular economy and the increasing value of added food products, their fortification with carrot pomace powder is of real interest.

Fortifying the biscuits with carrot pomace powder ensures a product with superior sensory qualities, high nutritional value and antioxidant capacity. The product "Biscuits fortified with carrot pomace powder" was appreciated by a panel of 10 tasters, receiving a score of 19.92 points and a "very good" rating.

The product "Biscuits fortified with carrot pomace powder" has a low content in available carbohydrates (46.49%), but a high content in proteins, total fibers, mineral elements (K, Ca, Mg, Fe, Cu Zn), total polyphenols. Also, due to its complex biochemical composition, this product has antioxidant capacity.

The product "Biscuits fortified with carrot pomace powder" according to the provisions of Regulation (EC) NO. 1924/2006 of the European Parliament and of the Council, it is high in fiber because it has a fiber content of more than 6g/100g.

Due to the antibacterial activity of carrot pomace powder, the product "Biscuits fortified with carrot pomace powder" has microbiological stability, with a shelf life of 25 days.

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