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DETERMINATION OF THE NUTRITIONAL COMPOSITION OF CARROT POMACE

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Abstract

Carrot (Daucus carota L.) is one of the most important root vegetables cultivated worldwide, due to its nutritional valueand the phytochemicals content which promotes health. Carrot root is a rich source of carotene, carbohydrates, fiber, minerals, vitamins and other biologically active compounds. The processing of carrot root involves the production of waste such as carrot pomace, which can represent a good source of important nutritional and bioactive compounds. The objective of this work was to evaluate the nutritional content of carrot pomace resulting as a by-product of obtaining carrot juice from carrots sold in local agro-food markets. The results obtained showed that the analyzed dried pomace carrot contains important amounts of nutritional compounds that vary depending on the origin of the carrot: 49.02-53.16% carbohydrates, 25.61-31.88% fiber, 5.48-6.95% minerals (ash), 6.32-7.34% protein, 0.88-1.36% fat. The highest fiber potential was recorded in the case of samples from the batch cultivated in Dudestii Noi, while carrot samples grown in Timisoara recorded the highest intake in proteins, lipids, minerals and carbohydrates. The values of the nutritional parameters suggest the use of dried pomace carrot to obtain products with added nutritional value. The superior use of carrot pomace, as a secondary product, can be an ecological way of limiting the waste resulting from the processing of carrot roots.

Key words*:carrot pomace, nutritional parameters, carrot roots, by-product valorization, waste.*

INTRODUCTION

Carrot (*Daucus carota* L.) among the most important vegetables root cultivated worldwide have attained popularity due to their nutritional value, being rich in nutrients and health-promoting compounds, including minerals, sugars, carotenoids and phenols (Nazar et al., 2023; Šeregelj et al., 2020). They are used fresh or made into juices, beverages, candies, preserves and dehydrated products. Even if carrot roots come in many varieties that vary with size, shape, and color (such as orange, purple, red, white and yellow), orange carrot is the most popular due to its high α- and β-carotene content that contributes to the provitamin A activity (Kamiloglu et al., 2015). Carrot is a significant source of natural bioactive compounds, including phenolics, and carotenoids, as well as ascorbic acid and tocopherols, being classified as a vitaminized food (Surbhi et al., 2018). Due to the presence of an appreciable level of different compounds, the carrot is considered a functional food with significant health-promoting properties: the prevention and therapy of cardiovascular diseases, cancer, diabetes, gastrointestinal diseases, ocular diseases, etc. (Nazar et al., 2023; Šeregelj et al., 2020). Important quantities of these nutritional and bioactive compounds are found in carrot pomace obtained as waste from the processing of carrot roots. On dry weight basis, carrot pomace contains: 4-5% protein, 8-9% reducing sugar, 5-6% minerals, 37-48% dietary fiber, 3.2 mg/g Na, 18.6 mg/g K, 1.8 mg/g P, 3.0 mg/g Ca, 1.1 mg/g Mg, 4.0 mg/g Cu, 10.8 mg/g Mn, 30.5 mg/g Fe, 29.4 mg/g Zn and important contents of vitamin B-complex, vitamin A, tocopherols, and ascorbic acid (Šeregelj et al., 2020). The recovery of these nutritional and bioactive compounds can generate functional ingredients and provide utilization of carrot waste in different food products that confer beneficial effects on human health (Ikram et al., 2024; Nazar et al., 2023; Šeregelj et al., 2020). Previous studies have shown that the composition of carrot pomace, has been studied

by many researchers. The results obtained by different researchers who analyzed the nutritional composition of carrot pomace resulting from the processing of carrot root, will be presented below. Important data regarding the composition of carrot pomace were presented by determining the nutritional profile of carrot pomace powder on fresh/dry weight basis: 83.40 ± 0.23% moisture, 5.83 ± 0.25% protein, 6.17 ± 0.08% ash, 52.73 ± 0.01% total carbohydrates, 42.59 ± 0.01% total dietary fiber. Carrot pomace powder is a promising source of polyphenols and prebiotics for improving good health (Mall and Patel, 2024). Carrot pomace comprises about 4-5% protein, 8-9% sugar, 5-6% minerals and 37-48% total dietary fiber, so the carrot product is a rich source of dietary fiber. In the same study, the dried carrot pomace contains 2.5% moisture, 5.5% ash, 1.3% fat, 0.7% protein, 20.9% crude fiber, 55.8% dietary fiber, 71.6% total carbohydrate (Ikram et al., 2024). Proximate composition of carrot pomace was also determined by Begum et al. (2023) who reported that carrot pomace powder used to obtain the assortment of bread with added nutritional value, contains 9.06% moisture, 6.71% ash, 1.19% raw fat, 13.09% raw fiber , 63.70% raw carbohydrate, 6.46% raw protein, 11.83 mg/100 g β-carotene, 1.53 mg/100 g vitamin C. In a study that propose to characterize the carrot pomace powders from four varieties (Baltimore, Niagara, Belgrado and Sirkana) it was found that carrot pomace powders had high contents of fiber, carbohydrates, ash, and proteins: 20.09-33.34%, 46.55-58.95%, 5.29-5.89%, respectively 6.87-9.14% (Luca et al., 2022). The analysis of carrot pomaces resulting from carrot processing into juice found that the powder of this pomace contains 7.12-7.55% moisture, 6.84-7.28% ash, 6.55-6.89% protein, 1.46-1.78% fat, 47.80-51.67% total fibers and 13.65-16.85% total sugar. The nutritional composition of carrot pomace allowed its use to obtain biscuits with added value. Considering the carrot and pepper waste (damaged, rotten, non-edible parts) the following nutritional parameters was found: <0.01% free fat, 1.52% crude protein, 6.34% total dietary fiber, 8.8% digestible carbohydrate, 7.22% total sugars, 5.24% reducing sugars, 18.8 dry matter and 2.11% total ash (Zhivkova, 2020). During an investigation on the potential of carrot pomace utilization, Sahni and Shere (2017) discover that powder of carrot pomace has the following proximate composition: 6.82% moisture, 1.44% fat, 11.12% raw fiber, 9.85% ash, 15.85% protein, 54.91% carbohydrates. Nutritional profile of carrot pomace reveals the fact that it is a cheap source of dietary fiber, thus justifying its use for fiber enrichment in food products. A high fiber bread was prepared by replacing maximum 4% Maida (super-refined wheat flour used in Indian cuisine to make pastries and other bakery) with carrot peel powder has the following nutritional composition: 8.10% moisture, 5.51% protein, 2.12% fat, 24.06% carbohydrate, 65.16% fiber, 3.15% ash. Study on the nutritional composition, and shelf stability of carrot pomace-incorporated cookies, noted that the incorporation of carrot pomace powder containing 6.54% moisture, 6.50% protein, 14.75% soluble fiber, 30% insoluble fiber, 5.12% ash, 5.456 μg/100 g total carotenoid, 607 μg/100 g β-carotene, contributes with a significant amount of micronutrients and fiber making the product very nutritious (Bellur & Prakash, 2015). The nutritional composition of carrot peels was determined being investigated the effect of adding carrot peel fibers and vitamin A on iron bioavailability in biscuits: 12.47% moisture, 6.09% protein, 2.05% fat, 9.87% fiber, 10.48% ash, 71.5% carbohydrates, 7136.06 μg retinol equivalent (RE)/100 g vitamine A (Khalil et al., 2011). Important values of the nutritional content of carrot pomace attest that these fluor is a good source of dietary fiber: 6.80% moisture, 5.26% ash, 4.93% total protein, 73.00% total dietary fiber, 15.38% soluble dietary fiber and 57.62% insoluble dietary fiber having a great potential to be used as functional ingredients in cookie formulations and to improve nutraceutical properties of cookies (Turksoy & Özkaya, 2011). From those presented above it can be observed that carrot pomace, resulting from the processing of the carrot root, still contains important amounts of nutritional compounds, which it varies within fairly wide limits. This can be explained by the different maturity and varieties, as well as by the different ratios of the anatomical parts in the studied products

(Iegorov et al., 2019). It can also be seen that the residual material left after carrot processing, usually resulting from carrot juice extraction or other processing methods, is a nutritionally rich by-product. The objective of this work was to evaluate the nutritional content of carrot pomace resulting as by-product for obtaining carrot juice from carrots sold in local agricultural markets.

MATERIALS AND METHODS

The analyzed material was composed from the residue (peel + pulp) resulting as waste from obtaining three batches of carrot juice using a fruit juicer. The notion of carrot pomace (identified as CP) designates the material consisting from the carrot peel resulting from peeling and the carrot pulp left after the preparation of carrot juice. The carrot roots were taken from three different agro-food markets located in Timisoara (Romania) and come from local producers in the area bordering Timisoara. Three groups of carrot samples were made up, marked in the text with L1 (cultivated in Timisoara), L2 (cultivated in Varias), L3 (cultivated in Dudestii Noi). For each group were chosen, random between 600-700 g carrot root. Before use, the carrot roots were cleaned by washing with tap water, rinsed with distilled water and dried by blotting with filter paper. The solid pulp left after squeezing the juice together with the peel resulting from peeling the carrot root (Figure 1) were dried in an oven at 60°C for 24 hours.

Figure 1. Fresh carrot pomace: peel and pulp, remaining after squeezing the carrot juice

The dried pulp and peel (Figure 2) were homogenized and ground using a kitchen grinder.

Figure 2. The dried carrot pomace: the peel and pulp

The homogeneous dry powder obtained in this way (Figure 3), corresponding to the carrot lots: L1, L2 and L3, was used to determine the concentrations of the nutritional parameters.

Figure 3. Dried carrot pomace powder

Determination of nutritional parameters of carrot pomace: moisture, fat, protein, ash, were performed in accordance with the AOAC (2006) method guidelines. AOAC method no. 925.05 was used to determine fat and ash, while methods no. 925.10 and no. 925.36 were used to determine moisture and protein content respectively. Briefly, moisture contents were determined by drying in the drying chamber (BINDER GmbH, Tuttlingen, Germany) at 105 °C up to a constant mass. Ash content of dried carrot pomace was determined, through the calcination method, at 550°C usingthe calcination furnace (Nabertherm Lilienthal, Germany). Protein content was determined by the Kjeldahl method using a KjeltecTM 8400/8420/8460 FOSS equipment. Digestion of the sample was carried out with sulfuric acid and potassium sulfate. After digestion and dilution with water, the sample was distilled in alkaline medium (NaOH), thus releasing ammonia which was quantified by titration with a standardized acid solution in the presence of colorimetric indicators methyl red and bromocresol green. The crude fat was determined using the Soxhlet method using hexane as extraction solvent and Soxtest Raypa SX-6 MP equipment at 75°C and an extraction

time of 50 minutes. Crude fibers were determined by using the Foss method (Fibertec™ 2010 Automated Crude & Detergent Fibre Solution) according AOAC 978.10 procedure. The method involves crude fibre determination by boiling the sample in acid hydrolysis with 1.25% H_2SO_4 for the extraction of sugars and starch, followed by alkaline hydrolysis with 1.25% NaOH, which removes proteins. and some hemi-cellulose and lignin. The organic substance remaining after this treatment is the crude fiber. The carbohydrate content was calculated by difference, applying the equation: Carbohydrates (%) = 100 - (protein + fat + ash + fiber + moisture) (Luca et al., 2022). The determinations were made in triplicate.

RESULTS AND DISCUSSIONS

The results obtained for the determination of moisture, ash, protein, fat, fiber and carbohydrate concentrations from the analyzed carrot pomace samples are presented in Table 1. The data presented in this table show that the analyzed dried pomace carrot contains important amounts of nutritional compounds which varies depending on the provenience of the analysed carrot lots and the nature of the analyzed parameter. The moisture content of carrot pomace provides data on the water content of the analyzed product,respectively the organic and inorganic dry substance content. A higher moisture content contributes to decreasing of the storage period, respectively to the loss of pomace powders quality attributes. The moisture content of carrot pomace, experimentally determined have low contents, between 6.28-7.12%. These values allow preservation, under normal weather conditions, for an acceptable period of time. The highest content was determined in L2 group, and the lowest in L1. Comparing the carrot pomace moisture values obtained experimentally with those reported in previous studies, it can be seen that they are comparable to those reported: 7.6% - in pomace powder, in the range 7.12-7.65% - in powders from carrot wastes, 6.80% - in carrot peel powder, 6.64% - in carrot pomace (Sahni and Shere, 2017; Luca et al., 2019; Turksoy and Özkaya, 2011; Bellur and Prakash, 2015). Lower humidity values were obtained: 3.78-5.91% - in carrot pomace powders, respectively 2.5% - in carrot pomace (Luca et al., 2022; Nazar et al., 2023).

The composition of carrot root,, reported by other authors, highlighted the following values: 9.58 g/100 g carbohydrates, 0.93 g/ 100 g protein, 0.24 g/100 g fat, 2.80 g/100 g fiber, 4.74 g/100 g total sugars (of which 3.59 g/100 g sucrose, 0.59 g/100g glucose and 0.55 g/100 g fructose (Ikram et al., 2024).

The ash content, respectively the inorganic matter content is a measure of the mineral amount contained in the analyzed product (Velciov et al., 2022). A high ash content shows increased concentrations of essential mineral elements that have numerous health benefits including tissue maintenance, bone and teeth formation and health, serving as cofactors and coenzymes to enhancing various enzyme systems, adding the regulation and coordination of most body functions, and other biochemical and physiological functions (Godswill et al., 2020). The carrot pomace samples taken in the experiment show important mineral contents, presenting values between 5.48-6.95%. It can be observed that the highest ash concentrations were determinated in the L1 group (6.95 ± 0.60%) and the small ones in the L2 group (5.48 ± 0.45%). These values confirm that carrot pomace is a valuable source of macro

Table 1. The concentrations of nutritional parameters of carrot pomace powder (mean values in triplates)

Specification	Parameter values (%)					
	Moisture	Ash	Protein	Fats	Fibers	Carbohydrate
Group 1 (L1)	6.28±0.40	6.95±0.60	7.34±0.80	1.36±0.16	25.61±1.521	53.16±1.87
Group 2 (L2)	7.12±0.53	5.48±0.45	6.32±0.49	0.88±0.12	31.88±1.52	49.02±1.31
Group 3 (L3)	6.52±0.42	6.34±0.49	6.45±0.51	1.23±0.19	29.76±1.33	52.11±1.85

and microelements (Ikram et al., 2024; Surbhi et al., 2018). The analyzed carrot pomace could be used as an addition in foods that it improves their nutritional quality and completes the content of mineral elements such as manganese, iron, potassium and zinc. Comparing the obtained values with those reported by other authors it can be seen that

they are comparable to those reported: 5-6% - in carrot pomace (Ikram et al., 2024) ; 6.17% - in carrot pomace powder (Mall and Patel, 2024); 6.71% - in carrot pomace powder (Begum et al., 2023) ; between 5.29-5.89% - in carrot pomace powders (Luca et al., 2022); 6.84-7.78% - in powders from carrot wastes (Catana et al., 2019) and 6.38% – in carrot pomace (Sahni and Shere, 2017). Lower values of the ash content: 3.15% - in carrot pomace powder and 5.12% - in carrot pomace were determined (Kamaliya et al., 2020; Bellur & Prakash, 2015). Higher values 7.29% and much higher 10.48% were reported by other authors (Ikram et al., 2024; Khalil et al., 2011). **Proteins,** the main source of amino acids and nitrogen, are irreplaceable nutrients for human food because they are involved in all physiological functions (Ivanović et al., 2023). Although most plant proteins provide the necessary amounts of essential amino acids for human needs, plant proteins are often recognized as incomplete or nutritionally inferior to animal proteins (Sá et al., 2020). However, the protein contents determined in the analyzed carrot pomace are valuable compounds in human nutrition. The analyzed carrot pomace show values between 6.32-7.34%. Highest protein percentage values were find out in L1 (7.34 ± 0.80%), lower values were determined in groups L3 and L2 (6.45 ± 0.51% and 6.32 ± 0.49%). These values are close to those established: 6.46% - in carrot powder, 6.87-9.14% – in carrot pomace powder, 6.55-6.89% in carrot powder wastes and 6.50% - in carrot pomace powder (Begum et al., 2023; Luca et al., 2022; Catană et al., 2019; Bellur et al., 2015). Lower values were found out: 5.83% - in carrot pomace powder, 0.7% - in carrot pomace, 6.09% and respectively 4.93% - in carrot pomace powder (Mall et al., 2024; Nazar et al., 2023; Kamaliya et al., 2020; Turksoy and Özkayan, 2011). The protein content, as well as other nutritional and biologically active compounds, make it possible to use the analyzed carrot pomace powder to fortify bakery and pastry products. Fat**,** a dietary macronutrient, gives foods their unique flavor and texture. This essential macronutrient, the most energy dense nutrient, helps absorb and transport carotenoids and fat-soluble vitamins being an essential component of cell membranes (Velciov et al., 2022). Even if the analyzed carrot pomace has lower fat contents, they are used as an additive to improve the formulation of cakes (Ikram et al., 2024). The analyzed samples of carrot pomace powder contain low and relatively close amounts of fats, the values being between 0.88-1.36%. The values of the fat content obtained in the analysis of carrot pomace taken in this study are lower than: 2.12% - in carrot pomace powder, 3.48% - in carrot pomace, 2.05% - in carrot peel (Kamaliya et al., 2020; Sahni and Shere, 2017; Khalil et al., 2011). Values close to those obtained in this study were determined: 1.3% - in carrot pomace, 1.19% - carrot pomace, through 0.70-1.13% - in carrot pomace powder and have slightly lower values than those obtained between 1.46-1.78% - in carrot powder wastes (Nazar et al., 2023; Begum et al., 2023; Luca et al., 2022; Catana et al., 2019). Dietary fibers are the edible parts of fruits and vegetables that are resistant to hydrolysis by digestive enzymes (Šeregelj et al., 2020). Dietary fibers are necessary for the body, because they help reduce the risk of many cancers, cardiovascular diseases and other gastrointestinal problems (Nazar et al., 2024). Carrot pomace is an excellent source of dietary fiber, soluble and insoluble fibers, which contributes to improved digestive health and satiety (Ikram et al., 2024). On a dry weight basis, the composition of dietary fiber includes carrot pomace as cellulose (51.6%), lignin (32.1%), hemicellulose (12.3%), and pectin (3.88 %) (Nazar et al., 2024). The results obtained from the analysis of carrot pomace (Table 1) showed increased amounts of dietary fibers, between: 49.02-53.16%. Higher and relatively close values were determined in the L1 and L3 lots (53.16 ± 1.87%, respectively 52.11 ± 1.85%). The values of fiber concentrations in carrot pomace are found between the limits: 28.29-33.34% - in carrot pomace (Luca et al., 2022) but they are smaller than those reported 69.85% - in carrot pomace powder (Ikram et al., 2024), 42.59% - in carrot pomace powder (Mall, et al., 2024), 71.62% - in carrot pomace (Kamaliya et al., 2020) and higher than the value determined: 17.94% in carrot pomace (Sahni and Shere, 2017). These data show that the analyzed carrot pomace powder can be considered as a source of dietary

fiber. Carbohydrates are one of the three macronutrients in the human diet, along with protein and fat, playing an important role in energy and plastic metabolism (Barnokhon et al., 2022). They act as an energy source, help control blood glucose and insulin metabolism, participate in cholesterol and triglyceride metabolism, and help with fermentation (Holesh et al., 2023). Previous studies reveal that carrot pomace contains considerable amounts of carbohydrates (Luca et al., 2022). Significant amounts of carbohydrates and relatively close were also identified in the analyzed carrot pomace samples, the concentration limits being between: 25.61-53.16%. It can be observed slightly higher carbohydrate concentrations in pomace carrots group L1 (53.16 ± 1.87%) and L2 (52.11 ± 1.85%) in comparison with the carbohydrate content of L3 group. Comparing the values of the carbohydrate content determined in this study with the values reported by different researchers it can be stated that these are positioned within the range of 46.55-58.95% - in carrot pomace and have lower values than 71.6% (Luca et al., 2022; Nazar et al., 2023). As a conclusion to the experimental results of the nutritional parameters of carrot pomace taken in the experiment, it can be stated that the analyzed carrot pomace powder contains important amounts of fibers, minerals, protein, carbohydrates and low amounts of fat.

CONCLUSIONS

Carrot pomace obtained as a by-product from the industrial processing of carrot roots contains significant amounts of nutritional and biologically active compounds, important for a good health. The experimental results obtained from the analysis of carrot pomace (6.28-7.12% moisture, 5.48-6.95% ash, 6.32-7.3% protein, 0.88-1.36% fat, 25.61-31.88% fiber and 49.02-53.16% carbohydrates) shows that it contains important amounts of nutritional products. The powder of analyzed pomace carrot is characterized by important contents of fibers, minerals, protein, carbohydrates and reduced amounts of fat, depending on the provenience of the analyzed carrot lots and the nature of the analyzed parameter. Group L1, cultivated in Timisoara, was distinguished by the highest content of protein, lipid, carbohydrates and minerals, while group L3, cultivated in Dudestii Noi, is rich in fiber, compared to the other samples analyzed. These nutritional values and the previous scientific research show that carrot pomace obtained from carrot root, after a preliminary processing, can be considered as an additive for improving the quality of some foods, respectively utilized in the development of healthy food. Also, the superior use of carrot pomace, as a secondary product, can be an ecological way of limiting the waste resulting from the processing of carrot roots.

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