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RESEARCH ARTICLE

Evaluation of phenolic acid, total phenolic content, antioxidant capacity and *in-vitro* simulated bioaccessibility of healthy snack: Aromatized pumpkin chips

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ABSTRACT

Pumpkin (*Cucurbita moschata* Duch.) is a vegetable which has positive effects on health due to its valuable nutrients and can therefore be used as a functional snack food. The objective of this study was to investigate the total phenolic contents, antioxidant capacities, *in-vitro* bioaccessibilities, and phenolic acids of pumpkin chips (PCs) supplemented with some aromatizing spices (cinnamon and ginger). According to the results, especially PCs aromatized with spices are rich in terms of phenolic content, antioxidant capacities and bioaccessibility. Within the phenolic acids, the *p*-hydroxybenzoic is the predominant phenolic acid in the PCs. The results of this research revealed that PCs were a functional snack thanks to their high antioxidant capacities, phenolic content, and their bioaccessibility. In addition, cinnamon and ginger further increased the functional properties of PCs. It is consequently thought that aromatized PCs could be an excellent alternative snack food for people from all ages.

Keywords: Antioxidant capacity; Bioaccessibility; Chips; Phenolic acid; Pumpkin; Snack food

INTRODUCTION

People assume that snack foods, such as chips, cookies, crackers, chocolates and candies, are enjoyable food products. These snack foods are consumed by people to have a good time. As in the examples, snack foods contain large amounts of refined sugar, salt and fat. Improvements in food science and technology facilitate the production of functional foods. In this context, as reported by Monteiro et al. (2020), healthy, natural, and appropriated snack foods are a trend in the world market. Thus, it is required to have new sources of functional characteristics in addition to other nutritive and natural materials. At this stage, fruits and vegetables have a very important role. Fruit snacks are an important part of the daily diet, which can help rising consumer demand for healthier food (Feng et al., 2021).

In general, while fat or oil is used as a fixative agent to flavour snack foods and salts are used on the snack surface. High-caloric value and lipid quantities, as well as low protein and fibre content, occur due to the production process of the classic snack (Capriles et al., 2007). Most of the diseases, such as cardiovascular diseases (Prospective Studies Collaboration, 2007), obesity, and type II diabetes (Hu et al., 2001), are believed to be induced by fat consumption. For this reason, the consumption of fat and salt should be restricted.

Five major species, which are *C. moschata, C. maxima, C. pepo, C. argyrosperma*, and *C. ficifolia,* belong to the genus of Cucurbita. Among them, *C. moschata* and *C. maxima* are widely cultivated in many parts of the world (Khalid Abbas et al., 2020). In this respect, pumpkin is a plant which has been used frequently as a functional food or medicine (Saganuwan, 2009) in many places. Pumpkin is a valuable source of vitamins, minerals, carotene, and pectin and includes bioactive substances such as phenolic compounds and terpenoids. Saura-Calixto et al. (2000) informed that pumpkin had higher dietary fibre contents compared to banana, potato, apple, and orange. In this context, pumpkin snacks are a rich source of dietary

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antioxidants just like polyphenols and β-carotene that play an important role in decreasing the risk of many chronic diseases.

For many years, spices have extensively been utilized as food flavourings, seasonings and preservatives and sometimes as medicine worldwide (Dearlove et al., 2008). For this reason, it is recommended that non-allergic individuals consume spices in their diets. Cinnamon has lots of pharmacological effects such as the excitation of the digestive system, the excitation of hypolipidemic effects, and antioxidant, anti-inflammatory, antifungal, antimutagenic, and anticarcinogenic activities (Jayaprakasha et al., 2007). Ginger is one of the most frequently used spices types. For centuries, ginger has been used as an important medicine for treating colds, nervous system disorders, gingival infections, tooth-aches, asthma, paralysis, constipation, and diabetes (Ali et al., 2008). Ginger contains antioxidants which have anti-inflammatory and anticarcinogenic effects upon phytochemicals (Stoilova et al., 2007).

As Jaworska et al. (2019) stated, crisp snacks mostly correlated with unhealthy food can be enriched with healthy additives. Due to the fact that pumpkin contains bioactive phenolic compounds, pumpkin consumption is recognized for its potential benefits on human health. In the present study, with the production of the aromatized PCs, aimed to produce an alternative snack and functional food for consumers. For this purpose, ginger and cinnamon were used to aromatize the pumpkin slices. At the same time, the PCs were produced by air drying in contrast to similar products made by frying in oil. Another novelty of this study is that; there is insufficient knowledge in the literature on the health-promoting phenolics, antioxidant capacity and bioaccessibility of PCs. Therefore, this study also aimed to investigate the TPC, antioxidant capacity, bioaccessibility, and phenolic acids of PCs.

MATERIALS AND METHODS

Materials

Pumpkin (*Cucurbita moschata* Duch.) was collected from a local field in Bursa, Turkey and stored in a cool room temperature prior to the analyses. Commercially available ginger and cinnamon were also purchased from a regional herbalist in the same city.

Methods

Chemicals

p-hydroxybenzoic acid, *p*-coumaric acid, chlorogenic acid, caffeic acid, ferulic acid, gallic acid, sinapic acid, and syringic acid were analytically graded (Sigma-Aldrich Chemical Co. LLC).

Preparation of pumpkin chips

Production stages of PCs are given in Fig. 1. Briefly, in the production of the aromatized PCs, pumpkins were washed carefully under running water to remove surface contaminants and cut into pieces to remove seeds, and then shells were peeled off. The fruit flesh of the pumpkin was cut into thin slices (2 mm thickness) using the kitchen robot for uniformity. The PCs were aromatized by different spices (cinnamon and ginger). The rate of the spices used was 1%. Cinnamon and ginger in powder form were mixed to stick to the pumpkin slices. The spices were not added to the control sample. These oil-free and salt-free thin pumpkin slices were dried in a dryer with a hot air oven at 70 °C for 70 minutes until 10-12% humidity and then cooled to room temperature. The aromatized PCs were stored in an airtight container to avoid the absorption of the moisture. The following codes were used to name the samples: PC for pumpkin chips (control); PC-C for pumpkin chips with cinnamon; and PC-G for pumpkin chips with ginger.

Extraction for extractable and hydrolysable phenolic compounds

The extractable and hydrolysable phenolics were determined based on a protocol described by Vitali et al. (2009) with minor modifications. For the extractable phenolic compounds, the following procedure was followed. First, to obtain the PCs powder, the PCs were ground by using a coffee grinder and sieved through a 212 µm sieve. The 20 mL

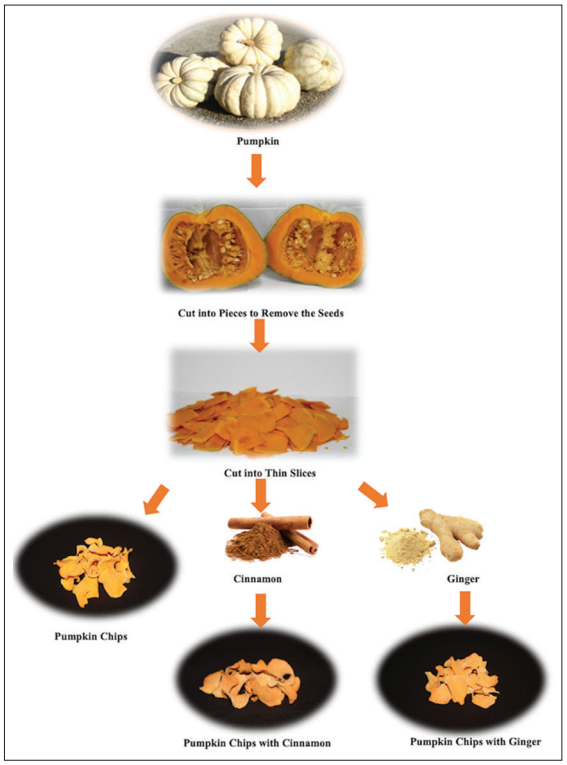

Fig 1. Production stages of pumpkin chips.

mixture of HCl conc./methanol/water (1/80/10,v/v/v) was added to 2 g sample and mixed with a rotary shaker (JB50-D, China P.R.) at 250 g for 2 h at 20 °C. At the end of the time, the mixture was centrifuged at 4 °C for 10 min at 3500 g in a centrifuge (Sigma 3K30, Germany). The supernatants which were separated from the extractable phenolic content were stored at -20 °C (in dark condition) until the experiments were carried out. To insulate the hydrolysable phenolics, the residues which were obtained from the extractable phenolics, were used. The residues were combined with the 20 mL mixture of methanol/H_2SO_4conc. (10/1) and held in the water bath (at 85 °C) for 20 h. At the end of the time, the samples were cooled at room temperature and centrifuged at 4 °C for 10 min at 3500 g in a centrifuge (Sigma 3K30, Germany). The supernatants of the extractable and hydrolysable phenolics were kept in the dark at -20 °C until the analyses were carried out.

Determination of total phenolic contents

The Folin-Ciocalteu colorimetric method was used for the determination of the extractable and hydrolysable phenolics, as defined by Naczk and Shahidi (2004) with minor modifications. The total phenolic content (TPC) was estimated as the sum of the extractable and hydrolysable phenolics of each sample. The absorbance of the PCs was measured spectrophotometrically at 750 nm wave length, and the results were expressed as mg gallic acid equivalents (mg GAE/100g).

Determination of antioxidant capacity

Due to the complexity of the composition of plant materials and possible reactions between them, the antioxidant capacity could not be evaluated using only one method (Valadez-Caemona et al., 2016). Therefore, in the present study, the antioxidant capacity (extractable and hydrolysable phenolics) of the PCs were studied using the four complementary methods. These methods were 2,2´-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) radical cation assay ($ABTS^{\bullet+}$), cupric ion reducing antioxidant capacity assay (CUPRAC) (Apak et al., 2007), 1,1-diphenyl-2-picrylhydrazyl free radical scavenging assay ($DPPH^{\bullet}$) (Brand-Williams et al., 1995) and ferric reducing antioxidant capacity assay (FRAP) (Benzie and Strain, 1996). The absorbance of the $ABTS^{\bullet+}$, CUPRAC, $DPPH^{\bullet}$ and FRAP methods was measured at 734, 450, 517 and 595 nm, respectively, by using UV-Vis spectrophotometer (Shimadzu, Japan). All the assays were run in triplicate, and the results were presented in terms of micromoles Trolox Equivalent (TE) per kg of dw (μmol TE/kg).

In-vitro bioaccessibilities of phenolics and antioxidants from pumpkin chips

The *in-vitro* digestion enzymatic extraction method was used in order to mimic the conditions in the human gastric and gastrointestinal tract, as previously described by Bouayed et al. (2012) with minor modifications. For the simulation of the gastric digestion, first of all, 1.0 g of ground PCs was mixed with 10 mL pure water and 0.5 mL of pepsin (20 g/L in 0.1 mol/L HCl) and incubated for 1 h, at 37 °C in a shaking water bath. At the end of the process, in order to mimic the intestinal digestion, pH was adjusted to 7.2. Further intestinal-simulated digestion was performed with the addition of 2.5 mL of bile/pancreatin solution (2.0 g/L of pancreatin and 12 g/L of bile salt in 0.1 mol/L $NaHCO_3$) and 2.5 mL of NaCl/KCl (120 mmol/L NaCl and 5 mmol/L KCl), and the samples were kept in a shaking water bath at 37 °C for 2.5 h. At the end of the time, the samples were centrifuged at 3500 g for 10 min, and the supernatant was separated and stored -18 °C until the analyses were carried out for the determination of bioaccessible phenolics. The TPC analysis was performed in the supernatant obtained as a result of the simulation of the gastrointestinal digestion. The supernatant obtained as a result of *in-vitro* digestion were used to calculate the total phenolic compounds symbolizing the bioaccessible phenolics. The percentage of bioaccessibility was also estimated by the ratio of bioaccessible phenolics to the TPC in the PCs before digestion.

The bioaccessible antioxidant capacity of each supernatant obtained as a result of simulated gastrointestinal digestions were analysed by the $ABTS^{\bullet+}$, CUPRAC (Apak et al., 2007), $DPPH^{\bullet}$ (Brand-Williams et al., 1995) and FRAP assays (Benzie and Strain, 1996). The results were given as mg GAE/kg and μmol TE/kg, respectively, for phenolic content and antioxidant capacity. Thus, the antioxidant capacity collected in the supernatant obtained from *in-vitro* digestion estimated and symbolized the bioaccessible antioxidant capacity. The bioaccessibility percentage was estimated by the ratio of bioaccessible antioxidant capacity to antioxidant capacity in the PCs before digestion.

Determination of phenolic acids

The phenolic acids of the PCs were analysed according to the approved procedures in High-Performance Liquid Chromatography (HPLC) elution conditions with minor modifications (Naczk and Shahidi, 2004; Mattilla et al., 2007). The HPLC chromatography system was equipped with the diode-array detector (DAD) and a reversed-phase C_{18} column (250 x 4.6 mm inner diameter 2.5 μm) (Perkin Elmer ODS). The column was employed at 30 °C to perform the analyses of phenolic acids. Source parameters were optimized to provide the highest sensitivity. The mobile phase consisted of a mixture of Solution A (40% of acetonitrile) and Solution B (2% of acetic acid). The conditions of elution were applied as follows: 0-15 min, 100% B; 15-30 min 85-100% B; 30-40 min 75-85% B; 40-50 min 50-75% B; 50-55 min 50% B; 55-60 min 50-

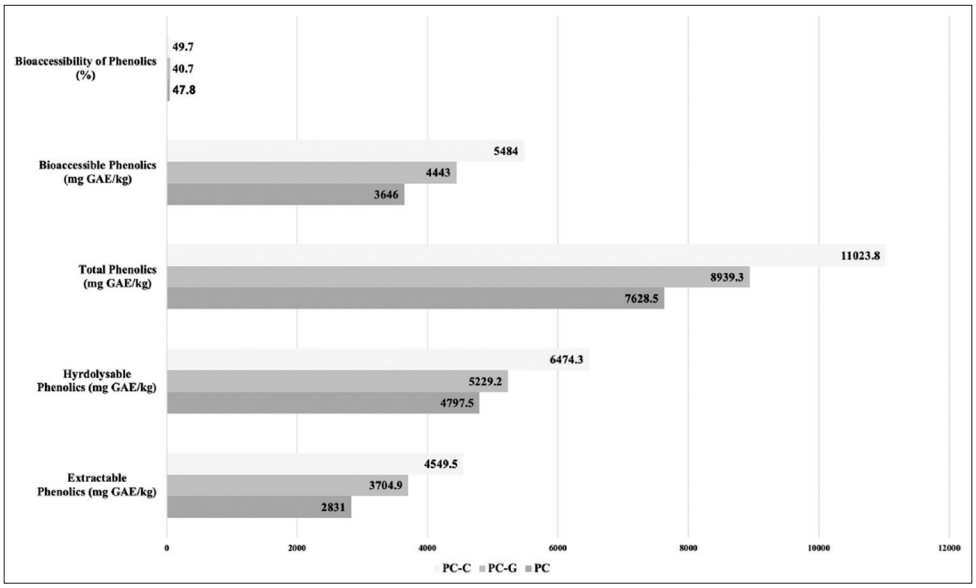

Fig 2. Phenolic contents of pumpkin chips and their bioaccessibilities. PC: Pumpkin chips; PC-C: Pumpkin chips with cinnamon; PC-G: Pumpkin chips with ginger".

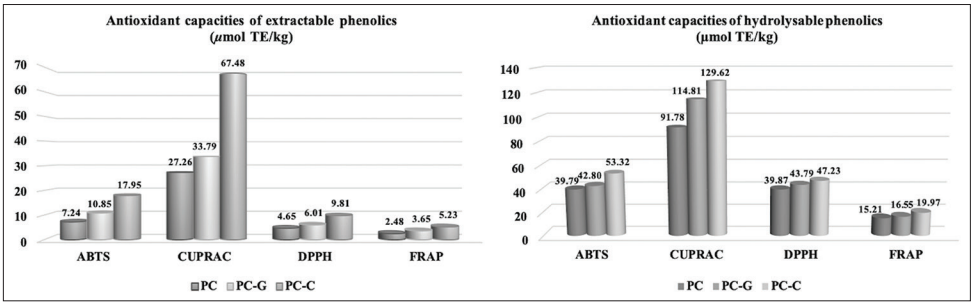

Fig 3. Extractable and hydrolysable antioxidant capacities of pumpkin chips..

100 % B; 60-70 min 100% A; 70 min 100% B. Before the following injection, 6 min post-time was applied. The total running time of the analyses, including the washing and reconditioning of the column, was 70 min. 10 µL volume was used for injection, and the flux ratio was adjusted to 1 mL/min at room temperature. The total period of a single run was also adjusted at 40 min. The retention times of the external standards were compared with compounds to identify the components. All standards (purchased from Sigma) were preconditioned as stock solutions at 2 mg/mL dissolved in methanol, and they were stored at -18 °C in dark conditions. The wavelengths used for the measurement of phenolic acids with the DAD were: 254 nm (*p*-hydroxybenzoic acid), 270 nm (gallic acid), 280 nm (syringic acid and *p*-coumaric acid) and 329 nm (chlorogenic acid, caffeic acid, ferulic acid and sinapic acid). The calibration curves were estimated based upon the linear correlation between the concentrations of standards. The concentrations of phenolic acids identified in the PCs extracts were within the limits of the calibration curves. All the measurements were based on peak area.

Colour measurement

The colour values were measured using a colorimeter (CR 400, Minolta, Japan). The standard white plate was used to calibrate the colorimeter before the measurement. The dimension *L*∗ means lightness, *a*∗ indicates redness, *b*∗ indicates yellowness. Each experiment was conducted in duplicate.

Sensory evaluation

The sensory characteristics of the aromatized pumpkin chips were evaluated by twenty semi-trained panellists. The samples were served to the panellists in an incidental order to guard against any bias. Water at room temperature was served to panellist to clear the mouth before each test sample. The aromatized chips were evaluated in terms of colour, flavour, taste, crunchiness and overall acceptability based on a nine-point hedonic scale (9-like extremely, 8-like very much, 7-like moderately, 6-like slightly, 5-neither like or dislike, 4-dislike slightly, 3-dislike moderately, 2-dislike very much, and 1-dislike extremely). Final judgement was calculated by averaging the scores given by all the panellists.

Statistical analysis

Means and standard deviations were estimated with the JMP IN 7.0.0 (SAS, Cary, North Carolina, USA) software. All the data obtained from three replicates and mean values were reported. Differences were considered to be significant at $p<0.05$, and the least significant difference (LSD) test was used to specify the differences among the mean values.

RESULTS AND DISCUSSION

Total phenolic contents and their bioaccessibilities

The results regarding the total phenolics and their bioaccessibilities are presented in Fig. 2. The results showed that the aromatization process with spices had a favourable effect on the levels of the extractable phenolic, hydrolysable phenolic and TPC of the PCs. The spice application resulted in a statistically significant increase ($p<0.05$) in the extractable phenolic, hydrolysable phenolic and TPC among different PC samples. This result may be due to the high phenolic content of ginger and cinnamon.

The extractable phenolics of the PCs ranged from 2831 to 4549.5 mg GAE/kg dw. The hydrolysable phenolics of the PCs changed between 4797.5 to 6474.3 mg GAE/kg dw. The TPC of the PCs ranged from 7628.5 to 11023.8 mg GAE/kg dw (Fig. 2). There were statistically significant ($p<0.05$) differences determined between the TPC of the extractable and hydrolysable phenolics. It was also clearly seen from the results that the hydrolysable phenolic content was higher than the extractable phenolic content. However, in a study conducted by Kita et al. (2014), it was observed that these values were much lower in potato chips. The

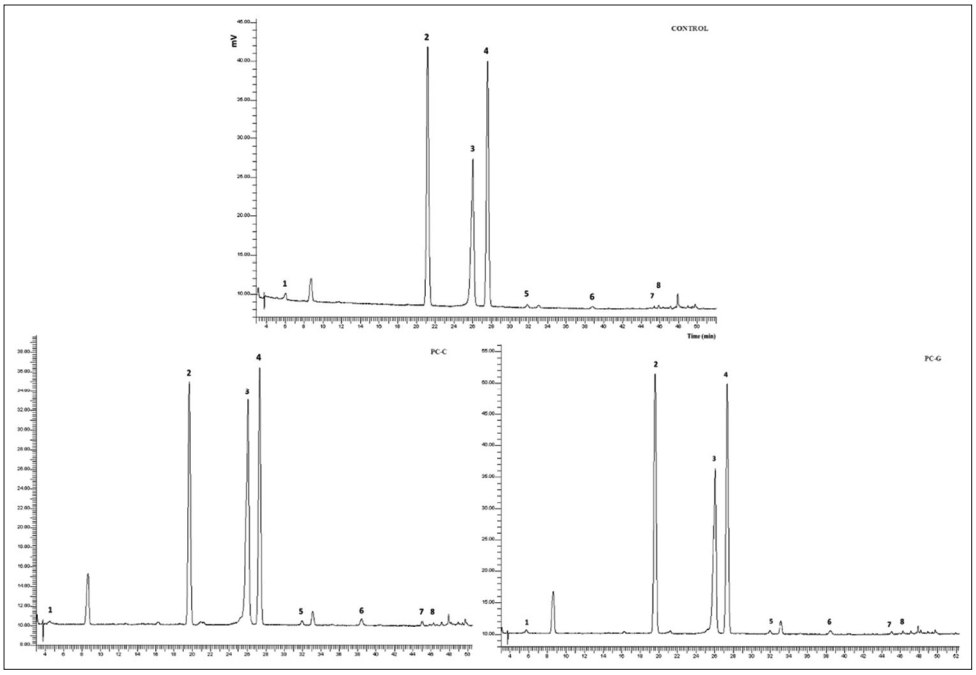

Fig 4. The chromatogram of phenolic acids in pumpkin chips. 1. Gallic 2. p-hydroxybenzoic 3. Chlorogenic 4. Caffeic 5. Syringic 6. p-coumaric 7. Ferulic 8. Sinapic"

Table 1: Bioaccessible antioxidants and bioaccessibility of antioxidant[a]

Sample	Bioaccessible Antioxidants (μmol TE/kg)				Bioaccessibility of Antioxidant (%)			
	ABTS	CUPRAC	DPPH	FRAP	ABTS	CUPRAC	DPPH	FRAP
PC	39 690±5.78[c]	14 110±0.64[c]	1060±0.08[c]	3600±0.04[c]	10.9±1.33[b]	3.9±0.27[b]	0.9±0.01[b]	1.0±0.01[b]
PC-G	53 840±0.59[b]	39 520±0.99[b]	1420±0.28[b]	7140±0.08[b]	12.2±1.21[b]	8.9±1.01[a]	1.6±0.16[a]	1.6±0.16[a]
PC-C	84 750±4.03[a]	45 130±0.76[a]	2850±0.04[a]	7940±0.40[a]	17.7±1.07[a]	9.5±0.17[a]	1.7±0.11[a]	1.7±0.11[a]

[a]Mean values ± standard deviation with different superscript in the same row are significantly different ($p<0.05$)

Table 2: Phenolic acid concentrations of pumpkin chips (mg/kg)[a]

Sample	Chlorogenic	Syringic	*p*-hydroxybenzoic	Caffeic	Gallic	Ferulic	*p*-coumaric	Sinapic
PC	810±0.33[a]	590±0.15[a]	1240±0.16[a]	1079±0.28[a]	1017±0.01[a]	2±0.01[c]	25±0.001[b]	9±0.001[a]
PC-G	1527±0.14[b]	1406±0.14[b]	1772±0.28[b]	1664±0.13[b]	1009±0.08[b]	3±0.01[bc]	40±0.001[ab]	2±0.0002[b]
PC-C	1455±0.28[c]	1384±0.31[b]	1665±0.17[c]	1643±0.14[bc]	1032±0.03[c]	7±0.008[a]	45±0.02[a]	1.2±0.0004[b]

[a]Mean values ± standard deviation with different superscript in the same row are significantly different ($p<0.05$)

Colour Parameters	PC: Pumpkin Chips (Control)	PC-C: Pumpkin Chips with Cinnamon	PC-G: Pumpkin Chips with Ginger
*L**	77.38±0.35^{a}	57.98±0.37^{b}	46.57±1.52^{c}
*a**	3.32±0.25^{c}	4.71±0.89 ^{b}	6.06±0.29^{a}
*b**	50.63±0.72^{a}	37.39±0.34^{b}	27.23±0.63^{c}

Fig 5. The colour parameters and photographs of pumpkin chips.

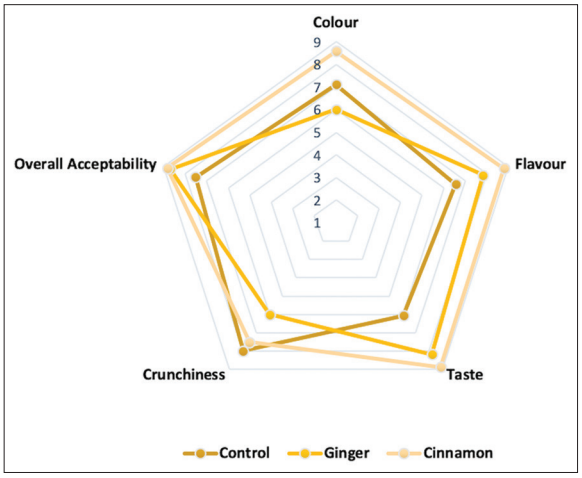

Fig 6. Sensory properties of aromatized pumpkin chips.

researcher found that the total polyphenol content of purple potato chips was 1910.6-4698.3 mg/kg dw, while that of red potato chips was 2273.8-3622.2 mg/kg dw.

Another noteworthy point in this study is that TPC further increased with the addition of cinnamon and ginger. The highest level of TPC was found in the PCs aromatized with cinnamon (11023.8 mg GAE/kg dw). The addition of cinnamon made a significant contribution to increasing the TPC of the PCs than the control sample. The differences in the TPC of the aromatized chips may be related to higher phenolics of cinnamon. Similarly, in a study carried out by Dhillon and Amarjeet (2013), cinnamon powder significantly increased the total phenolic substance and antioxidant capacity of bread compared to the control sample. This fact could be attributed to high levels of the phenolic substances of cinnamon, as informed by Wang et al. (2013).

Finally, the bioaccessible phenolics of the PCs ranged from 3646.0 to 5484.0 mg GAE/kg dw. The most abundant bioaccessible phenolics were also observed in the PC-C (5484.0 mg GAE/kg dw). The bioaccessible phenolics of the cinnamon-added sample increased approximately by 50 % compared to the control sample (Fig. 2).

Based on these results, it can be said that due to the bioactive components of cinnamon and ginger, PCs further increased their beneficial health effects and nutraceutical properties.

Antioxidant capacity and bioaccessibilities of pumpkin chips

The AC results obtained from the studied samples are shown in Fig. 3. In accordance with the results of all experiments ($ABTS^{\bullet+}$, CUPRAC, $DPPH^{\bullet}$ and FRAP), the AC of the PCs with spices were determined to be statistically significantly ($p<0.05$) higher than the control chips. A large number of phenolic contents might be responsible for higher antioxidant capacities of cinnamon and ginger. Vallverdú-Queralt et al. (2014) reported that phenolic compounds in cinnamon were responsible for antioxidant activities. Similar to that, the presented results show that the highest phenolic content and antioxidant capacity were found in the PCs with cinnamon.

In another study with potato chips, Kita et al. (2014) found that the antioxidant capacity of potato chips obtained from purple fleshed potatoes was between 26.8-37.0 mmol/kg dw and 27.2-37.7 mmol/kg dw for red fleshed potatoes for $ABTS^{\bullet+}$. In the same study, Kita et al. (2014) reported that the antioxidant capacity of potato chips obtained from purple potatoes varied between 23.9-38.7 mmol/kg dw and that, for red potatoes, it varied between 22.8-37.2 mmol/k7g dw for $DPPH^{\bullet}$. In another study, it was detected that the reducing capacity (FRAP) of freezing processing carrot chips (66.67 µmol Fe equivalent/g) and high-pressure processing carrot chips (45.39 µmol Fe equivalent/g) was significantly higher than that of non-processing carrot chips (23.48 µmol Fe equivalent/g) (Albertos et al., 2016).

Finally, in all the experiments of bioaccessible antioxidants ($ABTS^{\bullet+}$, CUPRAC, $DPPH^{\bullet}$ and FRAP), the PCs with

spices were found to be a significantly (p<0.05) higher bioaccessible antioxidant than the control chips. As can be observed from Table 1, the bioaccessibility of antioxidants was the highest in the PC-C samples, whereas it was relatively low in the PC-G samples (Table 1).

Phenolic acids of pumpkin chips

The HPLC quantitative analytical outcomes of phenolic acids obtained from the PCs are present in Table 2., and the chromatographic retention time is given in Fig. 4. According to the results of the HPLC analysis, a total of eight phenolics acids were isolated and identified from the PC samples. Within the phenolic acids, *p*-hydroxybenzoic was the predominant phenolic acid in the PCs. At the same time, caffeic, chlorogenic, and syringic acids were followed by *p*-hydroxybenzoic acid in descending amounts. On the other hand, *p*-coumaric, gallic, sinapic and ferulic acids were determined at a minor level. The levels of the phenolic acids of the PCs varied statistically significant (p<0.05) among the control sample and the samples with spices (Table 2).

The component to be identified was *p*-hydroxybenzoic at retention time of 20.273 min. In general, *p*-hydroxybenzoic acid, the major phenolic acid, ranged between 1240-1772 mg/kg. The *p*-hydroxybenzoic acid contents of the PCs with cinnamon and ginger were statistically significantly (p<0.05) higher than the control chips.

The caffeic acid standard was recorded at 27.339 min retention time. The ratio of caffeic acid ranged between 1079-1664 mg/kg. It was determined that the PCs which were aromatized with spices had statistically (p<0.05) higher caffeic acid than the other PCs. The highest caffeic acid content was found in the PC-C sample (1665 mg/kg), while the lowest content of caffeic acid was detected in the control chips (1079 mg/kg). Kulczyński and Gramza-Michałowska (2019) also reported that most of the pumpkin cultivars had high concentrations of caffeic acid.

The compound at 26.085 min was identified as chlorogenic acid by co-elution with the standard. This acid ranged between 810-1527 mg/kg. In the presented study, chlorogenic acid is the third most abundant acid. The PC-G sample had approximately 2-fold higher chlorogenic acid content than the control chips. According to Dragovic-Uzelac et al. (2005), the large amount of chlorogenic acid was caused by raw pumpkins and pumpkin purees. As a result, it appears that higher phenolic acid concentrations in the PCs are associated with the addition of cinnamon and ginger.

Colour analysis

The colour of a product is an important property for quality assessment and attractiveness as well as for acceptability. Therefore, this is a very important parameter for the snack food industry (Chauhan et al., 2019). The colour parameters of the chips were clearly affected by different spices. The colour parameters and photographs of the pumpkin chips are demonstrated in Fig. 5.

In comparison to the control sample, a decline in the L^* value was observed. The lowest L^* value was determined for PC-C (46.57), while the highest value was noted for PC (77.38). On the contrary, an increase in the a^* values was observed in aromatized chips compared to PC. Changes in the L^* and b^* values in aromatized chips followed similar trends; however, the a^* values for aromatized chips were in the opposite direction. This change may be due to ginger having a pale yellow colour and cinnamon also having various carotenoids.

Sensory properties of aromatized pumpkin chips

Sensory properties are very important criteria to determine the acceptability of foods by consumers (Carvalho et al., 2013). For this reason sensory analysis can be used to evaluate the ratio of liking and disliking for produced or developed new foods. As reported by Natabirwa et al. (2020), the >5 score for sensory attributes, which based on 9 point hedonic scale, that means the product moderately liked by panellist in terms of appearance, taste, flavour and overall acceptability.

The high sensory scores was observed in aromatized pumpkin chips. The aromatizing with ginger and cinnamon, perhaps holded down the pumpkin taste and flavour which do not like by some people. Fig. 6 shows the sensory evaluation scores of pumpkin chips. According to the results; sensory acceptability for flavour, taste, and overall acceptability was found to be significantly (p<0.05) higher in aromatized pumpkin chips with higher sensory scores. As a result, the high sensory scores of aromatized pumpkin chips were indicated of acceptable snack food to consumer.

CONCLUSIONS

The experimental results showed that aromatization with spices is an important factor affecting the nutritional properties of PCs. In this study, the results confirmed that not phenolic acids and antioxidant capacity but also bioaccessibility were influenced by aromatization with spices. One of the purposes of this study was to produce an alternative to classic varieties of chips containing high salt and fat. Aromatized PCs can ensure that pumpkin becomes a product that can be consumed all year, not just in winter, and can therefore provide more benefits than the functional properties of pumpkin. The results of this

study demonstrate that PCs, especially PCs aromatized with spices, are generally rich in phenolic content and antioxidant capacity, that their bioavailability is also high, and that they have, for that reason, functional advantages. Processing pumpkin as chips can be an excellent alternative to extend its shelf life and turn it into a high value-added product. In this way, a raw material with high nutritious and functional properties can be processed into a product that can be consumed in all seasons of the year. PCs can be an alternative, functional, and nutritious snack. The consumer awareness of the functional properties of food products is increasing day by day, which affects their purchasing decisions. Therefore, it is thought that the market demand for PC production will be high due to its nutritious and functional properties.

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