

# Effect of apple and rosehip pomaces on colour, total phenolics and antioxidant activity of corn extruded snacks

Wioletta Drożdż\*, Ewa Tomaszewska-Ciosk, Ewa Zdybel, Hanna Boruczowska, Tomasz Boruczowski, Piotr Regiec

Faculty of Food Science and Technology, Wrocław University of Environmental and Life Sciences, Poland,

\*Corresponding author: e-mail: wioletta.drozd@wnoz.up.wroc.pl

Extrusion cooking technology was applied for obtaining corn extrudates fortified with various level (10–20%) of rosehip pomace powder or apple pomace powder. The total polyphenols content, antioxidant activities (ABTS), organoleptic properties and colour of the extrudates were determined.

Pomace addition increased the level of total polyphenols content and antioxidant activity in obtained corn – pomace extrudates, especially in samples enriched with rosehip pomace. Extrudates with 20% of rosehip pomace addition characterized the highest polyphenols content and antioxidant activity. Only the slight decrease of some quality features – shape and size, taste and flavour, structure and colour of obtained extrudates was observed. Sample with fruit pomace addition showed increasing consistency evaluation. The extruded products by utilising fruit by-products got good evaluation of panelists and can be an excellent source of bioactive compounds in the daily human diet.

**Keywords:** apple pomace, rosehip pomace, extrusion, polyphenols, antioxidant activity.

## INTRODUCTION

The food industry produces a large amount of by-products, generating a lot of problems associated with their utilisation. Most of these products are composted or consumed as animal feed. In recent years, more and more attention is paid to the possibility of food waste as raw materials to produce new products<sup>1,2</sup>. The main reason for searching for alternative treatment directions of these wastes is to minimize their impact on the environment and use of valuable compounds remaining in the by-products, such as vitamins, fiber or polyphenols<sup>3</sup>.

The main by-product of fruit industry in Poland is apple pomace, obtained by crushing and pressing apples during the clear juice process recovery. It represents approximately 30% of the original fruits<sup>4</sup>. Apple pomace is a rich source of polyphenolic compounds belonging to the group of natural antioxidants<sup>5</sup> and dietary fiber as well<sup>6</sup>. Polyphenols play the complex role in the human body include responsibility for stimulating the growth of immunity, preventing tooth decay, and having beneficial effects in hypertension and hypercholesterolemia. Many studies also indicate that polyphenolic compounds inhibit the process of carcinogenesis at various stages of formation and development of cancer<sup>7</sup>. Therefore there has been an increase in the apple pomace utilization as a component of new functional foods<sup>8</sup>. Wang & Thomas<sup>9</sup> and Carson et al<sup>10</sup> worked out a technology for preparation of bakery products with apple pomace addition. Sensory evaluation demonstrated that the experimental products were the same or more desirable than the products received by traditional recipe.

Another way to utilize apple pomace may want to use of these by-products as additives to a crunchy snack products. Due to the high popularity of the extruded snack products, the introduction to the recipe supplements containing high amounts of fiber, vitamins and polyphenols, can significantly improve the health status of the population.

The aim of this study was to obtain nutritionally improved corn extruded snacks with apple and rosehip

pomaces as ingredients and their effect on some physico-chemical and sensory properties of the product.

## EXPERIMENTAL

### Fruit pomace and corn snacks preparation

The materials to be studied included corn grits, apple pomace and rosehip pomace. Commercial edible corn grits (moisture content 13–14%) were purchased from a company Sante A. Kowalski Warszawa (Poland). Dried apple pomace with a moisture content of 8% was supplied by the Fruit Processing Plant of “Agropol” Potycz (Poland); dried rosehip pomace with a moisture content of 7% came from the fruit processed at the laboratory of the Department of Fruit, Vegetables and Cereals Technology, Wrocław University of Environmental and Life Sciences (Poland). The pomaces were ground in a universal knife grinder Pulverisette 19 Fritsch to obtain 1mm particle size. Extruded products were manufactured from different ingredient combinations, corn grits only, and corn with different pomace at a low level 5% and a maximum level 20% (Tab.1). The samples were fixed in tightly-closed foil bags and conditioned at a temperature of 25°C for 24 hours. Immediately before the extrusion process the samples were re-stirred.

**Table 1.** Ingredients of the products

Sample	Contents	
Corn	100% corn grits	
Corn + rosehip pomace	10%	90% corn grits + 10% rosehip pomace
	15%	85% corn grits + 15% rosehip pomace
	20%	80% corn grits + 20% rosehip pomace
Corn + apple pomace	10%	90% corn grits + 10% apple pomace
	15%	85% corn grits + 15% apple pomace
	20%	80% corn grits + 20% apple pomace

The process of extrusion was conducted in a single-screw extruder type 20Dn by Brabender, with a compression ratio of 4:1 and a round nozzle 4 mm in diameter. The single screw was rotating at 180 rpm and the feeder at 50 rpm. The process of extrusion was carried out in temperature of 130°C for the first zone, 150°C for the second zone and 180°C for the third zone. The produced extrudates were kept in an air dryer at a temperature of 25°C for 48 hours.

#### Extractions of raw ingredients and extrudates

Two grams samples were extracted with 80% methanol (100 mL) by shaking for 24 h at room temperature. Then the samples were placed in an ultrasonic water bath for 5 minutes at 4°C. After being filtered through Schott filter papers, the extracts were used for the examination.

#### Analysis of polyphenols

Total phenols content in the obtained extracts were estimated by a colorimetric assay based on procedures described by Singleton and Rossi (1965)<sup>11</sup>. Total polyphenols was determined by the Folin-Ciocalteu reagent by using gallic acid (GA) as a standard for the calibration curve. Results were read after 1h at 765 nm in a spectrophotometer (Shimadzu UV-2401 PC). All determinations were performed in triplicate. The results of the assay were calculated and expressed as milligrams of gallic acid equivalent (GAE) per gram of dry weight (DW).

#### Antioxidant activity

The against ABTS radical was scavenging activity done according to the method of Re et al.<sup>12</sup>. The ABTS solution was diluted with redistilled water to reach absorbance of 0.700 (0.02) at 743 nm. After the addition of 60 mL of supernatant to 3mL of diluted ABTS solution, the absorbance was read exactly 6 min after initial mixing in a spectrophotometer (Shimadzu UV-2401 PC). The antioxidant activities ABTS, were expressed as Trolox equivalent antioxidant capacity (TEAC) by using the calibration curve plotted against different amounts of Trolox. TEAC values were calculated and are expressed as Trolox equivalents (TE) per 100 grams of dry weight (DW).

The total polyphenols contents and ABTS scavenging effects were examined for apple pomace, rosehip pomace, corn grits and milled extrudates. All measurements were performed in triplicate

#### Organoleptic properties

Sensory profiles were recorded for the obtaining extrudates using protocol for organoleptic evaluation of extruded products<sup>13</sup>. Attributes evaluated were shape and size (uniformity, smoothness, degree of expansion and color), consistency (crispness, hardness, brittleness, fragility), structure (porosity, appearance of the fracture and degree of crushing of extrudates when breaking), taste and smell (intensity of perceived taste and smell of a typical corn snacks) All attributes were determined using structured scale with a possible range of scores from 1 to 5 where the higher number (5) denoted better attributes of the product and the lowest number (1) the worst. A 10-member panel was recruited for sensory evaluation of obtained products; the panelists had previous experience

in extruded snack evaluation. The panel comprised of workers of Faculty of Food Science, Wroclaw University of Environmental and Life Sciences, in a wide range of age (25-45 years).

#### Measurement of colour assessment

Colour was assayed spectrophotometrically using a Minolta CR-200 spectrophotometer in extrudates comminuted to particle size of 400 µm. Samples were placed in a glass cuvette, and color values from the three readings were averaged to give representative L\* a\* b\* colour spaces, where L\* indicates lightness, a\* is the redness and b\* is the yellowness. The hue angle (H) was calculated as  $\tan^{-1}(b^*/a^*)$ , and expressed in degrees. Chroma (C) was calculated as  $(a^{*2} + b^{*2})^{0.5}$

Results received were subjected to a statistical analysis using Statistica v. 9.0 software. One-way and two-way analysis of variance was carried out at a confidence level of  $p \leq 0.05$ .

## RESULTS AND DISCUSSION

By-products from the fruit and vegetable industry in the form of rosehip and apple pomace were used as an additive in extruded snack products in order to improve their nutritional characteristics

The total polyphenols content in raw corn grits – major ingredient in extruded snack products, was 2.87 mg gallic acid/g. The total polyphenols value of fruit pomace used to produce extruded snack was considerable higher than unextruded corn. The greatest total polyphenols value was exhibited for rosehip pomace (29.20 mg gallic acid/g). It was observed a lower polyphenol content in apple pomace (6.49 mg gallic acid/g) compared to rosehip pomace, however it was twice more than in corn grits. Comparing with previous results on apple pomace<sup>14, 15</sup> the total polyphenols content in our research was very similar.

Both of the detected fruit pomace had higher antioxidant activity than raw corn grits (29,9 µM Trolox/100g). The ABTS scavenging effects were 6020 µM Trolox/100g and 141,15 µM Trolox/100 g for rosehip pomace and apple pomace respectively.

The results of total polyphenols value and antioxidant activity for extrudates were shown in Fig. 1. In this study, it is demonstrated that the addition of fruit pomace in extrudates caused positive influence on polyphenols value and antioxidant activity in corn – rosehip pomace extrudates and corn – apple pomace extrudates and it depended on fruit pomace addition level and fruit pomace varieties.

The polyphenols value and antioxidant activity of control sample were 2.62 mg galic acid/g and 28.5 µM Trolox/100g respectively. After extrusion the results were slightly lower compared to unextruded corn grits. This was agreeable to the finding by Stojceska et al.<sup>16</sup> and Chiu et al.<sup>17</sup>. The studies have shown that extrusion processing caused no negative influences on the ABTS scavenging abilities or even improved antioxidant activity of corn extrudates.

The polyphenols content of corn – apple pomace extrudates was in the range from 3.28 to 4.61 mg galic acid/g. These values differ significantly from the sample

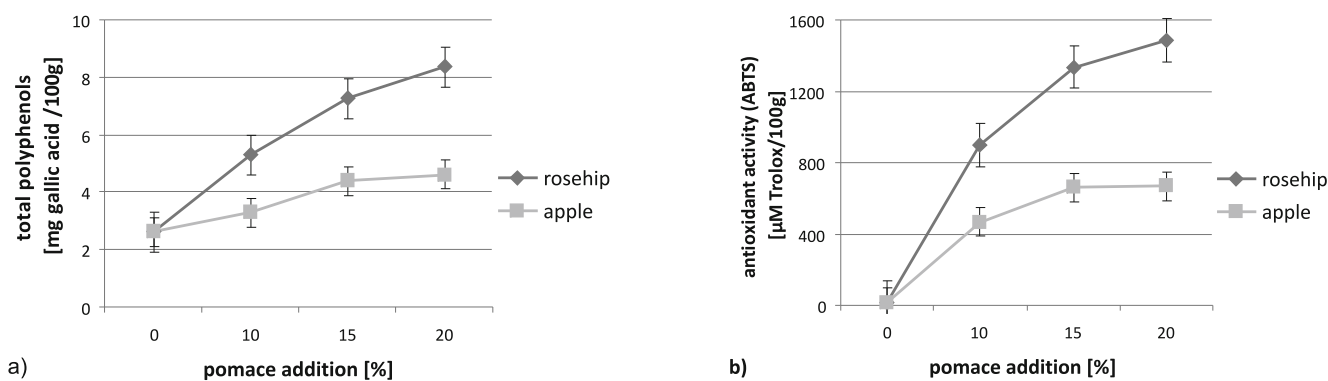


Figure 1. Total polyphenols content a) and antioxidant activity b) of extrudates

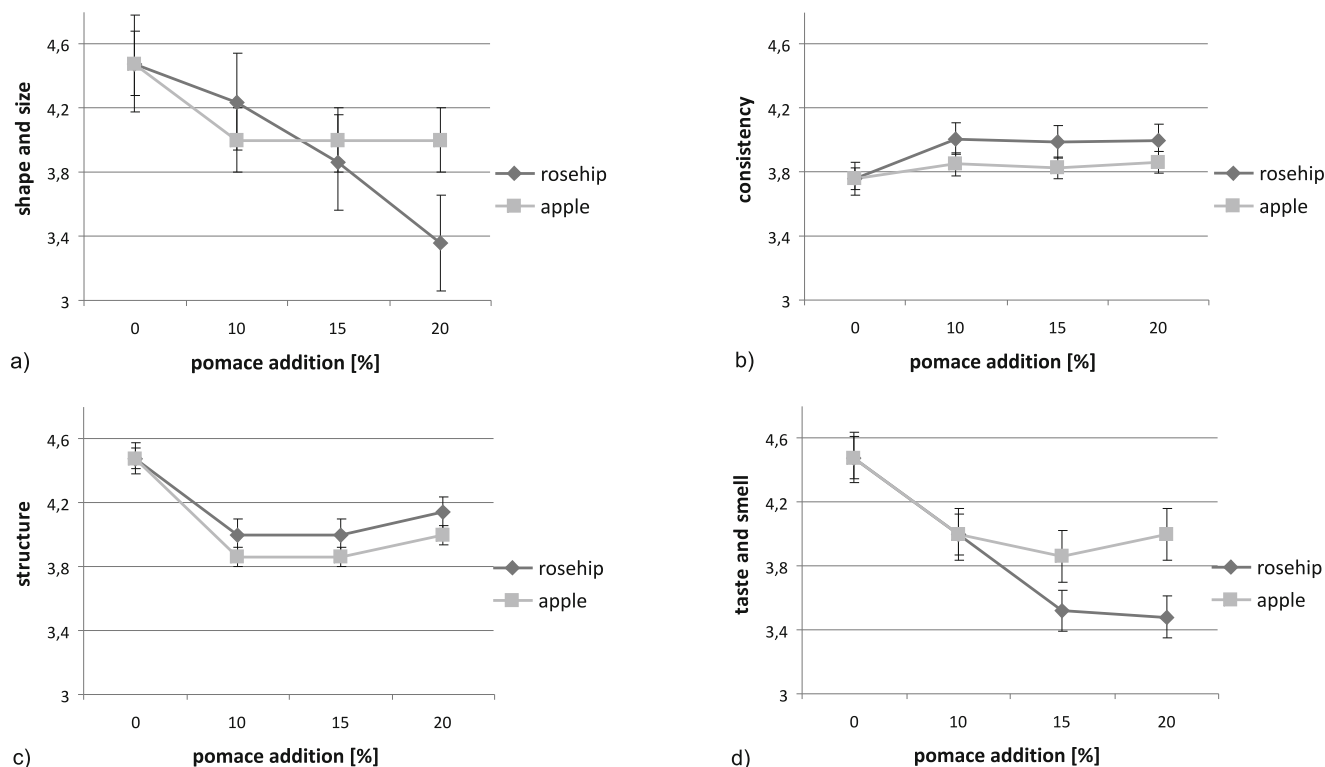


Figure 2. Organoleptic assessment of extrudates a) shape and size, b) consistency, c) structure, d) taste and smell

without pomace. With higher apple pomace addition, there was an increase in total polyphenols value but the samples with 15% and 20% of pomace did not differ statistically. Antioxidant activity of these extrudates increased from 46,77 to 76,92  $\mu\text{M}$  Trolox/100g and were significantly different in each formulation

Extrudates produced with rosehip pomace showed a range of total polyphenols between 5.3 and 8.35 mg gallic acid/g, and antioxidant activity between 660.7 and 1486.9  $\mu\text{M}$  Trolox/100g. The results were very high and were significantly higher compared to corn extrudates without pomace and from extrudates with apple pomace. Samples with 15% and 20% of rosehip pomace did not differ significantly in polyphenols content and antioxidant activity. According to the previous studies<sup>18, 19, 20</sup>, the rosehip pomace is a rich source of antioxidants, therefore even a small amount of this material in snacks caused a significant increase in antioxidant activity in a final product. Already a small addition (10%) of fruit pomace lead to the significant increase of polyphenols and antioxidants content in the sample.

Corn is a very common major ingredient in extruded cereal and snack products but the polyphenols and

antioxidants value is very low. The result revealed that corn crisps after enrichment of the rosehip or apple pomace could be an excellent source of polyphenols and antioxidants. Similar results were reported by another authors where extrudates were enriched with other ingredients (e.g., soy protein and beans) for higher nutritional functionality<sup>21, 22</sup>.

The food product offered to the consumer should not only have a high content of nutrients, but also should be characterized by sensory attractiveness.

Organoleptic evaluation is one of the most important indicators of the product quality. Meeting the requirements of both the appearance, texture, consistency, taste and possible high proportion of pomace is not an easy task.

The results of organoleptic properties of produced snacks were shown in Fig. 2. The addition of fruit pomace to extrudates resulted in progressively lower evaluation of some attributes.

However, the level of the apple pomace addition was shown to have not a significant effect on most of the sensory attributes. Organoleptic evaluation of these extrudates was about 4. Panelists rated them as the product of a smooth surface with small corrugations, fairly steadily

expanded, crisp and crumbly texture and slightly uneven porosity, pleasant slightly delicate aroma and typical flavor. Shape and size, as well as taste and flavour decreased significantly with rosehip pomace addition. These products have an uneven surface and were less expanded and characterized by taste and flavour worse than extrudates with apple pomace addition. Perhaps the use of suitable flavoring could have a positive impact on improving the attractiveness of extruded products with added rosehip pomace.

However, it could be observed that examined sample showed increasing consistency evaluation caused by the fruit pomace addition, which is possibly due to the organic acid content in fruit pomace, particularly rosehip pomace. Rosehip fruits are the richest natural source of ascorbic acid among all cultivated and wild trees and shrubs. The content of the acid in the fruit of rosehip is in the range 600–1000 mg per 100 g, and a large amount of this component remains in the pomace<sup>23</sup>. Some researches<sup>24, 25</sup> have found that the addition of organic acid to extrudates caused a positive effect on properties that affect the product.

The colour was measured colorimetrically and expressed in the Hunter scale. Analysis of variance indicated that the effect of apple and rosehip pomace content on extrudate colour was significant (Table 2). Pomace content significantly affected the colour L\*, a\* and b\* of extrudates in each formulation. The increase pomace content in samples led to the decrease in lightness of obtained extrudates to the level of 50.88 in the rosehip pomace and 52.08 in the case of apple pomace. The redness of the products also varied significantly in all extrudates. Increasing pomace content resulted with the higher redness especially in samples with rosehip pomace. Samples containing pomace showed lower value of b\* than samples without pomace. The increase in rosehip pomace content led to the decrease in yellowness of product but the yellowness of the products with apple pomace did not vary statistically significantly.

The hue angle of extrudates with apple pomace ranged from 80.48 to 86.31 as compared to the control sample which was 86.86. As pure yellow has a hue angle of 90, this reflects that the products have a yellowish colour. In comparison, extrudates with rosehip pomace values ranging from 77.04 to 79.40. This indicates a change more toward red. It is evident that with the increasing rosehip pomace level product became more reddish. This is due to the color of rosehip, the plant which contain anthocyanins-compounds affecting red colour of rosehip. The chroma represents the intensity or degree of the colour saturation. Chroma values for the products with pomace addition ranged from 21.77 to 28.62 (on a scale of 0–100), as compared to the control sample, which had

significantly higher chroma value 38.74. Furthermore, it can be seen that the product with apple pomace had less colour saturation (had a lower chroma value) compared to the product with rosehip pomace.

## CONCLUSION

The polyphenols content and antioxidant activities of obtained extrudates were higher for corn – pomace samples than for raw corn extrudates, although the properties were dependent on the pomace varieties and its addition level. Corn-rosehip pomace snacks characterized higher polyphenols content and antioxidant activity than corn-apple pomace snacks.

Despite the slight decrease of some quality features (shape and size, structure, taste and flavour) extrudates with 20% of rosehip pomace addition can be considered as the best due to the highest polyphenols content and antioxidant activity. Organoleptic properties of corn-pomace extrudates were on score level about of 3.5–4, which means that panellists evaluated the product as good. Snacks produced with the rosehip or apple pomace may be a new type of functional food because of its high content of polyphenols and antioxidants, which have a beneficial effect on the human body.

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**Table 2.** The results of extrudates colour (L\*, a\*, b\*)

Samples		L*	a*	b*
Corn		64.43	-4.21	38.39
Corn + rosehip pomace	10%	56.54	3.96	24.46
	15%	50.88	5.17	25.56
	20%	53.95	6.08	27.99
Corn + apple pomace	10%	55.64	1.90	21.88
	15%	52.43	2.93	21.62
	20%	52.09	3.97	21.53
LSD		1.61	0.12	0.68



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