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Phytochemical content and antioxidant activity in flesh and peel of three apple cultivars

Research article

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Abstract

The objective of this study was to evaluate and compare the bioactive compounds content and the antioxidant activity in flesh and peel from three apple cultivars, commonly cultivated in Romania (Golden Spur, Yonagold and Idared). The content of reducing sugar, glucose and total phenolic was determined by colorimetric methods, ascorbic acid by iodometric method and the antioxidant activity was evaluated by ABTS radical scavenging assay. The results show that studied chemical indices vary according to the analyzed cultivar and the part of the fruit. The samples are a rich source of bioactive compounds with an important role in human health, especially compound with considerable antioxidant activity. In peel the total phenolic contents were 3,56-5,44 times higher than the total phenolic contents in flesh and antioxidant activity in peel were 1,461-2,631 times higher than the antioxidant activity measured in flesh samples. The results of this study recommend introducing the investigated cultivars in diet as a source of naturals antioxidants.

Keywords: apple, ascorbic acid, sugars, phenolic compounds, antioxidant activity.

1. INTRODUCTION

The consumption of fresh fruits and vegetables has been associated with reducing the risk of some diseases and maintaining human health [1]. Apples are among the most consumed fruits in the world, both fresh and dried as well as processed (ciders, juices, wine, jams, compotes, tea concentrates and purees). Their chemical composition, rich in biologically active compounds, recommends apples as very valuable functional foods [2,3]. Apples are a rich source of macro and microelements (K, Na, Mg, Ca, P, Fe, Zn, Mn and Cu) [4,5,], organic acids (ascorbic, malic, citric, maleic, pyruvic and shikimic acids) [2,6], sugars (glucose, fructose, sucrose) sorbitol and xylitol [2,3], vitamins [3], polyphenols and dietary fibers [6,7]. Apples are recommended in weight loss diets as they are rich in pectin and free of fat and cholesterol.

Epidemiological studies have shown the preventive role of apple consumption in health, the role of protection against various diseases in humans, such as cancer, asthma, diabetes, inflammatory activity and cardiovascular disorders [1,8]. The studies explained these positive effects as being due to a chemical composition rich in biologically active compounds, especially compounds with antioxidant properties. Among these compounds, phenolic compounds play a significant role. It has been reported that apples contain a wide spectrum of phenolic compounds distributed differently in the fruit (in peel and flesh) [9,10]. Hydroxybenzoic acids, hydroxycinnamic acids (chlorogenic acid, caffeic acid, p-coumaric acid, ferulic acid, sinapic acid), flavanols (catechin and epicatechin), flavonols (quercetin, isoquercetin, rutin, kaempferol, astragalin), dihydrochalcones and anthocyanins are present in apple fruits. Quercetin conjugates are found exclusively in the peel of the apples [10].

The chemical composition and phytochemical concentration of apples depends on fruit maturity, cultural practices, environmental factors and storage period. [11]. The objective of this study was to evaluate the bioactive compounds content and the antioxidant activity in peel and flesh of three apple cultivars in order to provide information about the nutritional value for consumers and industrial processors.

2. MATERIALS AND METHODS

2.1. Materials

The biological material was represented by fruits of three apple cultivars: Golden Spur, Yonagold and Idared, grown in private orchard. All the apple cultivars were grown under the same horticultural practices. The fruits from the cultivars were harvested in their technological ripening stage, washed with distilled water and dried with a paper napkin. To prepare the samples, the fruits were peeled with a legume knife. The flesh sample was edible portion of the apple without the peel and the peel sample is the part of the apple removed from the knife with a thin layer of apple pulp glued to it. The prepared samples were analyzed from the point of view of phytochemical composition and antioxidant capacity.

2.2. Analysis methods

Total soluble solids content SSC (%) was determined using a digital refractometer (Kruss Optronic DR 301-95) at 20°C;

The titratable acid content (acidity) was determined by titration with 0.1N sodium hydroxide (NaOH) using phenolphthalein as indicator and expressed as mEq acid/100g fresh weight.

Reducing sugars (%) were extracted in distilled water (1:30 w/V), 60 minutes at 60°C and assayed colorimetric at 540 nm with 3,5 dinitrosalicylic acid reagent using glucose as standard [12]. The results were expressed in %.

Glucose (%) content was assayed at 500 nm by glucose oxidase/peroxidase method [12]. The results were calculated from calibration curve using glucose as standard.

Ascorbic acid was extracted in 2% hydrochloric acid, HCl; 1:30 w/v and determined by iodometric redox titration [13]. The ascorbic acid content was expressed as mg/100 g fresh weight.

Methanolic extract: For the determination of antioxidant activity and total phenolic content samples were extracted with 80% aqueous methanol (1:20 w:v) by sonicating for 60 min in a sonicate bath Fungilab

(Madrid, Spain) equipped with a digital timer and a temperature controller at 24°C. The resulting slurries were centrifuged at 4000 g for 5 min and the supernatants were analyzed.

The total phenolics content was determined colorimetric at 765 nm by using the Folin-Ciocalteu reagent [14]. The total phenolic content (TPC) was calculated using a standard curve prepared using gallic acid and expressed as mg GAE/100 g fresh weight.

ABTS radical cation scavenging activity was measured colorimetric at 734 nm using Trolox as standard [14]. The final results were expressed as μM TE/g fresh weight.

The spectrophotometric measurements were performed with a Thermo Scientific Evolution 600 UV-Vis spectrophotometer with VISION PRO software. All determinations were performed in triplicate, and all results were calculated as mean.

3. RESULTS AND DISCUSSION

The obtained results show that the studied chemical indices vary depending on the analyzed cultivar and they have a different distribution in different parts of the fruit.

Total soluble solids content (TSS) varies with the analyzed cultivar. TSS is a measure of the sweet taste of a fruit, being an important quality indicator that contributes to flavor perception and consumer acceptance. The values determined in our study vary between 13.55% (Yonagold) and 16,3% (Golden Spur) in the order: Golden Spur <Idared < Yonagold (figure 1). Our results are similar to data reported in the scientific literature. 11%-15% for ten apple grown in Romania [15], 10,5-14,7% for 22 old apple cultivars grown in Poland [16], 13,3-15,8% for five apple grown in Chile [17]. *The content of reducing sugars* differs depending on the variety of apple. The results obtained for flesh vary between 2,86% (Golden Spur) and 3,193% (Idared). For the peel the values vary between 2,355% (Yonagold) and 3,621 % (Golden Spur). The sugar content in apples is primarily composed of fructose, glucose, and sucrose [6]. *The glucose content* for flesh vary between 1,22 % (Golden Spur) and 1,367 % (Idared) and for the peel between 1,04 % (Yonagold) and 1,34% (Idared) (Figure 1).

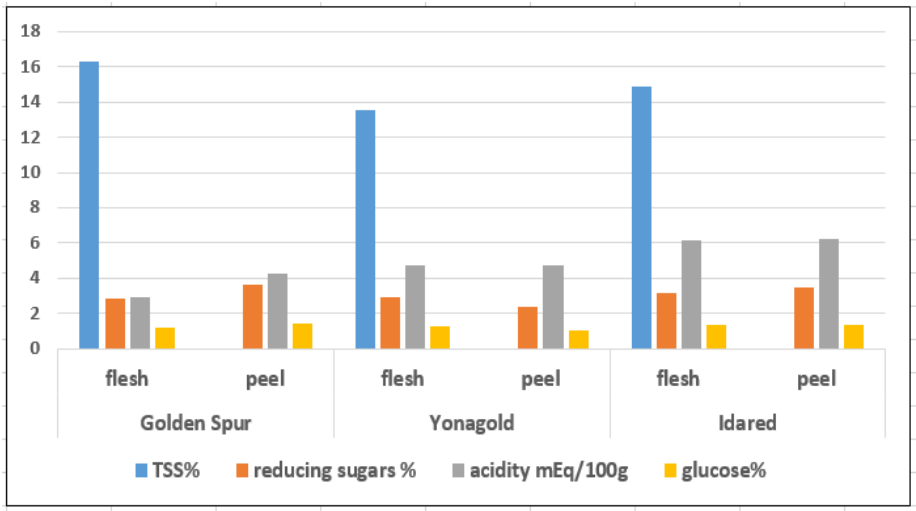

Figure 1. Total soluble solid content, reducing sugars, glucose content and total acidity

Another quality indicator for apples is the *total acidity* determined by the content of organic acids that have an important effect on fruit taste and aroma. These are mainly malic acid, citric acid, succinic acid, oxalic acid, ascorbic acid and tartaric acid [18]. These acids may aid digestion by stimulating the production of digestive enzymes and promoting a healthy gut environment [6].

The results obtained for total acidity in flesh vary between 2,9 mEq/100g (Golden Spur) and 6,14 mEq/100g (Idared). For the peel the values vary between 4,24 mEq/100g (Golden Spur) and 6,22 mEq/100g (Idared) as shown in the figure 1.

Among the phytochemicals present in apple fruit, *the ascorbic acid content* was also analyzed. Ascorbic acid, a vital nutrient for health is important in iron absorption and is an essential co-factor for biosynthesis of collagen, an important protein in skin, cartilage, tendons, ligaments, and blood vessels [19]. Ascorbic acid has antioxidant properties fighting against free radicals. The ascorbic acid content is presented in figure 2. The results obtained for flesh vary between 1,962 mg/100g (Yonagold) and 3,869 mg/100g (Golden Spur). For the peel the

values vary between 8,354 mg/100g (Yonagold) and 10,53 mg/100g (Golden Spur).

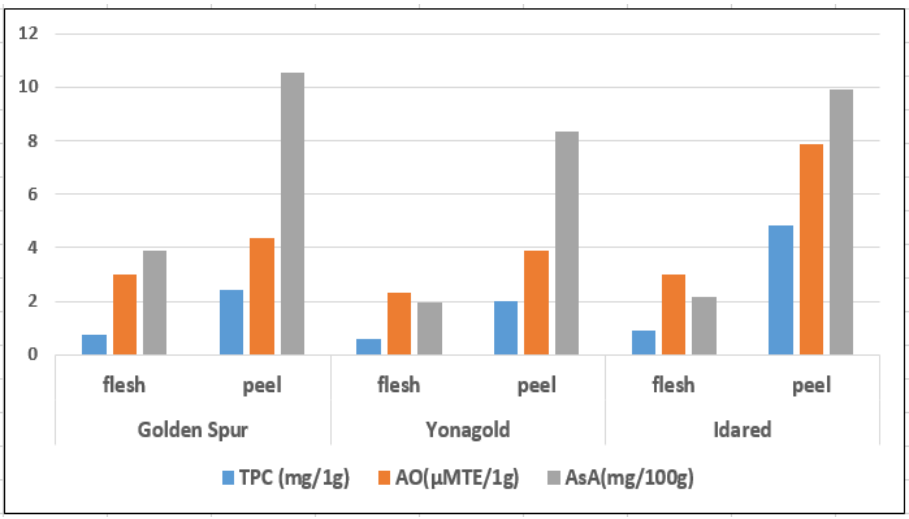

Figure 2. The ascorbic acid content, total phenolic compounds content and antioxidant activity

The content of total phenolic compounds (TPC) in flesh varies between 0,562 mg/g (Yonagold) and 0,8858 mg/1 g (Idared) while in peel varies between 2,0061 mg/g (Yonagold) and 4,8233 mg/g (Idared). It is observed that the content of phenolic compounds in the peel is higher than in the pulp: 3.23 times higher in the Golden Spur cultivar, 3.56 times higher in Yonagold cultivar and 5,44 times higher in Idared cultivar. This variation of the higher phenolic compound content in the peel is also confirmed in other studies [9,10].

Antioxidant activity. In this study antioxidant activity of the studied apple cultivars was determined by the ability of extracts to scavenge the ABTS radical, an efficient method that measures both the capacity of hydrophilic and hydrophobic substances [20]. The results are shown in figure 2. For the flesh the values of ABTS radical cation scavenging activity, express as Trolox equivalents ranged from 2,315 µMTE/g (Yonagold) to 2,9898 µMTE/g (Idared) while in peel vary between 3,8842 µMTE/g (Yonagold) and 7,8653 µMTE/g (Idared). As with the content of phenolic compounds, a higher antioxidant activity is

observed in the peel than that measured in the pulp: 1,461 times higher in the Golden Spur cultivar, 1,6778 times higher in Yonagold cultivar and 2,631 times higher in Idared cultivar.

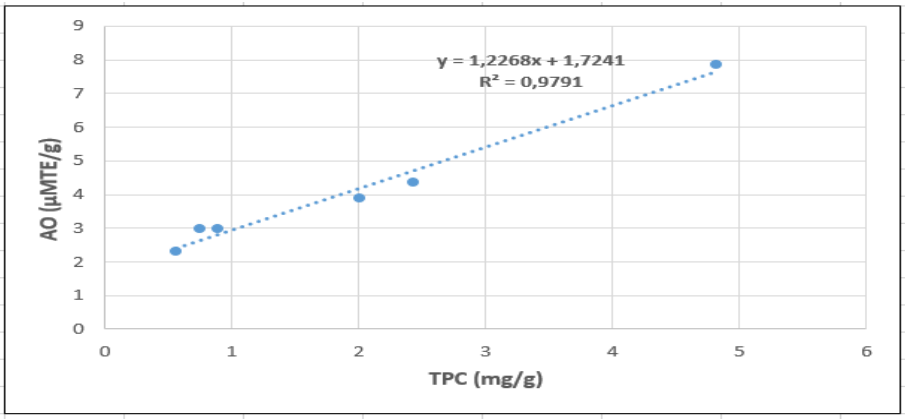

Figure 3. Correlation between antioxidant capacity and phenolic compounds content

Positive significant correlations have been observed when ABTS radical cation scavenging activities were compared with total phenolic compounds content, thus indicating that these compounds are responsible for the antioxidant activity (figure 3). This positive correlation was also reported in other studies [4, 9].

4. CONCLUSION

Apple is a rich source of phytochemicals with an important role in human health, especially compound with considerable antioxidant activity.

The obtained results show that the studied chemical indices vary depending on the analyzed cultivar and they have a different distribution in the fruit.

The high content of phenolic compounds confirms that a regular consumption of apples provides the body with satisfactory amounts of polyphenols whose potential for health has been demonstrated.

The highest content of polyphenols being in the peel and these determining a high antioxidant activity, it is recommended to consume the whole fruit.

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