

Preliminary research on the obtaining and nutritional characterization of apple peel powder

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Abstract

Apples and especially their skin are associated with multiple health benefits by preventing disease and maintaining overall health. Apple peel, considered as a by-product of apple processing during the preparation of sauces, apple preserves, dried rings and purees, is a rich source of carbohydrates, total dietary fiber, minerals as well as various phytochemicals, mainly polyphenols. Due to the increased content in nutritional compounds and other biologically active substances, apple peels represent an ingredient to be taken into account for the enrichment of the nutritional and therapeutic benefits of some food products. The purpose of this study was to obtain and analyze some nutritional parameters of apple peel powder by using native varieties apples grown in unpolluted areas. The concentrations of moisture, minerals (ash), proteins, fats, carbohydrates and dietary fibers were determined from three batches of summer apples grown in hilly areas of Caras-Severin County (Romania). The preliminary results obtained: 4.56 - 6.02% moisture, 2.56 - 3.62% minerals, 3.86 - 4.94% proteins, 3.11 - 4.03% fats, 35.15 - 38.31% dietary fibers and 61.78 - 65.44% carbohydrates, show that apple peel powders analyzed contain increased amounts of carbohydrates and dietary fibers, significant amounts of minerals and low protein and fat content. These values recommend the inclusion of dried apple peels in different food products. In addition, the superior valorization of apple peels resulting as a by-product from apple processing, offers an advantageous solution for reducing environmental pollution.

Keywords: apple peel powder, nutritional parameters, fruit peels as by-products.

1. Introduction

Fruits are an important part of the human diet; they are recommended as a significant necessity due to their health promotion benefits [1]. Consumption of fruits and fruit products is associated with protective effects against chronic diseases such as cardiovascular diseases, hypertension, type 2 diabetes, various types of cancer, asthma, obesity, cognitive disorders and depression, etc. [1, 2]. Also, secondary products (pomace, peels, seeds) resulting from the fruit processing industry have a high content of dietary fibers, polyphenols, lipids and proteins, which makes them a considerable source

of food additives [3]. Several researches have demonstrated the presence of a wide range of bioactive compounds in various by-products of fruit processing: carbohydrates (pectin, cellulose, hemicellulose), secondary metabolites (phenolics, glycosides, alkaloids, gums, mucilage's and volatile oils), lipids and proteins [3]. Among fruits, the apple (*Malus domestica*), a member of the Rosaceae family, is one of the most consumed fruits by people of all ages [4]. The beneficial effects for human health are due to the presence of several biologically active compounds, such as monosaccharides, minerals, dietary fiber and polyphenols, compounds

that play an important role due to their antioxidant properties, present in significant concentrations in apple skins compared to the pulp [5]. Therefore, the apple peel is a rich nutritional source because it provides resistance to various diseases [6, 7]. Research on bioactive substances, including polyphenols, polysaccharides, plant sterols, pentacyclic triterpenes, organic acids, vitamins (including vitamin C, E, β -carotene) and essential mineral elements (Ca, Fe, K, Mn, Zn, Mg, Cu) from apples, it is mainly concentrated in the pulp and skin of the fruit [7]. Apple is considered a functional food because it has a considerable contribution in the supply of antioxidants, vitamins and minerals, and its consumption is linked to the prevention of various diseases [8]. Apples, and especially apple peel, have been associated with multiple health benefits by preventing disease and maintaining overall health. Apples have been shown to exhibit antioxidant and antiproliferative activity, which may be responsible for protecting cellular components from oxidative damage as well as inhibiting the growth of tumor cells. Evidence from epidemiological studies has shown that apples can play a significant role in reducing the risk of chronic diseases such as cancer, type II diabetes, cardiovascular disease, lung disease and asthma [9]. Apple peel, considered a waste resulting from the processing of apples during the preparation of sauces, apple preserves, dried rings and purees [4], is a significant source of various phytochemicals, mainly polyphenols [10]. Due to the high content of antioxidants, pectin's, phytochemicals, fibers, vitamins A and C, minerals such as potassium, calcium, phosphorus, iron and folic acid [1] apple peels are a potentially attractive ingredient for a several food products [4, 11].

Previous research has shown that apple peel is a rich source of carbohydrates, total dietary fiber, including cellulose, hemicellulose, lignin, pectin and galacturonic acid, and minerals such as Ca, Mg, Zn, Fe and Cu [12]. In addition, apple skins do not contain phytic acid, which makes minerals such as zinc unavailable [12]. Analyzing the apple peel powder obtained from Star apple fruits (*Chrysophyllum albidum*) collected in the area of Akwa Ibom State (Nigeria), Akpabio et al., 2012, obtained the following values: 47.95% moisture content, 6.68% crude protein, 8.94% crude fat, 1.82 crude fiber, 3.15% ash, 79.39% carbohydrate [13]. The proximate composition of the apple peel powders from (*Malus domestica* Borkh. cv.

Bramley's Seedling from Northern Ireland) obtained under different drying, according to Massini et al., (2013), shows the following values: 7.5 % moisture, 2.23 ± 0.10 % total ash, 3.83 ± 0.23 % total fat, 5.07 ± 0.32 % total protein, 35.38 ± 2.22 total dietary fiber, 46.00 ± 8.27 total sugars (as glucose) - for oven-dried and 9.0 % moisture total ash, 2.49 ± 0.44 % total fat, 5.36 ± 0.19 % total protein, 32.49 ± 0.10 total dietary fiber, 46.00 ± 3.03 total sugars (as glucose) for freeze-dried [14]. Apple peel powder was also analyzed by Alsuhaibani (2015), who showed that apple peel powder from apples purchased from a local market in Saudi Arabia has the following approximate composition: 5.55 ± 0.42 % moisture, 2.75 ± 0.17 % fat, 7.53 ± 0.38 % protein, 48.23 ± 0.21 % fiber, 1.77 ± 0.07 % ash, 34.17 ± 2.14 % carbohydrate, and 19.55 ± 1.24 % pectin [12].

Analyzing the chemical composition of the dried peels of Red Delicious (*Malus sylvestris* var. Red Delicious) purchased from the Mysore District Hopcoms (CFTRI), Romelle et al. found that they contain 2.80 ± 0.17 % crude protein, 9.96 ± 1.52 % lipid, 1.39 ± 0.14 % ash, 13.95 ± 0.10 % crude fibers and 59.96 ± 0.44 % carbohydrates [15]. The nutritional profile of dry apple peel powder according to: Gaynor, D. D., & Gaynor, D. D. (2017), shows the following values: 1.46% moisture, 3.17 % ash, 7.31% protein, 5.65% fat, 56.3% total dietary fibers, 82.4 % carbohydrate and 410 kcal/100 g energy [16]. Analyzing the proximate compounds of dried apple peel powder obtained from Granny Smith apples purchased from local supermarket (Canada), Zhou (2018) obtained the following values: 2.37 ± 0.02 % moisture, 2.18 ± 0.16 % fat, 89.97 ± 0.39 % carbohydrate, 1.93 ± 0.02 % ash, 3.35 ± 0.12 % protein, 13.73 ± 0.93 % insoluble dietary fiber, 7.83 ± 0.15 % soluble dietary fiber, 21.53 ± 1.10 % total dietary fiber, 46.67 ± 2.34 % total sugar – for Granny Smith apple peel powder and 2.83 ± 0.04 % moisture, 2.52 ± 0.14 % fat, 87.43 ± 0.14 % carbohydrate, 1.73 ± 0.04 % ash, 5.49 ± 0.07 % protein, 32 ± 0.61 % insoluble dietary fiber, 9.97 ± 0.23 % soluble dietary fiber, 41.93 ± 0.78 % total dietary fiber, 22.83 ± 0.76 % total sugar – for commercial dried apple peel powder [17]. According to Nakov et al., 100g apple peel powder prepared from apples of Idared variety from Razgrad Province (Bulgaria) contain 3.23 ± 0.09 g moisture, 4.78 ± 0.01 g ash, 10.15 ± 0.24 g lipid, 3.20 ± 0.98 g protein, 32.03 ± 1.44 g soluble fiber, 11.86 ± 0.31 g insoluble fiber, 43.89 ± 1.85 g total

fiber, 81.87 ± 1.19 g total carbohydrates [11]. Regarding of physico-chemical properties and sensory qualities of juices extracted from five selected fruits and their peels Agbaje et al. (2020) reported that apple peel (dried) from Oba's market in Owo, Ondo state (Nigeria) contains $2.60 \pm 0.15\%$ crude protein, $9.65 \pm 1.80\%$ crude fat, $1.68 \pm 0.10\%$ ash, $14.05 \pm 0.05\%$ crude fiber, $72.02 \pm 0.6\%$ carbohydrate [18]. Estimation of proximate composition of apple peel powder is significant for assessment of the nutritional quality of this raw material. According to Ranjha et al., (2020), 100 g of apple peel powder obtained from Granny Smith apples (purchased from a local market in Islamabad-Pakistan) contain: 8.7 ± 0.07 g moisture, 1.9 ± 0.08 g ash, 1.1 ± 0.04 crude fat, 15.6 ± 0.1 crude fiber, 2.4 ± 0.06 g crude protein [19]. Analyzing the chemical composition of three fruit peel powders (apple, banana and mango), Zahid et al. (2021), reported that apple peel powder, obtained from the cultivated Pink lady ripen fruits, has the following proximate composition: 0.57 ± 0.02 % moisture, $8.44 \pm 0.48\%$ ash, $4.53 \pm 0.28\%$ fat, $2.37 \pm 0.04\%$ protein, $19.29 \pm 1.30\%$ dietary fiber, and $64.83 \pm 1.12\%$ carbohydrates [20].

Analyzing the nutritional composition of apple peel powder obtained from apple samples collected from the local market of Lahore (province of Punjab, Pakistan), Sadef et al. (2022), reported that the analyzed dried apple powder contains $11.9 \pm 0.82\%$ moisture (of total), $2.6 \pm 0.52\%$ ash, $0.18 \pm 0.04\%$ lipid, $7.6 \pm 0.06\%$ fiber, $76.5 \pm 1.4\%$ carbohydrates [6].

In this paper, we proposed the analysis of some nutritional parameters of apple peel powder obtained from the peel of local apples. The nutritional analysis is a common method to determine the nutritional and therapeutic benefits of apple peel as a byproduct resulting from the processing of apples during the preparation of preserves, dry rings and apple purees. The concentrations of proteins, carbohydrates, dietary fibers, fats, moisture and minerals (ash) were determined from three batches of summer apples grown in hilly areas of Caras Severin County (Romania).

2. Material and methods

Apple collection

Three batches (approximately 2 kg per batch), of summer apples (*Malus domestica*), were purchased in the first decade of September 2022 from local agro-food markets in Timișoara (Romania). According to the information provided by the producer, the apples were grown in unpolluted hilly areas of Caras Severin county. Until the time of preparation and analysis of apple peel powder, the apples were stored at about 5 °C in polyethylene bags.

Preparation of apple peel powder

The apples were well washed under running tap water and dried by blotting with filter paper. The peel obtained from apples by using hand peeler were dried in a ventilated oven at 55 - 60 °C until it became crispy. After drying, the apple peels were ground in a coffee grinder, and the resulting powders were kept cold in cool brown bags.

Analysis

The determination of the nutritional composition of the apple peel powder studied was performed according to AOAC Official Methods of Analysis, 2000 [21] and according to the recommendations of Velciov et al., 2022 [22] and Hussain et al, 2021 [23].

For moisture content, dried apple peel powder was dried in an oven at 105 °C to constant mass. The mineral substances (ash) were determined by the calcination method at 550 °C. The protein content was determined by the Kjeldahl method, using a conversion factor for nitrogen of 6.25.

The crude fat was determined using the Soxhlet method with hexane as solvent. Crude fibers were determined by using the method of acid base digestion. The carbohydrate content was obtained by difference.

3. Results and discussion

The results obtained when determining the nutritional parameters of the analysis are presented in table 1.

Table 1. The nutritional parameters of apple peel powder

Specification	Nutritional parameter, %					
	Moisture	Minerals	Protein	Fats	Fibers	Carbohydrate
Limits	4.56 - 6.02	2.56 - 3.62	3.86 - 4.94	3.11- 4.03	35.15 - 38.31	61.78 - 65.44
Mean value	5.48 ± 0.76	3.01 ± 0.45	4.31 ± 0.48	3.48 ± 0.40	36.39 ± 1.23	63.84 ± 1.53

These values fall within the range of values reported by other researchers, when analyzing similar products. Each determination represents the average of three measurements. As can be seen from the data presented in table 1, the determined nutritional parameters show different values that vary depending on the origin of the apples used to prepare apple peel powder and the analyzed parameter.

Moisture content is important for food preservation and in food processing therefore [13]. The analyzed apple peel powder contains relatively low amounts of moisture, within limits between 4.56 - 6.02%. The average value of humidity ($5.48 \pm 0.76\%$) shows that analyzed apple peel powder does not present a major risk of degradation over time.

Mineral content (ash) indicates the amount of inorganic matter and oxides present in the sample [13], respectively the sum of the mineral elements that are part of the apple peel powder samples. The mineral content was determined within current limits between 2.6 - 3.62%. The average value of the ash content ($3.01 \pm 0.45\%$) reveals that apple peel powder contains important amounts of mineral elements, essential for the normal functioning of the body and can be considered as a potential source of mineral elements in the form of essential macro and micro elements.

Proteins are important biomolecules for the body's homeostasis [24]. Protein deficiency is closely related to a number of diseases such as Kwashiorkor, Marasmus (energy deficiency), mental disorders, insufficiency of different organs, edema and immune system weakness [25]. Also, increased protein intake plays an important role in diets intended especially for athletes or diseases related to diabetes and the cardiovascular system [3]. The concentration of proteins, essential macronutrients from human nutrition determined in analyzed apple peel powder has values between 3.86 - 4.94%. The average value of this nutritional parameter ($4.31 \pm 0.48\%$) shows that peel powder has a low protein intake.

Lipids are essential macronutrients that play an important physiological and biochemical role in the function of the human body, such as energy storage, structural components of biological membranes, electron carriers, enzyme cofactors, light-absorbing pigments, hydrophobic anchors for proteins and emulsifying agents in the digestive tract [26].

Fats also provide an excellent source of energy, improve the transport of fat-soluble vitamins, isolate and protect internal tissues, and contribute to vital cellular processes [13]. Besides their important nutritional role in the human diet, lipids are also exploited as food ingredients, thus improving texture, taste and flavor of new formulations [3]. The fat concentration in the analyzed apple peel powder samples has values between 3.11-4.03. The average value of the fat concentration ($3.48 \pm 0.40\%$) shows that analyzed apple peel powder is a poor source of calories.

Dietary fiber refers to the sum of non-starch polysaccharides and lignin [3]. Various fruit by-products from the food processing industry, such as the beverage, canning, puree and juice industries, have been reported to contain significant amounts of cellulose, hemicellulose, pectin, gums and lignin [3]. The interest in knowing the dietary fiber content is closely associated with their role in decreasing many health disorders [11]. Cellulose, hemicellulose and lignin are well known for water absorption and regulation of the intestinal tract, while pectin and gums are important in cholesterol reduction and glucose regulation [27]. In addition, dietary fibers can be widely used in the food industry when they are incorporated into many foods in order to enrich their nutritional and sensory properties [11, 27]. The concentration of these macronutrients in the apple peel samples analyzed has values between 35.15 - 38.31%. The average value of dietary fiber content ($36.39 \pm 1.23\%$) confirms the fact that apple peel powder can be used as a source of dietary fiber.

Carbohydrates are the body's main source of energy, being necessary for the normal functioning of muscles and the brain and helping to use fats, protecting cells against external harmful effects [28]. The major metabolic role of carbohydrates in diets is the energy production [13]. Although there are different types of carbohydrates, only total carbohydrates are taken into consideration in food and remains when the protein, fat, moisture and ash of the food have been removed [12]. The analyzed apple peel powders contain increased amounts of carbohydrates, their concentration being between 61.78 - 65.44%. The fact that the analyzed apple peel powders can be used as sources of carbohydrates is also confirmed by the average value of their carbohydrate content ($63.84 \pm 1.53\%$).

From the presented data, we can state that the apple peel powders obtained and analyzed, under the conditions of the present experiment, contain increased amounts of carbohydrates and dietary fibers, important amounts of minerals and a reduced intake of fats and proteins. Also, according to previous research, apple peel powders represent a strong natural source of antioxidant and other phytochemicals that have multiple roles as anticancer, antidiabetic, antihypertensive, antiaging and anti-inflammatory in the prevention of many chronic diseases [10]. The determination of some antioxidant compounds levels in apple peel powders is the concern of the authors of this paper, and will be addressed in a subsequent study. The values of the nutritional parameters of apple peel powder recommend its use as a food additive used to enrich the nutritional and therapeutic quality of food products. In addition, the use of apple peels, resulting as secondary products from the processing of these fruits, for obtaining apple peel powder and its inclusion in various foods offers a correct and advantageous solution for reducing environmental pollution.

Conclusions

Dried apple peel powders obtained under the conditions of the present experiment contain increased amounts of carbohydrates and dietary fibers, significant amounts of minerals and relatively low amounts of proteins and fats. The preliminary results obtained (4.56 - 6.02% moisture, 2.56 - 3.62% minerals, 3.86 - 4.94% proteins, 3.11 - 4.03% fats, 35.15 - 38.31% dietary fibers and 61.78 - 65.44% carbohydrates) recommend its inclusion in different foods in order to increasing the nutritional value, especially of the carbohydrate and fiber content, but also of minerals. In addition, the superior recovery of apple peels, a by-product resulting from apple processing, as dried apple powder used for subsequent food applications, offers a correct and advantageous solution for reducing environmental pollution.

Compliance with Ethics Requirements: Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human or animal subjects (if exist) respect the specific regulation and standards.

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