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Analysis of vegetable's peels as a natural source of vitamins and minerals

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Abstract

Peels of vegetables and fruits are considered waste products and thrown into the environment. However, some researches on the peels of fruits revealed the presence of important phytochemicals having diverse biological activities. In the current study, peel samples of seven underground vegetables namely, *Beta vulgaris, Brassica rapa, Daucus carota, Ipomoea batatas, Raphanus sativus, Solanum tuberosum* and *Zingiber officinale* were evaluated for vitamin and mineral contents. The vitamin C content of the peels ranged between 43.6 to 122.5 mg/100g, while riboflavin, thiamin and niacin levels were between 0.3 to 0.8 mg/100g, non-detection to 0.4 mg/100g and 0.2 to 1.6 mg/100g, respectively. Appreciable amounts of various minerals such as calcium, sodium, magnesium, iron, manganese, zinc, potassium and phosphorus were detected in the peel samples. The overall findings confirmed that peels are rich source of minerals and vitamins and can be utilized as food, feed and dietary ingredients after appropriate processing.

Introduction

Vegetables and fruits are extremely important in human nutrition. They provide us important nutrients, minerals, dietary fiber, antioxidants and other beneficial phytochemicals. Vegetable are available almost throughout a year in a wide variety and used fresh, cooked and pickled. A growing number of scientific investigations have revealed that vegetable consumption is clearly linked with good health and reduced risk of diseases (Liu, 2003). In 2012, Boeing et al. published a detailed review on the association between the intake of vegetables and fruits, and the risk of several chronic diseases. They study showed that a high daily intake of fruits and vegetables promotes good health. With the increasing awareness of consumers about the nutritional importance of fruits and vegetables, the consumption of these is rising day by day.

Scientific investigations revealed the presence of a large number of biologically active phytochemicals in all parts of the plants such as stems, barks, peels, stalks, flowers, fruits, leaves, roots, latex, hulls, seeds, fruit rinds and pods (Kaneria *et al*., 2009; Karaalp *et al*., 2009; Aref *et al*., 2010; Rajaei *et al*., 2010). Earlier studies conducted on fruit peels and seeds (Singh *et al*., 2002; Jayaprakasha *et al*., 2003; Mandalari *et al*., 2007; Katalinic *et al*., 2010; Prasad *et al*., 2010; Singh and Immanuel, 2014) revealed that these possess antimicrobial, anticancer, antioxidant and hepatoprotective properties.

Peels of vegetables and fruits are often thrown as agro wastes, fed to livestock and utilized as fertilizers. Agro wastes are produced in great amounts during industrial food processing and household usage. These wastes are highly prone to microbial spoilage and therefore pose a serious threat to the environment. The food wastes are needed to be managed and utilized beneficially. Many strategies are developed which include the utilization of these wastes in food and non-food items. A recent study on the papaya peel and seed flours (Santos *et al*., 2014) showed these had high contents of protein and fiber, and therefore can be used as alternative sources of nutrients. The authors further discussed that peels can be added into various foods to add value. Abdrabba and Hussein (2015) worked on the peels of red grape and reported that the peels had high content of calcium, magnesium, phosphorus and potassium.

Underground vegetables are the precious source of various nutrients, beneficial phytochemicals such as flavonoids, reducing sugars, amino acids, tannins, saponins, phlobatannins, anthraquinones, carbohydrates, steroids, phytosterol, alkaloids, terpenoids, cardiac glycosides and chalcones (Schieber and Saldana, 2009; Chanda *et al.*, 2010; Kalpna *et al*., 2011; Gupta, 2012; Kandari and Gupta, 2012; Janjua *et al*., 2013; Geetha *et al.*, 2014; Parashar *et al.*, 2014). Screening of vegetable peels may lead to isolation of nutritionally and therapeutically useful compounds. In the, present investigation, we report the mineral and vitamin contents of peels of seven

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underground vegetables, that are commonly available and frequently consumed in Pakistan.

Materials and Methods

Plant materials

Seven fresh underground vegetables, namely *Beta vulgaris, Brassica rapa, Daucus carota, Ipomoea batatas, Raphanus sativus, Solanum tuberosum* and *Zingiber officinale* were procured from the local market of Peshawar. They were thoroughly washed with water and then peels were separated carefully. The peels were washed again, cut into small pieces and dried under shade. The dried samples were pulverized in a grinder (Retch Muhle-Germany), passed through the 30 mesh sieve and packed in clear polyethylene pouches. The samples were sealed using an electric sealer (PFS 300, Japan) and stored at 4°C until further analysis.

Mineral analysis

The dried peel powders of underground vegetables were evaluated by wet digestion method using a mixture of perchloric and acid nitric (Khattak, 2012). Each analysis was carried out in triplicate. One gram of each sample was digested with a 25 ml of diacid mixture (HNO_3:$HClO_4$, 5:1, v/v) in a fume cupboard. Heating was initially done at 80°C and then temperature was gradually increased to 250°C. After complete digestion, each sample was heated to near dryness (approximately 1-2 ml). The digested samples were cooled and transferred to flasks. The volume was brought up to 50 ml using double distilled deionized water and samples were then filtered through Whatman No. 42 filter paper. Analyses were done using atomic absorption spectrophotometer, flame photometer and spectrophotometer.

Determination of vitamin C

Vitamin C was determined in peel samples of underground vegetable by dichlorophenol Indophenol dye reduction method with slight modifications (Achikanu *et al*., 2013). About 0.5 g of the sample was weighed and macerated with 12 ml of 0.4% oxalic acid in a test tube for 30 minutes. Afterward it was centrifuged for 5 minutes and the solution was filtered using Whatman filter paper. One ml of the filtrate was transferred into a dry test tube and 9 ml of 2,6- dichlorophenol indophenol solution was added to it. The absorbance was taken at 15 and 30 seconds interval at 520 nm.

Estimation of thiamine

Thiamine contents were estimated by method as described by Koche (2011). Five gram of sample was homogenized in 50 ml ethanolic sodium hydroxide solution. The solution was filtered and 10 ml of the filtrate was added to 10 ml potassium dichromate solution. The absorbance was recorded at 360 nm.

Estimation of niacin

The peel samples of the vegetables were evaluated for niacin contents (Koche, 2011). Five gram of sample was mixed with 50 ml of 1N sulphuric acid. The solution was kept at room temperature for 30 minutes and 0.5 ml of ammonia solution was added to it. The mixture was filtered then and 10 ml of filtrate was mixed with 5 ml of potassium cyanide. Afterward the mixture was acidified with 5 ml 0.02 N sulfuric acid. The absorbance of the resulting solution was recorded at 420 nm.

Estimation of riboflavin

Riboflavin was assessed by taking 5 g peel powder, mixed with 120 ml of ethanol and kept for 2 hours. The extract was filtered and 10 ml of this was mixed with 10 ml of 5% potassium permanganate and 10 ml of 30% hydrogen peroxide solutions. This mixture was allowed to stand on hot water bath for 30 minutes. Later 2 ml of 40% sodium sulphate was added and the volume was made up to 50 ml. The absorbance was recorded at 510nm.

Results and Discussion

The vegetables wastes and their by-products are formed in great amounts during their household use and industrial processing. Increasing concern about environmental pollution that occurs from agriculture wastes has moved the attention of scientific community in converting these huge waste materials into valuable products. In the current study, peels of various underground vegetables were evaluated for vitamins and mineral contents.

The results regarding the vitamin contents of selected underground vegetables' peels are shown in Figures 1 to 4. The concentration levels are given in mg/100 on dry weight basis. The vitamin C content of *Beta vulgaris, Brassica rapa, Daucus carota, Ipomoea batatas, Raphanus sativus* and *Solanum tuberosum* were 117.5, 68.0, 61.3, 43.6, 122.5, 53.7 and 103.1 mg/100g, respectively (Figure 1). The peels of Ipomoea batatas showed the lowest vitamin C content, while *Raphanus sativus* plant showed the maximum value. There is no study on the plants to compare the results regarding the vitamin C contents. However, findings of a study, conducted by Oliveira *et al.* (2015) showed that peels of plum, nectarine

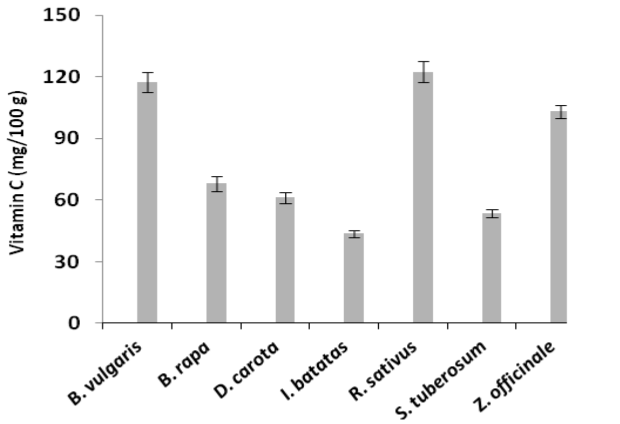

Figure 1. Vitamin C content in peel samples of underground vegetables. Values are the means of triplicate determinations (n = 3) ± standard deviations. The vertical bars represent the standard deviation for each data point

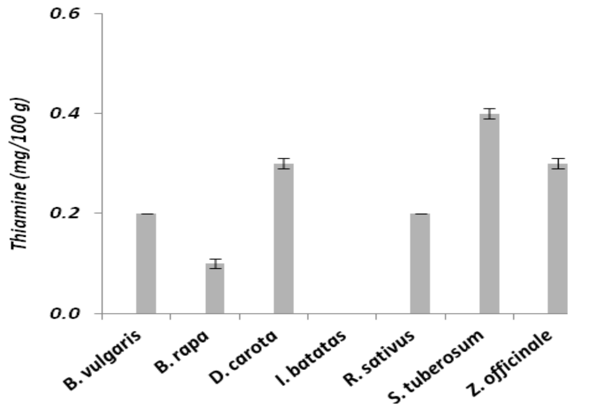

Figure 3. Thiamine content in peel samples of underground vegetables. Values are the means of triplicate determinations (n = 3) ± standard deviations. The vertical bars represent the standard deviation for each data point

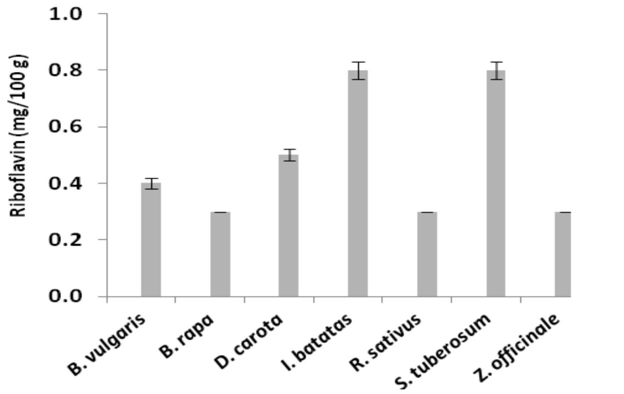

Figure 2. Riboflavin content in peel samples of underground vegetables. Values are the means of triplicate determinations (n = 3) ± standard deviations. The vertical bars represent the standard deviation for each data point

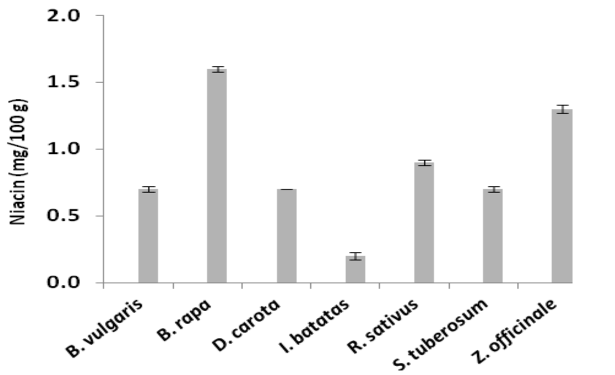

Figure 4. Niacin in peel samples of underground vegetables. Values are the means of triplicate determinations (n = 3) ± standard deviations. The vertical bars represent the standard deviation for each data point

and grape contain 105.0, 8.3 and 51.3 mg/100 g vitamin C contents, respectively. Another scientific investigation (Abdrabba and Hussein, 2015) on the chemical composition of red grape illustrated that the pulp, seed and peel samples have 10.63 23.40, 9.80 mg/100g vitamin C content, respectively. Vitamin C is the body's first line of defense in averting diseases and infections (Walingo, 2005). Riboflavin contents of the vegetable's peels are presented in Figure 2. The levels of riboflavin were in the range between 0.3 to 0.8 mg/100g. The peels of *Ipomoea batatas* have the maximum value for riboflavin content. An earlier study conducted by Chukwuka *et al.* (2013) showed that peel sample of the mature fruits of Carica papaya contain the highest riboflavin content (0.08 mg/100 g), as compared to that of the pulp and seed. Riboflavin helps to enhance the natural immunity by strengthening the antibody reserves and by reinforcing the defense system against infections (FAO and WHO, 2002; WHO and FAO, 2004). Thiamine content of the peels of selected vegetables ranged from non-detection to 0.4 mg/100g (Figure 3). No thiamin contents were detected in the peels of *Ipomoea batata*, while *Solanum tuberosum* peels showed the maximum concentrations of thiamin. Nutritional analysis of the fruits of *Carica papaya*, carried out by Chukwuka *et al.* (2013) showed that pulp, seed and peel sample of the fruits have 0.12, 0.03 and 0.06 mg /100 g thiamine, respectively. Thiamine ensures proper cardiac functions and prevents cataract, stress, depression and anxiety (FAO and WHO, 2002; WHO and FAO, 2004). The results regarding niacin's estimation are given in Figure 4. The data showed that the niacin contents of *Beta vulgaris, Brassica rapa, Daucus carota, Ipomoea batatas, Raphanus sativus* and *Solanum tuberosum* were 0.7, 1.6, 0.7, 0.2, 0.9, 0.7 to 1.3 mg/100g, respectively. The *Brassica rapa* showed the maximum niacin content. The findings of an earlier study done on the fruits of *Carica papaya* (Chukwuka *et al*., 2013) showed that the peel sample had higher niacin content (0.44mg/100g) than that of the pulp (0.33mg/100g) and seed (0.11 mg/100g) samples. Niacin helps control blood sugar, decrease

Table 1. Mineral composition (mg/100 g) of peel samples of underground vegetables

Minerals	Ca	Na	Mg	Fe	Mn	Zn	K	P
Beta vulgaris	39 ± 4	315 ± 13	44 ± 2	16 ± 0	2 ± 0	12 ± 0	993 ± 35	257 ± 15
Brassica rapa	159 ± 8	79 ± 3	267 ± 10	23 ± 1	2 ± 0	5 ± 0	1736 ± 19	277 ± 13
Daucus carota	121 ± 6	206 ± 6	167 ± 13	29 ± 1	6 ± 0	11 ± 0	1123 ± 45	232 ± 8
Ipomoea batatas	107 ± 12	283 ± 9	168 ± 7	10 ± 0	16 ± 1	21 ± 1	1108 ± 39	399 ± 17
Raphanus sativus	212 ± 13	361 ± 4	279 ± 9	27 ± 1	8 ± 0	17 ± 0	271 ± 8	515 ± 22
Solanum tuberosum	73 ± 3	206 ± 9	142 ± 7	11 ± 0	3 ± 0	9 ± 0	1895 ± 43	273 ± 11
Zingiber officinale	19 ± 1	110 ± 3	59 ±1	53 ± 2	18 ± 1	16 ± 1	2118 ± 43	197 ± 8

Values are means ± standard deviations of three determinations. The values are expressed on a dry weight basis

cholesterol levels, helps in the production of adrenal hormones and involved in fat metabolism (FAO and WHO, 2002; WHO and FAO, 2004).

No information is available in the literature regarding the niacin, thiamin and riboflavin contents of the vegetable peels. The results of a study, conducted by Ismail *et al.* (2013) on vegetables (carrot, brinjal, okra and spinach) and fruits (banana, guava) showed that the thiamin (B1), riboflavin (B2) and niacin (B3) were in the range of 0.02- 0.18mg/100gm, 0.016-0.2mg/100gm and 0.01-0.1mg/100gm, respectively. Hanif *et al*. (2006) worked on carrot, cabbage, lettuce, spinach, sweet pepper, potato, cauliflower, radish, tomato, and bottle gourd. They reported that thiamin, riboflavin, niacin and vitamin C ranged between 0.03 to 0.13, 0.03 to 0.15, 0.3 to 1.2 and 10 to 76 mg/100g. Janjua *et al*. (2013) analyzed the peel extracts of edible root of *Raphanus sativus* L. for phytochemicals and antibacterial activity. The results revealed the presence of tannins, saponins, flavonoids, anthraquinones, carbohydrates, reducing sugars, alkaloids, amino acids, terpenoids, cardiac glycosides signifying its medicinal use. The peel also showed significant antibacterial activity against several important pathogens. Chanda *et al*., (2010) worked on the possibility of using the plant peel waste as a source of low-cost natural antimicrobials and they found that the peels have the antibacterial activity against several pathogens and that these can be used in the prevention of infectious diseases.

Various mineral like calcium, sodium, magnesium, iron, manganese, zinc, potassium and phosphorus were evaluated for underground vegetable peels and their results are recorded in Table-1. The concentration levels are described in mg/100 g on dry weight basis. The calcium, sodium, magnesium, iron, manganese, zinc, potassium and phosphorus contents of the peel samples ranged between 19 to 212 mg/100g, 79 to 361 mg/100g, 44 to 279 mg/100g, 10 to 53 mg/100g, 2 to 18 mg/100g, 5 to 21 mg/100g, 993 to 2118 mg/100g and 197 to 515 mg/100g, respectively. Earlier, Ullah *et al.* (2012) worked on the peels powder of pomegranate (*Punica granatum* L.) and reported 10000 ±0.6 ppm, 1100 ±0.4 ppm, 60.5 ±0.2 ppm, 4.5 ± 0.8 ppm and 4.0 ± 0.65 ppm potassium, sodium, iron, manganese and zinc contents, respectively. Mineral analysis conducted by Achikanu *et al.* (2013) showed that the leafy vegetables contained calcium ranged from 91.33-873.33 mg/100ml, zinc 3.33-491.66 ml/100ml, manganese 11.53-120 g/ml, iron 13.85-80.42 mg/100ml and magnesium 14.69-44.45 mg/100ml and low level of potassium 1.65-4.90 mg/100ml. Minerals are present in all parts of body and are essential for life (WHO and FAO, 2004; Soetan *et al.*, 2010). Mineral deficiencies can lead to many health disorders. The results of our previous study (Khattak and Rahman, 2015) on the same seven underground vegetables i.e. *Beta vulgaris, Brassica rapa, Daucus carota, Ipomoea batatas, Raphanus sativus, Solanum tuberosum* and *Zingiber officinale* revealed that their peels are good sources of fiber, protein and ash contents. The peels also showed strong scavenging activities against DPPH radical and hydrogen peroxide. The results of that study also indicated that the peels are rich in flavonoids (63.7 to 147.7 mg/100g), phenolic (930.0 to 1658.2 mg/100g) and carotenoids (44.0 to 188.3 mg/100g). Abdrabba and Hussein (2015) accomplished a study on the proximate nutrients, chemical composition, minerals and vitamins of the pulps, seeds and peels of red grape at the optimum maturity. Their results showed that the peel had the highest content of calcium, magnesium, phosphors, and potassium.

Vitamins and mineral profiles of the peel samples of underground vegetables showed their medicinal and nutritional importance. After appropriate processing, peels can be used in pharmaceutical, cosmaceutical, nutraceutical and food preparations etc.

Conclusions

Current study revealed the presence of considerable amounts of water-soluble vitamins such as thiamin, riboflavin, niacin and vitamin C in the peel samples of seven underground vegetables. The peels were also found to have appreciable contents of calcium, sodium, magnesium, iron, manganese, zinc, potassium and phosphorus. The study suggests that the peels of vegetables should not be wasted, rather utilized in the preparations of health and nutritional products after appropriate processing. They can serve as cheap, natural, safe and environment friendly raw materials.

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