

Nutritional Content and Antioxidant Properties of Pulp Waste from *Daucus carota* and *Beta vulgaris*

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ABSTRACT

This study reports the chemical composition and antioxidant potential of pulp waste from two vegetables, carrot (*Daucus carota*) and beetroot (*Beta vulgaris*). Different *in vitro* assays used for determining antioxidant potential of extracts of pulp wastes were: 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging capacity, reducing power and total antioxidant activity by phosphomolybdenum method. Total polyphenols, tannins and antioxidative components such as vitamin C, total carotenoids and $\hat{\alpha}$ -carotene were analysed in the samples. The moisture content of samples ranged from 79 - 84%. The protein content was high in beetroot (13.23 mg/100g) and low in carrot (6.21mg/100g). Total polyphenols were higher in methanol extracts of samples (220-250 mg/100g) compared to ethanol and aqueous extracts. The antioxidant activity determined by the DPPH method exhibited 40% and 78% activity in methanol extracts of carrot and beetroot pulp waste (20 mg) respectively. Overall, the results suggest that carrot and beetroot pulp wastes can be exploited for their nutrients and antioxidant components and used for value addition in food formulations. Hence, these results pave the way for utilisation of bio-wastes from the food industry.

Keywords: Anthocyanins, $\hat{\alpha}$ -carotene, polyphenols, tannins, vegetables

INTRODUCTION

Residue from the processing of fruits and vegetables, traditionally considered as an environmental problem, are being increasingly recognised as sources for obtaining high-phenolic products. The polyphenolics from waste materials, being derived from agro-industrial production, may be used as functional food ingredients and as natural antioxidants to replace their synthetic equivalents that have experienced growing rejection (Zhou *et al.*, 2009).

Fruits and vegetables are good sources of dietary fibre. By-products from the fruit

and vegetable industry, in particular, are of interest since they are inexpensive and available in large quantities. Some of the agricultural by-products such as apples, citrus fruits and Brassica vegetables have already been used in the production of dietary fibre (Figuerola *et al.*, 2005; Grigelmo-Miguel & Martin-Belloso, 1999).

Pomace is the residue remaining when fruits are processed for juice, wine, or other products. Many studies have reported that fruit pomaces contain abundant phenolic compounds (Lu & Foo, 1997; Ruberto *et al.*, 2007). Hence, byproducts obtained from the

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juice and wine industry might be useful raw materials for creating new value-added products. Recovery of products with high phenolics from various pomaces such as grape (Louli, Ragoussis & Magoulas, 2004) and apple (Schieber *et al.*, 2003) has been reported.

Carrots and beetroots have been known to be good sources of natural antioxidants including carotenoids, vitamins, phenolic compounds and flavonoids. They are used for the manufacture of ready-to-drink vegetable juices. A considerable amount of vegetable pulp is left after filtration of juice and is available as a byproduct of this beverage industry. There are very few systematic studies carried out on possible utilisation of such waste material. Hence, the study was undertaken with the objective of analysing the pulp waste of carrot and beetroot for its chemical composition and potential antioxidant activity. This information is intended to help in further utilisation of these bio-wastes from industry.

MATERIALS AND METHODS

Chemicals used for the study were as follows: L-Ascorbic acid, β -carotene, 2, 2-Diphenyl-1-picrylhydrazyl (DPPH) were from Sigma (Sigma-Aldrich, USA) Chemical Co. All other chemicals were of analytical grade and obtained from E-Merck, Mumbai, Qualigens Fine Chemicals, Mumbai, India. Double glass distilled water was used for all analysis. All analysis were run in triplicates and averaged.

Preparation of carrot and beetroot pulp wastes

Carrot (*Daucus carota*) and beetroot (*Beta vulgaris*) were obtained from the local market, cleaned, peeled, grated, homogenised and filtered for separating juice. The pulp left after juice extraction was dried in an oven at $50 \pm 1^\circ\text{C}$ and powdered using a lab grinder and stored in air-tight jars under refrigeration at 4°C till use. A record of the

yield of pulp from vegetables and after converting to powder was maintained.

Physical characteristics of the samples

Colour

Color is generally the first attribute, which influences acceptability. Colour of dried powders by visual observation was determined using Munsell colour charts (2000).

Estimation of Bulk density

Bulk densities of the samples (g/100 mL) were determined by the method of Wang & Kinsella (1976). Three gram of the finely powdered sample was placed in a 25 mL graduated cylinder and packed gently by tapping the cylinder on rubber sheet until a constant volume was obtained and noted.

Water absorption capacity (WAC)

WAC of the sample (mL/100g) was determined by the centrifuge technique of Janicki & Walczak (1954). A 1.0 g sample taken in a centrifuge tube was mixed with 5.0 mL water. The slurry was weighed, kept aside for 30 min with gentle stirring with a glass rod every 5 min and centrifuged at 3000 rpm for 25 min. The amount of water retained was calculated by measurement of the difference in the weight of the sample before and after equilibration with water.

Estimation of moisture, fat, protein, dietary fiber and total ash

Dried powder of pulp waste were analysed for proximate composition. Moisture was estimated by vacuum oven (method 926.12, 41.1.02) procedure. The pulp left after juice extraction was weighed, dried overnight, cooled in a desiccator and weighed to get a constant weight. These samples were stored under refrigeration and moisture content was re-determined before analysis. Total ether extractives were estimated by Soxhlet apparatus using petroleum ether for

extraction (method 948.22, 40.1.05) with the solvent being evaporated and the residue weighed to determine the fat content. Protein by Kjeldahl nitrogen (method 960.52, 12.1.07) was determined utilising the principle that organic nitrogen when digested with sulphuric acid in the presence of a catalyst is converted into ammonium sulphate. Ammonia, liberated by making the solution alkaline, is distilled into a known volume of standard acid which is then back titrated. The protein content is obtained by multiplying the nitrogen value with 6.25. Ash by direct analysis (method 942.05, 4.1.10) (the greyish white residue remaining after the food sample is charred on a hot plate in a silica crucible, incinerated in a muffle furnace at 600°C for 3-5 hours and weighed), was determined according to the Association of Official Analytical Chemists (AOAC, 2005).

Dietary fibre consisting of insoluble and soluble fractions was estimated by the enzymatic gravimetric (Asp *et al.*, 1983) method. The sample was sequentially digested with enzymes and filtered through a dryer and weighed in a G2 crucible containing celite, then washed with water, ethanol and acetone. The residue was dried at 105°C to get constant weight and was incinerated at 550°C for 5-6 hours, cooled in a dessicator and weighed. Correction for *in vitro* indigestible protein was made by determining the protein content. This gives the insoluble fibre content.

For determination of soluble fibre, the volume of the filtrate and water washings of the residue was precipitated with ethanol and filtered through another dryer and weighed in a G2 crucible containing celite. Its residue was then washed with ethanol and acetone, dried at 105°C and weighed after cooling in a dessicator to get constant weight. Incineration and correction for protein was done in the same way as stated above for insoluble fibre. Blank values were obtained by following the above procedure without sample. The blank values were checked occasionally with each batch of

enzyme. Total carbohydrates were calculated by difference from the other components from 100.

Estimation of vitamin C, carotenoids and total anthocyanins

Ascorbic acid was estimated by 2, 6-dichlorophenol indophenol visual titration method, which is based on reduction of the dye colour from blue to pale pink by ascorbic acid (Ranganna, 1986). For estimation of carotenoids, the powdered samples were extracted in acetone and transferred to petroleum ether phase. Total carotene was read colorimetrically using petroleum ether for baseline correction. β -carotene was separated by column chromatography and read colorimetrically (Ranganna, 1986).

Total anthocyanins in powdered sample were determined by extracting with ethanolic HCl and measurement of colour at the wavelength of maximum absorption. The content was calculated by making use of the λ max (molecular extinction coefficient) value as 98.2 (Ranganna, 1986).

Estimation of phosphorus, iron and calcium

Phosphorus analysis was carried out by measuring the blue colour, which is formed when the ash solution was treated with ammonium molybdate. The phosphomolybdate thus formed was reduced and read colorimetrically. Iron was determined colorimetrically making use of the fact that ferric iron gives a blood red color with potassium thiocyanate. For calcium estimation, it was precipitated as oxalate, dissolved in H_2SO_4 and titrated against potassium permanganate (Raghuramulu, Nair & Kalyansundaram, 2003).

Analysis of anti-nutrients

Oxalates were extracted with hydrochloric acid, precipitated as calcium oxalate from the deproteinised extract and estimated by subsequent titration with potassium permanganate (Baker, 1952). Phytic acid

was extracted and determined according to the supernatant difference method (Thompson & Erdman, 1982).

Preparation of sample extracts in solvents

For estimation of polyphenols and antioxidant activity, samples were extracted with ethanol, methanol and in aqueous medium. A 1.0 g of sample was suspended with 100 mL solvent, allowed to extract for 3 hours with agitation, centrifuged at 3000 rpm and filtered. All analyses were carried out in fresh extracts.

Analysis of total polyphenol content

Samples were analysed for total polyphenol content as tannic acid equivalents (TAE) / 100 g of sample according to the Folin-Ciocalteu method (Matthaus, 2002). A known volume of the extract was dissolved in water. To the resulting solution, 0.2 mL of Folin-Ciocalteu reagent, and a saturated solution of Na_2CO_3 (0.5 mL) was added. This was made up to 10 mL with distilled water and incubated at 27 °C for 30 mins, and absorbance measured at 765 nm.

Analysis of tannin content

Tannins were estimated by colorimetric method based on the measurement of blue colour formed by the reduction of phosphotungstomolybdic acid by tannin like compounds in alkaline solution (AOAC, 1970).

Total antioxidant activity by phosphomolybdenum method

This assay is based on the reduction of Mo(VI) to Mo(V) by the sample analyte and formation of green phosphate/Mo(V) complex at acidic pH (Prieto, Pineda, & Aguilar, 1999). An aliquot of 0.1 mL sample with 1.0 mL of reagent solution was incubated at 95°C for 90 minutes and absorbance measured at 695 nm against a blank. For samples of unknown composition, antioxidant capacities are

expressed as equivalents of ascorbic acid (*i* mole/100 g of sample).

Free radical scavenging activity using DPPH

DPPH, a commercial oxidising radical is reduced by antioxidants. The disappearance of the DPPH radical absorption at a characteristic wavelength is monitored by a decrease in optical density (Oktay, Culcin, & Kufrevioglu, 2003). Different concentrations of extract were taken in different test tubes and the volume equalised with MeOH. Four mL of a 0.1 mM methanol solution of DPPH was added to these test tubes and shaken vigorously. The tubes were then incubated in the dark for 20 min. A control sample was prepared as above without extract, and methanol was used for the baseline correction. Changes in the absorbance of the samples were measured at 517 nm and radical scavenging activity expressed as the inhibition percentage.

Reducing power

In this assay, Fe^{3+} /ferricyanide complex was reduced to the ferrous form by antioxidants. The Fe^{2+} formed was monitored by measuring the formation of Perl's Prussian blue at 700 nm (Oyaizu, 1986). Different amounts of sample in 1.0 mL of distilled water were mixed with phosphate buffer (2.5 mL, 0.2M, pH 6.6) and potassium ferricyanide [$\text{K}_3\text{Fe}(\text{CN})_6$] (2.5 mL, 1%). The mixture was incubated at 50 °C for 20 min. A portion (2.5 mL) of trichloroacetic acid (10%) was added to the mixture, which was then centrifuged at 3000 rpm for 10 min. The upper layer of the solution (2.5 mL) and FeCl_3 (0.5 mL, 0.1%) were mixed and the absorbance was measured at 700 nm. Increased absorbance of the reaction mixture indicated increased reducing power.

Statistical analysis

The data were analysed for mean and standard deviation. Student's *t*-test was

Table 1. Physical characteristics of the pulp wastes

Samples	Physical characteristics				
	Colour*	Yield		Water absorption capacity of dry powder (ml/100g)	Bulk density of dry powder (g/100ml)
	Dry	As g/100g of whole fruit	As dry powder (g/100 g)		
Carrot	2.5 YR 8/3 Pink	35.45	13.31	1050.00±0.00	54.54±0.00
Beetroot	10 YR 3/3Dark brown	19.96	14.56	600.00±0.00	53.57±0.00

* Munsell Colour Charts (2000)

used to determine significant differences in polyphenols and antioxidant activity in pulp wastes. Correlation coefficient test was applied to test the association between the antioxidant components and the antioxidant activity of the pulp wastes using a statistical package SPSS 10.0 for windows. Probability level was fixed to $P < 0.05$.

RESULTS AND DISCUSSION

Physical characteristics of the pulp wastes

A preliminary investigation of the physical properties of food materials intended for future use as supplemental ingredients gives an idea about their possible functional behaviour during processing as well as their effect on the quality of the end product. The physical characteristics of pulp wastes are given in Table 1. The colour of food ingredients is important as it has a bearing on the visual appeal of the product to which they are added. The colour of the pulp wastes was analysed using Munsell colour charts. The dry powder of carrot was pink in colour whereas that of beetroot was dark brown. The yield of pulp waste obtained (as % of whole fruit) was higher in carrot pulp (35%) compared to beetroot (19%).

The yield of dry powder was almost similar for both pulp wastes, that is, 13% and 14%. Considering that these are

byproducts of the food industry, they are available in significant amounts for further use. Water absorption capacity (WAC) was higher in carrot pulp powder (1050 mL/100 g DW) compared to beetroot (600 mL/100 g DW) pulp powder. The WAC of pulp waste may be due to their high fibre contents. WAC can influence both the sensory and keeping quality of foods apart from affecting their processing behaviour.

The hydration property of dietary fibre refers to its ability to retain water within its matrix. Hence, this allows for enhanced viscosity of the food to which they are added (Figuerola *et al.*, 2005). The high water retention of fibre has been attributed to the SDF fraction (Grigelmo-Miguel & Martin-Belloso, 1999). High Water Retention Capacity (WRC) of carrot pulp has been previously reported and a significant increase in WRC was observed after blanching. The WRC of carrot peels was higher than that of pulp (Bao & Chang, 1994). The bulk density of dry powder was almost similar for both samples with 53% and 54% for beetroot and carrot pulp waste respectively.

Nutritional content of the pulp wastes

Since the pulp wastes used in the present study arose from edible parts of the carrot and beetroot, it was interesting to determine

Table 2. Chemical composition of carrot and beetroot pulp wastes (per 100 g)

Parameters	Carrot	Beetroot	Parameters	Carrot	Beetroot
<i>Proximate constituents</i>			<i>Antinutrients</i>		
Moisture* (g)	84.23±0.18	79.40±0.53	Total oxalate (mg)	0.039±0.00	0.24±0.01
Moisture (g)	7.54±0.44	7.45±0.07	Water soluble oxalate (mg)	0.019±0.00	0.18±0.00
Protein (g)	6.21±0.09	13.23±0.00	Phytate (mg)	61.53±4.46	169.67±3.56
Ether extractives (g)	2.72±0.09	0.31±0.01	Insoluble dietary fibre (g)	32.00±3.30	39.53±0.23
Carbohydrate (By difference)	32.22	11.97	Soluble dietary fibre (g)	13.53±0.57	21.33±0.46
<i>Minerals</i>			<i>Antioxidant components</i>		
Ash (g)	5.78±0.06	6.18±0.01	Total carotenes (mg)	4.00±0.02	ND [§]
Iron (mg)	11.66±0.00	3.66±0.00	β-carotene (mg)	3.92±0.61	ND [§]
Phosphorus (mg)	293.81±3.55	206.20±2.07	Anthocyanin (mg)	ND [§]	14.40±0.52
Calcium (mg)	291.20±0.00	205.00±2.08	Vitamin-C (mg)	3.53±0.11	3.6±0.00
			Tannins (mg)	318.00±3.00	610.50±6.53

* Fresh weight basis; § Not detected

their nutritional composition. The moisture content of the fresh beetroot and carrot pulp were 79% and 84%. These were dried and stored prior to analysis and at the time of analysis, the moisture content of dry powders was estimated again and found to be 7.45% and 7.54% (Table 2). It might be noted here that the moisture content of products on storage is an important determinant of their keeping quality. There is some amount of water ingress in samples especially during refrigerated storage and it increases as the duration of storage increases. Products with high moisture deteriorate on storage.

Protein content was high in beetroot (13.23%) and low in carrot (6.21%). The protein content of the carrot peels recorded by Chantaro, Devahastin & Chiewchan (2008) were high in both blanched and unblanched peels dried at different temperatures (9.6 -12.87 g/100g) compared

to our study. In another study Bao *et al.* (1994) reported the protein content of unblanched carrot pulp to be 4.2 g, water blanched as 5.1 g and acetic acid blanched as 5.0 g/100g of samples. These differences in values can be attributed to varietal differences of carrot and inherent biological variations. The protein content of different fibre concentrates from apple pomace and citrus peel studied by Figuerola *et al.* (2005), was found to be in the range of 3.64 to 8.42 g/100g. The protein contents of apple pomace (6.70 - 6.79 g/100g) were in close agreement for carrot pulp waste in our study.

Ether extractives were high in carrot (2.72%) compared to beetroot pulp waste (0.31%). Carrot peels studied by Chantaro *et al.* (2008) had lower lipid contents ranging from 1.23-1.75 g/100 g in both blanched and unblanched carrot peels respectively. Bao *et al.* (1994) reported lipid content in carrot as 1%. In another study by Chau, Chen & Lee

(2004), carrot pomace had a lipid content of 1.13 g/100g which was also lower than our values. Though generally vegetables are poor sources of lipids, they do provide fair amounts in some cases. The ash content was almost similar for both the residues (6.18% and 5.78%) indicating high mineral content. This value was in close agreement with the values of carrot pulp of 5.7- 6.2 g/100g studied by Bao *et al.* (1994) and of 7.67 g/100g found by Chau *et al.* (2004). Both the pulp wastes are good sources of calcium and phosphorus and carrot pulp waste was high in iron content (11.66%). These results indicate that if these byproducts were to be used for value addition, they would contribute considerable amounts of nutrients to products.

Total and β -carotene content of carrot pulp waste was 4.0 and 3.92 mg/100g respectively in our study (Table 2). β -carotene functions both as an antioxidant and an essential nutrient. The recommended dietary allowance for Indians for β -carotene is 4.8mg as per the latest revised recommendation (Narasinga Rao, 2010). Hence, a 25 g portion of carrot pulp waste can provide one fifth of a day's requirement of β -carotene for an adult. Bao *et al.* (1994) analysed the contents of α and β -carotene in carrot pulp by HPLC and reported values of 71.3% in unblanched, 110.3% and 103.9% in water and acetic acid blanched samples respectively. These values were much higher compared to our study. β -carotene content of carrot peels studied by Chantaro *et al.* (2008) was 20.45 mg/100g but at different temperatures of 60°C, 70°C and 80°C the content decreased to 8.8, 12.1 and 10.97 mg/100 g. In another study, carrot pulp waste was used as raw material for obtaining carotenoid powder by spray-drying and the stability of carotenoids at various temperatures was studied. A total of 10 carotenoids were found in carrot pulp waste with the value ranging from 0.40 – 54.23 μ g/g; in processed carotenoid powder, a total of 12 carotenoids were reported with values

ranging from 0.76-50.83 μ g/g (Chen & Tang, 1998).

The anthocyanin content of beetroot pulp waste was 14.4 mg/100 g and the vitamin C content was similar for both samples and ranged from 3.53-3.6 mg/100 g in our study. These vegetables were not a good source of vitamin C. High tannins were recorded in both carrot (318 mg/100g) and beetroot pulp wastes (610mg/100g). Tannins contribute towards antioxidant activity of foods. Antinutrients such as total oxalates, water soluble oxalates, phytates and fiber were analysed. Total oxalates were negligible in carrot compared to beetroot pulp wastes which had 0.24 mg/100 g of sample. However, in comparison to some vegetables like taro leaves and corns and Indian green leafy vegetables studied by Savage & Martensson (2010) who found total and water soluble oxalate content of 160-12576 mg and 143- 11899 mg/100 g respectively, these pulp wastes had a very insignificant amount indicating a high mineral bio-availability as oxalates are known to bind minerals and prevent their absorption.

The contents of total dietary fibre (TDF), insoluble dietary fibre (IDF) and soluble dietary fibre (SDF) were analysed. The IDF was high in both carrot and beetroot pulp wastes, that is, 32 and 39 g/100g respectively. The SDF was high in beetroot (21g/100g) compared to carrot (13g/100g) pulp waste. This indicates that these powders can be exploited for their natural fibre fractions as well as high SDF of beetroot which is known for its many physiological benefits. Varying levels of fibre fractions for vegetables have been reported by different authors. According to Chau *et al.* (2004), the TDF content of carrot pomace was 63.5 g/100g. In another study by Chantaro *et al.* (2008), fresh carrot peels were reported to contain 45.45 g/100g of TDF which was in close agreement with our study. Carrot flesh as such had a TDF content of 50 g/100g (Thebaudin *et al.*, 1997). Grigelmo-Miguel & Martin Belloso(1999) studied fruits, greens

Table 3. Total polyphenols and total antioxidant activity of the vegetable pulp wastes

Extracts	Carrot	Beet root	P-value
<i>Total polyphenols</i> (mg tannic acid equivalent/100 g of sample)			
Methanol	250.00±0.00	220.00±0.00	0.020*
Ethanol	110.00±10.95	90.00±0.00	
Aqueous	110.00±0.00	67.50±0.00	
<i>Total antioxidant activity</i> (µmoles of ascorbic acid/g of sample)			
Methanol	46788.92±200.88	15784.67±100.54	0.244 ^{ns}
Ethanol	32303.75±200.91	10735.08±131.59	
Aqueous	75048.92±211.45	91225.58±422.64	

* - P value ≤ 0.05 = marginally significant

ns - P value > 0.05 = not significant

and cereals for their TDF content and reported values ranging between 35.8 and 58.8 g/100g. The TDF content of carrot pulp waste in the present study was comparable to apple and asparagus dietary fibre content reported as 60.1 and 49.0 g/100g respectively. The IDF reported in the fruit fibre ranged from 22 - 46g/100g. The dietary fibre value of beetroot pulp waste in our study was similar to asparagus dietary fibre (Grigelmo-Miguel & Martin Belloso 1999).

Phytic acid is present in most foodstuffs, either as phytate salt or as a complex with protein. Phytate chelates with certain metal ions such as calcium, magnesium, zinc, copper and iron, to form insoluble complexes that are not readily broken down and may pass through the digestive tract unchanged, thus reducing the bioavailability of these minerals. Phytates also form strong complexes with proteins and this can lead to their reduced digestibility. Phytate content of carrot was 61.5 mg and that of beetroot pulp waste was 169.6 mg /100g. These values are in the lower range compared to phytic acid contents of many cereals indicating a high mineral bioavailability from pulp wastes.

Total polyphenols and total antioxidant activity

Vegetable materials contain many compounds with antioxidant activity. Several plants have been studied as sources of potentially safe natural antioxidants for the food industry; various compounds have been isolated with many of them being polyphenols. Polyphenolic compounds affect the functional and nutritional values of vegetable proteins by reducing the nutritional values of foodstuffs and contributing to the sensory and organoleptic properties of fruits and vegetables (colour, taste, astringency) (Serra & Ventura, 1997). Total phenolic contents (TPC) in carrot and beetroot pulp wastes extracted in aqueous and solvent medium are given in Table 3. Methanol extract had the highest polyphenol content in both carrot (250 mg) and beetroot (220 mg) pulp waste compared to ethanol and aqueous extracts of the samples, which ranged from 67-110 mg TAE/100 g sample. The difference between extracts was marginally significant (P value = 0.02). The total antioxidant activity was higher in aqueous extracts than in solvent extracts. The value ranged from 10735 - 91225 µmoles of ascorbic acid/100 g of sample. Between the two pulp wastes, there

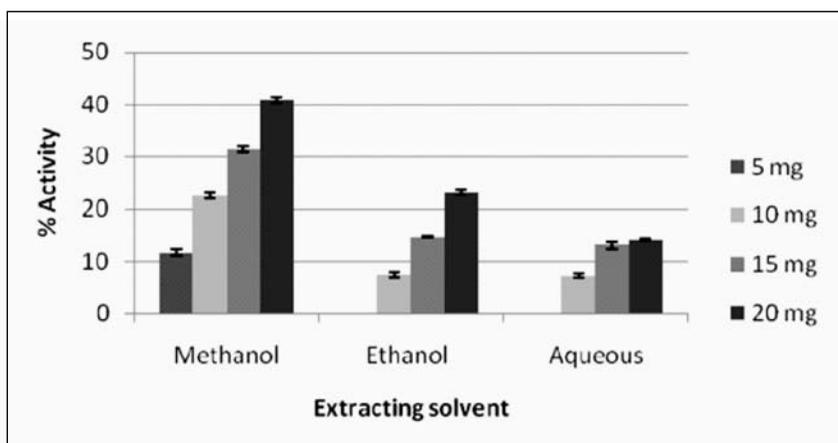


Figure 1. Free radical scavenging activity of carrot pulp waste

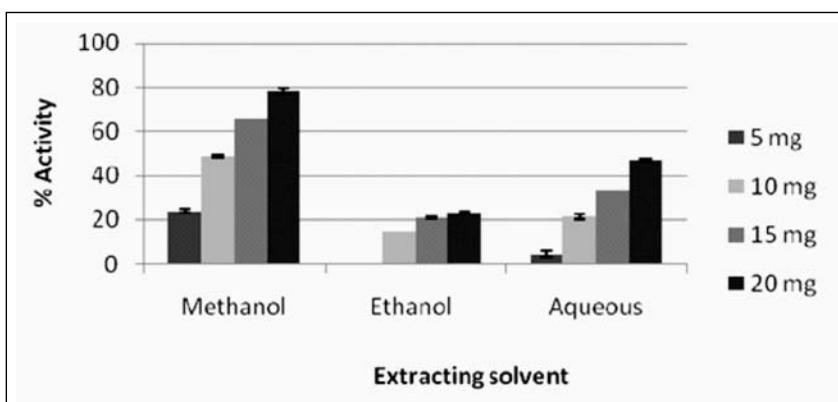


Figure 2. Free radical scavenging activity of beetroot pulp waste

was no significant difference in total antioxidant activity as determined by Student *t*-test ($P > 0.05$).

Antioxidant activity by free radical scavenging activity

Free radical scavenging activity was high in methanol extract compared to ethanol and aqueous extracts in both the samples. At 20 mg concentration, carrot and beetroot extracts had 40.8% and 78.6% activity respectively (Figures 1 and 2). Both the pulp wastes showed lesser activity in ethanol extract and no activity in aqueous extract at 5 mg

concentration. Statistically, there was no significant difference observed between the free radical scavenging activity of the two pulp wastes (0.051^{ns}). The IC_{50} of carrot pulp waste was 22.17 mg in methanol extract, 67.29 mg in ethanol extract and 68.77 mg in aqueous extract. IC_{50} of beetroot pulp was 10.24 mg in methanol extract, 33.64 mg in ethanol extract and 23.48 mg in aqueous extract.

Antioxidant activity by reducing power

The reducing power of both the pulp wastes had a similar trend in methanol extract

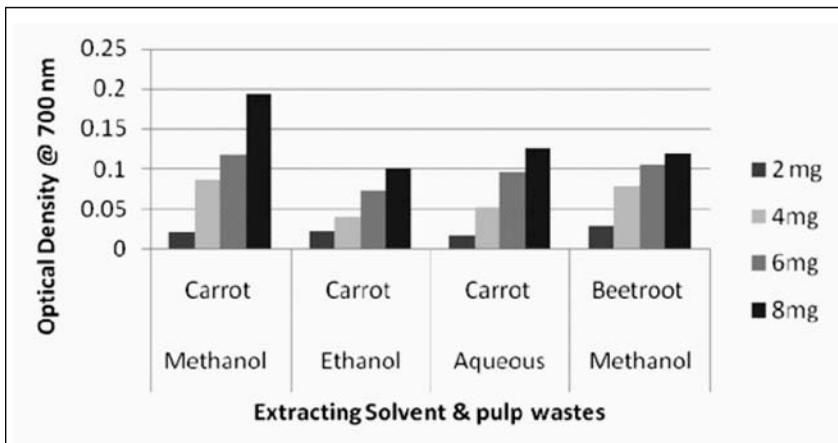


Figure 3. Reducing power of pulp wastes in different solvent and aqueous extracts

(Figure 3). But beetroot did not show any reducing power in ethanol and aqueous extracts. Carrot pulp waste had almost similar reducing power in both ethanol and aqueous extracts. There was a significant difference seen between reducing power of samples ($P \leq 0.01$) by this assay.

Correlation coefficient was determined to see whether there existed any relationship between antioxidant activity and antioxidant components. In free radical scavenging activity, only tannins were well correlated ($R^2=1$) and polyphenols were negatively correlated ($R^2=-1$). But in the case of reducing power, polyphenols were positively correlated and tannins were negatively correlated ($R^2=-1$). In the case of total antioxidant activity, positive correlation was seen with tannins in aqueous extract ($R^2=1$) and polyphenols in methanol and ethanol extracts.

CONCLUSIONS

The nutritional compositional analysis of carrot and beetroot pulp wastes indicate that both pulp wastes are good source of dietary fibre which includes specially the soluble fibre. Even a 25 g portion would provide 11.38 and 15.21 g of fibre which is equivalent

to 29% and 38% of recommended intake. The pulp wastes are a good source of calcium contributing 30-50% of calcium recommendation, and as the antinutrient content (oxalates and phytates) is very low, calcium absorption from these samples can be high. Carrot pulp waste had high iron content with 11 mg/100g, and if used as a supplement, the pulp waste can provide fair amounts of natural iron and calcium.

Among the two pulp wastes, carrot pulp waste exhibited high antioxidant activity. The antioxidant activity found in byproducts used may not only be due to the presence of polyphenol compounds, but also due to the presence of other phytochemical components. The antioxidant activity of pulp wastes could be correlated positively with tannins and polyphenols. Thus it can be concluded that the pulp wastes of the vegetable industry could be utilised as a source of supplement or further exploited for value addition as these were rich in nutrients, antioxidant components and exhibited antioxidant activity. In addition, inhibitory components such as oxalates and phytates were present in low amounts indicating higher bioaccessibility of nutrients from such materials.

ACKNOWLEDGEMENT

This study was funded by the Council of Scientific and Industrial Research, New Delhi, India.

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