Intl. J. Food. Ferment. Technol. 7(2): 317-323, December 2017

DOI: 10.5958/2321-5771.2017.00043.6

RESEARCH PAPER

Comparative Evaluation of Physico-chemical and Functional Properties of Apple, Carrot and Beetroot Pomace Powders

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Paper No.: 195 **Received:** 14-07-2017 **Revised:** 10-11-2017 **Accepted:** 18-12-2017

Abstract

In the present investigation physical, chemical and functional properties of apple, carrot and beetroot pomace powder were evaluated and compared in order to access its potential for valorisation of food products. Physical properties of pomace powders indicated that apple pomace powder (APP) had good flowability characteristics whereas carrot pomace powder (CPP) and beetroot pomace powder (BPP) were having fair flowability. All the three pomace powders were having intermediate cohesiveness. CPP had the highest water holding capacity (WHC), swelling capacity (SC) and oil absorption capacity (OAC) whereas WRC (water retention capacity) was found to be highest in the BPP. CPP and BPP showed good ash content while the highest crude fibre content was found in APP. Overall, all three pomace powders were having high crude fibre content and good hydration properties. The results obtained suggested that all three pomace powders are good source of dietary fibre and thus can be used for fibre enrichment in food products.

Keywords: Apple pomace powder, beetroot pomace powder, carrot pomace powder, fibre, functional properties, valorisation

Fruits and vegetables account for nearly 90% of the total horticulture production in the country. India is the second largest producer of fruits and vegetables in the world and is the leader in several horticultural crops (Ministry of Agriculture & Farmers Welfare, 2016). The surplus fruits and vegetables can be processed in a number of ways like canning, freezing, dehydration and processing into juice. Juice processing is an important sector of fruit processing and many fruits and vegetables are used for the extraction of their use.

However, juice processing industries also produce significant amount of pomace as a by-product which is not finding any proper use except for the use as an animal feed or land filling. Fruit and vegetable pomace powders can be used for fibre enrichment in the food products being inexpensive, available in large quantities and are especially characterized by a high dietary fibre resulting in high water binding capacity (WBC), relatively low enzyme digestible organic matter (Serena and Kundsen, 2007) and having better insoluble/soluble dietary fibre ratios than cereal brans (Grigelmo-Miguel and Martin-Belloso, 1999). It is essential to study the physico-chemical and functional properties of these pomace powders as they are particularly important in accessing their physiological function as dietary fibre and interaction of pomace powder with other food components; and its final effect on the physico-chemical, textual and sensory properties on the food product. Thus, it can provide valuable information for new product development particularly targeted for designing new 'functional foods'.

In this paper, the comparative evaluation of physical, chemical and functional properties of apple, carrot and beetroot pomace powders have been made and the results are presented here in this communication.

MATERIALS AND METHODS

Preparation of pomace powders

Apple pomace was procured and washed twice with warm water (30 °C) to reduce free sugar and ash content (Larrauri, 1999). It was then spread on aluminium trays and dried in a cabinet drier keeping drying bed thickness of 0.5 cm. Drying was carried out at 60°C for 7 hours (Lavelli and Corti, 2011). Carrot pomace was similarly spread on aluminium trays and kept in a cabinet drier. Drying bed thickness was 0.5 cm and drying was carried out at 65°C for 6 hours. Beetroot pomace was spread on aluminium trays and kept in cabinet drier keeping drying bed thickness of 0.5 cm and drying was carried out at 50°C for 6 hours. Dry pomace of apple, carrot and beetroot was pulverized using domestic grinder and sifted through sieve of 250 μm particle size, packed separately in airtight polypropylene jar and stored in cool and dry place. Apple, carrot and beetroot pomace has been shown in Plate 1.

Physical Characteristics Determination

Particle size distribution

The particle size distribution of the pomace powder was carried by measuring 25 g of the sample into an electric sieve shaker with varying sieve sizes for 30 min. The mass of the sample adsorbed by each sieve was weighed using an electronic weighing balance (Adekunle *et al*., 2013).

Bulk and tap density

Bulk and tap density was determined by the procedure followed by methods of Chegini and Ghobadian (2005) and Jinapong *et al*. (2008).

Flowability and cohesiveness

Flowability and cohesiveness of the powder were evaluated in terms of Carr index (CI) and Hausner ratio (HR) respectively (Jinapong *et al.* 2008). Both CI and HR were calculated from the bulk and tapped densities of the powder as shown below (Eq. 1 and 2) and classified according to the following table.

$$CI = \frac{(\rho \text{ tapped} - \rho \text{ bulk})}{\rho \text{ tapped}} \qquad \ldots(1)$$

$$HR = \rho \text{ tapped} / \rho \text{ bulk} \qquad \ldots(2)$$

CI (%)	Flowability	HR	Cohesiveness
<15	Very Good	<1.2	Low
15-20	Good	1.2-1.4	Intermediate
20-35	Fair	>1.4	High
35-45	Bad		
> 45	Very Bad		

Classification of the flowability and cohesiveness of the powder based on the CI and HR values (AOAC, 2000).

Plate 1: Apple, carrot and beetroot pomace powder

Chemical composition

Moisture, crude fat, protein (using the factor 6.25 × N), ash and crude fibre content of different samples of cookies were determined as per the standard methods (AACC, 2000). Total carbohydrate was obtained by difference.

Functional properties

Hydration properties

Hydration properties viz. water holding capacity (WHC), water retention capacity (WRC) and swelling capacity (SC) were determined by the procedure followed by Robertson *et al.* (2000) and Raghavendra *et al.* (2006).

Oil absorption capacity

Oil absorption capacity (OAC) was determined by the procedure followed by Sosulski *et al*. (1976) and Baljeet *et al*. (2014).

Statistical analysis

All analyses were performed in triplicates, and the results are expressed as the mean ± standard deviation (SD). ANOVA was performed and means were compared by post-hoc Tukey HSD test. P value < 0.05 was considered significant.

RESULTS AND DISCUSSION

Physical properties of pomace powders are presented in Table 1.

Particle size of fibre has profound role in dictating important digestive processes like transit time, fermentation and fecal excretion. Particle size of the fibre depends on the nature of cell wall polysaccharides, and on degree of processing it has undergone (Dhingra *et al*. 2012). Studies have shown that particle size affect the hydration properties (Auffret *et al.* 1994; Raghavendra *et al.* 2006). It is evident from the table that all three pomace powders majorly consisted of particles sized less than 150 μm and lowest percentage was of particles sized 150 μm. Particle size fractions from apple, carrot and beetroot pomace powder are shown in Plates 2, 3 and 4 respectively.

Bulk densities of pomace powders were 0.557 g/cm^3, 0.515 g/cm^3, and 0.631 g/cm^3 for APP, CPP and BPP respectively. Tap densities of pomace powders were 0.447 g/cm^3, 0.395 g/cm^3, and 0.451 g/cm^3 for APP, CPP and BPP respectively. The highest bulk density was recorded for BPP whereas the lowest was recorded in CPP. Low value (0.46 g/cm^3) of bulk density for apple fibre was also recorded by Chen *et al*. (1988) which could be due to small particle size attributed to the use of spray dried apple fibre.

Table 1: Physical properties of pomace powders

	Apple pomace powder	Carrot pomace powder	Beetroot pomace powder
Particle size distribution (%)			
212 μm	24.50	18.00	30.40
180 μm	10.10	11.44	11.88
150 μm	9.44	9.80	10.96
< 150 μm	55.96	60.76	46.76
Bulk Density (g/cm^3) *	0.557 ± 0.003^b	0.515 ± 0.006^c	0.631 ± 0.005^a
Tap Density (g/ cm^3) *	0.447 ± 0.000^a	0.395 ± 0.001^b	0.451 ± 0.002^a
Carr Index (%)	19.64	21.56	23.07
Hausner's Ratio	1.24	1.275	1.30

*Each value is average of three determinations; a,b,c The means within a line followed by different superscripts are significantly different at $p < 0.05$ by Tukey's test.

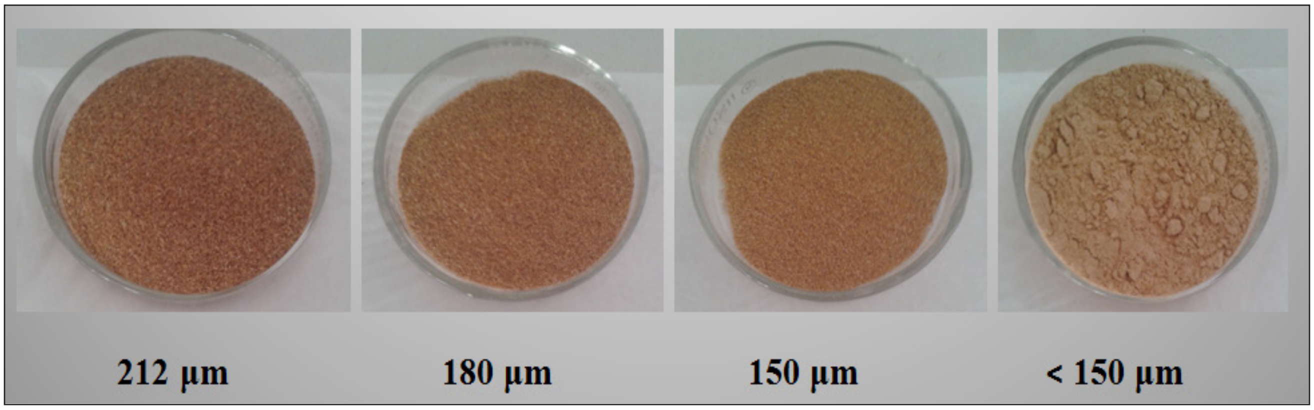

Plate 2: Particle size fraction of apple pomace powder

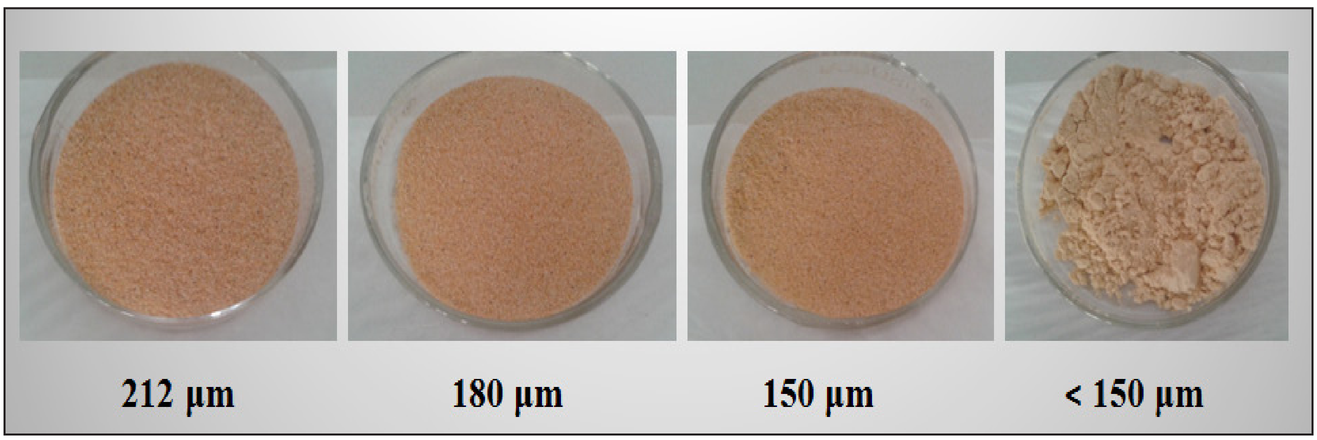

Plate 3: Particle size fraction of carrot pomace powder

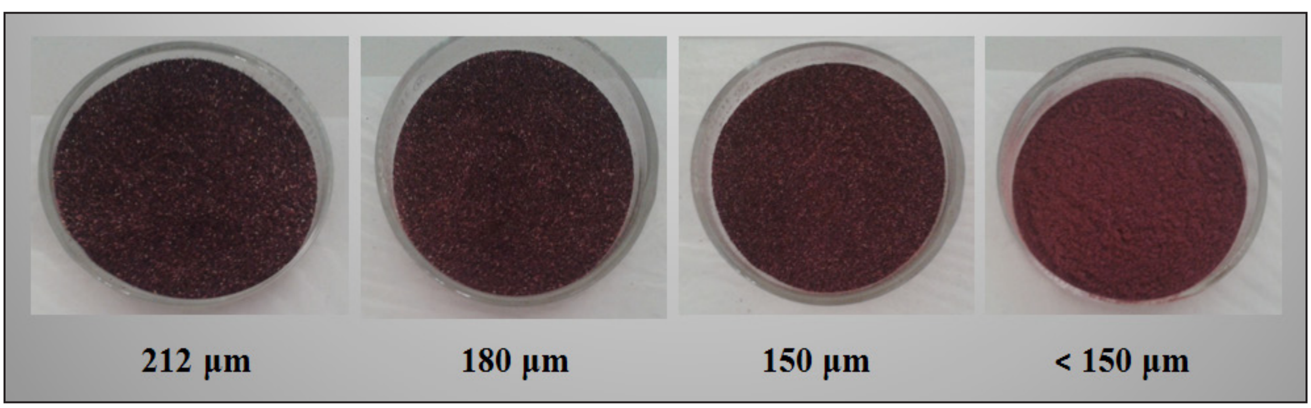

Plate 4: Particle size fraction of beetroot pomace powder

Carr index for APP, CPP and BPP was 19.64 %, 21.56% and 23.07 % respectively. Hausner's ratio for APP, BPP and CPP was 1.24, 1.275 and 1.30 respectively. It is evident from the values of Carr index that APP showed good flowability characteristics whereas CPP and BPP were having fair flowability. It could be observed from the values of Hausner's ratio that all the three pomace powders were having intermediate cohesiveness.

Table 2 summarizes the proximate composition of apple pomace powder (APP), carrot pomace powder (CPP) and beetroot pomace powder (BPP).

Table 2: Proximate composition of pomace powders

	Apple pomace powder	Carrot pomace powder	Beetroot pomace powder
Moisture (%)	7.78 ± 0.02^{a}	7.60 ± 0.05^{b}	6.82 ± 0.03^{c}
Fat (%)	1.82 ± 0.02^{b}	3.48 ± 0.03^{a}	1.44 ± 0.03^{c}
Crude Fibre (%)	21.51 ± 0.14^{a}	17.94 ± 0.16^{b}	11.12 ± 0.12^{c}
Ash (%)	2.28 ± 0.01^{c}	6.38 ± 0.03^{b}	9.86 ± 0.15^{a}
Protein (%)	4.59 ± 0.04^{c}	6.12 ± 0.03^{b}	15.85 ± 0.03^{a}
Carbohydrates (%)$^{\circ}$	62.02	58.48	54.91

*Each value is average of three determinations; a,b,c The means within a line followed by different superscripts are significantly different at $p < 0.05$ by Tukey's test; $^{\circ}$calculated by difference.

Moisture content of all pomace powders was found to be less than 10 %. Low moisture content of pomace powders is important for maintaining good storage stability by preventing deteriorative reactions because of high water activity.

All the samples showed low fat content, the lowest fat content was however found in BPP (1.44%) followed by APP (1.82%) and highest was found in CPP (3.48%). Though generally vegetables are poor sources of lipids, they do provide fair amounts in some cases (Shyamala and Jamuna, 2010).

Markedly high crude fibre content was observed in all pomace powders justifying their use for fibre enrichment. APP showed the highest crude fibre content (21.51%) followed by CPP (17.94%) and BPP (11.12%). Large variation however was observed in ash content. Lowest ash content was observed in APP (2.28%). APP contains inherently low ash content and washing with warm water further reduced the ash content. High ash content was observed in CPP (6.38%) and BPP (9.86%) representing high mineral content. Both CPP and BPP thus, are good sources of calcium, phosphorus and iron (Shyamala and Jamuna, 2010) and thus their supplementation in food will also increase mineral content along with enrichment of fibre. BPP showed highest protein content (15.85%), followed CPP (6.12%) and APP (4.59%). Higher protein content of BPP can be associated with the presence of nitrogenous betalains in BPP.

Proximate composition of APP was comparable to the values reported by Gazalli *et al.* (2013). Proximate composition of CPP is comparable to the values reported by Upadhyay *et al.* (2008) and Shyamala and Jamuna (2010). Proximate composition of BPP was however slightly different than the values reported by Shyamala and Jamuna (2010).

Functional properties of pomace powder include its hydration properties and oil absorption capacity. Data on functional properties of pomace powders is presented in Table 3.

Table 3: Functional properties of pomace powders

	Apple pomace powder	Carrot pomace powder	Beetroot pomace powder
Water Holding Capacity (g/g)	4.450 ± 0.102^{c}	5.425 ± 0.023^{a}	5.040 ± 0.104^{b}
Water Retention Capacity (g/g)	3.046 ± 0.055^{c}	4.109 ± 0.039^{b}	4.338 ± 0.087^{a}
Swelling Capacity (ml/g)	7 ± 0.00^{c}	11.25 ± 0.05^{a}	7.8 ± 0.00^{b}
Oil Absorption Capacity (g/g)	2.241 ± 0.068^{b}	2.442 ± 0.067^{a}	2.206 ± 0.064^{b}

*Each value is average of three determinations; a,b,c The means within a line followed by different superscripts are significantly different at $p < 0.05$ by Tukey's test.

The hydration properties of fibre are important for its physiological role as well as for its interventions in techno-functional properties of the food. Hydration property of fibre governs its efficacy in stool bulking. Water holding capacity, water retention capacity and swelling capacity provide information regarding the hydration capacity of fibre and give insights regarding its behaviour during gut transit and food processing (Dhingra *et al.* 2012).

Water holding capacity (WHC) is defined as the quantity of water that is bound to the fibres without the application of any external force. Highest WHC was observed in CPP (5.425 g/g) followed by BPP (5.040 g/g) and lowest WHC was observed in APP (4.450 g/g). Lowest WHC of APP can be associated with the presence of sugars which reduces WHC. WHC depends on fibre source and its chemical, physical and structural characteristics (Raghavarao *et al*. 2008).

Water retention capacity (WRC) is defined as the quantity of water that remains bound to the hydrated fibre following the application of an external force. The result shown that the highest WRC was observed in BPP (4.338 g/g) followed by CPP (4.109 g/g) and lowest WRC was observed in APP (3.046 g/g). Highest WRC of BPP can be associated with the high percentage of large particle size which maintains the fibre structure.

Highest SC was observed in CPP (11.25 ml/g) followed by BPP (7.80 ml/g) and lowest SC was observed in APP (7.00 ml/g). Sharoba *et al.* (2013) reported higher water holding and swelling capacity of carrot pomace as compared to orange waste, potato peels and green pea peels. The results of hydration properties of APP are comparable to that reported by Thebaudin *et al.* (1997).

Good hydration properties of pomace powders will allow its use as functional ingredient in food products as high WHC tend to exert their physiological effect by absorbing water in the gut and resulting in stool bulking. However, studies have shown that high affinity to water could have detrimental effect where it can affect the texture of the processed food (Chen *et al*. 1988; Sharoba *et al*. 2013; Sahni and Shere, 2016). CPP showed highest WHC and SC whereas WRC was found to be highest in BPP.

Highest OAC was documented in CPP (2.442 g/g) followed by APP and BPP which showed comparable results (Table 3). This can be justified on the basis of particle size as oil absorption capacity increase with decrease in particle size (Raghavendra *et al*. 2006). Oil absorption capacity (OAC) depends on chemical structure of the plant polysaccharides, its surface properties, overall charge density, thickness, hydrophobic nature of the fibre particle, particle size and drying (Carme *et al*. 2007; Fernandez-Lopez *et al*. 2009; Figuerola *et al.* 2005; Sharoba *et al*. 2013).

CONCLUSION

This study presented a comparative analysis of the physical, chemical and functional properties of apple, carrot and beetroot pomace powder. Proximate analysis of pomace powders showed that all three pomace powders have high crude fibre content which is responsible for resultant good hydration properties of pomace powders and thus justifying their use for fibre enrichment in food products. Overall, results conclude that all the three pomaces can be used for producing dietary fibre powders. Thus, being a cheap source of dietary fibre it will help in the valorisation of the food products at low cost and allows utilization of industrial waste.

ACKNOWLEDGMENTS

Author is grateful to Indian Council of Agricultural Research, New Delhi for the award of Junior Research Fellowship.

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