Incorporation of carrot pomace powder in wheat flour: effect on flour, dough and cookie characteristics

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Abstract Carrot pomace powder (CPP) of 72 and 120 mesh sizes was incorporated in wheat flour at 10, 15 and 20 % level and its impact on flour, dough and cookie characteristics was evaluated. Protein content of the flour blends (8.84–7.88 %) decreased and fibre content (4.63–6.68 %) increased upon blending of CPP in wheat flour. Wheat flour containing 120 mesh CPP showed better functional properties [water absorption (1.16–1.47 %), oil absorption (1.11–1.39 %), solubility index (41–50 %) and swelling power (1.34–1.39)] than those containing 72 mesh. Water solvent retention capacity and sucrose solvent retention capacity increased while lactic acid solvent retention capacity and sodium carbonate solvent retention capacity decreased with blending of CPP. Water absorption, dough development time and degree of softening increased whereas, dough stability and mixing tolerance decreased with increasing CPP. The highest decrease in pasting was observed flour containing 72 mesh CPP. Rheology of dough containing 120 mesh CPP closely resembled the control. Color of flour and cookies increased with blending of CPP irrespective of mesh size. Antioxidant activity of cookies was higher than the flour blends. The cookies containing CPP of 72

mesh showed the lowest hardness. However, cookies containing CPP of 120 mesh showed the best sensory properties. Incorporation of 120 mesh CPP produced low gluten cookies with manageable flour and dough characteristics and better antioxidant and sensory properties.

Keywords Cookies · Flour · Dough · Carrot pomace · Dietary fibre

Introduction

Wheat has long been used for the manufacture of different bakery products. It contains gluten protein that is associated with celiac disease. This has resulted in an increasing worldwide interest on gluten-free foodstuffs. Treatment of celiac disease requires a lifetime total elimination of gluten from the diet. As such not only people with gluten intolerance consume gluten-free foodstuffs but the rest of population also prefer low gluten or gluten free diets. Identifying cereal varieties naturally devoid of toxicity or developing such varieties through breeding is difficult due to the structural complexity and polymorphism of gliadin proteins (Rosell et al. 2014; Gimenez-Bastida et al. 2015). Therefore, diluting the gluten protein by some suitable ingredients like starch from different sources (Witczak et al. 2015), proteins (Mancebo et al. 2016), fibre (Masoodi and Chauhan 1998; Tsatsaragkou et al. 2015) or any other component could be a suitable alternative.

Carrot pomace is a by product of the carrot juice industry. Besides containing bioactive compounds like β -carotene (precursor of vitamin A), it has good residual amount of all the vitamins, minerals and dietary fibre (Kumar et al. 2012). It contains both alcohol soluble (glucose, fructose, galactose, arabinose, cellopentaose, cellotetraose, cellotriose,

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cellobiose, galactotetraose and galactotriose) and alcohol insoluble (rhamnose, arabinose, mannose, galactose, glucose and xylose) dietary fibre (Yoon et al. 2005). Insoluble carrot fibre lowers serum triglyceride, serum total cholesterol, and liver cholesterol, and results in a higher HDL:total cholesterol ratio as well as higher levels of fecal lipids, cholesterol and bile acids (Hsu et al. 2006). Differently micronized insoluble carrot dietary fibre shows different functional properties (Chau et al. 2007a), decreases caecal ammonia concentration, increases faecal output and moisture content and also reduces the activities of undesired β -D-glucosidase and β -D-glucuronidase in faeces (Chau et al. 2007b). Carrot pomace left over after juice extraction has not been utilized properly in food formulations. Keeping in view the above health implications of carrot pomace the present study was carried out to study the effect of addition of different proportions of 72 and 120 micronized carrot pomace powder (CPP) on the various aspects of mesh flour, dough and cookies.

Materials and methods

Preparation of carrot pomace powder and wheat flour blends

Fresh carrots (*Daucus carota*) procured from the market were peeled, washed and used for juice extraction in a juicer. The recovery of carrot juice and pomace varied from 60.0–63.87 to 35–37.2 %, respectively. The carrot pomace obtained was oven dried at a temperature of 50 ± 1 °C and powdered using a laboratory grinder. It was then sieved to obtain CPP of 72 (obtained by using 72 then 71 mesh sieve) and 120 (obtained by using 120 then 119 mesh sieve) mesh sizes and stored in air-tight jars under refrigeration at 4 °C till use. CPP was incorporated in wheat flour at 0, 10, 15, and 20 % levels each of 72 and 120 mesh sizes. After mixing in a mixer for 5 min, the samples were kept in polyethylene bags at room temperature.

Proximate composition

CPP and wheat flour blends were analyzed for moisture, crude protein, crude fibre, fat and ash content according to AOAC (2005).

Functional properties of flour

Water and oil absorption capacity

Water and oil absorption capacities (WAC and OAC) of the flour samples were determined as per Abbey and Ibeh (1988).

Water solubility index

Water solubility index (WSI) of the flour samples was determined according to AACC (2002) method with slight modifications and was calculated as

$$\text{WSI (\%)} = \frac{\text{Weight of dry solids in supernatant}}{\text{Dry weight of blend}} \times 100$$

Swelling power

Swelling power (SP) was determined by using the modified method of Subramanian et al. (1994) and was calculated as

$$\text{SP} = \frac{\text{Weight of the swollen flour sediment}}{\text{Weight of dry sample}}$$

Foam capacity and foam stability

The method described by Wani et al. (2013) was used for the determination of foaming capacity (FC) and foam stability (FS). The FC was expressed as a percentage increase in volume using the equation

$$\text{FC (\%)} = \frac{\text{Volume after whipping} - \text{Volume before whipping}}{\text{Volume before whipping}} \times 100$$

The foam volume was recorded for 1 h after whipping to determine the FS as percentage of the initial foam volume using the equation

$$\text{FS (\%)} = \frac{\text{Foam volume after 1 h}}{\text{Initial foam volume}} \times 100$$

Solvent retention capacity

Solvent retention capacity (SRC) was determined according to the method of Haynes et al. (2009) and was calculated by the equation

$$\text{SRC (\%)} = \frac{[\text{wet pellet (g)}/\text{flour (g)} - 1]}{\times [86/100 - \text{flour moisture (\%)}]} \times 100$$

Antioxidant activity

The antioxidant activity of flour and cookie samples (AA) was determined by the DPPH (2,2-di-phenyl-1-picryl-hydrazyl) radical scavenging method (Brand-Williams et al. 1995). Antioxidant activity was calculated as percent inhibition using the formula

$$\text{AA (\%)} = \frac{\text{Absorbance of control} - \text{Absorbance of sample}}{\text{Absorbance of control}} \times 100$$

Dough mixing properties

The mixing properties of control wheat flour and blends were analyzed according to the method of AACC (2002). The flour sample was loaded into the mixing bowl of farinograph (Brabender, Farinograph-E, Germany version 4.20) and distilled water was added for the optimum dough consistency (500 BU).

Pasting properties

Pasting property of control wheat flour and the blends was determined by using a rapid visco analyzer (RVA TEC-MASTER, Perten instruments, Australia). The test profile STD1 using 3.5 g sample dispersed in 25 g water was run for 13 min. The characteristic parameters like pasting temperature, peak viscosity, breakdown and setback were studied from the pasting curves obtained.

Dynamic rheometry

Rheological parameters were determined using a dynamic rheometer (MCR102, Anton Paar) at a temperature of 25 °C. Two gram of each fresh sample dough previously rested for 15 min in a polyethylene bag was analyzed for variations in G' (storage modulus measured in Pa) and G'' (loss modulus measured in Pa) as a function of angular frequency (rad/s) with measurement point duration of 2 s. A characteristic mechanical spectrum was obtained with the frequency sweep of 0–100 Hz performed at a constant strain within the linear viscoelastic range ($\gamma = 1$ Pa). The measurements were performed in triplicates and average values were reported in the spectrum.

Preparation of cookies

Cookies were prepared according to the recipe described by Tyagi et al. (2007). The control cookies contained 100 g fine wheat flour, 53 g sugar, 26.5 g shortening, 1.1 g glucose, 1.1 g sodium bicarbonate, 0.89 g sodium chloride and 12 ml water. In the blended cookies, 10, 15, and 20 g wheat flour was replaced with CPP for both 72 and 120 mesh sizes while keeping all the other ingredients constant. Cookie dough was made in a laboratory mixer. Fat and sugar were blended in a mixer with a flat beater for 2 min at low speed. Dough water containing the baking chemicals and sodium chloride was added to the resulting cream and mixed for 5 min at high speed to obtain a homogeneous mixture. The dough was sheeted to a thickness of 0.5 cm on a dough sheeter. Round shaped cookies were cut with a cookie die of diameter 5.5 cm. Baking was carried out at 120 °C for 15 min in an electric oven. The baked cookies were cooled to room

temperature and packed in air tight containers for further analysis.

Texture and spread ratio of cookies

The fracture force of cookies was measured using a texture analyzer (Model TA-XT2 Stable Micro Systems, UK). Fracture force (hardness) was recorded as the force required for shattering the cookies with the help of a blunt edged, 6 cm long and 0.1 mm thick knife probe. The analyzer was set at a 'return to start' cycle with a speed of 1 mm/s and a distance of 3 mm. Spread ratio of cookies was calculated by the equation

$$\text{Spread ratio} = \text{Diameter/Thickness}$$

Color characteristics

The color of flour blends and cookies was assessed in terms of L^* , a^* , and b^* values by using a Hunter/CIE – lab colorimeter (Hunter Lab D25, Hunter associates Lab, Reston, USA). The L^* value gives a measure of the lightness of the product color (100 for perfect white to 0 for black) as the eye would evaluate it. The a^* and b^* values determine redness/greenness and yellowness/blueness, respectively (Stojceska et al. 2008).

Sensory analysis of cookies

A group of 15 members comprising of staff and students from the department, evaluated the taste, texture, color and overall acceptability of the cookies. A nine-point hedonic scale was used ranging from 1 (dislike extremely) to 9 (like extremely). Water was provided to rinse the mouth between the evaluations.

Statistical analysis

Mean values, standard deviation and analysis of variance (ANOVA) were computed by using a commercial statistical package (IBM SPSS Statistics 21.0). Means were compared using Duncan's multiple range test at 5 % level of significance.

Results and discussion

Proximate composition

The composition of flour-CPP blends is shown in Table 1. The moisture content of dried CPP and wheat flour was 13.40 and 13.90 %, respectively. Moisture content of blends showed no significant difference because of almost

Table 1 Composition of flour containing different proportions of CPP

	CPP	Control	72 Mesh			120 Mesh		
			10 %			15 %		
			20 %			10 %		
Moisture content (%)	13.90 ± 0.16 ^b	13.40 ± 0.16 ^a	13.45 ± 0.01 ^a	13.47 ± 0.02 ^a	13.50 ± 0.24 ^a	13.45 ± 0.02 ^a	13.44 ± 0.02 ^a	13.49 ± 0.02 ^a
Protein content (%)	0.21 ± 0.01 ^a	9.80 ± 0.08 ^e	8.84 ± 0.00 ^d	8.36 ± 0.00 ^c	7.88 ± 0.00 ^b	8.84 ± 0.01 ^d	8.36 ± 0.02 ^c	7.88 ± 0.02 ^b
Fat content (%)	0.30 ± 0.01 ^a	3.20 ± 0.24 ^d	2.91 ± 0.01 ^c	2.76 ± 0.02 ^b	2.62 ± 0.02 ^c	2.96 ± 0.01 ^b	2.79 ± 0.02 ^{bc}	2.61 ± 0.01 ^b
Ash content (%)	0.76 ± 0.01 ^a	0.70 ± 0.08 ^a	0.70 ± 0.00 ^a	0.70 ± 0.01 ^a	0.70 ± 0.06 ^a	0.71 ± 0.02 ^a	0.71 ± 0.01 ^a	0.71 ± 0.06 ^a
Fibre content (%)	29.00 ± 2.4 ^c	2.59 ± 0.01 ^a	4.63 ± 0.01 ^{ab}	5.65 ± 0.01 ^b	6.67 ± 0.01 ^b	4.64 ± 0.01 ^{ab}	5.70 ± 0.01 ^b	6.68 ± 0.01 ^b

Values expressed are mean ± standard deviation

Means in the rows with different superscripts are significantly ($p \leq 0.05$) different

similar moisture content of wheat flour and CPP. Protein content was high in wheat flour (9.80 %) and negligible in CPP (0.21 %). Protein content of flour-CPP blends showed significant ($p \leq 0.05$) variation. The difference may be attributed to difference in composition of wheat flour and CPP. Similar changes were observed for fat, ash, reducing sugars and total sugars. The substitution of wheat flour with CPP invariably improved the fibre content of the blends, which is a desired nutritional effect. Change in proximate composition with respect to blending has also been observed by Zouari et al. (2016) in wheat flour blended with sesame peel flour. A number of researchers have also used fruit and vegetable by-products such as apple, pear, orange, peach, blackcurrant, cherry, artichoke, asparagus, onion, and carrot pomace for different purposes in refined food (Grigelmo-Miguel and Martín-Belloso 1999).

Functional properties of flour blends

Water and oil absorption capacity

Water and oil absorption capacity of control flour-CPP blends is given in Table 2. WAC represents the ability of a substance to associate with water under a limited water condition (Singh et al. 2000). WAC ranged from 1.16 to 1.30 ml/g for 72 mesh flour blends and from 1.16 to 1.47 ml/g for 120 mesh flour blends. WAC was seen to be the highest for blends containing 20 % of 120 mesh, nearly 1.35 times more than the wheat flour (1.08 ml/g). OAC is the tendency of flour to retain oil, which is an important property since it plays an important role in enhancing the mouth feel and retaining the flavour of food products (Aremu et al. 2007). OAC of flour-CPP blends (72 mesh) varied from 1.14 to 1.26 ml/g, while as those for 120 mesh flour blends, it varied from 1.11 to 1.39 ml/g. The highest OAC was observed for blends with 20 % of 120 mesh CPP. Higher values for blends containing 120 mesh than 72 mesh CPP could be due to the smaller particle size of former providing larger surface area. This could therefore be a better flavour retainer than others. The increase in WAC and OAC could be attributed to the increase in fibre content upon increasing the level of CPP, which led to increase in the competition between pomace and flour for the absorption of water and oil water. Similar results have been reported in barley flour blended with tomato pomace (Altan et al. 2008) and wheat flour blended with sesame peels flour (Zouari et al. 2016).

Swelling and solubility index

Swelling and solubility index of flour-CPP blends increased significantly upon increasing the level of CPP (Table 2).

Table 2 Effect of addition of CPP of different mesh size on the functional properties of flour (n = 3)

	Control	72 Mesh			120 Mesh		
		10 %	15 %	20 %	10 %	15 %	20 %
WAC (ml/g)	1.08 ± 0.00 ^a	1.16 ± 0.01 ^b	1.19 ± 0.03 ^b	1.30 ± 0.24 ^b	1.16 ± 0.24 ^b	1.23 ± 0.02 ^b	1.47 ± 0.02 ^d
OAC (ml/g)	1.11 ± 0.01 ^a	1.14 ± 0.02 ^b	1.14 ± 0.02 ^b	1.26 ± 0.02 ^c	1.11 ± 0.01 ^a	1.22 ± 0.01 ^b	1.39 ± 0.02 ^c
WSI (%)	35 ± 3.26 ^a	39 ± 3.26 ^{ab}	44 ± 2.44 ^{bc}	49 ± 2.44 ^c	41 ± 2.44 ^b	46 ± 1.63 ^{bc}	50 ± 2.44 ^c
SP	1.27 ± 0.02 ^a	1.32 ± 0.01 ^{ab}	1.35 ± 0.03 ^b	1.37 ± 0.03 ^b	1.34 ± 0.02 ^b	1.36 ± 0.02 ^b	1.39 ± 0.02 ^b
FC (%)	33 ± 1.16 ^b	30 ± 1.61 ^{ab}	28 ± 2.24 ^{ab}	25 ± 3.21 ^a	29 ± 3.12 ^{ab}	26 ± 2.14 ^a	24 ± 2.23 ^a
FS (%)	87.1 ± 0.03 ^c	86.33 ± 0.03 ^d	85.33 ± 0.03 ^c	83.29 ± 0.03 ^b	85.53 ± 0.91 ^d	84.39 ± 0.03 ^c	82.15 ± 0.03 ^b
WSRC (%)	71.12 ± 0.03 ^a	109.14 ± 0.03 ^b	160.16 ± 0.03 ^c	184.34 ± 0.03 ^d	115.16 ± 0.02 ^b	167.23 ± 0.02 ^c	191.41 ± 0.03 ^d
LaSRC (%)	115.60 ± 0.16 ^d	102.86 ± 0.02 ^c	96.60 ± 0.24 ^b	88.06 ± 0.01 ^a	101.36 ± 0.03 ^c	94.76 ± 0.32 ^b	89.03 ± 0.24 ^a
ScSRC (%)	136.12 ± 0.26 ^e	127.66 ± 0.03 ^d	119.84 ± 0.03 ^c	109.94 ± 0.03 ^a	119.8 ± 0.03 ^c	116.72 ± 0.01 ^b	107.83 ± 0.02 ^a
SuSRC (%)	95.46 ± 0.01 ^a	123.08 ± 0.02 ^b	147.28 ± 0.01 ^c	170.54 ± 0.03 ^d	131.04 ± 0.03 ^b	152.35 ± 0.03 ^c	176.11 ± 0.01 ^d

CI Compressibility index; WAC water absorption capacity; OAC oil absorption capacity; WSI water solubility index; WSRC water solvent retention capacity; LaSRC lactic acid solvent retention capacity; ScSRC sodium carbonate solvent retention capacity; SuSRC sucrose solvent retention capacity; FC foaming capacity; FS foam stability and SP swelling power

Values expressed are mean ± standard deviation. Means in the rows with different superscripts are significantly ($p \leq 0.05$) different

Swelling power is attributed to the capacity of starch molecules to hold water within its structure through hydrogen bonding. Swelling power of flour containing 72 mesh CPP ranged from 1.32 to 1.37, while those with 120 mesh ranged from 1.34 to 1.39. The highest swelling power was exhibited by blend containing 20 % CPP of 120 mesh, which may be due to increase in more fibrous and smaller particle size of CPP. Increase in swelling has also been reported by Zouari et al. (2016) for wheat flour blended with sesame peels flour. Water solubility index of flour blended with CPP of 72 mesh ranged from 39 to 49 %, while those with 120 mesh, it ranged from 41 to 50 %. The maximum water solubility index was observed for blends with 20 % of 120 mesh CPP. Duta and Culetu (2015) also observed increase in water solubility index of oat flour upon increasing the oat bran proportion in the blends.

Foaming capacity and foam stability

Foaming capacity and foam stability of flour blends decreased significantly upon increasing the level of blending (Table 2). However, it did not show a significant difference upon varying the particle size of CPP. Foaming capacity is attributed to the presence of proteins, which form a continuous cohesive film around the air bubbles in the foam. Proteins in the dispersion lower the surface tension at the air–water interface, thus creating foaming capacity. The decrease in foaming capacity and foam stability may be attributed to the dilution of protein content of wheat flour with the increasing level of CPP. Decrease in foaming capacity and foam stability has also been reported by Jan et al. (2015) for wheat flour blended with buckwheat flour. Ahmad et al. (2015) observed a decrease in these properties with blending of green tea powder in wheat flour.

Solvent retention capacity

Solvent retention capacity of flour-CPP blends is given in Table 2. Solvent retention capacity establishes a practical flour quality and functionality profile that helps in predicting baking performance of the flour components for quality end products. In general, water solvent retention capacity (WSRC) is influenced by all water absorbing components in flour, lactic acid solvent retention capacity (LaSRC) is associated with gluten protein characteristics, sodium carbonate solvent retention capacity (ScSRC) is related to levels of damaged starch and sucrose solvent retention capacity (SuSRC) is associated with pentosans (Barak et al. 2014). WSRC increased significantly ($p \leq 0.05$) with increase of CPP in the flour blends. Addition of CPP to wheat flour at different levels decreased LaSRC due to decrease in protein content. However, varying particle size of the CPP did not change the solvent retention capacities of the flours. Similar results of dilution effect on wheat proteins by the addition of apple skin powder at different levels have been reported by Rupasinghe et al. (2008). As the level of CPP increases in the flour blends, the damaged starch gets diluted and ScSRC decreases. There is increase in SuSRC with increase in the level of CPP. SuSRC is unique in the sense that it mimics the functional environment in cookie or high-sugar cracker dough and gives an indication for the flour arabinoxylan characteristics (Gaines 2000). Arabinoxylan content increases with increasing level of CPP. It is one of the main components of soluble and insoluble dietary fibres, which are known to exert various health benefits.

Dough mixing properties

The dough mixing properties of flour-CPP blends are given in Table 3. The wheat flour required 58.6 % water absorption to reach the optimum dough consistency (500 BU) whereas higher water absorption was observed for flour-CPP blends. Varying the particle size of CPP showed a significant effect on the mixing properties of flour-CPP blends. Blends with 120 mesh CPP showed higher water absorption than those containing 72 mesh CPP. This might be due to small particle size of 120 mesh CPP that had higher surface area. The values were in accordance with the greater water absorption properties of the wheat flour and the blends at room temperature (Table 2). Wheat flour showed lower dough development time, lower degree of softening, lower mixing tolerance index and higher dough stability than the flour-CPP blends. Water absorption, dough development time and degree of softening increased with increase in CPP in the blends irrespective of the mesh size. However, mixing tolerance index decreased with increase in CPP in the blends. Dough stability of 72 mesh blends was significantly higher than the 120 mesh blends. Deviations in the mixing properties of the flour blends may be attributed to increase in fibre content with incorporation of carrot pomace (Bae et al. 2014).

Pasting property

Results of pasting parameters (peak viscosity, trough viscosity, breakdown viscosity, final viscosity, setback viscosity, peak time, and pasting temperature) for wheat flour and four-CPP blends are given in Table 3. Pasting properties of flour are affected by their starch granule size, amylose and lipid contents, and amylopectin structure. Amylopectin is primarily responsible for granule swelling, whereas amylose and lipid restrict the swelling (Tester and Morrison 1990). Significant differences were observed in pasting characteristics of the blends. Pasting temperature provides an indication of the minimum temperature required to cook the flour. The highest pasting temperature (68.10 °C) was observed for wheat flour and the lowest (66.40 °C) for blend containing 20 % of 120 mesh CPP. High pasting temperature indicates the presence of more starch that is highly resistant to swelling and rupturing. Peak viscosity varied from 1864 to 2697cP. The highest peak viscosity was observed for wheat flour, which may be attributed to the swelling extent or water-binding capacity of starch (Wani et al. 2012). The lowest peak viscosity was observed for blend containing 20 % of 120 mesh CPP that might be due to small particle size of CPP and decrease in starch content upon addition of CPP. Similar trend was seen in final viscosity (ability of the material to form a viscous paste) and

Table 3 Effect of blending of CPP on the mixing and pasting properties of flour

	Control	72 Mesh			120 Mesh		
		10 %	15 %	20 %	10 %	15 %	20 %
Mixing properties							
Water absorption (%)	58.6 ± 1.83 ^a	60.4 ± 1.13 ^{ab}	64.3 ± 0.84 ^b	68.5 ± 0.70 ^c	61.2 ± 0.84 ^{ab}	65.9 ± 0.77 ^{bc}	69.2 ± 1.27 ^c
Dough development time (min)	2.1 ± 0.07 ^a	3.2 ± 0.14 ^b	6.8 ± 0.21 ^c	9.5 ± 0.35 ^d	3.6 ± 0.14 ^b	7.3 ± 0.21 ^c	9.9 ± 0.21 ^d
Degree of softening (BU)	42 ± 1.41 ^a	73 ± 2.12 ^b	90 ± 2.12 ^c	108 ± 2.82 ^d	78 ± 2.12 ^b	96 ± 3.53 ^c	113 ± 2.82 ^d
Dough stability (min)	10.3 ± 0.11 ^f	9.2 ± 0.08 ^e	8.5 ± 0.06 ^d	7.3 ± 0.05 ^b	8.9 ± 0.07 ^d	8.2 ± 0.06 ^c	6.9 ± 0.06 ^a
Mixing tolerance index (BU)	34.69 ± 1.12 ^d	28.28 ± 1.33 ^c	19.3 ± 1.01 ^b	12.54 ± 0.90 ^a	29.3 ± 1.12 ^c	20.15 ± 1.14 ^b	13.66 ± 1.01 ^a
Pasting properties							
Peak viscosity (cP)	2745 ± 12 ^f	2553 ± 16 ^d	2545 ± 19 ^{cd}	2697 ± 24 ^e	2536 ± 14 ^c	2391 ± 17 ^b	1864 ± 21 ^a
Trough viscosity (cP)	1525 ± 16 ^g	1209 ± 17 ^d	1177 ± 14 ^f	1376 ± 11 ^e	1031 ± 12 ^c	998 ± 9 ^b	926 ± 6 ^a
Breakdown viscosity (cP)	1220 ± 13 ^b	1344 ± 15 ^d	1368 ± 11 ^e	1391 ± 13 ^c	1305 ± 12 ^f	1332 ± 14 ^{cd}	1388 ± 11 ^a
Final viscosity (cP)	2638 ± 15 ^f	2211 ± 16 ^d	2174 ± 13 ^d	2328 ± 14 ^e	1804 ± 15 ^c	1729 ± 11 ^b	1631 ± 10 ^a
Setback viscosity (cP)	1113 ± 11 ^f	1002 ± 12 ^c	997 ± 11 ^e	952 ± 9 ^d	773 ± 10 ^c	739 ± 8 ^b	705 ± 7 ^a
Peak time (min)	6.40 ± 0.22 ^d	5.73 ± 0.31 ^b	5.60 ± 0.33 ^a	5.80 ± 0.21 ^c	5.81 ± 0.34 ^c	6.23 ± 0.24 ^d	5.80 ± 0.23 ^c
Pasting temperature (°C)	68.10 ± 2 ^a	67.85 ± 3 ^a	67.80 ± 3 ^a	66.40 ± 2 ^a	67.70 ± 4 ^a	67.75 ± 3 ^a	66.40 ± 4 ^a

Values expressed are mean ± standard deviation

Means in the rows with different superscripts are significantly ($p \leq 0.05$) different

setback (measure of retrogradation tendency or syneresis of flours upon cooling of cooked flour pastes). The weaker resistance of flour-CPP blends under heating and shear-mixing giving rise to decreased viscosity may be attributed to increase in non-starch compounds (Bae et al. 2014). Breakdown viscosity is a measure of degree of disintegration of granules caused due to the continuous shear and stress at elevated temperatures (Kaur and Singh 2005; Cruz et al. 2013). Breakdown values for the blends ranged from 938 to 1368cP. The lowest breakdown was observed for blends containing 20 % of 120 mesh CPP probably due to small particle size of the CPP and dilution of starch.

Dynamic rheometry

The elastic and storage modulus of the samples was found to increase with the increase in frequency as shown in Fig. 1. This depicts the elastic behaviour of the samples. The increase in the values of storage and loss modulus was higher in the angular frequency range of 0–100/s. This may be because with increase in frequency, the molecules are getting lesser time to rearrange themselves. The storage modulus (G') of the samples was dominant over the loss modulus (G'') throughout the frequency sweep employed. This indicates the solid-like behaviour of the samples, which means that the samples were viscoelastic in nature (Singh et al. 2001, 2011). Behaviour of the carrot pomace

incorporated dough samples was similar to the control wheat flour dough. However, increase in the extent of CPP resulted in stiffer and less extensible dough. The effect of CPP on the rheological properties of dough were consistent with previous research using apple pomace (Sudha et al. 2007) and water insoluble date fibre (Ahmed et al. 2013) incorporated wheat flour dough. The negative effect on the formation of the gluten network by excess amounts of CPP is attributed to the dilution of gluten protein (Wang et al. 2003). The behaviour of dough samples containing 120 mesh CPP resembled the wheat flour dough more closely than the dough samples containing 72 mesh CPP. This could be because of the smaller average size of the CPP particles in 120 mesh that do not interfere with the development of gluten network.

Color characteristics

Effect of incorporation of CPP on the color characteristics of wheat flour, flour-CPP blends and cookies are given in Table 4. CPP darkened the color of flour as well as cookies that varied directly with the level of substitution and particle size of CPP. L^* values of both flour as well as cookies with respect to the control showed a regular decrease upon increasing the level of CPP while a^* and b^* values increased and is consistent with Shiao et al. (2015) who studied the effect of pineapple core fibre on color of

Fig. 1 Shear storage (G') and loss (G'') moduli of wheat flour and CPP blends

Table 4 Color characteristics and antioxidant activity of flour blends and cookies (n = 3)

		Control	72 Mesh			120 Mesh		
			10 %	15 %	20 %	10 %	15 %	20 %
Flour								
L*	70.73 ± 1.17 ^{c*}	62.56 ± 1.13 ^{d*}	57.37 ± 1.32 ^{c*}	53.73 ± 1.71 ^{b*}	53.11 ± 1.86 ^b	49.31 ± 1.12 ^a	60.47 ± 1.81 ^{d*}	
a*	2.07 ± 0.12 ^a	2.01 ± 0.10 ^a	2.76 ± 0.11 ^c	3.38 ± 0.13 ^d	2.33 ± 0.12 ^b	2.89 ± 0.14 ^c	3.73 ± 0.13 ^e	
b*	9.73 ± 0.21 ^a	19.45 ± 0.23 ^b	23.73 ± 0.22 ^c	25.21 ± 0.24 ^d	22.54 ± 0.31 ^b	25.61 ± 0.27 ^d	22.53 ± 0.23 ^b	
Cookies								
L*	56.49 ± 1.21 ^g	53.88 ± 1.11 ^f	50.62 ± 1.09 ^c	49.17 ± 1.01 ^b	52.96 ± 0.96 ^c	51.32 ± 1.21 ^d	48.63 ± 0.99 ^a	
a*	5.45 ± 0.10 ^{a*}	6.37 ± 0.13 ^{d*}	5.87 ± 0.11 ^{b*}	6.04 ± 0.09 ^{c*}	5.85 ± 0.07 ^{bc*}	7.03 ± 0.10 ^{e*}	6.85 ± 0.04 ^{e*}	
b*	31.95 ± 1.10 ^{a*}	35.43 ± 1.21 ^{b*}	36.16 ± 1.13 ^{b*}	38.13 ± 1.14 ^{d*}	35.82 ± 1.09 ^{b*}	36.78 ± 1.05 ^{c*}	39.12 ± 1.19 ^{e*}	
Flour								
AA (%)	37.71 ± 0.51 ^{a*}	41.38 ± 0.50 ^b	43.61 ± 0.51 ^c	44.38 ± 0.53 ^d	43.38 ± 0.50 ^c	45.83 ± 0.25 ^e	49.27 ± 0.26 ^f	
Cookies								
AA (%)	33.38 ± 0.52 ^a	56.11 ± 0.54 ^{b*}	58.28 ± 0.51 ^{c*}	59.69 ± 0.93 ^{d*}	56.98 ± 0.41 ^{b*}	56.83 ± 0.34 ^{b*}	59.98 ± 0.31 ^{d*}	

Values expressed are mean ± standard deviation

Means in the rows with different superscripts are significantly ($p \leq 0.05$) different

AA Antioxidant activity

For the corresponding values of flour and cookie properties, means with * are significantly ($p \leq 0.05$) different in each column

Table 5 Texture, spread ratio and sensory analysis of cookies (n = 3)

	Control	72 Mesh			120 Mesh		
		10 %	15 %	20 %	10 %	15 %	20 %
Hardness (Kg)	5.11 ± 0.18 ^g	4.21 ± 0.15 ^d	3.76 ± 0.11 ^b	3.33 ± 0.08 ^a	4.52 ± 0.12 ^f	4.34 ± 0.10 ^e	4.12 ± 0.11 ^c
Spread ratio	5.76 ± 0.02 ^a	7.99 ± 0.02 ^b	7.79 ± 0.03 ^b	7.67 ± 0.32 ^b	8.11 ± 0.16 ^b	7.63 ± 0.02 ^b	7.50 ± 0.24 ^b
Sensory							
Color and appearance	7.64 ± 0.11 ^a	7.74 ± 0.07 ^a	7.89 ± 0.07 ^b	8.01 ± 0.14 ^c	7.89 ± 0.10 ^b	8.12 ± 0.06 ^c	8.21 ± 0.02 ^e
Flavor	7.55 ± 0.14 ^a	7.71 ± 0.03 ^b	7.77 ± 0.17 ^c	8.14 ± 0.11 ^d	7.84 ± 0.11 ^c	8.25 ± 0.07 ^d	8.34 ± 0.10 ^e
Texture	8.20 ± 0.09 ^b	8.17 ± 0.04 ^b	7.60 ± 0.07 ^a	7.55 ± 0.13 ^a	8.22 ± 0.11 ^b	7.75 ± 0.04 ^a	7.70 ± 0.09 ^a
Overall acceptability	7.50 ± 0.09 ^a	7.75 ± 0.09 ^b	7.70 ± 0.08 ^b	8.00 ± 0.09 ^d	7.85 ± 0.12 ^c	8.20 ± 0.05 ^e	8.51 ± 0.05 ^f

Values expressed are mean ± standard deviation

Means in the rows with different superscripts are significantly ($p \leq 0.05$) different

mantou. The highest a^* value (7.07) was observed for blends with 15 % of 120 mesh CPP and the highest b^* value (39.12) was for those with 20 % of 120 mesh CPP. Baking of dough into cookies showed a considerable change in color with decreasing L^* values and increasing a^* and b^* values as compared to the corresponding dough and is consistent with Sharma and Gujral (2014).

Antioxidant activity

Increasing the level of CPP resulted in a significant increase of antioxidant activity (41.38–49.27 %) in the flour blends. Baking of flour blends into cookies resulted in a significant increase in antioxidant activity (56.11–59.98 %). However, baking resulted in a

significant decrease in antioxidant activity of wheat flour cookies Table 4. Among the blends, those with 20 % of 120 mesh CPP showed the highest antioxidant activity for both flour (49.27 %) and cookies (59.98 %). This could be due to high content and reduced particle size of the CPP, which result in high extractability of antioxidant compounds. Zilic et al. (2016) reported a decrease in antioxidant activity of corn cookies and enhanced release of phenolic compounds associated to the dietary fibres upon baking, which results in higher antioxidant activity of cookies. Increase in antioxidant activity of cookies upon baking has also been reported by Sharma and Gujral (2014) and was attributed to the formation of brown coloured pigments due to Maillard browning during the baking process.

Texture and spread ratio of cookies

The effect of incorporation of CPP on texture and spread ratio of cookies is given in Table 5. Addition of CPP significantly decreased the hardness of cookies. Among the flour blends, those with 20 % of 72 mesh CPP showed the minimum hardness (3.76 kg), which could be attributed to its less homogeneous flour particle size due to addition of high particle size CPP that hinders the gluten development. Similar results were observed by Arun et al. (2015) for cookies blended with plantain peel and Duta and Culetu (2015) for oat-based gluten free cookies. Addition of CPP significantly increased the spread ratio of cookies. Similar results were reported by Zouari et al. (2016) for cookies blended with sesame peels. Among the flour blends, those with 20 % of 72 mesh CPP showed the maximum spread ratio (7.67), which could be due to addition of high particle size CPP that hinders the gluten development.

Sensory characteristics of cookies

The sensory analysis of control and CPP incorporated cookies is given in Table 5. Sensory scores for color increased with the level of CPP in the cookies. Blending of 20 % of 120 mesh CPP produced cookies with the highest color score (8.21), which could be due to small particle size of the CPP that provides uniformity to the cookie color. Flavor also increased with increase in the level of CPP. The highest flavor score (8.34) was obtained by cookies containing 20 % of 120 mesh CPP. Texture scores were the highest for wheat flour and 10 % CPP blend cookies, which decreased upon increasing the level of CPP. This might be due to large particle size of the CPP which reduced the hardness of cookies. The overall acceptability of cookies increased upon increasing the level of CPP and 20 % of 120 mesh flour cookies scored the highest overall acceptability. This might be due to small particle size of the CPP that provides uniformity to the flour particles. Results of the present analysis were in accordance with Duta and Culetu (2015) for oat-based gluten free cookies.

Conclusion

The present study evaluated the effect of blending CPP of 72 and 120 mesh size on dough and cookie making properties of wheat flour. Incorporation of 120 mesh CPP in wheat flour resulted into cookies with better antioxidants and sensory characteristics. Keeping in view the composition and properties of CPP, the present study leads to better utilization of this industrial waste.

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