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Physical, sensory and nutritional quality of anthocyanins rich pasta prepared using biofortified purple wheat

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Abstract

Oxidative stress has been implicated in the progression of a number of degenerative diseases, therefore, bioactive compounds such as polyphenols, anthocyanins and carotenoids have attracted the attention of food researchers and food manufactures due to their health-promoting and disease-preventing effects. This study was undertaken to develop anthocyanins rich pasta by using purple wheat (100%) and to compare its physical, functional and nutritional composition with yellow-brownish wheat (100%) pasta. Uncooked pasta was analysed for bulk density, water absorption and cooking time. Pasta seasoned with vegetables was analysed for sensory parameter using 9 point hedonic scale. Cooked pasta was dried to stabilize moisture and analysed for proximate composition, sugars, total and available (*in vitro*) calcium, iron and zinc, *in vitro* digestibility of protein and starch, phytic acid, total lysine, DPPH radical scavenging activity, total phenolic content (TPC), total flavonoid content (TFC) and total anthocyanin content (TAC). Independent t-test was used to differentiate the mean scores of physical and nutritional parameters. Bulk density (kg/l) and cooking time (min) of purple wheat pasta were observed as 0.53 kg/l and 8.1 min, respectively. Results of antioxidants indicated that pasta prepared with purple wheat had 64.93 mg TE per 100 g of DPPH radical scavenging, 125.63 mg GAE/100 g of TPC, 65.97 mg RE per 100 g of TFC and 4.32 mg C3GE/100 g of TAC. Pasta prepared with corresponding author: Dr. Varsha Rani, DES, Home Science Deptt. of Foods and Nutrition, KVK Faridabad, CCSHAU, Hisar-125004 Haryana, India; varshadangi@hau.ac.in; 8396074989 purple wheat also had significantly higher total lysine (4.21 g/16gN), *in vitro* digestibility of starch (42.10 %) and protein (79.02 %) and *in vitro* availability of calcium (51.59 %), iron (22.69 %) and zinc (38.50 %) than pasta prepared with yellow-brownish wheat.

1. Introduction

Oxidative stress has been implicated in the progression of a number of degenerative diseases such as diabetes, rheumatoid arthritis, osteoporosis, cancer, cystic fibrosis, Alzheimer's disease (AD), Parkinson's disease (PD), and amyotrophic lateral sclerosis (ALS). These diseases are characterized by extensive oxidative damage to lipids, proteins, and DNA (Arts and Hollman, 2005; Uttara *et al*., 2009; Patel *et al*., 2013). In recent years, importance of bioactive compounds such as dietary fiber, polyphenols, antocyanins, saponins and carotenoids, their natural food sources and processing techniques to enhance their level naturally have attracted attention of food researchers and food manufactures due to their health-promoting and disease-preventing effects (Havrlentov *et al*., 2014; Agarwal *et al*., 2020; Rai *et al*., 2020; Mounika and Hymavathi, 2021; Kulla *et al*., 2021). Purple wheat bran contains high antioxidant capacity determined by 3 assay, *i.e.*, ABTS, DPPH and ORAC with 74, 94, and 100 per cent inhibition of free radical ion as supported by *in vitro* research evidences (Gamel *et al*., 2020). Purple wheat possesses anti-ageing properties and reported that anthocyanin extract from purple wheat extends the life span of wild type and mev-1 (hn1) mutant worms by 9.2 to 10.5 per cent as these worms were found to be sensitive to oxidative stress reported *in vivo* study (Chen *et al*., 2013).

Wheat (*Triticum aestivum* L.) among cereals is at the heart of people in northern India and contributes over 60 per cent of daily diet. Wheat bran is high in dietary fibre, minerals, antioxidants and phytochemicals that protect against a number of chronic diseases linked to oxidative stress (Nidhi *et al*., 2021). The most often consumed wheat (*T. aestivum*) is tawny in colour and has a low quantity of anthocyanin, however, biofortified purple wheat has high mineral and anthocyanin pigment, and therefore high antioxidant profile and has attracted the attention of researchers and the food industry during recent years (Syter *et al*., 2018; Calderaro *et al*., 2019). In addition to high minerals and anthocyanins, lysine the limiting amino acid in white, golden and red lines of wheat is also found in purple wheat. *Triticum durum* (purple tetraploid wheat) was originally harvested in Abyssinia (Ethiopia) in 1870 and then reintroduced to Europe. Since its genotype has great potential to produce human health friendly cultivars, demand has risen substantially. Purple wheat became popular owing to its extremely high anthocyanins content (Lia *et al*., 2017; Grausgruber *et al*.,

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2018). The presence of anthocyanins such as cyanidin-3-glucoside and peonidin-3-glucoside, which have strong antioxidant and anti-inflammatory properties, contribute to purple colour of wheat grain.

Though, pasta is known as a truly Italian dish in European flavor, however, it has crossed borders and traveled around the globe. It is quite easy and nippy to cook, nutritionally exceptional, and loved by the children and teenagers. Good textures and culinary qualities of pasta are highly influenced by number of factors such as protein content, gluten strength, starch gelatinization and protein network formation and interactions of last two in presence of water. Milling performance of semolina with optimum degree of refinement, its ability to contribute better appearance, high breakage resistance, and cooking tolerance are the other important properties of durum wheat that influence pasta quality. Biofortified purple wheat can serve this purpose to a great extent. Higher antioxidant activity, iron, zinc and lysine can be the additional nutritional benefits to the consumers.

Being a natural store of pigments and phytochemicals, purple wheat grains could be used to provide commercial food products a desirable colour and durability. According to the findings of Mazzaracchio *et al*. (2012), there is a significant connection between the structure of anthocyanins and the structure of gluten molecules, which plays an essential role in the adsorption of pigments by gluten or its component. Recent research indicated that purple wheat was found to have anti-inflammatory properties (Sharma *et al*., 2018), elevate serum antioxidant status and suppress lipid peroxidation in rats (Jansakova *et al*., 2016), amplify life span in *Caenorhabditis elegans* (Chen *et al*., 2013), lower total cholesterol, triglyceride, and free fatty acid levels in serum in type 2 diabetic human patients (Liu *et al.*, 2018), and improve glucose or insulin resistance in mice (Sharma *et al*., 2020). Additionally, anthocyanins are capable of binding heavy metals (zinc, iron, and copper) and prevent against cardiovascular disease, cancer, rheumatoid arthritis and neurological illness (Fang *et al*., 2002; Lutsey *et al*., 2007; Janeckova *et al*., 2014). Ordinary tawny wheat can thus be replaced by purple wheat products to the daily diet as a novel nutritious and therapeutic meal.

Curing with diet has always been a sustainable approach and is very much in demand these days due to the increased awareness of consumers. Incorporating anthocyanins and phenolics into staple meals is one method for ensuring sufficient absorption (Ficco *et al*., 2016; Angelino *et al*., 2017). Because of the rising demand for novel products and the aesthetic attractiveness of naturally colored food, “colored” bread and pasta have been introduced to the market. The majority of the goods on the market are made using whole grains as the source of anthocyanins. Pasta was developed using a high quantity of bran fraction (up to 15 % (w/w)) with increased fibre and polyphenol content which was much greater than that of products made from the similar whole grains (Zanoletti *et al*., 2017). Keeping these facts in view, this research was undertaken to develop anthocyanins rich pasta using biofortified purple wheat and to evaluate pasta for physical, sensory and nutritional parameters.

2. Materials and Methods

2.1 Procurement of material

Purple wheat (NABIMG-10) seed was procured from the Punjab-based National Agri-Food Biotechnology Institute (NABI), whereas yellow brownish wheat and other materials needed for product preparation and packaging were purchased in one lot from the local market, Hisar. Broken seeds, dust, and other foreign elements were removed from the grain sample and cleaned.

2.2 Development of pasta

Spiral shape pasta was developed using semi automatic single screw La Parmigiana extruder. The flour was mixed and sieved then introduced it in the extruder. Predetermined amount of water was added to it. Flour was mixed with water for 5 min. Pasta was made under pressure using dye, which were taken on trays for drying. The pasta was dried in hot air oven at 50°C temperature for 4 h (Figure 1).

Figure 1: Pasta prepared using yellow brownish wheat (left) and purple wheat (right).

2.3 Physical characteristics of pasta

Bulk density was measured using methodology given by Vetrimani and Rahim (1994). Pieces of pasta approximately 1 cm in length were placed in a graded cylinder. The bottom of the cylinder was gently pressed on a laboratory bench until there was no further sample volume reduction. The bulk density of a sample was determined by dividing its weight by its volume (kg/l). Water absorption of pasta was determined using Padalino *et al.* (2013). Ten grams sample of equal-size strands was cooked for the best cooking duration. Cooked sample was reweighed and difference was calculated. Cooking time of pasta was determined using AACC (2010) method. A ten-gram sample was added to 200 ml of boiling water and maintained at a rolling boil. Starting at 4 min, sample was taken in every 30 seconds and pressed between two glass sheets. At the point there was no visible core of the product, the cooking time was calculated.

2.4 Sensory analysis

Pasta was boiled in water with a pinch of salt and a tea spoon of oil. It was boiled for 5 min or till soft.Water was strained and kept aside. Oil was heated in a pan, added chopped onion and fried slightly. Chopped capsicum, cabbage were added to it and cooked till soft. Salt tomato sauce, chilli sauce, soy sauce and vinegar were added and stirred properly. Boiled pasta was mixed to vegetable mixture and cooked for 2-3 min and subjected to sensory evaluation while hot. Cooked pasta was evaluated in terms of color, taste, aroma, appearance, texture and overall acceptability using 9 point hedonic rating scale by a panel of 30 semi-trained judges. Rating of pasta was expressed on a 9 to 1 point rating scale as liked extremely, liked very much, liked moderately, liked slightly, neither liked nor disliked, disliked slightly, disliked moderately, disliked very much and disliked extremely, respectively. An overall acceptability score of 6 or above was considered acceptable and further evaluated for nutritional parameters.

2.5 Nutritional analysis

The association of official analytical chemists (AOAC, 2010) methods were used to determine the moisture, carbohydrate, fats, protein, and ash in cooked and dried pasta samples. The micro-Kjeldhal apparatus was used to determine the nitrogen concentration of the samples. To convert it to crude protein, the nitrogen value was multiplied by 6.25. The moisture and ash contents of pasta were measured using weight difference method, while crude fat was determined using the Socs Plus apparatus using petroleum ether as the solvent, crude fiber was analyzed as acid and alkali resistant.

Samples for total sugars and starch were extracted using 80 per cent ethanol by employing the methodology of Cerning and Guilhot (1973) and the contents were estimated using the methods of Yemm and Willis (1954). Reducing sugar was determined according the methods of Somogyi (1945) and non-reducing sugar was calculated as a difference of total soluble sugar and reducing sugar.

The acid digested (HNO_3:$HClO_4$; 5:1 v/v) samples were estimated for total calcium, iron and zinc by atomic absorption spectrophotometer 240 FS (Australia) using the method earlier mentioned by John *et al.* (2020). *In vitro* available calcium and zinc were extracted as per method of Kim and Zemel (1986) and sample for *in vitro* available iron was extracted as per the methodology of Rao and Prabhavathi (1978) earlier described by John *et al.* (2020).

In vitro protein digestibility (%) was estimated using modified enzymatic method explained by Mertz *et al.* (1983) and *in vitro* starch digestibility (mg maltose released per g of starch) was assessed as per the method given by Singh *et al.* (1982). Total lysine (g/16 gN) was estimated by the method of Balsubramanian and Sadasivam (1987). Phytic acid (mg/100 g) content was analyzed by using the method of Davies and Reid (1979).

2.6 Antioxidant profile

Total anthocyanins content (TAC) was analysed in a type U-1100 spectrophotometer by following the methodology of Abdel-Aal and Hucl (1999), the acidified MeOH extract was filled in 1 cm thick cavities and measured at 535 nm. An empty microcuvette was used to set the reading to zero, followed by a cuvette containing just acidified MeOH. Using the calibration curve, the findings were determined and reported as mg cyanidin-3-glucoside equivalents per kg dry matter (ppm). The extinction coefficient was used to compute the total anthocyanin concentrations.

Total phenolic content (TPC) was measured spectrophotometrically using the Folin-Ciocalteu reagent as described by Singleton (1999). Acidified MeOH extract (0.1 ml) was added to the reaction mixture, which was then oxidised using 0.5 ml Folin-Ciocalteu reagent (1:10 Folin-Ciocalteu:water) and 0.8 ml 7.5 per cent Na_2CO_3. Instead of extract, 0.1 ml water was used to prepare the blank. The combination was heated in a water bath at 50°C for 5 min and then cooled to room temperature before being measured using a type U-1100 spectrophotometer at 760 nm.

Total flavonoids content was estimated using aluminium chloride colorimetric technique explained by Zhishen *et al.* (1999). From various sample aliquots, a final amount of 5 ml was prepared using distilled water. Then, in test tubes, added 0.5 ml of 5% $NaNO_2$ and, after 5 min, added 0.6 ml of 10% $AlCl_3$ and mixed again. After 6 min, 2 ml of 1N NaOH was added and stirred. With the addition of 2.1 ml distilled water, a volume of 10 ml was made. Pink colour absorption was measured at 510 nm.

The DPPH radical scavenging activity was measured using methodology given by Brand-Williams *et al.* (1995). Different known sample aliquots were collected using methanol, and the volume was built up to 1 ml. It was then filled with 3 ml of DPPH reagent and properly mixed before being incubated at 370°C for 20 min. Absorbance of oxidised solution was read against methanol as a blank at 517 nm.

2.7 Statistical analysis

The data obtained was statistically analyzed in terms of mean, standard deviation and independent t-test was used to compare the means of various parameters of pasta developed using light yellow-brownish wheat and purple wheat.

3. Results

It was observed that yellow-brownish wheat flour-based pasta had a bulk density of 0.58 kg/l and a cooking time of 8.3 min whereas purple wheat-based pasta had a bulk density of 0.53 kg/l and a cooking time of 8.1 min. Purple wheat-based pasta had a water absorption capacity of 2.69 g/g, whereas yellow-brownish wheat flour-based pasta had a capacity of 2.34 g/g. The water absorption capacity of purple wheat-based pasta was significantly higher (p<0.01) than yellow-brownish wheat flour-based pasta (Table 1) and as a result had less cooking time.

Table 1: Physical characteristics of anthocyanins rich pasta

Physical characteristics	Yellow-brownish wheat	Purple wheat	t-value
Bulk density (kg/l)	0.58 ± 0.01	0.53 ± 0.02	3.10*
Water absorption (g/g)	2.34 ± 0.07	2.69 ± 0.04	15.04**
Cooking time (min)	8.3 ± 0.25	8.1 ± 0.25	1.96NS

NS= non- significant (there was no difference between variables).
*=significant difference at 5% level of significance.
**=significant difference at 1% level of significance.

Purple wheat flour-based pasta was adjudged as liked very much by obtaining the mean score of 8.66 for overall acceptability. Results indicated that purple wheat-based pasta attained higher scores for aroma, texture, taste, and overall acceptability whereas yellow-brownish wheat flour-based pasta attained higher scores for colour and appearance (Table 2).

The moisture, crude protein, ash, fat, and crude fibre content of purple wheat flour pasta was 11.34, 13.19, 2.98, 2.99, and 5.17 per cent, respectively whereas the contents of same were 12.26, 11.16, 2.35, 1.85, and 3.76 per cent, respectively in pasta made from yellow-brownish wheat. Pasta prepared with purple wheat flour had significantly (p<0.05) higher amounts of crude protein, ash and crude fiber than the pasta prepared with yellow-brownish wheat flour (Table 3). Total soluble sugar, reducing sugar and non- reducing sugar contents in pasta prepared from yellow-brownish wheat flour were observed as 4.72, 1.47 and 3.25 per cent, respectively. However, the content of starch in the same pasta was found to be 61.42 per cent. The contents of total soluble sugar, reducing sugar and non- reducing sugar of pasta prepared from purple wheat flour were found to be significantly higher (p<0.05), whereas the content of starch was significantly lower (Table 3).

Table 2: Mean scores of organoleptic characteristics of anthocyanins rich pasta

Products	Mean scores					
Pasta	Color	Appearance	Aroma	Texture	Taste	Overall acceptability
Yellow brownish wheat	8.65 ± 0.69	8.69 ± 0.29	8.2 ± 0.76	8.3 ± 0.38	8.4 ± 0.38	8.45 ± 0.5
Purple wheat	8.3 ± 0.64	8.4 ± 0.19	8.79 ± 0.15	8.73 ± 0.22	9.1 ± 0.31	8.66 ± 0.30
t-value	1.29NS	2.90*	1.32NS	3.39*	4.94*	1.28NS

NS= non-significant (there was no difference between variables).
*=significant difference at 5% level of significance.

Table 3: Proximate and carbohydrate composition of anthocyanins rich pasta (%, on dry matter basis)

Parameters	Yellow-brownish wheat	Purple wheat	t-value
Moisture	12.26 ± 0.17	11.34 ± 0.49	6.14*
Crude protein	11.16 ± 1.27	13.19 ± 0.22	4.73*
Ash	2.35 ± 0.03	2.98 ± 0.37	4.07*
Fat	1.85 ± 0.33	2.99 ± 0.05	4.53*
Crude fiber	3.76 ± 0.5	5.17 ± 0.7	5.68**
Total soluble sugar	4.72 ± 0.8	6.10 ± 0.4	5.40**
Reducing sugar	1.47 ± 0.24	2.65 ± 0.51	7.37*
Non-reducing sugar	3.25 ± 0.15	4.35 ± 1.18	1.60NS
Starch	61.42 ± 1.2	58.36 ± 0.7	4.34*

NS= non-significant (there was no difference between variables).
*=significant difference at 5% level of significance.
**=significant difference at 1% level of significance.
Values are mean ± SD of three independent determinations

Table 4: Mineral profile and digestibility of macronutrients of anthocyanins rich pasta (on dry matter basis)

Products	Yellow-brownish wheat	Purple wheat	t-value
Iron (mg/100 g)	4.04 ± 0.58	6.27 ± 2.26	3.31*
Calcium (mg/100 g)	30.22 ± 0.89	51.83 ± 0.96	57.18**
Zinc (mg/100 g)	3.56 ± 0.23	4.81 ± 0.47	8.28*
Available iron (mg/100 g)	0.84 ± 0.33	1.40 ± 0.35	
	(20.27)	(22.69)	4.01*
Available calcium (mg/100 g)	12.79 ± 0.69	26.93 ± 0.92	
	(41.16)	(51.69)	42.59**
Available zinc (mg/100 g)	0.86 ± 0.91	1.65 ± 0.94	
	(27.72)	(38.50)	4.22*
Protein digestibility %	73.11 ± 1.79	79.02 ± 2.97	5.90**
Starch digestibility			
(mg maltose released/g)	36.74 ± 3.16	42.10 ± 0.21	5.86**

*=significant difference at 5% level of significance. **=significant difference at 1% level of significance.
Values are mean ± SD of three independent determinations.

Table 5: Phytic acid, total lysine and antioxidant profile of anthocyanins rich pasta

Products	Yellow-brownish wheat	Purple wheat	t-value
Phytic acid (mg/100 g)	208.37 ± 1.34	176.16 ± 1.13	31.83**
Total lysine (g/16 gN)	2.34 ± 0.38	3.21 ± 0.86	1.89ns
DPPH (mg TE/100 g)	26.01 ± 0.70	64.93 ± 0.99	55.60**
TPC (mg GAE/100 g)	101.98 ± 0.78	125.63 ± 0.81	72.86**
TFC (mg RE/100 g)	33.54 ± 0.96	65.97 ± 1.04	79.37**
TAC (mg C3GE/100 g)	0.39 ± 0.03	4.32 ± 0.36	68.19**

**=significant difference at 1% level of significance.
TPC: Total Phenolic Content; TFC: Total Flavonoid Content; TAC: Total anthocyanin content.
Values are mean ± SD of three independent determinations.

The contents of total iron (6.27 mg/100g), zinc (4.81 mg/100g) and total calcium (51.83 mg/100g) were considerably higher (p<0.05) in pasta made from purple wheat flour (Table 4). Purple wheat flour pasta also had significantly (p<0.05) higher levels of per cent *in vitro* availability of iron (22.69%), zinc (38.50%) and calcium (51.69%) than yellow-brownish flour pasta (Table 4). Further, results indicated that i*n vitro* digestibility of protein and starch of pasta made with yellow-brownish wheat flour was 73.11 per cent and 36.74 mg maltose released per gram, respectively. However, the digestibility of both of protein and starch were significantly higher (p<0.01) (79.02%; 42.10 mg maltose released per gram) in pasta prepared using purple wheat flour (Table 4).

Total lysine content in pasta prepared with yellow-brownish wheat flour was 2.34 g/16gN, whereas the content was slightly higher 3.21 g/16 gN in pasta prepared with purple wheat flour. It was observed that pasta prepared using purple wheat flour had significantly lower amount of phytic acid (176.16 mg/100 g) than pasta prepared of yellow-brownish wheat flour (208.37 mg/100 g) (Table 5). The results indicated that yellow-brownish wheat flour pasta had 26.01 mg TE per 100 g of DPPH radical scavenging activity, whereas purple wheat pasta had almost three times higher content (64.93 mg TE per 100 g) of DPPH radical scavenging activity. Total phenolic content was also found significantly higher in purple wheat pasta (125.63 mg GAE/ 100 g) than the yellow-brownish wheat pasta (101.98 mg GAE/100 g) (Table 5). Purple wheat pasta had almost two times higher level of total flavonoid content (65.97 mg RE per 100), than yellow-brownish wheat pasta which had a total flavonoid content of 33.54 mg RE per 100 g. Furthermore, it was shown that pasta made with purple wheat flour also had significantly (p<0.01) higher total anthocyanins content (4.32 mg C3GE/100 g) than pasta made with yellow-brownish wheat flour (0.39 mg C3GE/100 g) (Table 5).

4. Discussion

This study was conducted to develop anthocyanins rich pasta with enhanced antioxidants activity and therapeutic properties. Physical characteristics are potent to predict the quality of final product. Results indicated that pasta developed using purple wheat flour had lower bulk density and cooking time (Table 1), whereas higher water absorption. Low bulk density flour are easy to handle during packaging and storage and also suitable for production of pasta as it provide low paste thickness and viscosity during boiling. The higher water absorption of purple wheat pasta has been attributed to the higher fiber and protein content of purple wheat. Further, this was likely to the low thickness (1 mm) and high surface of the tagliatella-shape, which ensured fast water diffusion and absorption. The results of water absorption and cooking time with respect to purple wheat observed in present are corroborated with the findings of Ficco *et al.* (2016), Zanoletti *et al.* (2016), Kumari *et al.* (2020).

In present study, results indicated that purple wheat-based pasta attained higher scores for aroma, texture, taste, and overall acceptability (Table 2). A number of volatile compounds and specially the presence of anthocyanins such as cyanidin-3-glucoside and peonidin-3-glucoside in purple wheat contribute towards a distinct, however, acceptable colour and pleasant aroma and taste to pasta. The higher fat and fiber content of purple wheat might have contributed towards its better texture and taste. Similar positive influence of incorporation of colour wheat on sensory parameters of pasta and other products have been observed by Chen *et al.* (2013), Pasqualone *et al.* (2015), Li *et al.* (2015), Ficco *et al.* (2016), Usenko *et al.* (2018), Kumari *et al.* (2020).

In present study, regarding nutritional value of pasta, it was observed that purple wheat pasta had significantly (p<0.05) higher amounts of protein (13.19%), ash (2.98%), fat (2.99%), crude fiber (5.17%), total soluble sugar (6.10 mg/100 g), iron (4.04 mg/100 g), calcium (30.22 mg/100 g), zinc (3.56 mg/100 g) and lysine (3.21 g/16 gN) than yellow-brownish wheat pasta. In a previous study, both the individual amino acid and crude protein retention were found higher in chapatti prepared with colored wheat than white wheat (Sharma *et al*., 2022). The significantly higher content of ash in purple wheat pasta might be due to the high mineral index of purple wheat. Ficco *et al.* (2016) also observed a higher, *i.e.*, 9.8 per cent total dietary fiber (TDF) content in purple wheat flour than yellow durum wheat flour, *i.e.*, 8.4 per cent. Dietary fibers are the non-caloric carbohydrate which are resistant to be hydrolyzed by the digestive enzymes of human GIT and are considered important as these act as the substrate to healthy gut microflora, increase transit time and provide numerous health benefits, such as relieving constipation, weight reduction, and lowering the risk of diabetes and heart diseases. Similar positive influence of purple wheat incorporation on proximate composition of biscuits was observed by Pasqualone *et al.* (2015). Results of sugars and starch as observed in present study are in close proximity of those observed by Abdel-Aal *et al.* (2018) and Saini *et al.* (2021). The increased availability of minerals and digestibility of protein and starch in purple wheat pasta might be attributed to its lower phytic acid content (Table 5) as phytic acid make insoluble complex and hinder the availability of micro and macro nutrient in food matrix (John *et al*., 2020; Khare *et al*., 2021). The substantially higher lysine amount in purple wheat pasta might be due to the high protein content of purple wheat.

Antioxidant activity (DPPH, TPC and TFC) of purple wheat pasta was shown to be significantly (p<0.01) higher than in yellow-brownish wheat pasta. Similar results were observed due to the presence of many bioactive components in purple wheat, DPPH radical scavenging activity and TPC content were reported to be higher in purple wheat-based biscuits than in normal biscuits (Pasqualone *et al*., 2015). Purple wheat-based pasta had higher TPC and TFC levels than regular wheat-based pasta. Similar results were observed by Yu and Beta (2015), Parizad *et al.* (2020). Cooking increased the antioxidant content and activity of final product significantly as reported by Yu and Beta (2015), Li and Beta (2011), Pasqualone *et al*. (2015). However, it was also reported by Li *et al.* (2015) that antioxidant activity was shown to be lower in noodles than in flour which might be attributed to antioxidant loss during the mixing and kneading process.

Purple wheat-based pasta had higher content of anthocyanins than yellow-brownish wheat-based pasta. Similar results were observed by Pasqualone *et al*. (2015), Ficco *et al*. (2016), Eliasova *et al*. (2020), Sharma *et al*. (2020), Seo *et al*. (2021). Grausgruber *et al.* (2018) revealed that fractionation can significantly amplify the concentration of anthocyanins, whereas heat and light can mortify anthocyanins during drying, processing and storage. Kumari *et al.* (2020) further revealed that breakdown product of anthocyanins after heating has stronger antioxidant activity than the coloured and glycocylated forms. Anthocyanins are also reported to have masking and protective effects on proteins and amino acids from heating and oxidative changes as minimum cooking loss of amino acid was observed in chapatti prepared using purple wheat (Sharma *et al*., 2022).

5. Conclusion

Considering the nutritional and antioxidant profiles of purple wheat, as well as the sensory and physical characteristics of the developed product, it is possible to conclude that purple durum wheat can be successfully used to develop anthocyanins rich nutritious and appealing pasta with the antioxidant power of large quantity of blueberries without sacrificing sensory attributes of final product. Purple wheat pasta had higher levels of protein, dietary fibre, antioxidant and minerals and also enhanced availability and digestibility of nutrient. Developed pasta may be beneficial in the treatment of oxidative stress due to its high antioxidant content and it will also add diversity due to its unique colour. Further, food products developed with anthocyanins rich purple wheat may offer health benefits due to its high antioxidant activity however; further research should be conducted to analyze its retention and bioavailability during high pressure high temperature cooking.

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Conflict of interest

The authors declare no conflicts of interest relevant to this article.

References

AACC (2010). Approved methods of analysis. The American Association of Cereal Chemists, St. Paul Minnesota.

Abdel- Aal, M.; Hucl, P. and Rabalski, I. (2018). Compositional and antioxidant properties of anthocyanin-rich products prepared from purple wheat. Food Chemistry, **1**:30-34.

Abdel-Aal, P. and Hucl, E. S. M. (1999). A rapid method for quantifying total anthocyanins in blue aleurone and purple pericarp wheat. Cereal Chemistry, **76**:350-354.

Agarwal, S.; Tripathi, S.; Arshi and Mishra, N. (2020). Nutritional composition and antioxidant profiles of *Nigella sativa* L. seeds. Ann. Phytomed., **9**(2):207-214. http://dx.doi.org/10.21276/ap.2020.9.2.18.

Angelino, D.; Cossu, M.; Marti, A.; Zanoletti, M.; Chiavaroli, L.; Brighenti, F.; Del Rio, D. and Martini, D. (2017). Bioaccessibility and bioavailability of phenolic compounds in bread: A review. Food Funct., **8**:2368-2393.

AOAC (2010). Official Methods of Analysis 15th edition (Volume-1 and 2). Association of Official Analytical Chemists, International, Suite 500, 481, North Frederick Avenue, Maryland, 20877-2417, U.S.A.

Arts, I.C. and Hollman, P.C. (2005). Polyphenols and disease risk in epidemiologic studies. American Journal of Clinical Nutrition **81**(1): 317-325.

Balasubramanian, T. and Sadasivam, S. (1987). Changes in starch, oil, protein and amino acids in developing seeds of okra (*Abelmoschus esculentus* L. Moench). Plant Foods Human Nutri., 37:41-46.

Brand-Williams, W.; Cuvelier, M.E. and Berset, C. (1995). Use of a free radical method to evaluate antioxidant activity. Food Science and Technology, **28**(1):25-30.

Calderaro, A.; Barreca, D.; Bellocco, E.; Smeriglio, E.; Trombetta, D. and Lagana. D. (2019). Colored phytonutrients: Role and applications in the functional foods of anthocyanins. In Phytonutrients in Food, 1st edition., pp:177-195.

Cerning, J. and Guilhot, J. (1973). Changes in carbohydrate composition during maturation of wheat and barley kernel. Cereal Chem., **50**: 220-222.

Chen, W.; Muller, D.; Richling, E. and Wink, M. (2013). Anthocyanin-rich purple wheat prolongs the life span of *Caenorhabditis elegans* probably by activating the DAF-16/FOXO transcription factor. J. Agric. Food Chem., **61**:3047-3053.

Davies, N.T. and Reid, H. (1979). An evaluation of the phytate, zinc, copper, iron and manganese contents of, and Zn availability from, soya-based textured-vegetable-protein meat-substitutes or meat extenders. British J. Nutrition, **41**:579-589.

Eliasova, M.; Kotikova, Z.; Lachman, J.; Orsak, M. and Martinek, P. (2020). Influence of baking on anthocyanin content in colored- grain wheat bread. Plant, Soil and Enviroment, **66**(8):381-386.

Fang, Y.Z.; Yang S. and Wu, G. (2002). Free radicals, antioxidants and nutrition. Nutrition, **18**:872-879.

Ficco, M. B. D.; Simone, De. V.; Leonardis, De. M. A.; Giovanniello, V.; Nobile, D. A. M.; Padalino, L.; Borrelli, M. G. and Vita, De. P. (2016). Use of purple durum wheat to produce naturally functional fresh and dry pasta. Food Chemistry, **205:**187-195.

Gamel, T. H.; Wright, J. A.; Pickard, M. and Abdel- Aal, M. (2020). Characterization of anthocyanins-containing purple wheat prototype products as functional foods with potential health benefits. Cereal Chemistry, **97**(1):34-38.

Grausgruber, H.; Atzegersdorfer, K. and Bohmdorefr, S. (2018). Purple and blue wheat- health- promoting grains with increased antioxidant activity. Cereal Foods World, **63**:217-220.

Havrlentova, M.; Psenakova, I.; Zofajova, A.; Ruckschloss, L. and Kraic, J. (2014). Anthocyanins in wheat seed, a mini review. Nova Biotechnological Chimica, **13**:1-10.

Janeckova, M.; Hrivna, L.; Juzl, M.; Nedomova, S.; Vyhnanek, T.; Trojan, V. and Mrkvicova, E. (2014). Possibilities of using purple wheat in producing bakery products. Mendel Net., **41**:412- 416.

Jansakova, K.; Babickova, J.; Havrlentova, M.; Hodosy, J. and Kraic, J. (2016). The effects of anthocyanin rich wheat diet on the oxidative status and behavior of rats. Croat. Med. J., **57**:119-129.

John, J.; Rani, V.; Sangwan, V.; Sonia and Reena (2020). Garden cress seeds a promising alternative for the development of nutrient dense muffins. Europ. J. Nutr. Food. Safety, **12**(9):138-146.

Khare, B.; Sangwan, V. and Rani, V. (2021). Influence of sprouting on proximate composition, dietary fiber, nutrient availability, antinutrient, and antioxidant activity of flaxseed varieties. J. Food Process Preserv., 00:e15344. https://doi.org/10.1111/jfpp.15344.

Kim, H. and Zemel, M.B. (1986). *In vitro* estimation of the potential bioavailability of calcium from sea mustard milk and spinach under stimulated normal and reduced gastric acid conditions. J. Food Sci.**,** **51**:957-963.

Kulla, S.; Hymavathi T.V.; Kumari, B. A.; Reddy R. G. and Rani, D.V. (2021). Impact of germination on the nutritional, antioxidant and antinutrient characteristics of selected minor millet flours. Ann. Phytomed., **10**(1):178-184. http://dx.doi.org/10.21276/ap.2021.10.1.18

Kumari, A.; Sharma, S.; Sharma, N.; Chunduri, V.; Kapoor, P.; Kaur, S.; Goyal, A. and Garg, M. (2020). Influence of biofortified colored wheats (purple, blue and black) on physicochemical, antioxidant and sensory characteristics of chapatti (Indian flatbread). Molecules, **25**(5071): 1-14.

Li, W. and Beta, T. (2011). Flour and bread from black-, purple-, and blue-colored wheats. In: Flour and Breads and Their Fortification in Health and Disease Prevention, 2nd ed.; Victor Preedy, V.,Watson, R., Eds.; Elsevier: Amsterdam, The Netherlands, pp:59-67.

Li, Y.; Ma, D.; Sun, D.; Wang, C.; Zhang, J.; Xie, Y. and Guo, T. (2015). Total phenolic, flavonoid content, and antioxidant activity of flour, noodles, and steamed bread made from different colored grains by three milling methods. The Crop J., **3**:328-334.

Lia, D.; Wanga, P.; Luob, Y.; Zhaoa, M. and Chena, F. (2017). Health benefits of anthocyanin and molecular mechanisms: update fronm recent decade. Crit. Rev. Fd. Sci. Nutr., **57**:1729-1741.

Liu, Y.; Qiu, J.; Yue, Y.; Li, K. and Ren, G. (2018). Dietary black-grained wheat intake improves glycemic control and inflammatory profile in patients with type 2 diabetes: A randomized controlled trial. Ther. Clin. Risk Manag., **14**:247.

Lutsey, P. L.; Jacobs, D. R.; Kori, S.; Mayer-Davis, E.; Shea, S. and Stefen, L. M. (2007). Whole grain intake and its cross- sectional association with obesity, insulin resistance, inflammation, diabetes and subclinical CVD: The MESA study. British J. Nutr., **98**:397-405.

Mazzaracchio, P.; Tozzi, S.; Barbiroli, G.; Kindl, M. and Pifferi, P.G. (2012). Adsorption behaviour of some anthocyanins by wheat gluten and its fractions in acidic conditions. Int. J. Food. Sci. Tech., **47**:390-398.

Mertz, E.T.; Kitlers, A.W. and Aretell, J.D . (1983). *In vitro* digestibility of protein in major food cereals. Fed. Proc.**,** **42**:6026-6028.

Mounika, M. and Hymavathi, T.V. (2021). Nutrient and phytonutrient quality of nutricereals incorporated flour mix suitable for diabetics. Ann. Phytomed., **10**(1):132-140.http:// dx.doi.org/10.21276/ ap.2021. 10.1.14.

Nidhi, ;Kaur, D.; Puranik, V. and Mishra, P. (2021). Effects of extraction solvents on cultivars of wheat (PBW-154 and HD-2967) bran antioxidant properties. Ann. Phytomed., **10**(2):354-359. http://dx.doi.org/ 10.21276/ ap.2021.10.2.47.

Padalino, L.; Mastromatteo, M.; Lecce, L.; Cozzolino, F. and Del Nobile, M. A. (2013). Manufacture and characterization of gluten-free spaghetti enriched with vegetable flour. Journal of Cereal Science, **57**:333-342. http:/ /dx.doi.org/10.1016/j.jcs.2012.12.010.

Parizad, A, P.; Marengo, M.; Bonomi, F.; Scarafoni, A.; Cecchini, C.; Pagani, A. M.; Marti, A. and Iametti, S. (2020). Foods, **9**(163):1-13.

Pasqualone, A.; Bianco, M. A.; Paradiso, M. V.; Summo, C.; Gambacorta, G.; Caponio, F. and Blanco, A. (2015). Production and characterization of functional biscuits obtained from purple wheat. Food Chemistry, **180**:64-70.

Patel, K.K.; Jain, A. and Patel, D. K. (2013). Medicinal significance, pharmacological activities and analytical aspects of anthocyanins 'delphinidin': A concise report. J. Acute Dis., **2**(3):169-178.

Rao, B.S.N. and Prabhavathi, T. (1978). An *in vitro* method for predicting the bioavailability of iron from foods. Am. J. Clin. Nutr., **31**:169.

Rai, H. K.; Rai,.C.; Arvind and Saloni (2020). Process optimization of low calorie and fiber enriched 'Sandesh' using response surface methodology (RSM). Ann. Phytomed., **9**(1):229-236. http:// dx.doi.org/ 10.21276/ap. 2020.9.1.31

Saini, P.; Kumar, N.; Kumar, S.; Mwaurah, W. P.; Panghal, A.; Attkan, K. A.; Singh, K. V.; Garg, K. M. and Singh, V. (2021). Bioactive compounds, nutritional benefits and food applications of colored wheat: A comprehensive review. Crit. Rev. Fd. Sci., Nutr., **61**(19):3197-3210, DOI: 10.1080/ 10408 398. 2020. 1793727.

Seo, Y.; Moon, Y. and Kweon, M. (2021). Effect of purple wheat bran addition on quality and antioxidant property of bread and optimization of bread- making conditions. Appl. Sci. **11**(4034): 1-18.

Sharma, S.; Chunduri, V.; Kumar, A.; Kumar, R.; Khare, P.; Kondepudi, K.K.; Garg, M. (2018). Anthocyanin bio-fortified colored wheat: Nutritional and functional characterization. PLoS ONE, 13, e0194367.

Sharma, S.; Khare, P.; Kumar, A.; Chunduri, V.; Kumar, A.; Kapoor, P.; Mangal, P.; Kondepudi, K.K.; Bishnoi, M.; Garg, M. (2020). Anthocyanin-biofortified Colored Wheat Prevents High Fat Diet-induced Alterations in Mice: Nutrigenomics Studies. Mol. Nutr. Food Res., **64**:1900999.

Sharma, N.; Kumari , A.; Chunduri, V.; Kaur, S.; Banda, J.; Goyal , A. and Garg, M. (2022) Anthocyanin biofortified black, blue and purple wheat exhibited lower amino acid cooking losses than white wheat. LWT - Food Science and Technology, **154**:112802 https://doi.org/ 10.1016/j.lwt.2021.112802.

Singh, U.; Khedekar, M.S. and Jambunathan, R. (1982). Studies on *desi, kabuli,* and chickpea cultivars. The level of amylase inhibitors, level of oligosaccharides and *in vitro* starch digestibility. J. Food Sci.**,** **47**: 510.

Singleton, V. L. and Rossi, J.A. (1999). Colorimetry of total phenolics with phosphomolybdic- phosphotungstic acid reagents. American Journal of Enology and Viticulture, **16**:144-158.

Somogyi, M. (1945). A new reagent for the determination of sugar. J. Biol. Chem., **160**:160-161.

Syter, O.; Bosko, P.; Zivcak, M.; Brestic, M. and Smetanska, I. (2018). Bioactive phytochemicals and antioxidant properties of the grains and sprouts of colored wheat genotypes. Molecules, **23**(2282):1-14.

Usenko, I. N.; Khlestkina, K. E.; Asavasnti, S.; Gordeeva, I. E.; Yudina, S. R. and Otmakhova, S. Y. (2018). Possibilities of enriching food products with anthocyanins by using new form of cereals. Foods and Raw Materials, **6**(1):128-136.

Uttara, B.; Singh, V. A.; Zamboni, P. and Mahajan, T. R. (2009). Oxidative stress and neurodegenerative disease: A review of upstream and downstream antioxidant therapeutic options. Current Neuropharmacology, **7**: 65-74.

Vetrimani, R. and Rahim, A. (1994). Effect of drying of vermicelli in hot air oven on its cooking quality. J. Fd. Sci. Tech., **31**:400-403.

Yemm, E. W. and Willis, A. J. (1954). The estimation of carbohydrates in plant extract by anthrone. Biochem. J. **57**:508.

Yu, L. and Beta, T. (2015). Identification and antioxidant properties of phenolic compounds during production of bread from purple wheat grain. Molecules, **20**:15525-15549.

Zanoletti, M.; Parizad, A. P.; Lavelli, V.; Cecchini, C.; Menesatti, P.; Marti, A. and Pagani, A. (2016). Debranning of purple wheat: Recovery of anthocyanin- rich fractions and their use in pasta production. Food Science and Technology, pp:1-28.

Zanoletti, M. A.; Parizad, P.; Lavelli, V.; Cecchini, C.; Menesatti, P.; Marti, A. and Pagani, M.A. (2017). Debranning of purple wheat: Recovery of anthocyanin-rich fractions and their use in pasta production. LWT Food Sci. Technol., **75**:663-669.

Zhishen, J.; Mengcheng, T. and Jianming, W. (1999). The determination of flavonoid contents in mulberry and their scavenging effects on superoxide radicals. Food Chemistry, **64**(4):555-559.

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