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Comparative Evaluation of Physico-Chemical and Nutritional Properties of Black Wheat

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ABSTRACT: Black wheat is a colored wheat with high anthocyanin content with various health benefits as reported in previous literature. The present investigation focuses on nutritional exploration(moisture, protein, carbohydrates, fat, total ash, dietary fiber and energy value determination) and mineral composition(iron, zinc phosphorous, copper, potassium, selenium, magnesium and manganese) and physical quality (grain dimensions, size, volume of seed, arithmetic diameter, geometric diameter, flat surface area, transverse area, sphericity, 1000 kernel weight, bulk density, true density, fractional porosity and angle of repose) evaluation of Black wheat in comparison with normal Netravati wheat for value addition with better health benefits as a nutraceuticals in health foods and found that the Black wheat grains had lower values of most of physical properties except length and percent porosity as compared to local wheat variety Netravati. On the other had the Black wheat was rich in protein (14.49%), dietary fiber (5.11%), carbohydrates (67.23%) and total ash (2.13%) with rich in all the minerals tested indicating higher nutritive value as compared to normal wheat that open a new avenues for the wheat growers and processers to explore the Black Wheat for its value addition. Black wheat since rich in protein (14.49%), zinc (3.96mg/100g) and iron content (15.23mg/100g) could be exploited for nutrition and flour of this could be used to fortify conventional flours which are low in protein, zinc and iron content.

Key words: wheat, physical characteristics, chemical composition, minerals.

INTRODUCTION

Wheat is a good source of starch, proteins, minerals and dietary fiber majoritily contributing towards daily caloric requirements of wheat consuming population. Wheat belongs to the cereal family Gramineae, subfamily Hordeae, tribe Triticeae, genus *Triticum*. Ordinary wheat variety that is grown all over the world is amber or white in colour. It is important to mention that the regular wheat varieties contain a very small quantity of anthocyanins but the coloured ones are loaded with them. For example, black wheat has 28 times more anthocyanins than the conventional ones. The Zn content of wheat varieties in India on an average is 28.31mg/Kg. The grain Zn content of wheat in different countries since the 1960s ranged from 8.00 to 88.20 mg/kg with an average value of 31.84 mg/kg (Wang *et al.,* (2012) and Oury *et al.,* (2006). Wheat is an important part of the daily diet in developing countries, yet it has a low Zn level. To achieve the human body's Zn requirements, wheat grain Zn concentration must reach 45.00 mg/kg (Liu *et al.,* 2017). Low quantities of grain iron (27 to 55 ppm) and zinc are seen in the Indian bread wheat (aestivum) and pasta wheat (durum wheat) varieties (20-50 ppm). But the black wheat is having high Zn content *i.e.* 34.80mg/Kg (Huang *et al.* (2018). Wheat grains have an average Zn concentration of 28.48 mg/kg, which is lower than the globally recommended quantity.

The average Zn content of wheat cultivars in India is 28.31 mg/kg. Since the 1960s, the Zn content of wheat grain has fluctuated from 8.00 to 88.20 mg/kg, with an average value of 31.84 mg/kg. Many countries add nutrients to food in order to meet human needs. Bio fortification breeding will play an important role in supplying enough nutrients. Wheat is one of the world's major food crops, the nutritional quality of which has received more and more attention.

Black-grained wheat (BGW) is a new wheat variety which has been in development in China during the last 20 years; this black-grained genotype is developed from a previously existing blue and purple line (Sun *et al.,*

1996, 1999). It is rich in protein and antioxidant also contains high quality proteins than normal wheat. NABI Mohali developed colored wheat lines with high anthocyanin, zinc and iron content by the combination of genes for both purple and blue colors through constant breeding programmes to increase consumer demands and enhancement in normal wheat nutritional value with respect to health, nutrition and convenience as like quality protein maize with high lysine and tryptophan content (Prasanna *et al*., 2011), purple colored carrots (Montilla *et al.*, 2011), potatoes, sweet potatoes and maize (Petroni *et al.*, 2014) with high anthocyanin content. The cross between high yielding Indian cultivars and colored wheat procured from Japan and America is as rich in anthocynanins as blueberries and high in zinc has been utilized to develop coloured wheat varieties by NABI scientists.

Black wheat consumption is associated with several health benefits such as protecting endothelial cells, preventing heart and cardiovascular diseases (CVD) and as anticancer agents (Dykes, 2007 and Liu, 2007). Considering these valuable compositions, BGW should receive more attention as an alternative source of nutrients and health-protective components in the human diet.

The black wheat since much healthier with increasing the nutrition quotient of products as compared to white wheat, having potential to tackle under-nutrition problem and meet the target of reducing it by 2% a year in the country it can be a good alternative in National Nutrition Mission (NNM) or 'Poshan Abhiyaan' for improving the nutritional status of young children, adolescent girls and women. It could benefits farmers by fetching higher prices of their output than the production cost (Kumari and Tzudir, 2021).The research work on this newly evolved variety of black wheat which is rich in anthocyanin and phytochemicals is very limited and hence there is an urgent need to carry out the thorough research on top priority along with its processing and value addition. Therefore in present investigation the work was carried out to evaluate and compare the , physico-chemical and nutritional properties of Black wheat in comparison with common wheat.

MATERIALS AND METHODS

Black wheat grains were obtained from local area of Punjab and Netravati wheat variety was obtained from Seed Research Centre VNMKV, Parbhani. Chemicals used in this investigation were of analytical grade and sufficient glassware required was available in the laboratory, Department of Food Engineering, College of Food Technology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani.

A. Methods

Determination of Dimensional Characteristics properties of Black wheat grains. Grain dimensions (L, W and T) was measured by vernier caliper by taking the grains randomly The size of the grain in terms of length (L), width (W) and thickness (T) was calculated by equation given by EL–Raie *et al.*, (1996). The seed volume (V), geometric diameter (Dg), arithmetic diameter (Da), percent of sphericity (S), area of surface (Af), and area of transverse surface (At) of the individual seeds was determined by the formulas given by El Fawal *et al*., (2009) as given below:

$$V = \frac{\pi}{6}LWT, \text{ mm}^3$$

$$S = \frac{(LWT)^{\frac{1}{3}}}{L} \times 100, \%$$

$$D_a = \frac{(L+W+T)}{3}, \text{ mm}$$

$$D_g = (LWT)^{\frac{1}{3}}, \text{ mm}$$

$$A_t = \frac{\pi}{4}TW, \text{ mm}^2$$

Where: L: length of seed, mm, W: width of seed, mm T: thickness of seed, mm

Thousand kernel weight: Thousand kernel weights of wheat was recorded by the method described by P. Ramya *et al.*, (2010); in grams/thousand kernels.

Bulk density: The bulk density, defined as the ratio of the mass sample of the seeds to its total volume, was determined by the method described by Boumans, 1985 and calculated as g/ml.

True density: The true density was determined by measuring the actual volume of a known weight of a random wheat grains, a method described by Matouk *et al.*, (2004).

Porosity: The percent porosity was calculated as per Matouk *et al.*, (2004).

Nutritional analysis. Nutritional analysis i.e. moisture, crude protein, ash, fat and crude fibre contents of Black and Netravati wheat flour was determined according to standard procedure of AOAC (1990).

Mineral analysis using atomic absorption spectrometry (AAS). The mineral contents of Black wheat flour and Netravati wheat flour was evaluated by method described in AOAC (1990) using Atomic Absorption Spectrophotometer .

RESULTS AND DISCUSSION

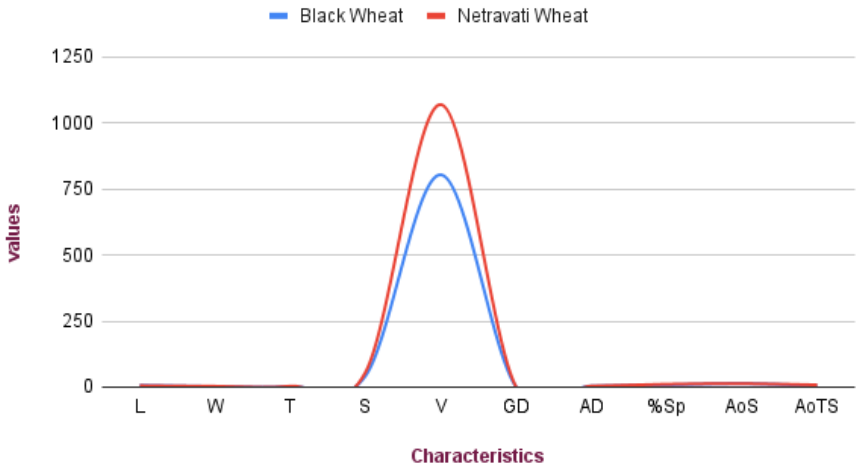
A. Dimensional characteristics of Black wheat

The data presented in Table 1and Fig. 1 revealed that in the dimensional characteristics of wheat under study the length, width and thickness of the Black wheat grains were 6.56mm, 2.51mm and 2.59mm and 5.39mm, 3.06mm and 3.44 for Netravati wheat grains respectively. The results were in agreement with Soliman *et al.* (2009) reported for the length of different wheat grains as 6.60 to 7.20 mm, breadth 3.43 to 3.80 mm and thickness 3.01 to 3.31 mm. The size on the basis of arthmatic calculations of both the wheat showed that the Black wheat grains were less in size (42.65) than Netravati wheat grains (56.74) and this might be due to more values for width and thickness of later.

Table 1: Dimensional characteristics of Black wheat.

Characteristics	Wheat type	
	Black Wheat	Netravati Wheat
Length(mm)	6.56	5.39
Width(mm)	2.51	3.06
Thickness(mm)	2.59	3.44
Size(mm^3)	42.65	56.74
Volume(mm^3)	803.86	1069.47
Geometric diameter(mm)	0.54	0.58
Arithmetic diameter(mm)	3.89	3.96
Percent of Sphericity(%)	8.28	10.85
Area of surface(mm^2)	12.93	12.95
Area of transverse surface(mm^2)	5.11	8.27

* Each value is average of three determinations



Where, L-Length(mm), W-Width(mm), T-Thickness(mm), S-Size(mm^3), V-Volume(mm^3), GD- Geometric diameter(mm), AD-Arithmetic diameter(mm), % Sp-Percent of Sphericity(%), AoS-Area of surface(mm^2), AoTS-Area of transverse surface(mm^2).

Fig. 1. Dimensional characteristics of Black wheat.

The size of the wheat grains was used to calculate volume of seed, arithmetic diameter, geometric diameter and Sphericity of wheat grains. It was found that the volume of wheat seed, geometric diameter, arithmetic diameter and sphericity of Black wheat grains was 803.36mm^3, 0.54mm, 3.89mm and 8.28 percent respectively. All these values were less as compared to Netravati wheat variety might be due to difference in width and thickness with varietal difference. Gürsoy and Güzel (2010) reported that the geometric mean diameter of wheat grains was ranged from 3.71 to 4.14 mm, equivalent sphere diameter 3.72 to 4.17 mm and sphericity 53.3 to 58.7%. Also the flat surface area and the area of transverse surface for Black wheat grains was 12.93 mm^2 and 5.11 mm^2 respectively. The results for flat surface area and transverse surface area were 19.724 mm^2 and 10.039 mm^2 respectively as reported by Fawal *et al.* (2009) for wheat grains.

B. Physical characteristics of Black wheat

The physical properties of seed play an important role to select the proper sorting, separating and cleaning equipment and the main dimensions are considered in selecting and designing the suitable size of the screen perforations. It is revealed from Table 2 that the thousand kernel weight for Black wheat grains was 29.88g which was low as compared to Netravati wheat grains *i.e.* 35.45g. The thousand kernel weight is a useful tool for the assessment of the potential milling yield. Soliman *et al.* (2009) reported thousand kernel weight for different wheat varieties as 41.706, 49.406 and 55.919 g respectively. The kernel size contributes directly towards the improvement of grain yield as well as milling yield.

Table 2: Physical characteristics of Black wheat.

Characteristics	Wheat type	
	Black Wheat	Netravati Wheat
1000 kernel weight (g)	29.88	35.45
Bulk density (g/ml)	0.73	0.83
True Density(g/ml)	1.22	1.27
Porosity(%)	40	35
Angle of repose(°)	15.61	34.99

* Each value is average of three determinations

Khan *et al.* (2009) indicated that the wheat varieties possessing a higher grain weight present a better potential for grinding and flour extraction. That is why the wide variation of grain weight could be used for improvement of this trait for creation of genotypes appropriate for maximum flour outputs. The bulk, true densities and percent porosity of Black wheat kernels were 0.73g/ml, 1.22g/ml and 40percent respectively which were found to be lower as compared to control Netravati wheat variety except percent porosity which was higher in Black wheat as shown in Table 4. This might be due to higher weight of later grains. The values are in close agreement with the values of bulk and true densities 0.791g/ml, 1.103g/ml and 28.28 percent respectively for wheat varieties as reported by Babi *et al.* (2011).

In our investigation though the black wheat variety had lower thousand kernel weight as compared to local standard under study *i.e.* Netravati wheat variety, it is having higher neutraceutical values can be used for value addition for getting more health benefits. As presented the higher values of the physical grain characters for length, degree of sphericity and fractional porosity were observed in black wheat variety comparison with Netravati wheat grains exhibited higher values for grain width, thickness, size, 1000 kernel weight, bulk density, true density and angle of repose included in the study. Kernel shape depends not only on wheat genus or species but also on wheat variety and agro-climatic conditions.

C. Proximate Analysis of Black wheat flour

Nutritional analysis or chemical composition generally represents the nutritional quality of product. The quality of final product is a function of raw materials quality. The present investigation was initiated to study nutritional analysis of raw materials and the data is summarized in Table 3.

Table 3: Proximate Analysis of Black wheat flour.

Characteristics	Flour Type	
	Black Wheat	**Netravati Wheat**
Moisture (%)	9.61	12.91
Protein (%)	14.49	11.86
Fat (%)	1.42	1.79
Carbohydrate (%)	67.23	67.01
Total Ash (%)	2.13	1.28
Dietary Fiber (%)	5.11	4.16
Energy Value (kcal/100g)	339.66	331.59

* Each value is average of three determinations

The protein content in the Black wheat flour was 14.49 percent which was significantly higher than Netravati wheat flour having 11.86 percent protein content. Fat content was more in Netravati wheat flour (1.79) as compared to Black wheat flour (1.42) on the other hand carbohydrates, total ash and dietary fiber content were higher in Black wheat flour (67.23, 2.13 and 5.11 percent) than Netravati wheat flour (67.0, 1.28 and 4.16 percent) respectively. Energy values ranged from 339.66 to 331.59 kcal/100 g for Black and Netravti wheat flour respectively. Considerable highest protein content in the Black wheat flour revealed that it can be used for varied wheat-based products.

Previous studies have reported carbohydrate 76.2%, protein 11%, dietary fibre 13% by Sharma *et al.* (2018) for Black donor wheat and protein 12.9 ± 0.106%, total dietary fibre 1.15 ± 0.057%, fat 1.7 ± 0.166% by Tian *et al.* (2018) for ZP Black 1 wheat. The chemical composition is dependent on the genetic makeup of the cultivars, climatic variations, irrigation practices, milling, soil fertility, and agricultural practices, which might explain the difference among various studies.

D. Mineral Analysis of Black wheat flour

Mineral content of Black wheat flour is essential in justifying its food value. Iron, zinc phosphorous, copper, potassium, selenium, magnesium and manganese are the minerals of interest in current study. Minerals play a key role in various physiological functions of the body especially in the building and regulation processes. The data pertaining to mineral composition of Black wheat flour in comparison with Netravati wheat flour is presented in Table 4.

The data presented in Table 4 and Fig. 2 revealed that Black wheat flour contained higher concentrations of all the minerals Zinc, copper, iron, manganese, Selenium, magnesium, potassium, and phosphorus as (3.96, 4.03, 15.23, 3.74, 0.082, 250, 417.5 and 470mg/100g) respectively. Zinc (Zn) and selenium (Se), two micronutrients, are essential for human growth, development, and immune system maintenance. The Recommended Dietary Allowance (RDA) for Zn and Se nutrients are 15 mg and 0.07 mg/day for both adults and children respectively (Lu *et al.*, 2008). It can be seen from mineral analysis of Black wheat flour that since the Black wheat flour is rich in zinc (3.96mg/100g) and selenium (0.082mg/100g) as compared to normal wheat Netravati, it could be used for fortifications in different flours. The Black wheat flour had almost all the minerals in higher concentration as compare to Netravati wheat flour. Specifically the content of iron and zinc had higher concentration values than normal wheat flour.

The Black wheat flour contained 0.082mg/100g of selenium which was higher as compared to Netravati wheat variety in the study (0.057mg/100g). Li *et al.* (2006) has stated presence of 1.04 mg/kg Se in BW in comparison to 0.26 mg/kg in conventional wheat. Sharma *et al.* (2018) stated that colored wheats are rich in zinc and iron minerals than white wheat and offer advantage of double-fortification. The results are in close agreement to Huang *et al.* (2018) and Kumari and Tzudir (2021).

Table 4: Mineral composition of Black wheat flour (mg/100g).

Minerals(mg/100g)	Flour Type	
	Black Wheat	Netravati Wheat
Zinc	3.96	3.93
Copper	4.03	2.39
Iron	15.23	11.49
Manganese	3.74	2.98
Selenium	0.082	0.057
Magnesium	250	186
Potassium	417.5	464
Phosphorous	470	397

*Each value is average of three determinations

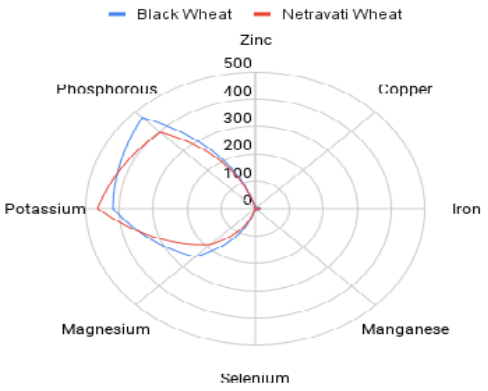


Fig. 2. Mineral composition of Black wheat flour (mg/100g).

CONCLUSION

The physical properties of raw materials provide information on both their technological suitability and optimum treatment in the production process. From this investigation it can be concluded that the Black wheat grain flour with protein 14.49%, carbohydrate 67.23% and dietary fiber 5.11% with theoretical energy value (339.66kcal/100g) and higher concentrations of all the minerals Zinc, copper, iron, manganese, Selenium, magnesium, potassium, and phosphorus as (3.96, 4.03, 15.23, 3.74, 0.082, 250, 417.5 and 470mg/100g) was proved to be more superior in all respects as compared to experimental control Netravati wheat. Zinc deficiency is a worldwide problem and Black wheat variety with rich in Zn is a new approach in food processing. Black wheat is much healthier as it increases the nutrition quotient of products when compared to white wheat that open a new avenues for the wheat growers and processers to explore the Black Wheat for its value addition. Black wheat since rich in protein (14.49%),zinc(3.96mg/100g) and iron content (15.23mg/100g) could be exploited for nutrition and flour of this could be used to fortify conventional flours which are low in protein, zinc and iron content. More research should be targeted towards health outcomes of Black wheat and its phytochemicals in food products are the next logical steps in this research field.

Conflict of Interest. The authors declare no conflict of interest.

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