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## Rashmi

M.Sc. Scholar, Department of Food Science and Nutrition, College of Community and Applied Sciences, MPUAT, Udaipur, Rajasthan, India

## Dr. Renu Mogra

Professor, Department of Food Science and Nutrition, College of Community and Applied Sciences, MPUAT, Udaipur, Rajasthan, India

## Kanoj

M.Sc. Scholar, Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur Rajasthan, India

## Corresponding Author:

### Rashmi

M.Sc. Scholar, Department of Food Science and Nutrition, College of Community and Applied Sciences, MPUAT, Udaipur, Rajasthan, India

## Physical properties and nutritional composition of black wheat for development of value-added products

Rashmi, Dr. Renu Mogra and Kanoj

### Abstract

Black wheat packs a powerful nutritional punch, as it is high in anthocyanins, protein, dietary fibre, and micronutrients. Black wheat contains a high concentration of anti-oxidants, which are useful in the treatment of diabetes, coronary artery disease, type 2 diabetes, autoimmune diseases, hypertension, obesity, inflammation, vision health and cancer. Because of its numerous health benefits, black wheat is becoming increasingly favoured among health-conscious people. Except for grain colour and nutrient composition, it is morphologically similar to white wheat. In this study, black wheat grain and their flour were analysed for their physical properties and nutritional composition respectively. Black wheat has a thousand kernel weight, thousand kernel volume, bulk density, swelling capacity, swelling index, hydration capacity, and hydration index of  $35.02 \pm 0.16$  g,  $40 \pm 0.01$  ml,  $0.83 \pm 0.02$  g/ml,  $0.17 \pm 0.00$  ml,  $0.43 \pm 0.00$  ml,  $1.95 \pm 0.03$  ml, and  $5.56 \pm 0.05$  ml, respectively. It was found that black wheat flour contains higher amount of crude protein, crude fibre, calcium and iron content. Our findings suggest that black wheat may be a better alternative to regular wheat because it contains more health-promoting nutrients.

**Keywords:** Black wheat, anthocyanin, pigment, health benefits, nutrients

### 1. Introduction

Wheat (*Triticum aestivum* L.) is the most important and widely farmed food crop in the world. It is the oldest known staple food crop and is known as the "King of Cereals" due to its high yield and broad adaptability (Kanoj *et al.* 2022) [8]. This crop is critical for the country's economic growth, as well as for ensuring food security. Wheat is consumed by 33.3 percent of the world's population, and India is well-known for its wheat production and distribution (Hemalatha *et al.* 2013) [6].

It contains nutrients (70%), protein (10-12%), fat (2.0%), minerals (1.8%), crude fibres (2.2%), and vitamins such as thiamine, riboflavin, and niacin, as well as trace amounts of vitamin A, but the majority of these nutrient content are removed during the milling operation along with the wheat germ and bran (Britannica, 2021). Aside from being healthy, its protein is notable for a specific component known as "gluten," which bakers require. Because of its superior processing quality, it is used in bread, cookies, pasta, pizza, and other conventional and processed foods all over the globe (Li *et al.* 2006; Li & Beta, 2011) [13, 12].

In recent years, consumer preferences have shifted, and they now prefer a well-balanced food profile to an energy-dense diet that provides metabolic, physiological, and functional health benefits. A growing portion of the worldwide people is struggling to cope from a variety of diseases and health issues as a result of insufficient protein, vitamins, critical macro and micronutrients, including iron and zinc, in their daily diets (Balyan *et al.* 2013) [3].

Seeing as wheat is a staple food crop in many parts of the world, it is thought that developing anthocyanin-bio fortified wheat will influence human lifestyles (Sharma *et al.* 2021) [18]. After years of research, the National Argo-Food Biotechnology Institute of Mohali, Punjab, developed black wheat in 2017 (Kumari & Tzudir, 2021) [11]. It was approved for human consumption by the Food Safety and Standards Authority of India (FSSAI) in June 2018 under F.No.04/Std/PA/FSSAI/2018 (Kumari & Tzudir, 2021) [11].

Black wheat is a coloured wheat that was developed by crossing purple and blue wheat. The outer layer of anthocyanin is responsible for the black colour of wheat grain. It contains a variety of nutritional and bioactive compounds such as phenolic compounds, anthocyanins, carotenoids, phytic acid, essential amino acids, dietary fibres, vitamins, and minerals such as phosphorus, potassium, calcium, magnesium, manganese, selenium and copper (Garg *et al.* 2016) [5]. Black wheat also contains higher amount of iron and zinc than white wheat, indicating double bio-fortification.

Advanced coloured wheat with high anthocyanin, iron, and zinc contents demonstrated antioxidant and anti-inflammatory activity, as well as desirable properties for product development and commercialization (Sharma *et al.* 2018) [16]. Anthocyanins are water-soluble flavonoids and ranges in common wheat from 5 to 15 ppm to 40 to 140 ppm in black wheat, which also has 60% more iron and 35% more zinc than common wheat. It is estimated that 100 g of black wheat contains around 71 g carbohydrates, 13 g protein, 10 g fibre, and 3.40 g fat (Kumari & Tzudir, 2021) [11].

Black wheat has also been shown to help with the management and cure of a number of chronic diseases, including cancer, cardiovascular disease, diabetes, obesity, stress management, inflammation, hypertension and ageing (Garg *et al.* 2016) [5].

Because of its health-promoting and disease-prevention properties. Black wheat is gaining popularity among researchers and food industry (Saini *et al.* 2021) [17].

## 2. Materials and Methods

### 2.1 Procurement and preparation of black wheat flour

Black wheat was procured in a single lot from the local market of the Udaipur city. The grains sample of black wheat were cleaned properly to remove any dirt, dust, insect or other food grain concrete mixture. The clean graded materials were ground into flour in an electric grinder and sieved through sieve. Before use, the flour samples were stored in an airtight container.

### 2.2 Physical Properties of black Wheat

The thousand kernel weight and thousand kernel volumes of black wheat was determined by using the method described by Williams *et al.* (1983) [20]. One hundred kernels for each sample were manually counted and weighted in an electronic balance. The weight was multiplied by ten and indicated as thousand kernel weight in grams. Then these kernels transferred to a 50 ml measuring cylinder, and 25 ml of distilled water was added to it. The cylinder was gently stirred to ensure that no air bubbles were trapped inside, and the seeds volume was calculated as total volume minus 25 ml and indicated in ml.

Method suggested by Okaka and Potter's (1977) [21] was used to calculate bulk density. Fifty grams of black wheat seeds were filled into a 100 ml graduated cylinder by gently tapping it on a bench top 20-30 times. The bulk density was determined as weight of seeds (g)/final volume of seeds (ml). Also swelling capacity, swelling index, hydration capacity and hydration index was determined by using the method given by Bishnoi and Khetrpal (1993) [22].

### 2.3 Nutritional composition of black wheat flour

Proximate analysis was conducted on the black wheat flours according to Association of Official Analytical Chemists (AOAC 2000) [2] standard methods. Flour was analysed for moisture content using (NIN 2003) [15]. In a dried and weighed petri dish, a ten-gram sample was weighed. The sample and petri dish were weighed at regular intervals until a constant weight was obtained.

Crude fat analysis was conducted based on Soxhlet Extraction Method (AOAC 2000) [2]. Ash content analysis was carried out based on dry ashing method by burn up samples in a muffle furnace at 550 °C to white ash (AOAC 2000) [2]. Crude protein analysis was determined based on Micro-Kjeldahl

Method (AOAC 2000) [2].

Carbohydrate content was calculated from moisture, crude fat, ash, and crude protein contents as follows: % Carbohydrate = 100% – (Moisture + Crude fat + Ash + Crude protein) % The energy content was calculated using physiological fuel values of 4 Kcal per gram for protein, 9 Kcal per gram for fat and 4 Kcal per gram for carbohydrate content as follow: Energy (Kcal/100 g) = (% protein × 4) + (% carbohydrates × 4) + (% fat × 9) for mineral estimation, the samples were wet acid digested, using a nitric acid and perchloric acid mixture (HNO<sub>3</sub>:HClO<sub>4</sub>, 5:1 w/v). The total amounts of iron, calcium, and phosphorous in the digested samples were determined by Atomic Absorption Spectrophotometry (Lindsey and Norwell, 1969) [14].

## 3. Results and discussion

### 3.1 Physical properties of black wheat

The data on physico-chemical properties of black wheat are presented in Table 1. The average thousand kernel weight and volume of black wheat grain were found to be 35.02±0.16 g and 40±0.01 ml, respectively. According to (Kumari *et al.* 2020) [10], the thousand kernel weight of black wheat is 43.55±0.60 g that is on higher side than our results. The result of thousand kernel weight was lower than in previous studies because it can be influenced by a variety of factors such as climatic factors, geographical location, grain variety, and so on (Agrifacts, 2007) [1]. The bulk density of black wheat was determined to be 0.83±0.02 g/ml. Excess moisture content and insect attack frequently affect grain bulk density (FAO, 2012) [4], which is important in determining quality standards, material handling, and applications in various food sector (Karuna *et al.* 1996) [9].

Swelling capacity is referred to as the amount of water a molecule holds in response to its volume of growth, which it retains until a colloidal suspension is obtained and uptake is prevented by intermolecular interactions in the swollen particle (Houssou and Ayernor, 2002) [7]. The swelling capacity and swelling index of black wheat were found to be 0.17±0.00 ml and 0.43±0.00 ml, respectively.

According to the hydration capacity and hydration index results, black wheat has a hydration capacity of (1.95±0.03 g) and a hydration index of (5.56±0.05 g).

**Table 1:** Physical properties of black wheat

S. No	Physical property	Mean ± SD
1.	Thousand kernel weight (g)	35.02±0.16
2.	Thousand kernel volume (ml)	40±0.01
3.	Bulk density (g/ml)	0.83±0.02
4.	Swelling capacity (ml)	0.17±0.00
5.	Swelling index (ml)	0.43±0.00
6	Hydration capacity (g)	1.95±0.03
7.	Hydration index (g)	5.56±0.05

All the values are (Mean ± SD) of three observations

### 3.2 Nutritional composition of black wheat flour

Proximate composition: The table 2. Is furnished with the results of proximate composition of black wheat flour. The mean moisture content of black wheat flour was noted to be 6.20±0.35 g per 100 g. One other study (Tian *et al.* 2018) [19] reported that the mean moisture content for black wheat flour was 12.6±0.043, which is significantly higher than the current study. The current study found a mean value of crude protein (11.74±0.44 per 100 g). Whereas (Tian *et al.* 2018) [19]

reported the protein content to be  $12.9 \pm 0.10$ . The variability in reported moisture and protein content could be due to differing soil compositions of cultivation locations, various climatic factors, various stages of seed maturation, and different climate conditions.

The mean ash content of black wheat flour was found  $1.61 \pm 0.60$  g/100 g while Kumari *et al.* 2020<sup>[10]</sup> reported the mean ash content of black wheat flour was  $1.83 \pm 0.29$  g/100 g. The amount of ash in a food material indicates the number of mineral contents.

The mean fat content and crude fiber content of black wheat flour in the present study was  $1.88 \pm 0.51$  g per 100 grams and  $9.86 \pm 0.42$  g/100 grams respectively. According to the study of (Tian *et al.* 2018)<sup>[19]</sup> fat content of black wheat flour as  $1.7 \pm 0.166$  g per 100 grams and fiber content comparatively on the higher side as compared to green wheat flour ( $1.11 \pm 0.042$  g/100 g), blue wheat flour ( $1.01 \pm 0.113$  g/100 g).

The carbohydrate and energy content of black wheat flour was found to be  $69.53 \pm 0.29$  g per 100 g and  $42.64 \pm 4.07$  Kcal per 100 g respectively.

**Table 2:** Proximate composition of black wheat flour (per 100 g on dry weight basis)

S. No	Nutrients	Mean $\pm$ SD
1	Moisture (g)	$6.20 \pm 0.35$
2	Crude protein (g)	$11.74 \pm 0.44$
3	Fat (g)	$1.88 \pm 0.51$
4	Ash (g)	$1.61 \pm 0.60$
5	Crude fiber (g)	$9.86 \pm 0.42$
6	Carbohydrates (g)	$69.53 \pm 0.29$
7	Energy (kcal)	$342.64 \pm 4.07$

All the values are (Mean  $\pm$  SD) of three observations

The calcium, iron, and phosphorus content of black wheat flour is shown in Table 3. Clearly that the calcium content of black wheat flour was found as ( $46.66 \pm 1.15$  mg/100g). Whereas Tian *et al.* (2018)<sup>[19]</sup> and Saini *et al.* (2021)<sup>[17]</sup> reported a higher calcium content ( $184 \pm 1.414$  mg per 100g). The iron content of black wheat flour was  $41.85 \pm 0.13$  mg per 100 g, while Saini *et al.* (2021)<sup>[17]</sup> reported iron content in black wheat ranging from 39 to 79.3 mg/100 g respectively. Variation in iron content may be due to different wheat variety and growing conditions. Phosphorus content of black wheat flour was determined to be  $322.19 \pm 0.02$  mg per 100 grams.

**Table 3:** Mineral content of black wheat flour (mg per 100 g on dry weight basis)

S. No.	Nutrients	Mean $\pm$ SD
1.	Iron	$41.85 \pm 0.13$
2.	Calcium	$46.66 \pm 1.15$
3.	Phosphorus	$322.19 \pm 0.02$

All the values are (Mean  $\pm$  SD) of three observations

#### 4. Conclusion

Wheat and wheat products are main staple foods consumed around the world. According to this study, black wheat is an excellent source of fibres, proteins, iron, calcium, zinc and have a higher antioxidant potential. As a result, including black wheat in your diet is recommended for health reasons. Regardless, black wheat possessed all of the characteristics required for commercial research and development, thereby paving the way for their industrial uses.

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