www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(8): 1615-1621

www.thepharmajournal.com
Received: 07-06-2021
Accepted: 09-07-2021

Ankita Dobhal
Ph.D. Scholar, Department of Foods and Nutrition, College of Home Science, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar, Uttarakhand, India

Pratima Awasthi
Professor, Department of Foods and Nutrition, College of Home Science, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar, Uttarakhand, India

Corresponding Author:
Ankita Dobhal
Ph.D. Scholar, Department of Foods and Nutrition, College of Home Science, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar, Uttarakhand, India

Comparison of nutritional profile of barley flour and refined wheat flour

Ankita Dobhal and Pratima Awasthi

Abstract
The present study was conducted to investigate the nutritional composition of barley flour and refined wheat flour. Both the flours were analyzed for their proximate composition, mineral content (calcium, iron and phosphorus) and other nutritional parameters such as dietary fibre, total starch, resistant starch, gluten content, *in-vitro* protein digestibility and total antioxidant activity. Results of proximate composition revealed that crude protein, crude fat, crude fibre and total ash content of barley flour were significantly higher than refined wheat flour, whereas, barley flour had significantly lower moisture and carbohydrate content as compared to refined wheat flour. Minerals *viz*., calcium, iron and phosphorus were found to be significantly higher in barley flour as compared to refined wheat flour. Total starch content, gluten content and *in-vitro* protein digestibility of barley flour was significantly lower than refined wheat flour. However, in terms of nutritional parameters like dietary fibre, resistant starch and total antioxidant activity, barley flour had significantly higher values than refined wheat flour. Overall, barley flour had higher nutritive value as compared to refined wheat flour.

Keywords: barley flour, refined wheat flour, proximate composition, mineral content, other nutritional parameters

1. Introduction

Cereals are the major sources of dietary carbohydrates for human nutrition. They contain 60 to 70 per cent starch and are therefore considered excellent energy rich food. Globally, in about 75 per cent of the countries, cereals and millets are the staple foods (Khader, 2001) [1]. The most important species of cereals grown worldwide are wheat, rice, maize, barley, and sorghum. Other species like millets, rye and oats are of minor or regional importance (Afify *et al*., 2016) [2].

Flour is generally a powdered substance, made by grinding raw grains and is used to make different foods. For most of the processed food products, refined flours are preferred over whole grain flours because of their bland taste and ease of processing (Brennan *et al*., 2013) [3]. However, during refining, most nutritious fractions of the grain i.e. bran and germ are removed. As a result, refined flours are mostly composed of carbohydrates. Milling operations generally remove most of the indigestible fibre from the grains (Potter and Hotchkiss, 1996) [4].

Wheat (*Triticum aestivum* L.) is one of the oldest and most important staple food crops in the world (Tama's *et al*., 2009) [5]. According to FAO (2012) [6], the estimated global wheat production in the year 2011-2012 was 699.4 million metric tons. Wheat is rich in carbohydrates. It also contains protein, fat, fibre, vitamins and minerals. However, refined wheat flour is deficient in many nutrients along with essential amino acid lysine (Mishra and Chandra, 2012) [7].

In some areas, local grains are preferred in terms of taste, nutrition needs of local people as well as sustainability. One such crop is barley, which has evolved through domestication to today as a major world crop and ranks fourth based on acreage and production. It is an excellent source of both soluble and insoluble fibre. Barley grain provides comparatively well-balanced protein to fulfill amino acid requirements. Many scientific evidences suggest that adding barley to the diet can help lower serum cholesterol. Barley is not commonly used as a major ingredient in food commodities. However, partial substitution of whole wheat flour, refined wheat flour or other cereal flours with barley flour may result in development of several functional food products (Izydorczyk *et al*., 2001) [8].

Hence, the present study was undertaken to compare the nutritional characteristics of barley flour and refined wheat flour in details so that barley flour can be used as a substitute over refined wheat flour for developing various functional food products.

Materials and Methods

Procurement of raw materials

Barley flour was purchased from main market, Rudrapur, Uttarakhand, whereas, refined wheat flour was purchased from local market of Pantnagar, Uttarakhand. Analytical grade chemicals were purchased from allied chemicals, Pantnagar, Uttarakhand.

Proximate composition

Proximate composition *viz*. moisture, crude protein, crude fat, crude fibre and total ash content of barley flour and refined wheat flour were determined by standard procedures given by AOAC (1995) [9]. Carbohydrate content was calculated by difference and energy value was calculated using the method given by Mudambi and Rao (1989) [10]. All readings were taken in triplicate.

Estimation of minerals

Calcium

Titration method given by AOAC (1995) [9] was used to determine the calcium content in flour samples.

Iron

Iron was estimated colorimetrically by Wong's method as quoted by Ranganna (1986) [11] using the principle that ferric ion gives blood red color with potassium thiocyanate.

Phosphorus

Phosphorus estimation in the flour samples was done with the method of Fiske and Subbarow (1925) [12] described by Ranganna (1986) [11].

Other nutritional parameters

Dietary fibre

It was determined by the method given by Asp and Johansson (1981) [13].

Total starch

Total starch was estimated colorimetrically by anthrone reagent method as quoted by Ranganna (1986) [11].

Resistant starch

Resistant starch was determined by using the glucose oxidase assay given by McCleary *et al.* (2002) [14] with slight modification.

Gluten content

Gluten content was determined using AOAC (2000) [15] procedure.

In-vitro protein digestibility

Estimation of *in-vitro* protein digestibility of the samples was done by the method given by Akeson and Stahman (1964) [16] and protein extraction as per the method of De Groot and Slump (1969) [17].

Total antioxidant activity

Total antioxidant activity was determined by the 1, 1-diphenyl-2-picryl-hydrazyl (DPPH) method of Brand-Williams *et al*. (1995) [18].

Statistical analysis

The experiments were performed in triplicate and the data obtained was subjected to statistical analysis. The results are presented as the mean value of the individual measurements with the corresponding standard deviation (SD), using Microsoft Excel. One way ANOVA was applied in the data using WASP- Web *Agri Stat* Package 2.0, to find out significant difference between the nutritional composition of barley flour and refined wheat flour.

Results and Discussion

1. Proximate composition

Proximate composition of barley flour and refined wheat flour has been presented in Table 1.

Table 1: Proximate composition of barley flour and refined wheat flour

Nutrient	Barley flour	Refined wheat flour	CV	S.Em.±	CD at 5%
Moisture (%)	11.64 ± 0.04^a	12.49 ± 0.03^b	0.29	0.04	0.08
Crude protein (%)	12.85 ± 0.03^a	11.27 ± 0.04^b	0.28	0.03	0.08
Crude fat (%)	2.31 ± 0.03^a	1.51 ± 0.03^b	1.48	0.03	0.06
Crude fibre (%)	7.05 ± 0.04^a	0.45 ± 0.02^b	0.84	0.03	0.07
Total ash (%)	2.57 ± 0.02^a	0.69 ± 0.02^b	1.23	0.02	0.05
Carbohydrate (%)	63.18 ± 0.05^a	73.59 ± 0.10^b	0.11	0.08	0.18
Physiological energy (Kcal/100g)	324.91 ± 0.13^a	353.03 ± 0.07^b	0.03	0.10	0.23

Results are expressed as mean ± S.D, n=3
Different alphabets in superscript in each row show significant difference between values
CV- coefficient of variation, S.Em- standard error of mean, CD-critical difference

Moisture

Moisture content depicts the water content of a food sample. Moisture analysis is a prerequisite to determine other food constituents. In the present study, moisture content in barley flour was found to be 11.64 per cent, whereas, the moisture content found in refined wheat flour was 12.49 per cent. Abadi and Naser (2019) [19] reported 12.60 per cent and 12.05 per cent moisture content in experimental barley flour variety IPA 265 and IPA 99 respectively. Beigh *et al*. (2019) [20] quoted 11.50 per cent moisture content in barley flour, whereas, O'Shea *et al*. (2016) [21] quoted 11.90 per cent moisture content in wholegrain barley flour. According to El-Taib *et al*. (2018) [22], moisture content in wheat flour was 12.40 per cent. Aleem Zaker *et al*. (2012) [23] reported 13.20 per cent moisture content in refined wheat flour, whereas, Islam *et al*. (2012) [24] reported 12.98 per cent moisture content in refined wheat flour. Shelf life of the food sample depends upon the moisture content. Higher moisture content indicates lower shelf life of a product.

Crude protein

Crude protein is a measure of the protein content of a food. In the present study, significant difference was found in the values of crude protein present in barley flour and refined

wheat flour. Crude protein content of barley flour and refined wheat flour was found to be 12.85 per cent and 11.27 per cent respectively. Del Carmen Robles-Ramírez *et al.* (2020) [25] reported protein content of 12.40 per cent in barley flour and 11.33 per cent in wheat flour. Arshid *et al*. (2018) [26] mentioned 13.63 per cent and 11.54 per cent protein content in barley flour and wheat flour respectively. Deng *et al.* (2020) [27] reported 12.17 per cent protein content in ordinary barley flour, whereas, Panizo-Casado *et al.* (2020) [28] reported the protein concentrations for the barley landraces in between 10.80 per cent to 14.00 per cent on dry-weight basis.
Marpalle *et al*. (2014) [29] reported 10.37 per cent protein content in refined wheat flour, whereas, Doblado-Maldonado *et al*. (2012) [30] reported 11.70 per cent protein content in all-purpose wheat flour. Aleem Zaker *et al*. (2012) [23] reported 11.87 per cent crude protein content in refined wheat flour.

Crude fat

Crude fat also called ether extract or free lipid content is a measure of fat content present in food products. Crude fat content in barley flour was found to be 2.31 per cent, whereas, crude fat content found in refined wheat flour was 1.51 per cent. Abadi and Naser (2019) [19] reported 2.80 per cent and 1.50 per cent crude fat content in experimental barley flour variety IPA 265 and IPA 99 respectively. According to El-Taib *et al*. (2018) [22], lipid content in barley flour and wheat flour was 2.77 per cent and 1.21 per cent respectively. Ali (2015) [31] reported 2.68 per cent crude fat in barley flour, whereas, Beigh *et al*. (2019) [20] reported 2.25 per cent crude fat in barley flour.
Marpalle *et al*. (2014) [29] reported 2.33 per cent fat content in refined wheat flour, whereas, Islam *et al*. (2012) [24] reported 1.80 per cent fat content in refined wheat flour. Dhillon and Tanwar (2018) [32] mentioned 1.15 per cent fat content in refined wheat flour. Aleem Zaker *et al*. (2012) [23] reported 1.38 per cent crude fat content in refined wheat flour.

Crude fibre

Crude fibre is a measure of *fibre* content in food. It is the insoluble residue obtained through acid hydrolysis followed by alkaline hydrolysis of food. It is a measure of the amount of indigestible cellulose, lignin, pentosans, etc. present in foods. Results of the present study revealed crude fibre content of 7.05 per cent in barley flour, which was significantly higher than the crude fibre content of refined wheat flour i.e. 0.45 per cent. Abadi and Naser (2019) [19] reported 5.90 per cent and 6.15 per cent crude fibre content in experimental barley flour variety IPA 265 and IPA 99 respectively. According to El-Taib *et al.* (2018) [22], crude fibre content in barley flour and wheat flour was 4.53 per cent and 0.59 per cent respectively, whereas, Din *et al.* (2009) [33] mentioned 6.75 per cent crude fibre in barley flour. According to Panizo-Casado *et al*. (2020) [28], the mean concentrations of crude fibre in 42 barley landraces varied considerably from 4.20 per cent to 8.10 per cent on dry weight basis.
Dhillon and Tanwar (2018) [32] mentioned 0 per cent fibre content in refined wheat flour, whereas, Islam *et al*. (2012) [24] mentioned 0.85 per cent fibre content in refined wheat flour. Ullah *et al*. (2016) [34] quoted 0.71 per cent crude fibre content in refined wheat flour, whereas, Desai *et al*. (2010) [35] quoted 0.36 per cent crude fibre content in wheat flour.

Total ash

Total ash represents the mineral content of a sample. Total ash content in barley flour was found to be 2.57 per cent which was significantly higher than the total ash content of refined wheat flour i.e. 0.69 per cent, which clearly signifies that barley flour is rich in minerals as compared to white flour or refined wheat flour which is deficient in many essential minerals. del Carmen Robles-Ramírez *et al.* (2020) [25] reported slightly lower values for total ash content in barley flour and refined wheat flour which were 2.51 per cent and 0.50 per cent respectively. Arshid *et al*. (2018) [26] mentioned 3.05 per cent ash content in barley flour. According to El-Taib *et al*. (2018) [22], ash content in barley flour and wheat flour was 2.44 per cent and 0.49 per cent respectively, whereas, Beigh *et al*. (2019) [20] quoted 2.32 per cent total ash content in barley flour.
Sanz-Penella *et al*. (2013) [36] reported 0.53 per cent ash content in wheat flour, whereas, Marpalle *et al*. (2014) [29] reported 0.67 per cent ash content in refined wheat flour. Dhillon and Tanwar (2018) [32] mentioned 0.60 per cent ash content in refined wheat flour, whereas, Aleem Zaker *et al*. (2012) [23] mentioned 0.53 per cent total ash content in refined wheat flour.

Carbohydrate

Carbohydrates are sugar molecules and are one of the three major nutrients present in foods along with proteins and fats. In the present study, carbohydrate content of 63.18 per cent was found in barley flour and 73.59 per cent in refined wheat flour. Abadi and Naser (2019) [19] reported 66.50 per cent and 69.40 per cent carbohydrate content in experimental barley flour variety IPA 265 and IPA 99 respectively. Beigh *et al*. (2019) [20] quoted 67.40 per cent carbohydrate content in barley flour, whereas, Abeshu and Abrha (2017) [37] quoted carbohydrate content in Ardu-12-60B barley variety to be 58.45 per cent.
Dhillon and Tanwar (2018) [32] reported 77.59 per cent carbohydrate content in refined wheat flour, whereas, Islam *et al*. (2012) [24] reported 71.23 per cent carbohydrate content in refined wheat flour. Rani and Singh (2018) [38] quoted 74.21 per cent carbohydrate content in refined wheat flour.

Physiological energy

On the basis of proximate composition, the calculated physiological energy value of barley flour was 324.91 Kcal/100g and of refined wheat flour was 353.03 Kcal/100g. Beigh *et al*. (2019) [20] reported the calorific value of barley flour to be 371.92 Kcal/100g. Abeshu and Abrha (2017) [37] mentioned physiological energy value of Belemi barley variety to be 324.30 Kcal/100g, which was almost similar to the energy value reported in present study and 320.11 Kcal/100g in Diribie barley variety. Rani and Singh (2018) [38] quoted 358.65 Kcal/100g energy value in refined wheat flour, whereas, Ahmed and Ashraf (2019) [39] quoted 360.93 Kcal/100g calorific value in wheat flour.

2. Mineral composition

The results of mineral content in barley flour and refined wheat flour have been presented in Table 2.

Table 2: Mineral composition of barley flour and refined wheat flour

Mineral	Barley flour	Refined wheat flour	CV	S.Em.±	CD at 5%
Calcium (mg/100g)	43.15 ± 0.13^a	21.87 ± 0.08^b	0.34	0.11	0.25

Iron (mg/100g)	6.29 ± 0.03[a]	2.11 ± 0.04[b]	0.79	0.03	0.08
Phosphorus (mg/100g)	362.27 ± 0.15[a]	77.22 ± 0.11[b]	0.06	0.13	0.29

Results are expressed as mean ± S.D, n=3
Different alphabets in superscript in each row show significant difference between values
CV- coefficient of variation, S.Em- standard error of mean, CD-critical difference

Calcium
In the present study, calcium content in barley flour was observed as 43.15 mg/100g which was significantly higher than calcium content in refined wheat flour i.e. 21.87 mg/100g. El-Taib *et al.* (2018) [22] reported calcium content in barley flour to be 36.60 mg/100g. According to Panizo-Casado *et al.* (2020) [28], the mean concentrations of calcium in 42 barley landraces varied considerably from 36.30 mg/100g to 53.80 mg/100g. Platel *et al.* (2010) [40] mentioned 38.91 mg/100g calcium content in unmalted barley.
Sanz-Penella *et al.* (2013) [36] reported 22 mg/100g calcium content in wheat flour, which was quite similar to the result found in present study. Doblado-Maldonado *et al.* (2012) [30] reported 17 mg/100g calcium content in all-purpose wheat flour, whereas, Oghbaei and Prakash (2013) [41] quoted 30.24 mg/ 100g calcium content in refined wheat flour.

Iron
Iron content in barley flour was found to be 6.29 mg/100g which was significantly higher than iron content found in refined wheat flour i.e. 2.11 mg/100g. El-Taib *et al.* (2018) [22] reported iron content in barley flour to be 4.27 mg/100g. According to Panizo-Casado *et al.* (2020) [28], the mean concentrations of iron in 42 barley landraces varied considerably from 3.37 mg/100g to 6.83 mg/100g. Sanz-Penella *et al.* (2013) [36] reported 1.27 mg/100g iron content in wheat flour, whereas, Doblado-Maldonado *et al.* (2012) [30] reported higher values of iron in all-purpose wheat flour i.e. 5.27 mg/100g. Oghbaei and Prakash (2013) [41] quoted 2.87 per cent iron content in refined wheat flour.

Phosphorus
In the present study, phosphorus was found in abundance in barley flour i.e. 362.27 mg/100g. Whereas, phosphorus content in refined wheat flour was found to be 77.22 mg/100g, which was significantly lower than phosphorus content in barley flour. El-Taib *et al.* (2018) [22] reported phosphorus content in barley flour to be 360 mg/100g. According to Panizo-Casado *et al.* (2020) [28], the mean concentrations of phosphorus in 42 barley landraces varied considerably from 182.90 mg/100g to 517.90 mg/100g. Farooqui *et al.* (2018) [42] mentioned 320 mg/100g phosphorus content in non-germinated barley flour. Sanz-Penella *et al.* (2013) [36] reported 111 mg/100g phosphorus content in wheat flour, whereas, Doblado-Maldonado *et al.* (2012) [30] reported higher values of phosphorus in all-purpose wheat flour i.e. 123 mg/100g.

3. Other nutritional parameters
The results of other nutritional parameters in barley flour and refined wheat flour have been presented in Table 3.

Table 3: Other nutritional parameters of barley flour and refined wheat flour

Nutritional parameter	Barley flour	Refined wheat flour	CV	S.Em.±	CD at 5%
Total dietary fibre (%)	17.56 ± 0.04[a]	3.21 ± 0.04[b]	0.37	0.04	0.09
Insoluble dietary fibre (%)	13.05 ± 0.04[a]	2.08 ± 0.03[b]	0.44	0.03	0.08
Soluble dietary fibre (%)	4.51 ± 0.03[a]	1.13 ± 0.01[b]	0.82	0.02	0.05
Total starch (%)	64.27 ± 0.06[a]	68.26 ± 0.06[b]	0.09	0.06	0.14
Resistant starch (%)	5.45 ± 0.04[a]	0.84 ± 0.03[b]	1.01	0.03	0.07
Wet gluten (%)	17.27 ± 0.05[a]	27.52 ± 0.05[b]	0.20	0.05	0.10
Dry gluten (%)	5.91 ± 0.04[a]	9.01 ± 0.08[b]	0.79	0.06	0.13
In-vitro protein digestibility (%)	72.23 ± 0.05[a]	74.46 ± 0.04[b]	0.06	0.05	0.10
Total antioxidant activity (%)	28.56 ± 0.04[a]	17.42 ± 0.05[b]	0.21	0.05	0.11

Results are expressed as mean ± S.D, n=3
Different alphabets in superscript in each row show significant difference between values
CV- coefficient of variation, S.Em- standard error of mean, CD-critical difference

Total dietary fibre
Roughage or dietary fibre is the portion of plant-derived food which is not completely digested by human digestive enzymes. In the present study, total dietary fibre content in barley flour was found to be significantly higher than refined wheat flour. The values for total dietary fibre content in barley flour and refined wheat flour were found to be 17.56 per cent and 3.21 per cent respectively. Regular consumption of diet high in fibre is commonly associated with good health and lower risk of several diseases.
del Carmen Robles-Ramírez *et al.* (2020) [25] reported total dietary fibre content in barley flour and wheat flour as 17.89 per cent and 3.89 per cent respectively, which is very close to the values reported in present study. El-Taib *et al.* (2018) [22] reported 19.00 per cent and 4.88 per cent total dietary fibre in barley flour and wheat flour respectively. O'Shea *et al.* (2016) [21] mentioned 17.00 per cent and 3.70 per cent total dietary fibre in wholegrain barley flour and wheat flour respectively. Oghbaei and Prakash (2013) [41] quoted 3.24 per cent total dietary fibre in refined wheat flour, whereas, Aprodu and Banu (2017) [43] quoted 3.14 per cent total dietary fibre in wheat flour.

Insoluble dietary fibre
Insoluble dietary fibre adds bulk to the diet and helps to pass the food quickly through stomach and intestines. Insoluble dietary fibre content in barley flour was found to be significantly higher than refined wheat flour. The values for insoluble dietary fibre content in barley flour and refined wheat flour were found to be 13.05 per cent and 2.08 per cent respectively.
Ragaee *et al.* (2011) [44] reported 14.00 per cent and 2.40 per cent insoluble dietary fibre in barley flour and white flour respectively. According to Aprodu and Banu (2017) [43],

insoluble dietary fibre content in hulled barley flour and wheat flour was found to be 12.10 per cent and 9.42 per cent respectively. El-Taib *et al*. (2018) [22] mentioned 16.70 per cent and 3.10 per cent insoluble dietary fibre in barley flour and wheat flour respectively. Sanz-Penella *et al*. (2013) [36] reported 1.91 per cent insoluble dietary fibre content in wheat bread, whereas, Oghbaei and Prakash (2013) [41] reported 3.00 per cent insoluble dietary fibre in refined wheat flour.

Soluble dietary fibre

Soluble dietary fibre dissolves in water to form a gel-like material. It helps in lowering blood glucose and cholesterol levels. In the present study, soluble dietary fibre content in barley flour was found to be significantly higher than refined wheat flour. The values for soluble dietary fibre content in barley flour and refined wheat flour were found to be 4.51 per cent and 1.13 per cent respectively.

Ragaee *et al*. (2011) [44] reported 6.50 per cent and 1.50 per cent soluble dietary fibre in barley flour and white flour respectively, whereas, Kinner *et al*. (2011) [45] reported 4.27 per cent soluble dietary fibre in naked barley flour. According to Aprodu and Banu (2017) [43], soluble dietary fibre content in hulled barley flour and wheat flour was found to be 4.10 per cent and 3.64 per cent respectively. Pedersen *et al*. (1989) [46] quoted 3.80 per cent and 3.70 per cent soluble dietary fibre content in wholemeal barley flour and semi-refined barley flour respectively. Al Shehry (2017) [47] reported 4.75 per cent soluble dietary fibre in hull-less barley flour. Oghbaei and Prakash (2013) [41] mentioned 0.24 per cent soluble dietary fibre in refined wheat flour.

Total starch

Starch is the most common type of carbohydrate contained in many staple foods in the human diet. Total starch content in barley flour was found to be significantly lower than the starch content in refined wheat flour, which was 64.27 per cent and 68.26 per cent in barley flour and refined wheat flour respectively. Altan *et al*. (2009) [48] quoted 68.40 per cent starch content in barley flour, whereas, Bai *et al*. (2018) [49] quoted 60.00 per cent starch content in hull-less barley flour. Deng *et al*. (2020) [27] mentioned 64.56 per cent total starch in ordinary barley flour, which was slightly higher than the value reported in present study. O'Shea *et al*. (2016) [21] mentioned 56.00 per cent and 69.00 per cent total starch content in wholegrain barley flour and wheat flour respectively. Yadav *et al*. (2010) [50] reported 65.60 per cent and 69.80 per cent total starch content in barley and wheat respectively.

Resistant starch

Starch which escapes digestion in the small intestine of healthy individuals is called resistant starch. It is used as a dietary supplement because of its several health benefits. In the present study, resistant starch was found to be significantly higher in barley flour as compared to refined wheat flour. The values for resistant starch in barley flour and refined wheat flour are 5.45 per cent and 0.84 per cent respectively.

Beigh *et al*. (2019) [20] reported 5.18 per cent resistant starch content in barley flour, which was slightly lower than the value reported in present study. However, Deng *et al*. (2020) [27] reported 5.53 per cent resistant starch in ordinary barley flour, which was slightly higher than the value reported in present study. Nigudkar (2014) [51] mentioned 0.65 per cent resistant starch content in refined wheat flour, whereas, Tiwari (2013) [52] mentioned 1.01 per cent resistant starch content in refined wheat flour.

Wet gluten content

Gluten is a family of proteins found in cereals like wheat, rye and barley. Wet gluten content in barley flour was found to be 17.27 per cent, which was significantly lower than the wet gluten content found in refined wheat flour i.e. 27.52 per cent. The two main proteins found in gluten are gliadin and glutenin. Gliadin is mostly responsible for the adverse health effects of gluten.

Afify *et al*. (2016) [2] reported wet gluten content of wheat flour to be 26.03 per cent, whereas, Sheikholeslami *et al*. (2018) [53] reported 27.00 per cent wet gluten in wheat flour, which is almost similar to the value reported in present study. Dhingra and Jood (2004) [54] mentioned 30.60 per cent wet gluten in wheat flour, whereas, 23.00 per cent wet gluten in 20 per cent barley incorporated wheat flour. Gupta *et al*. (2011) [55] quoted 29.12 per cent wet gluten in wheat flour, whereas, 22.00 per cent wet gluten in 40 per cent barley incorporated wheat flour.

Dry gluten content

Dry gluten content in barley flour was found to be 5.91 per cent, which was significantly lower than the dry gluten content found in refined wheat flour i.e. 9.01 per cent. Sheikholeslami *et al*. (2018) [53] reported 9.70 per cent dry gluten in wheat flour, which is slightly higher than the value reported in present study. Dhingra and Jood (2004) [54] mentioned 10.30 per cent dry gluten in wheat flour, whereas, 8.00 per cent dry gluten in 20 per cent barley incorporated wheat flour. Gupta *et al*. (2011) [55] also reported the same values *viz*., 10.30 per cent dry gluten in wheat flour, whereas, 8.00 per cent dry gluten in 40 per cent barley incorporated wheat flour. Marpalle *et al*. (2014) [29] reported 9.26 per cent dry gluten in refined wheat flour. Aleem Zaker *et al*. (2012) [23] reported 8.72 per cent dry gluten content in refined wheat flour.

***In-vitro* protein digestibility**

Protein digestibility means how effectively our body can use a particular dietary protein source. *In-vitro* protein digestibility of barley flour was found to be 72.23 per cent, whereas, *in-vitro* protein digestibility of refined wheat flour was found to be 74.46 per cent. Ertop *et al*. (2020) [56] reported protein digestibility of barley flour and wheat flour to be 65.19 per cent and 74.46 per cent respectively. Bai *et al*. (2018) [49] quoted 72.30 per cent protein digestibility in hull-less barley flour, which was almost similar to the value reported in present study. Rantanen (2020) [57] mentioned 74.68 per cent protein digestibility in wheat flour, whereas 79.69 per cent protein digestibility of germinated barley flour. Ahmed and Ashraf (2019) [39] quoted 74.99 per cent protein digestibility of wheat flour.

Total antioxidant activity

Total antioxidant capacity is a measure used to assess the antioxidant level of biological samples. In the present study, total antioxidant activity of barley flour was found to be 28.56 per cent, which was significantly higher than the antioxidant activity of refined wheat flour, i.e. 17.42 per cent. Adhikari *et al*. (2016) [58] reported 28.64 per cent and 23.72 per cent total antioxidant activity in barley flour and wheat flour respectively. Farooqui *et al*. (2018) [42] mentioned lower values of total antioxidant activity in non-germinated and germinated barley flour as 11.37 per cent and 14.36 per cent respectively. Rani and Singh (2018) [38] quoted 17.34 per cent total antioxidant activity in refined wheat flour.

Conclusion

From the above discussion, it can be concluded that barley flour has better nutritional profile as compared to refined wheat flour. Being rich in protein, dietary fibre (soluble as well as insoluble), resistant starch and antioxidants, barley flour can be a better substitute for commercial refined wheat flour in order to develop value added products with better nutritional quality. Studying functional properties of barley flour and refined wheat flour may assist in developing various processed products either by blending barley flour with refined wheat flour or other cereal flours.

Acknowledgement

The authors are thankful to the Department of Foods and Nutrition, College of Home Science, GBPUAT, Pantnagar, for providing needful research facilities and University Grants Commission (UGC) for providing financial assistance through UGC-NET-JRF fellowship.

References

1. Khader V. Textbook of Food Science and Technology. ICAR, New Delhi 2001.
2. Afify AEM, Abbas MS, Abd El-Lattefi BM, Ali AM. Chemical, rheological and physical properties of germinated wheat and naked barley. International Journal of ChemTech Research 2016;9(9):521-31.
3. Brennan MA, Derbyshire E, Tiwari BK, Brennan CS. Ready-to-eat snack products: the role of extrusion technology in developing consumer acceptable and nutritious snacks. International Journal of Food Science and Technology 2013;48(5):893-902.
4. Potter NN, Hotchkiss JH. Food Science 1996,478-513.
5. Tamás C, Kisgyörgy BN, Rakszegi M, Wilkinson MD, Yang MS, Láng L *et al*. Transgenic approach to improve wheat (*Triticum aestivum* L.) nutritional quality. Plant Cell Reports 2009;28(7):1085-1094.
6. Food and Agricultural Organization (FAO). Food Outlook: Global Market analysis. Rome, Italy 2012, ISSN 0251-1959.
7. Mishra N, Chandra R. Development of functional biscuit from soy flour & rice bran. International Journal of Agricultural and Food Science 2012;2(1):14-20.
8. Izydorczyk MS, Hussain A, MacGregor AW. Effect of barley and barley components on rheological properties of wheat dough. Journal of Cereal Science 2001;34(3):251-260.
9. AOAC. Official Methods of Analysis. Association of Official Analytical Chemists. Edn 16, Washington DC, USA 1995.
10. Mudambi SR, Rao SM. Food Science. New Age International, New Delhi 1989,221p.
11. Ranganna S. Hand book of Analysis and Quality control for Fruit and Vegetable products. Tata McGraw-Hill Publishing Co. Pvt. Ltd., New Delhi 1986,105-112.
12. Fiske CH, Subbarow Y. The colorimetric determination of phosphorus. Journal of Biological Chemistry 1925;66(2):375-400.
13. Asp NG, Johansson CG. Techniques for measuring dietary fibre: principle aims of method and comparison of results obtained by different techniques. In: James, W.P.T. and Theander, O. eds. The Analysis of Dietary Fibre in Food. New York, Basel, Marcel Dekker, Inc 1981,173-190.
14. McCleary BV, McNally M, Rossiter P. Measurement of resistant starch by enzymatic digestion in starch and selected plant materials: collaborative study. Journal of AOAC International 2002;85(5):1103-1111.
15. AOAC. Official Methods of Analysis. Association of Official Analytical Chemists. Hornitz W, ed., Washington DC, USA 2000.
16. Akeson WR, Stahmann MA. A pepsin pancreatin digest index of protein quality evaluation. The Journal of Nutrition 1964;83(3):257-261.
17. De Groot AP, Slump P. Effects of severe alkali treatment of proteins on amino acid composition and nutritive value. The Journal of Nutrition 1969;98(1):45-56.
18. Brand-Williams W, Cuvelier ME, Berset CLWT. Use of a free radical method to evaluate antioxidant activity. LWT-Food Science and Technology 1995;28(1):25-30.
19. Abadi FA, Naser JM. Effect of wet gluten addition on stalin charaterisics of barley bread. The Iraqi Journal of Agricultural Science 2019;50(1):390-397.
20. Beigh M, Hussain SZ, Qadri T, Naseer B, Raja T, Naik H. Investigation of process and product parameters for physico-chemical properties of low Glycemic Index water chestnut and barley flour-based extruded snacks. British Food Journal 2019;122(1):227-241.
21. O'Shea N, Kilcawley KN, Gallagher E. Influence of α-amylase and xylanase on the chemical, physical and volatile compound properties of wheat bread supplemented with wholegrain barley flour. European Food Research and Technology 2016;242(9):1503-1514.
22. El-Taib HI, Rizk IRSA, Yousif EI, Hassan AA. Effect of barley flour on wheat bread quality. Arab Universities Journal of Agricultural Sciences 2018;26(Special issue (2A):1109-1119.
23. Aleem Zaker MD, Genitha TR, Hashmi SI. Effects of defatted soy flour incorporation on physical, sensorial and nutritional properties of biscuits. Journal of Food Processing and Technology 2012;3(4):1-4.
24. Islam MZ, Taneya MLJ, Shams-Ud-Din M, Syduzzaman M, Hoque MM. Physicochemical and functional properties of brown rice (*Oryza sativa*) and wheat (*Triticum aestivum*) flour and quality of composite biscuit made thereof. The Agriculturists 2012;10(2):20-28.
25. del Carmen Robles-Ramírez M, Ortega-Robles E, Monterrubio-López R, Mora-Escobedo R, del Carmen Beltrán-Orozco M. Barley bread with improved sensory and antioxidant properties. International Journal of Gastronomy and Food Science 2020;22:100279.
26. Arshid Z, Majeed M, Pasha I, Khan MU, Shariati MA, Pigorev I. Development And Characterization Of Barley Supplemented Flavored Chapattis. Potravinarstvo 2018;12(1):99-107.
27. Deng XQ, Pan ZF, Li Q, Deng GB, Long H, Tashi N *et al*. Nutritional components, *in vitro* digestibility, and textural properties of cookies made from whole hull-less barley. Cereal Chemistry 2020;97(1):39-52.
28. Panizo-Casado M, Déniz-Expósito P, Rodríguez-Galdón B, Afonso-Morales D, Ríos-Mesa D, Díaz-Romero C *et al*. The chemical composition of barley grain (*Hordeum vulgare* L.) landraces from the Canary Islands. Journal of Food Science 2020;85(6):1725-1734.
29. Marpalle P, Sonawane SK, Arya SS. Effect of flaxseed flour addition on physicochemical and sensory properties of functional bread. LWT-Food Science and Technology 2014;58(2):614-619.

30. Doblado-Maldonado AF, Pike OA, Sweley JC, Rose, DJ. Key issues and challenges in whole wheat flour milling and storage. Journal of Cereal Science 2012;56(2):119-126.
31. Ali RG. Effect of some treatments on quality and milling properties of barley. Annals of Agricultural Science, Moshtohor 2015;53(4):549-556.
32. Dhillon PK, Tanwar B. Muffins Incorporated with Multiple Blend Functional Ingredients: Development, Sensory Evaluation, Proximate Composition and Total Antioxidant Activity. Journal of Agricultural Engineering and Food Technology 2018;5(3):122-126.
33. Din A, Anjum FM, Zahoor T, Nawaz H. Extraction and utilization of barley β-glucan for the preparation of functional beverage. International Journal of Agriculture and Biology 2009;11(6):737-740.
34. Ullah F, Ahmad S, Wahab S, Zeb A, Khan Khattak M, Khan S *et al*. Quality evaluation of biscuits supplemented with alfalfa seed flour. Foods 2016;5(4):68.
35. Desai AD, Kulkarni SS, Sahoo AK, Ranveer RC, Dandge PB. Effect of supplementation of malted ragi flour on the nutritional and sensorial quality characteristics of cake. Advance Journal of Food Science and Technology 2010;2(1):67-71.
36. Sanz-Penella JM, Wronkowska M, Soral-Smietana M, Haros M. Effect of whole amaranth flour on bread properties and nutritive value. LWT-Food Science and Technology 2013;50(2):679-685.
37. Abeshu Y, Abrha E. Evaluation of Proximate and Mineral Composition Profile for Different Food Barley Varieties Grown in Central High lands of Ethiopia. World Journal of Food Science and Technology 2017;1(3):97-100.
38. Rani S, Singh R. Characterization of nutritional, rheological and infrared spectroscopy of refined wheat, soybean and sorghum flour. International Journal of Recent Scientific Research 2018;9(4):25992-25996.
39. Ahmed HAM, Ashraf SA. Physico-Chemical, Textural and Sensory Characteristics of Wheat Flour Biscuits Supplemented with Different Levels of Whey Protein Concentrate. Current Research in Nutrition and Food Science Journal 2019;7(3):761-771.
40. Platel K, Eipeson SW, Srinivasan K. Bioaccessible mineral content of malted finger millet (*Eleusine coracana*), wheat (*Triticum aestivum*), and barley (*Hordeum vulgare*). Journal of Agricultural and Food Chemistry 2010;58(13):8100-8103.
41. Oghbaei M, Prakash J. Effect of Fractional Milling of Wheat on Nutritional Quality of Milled Fractions. Trends in Carbohydrate Research 2013,5(1).
42. Farooqui AS, Syed HM, Talpade NN, Sontakke MD, Ghatge PU. Influence of germination on chemical and nutritional properties of Barley flour. Journal of Pharmacognosy and Phytochemistry 2018;7(2):3855-3858.
43. Aprodu I, Banu I. Milling, functional and thermo-mechanical properties of wheat, rye, triticale, barley and oat. Journal of Cereal Science 2017;77:42-48.
44. Ragaee S, Guzar I, Dhull N, Seetharaman K. Effects of fiber addition on antioxidant capacity and nutritional quality of wheat bread. LWT-Food Science and Technology 2011;44(10):2147-2153.
45. Kinner M, Nitschko S, Sommeregger J, Petrasch A, Linsberger-Martin G, Grausgruber H *et al*. Naked barley—optimized recipe for pure barley bread with sufficient beta-glucan according to the EFSA health claims. Journal of Cereal Science 2011;53(2):225-230.
46. Pedersen B, Hansen M, Munck L, Eggum BO. Weaning foods with improved energy and nutrient density prepared from germinated cereals. 2. Nutritional evaluation of gruels based on barley. Food and Nutrition Bulletin 1989;11(2):1-7.
47. Al Shehry GA. Preparation and quality evaluation of pasta substituted with hull-less barley. Australian Journal of Basic and Applied Sciences 2017;11(1):98-106.
48. Altan A, McCarthy KL, Maskan M. Effect of extrusion cooking on functional properties and *in vitro* starch digestibility of barley-based extrudates from fruit and vegetable by-products. Journal of Food Science 2009;74(2):E77-E86.
49. Bai T, Nosworthy MG, House JD, Nickerson MT. Effect of tempering moisture and infrared heating temperature on the nutritional properties of desi chickpea and hull-less barley flours, and their blends. Food Research International 2018;108:430-439.
50. Yadav BS, Sharma A, Yadav RB. Resistant starch content of conventionally boiled and pressure-cooked cereals, legumes and tubers. Journal of Food Science and Technology 2010;47(1):84-88.
51. Nigudkar MR. Estimation of resistant starch content of selected routinely consumed Indian food preparations. Current Research in Nutrition and Food Science Journal 2014;2(2):73-83.
52. Tiwari N. Formulation, quality evaluation and therapeutic assessment of finger millet and foxtail millet flour incorporated buns for diabetics. Thesis, Ph.D. G. B. Pant University of Agriculture and Technology, Pantnagar 2013.
53. Sheikholeslami Z, Karimi M, Komeili HR, Mahfouzi M. A new mixed bread formula with improved physicochemical properties by using hull-less barley flour at the presence of guar gum and ascorbic acid. LWT-Food Science and Technology 2018;93:628-633.
54. Dhingra S, Jood S. Effect of flour blending on functional, baking and organoleptic characteristics of bread. International Journal of Food Science and Technology 2004;39(2):213-222.
55. Gupta M, Bawa AS, Semwal AD. Effect of barley flour blending on functional, baking and organoleptic characteristics of high-fiber rusks. Journal of Food Processing and Preservation 2011;35(1):46-63.
56. Ertop MH, Bektaş M, Atasoy R. Effect of cereals milling on the contents of phytic acid and digestibility of minerals and protein. Ukrainian Food Journal 2020;9(1):136-147.
57. Rantanen T. *In vitro* digestion of malts and germinated faba beans-setting the methodology (Master's thesis, Itä-Suomen yliopisto) 2020.
58. Adhikari BM, Bajracharya A, Shrestha AK. Comparison of nutritional properties of Stinging nettle (Urtica dioica) flour with wheat and barley flours. Food Science and Nutrition 2016;4(1):119-124.