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ORIGINAL ARTICLE

Nutritional Characterization and Evaluation of Wheat and Barley Cultivated in Ha'il and Al-Qassim Province of Saudi Arabia

Amir Mahgoub Awadelkarim[1], Syed Amir Ashraf[1*], Mohd Adnan[2], Eyad Alshammari[1], Abdel Moneim E. Sulieman[3]

[1]Department of Clinical Nutrition, College of Applied Medical Sciences, University of Ha'il, Ha'il, P.O.Box 2440, Saudi Arabia.

[2]Department of Clinical Laboratory Sciences, College of Applied Medical Sciences, University of Ha'il, Ha'il, P.O.Box 2440, Saudi Arabia.

[3]Department of Biology, College of Science, University of Ha'il, Ha'il, P.O.Box 2440, Saudi Arabia.

* Corresponding author's E-mail address: s.amir@uoh.edu.sa

ABSTRACT

Cereals are one of the important leading crops in world agriculture, which are the major source of protein for the diets of humans and livestock. This study aims to evaluate the nutritional status of wheat and barley sample collected from Hail and Qassim region of Saudi Arabia. Among tested samples, we found that Wheat Hail (WH) had highest protein content (16.49 %) followed by Barley Hail (BH) 12.61%, Wheat Qassim (WQ) 10.78% and Barley Qassim (BQ) 10.54%. However, we found that Leucine content in BH (5.43%) was highest among all the essential amino acids tested. In addition to that, mineral analysis showed thatthe entire sample had high percentage of phosphorus, followed by potassium and calcium. Based on nutritional composition similarity index of barley and wheat, barley should be considered for developing barely based food products intended for human consumption, as it will reduce the burden to main cereal crops.

Keywords: *Wheat, Barley,Proximate analysis, Essential amino acid, Hail Province*

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INTRODUCTION

Cereals are important crops since ancient times. Indeed, their successful production, storage and use have contributed for the development of modern civilization. The term cereal is derived from Latin word '*cerealis*' meaning 'grain' which is usually composed of the endosperm, germ, and bran [1]. In addition to that, cereal grain is considered as the first agricultural attempts done by man. Major cereals growing worldwide are wheat, barley, rice, maize, sorghum and millet etc. [2]. Wheat (*Triticumaestivum* L.) is one of the leading cereal grains produced and consumed worldwide. It is the basis for numerous food produce and is one of the most important sources of energy for living population [3]. Moreover,it is considered as a good source of protein, minerals, vitamins (B complex) and dietary fiber i.e. in total excellent health-building food. Thus, it has become the principal cereal, being more widely used for the making of bread than any other cereals because of the quality and quantity of its characteristic protein called gluten [4]. Interestingly, wheat provides nearly 78.10% of carbohydrate, 14.70% of protein, 2.10% of fat, 2.10% of mineralsand considerable proportions of vitamins (thiamine and vitamin-B) and minerals such as zinc, iron, phosphorus, manganese,, selenium, iron, potassium and copper [5, 6].Moreover,wheat is also a good source of trace minerals like selenium and magnesium and other nutrients essential for good health. The bran, which consists of pericarp, testa and aleurone layer, a dietary source for fiber, potassium, phosphorus, magnesium, calcium, and niacin in small quantities [7]. Moreover, wheat and wheat products get major attention on the shelves of Hypermarkets.

Barley (*Hordeum vulgare* L.) on the other side is the fourth most important cereal crop worldwide after wheat, corn, rice, and belongs to family Poaceae, which is one of the oldest cultivated cereal grains [8].

However, barley may be considered relatively underutilized with regard to its potential use as an ingredient in processed human foods. In addition, use of barley food today remains important in some cultures around the world, particularly in Asia and Northern Africa, with curiosity to produce more barley food products because of its nutritional value [9]. Whole barley grain consisted of about 65–68% starch, 10–17% protein, 4–9% ß-glucan, 2–3% free lipids, 1.5–2.5% minerals and vitamins (thymine and riboflavin). Bioactive component such as ß-glucans; an anti-cholesterol agent in barley helps in lowering the plasma cholesterol, glycemic index and reduce the risk of colon cancer, acetylcholine; substance important in nourishing our nervous system and helps in recovering memory loss [10]. Moreover,barley is easily digestible, due to its low gluten content as well as they are high in lysine content too. Barley food product provides cooling and soothing effect in body sustained for a longer time [11]. At present, only 2% of barley is used for human consumption. However, there is a great potential to utilize barley in large number for cereal-based food products as a substitute partially or wholly for currently used cereal grains such as wheat [9]. Additionally, foods made from whole barley flour in combination with other cereals would be valuable not only for their rich and hearty taste, but also for several health benefits. However, wheat and barley have many nutritional similarities, but they do differ in the relative proportion of their principal components and subsequently in the chemical composition of whole grain flours.

Hail and Al-Qassim (Capital -Buraydah), a north-western region and central region of Saudi Arabia respectively are the major agricultural producing land of Saudi Arabia as shown in Fig. 1.A large percentage of the kingdom's wheat production comes from Ha'il Province. However, Al-Qassim is well known for dates as well as other agriculture produces. The aim of this study was to evaluate the nutritional status and microbiological assessment of wheat and barley sample collected from Hail and Al-Qassim regions of Saudi Arabia.

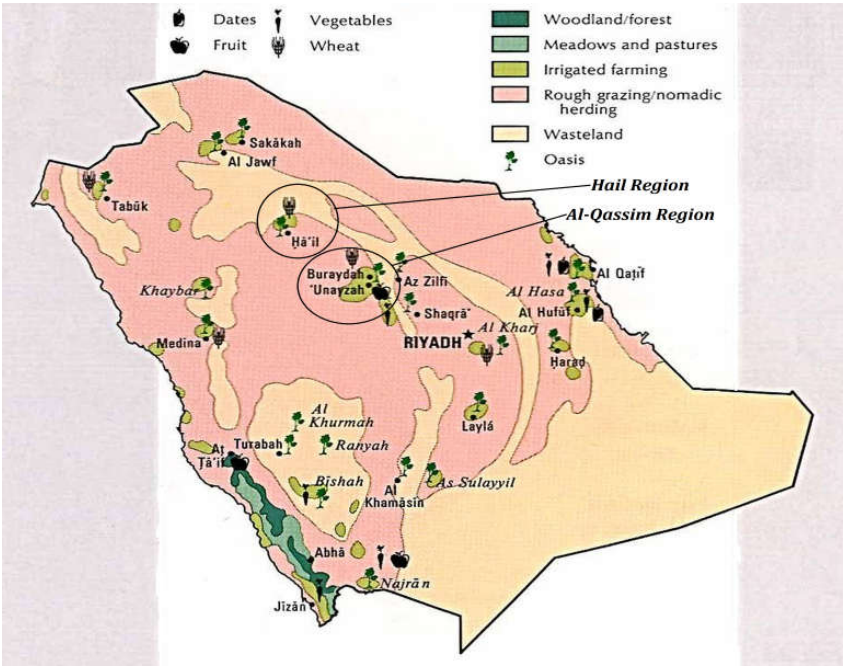

Figure1. Geographical map of Saudi Arabia illustrating the agricultural regions and depicting the Hail and Al-Qassim

MATERIAL AND METHODS

Procurement of sample

The raw wheat and barley were obtained from the local market of Hail and Qassim province of Saudi Arabia and cleaned well to make free from foreign material. The grinding of wheat and barley were done to make a uniform particle size by using Luminex grinder. The grounded material was sieved using 60 mesh size sieve to get uniform particle size and stored in airtight clean containers for further use.

Proximate analysis

Moisture, ash, fat and crude fibre content were determined according to AOAC (2006) methods. Protein content was determined according to (Kjeldahl method) using factor 6.25, and dietary fiber was determined by AOAC 2006 [12].

Carbohydrate determination

The carbohydrate content was calculated using the following formula: Available carbohydrate (%), = 100 – [protein (%) + Moisture (%) + Ash (%) + Fiber (%) + Crude Fat (%)] [13].

Determination of amino acids

The amino acid content of samples were determined as per method developed by Jajic, Krstovic, Glamocic, Jaksic, &Abramovic, 2013 using Pico-Tag reverse-Phase HPLC (Waters Corporation, USA)[14].

Determination of mineral contents

One gram of dried sample and 50 ml of 20% Nitric acid (HNO_3) were added to Erlenmeyer flask. The mixture was heated to 70–85°C for 48 h. During heating period the volume of the flask was maintained at the same level by intermittently adding 20% nitric acid. After the completion of digestion the content of Erlenmeyer flask was filtered using Nalgene filter (Thermo scientific) unit. The filtrate was collected in 100 ml volumetric flask and allowed to cool. After cooling the volume was made up to 100 ml using deionized water (Milli Q) and analyzed with ICP-MS. For the sample preparation, all the glassware was washed with deionized water and rinsed three times with 20% nitric acid [15].

Statistical analysis

All the experiments were carried out in triplicates. Results were expressed as mean of three independent experiments (n = 3). The analysis of variance (ANOVA) was performed to examine significant effect in all parameters measured. Duncan Multiple Range Test was used to separate the means[16].

RESULTS AND DISCUSSION

Proximate analysis of wheat and barley flour

The Proximate analysis was linked to the nutritional quality and the presence of specific elements or bioactive compounds suitable to satisfy the nutritional needs of consumers and they contribute to their welfare and health [17]. The proximate composition (moisture, ash, fat, protein, fiber and carbohydrate) of wheat and barley samples collected from Hail and Al-Qassim region were determined as per AOAC method as mentioned in material method section and were found to be significantly different to each sample as presented in Table 1. According to the results, we found that moisture content for wheat and barley from Hail was lower (7.27% and 6.58 %) than Al-Qassim samples (7.48% and 6.78%) respectively. This could be due to climatic conditions of Hail and Al-Qassim. However, ash percentage was found to be higher in both barley samples than wheat. Previous study reported that, the ash content for wheat and barley in between 1.57 % - 2.40%, which wass in accordance to our study[18]. Among the tested sample WH had highest protein content (16.49 %) than WQ. Our results were in accordance with previous studies[5, 7, 19].They reported protein content in the range of 10-16%. In addition to that, the major storage proteins in wheatswere gliadins and glutenins. However, barley has hordeins and glutelins[20]. When crude fibre content among the wheat and barley sample was assessed, it was found that both BQ and BH had high percentage of crude fiber compared to WH and WQ. However, among them BQ had the highest percentage than BH. Barley flour was an excellent source of soluble and insoluble dietary fiber [21]. Our results were in the line of previous report suggesting crude in Wheat and barley 2.01 – 2.24 and 2.85-3.25 % respectively [18].

Table 1. Proximate composition of wheat and barley flour

Parameter %	WQ	WH	BQ	BH	$Lsd_{0.05}$	SE±
Moisture	7.48^{a} ±0.03	7.27^{a} ±0.06	6.87^{b} ±0.11	6.58^{c} ±0.23	0.2455^{**}	0.07528
Ash	1.47^{bc} ±0.18	1.27^{c} ±0.12	1.80^{a} ±0.13	1.68^{ab} ±0.06	0.2382^{**}	0.07303
Fat	2.35^{ab} ±0.26	2.97^{a} ±0.75	2.30^{ab} ±0.46	1.52^{b} ±0.45	0.9638^{*}	0.2955
Crude protein	10.78^{c} ±0.11	16.49^{a} ±0.01	10.54^{c} ±0.61	12.61^{b} ±0.10	0.5864^{**}	0.1798
Crude fiber	2.17^{c} ±0.24	2.08^{c} ±0.28	3.25^{a} ±0.22	2.70^{b} ±0.00	0.4038^{**}	0.1238
Carbohydrates	75.90^{a} ±0.28	69.89^{b} ±0.80	73.48^{ab} ±3.72	74.91^{a} ±0.09	3.597^{**}	1.103

Mean±SD value(s) having different superscript(s) in a row are significantly different (P≤0.05).

Amino acid profiling

The inability of humans and many farm animals to synthesize certain amino acids has started tremendous attention in food and cereal grains to fulfill the outcome by so called essential amino acid[22]. Analysis of

essential amino acids in wheat and barley sample showed that, among all the amino acid tested leucine was found to be highest i.e.; BH (5.43 %), BQ (5.39%), WH (5.14%) and WQ (5.06%) as presented in Table 2. followed by phenylalanine. The presented results were found to be in accordance with the previous studies conducted by Xiao-Ling J *et al.,* 2008[23]. Other than phenylalanine and leucine; valine and isoleucine was also found to be in the range of 3.45-4.10%. Moreover, wheat and barley found to be a good source of essential amino acids, the building blocks of proteins. This could deliver sufficient amount of essential amino acids for human diets as well as animal feed. Incorporation of barley flour in human diet can boost nutritional deficiency in the developing countries as well as developed countries with easing the burden on regular crops such as wheat [24].

Table 2. Essential amino acid composition of wheat and barley flour

Amino acid Profile (%)	WH	WQ	BH	BQ
Phenylalanine	4.90±0.020 ^{b}	4.81±0.060 ^{b}	5.20±0.072 ^{a}	5.25±0.127 ^{a}
Histidine	2.17±0.063 ^{a}	2.03 ±0.043 ^{ad}	1.95 ±0.055 ^{bd}	1.78 ±0.095 ^{c}
Isoleucine	3.45±0.047^{a}	3.49±0.058^{a}	3.46±0.036 ^{a}	3.51±0.057 ^{a}
Leucine	5.14±0.121 ^{b}	5.06±0.051^{b}	5.43±0.015 ^{a}	5.39±0.066 ^{a}
Lysine	2.07±0.060 ^{b}	1.92±0.066^{c}	3.24±0.104 ^{a}	3.20±0.015 ^{a}
Methionine	1.16±0.043 ^{c}	1.32±0.01^{b}	1.66±0.043 ^{a}	1.59±0.055 ^{a}
Threonine	2.54 ±0.1^{c}	2.70 ±0.030^{b}	3.26 ±0.133^{a}	3.29 ±0.13^{a}
Tryptophan	1.06 ±0.072 ^{c}	1.26 ±0.049 ^{b}	1.91 ±0.066 ^{a}	1.98 ±0.015 ^{a}
Valine	3.75±0.098 ^{c}	3.67±0.028 ^{c}	3.93±0.023 ^{b}	4.10±0.110 ^{a}

Mean±SD values bearing same superscripts within a row are not significantly different (P≤0.05).

Table 3. Minerals composition of wheat and barley sample

Mineral (mg kg^{-1})	WH	WQ	BH	BQ	Lsd$_{0.05}$	SE±
Pb	ND	0.020^{b}±0.0	ND	0.047^{a} ±0.01	0.026**	0.0093
Cd	0.010^{a}±0.00	ND	ND		0.027^{NS}	0.0081
As	ND	ND	ND	0.037 ±0.0	-	-
Cu	4.420^{a}±0.04	3.233^{d}±0.07	3.460^{c}±0.07	4.013^{b} ±0.08	0.1191**	0.03651
Zn	30.50^{b}±0.56	29.24^{c}±0.34	22.80^{d}±0.15	54.37^{a} ±0.25	0.6763**	0.2074
Su	ND	ND	ND	ND	-	-
Mn	16.67^{b}±0.36	15.90^{c}±0.17	14.54^{d}±0.48	19.46^{a} ±0.03	0.5864**	0.1798
Fe	35.29^{b}±0.39	22.48^{d}±0.07	65.53^{a}±0.44	26.52^{c} ±0.45	0.702**	0.2153
Cr	0.160^{a}±0.03	0.0567^{c}±0.01	ND	0.098^{b} ±0.00	0.0006318**	0.00018
Na	146.26^{a}±0.03	128.88^{b}±0.72	0.507^{d}±0.02	43.58^{c} ±0.12	0.6841**	0.2098
Ca	709.33^{d}±1.04	898.17^{b}±0.11	736.63^{c}±0.06	1046.14^{a} ±0.22	1.005**	0.3082
K	4413^{b}±5.12	4139.16^{c}±0.24	3.633^{d}±0.12	4978.02^{a} ±0.47	4.846**	1.486
P	5171.81^{a}±0.33	4155.00^{c}±2.00	4371.00^{b}±1.00	2830.45^{d} ±0.49	2.176**	0.6673
Al	2.883^{a}±0.03	2.600^{b}±0.10	2.423^{c} ±0.08	ND	0.1548**	0.04472
Hg	ND	ND	ND	ND	-	-
Ni	0.030^{a} ±0.00	0.0267^{b} ±0.01	ND	0.01833^{c} ±0.00	0.0006318*	0.0001826
Mg	262.61^{b} ±0.54	239.00^{c} ±2.00	1.210^{d} ±0.02	646.33^{a} ±3.51	3.838**	1.177

Mean±SD value(s) having different superscript(s) in a row are significantly different (P≤0.05).ND: Not Detected.

Mineral analysis

Mineral elements were found to be an essential components for plant metabolism and often accumulated in seeds. They are important in plant growth and development as essential nutrients. Man and other monogastric animals poorly utilize minerals from cereals because some endogenous and exogenous factors decrease the absorption of minerals from plant foods [25]. Various elements are known to be

essentially needed for normal physiological functions in humans [26]. The mineral contents of cereal grains are affected by a number of factors including soil, climate and cultural practices. Here in this study, we have also screened mineral components from our samples as presented in Table 3. We found that phosphorus, potassium and calcium were highest in mg kg^{-1} level. Calcium was considered as an essential elements for a number of physiological processes along with working as structural material for bone in combination with phosphorus. Supplementation of calcium can prevent the bone fracture and provide amelioration of calcium deficiency related disorders[27]. Both the elements (Ca and P) are essential for bone formation. Previous study reported that, the calcium content of barley in the range of 80- 410 mg kg-1 [8, 28]. Our results for calcium were little on higher side; this could be due to geographical factors of sample. Other significant nutrient elements are also estimated in the Wheat and barley sample, which includes copper, zinc, manganese, iron, chromium and aluminum. However, mercury was absent in the entire tested sample, in addition to that a very negligible amount of lead found in WQ (0.02 mg kg^{-1}) and BQ (0.047 mg kg^{-1}), followed by cadmium in WH (0.010 mg kg^{-1}) and arsenic in BQ (0.037 mg kg^{-1}).

CONCLUSION

Over three billion peoples are currently malnourished and this global crisis in nutritional health is the result of dysfunctional food systems that do not consistently supply enough of the essential nutrients. Protein deficiency is a major dietary problem faced by the people worldwide, particularly from the under developed and developing countries. Wheat is the major crop cultivated worldwide as staple food. However, barley is relatively underutilized with regard to its potential use as an ingredient in processed human foods and used as a staple food in few countries only (Ethiopia, India, China and Morocco).Comparatively, mineral composition of barley wass also as good as wheat. Based on our evaluation, chemical composition and nutritional facts, it gives the impression that barley is having potential of being staple food in the category of cereal based food products as a substitute partially or wholly for currently used cereal grains such as wheat.

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