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Characterization and Nutritive Values of Amaranth Seeds

Akanksha Singh[1*] and Darshan Punia[1]

[1]*Department of Food and Nutrition, College of Home Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana - 125004, India.*

Authors' contributions

This work was carried out in collaboration between both authors. Author AS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author DP managed the analyses of the study and literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Backgrounds: Amaranthus have small lenticular seeds with a curved embryo that surrounds a starchy perisperm and with a seed coat whose color varies among black, brown, yellow and cream-white the present investigation was carried out to analyze the physico-chemical properties and nutritional composition of amaranth.

Methodology: Amaranth grains were procured from the Medicinal Aromatic and Underutilized Plant Section, Department of Genetics and Plant Breeding, College of Agriculture, CCS Haryana Agricultural University, Hisar. Amaranth flour was assessed for its physico-chemical properties and nutrient composition.

Results: Results on physico-chemical properties revealed that bulk density of amaranth flour was 6.06 g/ml, water absorption capacity 9.40 ml/g and fat absorption capacity 58.16%. Swelling capacity of amaranth was 2.54 ml/g. The results of proximate composition revealed that amaranth flour had 10.33% moisture. 14.29% protein, 5.80% fat, 2.84% ash and 4.91% crude fibre. Albumin,

**Corresponding author: E-mail: akanksha513510@gmail.com;*

globulin, prolamin and glutelin fractions of amaranth were 9.82, 9.50, 1.42 and 1.28 per cent, respectively. The total, soluble and insoluble dietary fibre content of amaranth was 27.34, 9.40 and 17.95%, respectively. Calcium, zinc, iron and potassium contents were 272.03 mg/100 g, 5.81 mg/100 g, 13.76 mg/100 g and 329.87 mg/100 g, respectively.

Conclusion: It can be concluded from the results of present investigation that amaranth is very good source of protein (14.87%), crude fibre (4.91%), ash (2.84%), dietary fibre (27.34%) and minerals specially calcium (272.03 mg/100 g), iron (13.76 mg/100 g) and potassium (329.87 mg/100 g). Amaranth, a pseudo cereal rich in nutrients can be utilized in preparation of traditional products.

Keywords: Amaranthus seed; plant breeding; nutrition; pseudo cereal.

1. INTRODUCTION

Amaranthus belonging to the family *Amaranthaceae,* comprises a series of wild, weedy and cultivated species and found worldwide in almost all agricultural environments. Amaranthus species have different centers of domestication and origin, being widely distributed in North America, Central America, and the South American Andes, where the greatest genetic diversity is found [1,2]. Among all the species, *Amaranthus caudatus, Amaranthus hypochondriacus* and *Amaranthus cruentus* are mainly cultivated for their seeds [3,4] and are considered as pseudocereals, with a high seed protein content and a high lysine content [5,6]. Amaranth is a plant with high nutritional value, whose nutrients are concentrated in the leaves and the grains. Amaranth seeds have attracted attention as a human nutritional source because, compared with the major cereals, they contain higher amount of protein with a well balanced amino acid composition as well as minerals, vitamins, and phytochemicals compared to those of major cereals such as wheat and rice [7,8]. The amaranth grain can be toasted, popped, extruded or milled into flour and can therefore be consumed as such or included in other cereal products such as bread, cakes, muffins, pancakes, cookies, dumplings, noodles and crackers. The optimal nutritive composition of this seed has made its use attractive as a blending food source to improve the nutritional value of some cereal by-products. In Mexico, the popped amaranth confection, ‘alegria’ is a popular favorite among locals and tourists. The flour or flaked forms are combined with wheat or other flours to make bread, cereals, cookies and other baked goods. Amaranth used to make up only 10-20% of the flour blend, but it can be blended at 50-75% levels and still maintain functional properties and flavor. Coarsely ground amaranth is used to make a tasty and nutritious porridge cooked by itself or mixed with other grains and pseudo cereals such as oats, wheat, milled flax seed.

2. MATERIALS AND METHODS

2.1 Procurement of Material

Amaranth grains were procured in a single lot from the Medicinal Aromatic and Underutilized Plants Section, Department of Genetics and Plant Breeding, College of Agriculture, Chaudhary Charan Singh Haryana Agricultural University, Hisar.

2.2 Preparation of Amaranth Flour

Amaranth grains were cleaned and washed under tap water to remove dirt, dust and foreign materials (Fig. 1). The washed grains were spread over filter paper sheet and dried completely. After drying, the grains were ground in an electric grinder to fine powder and stored in air tight plastic containers at room temperature for further analysis.

2.3 Physico-chemical Characteristics of Amaranth

Amaranth was analyzed for the following physico-chemical characteristics.

2.3.1 Bulk density

The bulk density of amaranth flour was determined by the method of AOAC [8]. Five grams amaranth sample was weighed accurately and transferred to graduated measuring cylinders. Sample volume was recorded by subtracting 5 ml from the total volume. The bulk density was calculated as weight per unit volume (g/ml). It was calculated by using equation mentioned below:

Bulk Density (g/ml) = ((Mass of sample and graduated cylinder) – (Mass of graduated cylinder)/Volume of sample (ml))

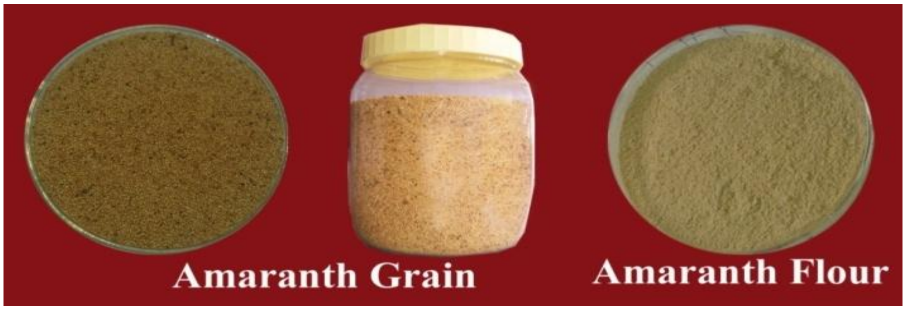

Fig. 1. Figure showing amarnath whole grains and processed amarnath flour

2.3.2 Water absorption capacity

Water absorption capacity was determined by the method [9]. One gram of amaranth flour was suspended in 10 ml distilled water, stirred for 2 min, and then centrifuged at 3700 rpm for 25 minutes. The volume of free liquid was measured and the retained volume was expressed as milliliter of water absorbed per gram of sample.

2.3.3 Fat absorption capacity

The fat absorption capacity of amaranth was determined by the method of AOAC [8]. One gram sample was weighed into 25 ml graduated conical centrifuge tube and about 10 ml of hydrogenated fat was added. The suspension was centrifuged at 2000 rpm for 30 min. The separated fat was then removed with a pipette and the tubes were inverted for 25 min to drain the fat prior to be reweighing. The fat absorption capacity was expressed as percent fat absorption based on the original sample weight.

2.3.4 Swelling capacity

Swelling capacity was determined according to the method of [10]. Dried accurately weighed sample (0.2 g) was placed in a graduated test tube; 10 ml of water containing 0.02% sodium azide was added, mixing thoroughly. Tubes were left at room temperature for 18 h. Then the volume was recorded. Swelling capacity was calculated as ml per gram of dry sample.

Swelling capacity (ml /g) = (Volume occupied by sample / Original sample weight)

2.3.5 Water holding capacity

The water-holding capacity (WHC) was measured by the method of [11]. A sample of 5 g was mixed with 20 ml distilled water and placed in pre- weighed centrifuge tube. The mixture was mixed vigorously for 2 min with a spatula and centrifuged for 10 min at 2000 rpm. After the supernatant was removed, the weight gain in sample was recorded.

Water holding capacity (g/ml) = (Hydrated weight – Original weight / Sample weight)

2.4 Nutritional Evaluation of Amaranth

Proximate composition including moisture, protein, fat, ash and crude fibre was determined by standard methods [8]. Total, soluble and insoluble dietary fibre constituents were determined by the enzymatic method [12]. Total minerals were determined according to the method [13].

2.5 Statistical Analysis

Suitable standard statistical methods like mean and critical difference were used for interpretation of data (Sheoran et al., 1999).

3. RESULTS

3.1 Physico-chemical Properties of Amaranth Flour

The data on physico-chemical properties of amaranth flour are presented in Table 1.

The data presented in Table 1 showed that bulk density of amaranth flour was 6.06 g/ml and the water absorption capacity 9.40 ml/g. The water holding capacity of amaranth flour was 4.20 g/ml and swelling capacity 2.54 ml/g. The fat absorption capacity of amaranth flour was 58.16 ml/g.

Table 1. Physico-chemical properties of amaranth flour

Physico-chemical properties				
Bulk density (g/ml)	**Water absorption capacity (ml/g)**	**Water holding capacity (g/ml)**	**Swelling capacity (ml/g)**	**Fat absorption capacity (per cent)**
6.06±0.06	9.40±0.11	4.20±0.17	2.54±0.01	58.16±0.67

Values are mean ± SE of three independent determinations

Table 2. Nutritional composition of amaranth flour

Parameter	Mean ±SE
Proximate composition (%)	
Moisture	10.33±0.30
Crude Protein	14.69±0.50
Fat	5.80±0.11
Ash	2.84 ±0.02
Crude Fibre	4.91±0.02
Total Carbohydrates	61.43±0.52
Protein fractions (%)	
Albumin	9.82± 0.17
Globulin	9.50±0.10
Prolamin	1.42±0.07
Glutelin	1.28 ±0.12
Dietary fibre (%)	
Total dietary fibre	27.34±1.27
Soluble dietary fibre	9.40±0.23
Insoluble dietary fibre	17.95±1.33
Total minerals (mg/100 g)	
Calcium	272.03±2.08
Zinc	5.81±0.01
Iron	13.76±0.02
Potassium	329.87± 0.02

Values are mean ± SE of three independent determinations

3.2 Nutritional Composition of Amaranth Flour

3.2.1 Proximate composition

The results on proximate composition of amaranth flour are presented in Table 2. The amaranth flour had 10.33% moisture. The protein, fat, ash and crude fibre contents were 14.69, 5.80, 2.84% and 4.91%, respectively. The carbohydrate content of amaranth flour was 61.43%.

3.2.2 Protein fractions

Albumin fraction of amaranth flour was 9.82 per cent. The globulin, prolamin and glutelin fractions were 9.50, 1.43 and 1.28 per cent, respectively.

3.2.3 Dietary fibre

The total dietary fibre, soluble dietary fibre and insoluble dietary fibre content of amaranth flour were 27.34, 9.40 and 17.95 per cent, respectively.

3.2.4 Minerals

Total calcium, zinc, iron and potassium contents of amaranth flour were 272.03, 5.81, 13.76 and 329.87 mg/100 g, respectively. The available calcium and available iron contents were 84.79 and 3.16 mg/100 g, respectively.

4. DISCUSSION

The results obtained have been discussed here. There was substantial diversity in amaranth for the various physical traits (Table 1). Bulk density, water absorption capacity, water holding capacity, swelling capacity and fat absorption capacity were 6.06 g/ml, 9.40 ml/g, 4.20 g/ml, 2.54 ml/g and 58.16 per cent, respectively. Study reported lower values for bulk density (0.067g/cc, 0.64 g/cm^3, 0.85 g/ml) [14] reported lower values for water absorption capacity 4.84 ml/g. Almost similar values for swelling capacity (2.48 ml/g) in amaranth grain and water holding capacity of amaranth grains was higher 125%. [15] The data in Table 2 depicted that moisture content of amaranth was 10.33 per cent which is in close agreement to the values (10.5%) and Mburu et al. 2011 (10.2%) [16] and reported higher moisture values (12.01 and 12.73%, respectively) than obtained in present study [17].

Analysis of grain amaranth showed that the grains were rich in protein (14.69%), lipids (5.80%) and fibre (4.91%). Grain amaranth had higher levels of protein than most cereal grains of regular consumption (wheat 12-14%, rice 7-10%, corn 9-10%). Amaranth grains contain relatively minor protein content when compared with legume seeds such as bean (*Phasealus vulgaris*) (28%) or soya (*Glycine max*) (36%).The values obtained in present syudy for protein are comparable with the published data [5]. Earlier workers [18,12] reported higher values of protein (15.78 to 17.85%) than obtained in present study. The amaranth varieties grown in Uganada have been found to have protein content of 12-13% (Muyonga et al. 2008). The variations observed in protein content can most probably be attributed to differences in the varieties of the seeds tested and, to a lesser extent, the climatic conditions and cultural practices [5].

According to the results, the content of albumin, globulin, prolamin and glutelin were 9.82, 9.50, 1.42 and 1.28 per cent, respectively, where the content of albumin was maximum. The protein in amaranth, quinoa and buckwheat are composed mainly of globulins and albumins and contain very little or no storage protein (Prolamins and glutelins) [19]. The content of albumins and globulins in the seeds of amaranth, kañiwa and quinoa were comparatively higher than that of rice, wheat and maize. The amount of glutelins and other insoluble proteins in the seeds of amaranth, quinoa and kaniwa were comparatively similar, whereas rice possessed a higher content of glutelins and insoluble proteins amongst other cereals [6].

Another important feature of amaranth composition is fat content. The values obtained in present study (5.8%) fat are comparable to the findings of earlier workers [20,19]. Somewhat higher values of amaranth than obtained in present study are also mentioned earlier [21,22]. The lipid content shows wide variation between (1.9-9.7%) depending upon species and genotypes [18,23]. Amaranth lipids are characterized by a high degree of unsaturation, which is desirable from nutritional point of view.

The total carbohydrate content of amaranth in present study was 61.43%, higher values for carbohydrates (72.15%) in amaranth [14].

Dietary fibre is another component of physiological relevance found in abundant amounts in amaranth. It is generally accepted that the consumption food of naturally rich in dietary fibre is beneficial to the maintenance of health [24]. The findings of study also indicated that amaranth had high amount of dietary fibre with a value of 27.34% total dietary fibre, 17.95%, insoluble dietary fibre and 9.40% soluble dietary fibre. These values are higher than the values (total dietary fibre 14.87, insoluble dietary fibre 12.64 and soluble dietary fibre 2.20%) 20.6% dietary fibre in amaranth [4]. The values of total dietary fibre are in agreement with data reported 14-16% [3] and 14.2% of dietary fiber in *A. cruentus* flour (8.1% soluble, 6.1% insoluble) [25]. Amaranth has got slightly lower dietary fibre than wheat() The fraction of insoluble dietary fibre varies 19.5-27.9% in *Amaranthus cruentus* while 33.1-49.3% in *Amaranthus hypochondriacus* [15,26].

In present study, mineral composition of the amaranth showed that calcium and iron were the most abundant elements present i.e. 272.03 mg/100 g and 13.76 mg/100 g, respectively. Amaranth had 5.81 mg/100 g zinc and 329.87 mg/100 g potassium. The findings of present study showed that they are in close agreement [7], significantly lower amount of minerals as compared to the values of present study whereas significantly higher amount of mineral values [27]. Amaranth was rich in calcium compared to other cereals and pseudo cereals [28,29]. The mineral content (ash) of amaranth is about twice as high as in other cereals particularly in calcium, magnesium, iron, potassium, and zinc [30,16]. The variations in minerals could be explained by factors such as variety, soil, types and amount of fertilizers applied.

5. CONCLUSION

It can be concluded from the results of present investigation that amaranth is very good source of protein (14.87%), crude fibre (4.91%), ash (2.84%), dietary fibre (27.34%) and minerals specially calcium (272.03 mg/100 g), iron (13.76 mg/100 g) and potassium (329.87 mg/100 g). Amaranth, a pseudo cereal rich in nutrients.

6. RECOMMENDATIONS

The study revealed that the amaranth flour is a good source of protein, dietary fibre, calcium and iron.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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