International Journal of Home Science

ISSN: 2395-7476
IJHS 2020; 6(2): 378-383

www.homesciencejournal.com
Received: 16-03-2020
Accepted: 18-04-2020

Akanksha Singh
Department of Food Science and Nutrition, College of Home Science, GBPUAT, Pantnagar, Uttarakhand, India

Darshan Punia
Department of Foods and Nutrition, I.C College of Home Science, CCS Haryana Agricultural University, Hisar, Haryana, India

Corresponding Author:
Akanksha Singh
Department of Food Science and Nutrition, College of Home Science, GBPUAT, Pantnagar, Uttarakhand, India

An inside review of amaranth seeds: A potential nutritive pseudo cereal of India

Akanksha Singh and Darshan Punia

Abstract
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 are cultivated in different regions of South and Central America, India, and Nepal. In India, Amaranthus is chiefly grown in Himalayas from Kashmir to Bhutan and some extent in the states of Gujarat, Maharashtra, Karnataka and eastern parts of Uttar Pradesh and used as an important ingredient in food. Amaranth is a fast growing crop which can grow under varied soil and agro climatic conditions and is also resistant to heat and drought with no major disease problems. It is a rare plant whose leaves are eaten as vegetable while seeds are eaten as cereal. The amaranth grains 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.

Keywords: Amaranth, cereal, nutritional value, foods, disease

1. Introduction
Comprehensive review of literature is must in any research endeavour as it provides a sound theoretical framework for research. It not only helps the investigator to define the frontiers of the field but also helps in avoiding unintentional replication of previous work done. In paper, some of the closely related research findings having direct or indirect bearing on the present experimental research have been reviewed and presented as under:
1.1 Physico-chemical properties of amaranth
1.2 Chemical composition of amaranth
1.3 Sensory attributes and nutritional evaluation of products

1.1 Physico-chemical properties of amaranth
Physico-chemical properties like bulk density, water absorption capacity and oil absorption capacity are not so valuable at home scale level but, very important for commercial production. Bulk density is important in terms of manufacturing or packaging purposes of products. As packaging used for food would depend on the bulk density of raw products. Low bulk density of product means it is suitable for making high nutrient dense formulation food. More the water absorption capacity means product will absorb water, toxins, waste material and have laxative action. Less oil absorption capacity will help to produce products that absorb less amount of oil in preparation.
Sindhuja *et al*. (2005) [36] prepared cookies by incorporating amaranth seed (*Amaranthus gangeticus)* flour showed a small reduction in water absorption capacity from 58.0 to 56.5%, a considerable reduction in farinograph stability from 3.0 to 1.5 minute. Resio *et al*. (2005) [30] analyzed physico-chemical properties (swelling power, solubility, and water absorption) of amaranth and compared with corn starch. The results indicated that swelling power and water absorption capacity were higher for amaranth than for corn starch. Zapotoczny *et al*. (2006) [40] studied the water and fat absorption of raw and processed amaranth seeds and reported that water absorption of amaranth seeds increased significantly (over fivefold) due to puffing, from 130.78 g/100 g of the product for raw material to 698.78 g/100 g of the product for seeds puffed at an air stream temperature of 330 °C. Puffing also resulted in significantly increased

fat absorption of amaranth seeds as compared with unpuffed ones (90.29 g/100 g of the product), reaching 158.65 g/100 g of the product for processed seeds in the variant with an air stream temperature of 290°C.. Amaranth seeds had bulk density 843 g dm^{-3}. Amaranth whole flour had a high content of proteins (17.7%) and lipid (7.32%) (Dodok *et al*. (2006) [14]. Addition of 10% amaranth or quinoa flours did not cause significant changes in rheological properties. However, higher additions (20% and 30%) resulted in significant changes in stability, the degree of softening and elasticity. Substitution of wheat flour by amaranth or quinoa flours resulted in an increase of water absorption capacity (Tomoskozi *et al.* 2011) [38]. Seed weight of amaranth as 0.786 g/1000 grains, seed volume 22ml/1000 grains and seed density was recorded as 4355 g/ml. Hydration capacity of amaranth was 0.006g/100 grains, and swelling capacity of amaranth was recorded as 0.11 ml /100 grains. The swelling index of amaranth grain was 0.55ml/100 grains (Shyam *et al*. (2013) [35].

Chauhan and Singh (2013) studied influence of germination on physico – chemical properties of amaranth (*Amaranthus Spp*.) flour. They reported that the water absorption index of amaranth grain increased from 3.45 to 3.82 when germinated at 32°C for 16 hours but reduced at 24 hours and lesser hours of germination periods. Water solubility index decreased significantly from 5.29 to 5.18 at 16 h germination time as compared to control whereas, significant increase was shown in water solubility index at 20 h but no significant change was found at 24 h germination. Control or ungerminated flour had the maximum bulk density i.e. 0.61 and germination significantly decreased the bulk density of amaranth flour from 0.61 to 0.53 g/ml. Adeniyi *et al*. (2014) [1] determined the physical properties of dry amaranth grains germinated at 30 °C, 32 °C, 34 °C, 36 °C, 38 °C, 40 °C which were designated as T30, T32, T34, T36, T38, T40, respectively and T00 for the negative control. The water absorption capacity increased from 107.58% in T00 to 118.97% in T30 with the peak value of 124.94% in T40. The oil absorption capacity increased from 31.07% in the control to 33.13% in T30 with the peak value of 35.96% in T38. The emulsifying capacity was 2.01% in T00 and increased to 24.63% in T30. This property increased with increase in germination temperature to the maximum value of 31.17% in T40.

Burgos *et al*. (2015) [10] studied the physical properties of the precooked kiwicha grains. The raw grains (RG) showed a higher bulk density (0.85 g/ml) than puffed amaranth (0.18 g/ml) and laminated kiwicha (0.38 g/ml). They also showed that raw grains of amaranth had 0.85g/ml bulk density, 2.33ml/g water absorption index and 2.48 ml/g swelling power.

1.2 Chemical composition of amaranth

Varieties *Amaranthus caudatus* and *Amaranthus cruentus* and reported lipid, crude and dietary fibre, ash and sugar contents as 71, 43, 140, 30 and 18 g kg^{-1} in raw *A. caudatus* and 85, 39, 134, 40 and 22 g kg^{-1} in raw *A. cruentus* seeds, respectively. Sucrose was the dominant sugar in the raw and thermal treated seeds of both species, while glucose and galactose were the dominant ones in the high protein and the germinated seed flours. Phosphorus, potassium, magnesium and calcium were the dominant minerals in the raw seeds of both species (Gamel *et al.* 2005) [18]. Popped amaranth supplementation of up to 20% contributed to the increased content of zinc (from 7.21 to 12.59 mg kg-1), magnesium (from 137.80 to 396.90 mg kg-1), and calcium (from 80.79 to 219.04 mg kg-1, squalene (from 3.50 to 43.0 mg 100 g-1) and protein (from 12.6 to 13.9%) Consequently, by increasing amaranth levels in the bread samples, water absorption, loaf weight and bread yield increased (Bodroza-Solarov *et al*. 2007) [7]. Gamel *et al.* (2006) [19] observed the effects of seed treatments, including cooking, popping, germination and flour air classification on several components of *Amaranthus caudatus* and *Amaranthus cruentus* seeds, including oil, sugars, fibre, minerals and vitamins. The findings indicated that Air classification increased the content of minerals by more than 35% while thermal treatments did not affect their content and germination increased the calcium and zinc contents. The ascorbic acid contents were 0.030 and 0.023 g kg-1 sample in raw *Amaranthus. caudatus* and *Amaranthus. cruentus* seeds, respectively. All the treatments reduced the ascorbic acid content, with a high effect for the air classification and the germinated seeds dried at 90 °C. The levels of vitamin B complex, including niacin, niacin amide, pyridoxine and riboflavin increased in the high protein flour fraction. Resio *et al.* (2005) [30] found that *Amaranthus cruentus* had 10.5% moisture, 16.8% protein, 3.1% ash and 0.90% average diameter. Mariotti *et al.* (2009) showed that amaranth flour had 12.01% moisture, 15.78% protein, 8.16% lipids and 8% fibre. Jubete *et al*. (2009) [2, 3] studied nutritive value and chemical composition of pseudocereals as gluten-free ingredients. They found 11.6% protein, 8.8%, fat, 17.2% dietary fibre and 3.3% ash in amaranth grain. The mineral content in amaranth grain was 180.1mg/100g calcium, 1.6mg/100g zinc, 279.2mg/100g magnesium and 9.2 mg/100g iron. Mlakar *et al*. (2009) [27] reported that seed of grain amaranth was on average composed of 13.1 to 21.0% of crude protein; 5.6 to 10.9% of crude fat; 48 to 69% of starch; 3.1 to 14.2% of dietary fibre and 2.5 to 4.4% of ash. Kaur *et al*. (2010) [21] observed that the ash, lipid, and protein content of the amaranth flour were within the range of 1.7% to 3.8%, 3.8% to 7.4%, and 6.6% to 19.8%, respectively. Srivastava and Roy (2011) [37] showed that at pH 7 albumin and prolamine were present, whereas at pH 4, 5 and 6 all 4 protein fractions were precipitated in amaranth seed flour. According to the quantitative estimation of the albumin, globulin, prolamin and glutelin in the seed flour the contents were 26.4, 25.0, 5.81 and 42.7%, respectively. Mburu *et al. (*2011) [24] analyzed raw and processed amaranth grain for their nutritional content. They found that moisture content was 10.2 and 2.4%; protein 17.2 and 16.7%; fat 7.0 and 7.0% ash 2.7 and 2.6%; crude fiber 3.8 and 3.1%; carbohydrates 59.2 and 68.3%, respectively. Amaranth grain contained good amount of unsaturated fatty acids (76.1%), with predominant ones being oleic (36.3%) and linoleic (35.9%).They concluded that processing amaranth grain did not significantly affect its nutritional and physicochemical properties.

Menegassi *et al*. (2011) [26] studied the comparison of nutritional properties of whole amaranth (*Amaranthus cruentus*, Alegria) flour and defatted amaranth flour. They found whole amaranth flour had 12.8% protein and defatted had 13.3%, whole flour had 6.0% fat while defatted had 1.0% and ash content was 2.9% in whole flour and 3.0% in defatted flour, total dietary fibre was 13.0% in whole flour and 13.8% in defatted flour. Carbohydrate content of amaranth was 62.9%. The ash content was 2.7% of which 13.9, 5.2, 190, 220, 323 and 326 mg/100g for iron, zinc, calcium, magnesium, phosphorus and potassium respectively. Mburu *et al*. (2012) [24] found that the protein content of grain amaranth species varies from 12.5% to 17.6% which was comparatively higher than that of maize and most other grains, with a methionine and lysine content of 0.6 to 1.7 and 3.4 to 6.4g/

16g N respectively. Total carbohydrate content of amaranth excluding its crude fiber was 33.67% (i.e. 66.33% carbohydrate including fiber). The tannin and phytate content of raw amaranth was 1.49 and 237.75mg/100gm respectively. They also found 13.73 mg iron/100g, 4.23 mg zinc/100g and 76.18 mg calcium/100g. According to Emire and Arega (2012) [15] the crude fat content of Amaranth grain was 7.49%. Klimczak *et al*. (2002) estimated that total content of phenolic compounds ranged from 39.17 mg/100 g of *Amaranthus caudatus* to 56.22 mg/100 g of *Amaranthus paniculatus* seeds (Emire and Arega 2012) [15].

1.3 Sensory attributes and nutritional evaluation of products

Bala (2005) [5] prepared amaranthus leaves powder (ALP), amaranthus flour (AF) and amaranthus protein concentrate (APC) and utilized for the preparation of *Noodles* by incorporation of different levels of AF (10, 20 and 30 per cent), APC (5, 10 and 15 per cent) and ALP (2, 4 and 6 per cent). She reported that amaranthus seeds had higher fat (5.02 per cent), protein (15.6 per cent), fiber (3.5 per cent) and minerals as compared to wheat, which contributed to the better nutritional profile of developed *Noodles.*

Sindhuja *et al*. (2005) [36] prepared cookies by incorporating amaranth seed (*Amaranthus gangeticus)* flour, which were rich in protein at 0–35% levels. Incorporation of amaranth flour improved the colour of the cookies from pale cream to golden brown. The cookies became crispier which was evident from the reduction in the breaking strength value from 6.2 to 4.02 kg. Considering the colour, taste, flavour, surface appearance of the cookies, 25% incorporation of amaranth flour was found to be optimum and most acceptable by the panellists. Cooked, extruded, and popped amaranth seeds had starch digestibility (92.4, 91.2, and 101.3, respectively) similar to that of white bread (83.39). It was revealed that replacement by 30% amaranth flour decreased overall acceptability scores of conventional cakes due to its lower specific volume and darker color. Amaranth flour levels had no significant effect on overall acceptability of reduced fat (RF) cakes. Hence, the sum of wheat flour and corn starch could be successfully replaced by up to 20% amaranth flour in conventional and up to 30% in reduced fat cakes without negatively affecting sensory quality in fresh cakes. Moisture losses for all the cakes were similar, per day during storage. After six days of storage, both conventional and reduced fat amaranth-containing cakes had higher hardness and chewiness values than control cakes (Capriles *et al*. 2008) [12].

Muyonga *et al.* (2008) [29] incorporated grain amaranth in commonly consumed snack foods by children in Uganda. Acceptable cakes and cookies were developed with amaranth making up to70% of the flour used. In other products such as *baggia* (a snack made by cold extrusion of dough followed by deep frying) and *kabalagala* (a snack made by rolling dough into a flat shape, cutting into a round shape and then deep frying), acceptable products were made with 100%amaranth flour. Mlakar *et al.* (2009) [27] investigated the baking potential of composite wholemeal amaranth flour and reported that at 10% substitution level, bread loaf volume was not negatively influenced and that texture and aroma were not impaired up to 30% substitution level. Also, it was reported that the addition of amaranth flour to common wheat, refined flour tended to stabilize dough and increase its resistance an increase in degree of softening with an increase in amaranth substitution, but a decrease in farinographic quality as amaranth substitution increased.

Schoenlechner *et al*. (2010) [34] investigated the use of amaranth, quinoa and buckwheat for the production of gluten-free pasta with good textural quality, in particular, low cooking loss, optimal cooking weight and texture firmness. Amaranth showed least suitability for pasta production as it lowered texture firmness and decreased cooking time and cooking tolerance. Pasta from quinoa were better agglutinated, but showed increased cooking loss. Amaranth flour had 8.42% moisture, 14.13% protein, 6.98% fat 2.32% and 2.29% crude fibre and the substitution of wheat flour by amaranth and/or quinoa seeds flours resulted in the changes in rheological properties of dough and test bread quality parameters (volume, crumb firmness). The addition of 30% amaranth flour in bread caused important quality deterioration in comparison to wheat bread. The results suggest that purpose of amaranth and/or quinoa used in bread making was primarily to increase the nutritive value (Tomoskozi *et al.* 2011) [38]. Emire and Arega (2012) [15] developed value added products from blends of amaranth flour with wheat flour. They concluded that the flour blend containing up to 10% of amaranth and baked at 220 C for 18 min. can be used in industrial bread production. They found that protein, fat, ash, iron, zinc, phosphorous and calcium contents in the blends increased significantly with an increase in amaranth substitution. The amaranth flour substitution of 5 to 30% increased water absorption and quality of the dough. Lemos *et al*. (2012) [22] evaluated the effect of incorporation of whole amaranth flour on the physical properties and nutritional value of cheese bread. Amaranth flour was incorporated at 10, 15, and 20% proportions in different formulations. Increasing amaranth levels darkened the product, reduced specific volume, and increased compression force. Bread with 10% amaranth flour exhibited slight differences in physical properties compared with the controls. These results demonstrated the possibility of incorporating 10% of whole amaranth flour in the formulation of cheese bread.

Yamani *et al*. (2012) [39] studied that amaranth contained 40% albumins, 20% globulins, 25 - 30% glutelins, and 2 – 3% prolamins .They reported that amaranth had 14.80% protein, 8.81% fat, 3.9% crude fibre, 3.25% ash and 11.14% dietary fibre.

Cabrera-Chavez *et al. (*2012) [11] reported that Amaranth seeds (*Amaranthus hypochondriacus*) were a mixture of organically grown commercial and non-commercial varieties milled just prior to use into amaranth flour ,25 parts of amaranth flour were mixed with 75 parts of rice flour to prepare amaranth-enriched pasta. This mixture of flours contained: 73.7 g total starch; 6.0 g damaged starch; 12.9 g protein; 2.9 g lipids; 1.3 g ash; 5.3 g fiber, in 100 g dry matter.

Emire *and Arega* (2012) [15] used amaranth flour for development of value added bread from blends of amaranth flour with wheat flour in various levels like 5%, 10% and 15%. The 10% amaranth bread baked at 220 ℃ for 18 min scored the highest overall sensory attributes and was accepted by panelists.

Sanz- Penella *et al.* (2013) [33] investigated the effect of replacing wheat flour by whole *Amaranthus cruentus* flour (up to 40 g/100 g) to evaluate its potential utility as a nutritious breadmaking ingredient. The incorporation of amaranth flour significantly increased protein, lipid, ash, dietary fibre and mineral contents. An increase in crumb hardness and elasticity was observed, and tristimulus colour values were significantly affected when the amaranth concentration was raised. Thus, the inclusion of amaranth flour could be limited to a maximum proportion of 20 g/100 g, thereby maintaining both product quality as well as the nutritional benefit of this ingredient.

Fiorda *et al*.(2013) [17] found that vermicelli-type pasta in the proportion of 10:60:30 (pre-gelatinised flour:cassava starch:amaranth flour) showed the best results in the quality tests, with a cooking time of 3 min, mass increase of 101.5% and 0.6% solids loss to the cooking water, superior to the commercial pasta. Acceptance testing showed that this was a very good pasta (score of 7.2 on a 9-point scale) and obtained 42% buying intention amongst the consumers.

Mugalavai (2013) [28] prepared the u*gali* and *Porridge by* composites with 100: whole amaranth flour., 80:20 whole amaranth flour: whole maize meal flour, 70:30 whole amaranth flour: whole maize meal flour, 60:40 whole amaranth flour: whole maize meal flour, 50:50 whole maize meal: whole amaranth flour They found (80:20) were the most acceptable.

Mugalavai (2013) [28] determined the functional properties and culinary characteristics (colour, texture, flavour) of commonly consumed products (*ugali* and *porridge*) which were made in varying treatments of amaranth flour: maize meal flour (100:00; 80:20; 70:30; 60:40; 50:50). The *porridge* and *ugali* composites with high amounts of amaranth grain flour (80:20) were the most acceptable, and from the nutritional point, the most nutritious.

Shyam *et al.* (2013) [35] prepared cakes from blends containing varying proportions (20, 40, 60, 80 and 100 per cent) of amaranth flour, using the sponge cake method. The overall acceptability scores of 40 per cent amaranth flour cakes were maximum and more than control for cakes (8.3). They reported 40% amaranth flour cakes had 377 kcal., 9.14% protein, 18.77% fat, 39.80% carbohydrates, 178.87 mg/100g calcium and 2.36 mg/100g iron.

Breshears *et al*. (2013) [8] developed a nutrient-dense gluten-free bread (GFB) using either amaranth or Montina flour in a standardized gluten-free lean bread recipe for the purpose of comparing the nutritional, sensory attributes. Nutritionally, both developed breads provided at least 26% more iron than the commercial GFB and 40% more fiber while the amaranth bread provided twice as much folate. Significant differences ($p < 0.05$) in sensory attributes (appearance, texture, flavor, tenderness, and overall acceptability) of both amaranth- and Montina-based breads were not reported between the groups.

Rubio *et al.* (2014) [32] prepared gluten free pasta by using 90% amaranth flour blend and 10% semolina, and they found amaranth flour blend was suitable for increasing the nutritional quality through high quality protein and even to obtain gluten-free pasta with acceptable cooking quality. Pasta had 7% moisture, 16.2% protein, 0.4% fat and 75.9% carbohydrates.

Filipcev (2014) [16] prepared breads by substitution of 10% or 20% amaranth in various forms: steamed and non steamed raw amaranth flour, steamed and non steamed milled popped amaranth and steamed popped amaranth Samples containing 20% steamed popped amaranth flour, 10% and 20% popped amaranth flour and 10% steamed amaranth flour had significantly lower specific volume than the control. Only the addition of 10% raw amaranth flour or steamed whole popped grains resulted in a significantly higher specific volume. In relation to the control, significantly softest crumb was presented by samples containing 20% raw amaranth flour and 10% steamed whole popped grains whereas significantly harder crumb was observed in breads with popped flour (10, 20%), 10% steamed flour and 20% steamed popped flour.

Rozylo *et al*. (2015) [31] described the changes in the physical properties of bread caused by the addition of fresh or freeze-dried amaranth sourdough. Control gluten-free bread was prepared from corn, rice and amaranth flour in two variants (45:45:10% and 40:40:20%). Amaranth flour was substituted with fresh or freeze-dried sourdough. Sensory evaluation of bread showed that bread with 20% amaranth sourdough is characterized by an unfavourable taste and smell; however, gluten-free bread with 10% amaranth sourdough was accepted by consumers.

Jain and Grewal (2015) [20] developed the value added extruded snacks by incorporating amaranth flour (raw and roasted) at 20, 40 and 60%, amaranth protein concentrate (APC) at 10, 20 and 30% and guar gum at 0.5 and 1.0% to the standardized mixed cereal flour composition, prepared with maize: rice: wheat (80:10:10) extruded at moisture content 12% and feed rate 13 kg/hr (control). Developed snacks were evaluated for physical properties, functional characteristics, sensory attributes and proximate composition. They found that, incorporation of higher level of amaranth flour and amaranth protein concentrate in the mixed cereal formulation increased the solubility index, bulk density and hardness and decreased the absorption index, expansion ratio and sectional expansion index of extrudates RTE snacks containing 20% APC, 40% raw or 60% roasted amaranth flour were adjudged 'liked very much' by the judges.

Bhat *et al.* (2015) [6, 9] prepared fortified cookies by using 7% amaranth flour, 7% refined wheat flour and 18%. oats . The parameters like taste, colour and the crunchiness of the cookies were evaluated for sensory analysis to understand the consumer acceptability of the product. The average score for taste was observed to be 9, indicating 'like extremely'. While for colour, it was estimated to be 7 indicating 'like moderately' and for the crunchiness of the biscuits an average of 9 was evaluated which indicated 'like very much'.

Chauhan *et al.* (2016) studied physical, textural, and sensory characteristics of wheat and amaranth flour blend cookies. They revealed that the amaranth flour is a good source of protein, fiber, and fat as compared with wheat flour. The physical properties of the amaranth-enriched cookies were affected in a positive way by demonstrating a decrease in bake loss, an increase in diameter, a higher spread ratio, and lesser hardness, leading to softer eating characteristics which are required in cookies. Colour characteristics of the cookies were significantly influenced by the addition of amaranth flour. The amaranth-formulated cookies up to 60% were well accepted by their sensory characteristics. So, the use of amaranth flour in cookie was effective for technological and nutritional advantages of cookies.

Martinz *et al*. (2016) investigated technological and sensory quality of pasta made from bread wheat flour substituted with wholemeal amaranth flour (*Amaranthus mantegazzianus*) at four levels, 15, 30, 40 and 50% w/w. The quality of the resulted pasta was compared to that of control pasta made from bread wheat flour. The flours were analysed for chemical composition and pasting properties. The pasta obtained from amaranth flour showed some detriment of the technological and sensory quality. So, a maximum substitution level of 30% w/w was defined.

2. References

1. Adeniyi PO, Obatolu AV. Effect of Germination Temperature on the Functional Properties of Grain Amaranthus. American Journal of Food Science and Technology. 2014; 2:76-79.
2. Jubete AL, Arendt EK, Gallagher E. Nutritive value and

chemical composition of pseudocereals as gluten-free ingredients. International Journal of Food Science and Nutrition. 2009; 60(1):240-257.
3. Jubete AL, Holse M, Hansen A, Arendt EK, Gallagher E. Impact of baking on the vitamin E content of the pseudocereals amaranth, quinoa and buckwheat. Cereal Chemistry. 2009; 86(5):511-515.
4. Jubete AL, Wijngaard HH, Arendt EK, Gallagher E. Polyphenol composition and *in-vitro* antioxidant activity of amaranth, quinoa and buckwheat as affected by sprouting and bread baking. Food Chemistry. 2010; 119(2):770-778.
5. Bala K. Utilization of amaranth for value added biscuits and noodles. Project report submitted to CCS, Haryana Agricultural University, 2005
6. Bhat A, Satpathy G, Gupta RK. Evaluation of Nutraceutical properties of *Amaranthus hypochondriacus* L. grains and formulation of value added cookies. Journal of Pharmacognosy and Phytochemistry. 2015; 3(5):51-54.
7. Bodroza-Solarov B, Filipcev Z, Kevresan A, Mandic, O Simurina. Quality of Bread Supplemented with Popped *Amaranthus cruentus* Grain. Journal of Food Processing Engineering, 2007; 31(5):602- 618
8. Breshears Kl Crowe KM. Sensory and Textural Evaluation of Gluten-Free Bread Substituted With Amaranth and Montinaâ Flour. Journal of Food Research. 2013; 2(4):1-10.
9. Bhat A, Satpathy G, Gupta RK. Evaluation of Nutraceutical properties of *Amaranthus hypochondriacus* L. grains and formulation of value added cookies. Journal of Pharmacognosy and Phytochemistry. 2015; 3(5):51-54.
10. Burgos VE, Armadai M. Characterization and nutritional value of precooked products of kiwicha grains (*Amaranthus caudatus*). Food Science and Technology, 2015; 35(3):531-538.
11. Cabrera-Chavez F, Calderon de la Barca AM, Islas-Rubio AR, Marti A, Marengo M, Pagani MA. Molecular rearrangements in extrusion processes for the production of amaranth-enriched, gluten-free rice pasta. Journal of Food Science and Technology. 2012; 47:421-426.
12. Capriles VD, Coelho KD, Guerra-Matias AC, Arêas JAG. Effects of Processing Methods on Amaranth Starch Digestibility and Predicted Glycemic Index. Journal of Food Science. 2008; 73(7):160-164.
13. Chauhan A, Singh S. Influence of Germination on Physico – chemical Properties of Amaranth (*Amaranthus Spp.*) Flour. International Journal of Agriculture and Food Science Technology. 2013; 4(3):215-220.
14. Dodok L, Modhir AA, Halasova G, Polacek I, Hozova B. Importance and utilization of amaranth in food industry Part I. Characteristic of grain and average chemical constitution of whole amaranth flour, 2006.
15. Emire SD, Arega M. Value added product development and quality characterization of amaranth (*Amaranthus caudatus* L.) grown in East Africa. African Journal of Food Science and Technology. 2012; 3(6):129-141.
16. Filipcev BV. Texture and stress relaxation of spelt-amaranth composite breads. Food and Feed Research. 2014; 41(1):1-9.
17. Fiorda FA, Júnior MSS, Silva FA, Souto LRF, Grosmann MVE. Amaranth flour, cassava starch and cassava bagasse in the production of gluten-free pasta: technological and sensory aspects. International Journal of Food Science and Technology. 2013; 48(9):1977-1984.
18. Gamel TH, Linssen JP, Mesallem AS, Damir AA, Shekib LA. Effect of seed treatments on the chemical composition and properties of two amaranth species: starch and protein. Journal Food Science and Agriculture. 2005; 85:315-327.
19. Gamel TH, Linssen JPH, Mesallam AS, Damir AA, Shekib LA. Effect of seed treatments on the chemical composition of two amaranth species: oil, sugars, fibres, minerals and vitamins. Journal Science of Food and Agriculture. 2006; 86:82 - 89.
20. Jain A, Grewal RB. Development and quality evaluation of value added extruded snacks by supplementing Amaranth and Guar gum in mixed cereal flour formulation constituting maize, rice and wheat. International Journal of Recent Scientific Research. 2015; 6(9):6221-6227.
21. Kaur S, Singh N, Rana JC. *Amaranthus hypochondriacus* and *Amaranthus caudatus* germplasm: characteristics of plants, grain and flours. Food Chemistry. 2010; 123:1227-1234.
22. Lemos ADR, Capriles VD, Silva MEMPS, Areas JAG. Effect of incorporation of amaranth on the physical properties and nutritional value of cheese bread. Ciênc. Tecnology Aliment. 2012; 32(3):427-43.
23. Martinez CS, Ribotta PD, Leon AE, Anon MC. Effect of amaranth flour (*Amaranthus mantegazzianus*) on the technological and sensory quality of bread wheat pasta. Food Science and Technology International. 2016; 127-135.
24. Mburu MV, Gikongo NK, Kenji GM, Nwasaru AM. Nutritional and functional properties of a complimentary food based on Kenyan amaranth grain (*Amaranthus cruentus*). African Journal of Food, Agriculture Nutrition and Development. 2012; 12(2):122-128.
25. Mburu M, Gikonyo N, Kenji G, Mwasaru A. Properties of a complementary food based on Amaranth grain (*Amaranthus cruentus*) grown in Kenya. Journal of Agric, Food Technology, 2011; 9:153-178.
26. Menegassi B, Pilosof AMR, Arêas JAG. Comparison of properties of native and extruded amaranth (*Amaranthus cruentus*, Alegria) flour. Food Science and Technology. 2011; 44(9):1915-1921.
27. Mlakar SG, Turinek M, Jakop M, Bavec M, Bavec F. Nutrition value and use of grain amaranth: potential future application in bread making. University of Maribor, Faculty of Agriculture and Life Sciences, Pivola 10, 2311.Hoce, Slovenia. Agriculture. 2009; 6:43-53.
28. Mugalavai VK. Effect of amaranth: maize flour ratio on the quality and acceptability of Ugali and *Porridge* (Kenyan Cereal Staples). Journal of Agricultural and Biological Science. 2013; 8:6-12.
29. Muyonga JH, Nabakabya D, Dorothy N, Nakimbugwe L, Masinde D. Efforts to promote amaranth production and consumption in uganda to fight malnutrition. International Union of Food Science and Technology. 2008; 5:1-10.
30. Resio ANC, Roberto J, Aguerre B. Analysis of simultaneous water absorption and water–starch reaction during soaking of amaranth grain. Journal of Food Engineering. 2005; 68:265-270.
31. Rozylo R, Dziki D, Gawlik-Dziki U, Cacak-Pietrzak G, Mis A, Ruby S. Physical properties of gluten-free bread caused by water addition. Int. Agrophys. 2015; 29:353-

364.
32. Rubio AR, Barca AMCDL, Cabrera-Chavez F, Cota-Gastélum AG, Beta T. Effect of semolina replacement with a raw: popped amaranth flour blend on cooking quality and texture of pasta. Journal of Food Science and Technology. 2014; 57:217-222.
33. Sanz-Penella JM, Wronkowska M, Soral-Smietana M, Haros M. Effect of whole amaranth flour on bread properties and nutritive value. Journal of Food Science and Technology. 2013; 50:679-685.
34. Schoenlechner R, Mandala I, Kiskini A, Kostaropoulos A, Berghofer E. Effect of water, albumen and fat on the quality of gluten-free bread containing amaranth. International Journal of Food Science & Technology. 2010; 45:661-669.
35. Shyam SR, Raghuvanshi RS. Standardization of Cakes by using Different Levels of Amaranth Flour and its Acceptability. International Journal of Science and Research. 2013; 4(6):1859-1861.
36. Sindhuja A, Sudha ML, Rahim A. Effect of incorporation of amaranth flour on the quality of cookies. European Food Research Technology. 2005; 221:597-601.
37. Srivastava R, Roy BK. Effect of varying pH on protein composition and yield of amaranth seed (*Amaranthus blitum*). Journal of Environmental Biology. 2011; 32:629-634.
38. Tomoskozi S, Gyenge L, Pelceder A, Abonyi T, Schonlechner R, Lasztity R. Effects of Flour and Protein Preparations from Amaranth and Quinoa Seeds on the Rheological Properties of wheat-flour dough and bread crumb. Journal of Food Science. 2011; 29(2):109-116.
39. Yamani BV, Lannes SCS. Applications of Quinoa (*Chenopodium quinoa* Willd.) and Amaranth (Amaranthus Spp.) and Their Influence in the Nutritional Value of Cereal Based Foods. Food and Public Health. 2012; 2(6):265-275.
40. Zapotoczny P, Markowsk M, Majewska, K, Ratajski, A, Konopko, K. Effect of temperature on the physical, functional, and mechanical characteristics of hot-air-puffed amaranth seeds. Journal of Food Engineering, 2006; 76(4):469-476.