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Assessment of functional properties of amaranth seed flour

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Abstract
Presently amaranth is considered to be an alternative crop and researchers all over the world have focused on improving agronomic features of the crop as well as techniques used for processing the pseudo-cereal. Functional properties of cereal play very important role in food production. This study evaluated parameters of functional properties such as water and oil absorption capacity, foaming capacity and stability and least gelation concentration of amaranth seed flour were analyzed. The functional properties of raw amaranth flour indicate its suitability for use as a substitute for other flour based food products commonly consumed by Indians, which in turns provides wide scope of its utilization in food industry.

Keywords: Amaranth seed flour, water and oil absorption capacity, least gelation concentration, foaming capacity and stability

Introduction

Grains have generally been classified as either cereal or legume grains. Amaranth seeds are classified as pseudocereals. Amaranth seeds are gaining popularity in some countries because of their high nutritional value and properties which can be used as substitute of cereals. Pseudocereals are seeds or fruits of plants consumed as cereal grains, but are not derived from grasses (Gordon, 2006) [8]. Amaranth originated in the Americas, and has been cultivated for more than 8,000 years (Yarger, 2008) [30]. *Amaranthus L*. species have about 60 varieties on the American continent, and *Amaranthus caudatus, Amaranthus hypochondriacus and Amaranthus cruentus* are the most important varieties (Kram and Szot, 1999) [13]. The seeds are small and mostly spherical, and majorly classified as grain-type or vegetable-type seeds. Amaranth seed colour varying from off white to pale pink but mostly seed of the grain type has a pale colour, while the seed of the vegetable type is black and shiny. Both types of seed are consumable and can be substitute as flour sources (Yarger, 2008) [30]. The seeds have been reported to be drought tolerant and highly adaptable to the tropics as a potential crop for improving food availability and food security in sub-Saharan Africa (Piha, 1995) [20].

Amaranth grains can be milled into flour, or popped like pop corn (Ronoh *et al*. 2009; Yarger, 2008) [22, 30]. Its high protein content, reported to be about 16 to 18 per cent has attracted increasing interest by the international community (Ronoh *et al.* 2009) [22], and it's have complete essential amino acid patterns predict its high protein quality (Mugalavai, 2013) [15]. Amaranth protein is rich in lysine (exogenous amino acids), contains significant amounts of iron, calcium, B vitamins, vitamin A, E and C (Kram and Szot, 1999) [13]. The environmental adaptability and nutritional composition of amaranth grain are quality attributes that can be used to attract and promote the utilization of the grain in India, especially by the vulnerable groups (women and children), to help sustain nutrition security.

The study investigates physical and functional properties of amaranth seed and flour. As physical and functional properties like water absorption capacity, bulk density and oil absorption capacity are not so valuable at home scale level but, very important for commercial production. Bulk density is important in terms for 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 act as a sponge in the intestinal tract, swells as they absorb water, toxins, waste material and have laxative action. It also reduces the calorie value of products. Less oil absorption capacity will help to produce products that absorb less amount of oil in preparation for example addition of wheat bran in products like potato chips, tend to absorb less amount of oil (Iyer, 1997) [9]. These properties are useful in making compatible application of flour for a specific product. This reduces processing losses and helps in improving the overall quality of product. Physical and functional properties are affected by some factors such as size, form and moisture content of the grain.

Materials and Methods

Amaranth seed was purchased from local market along with other materials in bulk to avoid varietal difference.

Preparation of grain amaranth flour

The amaranth seeds were properly cleaned, winnowed and sorted manually for removal of stones, sand and all forms of dirt. The grains were then finely ground using a mill followed by sieving. The flour was packaged in a well-sealed low density polyethylene bag for analysing functional properties.

Functional properties

Water absorption capacity

The water absorption capacity was determined by the method of Sosulski *et al.* (1976) [28]. The amaranth sample (1.0g) was mixed with 10ml distilled water kept at ambient temperature for 30 min and centrifuged for 10 min at 2000 rpm. Excess water was decanted and each sample was allowed to drain by inverting the tube over absorbent paper. Water absorption capacity was expressed as percent water bound per gram of the sample.

$$\text{Water Absorption Capacity} = \frac{\text{Weight of sample after centrifugation} - \text{Weight of sample before centrifugation}}{\text{Weight of sample taken(g)}} \times 100$$

Oil absorption capacity

The oil absorption capacity was determined by the method of Sosulski *et al.* (1976) [28]. The amaranth sample (1.0g) was mixed with 10ml refined soybean oil kept at ambient temperature for 30 min and centrifuged for 10 min at 2000 rpm. Excess oil was decanted and each sample was allowed to drain by inverting the tube over absorbent paper. Oil absorption capacity was expressed as percent oil bound per gram of the sample.

$$\text{Oil absorption capacity} = \frac{\text{Weight of sample after centrifugation} - \text{Weight of sample before centrifugation}}{\text{Weight of sample taken(g)}} \times 100$$

Least gelation concentration

The least gelatinization concentration was determined using method of Coffmann and Garciaj (1977) [6] the flour dispersions of 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34 per cent (w/v) prepared in 5 ml distilled water were heated at 90 °C for 1 hour in water bath. The contents were cooled under tap water and kept for 2 hour at 10 °C. The least gelation concentration was determined as that concentration when the sample from inverted tube did not slip.

Foaming capacity

Foaming capacity was determined as described by Narayana and Narsingha (1982) [16]. One gram amaranth seed flour sample was added to 50 ml distilled water at 30° C in a graduated cylinder. The suspension was mixed and shaken for 5 minutes to foam. The volume of foam after whipping for 30 seconds was expressed as foaming capacity.

$$\text{Foaming capacity} = \frac{\text{Volume of Foam (AW)} - \text{Volume of Foam (BW)}}{\text{Volume of Foam (BW)}} \times 100$$

Where, AW = after whipping, BW = before whipping, FC = Foaming capacity

Foaming stability

$$\text{Foaming stability} = \frac{\text{Foam volume after 1 hour of whipping}}{\text{Foam volume after whipping}} \times 100$$

Result and Discussion

Functional properties of amaranth seed flour

The functional properties are the properties of flours that primarily determine their utilization in different food products. Functional properties such as water and oil absorption capacities, swelling capacity, foaming capacity and stability, dispersibility, least gelation concentration and wettability are performed to judge the quality of raw material. These properties are useful in making compatible application of flour for a specific product. This reduces processing losses and helps in improving the overall quality of product. Results regarding functional properties of amaranth seed flour are presented in Table 1.

Table 1: Functional properties of amaranth seed flour

S. No.	Functional Properties	Mean ± SD
1.	Water absorption capacity (%)	134.02±0.02
2.	Oil absorption capacity (%)	143.62±0.01
3.	Least gelation concentration (w/v)	11.01±0.03
4.	Foaming capacity (%)	13.72±0.01
5.	Foaming stability (%)	85.16 ±0.02

Water absorption capacity

Water Absorption Capacity (WAC) is amongst the important functional properties for additives supplemented in food systems. The water and oil absorption capacities are essential functional properties of protein which may be defined as the amount of water or oil retained by a known weight of flour under specific conditions. Capillary, pore size and the charges on the protein molecules affect the water holding capacity. This is due to strong correlation of extent of protein hydration with polar constituents along with the hydrophilic interaction through hydrogen bonding. The higher protein content in the flour might be responsible for high hydrogen bonding and high electrostatic repulsion (Altschul and Wilcke, 1985) [4].

Water absorption capacity is the ability of the flour to associate with water under a condition where water is limiting, which is mainly dependent on proteins at room temperature (Otegbayo *et al.* 2013) [18], and to a lesser extent on starch and cellulose.

The water absorption capacity is the ability of the flour to hold water against gravity wherein proteins and carbohydrates enhance the water absorption capacity of flour by providing hydrophilic parts like polar and charged side chains (Pomeranz, 1985) [21].

Table 1 data shows water absorption capacity of amaranth seed flour was 134.02 per cent which is quite close to value quoted by Sindhu and Khatkar (2016) [25] and higher than results of Aseniyi and Obatolu (2014) [5] reported 107 per cent for *A. hypochondricus* while Shevkani *et al.* (2014) [23] observed water absorption capacity of flour in the range of 209-243 per cent for same variety of amaranth, similarly Tanimola *et al.* (2016) [23] reported 1.60(g/g) WAC in amaranth seed flour.

The water absorption capacity of amaranth seed flour in present investigation was comparable with the soybean (130%) and chick pea (133 to 147%), and lower than dry bean (223 to 265%) reported in literature (Oshodi and Ekperigia, 1989; Kaur and Singh, 2005; Siddiq *et al.* 2010) [17, 24].

Oil Absorption Capacity (OAC)

Oil Absorption Capacity (OAC) increases the palatability of foods and critical assessment of flavor retention (Kinsella, 1976) [28]. The oil absorbing capacity is the ability of the flour mix protein to absorb and retain oil, which in terms influence the texture and mouth feel of food products like baked goods and doughnuts.

In this study oil absorption capacity of raw amaranth seed flour was found to be 143.62 per cent that was comparable with the results of Khan and Dutta (2018), Pachelo de Delahaye (1987) [19] and Sindhu and Khatkar (2016) [25] that was reported to be 138 per cent, 150 per cent and 144 per cent respectively.

Least Gelation Concentration (LGC)

Least Gelation Concentration (LGC) is considered as the gelling ability of flour which provide structural matrix for holding water and other water soluble materials like sugars and aromas. The LGC of different flours may vary depending on the relative ratios of different constituent like proteins, carbohydrates and lipids. It also serves as a good binder or provides consistency in food preparations especially the semi-solid products (Adeyemi and Umer, 1994) [2]. The increasing concentration of proteins in the flour facilitates the gelation properties which may be due to the enhanced interaction among the binding forces (Lawal *et al.* 2004) [14]. Graves and Pockham (1996) reported that when starch mixture is added to cold water a small amount of water is absorbed, causing a reversible swelling. But when it is heated, the water begins to penetrate the starch granules in quantity, causing them to swell and loss their birefringence. The loss of birefringence occurs as the molecular order is changed and the starch is solubilized. The term gelation is used to describe this gradual process. Continued heating of the starch grains (pasting) causes them to swell enormously and soften, forming a paste. The combination of gelatinization and pasting transforms the temporary suspension of starch grains into a more permanent one in which the swollen starch grains are suspended in hot water. This process can occur within a food. The result of LGC of amaranth seed flour was 11 per cent w/v as presented in Table 1 and it's in line with result (10% w/v) reported by Singhal and Kulkarni, (1991) [26].

Foaming Capacity and Foaming Stability (FC & FS)

Foam is a colloid of many gas bubbles trapped in a liquid or solids, small air bubbles are surrounded by thin liquid films. Foam can be produced by whipping air in to liquid as much and fast as possible (Siwaporn *et al.* 2008) [27].

Flours are capable of producing foams because proteins in flours are surface active. Soluble proteins help to reduce surface tension at the interface between surrounding liquid and air bubbles. Thus, the coalescence of the bubbles is obstructed. In addition, protein molecules can unfold and interact with one another to form multilayer protein films with an increased flexibility at the air-liquid interface. It's very difficult for air bubbles to break, and the foams are more stabilized (Adebowale and Lawal, 2005).

Foaming capacity is related to the proteins ability to rapidly diffuse to the interface, reorient, and form a viscous film without excessive aggregation or coagulation, whereas foaming stability is influenced by intermolecular cohesiveness and viscosity of this interfacial film as well as a certain degree of elasticity permitting localized contact deformation (Kinsella, 1981) [12].

In the present study foam capacity and foam stability of raw amaranth seed flour was observed to be 13.72 per cent and 85.16 per cent respectively which is comparable to the results quoted by Shevkani *et.al*. (2014) [23]. According to them the foam capacity of raw amaranth flour ranged from 15 to 30 per cent and foam stability ranged from 30 to 90 per cent for different varieties of amaranth seeds. Amaranth proteins have turned more soluble with better foaming properties upon enzymatic hydrolysis (Condes *et al.* 2009).

There was an inverse relationship between foam capacity and foam stability. Flours with high foaming ability could form large air bubbles surrounded by thinner and a less flexible protein film. These air bubbles might be easier to collapse and consequently lowered the foam stability (Jitngarmkusol *et al.* 2008) [10]. Shevkani *et al.* (2014) [23] reported that there was significant difference in the foaming capacity of whole wheat flour (12.16 per cent) and raw amaranth flour (23.59 per cent). Foaming stability of whole wheat flour and amaranth flour was found to be 90.43 per cent and 90.02 per cent respectively. Foam stability is important since success of any whipping agent depends on its ability to maintain the whip as long as possible. Food ingredients with good foaming capacity and stability can be used in bakery products (Akubor *et al.* 2000).

Conclusion

This study concluded that amaranth seeds possess remarkable functional properties as a pseudo-cereal. The functional properties of amaranth grain flour showed its suitability for use as a substitute for other pastes commonly consumed by people as a staple food or in different forms. Hence, a variety of innovative bakery food products as well as pre-mixes can be developed by using amaranth flour to suit the consumer needs.

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