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Physical and Physiochemical Properties of the Fresh and Roasted *Amaranthus viridis* L. – A Comparative Study

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Abstract

This study provides insights about the impact of heat on the anti-nutrients and functional groups present in the amaranth seeds. Fresh amaranth seeds were obtained, cleaned, washed, dried, grind and sieved to obtain a fine flour (powder). The 1000 grain weight of the fresh and roasted amaranth seeds are found to be 0.69g and 0.68g respectively. The angle of repose was found to be 26.73° in fresh amaranth seeds and 28.93° in roasted amaranth seeds showing excellent flow properties. The bulk density, true density and porosity is found to be 491.78kg/m^3, 1965kg/m^3 and 74.97% in fresh amaranth seeds and 552.75kg/m^3, 1904kg/m^3 and 70.97% in roasted amaranth seed flour respectively helping in optimum storage, processing and shelf-life. The functional groups are estimated and compared. The anti-nutrients such as oxalate, phytate and tannin are compared in fresh amaranth seeds as 544.0mg/100g, 1791.00mg/100g and 607.00mg/100g whereas after roasting it is reduced to 263.00mg/100g, 1279.00mg/100g and 573.00mg/100g respectively.

Key words : Pseudomillet, Amaranth seeds, Physical parameters, Anti-Nutrients, Functional groups.

Amaranth grain belonging to the Amaranthaceae family, recognized as a pseudo-millet or pseudocereals has gained more interest in recent years due to the exceptional nutritional profile. It is considered as a pseudocereal or pseudomillets due to its similarity in cooking properties, flavour and dense nutritional profile. The word amaranth is derived from the Greek word 'Amarantos' meaning 'the one that doesn't wither' or 'the

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never fading flower'. Currently it is widely cultivated and consumed in India, China, Nepal, Malaysia, Indonesia, Mexico, Central America, Southern and Eastern Africa. It is consumed as leafy vegetables and pseudomillet (pseudocereal). They are highly resistant to drought and salinity stress and can adapt to any environmental, soil and climate conditions and grow well in high nitrogenous soil.

Amaranth grains are exceptionally gaining popularity for its gluten-free ability. It is easily digestible serving as a good option for individuals with digestive issues (celiac disease) or for younger children. These provides energy, good source of dietary fibers, are high in protein, well balanced amino acid especially lysine, has several antioxidants, lipids with high unsaturated fats, essential micronutrients like vitamins and various minerals such as iron, phosphorus, magnesium, copper and notably manganese and vivid bioactive components such as polyphenols, squalene, flavonoid (rutin), saponins, phytosterols, betaxanthins, betalains, tocotrienols, antimicrobial peptides and fagopyritols. Due to the presence of these components, it exhibits anti-oxidant potential, anti-inflammatory properties, antitumor activity, hypolipidemic efficacy, anticancer activity, antidiabetic effect, hepatoprotective effect and neuroprotective activity.

Common products made from amaranth grains includes flour, flakes, porridge and oil. It is also considered as a cooking oil due to its stability and its ability to not react easily. It plays a vital role as a flour in baking industry to make gluten-free bakery foods by mixing amaranth flour with wheat. Popped amaranth seeds are used to make candies, snack cakes and molasses.[1,2,3]

Design of the study :
Sample selection and procurement :

The fresh, clean, certified amaranth seeds were selected based on the uniformity in its size and shape, consistent colour based on the variety and the seeds that are free from dirt, broken particles and other debris. Such type of amaranth seeds is procured from the local market as it is convenient for the researcher.

Authentication of the Amaranth grains :

The procured amaranth seeds were sowed, grown into a plant and where tested and obtained an authentication certificate from the BSI (Botanical Survey of India), Tamil Nadu Agricultural University (TNAU), Coimbatore, Tamil Nadu. It is identified by the botanist as *Amaranthus viridis* L. of Amaranthaceae family.

Physical Parameters of the Fresh and Roasted Amaranth seeds (flour) :

The physical properties of the amaranth seed is measured to determine its optimum processing, handling and storage. These are generally small, lenticular shaped seeds which has a diameter around 1–1.5mm, an average weight ranging from 0.6–1.3 mg per seed and the average height ranges from 1.0 and 2.0mm. There are vivid variety of plants from bushy to lateral shoots with creeping stems, based on which the variety is identified which in-turn gives different variety of seeds, stems and leaves for consumption. The colour of the seeds can be white, yellow, brown or completely black based on the variety[2].

1000 grain weight :

It is measured to know the size and uniformity of the amaranth seeds. Around 100 amaranth grains are randomly selected and is weighed in an electronic balance (digital) which has an accuracy of 0.001g and then the value is multiplied by 10 to obtain the 1000 grains mass. The process is repeated thrice and the average 1000 grain weight is estimated[3]. The 1000 grain weight of the fresh amaranth seed and the roasted amaranth seed is estimated and compared.

Angle of Repose :

The angle of repose shows the stability and flowability of the flour to check flow and clumping properties. The fresh amaranth flour and the dried amaranth flour is placed as a slanting pile on a uniform surface and the pile height and the radius is estimated to find the angle of repose in degrees and is then compared with the standard table[3]. The angle of repose is estimated in the fresh and the roasted amaranth grains and is compared.

$$\theta = \tan^{-1}(r/h)$$

Where,

θ = Angle of repose, degrees,

h = Height of cone formed, mm,

r = Radius of the base of the pile, mm.

Bulk Density (ρ_b) :

The bulk density is the ratio between the weight of the amaranth grains (flour) and the space (*i.e*) the volume it has occupied including the void space present in-between the grain (flour) particles. It helps in estimating the mixing and blending capability of the amaranth seed flour with other food ingredients, its flowing properties and the handling and storage conditions[3]. The bulk density of the fresh amaranth seed and the roasted amaranth seed is evaluated and compared.

$$\text{Bulk density} = \frac{\text{Weight of the flour}}{\text{Bulk volume of the flour}}$$

True Density (ρ_t) :

The true density is similar to that of the bulk density which is measured by defining the ratio between the weight of the amaranth grains (flour) and the space (*i.e*) the volume it has occupied which excludes the void spaces in-between the grain particles. It helps in determining the purity and consistency of the grains (flour) and helps in formulating the product. This also helps in understanding the behavior of the amaranth grains[3]. The obtained true density is compared in the fresh and the roasted amaranth grains.

$$\text{True density} = \frac{\text{Weight of the flour}}{\text{True volume of the flour}}$$

Porosity (ε) :

Porosity is the void spaces found in-between the amaranth grain (flour) particles where the particles are not occupied. In simple words it is the empty spaces within the bulk volume. It helps in understanding the texture, aeration and moisture absorbing capacity of the amaranth grain flour[3].

$$\varepsilon = (1 - \rho b / \rho t) \times 100$$

Processing the Amaranth Grains flour :

The procured amaranth seeds are first cleaned to remove any impurities like dirt, foreign or any undesirable particles, then it is washed with clean water, drained and then air dried to remove any excess water and making it shelf-stable before roasting. After which the seeds are roasted for few minutes or until it turns aromatic and emits a nutty flavour. The roasted amaranth grains are then ground into a fine powder using a stone grinder and is then sieved through a 60mm mesh to obtain a fine, uniform amaranth seed flour.

Physiochemical properties :

The physical and chemical properties of a certain (food) product combined together is known as the physiochemical properties. The functional groups and the anti-nutritional factors (oxalate, phytate and tannin) are estimated in the fresh and the roasted amaranth grain flour.

Analyzing the Anti-Nutritional factors :

Anti-nutrients are certain components present in the food products that interfere with or inhibit the absorption, utilization and digestion of certain nutrients in the body. These are commonly found in various legumes, cereals and some fruits and vegetables. It generally causes digestive discomfort and also lowers the bioavailability of the nutrients.

Fresh amaranth flour has a moderate level of oxalate, phytate and tannin. Oxalate binds with calcium and reduces its absorption, whereas phytate reduces the bioavailability of calcium, iron and zinc and tannin reduces the digestibility of protein and certain minerals. These anti-nutrients can be reduced using some of the methods such as soaking, boiling, sprouting, roasting and few other heating processes. The anti-nutrients such as oxalate, phytate and tannin are analyzed in the fresh and roasted amaranth grains flour.

Estimating the functional groups :

The functional groups are the chemical structure corresponding to a particular group of molecules present in the food. These impacts the chemical properties and behaviour in that particular food indirectly contributing to the flavour, texture and especially the nutritional value. Estimation of the functional groups helps in determining the method of cooking, processing techniques and the handling and storage. The functional group is estimated using Fourier Transform Infrared Spectroscopy (FTIR).

Statistical analysis :

Certain physical and the physiochemical properties value's measurements were conducted thrice and the mean values of the measurements were calculated along with the standard deviation.

Findings and Interpretation :

Physical Parameters of the Fresh and Roasted Amaranth seeds (flour) :

The physical parameters like 1000 grain weight, angle of repose, bulk density, true density and porosity are estimated and compared in the fresh and roasted amaranth

Table-1. Physical parameters measured in the Fresh and Roasted Amaranth seeds (flour)

S.No	Parameters	Measurements	
		Fresh Amaranth Flour	Roasted amaranth Flour
1	1000 grain weight	0.69±0.0083g	0.68±0.0531g
2	Angle of Repose	26.73°±0.94°	28.93°±0.04°
3	Bulk density	491.78kg/m^3	552.75kg/m^3
4	True Density	1965kg/m^3	1904kg/m^3
5	Porosity	74.97%	70.97%

seeds flour. The 1000 grain weight shows the mass of the grains, angle of repose of shows the flowing and clumping properties, whereas bulk density, true density and porosity helps in understanding the handling process, texture, moisture absorbing capability and storage.

From the Table-1, 1000 grain weight, Angle of Repose, Bulk density, True Density and Porosity are found to be 0.69g, 26.73°, 491.78kg/m^3, 1965kg/m^3 jnd 74.97% in fresh amaranth seed flour and 0.68g, 28.93°, 552.75kg/m^3, 1904kg/m^3 and 70.97% respectively. All these values shows that the grains have roasted to a optimum levels.

Physiochemical properties – A comparison:

The physiochemical properties such as anti-nutrients and functional groups present in the fresh and roasted amaranth seed flour which helps in understanding the impact of heat (roasting).

Analyzing the Anti-Nutritional factors :

Anti-nutrients are the components present in the food product that interferes with the absorption of certain nutrients in the body. Oxalate, Phytate and Tannins levels are estimated in the fresh and roasted amaranth seed flour and compared

Table-2. Comparison of Anti-Nutritional factors

S.No	Ingredients	Result (mg/100 g)		
		Oxalate	Phytate	Tannin
1	Fresh Amaranth seed flour	544.0	1791.0	607.0
2	Roasted Amaranth seed flour	263.0	1279.0	573.0

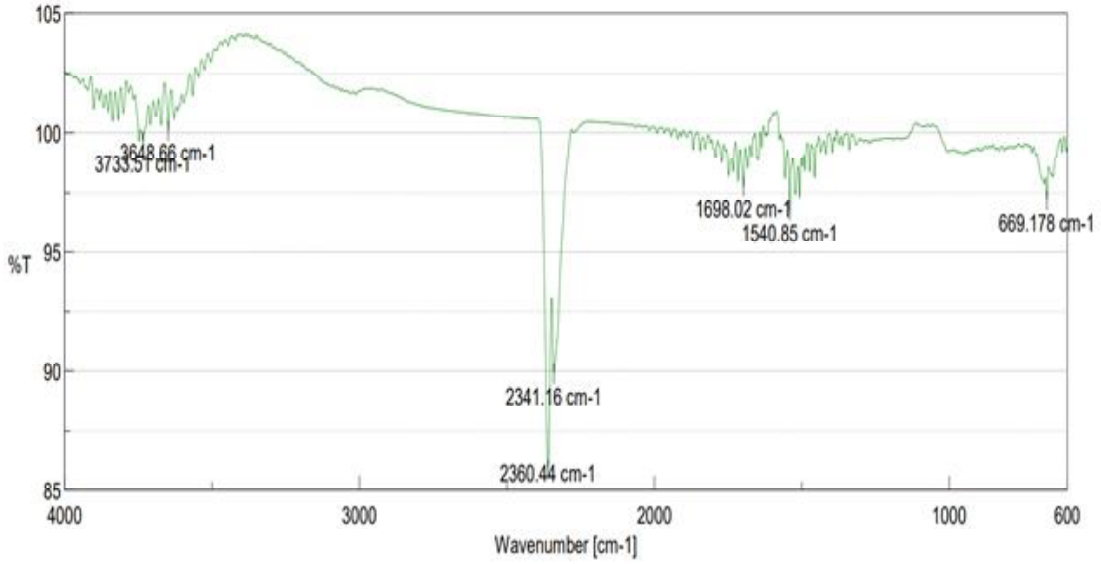

Figure 1 – Functional groups in Fresh Amaranth grain flour

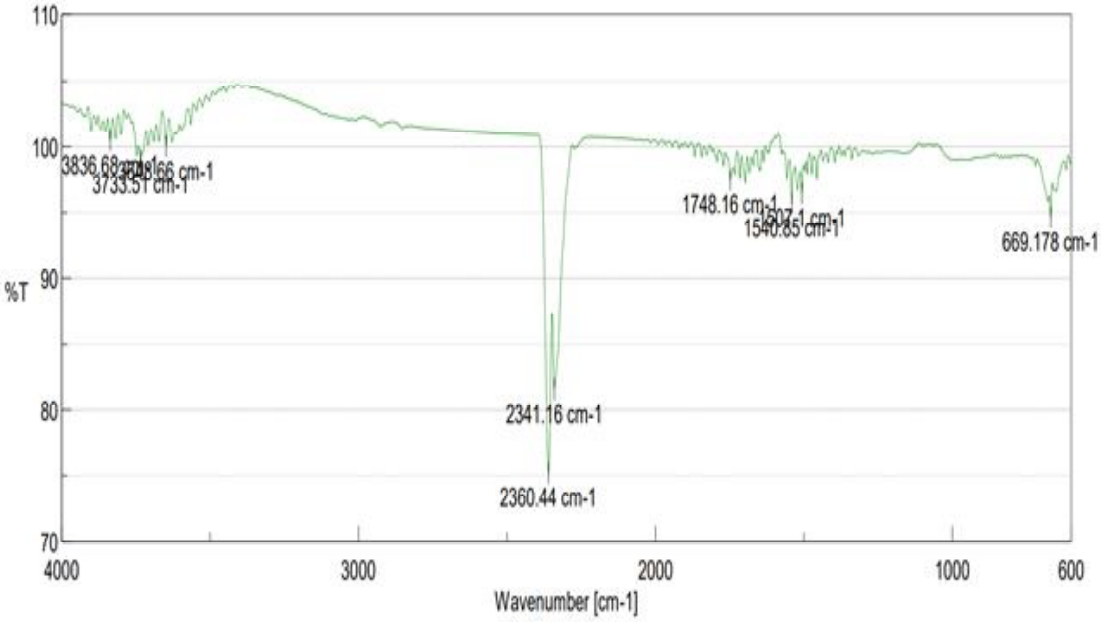

Figure 2 – Functional groups in Roasted Amaranth grain flour

From the above Table-2, the fresh amaranth seed flour has 544.0mg/100g of oxalate, 1791.00mg/100g of phytate and 607.00mg/100g of tannin and the roasted amaranth seed flour has 263.00mg/100g of oxalate, 1279.00mg/100g of phytate and 573.00mg/100g of tannin.

Estimating the functional groups :

The functional groups are the chemical structure corresponding to a particular group of molecules present in the food that exhibits different chemical properties and behaviour impacting its flavour.

From the Figure 1 and Figure 2, the FTIR spectroscopy peak shows the presence of functional groups such as alcohol, conjugated acid, conjugated aldehyde, nitro compound, halo compound and alkene are found in the fresh amaranth grain flour and the same is found in roasted amaranth grain flour along with an extra strong peak for esters and δ-lactone.

The findings of the study showed the impact of roasting on the amaranth grains. The physical parameters such as 1000 grain weight showed that the mass had lowered from fresh to roasted amaranth grains showing the moisture had been reduced; the angle of repose was found to be high in the roasted amaranth grains showing excelled flow properties when compared with the standard chart which was because the roasted amaranth seeds had low moisture. The bulk density increases after roasting as the moisture was removed due to which the flour was allowed to pack tightly whereas the true density lowers after roasting the amaranth grains due to reduced moisture, as the water couldn't fill the internal structures and also might potentially expand while roasting and the porosity decreased because after roasting it became more denser with lesser air space making it to pack more efficiently. These comparison shows the amaranth grains had been roasted to an optimum level and helped in understanding the handling process, texture, blending nature with other products, processing method and storage. The anti-nutrients such as oxalate, phytate and tannin had been reduced significantly after roasting showing it as a good method of processing the amaranth grain. The FTIR spectroscopy peak was similar in both the fresh and roasted amaranth grain flour, the functional groups such as alcohol, conjugated acid, conjugated aldehyde, nitro compound, halo compound and alkene are commonly found.

Conflict of Interest

There is no conflict of interest.

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