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Physico-chemical characterisation of pumpkin seeds

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Abstract
Different physicochemical characteristics of pumpkin seeds were analysed for whole pumpkin seed and kernels. The length, width, thickness and geometric mean diameter of whole pumpkin seed were found to be 16.81±0.91 mm, 8.87±0.61 mm, 2.75±0.18 mm and 7.42±0.35 mm respectively, while the corresponding values for kernel were found to be 11.65±0.69 mm, 5.80±0.26 mm, 2.52±0.29 mm and 5.54±0.29 mm respectively. The seeds had a lower bulk density and a higher true density than the kernels. The porosity and 1000 seed weight of whole pumpkin seed were also higher than the kernel. The husk content of the pumpkin seed is 26.75±0.98%. Both whole pumpkin seed and kernels has high nutritional values. The proximate composition of moisture, protein, crude fat, crude fibre, ash and carbohydrate for whole pumpkin seed were 5.53±0.26%, 28.90±1.36%, 31.75±0.45%, 4.59±1.01%, 6.90±0.14% and 27.86±1.50% while the corresponding composition of kernel were 4.43±0.44%, 31.98±1.18%, 38.29±1.51%, 4.26±0.43%, 2.36±0.10% and 33.11±2.94% respectively. The free fatty acid composition of pumpkin seed kernels was highest in linoleic acid (37.89%) and least in linolenic acid (0.18%). The mineral content of pumpkin seed kernels were Zinc, Phosphorus, manganese, potassium, magnesium, copper, calcium, iron, sodium and cobalt respectively.

Keywords: pumpkin seed, cucurbita, physical, chemical, free fatty acids

Introduction
Pumpkin belongs to the genus *Cucurbita* and family *Cucurbitaceae*. Pumpkin is a versatile fruit and is used for various food processing applications. Ranging from agricultural purposes to commercial and ornamental sales, pumpkins are grown all over the world for a variety of reasons with versatile uses as cooking from the fleshy shell, to the seeds, even the flowers, most parts of which are edible. Generally pumpkin seeds are by-product in the food industry. Like other members of *Cucurbitaceae*, pumpkin fruits bear numerous seeds. Pumpkin are variable in size, shape, colour, and weight. Depending upon the polyphenolic pigments present in it, the colour of pumpkins ranges from golden-yellow to orange flesh, having a weigh of 4-6 kg with the largest capable of reaching a weight of over 25 kg. They have a moderately hard flesh with a thick edible flesh below and a central cavity containing numerous small, off-white colored seeds interspersed in a net-like structure. The seed content of pumpkin fruit varies from 3.52% to 4.27%. It has high nutritional value, provides good quality oil, and excellent source of protein and have pharmacological activities such as antidiabetic, antifungal, antibacterial and antiinflammation activities, and antioxidant effects. Pumpkin seeds have historically been used to produce oil, fortify breads, consumed as a snack or even for medicinal purposes.
The pumpkin seed has many health benefits and are consider as nutritional powerhouses, with a wide variety of nutrients ranging from magnesium and manganese to copper, protein and zinc. The pumpkin seeds have antiparasitic activity due to the presence of cucurbitin. The objective of this study was to determine the physical properties of pumpkin seeds, so that the knowledge gained will be used in design and development of equipments for cleaning, grading, dehydration, and handling and also to study the nutritional composition, to know the importance and the health benefits of pumpkin seeds to the consumers.

Materials and Methods
The dried whole pumpkin seeds were procured from single source from local market, Anand, Gujarat. Seeds were cleaned manually to remove any unwanted particles like damaged seeds, undersized and immature seeds and other extraneous materials.

Cleaning was done by winnowing and hand sorting and dehulled manually. Samples were then packed in airtight plastic bags and stored in refrigerator for analysis.

Physical characteristics

Three principal dimensions viz. length, width and thickness of whole pumpkin seeds and kernels were measured by using a digital micrometer with accuracy of 0.01 mm (0-25mm). Measurement was made on 100 randomly drawn seeds from the test samples for both whole pumpkin seeds and kernels. These values were used to calculate the geometric mean diameter of pumpkin seeds by using standard relationships (Mohsenin, 1986) [14].

$$\text{Geometric mean diameter (Dg)} = (\text{LWT})^{1/3}$$

Where, L is the length, W is the width and T is the thickness (all in mm).

The true density defined as the ratio of mass of the sample to its seed volume, was determined using the water displacement method. Fifty milliliter of water was placed in a 100 ml graduated measuring cylinder and 5 g seeds were immersed in that water. The amount of displaced water was recorded from the graduated scale of the cylinder. The ratio of weight of seeds to the volume of displaced water gave the true density (Mohsenin, 1986) [14].

$$\text{True density} = \frac{\text{Weight of sample in air (g)}}{\text{Volume of displaced fluid (cm3)}}$$

For measuring the bulk density, a known amount of the sample (5g) was weighed into a 10ml measuring cylinder. The bottom of the cylinder was gently tapped for five minutes from a height of 5 cm. the bulk density was taken as the mass per unit volume of the sample.

$$\text{Bulk density (g/ml or g/cm3)} = \frac{\text{Weight of the sample}}{\text{Volume of the Sample after tapping}}$$

The porosity (ε) of bulk seeds was computed from the values of true density and bulk density using the relationship given by Mohsenin (1986) [14].

$$\text{Porosity } (\varepsilon) = 1 - \frac{\text{Bulk density}}{\text{True density}} \text{ x } 100$$

Husk content was estimated by dehulling 250 g of pumpkin seed manually. Husk content was calculated in percentage of weight of whole pumpkin seed as per the following expression:

$$\text{Husk content (\%)} = \frac{\text{Weight of Husk}}{\text{Weight of whole pumpkin seed}} \text{ x } 100$$

1000 seed weight of both whole and dehulled pumpkin seeds were determined in triplicate by weighing 1000 seeds in an electronic balance (Mettler, Japan, p=0.001g).

Chemical characteristics

The recommended methods of the Association of Official Analytical Chemists (AOAC, 2000) [5] were used to determine the chemical composition of the pumpkin seeds (whole pumpkin seeds and kernels) including the contents of moisture, crude protein, ash, crude fibre, crude fat and carbohydrate. The moisture content of the seeds was determined by drying the weighed sample to a constant weight in hot air oven at 105±1 °C. The percent nitrogen was estimated by Micro-Kjeldahl method and the crude protein content was quantified by multiplying with the factor 6.25. Ash content was determined by first incinerated the sample on slow flame burner and igniting it in a muffle furnace at 550ºC until light grey ash were obtained (about 4 to 6 h). Crude fibre content was determined by gravimetric method. Crude fat content was determined by continues extraction in a Soxhlet apparatus for 5 h using hexane as a solvent. After evaporation of the solvent, the fat content was determined gravimetrically. Total Carbohydrate content was obtained by subtracting (crude protein + crude fat + ash content + crude fibre) from 100. The phytic acid content of the flaxseeds was analyzed according to the method given by Lolas and Markakis (1975) [12] All the analysis were carried out in triplicate and average values are reported.

To determine the free fatty acid composition of the pumpkin seed oil, gas chromatography (GC) was used. Fatty acid methyl esters (FAMES) were prepared as per the method described by Christie (1992) [8]. Free fatty acid profile were analyzed at SICART, Sardar Patel University, V. V. Nagar.

Mineral contents was determined by using Inductive couple plasma-optical emission spectrometry, ICP-OES (Model Optima 7000 DV). The sample was digested into wet digestion using a mixture of diacid mixture (concentrated nitric acid: percholic acid, 2:1) respectively.

Results and Discussion

The results obtained for various physical properties such as length, width, thickness, true density, bulk density, geometric mean diameter, porosity, 1000 seed weight and husk content as well as the chemical properties such as moisture, crude protein, crude fibre, crude fat, ash, carbohydrate, phytic acid, free fatty acid composition and mineral content of whole pumpkin seed and kernel using the above methods were discussed below.

Physical Properties

The physical properties of the seed are the pre-requisites for the design of equipment for handling, dehulling and other processes Size of seed is important for designing screening and sieving machines. Joshi *et al.*, (1993) [10] and Altuntas, (2008) [4] reported that the physical properties of pumpkin seeds are function of seed moisture. The moisture content for whole pumpkin seed and kernel in the present study was 5.53±0.26% (d.b) and 4.43±0.44% (d.b) respectively.

Table 1: Physical characteristics of pumpkin seeds

Sl. No.	Parameters	Whole pumpkin seed (%)	Kernel (%)
1	Length (mm)	16.81±0.91	11.65±0.69
2	Width (mm)	8.87±0.61	5.80±0.26
3	Thickness (mm)	2.75±0.18	2.52±0.29
4	True density (kg/m^3)	1157±1.02	1068±0.94
5	Bulk density (kg/m^3)	398±0.80	475±0.95
6	Geometric mean diameter, Dg (mm)	7.42±0.35	5.54±0.29
7	Porosity (%)	65.60±0.47	55.52±0.55
8	1000 seed weight (g)	202.2±0.75	148.1±0.87
9	Husk content (%)	26.75±0.98	-

*length, width and thickness =average of 100 seeds; true density, bulk density, 1000
seed weight= average of 3 replications.

The mean length (L), width (W) and thickness (T) values of whole pumpkin seed and kernel were 16.81±0.91mm,

8.87±0.61mm, 2.75±0.18mm and 11.65±0.69mm, 5.80±0.26mm, 2.52±0.29mm, respectively at a moisture content of 5.53±0.26% (d.b) for whole pumpkin seed and 4.43±0.44% (d.b) for kernel. Whole pumpkin seed has higher dimensions as compare to the kernel which is due to removal of hull. The results obtained are in good accordance with the results reported by Joshi *et al.,* (1993) [10] and Altuntas, (2008) [4].

The whole pumpkin seeds had a lower bulk density and a higher true density than the kernels. The mean value obtained for bulk density and true density are 398±0.80 kg/m^3 and 1157±1.02 kg/m^3 for whole pumpkin seed whereas for kernel, it was found to be 475±0.95 kg/m^3 and 1068±0.94 kg/m^3. These results were in agreement with the ranges reported by Milani *et al*., (2007) [13] and Altuntas, (2008) [4]. The 1000 seed weight, geometric mean diameter and porosity values for whole pumpkin seed (202.2±0.75g, 7.42±0.35mm, 65.60±0.47%) are greater than the dehulled pumpkin seed (148.1±0.87g, 5.54±0.29mm, 55.52±0.55%). Husk content of pumpkin seed was found to be 26.75±0.98%. The results obtained were found to be similar with the earlier findings reported by Yildiz *et al*., (2013) [16].

Chemical Properties

The moisture content of whole pumpkin seed (5.53±0.26%) was higher than the kernels (4.43±0.44%). The results of moisture content were found similar with the earlier findings reported by Elinge *et al.,* (2012) [9], Steiner-Asiedu *et al*., (2014) [7] and Al-Anoos *et al.,* (2015) [2]. The kernel has high protein content, crude fat content and total carbohydrate than whole pumpkin seed. The results of protein, crude fat, ash and carbohydrate observed during the present study are in good accordance with the results reported by Gohari Ardabili *et al*., (2011) [6], Eling *et al*., (2012) [9] and Steiner-Asiedu *et al*., (2014) [7]. Fat content was moderately less compared to the result reported by Alfawaz (2004) [3] and Achu *et al*., (2005) [1]. Crude fibre was in accordance with the findings reported by Al-Anoos *et al.,* (2015) [2] and Alfawaz (2004) [3] but moderately less compared to the result reported by Karanja *et al*., (2013) [11]. The phytic acid content of whole pumpkin seed were found to be higher than the kernels. However, some differences in the composition may be due to environmental stress, climatic conditions, geographical, cultivation and harvesting practices.

Table 2: Chemical composition of whole pumpkin seed and kernel

Composition	Mean value ± S.D.	
	Whole pumpkin seeds	Kernel
Moisture, %	5.53±0.26	4.43±0.44
Crude protein, %	28.90±1.36	31.98±1.18
Crude fat, %	31.75±0.45	38.29±1.51
Crude fiber, %	4.59±1.01	4.26±0.43
Ash, %	6.90±0.14	2.36±0.10
Total Carbohydrates, % (by difference)	27.86±1.50	33.11±2.94
Phytic acid, %	1.867±0.01	1.547±0.03

Table 3, shows the free fatty acid composition of pumpkin seed oil. It mainly consists of linoleic acid, oleic acid, palmitic acid, stearic acid, palmitolic acid, arachidic acid, erusic acid, behenic acid and linolenic acid. Major free fatty acid compounds of pumpkin seeds are linolenic acid, oleic acid, palmitic acid and stearic acid. Rodriguez-Miranda *et al*., 2013 [15] also reported linolenic acid, oleic acid, palmitic acid and stearic acid as the major free fatty acid compounds in pumpkin seed oil. Similarly, Gohari Ardabili *et al*., (2011) [6] reported the major free fatty acids compounds of pumpkin seeds as linoleic acid, oleic acid, palmitic acid and stearic acid with slightly higher values of linoleic acid (39.84±0.08%) and oleic acid (38.84±0.37%) and lower values of palmitic acid (10.68±0.42%) and stearic acid (8.67±0.27%). The results obtained were found to be in similar with the findings of Elinge *et al.,* (2012) [9]. The differences in free fatty acids composition might be attributed due to the factors such as variety, origin, and drying conditions, among others.

Table 3: Free Fatty acid composition of pumpkin seed oil

Sl. no.	Fatty acid	Mean value (%)
1	Palmitic Acid	17.63
2	Palmitolic Acid	0.33
3	Stearic Acid	14.96
4	Oleic Acid	27.75
5	Linoleic Acid	37.89
6	Linolinic Acid	0.18
7	Arachidic Acid	0.30
8	Behenic Acid	0.21
9	Eursic acid	0.21

The mineral content in pumpkin seed kernel were found to be Zinc (907 mg), Phosphorus (848.6 mg), manganese (487 mg), potassium (404.9 mg), magnesium (335.6 mg), copper (124 mg), calcium (25.7 mg), iron (16.1 mg), sodium (2.2 mg) and cobalt (0.6 mg). Table 4 shows the mineral composition of pumpkin seed kernels. Elinge *et al*., (2012) [9] also reported that pumpkin seeds has rich source of minerals comprising of potassium, sodium, calcium, magnesium, phosphorus, iron, cobalt, manganese and zinc. This indicates that pumpkin seeds could be used as a supplement in food.

Table 4: Mineral composition of pumpkin seed kernels.

Sl. no.	Minerals	Mean value (mg/100g)
1	Iron (Fe)	16.1
2	Manganese (Mn)	487
3	Zinc (Zn)	907
4	Copper (Cu)	124
5	Phosphorus (P)	848.6
6	Potassium (K)	404.9
7	Calcium (Ca)	25.7
8	Magnesium (Mg)	335.6
9	Sodium (Na)	2.2
10	Cobalt (Co)	0.6

Conclusion

It can be concluded that pumpkin seeds has a high nutritional value and can provides good quality oil and excellent source of protein. These seeds may also serve as a constituents of minerals to humans through development of various value added products. Considering a high yield of oil and its free fatty acid profile of seeds similar to sesame, sunflower, peanuts and soyabean oils, the pumpkin seed oil can be considered as a new and valuable source of edible oil. The use of these underutilized pumpkin seeds will also capture a new opportunity and emerging market share in the food industry, besides contributing to the formulation of new food products and minimizing losses.

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