www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(5): 1860-1865

www.thepharmajournal.com
Received: 07-03-2023
Accepted: 20-04-2023

Poornima KR
Student, M. Tech, Department of Processing and Food Engineering, College of Agricultural Engineering, UAS, GKVK, Bangalore, Karnataka, India

Dr. Viresh Kumargouda
Assistant Professor, Department of Processing and Food Engineering, College of Agricultural Engineering, UAS, GKVK, Bangalore, Karnataka, India

Dr. Dronachari Manvi
Assistant Professor, Department of Processing and Food Engineering, College of Agricultural Engineering, UAS, GKVK, Bangalore, Karnataka, India

Dr. Jayashree GC
Assistant Professor, Department of Farm Machinery and Power Engineering, College of Agricultural Engineering, UAS, GKVK, Bangalore, Karnataka, India

Er. Krishnamma PN
Assistant Professor, Department of Processing and Food Engineering, College of Agricultural Engineering, UAS, GKVK, Bangalore, Karnataka, India

Dr. Vimala M
Assistant Professor Department of Agricultural Statistics, Applied Mathematics and Computer science, UAS, GKVK, Bangalore, Karnataka, India

Corresponding Author:
Poornima KR
Student, M. Tech, Department of Processing and Food Engineering, College of Agricultural Engineering, UAS, GKVK, Bangalore, Karnataka, India

Studies on engineering properties of moringa (*Moringa oleifera* L.) pods

Poornima KR, Dr. Viresh Kumargouda, Dr. Dronachari Manvi, Dr. Jayashree GC, Er. Krishnamma PN and Dr. Vimala M

Abstract
Engineering properties such as size, geometric mean diameter, sphericity, test weight, bulk density, true density, shape, and porosity of graded and ungraded moringa pods differentiated based on length were measured at three different moisture levels such as 6, 9 and 12% (w.b.). The length of graded moringa pods varied linearly from 223.60 to 255.20 mm and for ungraded pods it varied from 248.00 to 364.50 mm. The breadth of graded and ungraded moringa pods varied from 24.19 to 27.37 mm and 24.58 to 28.65 mm. The thickness, geometric mean diameter and sphericity of graded moringa pods varied from 5.26 to 7.00 mm, 30.52 to 36.56 mm and 0.136 to 0.143. Whereas the thickness, geometric mean diameter and sphericity of ungraded moringa pods varied from 6.52 to 7.68 mm, 34.12 to 43.12 mm and 0.137 to 0.118. The 100 pod weight, bulk density, true density and porosity of graded moringa pods varied from 230 to 360 g, 0.079 to 0.089 kg/m^3, 0.31 to 0.48 kg/m^3 and 71.78 to 80.20%. While the 100 pod weight, bulk density, true density and porosity of ungraded moringa pods varied from 305 to 406 g, 0.077 to 0.092 kg/m^3, 0.31 to 0.48 kg/m^3 and 76.77 to 80.83%.

Keywords: engineering, moringa, pods, *Moringa oleifera* L.

1. Introduction

Moringa oleifera, commonly known as drumstick is reported to be the most extensively grown crop of the family Moringaceae. It is a fast growing, perennial softwood with low quality timber. Although it is not widely used for timber purpose, it's been traditionally used for culinary purpose and in ayurveda medicine. It is also described as one of the most beneficial trees of the tropics. It is stated to be an important crop in Ethiopia, India, Philippines and the Sudan.

The importance that the crops holds could be defined with the usage of its leaves, twigs, bark, flowers and fruits. The leaves and young pods of moringa are most commonly used in culinary in India. Other than cooking, it is used for several other purposes including live fencing, as green manure (leaves), as animal forage (leaves and seed cake), medicinal uses (all plant parts), gum extracting (from barks), in alley cropping and biogas production (Abdull Razis *et al.*, 2014) [1].

The pod is abundant in the amino acid lysine, whereas the leaves are abundant in protein, beta-carotene, iron, and ascorbic acid (Chawla *et al.*, 1988; Dogra *et al.*, 1975) [3, 5]. Among all the parts of the tree, the pods hold their own significance. It is majorly been used for consumption purpose. The young pods are best chosen for cooking some traditional recipe. Due to their high protein and fibre content, the pods are useful in the treatment of under nutrition, diarrhoea, digestive issues and the prevention of colon cancer (Liu *et al.*, 2018). The three lobed, 20 - 60 cm long pods that make up the fruits hang from the branches. They split into three sections when they are dried. There are between 12 and 35 seeds in each pod (Foidl *et al.*, 2001) [6].

Understanding engineering properties is useful and required in the design and development of agricultural equipment (Sahay and Singh, 1994) [14]. Such physical and engineering properties of peanut pods (Balasubramanian *et al.*, 2011), moringa seeds (Mahmoud *et al.*, 2019) [9] and karanja kernel (Pradhan *et al.*, 2008) have been determined by researchers. In this study, the engineering properties such as size, geometric mean diameter, sphericity, test weight, bulk density, true density, shape, and porosity of moringa pods were measured at three different moisture levels.

2. Materials and Methods
The dried moringa pods were procured from Integrated Farming System, University of Agricultural Sciences, GKVK, Bengaluru for conducting the experiments. The harvested dried moringa pods were kept sunlight to reduce the moisture levels for experimental purposes. The moringa pods were stored in plastic bags to avoid the moisture migration and to prevent insect attack.

2.1 Physical and engineering properties of moringa pods
2.1.1 Category of Pods
Two categories of pods were used for conducting trials. They were:
G = Graded pods
UG = Ungraded pods
The graded and ungraded moringa pods is shown in Fig. 1.

Fig 1: Ungraded and graded moringa pod samples differentiated based on length

2.1.2 Determination of moisture content
The moisture content of the moringa pods was determined by oven method. Three samples of 35 g each of graded and ungraded pods were weighed and placed in an oven. The samples were heated at 65°C for 24h (Oloyede *et al.*, 2015) [12] until constant weight was obtained. Then the samples were taken out from oven, cooled in desiccator and weighed using an electronic balance. The moisture content was calculated by using the following formula:

$$\text{Moisture content \% (w.b.)} = \frac{\text{(Initial weight of sample)- (Final weight of sample)}}{\text{(Initial weight of sample)}} \times 100$$

2.1.3 Size of pods
To determine the average size of the moringa pods, a sample of 10 pods of each graded and ungraded was picked separately and their three major dimensions namely, length (L), width (B) and thickness (T) were measured using a digital vernier calliper (Mitutoyo Corporation, Japan: Model CD-6"ASX) having an accuracy of ±0.01 mm (Bahnasawy, 2007). The readings were replicated three times individually for graded and ungraded pods.
The geometric mean diameter (D) was determined using the following equation (Mohsenin, 1970) [11]:

$$\text{Geometric mean diameter, } D_g = (L \times B \times T)^{1/3}$$

Where,
L = Length, mm
B = Width, mm
T = Thickness, mm

Sphericity was determined using the following equation (Mohsenin, 1970) [11]:

$$\text{Sphericity, } \varphi = \frac{D_g}{L}$$

Where,
Dg = Geometric mean diameter
L = Length

2.1.4 Shape of moringa pods
The shape of moringa pods were determined through visual observations and by comparing with the standard shapes. The procedure for recording the shape of pods is as per Mohsenin (1986) [10] and Kachru *et al.* (1994) [7].

2.2 Gravimetric properties
It was determined by considering the average value of each ten graded and ungraded moringa pods. The readings were replicated three times individually for graded and ungraded pods (Dash *et al*. 2008) [4].

2.2.1 100 pod weight
The weight of moringa pods and seeds were measured using an electronic balance (PS 200/2000/C/2- RADWAG, Poland) with an accuracy of ±0.01 g.

2.2.2 Bulk density
The samples of moringa pods were filled into a container of standard size 100×100×100 mm up to the top level. The excess samples were removed so that the top surface was perfectly level and even. Care was taken to see that moringa pods and seeds were not compressed in any way. Then the samples in the container was weighed by using an electronic balance (Mohsenin, 1970) [11]. This procedure was replicated for three times individually for graded and ungraded pods. The bulk density was calculated by using the following formula:

$$\text{Bulk density, (kg/m}^3\text{)} = \frac{\text{Weight of sample (kg)}}{\text{Volume of the sample (m}^3\text{)}}$$

2.2.3 True density
The true density of moringa pods were measured by using liquid displacement method. Toluene (C_7H_8) was used instead of water because it was absorbed by the sample to a lesser extent, 50 ml of toluene was taken in a 100 ml measuring jar and weighed and then sample of pods and seeds were poured into the jar. The change in the level of toluene in the jar was recorded. This procedure was repeated for three times each for graded and ungraded pods (Mohsenin, 1970) [11]. The true densities of the samples were calculated using the formula:

$$\text{True density, (kg/m}^3\text{)} = \frac{\text{Weight of sample (kg)}}{\text{Volume of sample (m}^3\text{)}}$$

Volume of sample = Final toluene level in – Initial toluene level measuring jar in measuring jar

2.2.4 Porosity
The porosity is also known as the packing factor and it was determined from bulk density and true density of sample. The porosity was calculated by using the following formula (Mohsenin, 1970) [11]:

$$\text{Porosity, (\%)} = \frac{\text{True density -Bulk density}}{\text{True density}} \times 100$$

2.3 Statistical analysis
The results of the physical and engineering properties of graded and ungraded moringa pods were verified using two factor analysis of variance (ANOVA) to determine the significant differences among treatments at 5% level of significance (p<0.05) using OPSTAT software.

3. Results and Discussion
3.1 Physical and engineering properties of moringa pods
3.1.1 Size of moringa pods
The length of moringa pods at moisture content of 6 to 12% varied from 223.60 to 255.20 mm for graded pods, while it varied from 248.00 to 364.50 mm for ungraded pods. The mean value obtained for graded and ungraded pods were 242.00 and 324.97 mm. Whereas, the mean value obtained for moisture content such as 6, 9 and 12% were 236.19, 303.90 and 310.36 mm. The grand mean value obtained was 283.01 mm and all treatment combinations were found to be significantly different. The effect of moisture content on length of graded and ungraded moringa pods is shown in Fig. 2.

The breadth of moringa pods at moisture content ranged from 6 to 12% varied from 24.19 to 27.37 mm for graded pods, while the breadth of ungraded pods varied from 24.58 to 28.65 mm. The mean value of breadth for graded and ungraded pods obtained were 25.69 and 26.78 mm. At 6% moisture content, the mean value of breadth was found to be 24.42 mm, at 9% moisture content it was found to be 25.74 mm and at 12% moisture content it was found to be 28.55 mm. The grand mean value obtained was 26.17 mm and all treatment combinations were found to be significantly different. The effect of moisture content on breadth of graded and ungraded moringa pods was shown in Fig. 3.

The thickness of graded pods varied from 5.26 to 7.00 mm, whereas the thickness of ungraded pods varied from 6.52 to 7.68 mm at moisture content ranged from 6 to 12%. The mean value of thickness for graded and ungraded pods obtained were 6.35 and 7.146 mm. At 6% moisture content, the mean value of thickness was found to be 5.89 mm, at 9% moisture content it was found to be 6.99 mm and at 12% moisture content it was found to be 7.35 mm. The grand mean value obtained was 6.73 mm and all treatment combinations were observed to be significantly different. The effect of moisture content on thickness of graded and ungraded moringa pods is shown in Fig. 4.

The geometric mean diameter for graded pods varied from 30.52 to 36.56 mm and for ungraded pods it varied from 34.12 to 43.12 mm at moisture content ranged from 6 to 12%. The mean value obtained for graded and ungraded pods were 33.88 and 39.69 mm. At 6% moisture content, the mean value of geometric mean diameter was found to be 32.38 mm, at 9% moisture content it was found to be 38.07 mm and at 12% moisture content it was found to be 39.91 mm. The grand mean value obtained was 36.72 mm and all treatment combinations were found to be significantly different. The effect of moisture content on geometric mean diameter of graded and ungraded moringa pods is shown in Fig. 5.

The sphericity of graded pods varied from 0.136 to 0.143 and for ungraded pods it varied from 0.137 to 0.118. The mean value of sphericity for graded and ungraded pods obtained were 0.139 and 0.123. At 6% moisture content, the mean value of sphericity was found to be 0.135, at 9% moisture content it was found to be 0.127 and at 12% moisture content it was found to be 0. 132. The grand mean value obtained was 0.131 and all treatment combinations were found to be significantly different. The effect of moisture content on sphericity of graded and ungraded moringa pods is shown in Fig. 6.

These findings of effect of moisture content on length, breadth, thickness, geometric mean diameter and sphericity were in accordance with the reported values by Oloyede *et al.* (2015) [12]. The effect of moisture content on length, breadth, thickness, geometric mean diameter and sphericity were shown in Table 1.

3.1.2 Shape of moringa pods
The shape of the moringa pods was observed visually and recorded. It was then compared with the standard chart. The shape of the moringa pods was recorded as elongated.

3.2 Gravimetric properties
3.2.1 100 pod weight
The graded pods had 100 pod weight varied from 230 to 360 g and for ungraded pods it varied from 305 to 406 g at moisture content ranged from 6 to 12%. The mean value of 100 pod weight for graded and ungraded pods obtained was 293.82 and 364.27 g. The mean value of 100 pod weight for three moisture contents such as 6, 9 and 12% were found to be 267.94, 335.55 and 383.63 g. The grand mean was found to be 328.50 g and all treatment combinations were found to be significantly different. The effect of moisture content on 100 pod weight of graded and ungraded moringa pods is shown in Fig. 7.

3.2.2 Bulk density
The bulk density of graded pods varied from 0.079 to 0.089 kg/m^3 and for ungraded pods it varied from 0.077 to 0.092 kg/m^3 at moisture content ranged from 6 to 12%. The mean value of bulk density for graded and ungraded pods obtained were 0.08 kg/m^3 and 0.07 kg/m^3. At 6% moisture content, the mean value of bulk density was found to be 0.079 kg/m^3, at 9% moisture content it was found to be 0.075 kg/m^3 and at 12% moisture content it was found to be 0.091 kg/m^3. The grand mean obtained was 0.081 kg/m^3 and all treatment combinations were found to be significantly different. The effect of moisture content on bulk density of graded and ungraded moringa pods is shown in Fig. 8.

3.2.3 True density
The true density of graded pods varied from 0.28 to 0.45 kg/m^3 and for ungraded pods it varied from 0.31 to 0.48 kg/m^3 at moisture content ranged from 6 to 12%. The mean value of true density for graded and ungraded pods obtained were 0.35 $kg/m^3$and 0.40 kg/m^3. At 6% moisture content, the mean value of true density was found to be 0.29 kg/m^3, at 9% moisture content it was found to be 0.37 kg/m^3 and at 12% moisture content it was found to be 0.46 kg/m^3. The grand mean obtained was 0.37 kg/m^3 and all treatment combinations were found to be significantly different. The effect of moisture content on true density of graded and ungraded moringa pods is shown in Fig. 9.

3.2.4 Porosity
The porosity of graded pods varied from 71.78 to 80.20% and it varied from 76.77 to 80.83% for ungraded pods at moisture content ranged from 6 to 12%. The mean value of porosity for

graded and ungraded pods obtained were 75.71% and 80.14%. At 6% moisture content, the mean value of porosity was found to be 74.27%, at 9% moisture content it was found to be 79.00% and at 12% moisture content it was found to be 80.51%. The grand mean obtained was 77.93% and all treatment combinations were found to be significantly different. The effect of moisture content on porosity of graded and ungraded moringa pods is presented in Fig. 10.

These findings of effect of moisture content on 100 pod weight, bulk density, true density and porosity were in accordance with the reported values by Oloyede *et al.* (2015) [12]. The effect of moisture content on 100 pod weight, bulk density, true density and porosity were shown in Table 2.

Table 1: Effect of moisture content on length, breadth, thickness, geometric mean diameter and sphericity

Parameters	Graded pods			Ungraded pods		
	M_1	M_2	M_3	M_1	M_2	M_3
Length (mm)	223.60	246.00	255.20	248.00	360.80	364.50
Breadth (mm)	24.19	24.40	27.37	24.58	27.83	28.65
Thickness (mm)	5.26	6.77	7.00	6.52	7.20	7.68
Geometric mean diameter (mm)	30.52	34.37	36.56	34.12	41.65	43.12
Sphericity	0.136	0.139	0.143	0.137	0.115	0.118

Table 2: Effect of moisture content on 100 pod weight, bulk density, true density and porosity

Parameters	Graded pods			Ungraded pods		
	M_1	M_2	M_3	M_1	M_2	M_3
100 pod weight (g)	230	290	360	305	380	406
Bulk density (kg/m^3)	0.079	0.082	0.089	0.077	0.072	0.092
True density (kg/m^3)	0.28	0.33	0.45	0.31	0.42	0.48
Porosity (%)	71.78	75.15	80.20	76.77	82.85	80.83

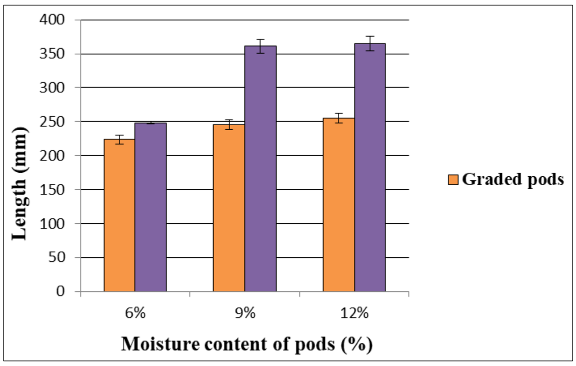

Fig 2: Effect of moisture content on length of graded and ungraded moringa pods

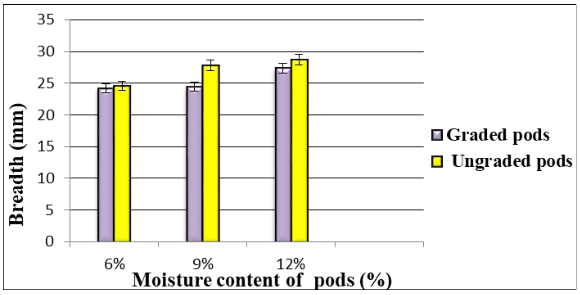

Fig 3: Effect of moisture content on breadth of graded and ungraded moringa pods

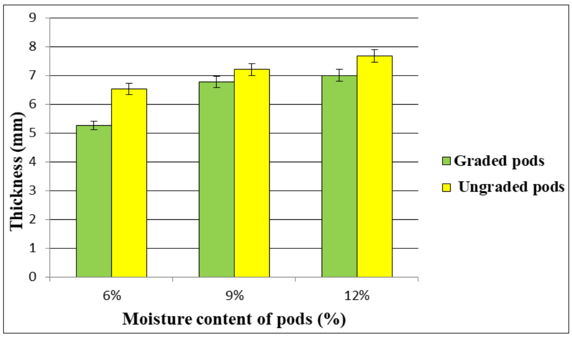

Fig 4: Effect of moisture content on thickness of graded and ungraded moringa pods

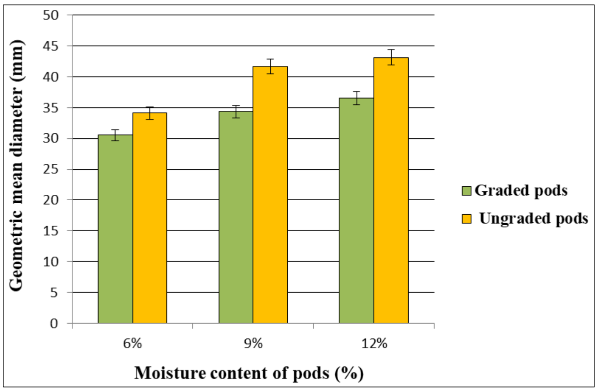

Fig 5: Effect of moisture content on geometric mean diameter of graded and ungraded moringa pods

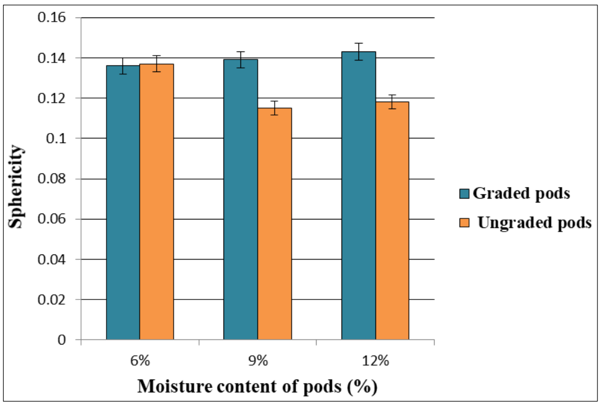

Fig 6: Effect of moisture content on sphericity of graded and ungraded moringa pods

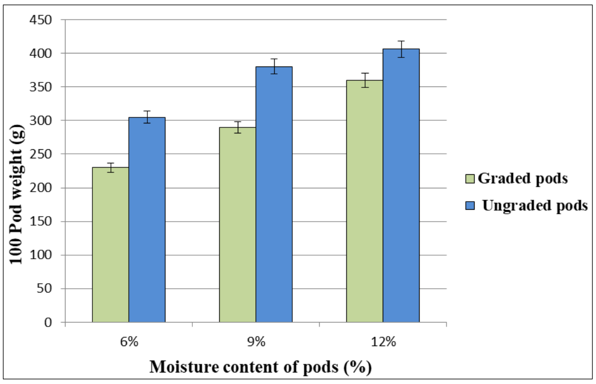

Fig 7: Effect of moisture content on 100 pod weight of graded and ungraded moringa pods

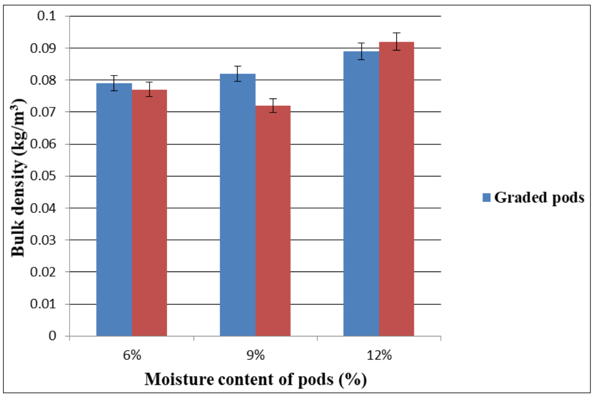

Fig 8: Effect of moisture content on bulk density of graded and ungraded moringa pods

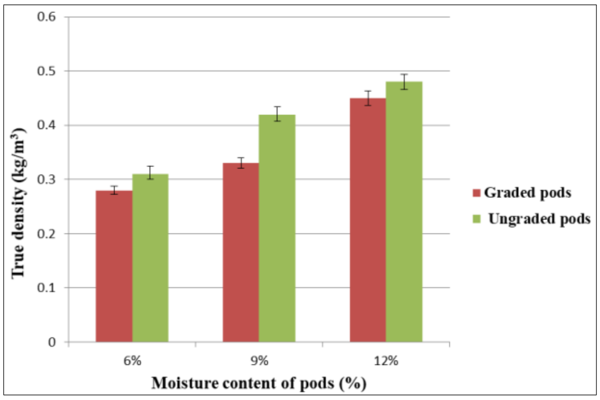

Fig 9: Effect of moisture content on true density of graded and ungraded moringa pods

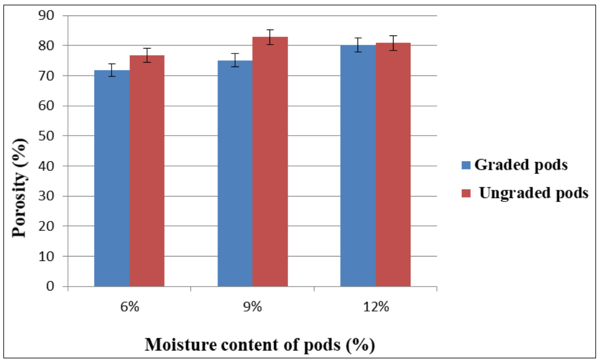

Fig 10: Effect of moisture content on porosity of graded and ungraded moringa pods

4. Conclusion

The following conclusions are revealed from the investigation of some physical properties of moringa pods for moisture content range of 6-12% (w.b.). It was found that the increase in moisture content of pods increased all the measured engineering properties except bulk density which however, decreased with increase in moisture content.

5. References

1. Abdull Razis AF, Ibrahim MD, Kntayya SB. Health benefits of *Moringa oleifera*. Asian Pac. J Cancer Prev. 2014;15(20):8571-8576.
2. Bahnasawy AH. Studies on some physical and mechanical properties of garlic. Int. J Food Engg. 2007;3(6):1-18.
3. Chawla S, Saxena A, Seshadri S. *In-vitro* availability of iron in various green leafy vegetables. J Sci. Food Agric. 1988;46(1):125-127.
4. Dash AK, Pradhan RC, Das LM, Naik SN. Some physical properties of simarouba fruit and kernel, Int. J Agro. Physics. 2008;22(5):111-116.
5. Dogra P, Sngh D, Tandon S. Vitamin content in Moringa. J. Current Sci. 1975;44(3):30-31.
6. Foidl N, Makkar HPS, Becker K. The potential of Moringa oleifera for agricultural and industrial uses. What development potential for Moringa products; c2001.
7. Kachru RP, Gupta RK, Alam A. Physico-chemical constituents and engineering properties of food crops. Scientific Publishers, Jodhpur; c1994. p. 1-106.
8. Liu Y, Wang XY, Wei XM, Gao ZT, Han JP. Values, properties and utility of different parts of *Moringa*

oleifera: An overview. Chin. Herb. Med. 2018;10(4):371-378.
9. Mahmoud WA, Elkaoud NSM. Engineering properties of moringa oleifera seeds related to an oil expeller design. Misr. J. Agric. Eng. 2019;36(4):1177-1192.
10. Mohsenin MN. Physical properties of plant and animal materials. Gorden and Breach Science Publishers. New York, USA, 1986.
11. Mohsenin NN. Physical Properties of Plant and Animal Materials. Gordon and Breach Science Publishers, New York, USA, 1970.
12. Oloyede DO, Aviara NA, Shittu SK. Measurement of engineering properties necessary to the design of drumstick (*Moringa oleifera* L.) Pod Sheller. J Biosyst. Eng. 2015;40(3):201-211.
13. Pradhan RC, Naik SN, Bhatnagar N, Swain SK. Moisture-dependent physical properties of Karanja (*Pongamia pinnata*) kernel. Ind. Crops Prod. 2008;28(2):155-161.
14. Sahay KM, Singh KK. Unit operations in agricultural processing. Vikas Publishing House Pvt. Ltd., New Delhi; c1994. p. 154-194