The Bioscan 11(1): 223-226, 2016
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

PHYSICAL AND MECHANICAL PROPERTIES OF SIMAROUBA NUTLETS AND KERNEL

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KEYWORDS
Simarouba
Moisture content
Physical property
Nutlet
Kernel
Compression strength

Received on :
04.01.2016

Accepted on :
08.03.2016

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ABSTRACT
The aim of physical properties determination is required for the development of post harvest/processing equipment. The study was conducted to explore the physical properties of Simarouba glauca L. nutlet and kernel, namely, dimensions, 100 unit mass, geometric mean diameter, sphericity, true density, bulk density, porosity, angle of repose, static co-efficient of friction and compression strength of load. The nutlet had 4% (w.b.) moisture content. The average nutlet length, width, thickness and 100 unit mass were 20.1, 12.7 and 10.1 mm; and 97 g, while the corresponding value for kernel were 14.50, 8.10, 6.80 mm; and 38 g, respectively. The sphericity and geometric mean diameter of nutlet were 0.66 and 13.35 mm more, respectively, than those of kernel. Bulk densities of nutlet and kernels were 492.20 and 486.00 kg/m^3, the corresponding true densities were 833.30 and 873.30 kg/m^3, and the corresponding porosities were 40.93 and 44.34%, respectively. The angle of repose of nutlet and kernel were 26.9 and 25.08°, respectively. The co-efficient of static friction of nutlet of plywood, galvanized iron sheet, and glass were 23, 10 and 18 μ_s, respectively, than those of kernel. The compression strength load of nutlet was 30.27 KN more, respectively, than those of kernel.

INTRODUCTION

Simarouba glauca belongs to family simarubaceae, commonly known as "The Paradise Tree" or "King Oil Seed Tree", is a very rapid growing tree and versatile multipurpose evergreen tree, found growing in different climatic conditions. In India, it is mainly grown in Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu. It produces bright green leaves 20-50 cm length, yellow flowers and oval elongated purple colored fleshy fruits. Its cultivation depends upon rainfall distribution (around 400 mm), water holding capacity of the soil and sub-soil moisture. It is suited for temperature range of 10-40°C, with pH of the soil to be 5.5-8.0 also.

Simarouba glauca seed oil have good nutritional profile and other physico-chemical properties which got improved after the process of refining, therefore it can be used as a potential oil seed resource for edible purpose and bio-fuel production (Duhan *et al.,* 2011). The seeds of simarouba contain about 40% kernel and the kernels contain about 55-65% oil. The amount of oil would be 1000-2000 kg/ha/year for a plant spacing of 5 m X 5 m (Syama sundar Joshi and Shantha Joshi, 2007). Dry seeds of simarouba contain 32-40% protein, with 59-62% unsaturated fatty acids (Armour, 1959). The bark and leaf extract of Simarouba is well known for its different types of pharmacological properties such as haemostatic, antihelmenthic, anti parasitic, anti dysentric, antipyretic and anti cancerous (Patil Manasi *et al.,* 2011). One of the present study analyses the antifungal properties of Simarouba glauca, a medicinal plant well known for its antimicrobial, antidysenteric, antiherpetic, antihelminthic and antiprotozoal activity (Khaling Mikawlrawng *et al.,* 2014). The main use of the kernel oil is as a bio-fuel for the production of bio-diesel. The oil can also be used for cooking and soap production (Joshi and Hiremath, 2000). The energy produced from the simarouba can also use in the residential sector is an important area for campaigns to conserve energy which is conventional also (Somashekar and Nagesha, 2010). The dried simarouba nutlets are hard to brea and the major problems after harvesting is dehusking and shelling. Nutlets should be dry for the process of decortications otherwise it leads to time consuming and again has to dry after separation of kernel from the nutlets. The major green energy components and their sources from simarouba are biodiesel from seeds, ethanol and biogas from fruit pulp, oil cake and thermal power from leaf litter, shell, unwanted branches (Syamasundar Joshi and Shantha Joshi, 2007). Biodiesel contains no petroleum but it can be blended at any level with petroleum diesel to create a biodiesel blend. It can be used in compression-ignition (diesel) engines with little or no modification. Biodiesel is simple to use biodegradable, nontoxic and essentially free of sulphur and aromatics (Savitha and Naik, 2011).

The physical properties of oilseeds are important in designing and fabricating particular equipments and structures for handling, transporting, processing and storing and also for assessing the behavior of the product quality (Kashaninejad *et al.,* 2006; Bart-Plange and Baryeh, 2003). Physical properties of simarouba glauca L. are essential to design equipments for decortications (threshing bar, size reduction process etc.,), drying, cleaning, grading, storage and oil extraction. Moisture content is useful information in the drying process. The size (such as length, breadth, thickness, arithmetic mean diameter and geometric mean diameter) and shape are important in designing of separating, harvesting, sizing and grinding machines. The product shape can be determined in terms of its sphericity and aspect ratio which affect the flow ability characteristics of the products. Bulk density, true density and unit mass are used in determining the size of storage bin and also affect the structural loads, the angle of repose is important in designing of storage and transporting structures. Porosity (calculated from bulk density and true density), surface area affect the resistance to airflow through the bulk material bed and data on them are necessary in designing the drying process. Fruit part fraction gives an overall idea about the composition of kernel and shell which affect the oil yield of the product (Pradhan *et al.,* 2009).The aim of this study was to investigate the physical properties of simarouba nutlet and kernel.

MATERIALS AND METHODS

The proposed study was conducted at Department of Agricultural Engineering, University of Agricultural Sciences, GKVK, Bangalore. Simarouba nutlets were procured from Dr. Syamsundar Joshi, Department of Botany, UAS, GKVK, Bangalore for conducting the experiments.

Decortication

The drying role is important for decortication to get maximum number of kernels. The simarouba nutlets were sun dried for decortication which means easy separation of kernels from the shell.

Moisture content

The moisture content of the nutlets and kernels was determined by using ASAE Standards (Joseph, 1993). Nutlets of 10 g were dried in an air ventilated oven at 105ºC for 48h and the final weight was measured after drying. The moisture content (wet basis) was calculated as:

$$\text{Moisture content (Wb, \%)} \quad \frac{\text{Intial wt. of sample (g)} \quad \text{Final wt. of sample (g)}}{\text{Initial wt. of sample (g)}} \quad 100$$

Physical characteristics

The nutlet and kernel material was divided and samples were collected. The same samples were used for conducting the experiment. Hence, measurements of all size and shape indices as well as the nutlet and kernel mass were replicated.

The average size of the nutlets/kernels, were determined by selecting a randomly picked sample of 100 nutlets/kernels. Three major dimensions namely, length (*l*), width (*b*) and thickness (*t*) were measured using a digital vernier calipers (Model CD-6BS-Mitutoyo Corporation, Japan) with an accuracy of ± 0.01 mm.

Geometric mean diameter,*Dg*, of the nutlet and kernel were calculated by using the following relationships (Mohsenin, 1986):

$Dg = (lbt)^{1/3}$

Sphericity (S) of the nutlets/kernels was calculated as (Razari *et al.,* 2007).

$$S \quad \frac{lbt)^{1/3}}{l}$$

The 100 unit mass of nutlets as well as kernels were taken using an electronic balance (Model PS200/2000/C/2-RADWAG, Poland) with an accuracy of ± 0.001 g. To evaluate the 100 unit mass, randomly selected samples were weighted and readings were recorded. The reported value is a mean of 20 replications.

Bulk density was calculated from the mass of bulk material divided by volume containing the mass. The nutlets/kernels were filled in a container of standard size 10×10×10 cm up to the top. The nutlets/kernels in the container were weighed in an electronic balance. The true density, defined as the ratio between the mass and the true volume of the bulk material (nutlet and kernel), was determined using the toluene (C_7H_8) displacement method (Mohsenin, 1980). The density ratio is the ratio of mass density to bulk density expressed as percentage, while porosity of bulk materials was calculated from bulk and true densities using the relationship (Mohsenin, 1986; Ozdemir and Akinci, 2004*)* as follows:

$$\text{Bulk density (kg/m}^3) \quad \frac{\text{Weight of nutlets (kg)}}{\text{Volume of nutlets (m}^3)}$$

$$\text{True density (kg/m}^3) \quad \frac{\text{Weight of nutlets (kg)}}{\text{Volume of nutlets (m}^3)}$$

Volume of nutlets = {Initial toluene level in the jar - Final toluene level in the jar}

$$\text{Porosity (\%)} \quad \frac{\text{True density} \quad \text{Bulk density}}{\text{True density}} \quad 100$$

Angle of repose is the angle between base and slope of the cone formed on a free vertical fall of grains on to a horizontal plane. The angle of repose was measured by the emptying method, a bottomless cylinder was used. The cylinder was placed over a plain surface and nutlets/kernels were poured into the hollow portion. The cylinder was lifted slowly allowing the sample to flow down and form a natural slope. The angle of repose was calculated from the height and diameter of the pile as (Mohsenin, 1986).

$$\tan^{1}\frac{2h}{D}$$

Where,

θ - Angle of repose (º)

h - Height of the pile (cm)

D - Diameter of the pile (cm)

Coefficient of static friction of grains were determined against three material surfaces namely plywood, galvanized steel sheet and glass by inclined surfaces method. The static angle of friction was recorded when the grain just began to slide on the test surface. Other researchers have used this method (Shafiee *et al.*, 2009; Karababa, 2006; Sacilik *et al.*, 2003; Kaleemullah and Gunasekar, 2002).

$\mu_s = \tan\theta$

Where,

μ_s = Co-efficient of static friction

θ = Angle of inclination of material surface

The compression strength was measured in an Instron

Instrument, piston probe used to find the maximum load corresponding to the failure of the specimen was recorded in a digital meter, which indicates the compression strength (Guner *et al.*, 2003).

RESULTS AND DISCUSSION

The average moisture content of simarouba nutlet and kernel are shown in Table 1. The decortication process requires low moistured nutlets for easy separation of kernel from the shell otherwise it would take more time to separation process. This indicates that the drying process should be carried out after the harvest/collection of nutlets for easy operation and also to get good amount of oil. The oil content of simarouba kernel is greater as compared to the oil content of seed like rapeseed, jatropha, karanja and neem (Anil Duhan *et al.*, 2011; Pradhan *et al.*, 2009; Bup Nde *et al.*, 2013).

Other physical and mechanical properties

A summary of the results of determined physical parameters of nutlet and kernel is shown in Table 1. The 100-unit mass, fraction of nutlet parts, arithmetic diameter and geometric diameter are provided along with other physical parameters.

The nutlet and kernel length, width and thickness are found to be 20.1, 12.7, 10.1 mm and 14.5, 8.1, 6.8 mm, respectively. Corresponding values for the jatropha seed (Garnayak *et al.*, 2008; Sirisomboon *et al.*, 2007) are 18.65 to 21.02, 11.34 to 11.97 and 8.91 to 9.58 mm. The length and stem-end diameter of neem nut are 14.56 and 7.72 mm, respectively (Visvanathan *et al.*, 1996). The simarouba nutlet is thus bigger than jatropha seed and neem nut (Bup Nde *et al.*, 2013). The importance of these dimensions in determining aperture sizes and other parameters in machine design have been discussed by Mohsenin (1986), highlighted lately by Omobuwajo *et al.* (1999) and these information helps in processing (Bup Nde *et al.*, 2013).

The nutlet shape is determined in terms of its sphericity and aspect ratio. The sphericity of simarouba nutlet and kernel are found to be 0.66 and 0.62, respectively. These values are closer to the corresponding values of 0.64 and 0.68 as reported for jatropha (Sirisomboon *et al.*, 2007). The 100 nutlet and kernel mass are 97 and 38 g, respectively.

The bulk density of nutlet and kernel are 492.20 and 486.00 kg/m^3, respectively. This indicates that the bulk density of the nutlet is higher than the kernel. This indicates that nutlets need more space per unit mass than kernels. The true density of the nutlet is less than the density of water (1000 kg/m^3) due to the air pores between the shell and the kernel. The true density of kernel is higher than nutlets. This indicates that separation of fruit shells from kernels after decortication could be done by blowing air (winnowing) or floating in water.

The porosity of simarouba nutlet and kernel are found to be 40.93 and 44.34%, respectively. Since the porosity depends on the bulk as well as true densities, the magnitude of variation in porosity depends on these factors only. The porosity of the bulk of kernel is higher than that of the nutlets. This indicates that floating in water of the bulk of nutlet is easier than of the bulk kernel.Adhesion between container wall and material affected the value of angle of repose. The angle of repose of simarouba nutlet is higher than the kernel. This might have been due to the viscous surface and the least hardness of nutlets leading to the highest cohesion among the individual nutlets and therefore to the higher angle of repose. This value implies the highest flow ability of the nutlets compared to the kernels. It is, nevertheless, important to note that the angle of repose for the simarouba nutlet and kernel is lower than for the jatropha seed and kernel (Karaj *et al.*, 2008).

Coefficient of static friction of nutlets and kernels on various surfaces shows minute difference. This mean there were no much association between nutlets, kernels and surface used for testing static coefficient of friction. The result shows, that static friction of wood for nutlet is higher than other surfaces and static friction of glass for kernel was the lowest represented in Table 1.

The compression strength of nutlets/kernels increased with the decrease of moisture content. This may be due to the hardening of the nutlets/kernels at lower m.c. The nutlets have higher compression strength compared to kernels as the nutlets have a harder shell covering. Similar results were found for almond, pistachio, cashew nuts and kernels (Aydin 2003; Polat *et al.* 2007; Bart Plange *et al.* 2012).

Table 1: Physical and Mechanical Properties of Simarouba nutlets and kernel

Physical properties	Moisture content % w.b.)Simarouba nutlets 4	Moisture content % (w.b.) Simarouba kernel 4
Length (mm)	20.10	14.50
Width (mm)	12.70	8.10
Thickness (mm)	10.10	6.80
Geometrical mean diameter (mm)	13.35	9.07
Sphericity	0.66	0.62
100 mass of nuts (g)	97.00	38.00
True density (kg/m^3)	833.30	873.30
Bulk density (kg/m^3)	492.20	486.00
Porosity (%)	40.93	44.34
Angle of repose (0^0)	26.90	25.08
Static Co-efficient of friction (μ_s)		
Wood	23.00	19.00
Galavanized Iron	20.00	19.00
Glass	18.00	17.00
Compression strength load (KN)	30.27	4.77

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The Bioscan
An International Quarterly Journal of Life Sciences
ISSN : 0973-7049
Volume 10, Number 1: 2015

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33. A comparative evaluation of electrocardiograms recorded in classical limb and experimental methods in native cats of Odisha, India
Subhashree Sarangi, A. P. K. Mahapatra, S. Mohapatra and A. K. Kundu — 1611 - 1613
34. Seriodiagnosis and electron microscopy of bean common mosaic virus (BCMV) infecting cowpea in southern Karnataka, India
B. S. Pavithra, Kedarnath, H. M. Renuka, H. A. Prameela and K. T. Rangaswamy — 1615 - 1620
35. Stability analysis for seed yield and its components in coriander (*Coriandrum sativum* L.)
M. S. Darvhankar, G. U. Kulkarni, V. V. Baraskar, H. V. Solanki and P. A. Vavdiya — 1621 - 1626
36. Leaf characteristics of betelvine (*Piper betel* L.) as influenced by climate
H. Mohanta and A. Pariari — 1627 - 1629
37. Evaluation of early cauliflower (*Brassica oleracea* var. *Botrytis* L.) germplasm under tropical conditions for various horticultural traits
H. M. Santhosha, B. Varalakshmi and R. Krishna Manohar — 1631 - 1635
38. Seasonal variation of the foliar constituents of primary (*Machilus bombycina*) and secondary (*Litsea citrata*) food plants of *Antheraea assamensis* Helfer (Muga silkworm) in Nagaland
B. T. Kakati, L. N. Kakati and B. C. Chutia — 1637 - 1640
39. Role of environmental factors on the bacterial blight (BLB) disease of cotton caused by *Xanthomonas campestris* pv. malvacearum under south Gujarat condtion
Prashant, B. Sandipan, H. R. Desai and B. G. Solanki — 1641 - 1644
40. Effect of PGR on clonal propagation of Madhunashini (*Gymnema sylvestre* R. Br.) through rooted cutting
J. R. Chavda, B. S. Desai, S. K. Jha, M. B. Tandel and D. P. Patel — 1645 - 1648
41. Fortification of buck wheat for improvement in safety and quality of 'Kulcha' : A traditional Kashmiri baked product
Quraazah Akeemu Amin, Hafiza Ahsan, Towseef A. Wani and Qazi Nissar — 1649 - 1653
42. Growth assessment of spiny lobster (*Panulirus homarus*) under open sea cage culture in Tharuvaikulam of Tamil Nadu coast, South India
S. Athithan and A. Gopal Akannan — 1655 - 1658
43. First record on non-native loricariid catfish, *Pterygoplichthys disjunctivus* (Weber, 1991) (Siluriformes, Loricariidae) in Cauvery river of peninsular India
Preetha Panikkar, T. D. Jagadeesh, D. S. Krishna Rao, U. K. Sarkar and M. Naskar — 1659 - 1663
44. Growth and yield of mungbean (*Vigna radiata* L.) in response to the application of sulphur and boron under rainfed conditions
Mohit Singh, Pawan Sirothia, Mohammad Amin Bhat, Pawan Tiwari and Anurag Namdeo — 1665 - 1669
45. Kairomonal effect of *Corcyra cephalonica* stainton and their influence on the parasitic and predation potential of *Trichogramma chilonis* Ishii and *Chrysoperla zastrowi silemi* (Esben-Pterson) against eggs of *Spodoptera litura* (Fab.)
P. Parthiban, C. Chinniah and M. Kalyanasundram — 1671 - 1674