Some Physical & Mechanical properties of Marking Nut and kernel

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Abstract : Marking nut or 'SemecarpusAnacardium L.' also known as 'bibba' or 'bhilawa'. Marking nut has a double walled shell and cracking shells yields toxic resin (Bhilawan shell liquid) & enclosed dry kernel. Present study objective is to determine design parameters of marking nut & kernel for development of efficient marking nut deshelling machine. X-rays images of nuts by AGFA Image processing software of 100 marking nuts show tremendous variation in shape & size of nut & kernel. Sphericity, bulk density, thousand nut mass were found in range of 0.92 to 0.79, 572.22 to 528.48 kg/m^3, 2015.40 to 3365 grams & corresponding values for Kernel 0.63 to 0.67, 540 to 478.62 Kg/m^3, 232 to 410 grams. Average shell thickness was found to be 3.5mm. For marking nuts at 12% moisture (d.b) Hardness & deformation was found 87.64N & 3.20mm, at 9.63% moisture (d.b) 93.98N & 2.50mm, at 4.86% moisture 118N & 0.65mm, respectively. Rupture force for nuts by compression was found to be in range of 23.21Kg to 37.34Kg. Texture profile analysis of kernel was performed at 3.02% moisture (d.b) & Hardness was found to be 19.98N at cycle-1, 17.77N at cycle-2, this shows kernel is delicate then the nut & easily cracked at lower forces. Springiness & cohesiveness were determined and found to be 0.62 & 0.53, respectively.

Keywords: Marking nut; Bhilawan shell liquid (BSL); physical properties, mechanical properties.

INTRODUCTION

Marking nut *(SemecarpusAnacardium L.)* is a well known medicinal plant & native of India. It is called ‘*Bibba*’ in Marathi, '*Bhallatak*' in Sanskrit, ‘*Bhilawa*’ in Hindi & in English it’s known as Dhobi nut, marany nut, marsh nut or oriental cashew. It is a deciduous tree growing up to 20-40 feet in height & is widely distributed in tropical region, central parts of India & common in dry deciduous forests of Maharashtra spreading through Khandesh, Marathwada & east Maharashtra; also found in states of Bihar, Bengal & Orissa. Marking nut is traditionally used in marking lines, lacquers & varnishes, water proofing fabrics, anti-corrosive paint, insecticides, antiseptics etc. Marking nut is a drupe or receptacle unlike cashew nut & upper portion of nut is a fleshy false fruit which is edible when ripe & collected in months of december to march. Marking nut which is orange in colour turns black after exposure to air and heat. Nut is a hard double walled shell, outer shell or pericarp exudes toxic resin known as BSL (Bhilawan Shell liquid) which is a rich source of phenols, bioflavonoids, bhilwanols & show versatile medicinal properties. Dry kernel is protected inside lignified mesocarp, it is called ‘Godambi’ in Local dry fruit market. It is used as a delicacy in bakery, in Ayurveda it is prescribed best to eat for women during pregnancy & lactation, kernel consumption is also known for its aphrodisiac property. (Sharma *et. al.*, 2012).

The Unique physical characteristics of marking nut & kernel set them apart from other agricultural produce. Highly irregular in shape & size sets complications for its mechanical processing. Traditional method of marking nut deshelling is very crude; Skin blisters, lesions, black marks are common on workers hands, face & arms. Therefore, present study is to determine Engineering properties of marking nut & kernel, with objective to develop a marking nut desheller which aims to reduce the drudgery involved. The physical and mechanical properties of an agricultural produce, helps optimize many problems related to how it behaves under agricultural process operations such as handling, harvesting, threshing, deshelling, cleaning, sorting etc. on other hands Mechanical properties analyze the behavior of products under force; force can be impact or compression. Engineering properties are important for development of processing machine, grading and sorting sensors.

MATERIALS & METHODS

Marking nuts & kernels for present study were purchased from Local Market in Mondha, Aurangabad, Maharashtra. Nuts were cleaned & ensured free of foreign particles. High variations in shape & size of marking nut & Kernels were observed. Nuts & Kernels were then sorted simply into three groups small, medium & large.

- **Moisture content**

Moisture content (M.C) of nut & kernel was determined on arrival by using standard oven drying method at an air temperature of 135 degree Celsius for 2 hours (AOAC 2005; method 930.15).

%M.C (wet weight basis) = W_i -W_d ÷ W_i * 100

Where: W_d = Wt. Of nuts after drying, W_i= Initial Wt. of nuts.

- **Physical & mechanical parameters-**

Lengths (L), Width (W), Thickness (T) were determined by using Vernier Calliper (Mitotoyo, Japan) with error of ± 0.02mm & 200 replications were performed.

Geometric mean diameter (D_g) & **Sphericity** (Φ) were calculated by below relationships. 100 replications were performed.

D_g= (LWT) $^{1/3}$

$\Phi = D_g/L$

Thousand nut mass was determined by weighing 1000 randomly selected marking nuts on digital electronic top balance having an accuracy of 0.01g . (Patil. *et. al.*, 2014).

Nuts were dropped into a container with known mass and volume (500 ml) from a height of 150mm at a constant rate. **Bulk density** was calculated from the mass of bulk nut divided by the volume containing mass. Bulk density formula is given in below Relationship. (Patil *et. al.*, 2014)

$B_d = M_b / V_b$

Where: B_d -bulk density (kg/m^3), M_b – mass of seeds (kg), V_b – volume of container (m^3).

Marking nuts tremendously vary in shape & size, to understand its inner structure while nut is still intact; **X-rays** of 100 nuts were taken with help of '***AGFA***' Image processing Software.

- **Compression Loading**

Texture analyzer Brookfield CT-3 10K was used to determine textural properties such as Hardness (N), deformation at hardness (mm) for marking nuts at different moisture contents i.e. 12%, 9.63%, and 4.86% (wet basis.); TPA (Texture Profile Analysis or Double Compression) test for Kernel was performed which determined Hardness (N), Cohesiveness & Springiness values. Compression test for nuts was carried by TA4/100 probe, which is clear acrylic cylinder probe 38.1mm in diameter and 20mm long. For TPA test for kernels TA39 probe, which is stainless steel rod with 2mm in diameter and 20mm long was used.

For determining rupture force of marking nuts a compression loading test was performed, Load cell assembly of capacity 300 kg, EProWeighing Module, LCD display were used & 100 random nuts were sorted, compressed & force values were recorded. Marking nuts were loaded on fixed base plate of load cell and mounted on pillar drill table, a moving parallel plate is fixed to a drill chuck and lever of pillar table was used as driving unit for compression force. Nut was held by one hand and compressed through Y-axis by moving parallel plate (1cm^2) until the dual wall shell ruptured. (Guner, 2003) (Kihckan & Guner, 2007).

RESULTS & DISCUSSIONS

A Summary of results of Sphericity, thousand nuts mass, nut & kernel fractions, shell thickness are shown in Table 1 & Table 2.

Table 1. Physical properties of marking nut kernel

Physical Parameter	Kernel Small	Medium	Large
Length (L), mm	10.5 (±0.60)	16.8 (±1.12)	21.8 (±1.41)
Width (W), mm	10.1 (±0.75)	14.5 (±1.23)	19 (±1.41)
Thickness (T), mm	3 (±0.45)	5 (±0.88)	8.5 (±0.97)
Sphericity, *Φ*	0.63 (±0.03)	0.62 (±0.03)	0.67 (±0.04)
Bulk density (B_d), kg/m^3	540 (±14.7)	503.55 (±22.68)	478.62 (±18.73)
Thousand nut mass, grams	232 (±12.3)	342 (±8.93)	410 (±10.53)

Table 2. Physical properties of marking nut at 9.63% moisture dry basis

Physical Parameter	Marking nut small	Medium	large
Length (L), mm	12 (±2.38)	19.35 (±2.15)	28.70 (±1.45)
Width (W), mm	15.18 (±2.05)	21.51 (±1.80)	27.20 (±1.83)
Thickness (T), mm	8 (±1.17)	12 (±1.29)	16.58 (±1.17)
Geometrical mean dia. (mm)	16.37 (±1.15)	16.43 (±0.96)	16.02 (±0.62)
Sphericity, *Φ*	0.92 (±0.06)	0.85 (±0.06)	0.79 (±0.02)
Bulk density (B_d), kg/m^3	572.22 (±12.58)	559.29 (±18.92)	528.48 (±25.65)
Thousand nut mass, grams	2015.40 (±27.83)	2850.10 (±51.31)	3365 (±34.03)
Shell fraction %	88.49	88	87.82
Kernel fraction %	11.51	12	12.18
Shell thickness, mm	3.2	3.8	3.5

Moisture content of marking nuts was found to be 9.63% dry basis (d.b). The average values for length, width & thickness for marking nut groups was found to be in range of 12 to 28.70 mm, 15.18 to 27.20 mm, and 8 to 16.58 mm respectively. Average values for marking nuts at 7.60% M.C (d.b) (Patil *et. al.*, 2014) are 14.73 to 21.40mm, 12.99 to 18.17mm and 7.58 to 8.48mm. This indicates that marking nuts length, width & thickness highly varies amongst itself. Corresponding average values of cashew nuts length, width and thickness are (Addo and Teye, 2012) 41.5mm, 31.89mm and 32.76mm, therefore marking nut is smaller than cashew nuts. The dimensions are important for determining aperture sizes, clearance between processing unit, tool for deshelling, conveyor belt fabrication, hopper size etc. The shape of nuts is determined in terms of sphericity. Sphericity value range is from 0.01 to 0.9 and value closer to 0.9 indicates nut shape is more likely towards a sphere and value closer to 0.01 indicates nuts are not spherical. The Sphericity of marking nuts and kernels are found to be in range of 0.92 to 0.79 and 0.63 to 0.67, respectively. Corresponding sphericity values for marking nuts and kernels (Patil *et. al.*, 2014) are 0.77 to 0.69 and 0.62 to 0.55, respectively. In this study, kernels are less spherical than marking nuts. It is also observed that as marking nuts size goes on increasing sphericity decreases, it means that larger nuts are less spherical and small sized nuts are more spherical in shape. Shape identification is important to determine other design parameters.

The thousand marking nut and kernel weight are in the range of 2015.40 to 3365 gm and 232 to 410 gm, respectively. The thousand marking nut & kernel weight was (Patil *et. al.,* 2014) 1549.75 to 2575.45 gm and 170.14 to 276.52 gm, respectively. Bulk density of marking nut and kernel are 572.22 to 528.48 kg/m^3 and 540 to 478.62 kg/m^3, respectively. The bulk density of marking nuts and kernels by (Patil *et. al*, 2014) was in range of 576.98 to 537.65 kg/m^3 and 591 to 485.50 kg/m^3, respectively. From both results it is clear that bulk densities of nut and kernel coincide. This also indicates that nut will require more space per unit mass than kernels. The bulk density of cashew nut and kernel (Addo and Teye, 2012) increased linearly from 625.62 to 592.68 kg/m^3 and 559.60 to 505.06 kg/m^3, respectively. This indicates that cashew kernels can be sorted from cashew nuts easily, but marking nuts and kernel sorting is more complicated. X-rays gave us insight of nuts internal structure when nuts are still intact. Nuts dual wall is visible and average shell width is 3.5mm. There is another lignified enclosure with fiber like outer surface, inside this a seed or kernel is enclosed. There is a slight 'C' curve bend observed in nuts which makes every nut different in shape.

Mechanical properties

Mechanical properties of marking nuts and kernels determined using CT-3 10K Texture Analyzer are Hardness (N), deformation at hardness (mm); Springiness and cohesiveness for kernels were also determined and are presented in table 3. Avg. Hardness observed at 4.86% moisture content is highest which linearly goes on decreasing with increase in moisture content. This indicates at lower moisture content nuts shell oil congeals making it brittle and hard to rupture, but at higher moisture shells expels more oil and are less hard. Kernel Hardness at cycle-1 is 19.8N and at cycle-2 is 17.11N. Kernel hardness is very less and it can be easily damaged compared to marking nut because of the outer hard shell of nuts. Springiness is how much product springs back after first deformation & cohesiveness is how well a product withstands second deformation, these values are used for quality determination. Kernel springiness value 0.62 indicates less adhesion. Cohesiveness value 0.53 shows moderate cohesion, which indicates kernel, is tolerant for handling, packaging & storage stresses. Rupture force of marking nut through Y-axis (thickness) is 23.21 to 31.34Kg. Corresponding rupture force of marking nut by (Patil *et. al.*, 2014) is 37.17Kg. The maximum compressive load of cashew nuts (Addo and Teye, 2012) is from 0.146 to 0.213kN i.e. approx. 14.6 to 21.3Kg. Thus, force required for rupture by compression for marking nuts is higher than cashew nuts.

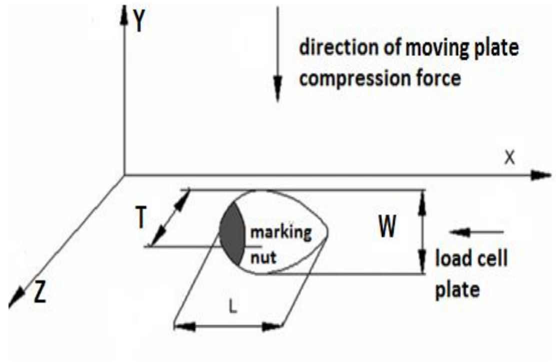

Fig no. 1 Compression loading direction of marking nut

Table 3. Textural properties of marking nut and kernel

Sample	**Marking nut at 4.86% Moisture**	**Marking nut at 9.63% moisture**	**Marking nut at 12% moisture**	**Kernel at 3.02% moisture**
Test type	compression	compression	compression	TPA
Probe used	TA4	TA4	TA4	TA39
Hardness, N	118	93.98	87.64	Cycle1 -19.98 Cycle 2-17.77
Deformation, mm	0.65	2.50	3.20	0.99
Springiness	-	-	-	0.62
Cohesiveness	-	-	-	0.53

Table 4. Compression loading values for marking nut

Marking nut	**Small**	**S.D**	**Medium**	**S.D**	**Large**	**S.D**
Min. rupture Force, Kg	12.4	-	8.88	-	19.8	-
Max. rupture Force, Kg	39.75	-	46.05	-	39.8	-
Avg. Rupture force	23.21	(±5.95)	26.24	(±8.97)	31.34	(±5.75)

CONCLUSION

Marking nuts have high irregularity in its physical and mechanical properties. Nuts hardness increases with decrease in moisture content. kernel extraction will require proper cracking force to not damage kernel, as kernel is soft and easily damaged.

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