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Comparison between Compressive Strength of Rudraksha bead (*Elaeocarpus Ganitrus Roxb.*) in Vertical and Horizontal Plane and Bead Properties

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Abstract: ***Rudraksha (Elaeocarpus Ganitrus Roxb.) shows multi-elemental composition by virtue of which it is used to make the medicines, cosmetics, spiritual gems etc. The use of Rudraksha is increasing with passage of time and its cultivation is started in plains. Earlier studies were based on pharmaceutical and chemical properties. Its physical and engineering properties were not studied which varies largely with climate, soil type and altitude. Present study is based on useful physical and engineering properties of Rudraksha beads to extract useful information for design and development of grading system for value addition, conveying and milling units for design and development of processing units to satisfy global requirement of Rudraksha. The horizontal and vertical compressive strength of beads were monitored by using compression testing machine. Results showed that the compressive strength is increasing with small variations in geometrical parameters of bead. The range of compressive strength was found between 0.36 MPa to 0.80 MPa (N/mm^2). After cracking us also found that in the various chamber (depend on the mukhi) inside the bead 0-3 seeds are available. To convert the Rudraksha bead into usable form it is required to be milled properly in the form of fine powder. The texture, tri-axial dimension and beads of Rudraksha were studied. The tri-axial dimension of Rudraksha green fruit is ranging from 17 mm to 33 mm. The arithmetic mean of density of Rudraksha beads of large, medium and small size are 0.82 g/cc, 1.15 g/cc and 1.01 g/cc with standard deviation of 6.8 %, 8.5 % and 10.4 % respectively. Present document is useful to design a machine to crack and make in powder form. So that compressive strength of Rudraksha bead is useful for designing a machine like milling machine, grinding machine and crushing machine to mill and crush the Rudraksha bead. These studies can change economic status of marginal and small farmers in hilly region as well as in plains.***

Keywords: Compressive strength, Rudraksha beads, Cortical thickness and weighing machine with load cell, Rudraksha, Grading Green Fruit, Beads.

I. INTRODUCTION

Rudraksha (*Elaeocarpus Ganitrus Roxb.*) is considered as versatile material due to its use in numerous useful work. Presently, 38 varieties of Rudraksha is recognized and cultivated in Nepal, Indonesia, Java, Sri-Lanka, India and some other countries of south–east Asia. In India it is cultivated in Assam, Bihar, Bengal, Himalayan Strips, and Garhwal region, Dehradun, Madhya Pradesh and Maharashtra, Sikkim. Green fruit of Rudraksha is harvested for further utilization as different products to avoid drudgery of peeling. To obtain beads peeled ample is stream washed, dried. Further processing is dependent on utilization. It is used as Ratna in garland to medicinal drug due to its multi-elemental composition for curing several severe ailments like heart attack and cancer [2]. It is also utilized for medicinal cosmetics to cure sinus and number of skin diseases. It is considered to have very high cosmic force due to its link with eye of Lord Shiva in various old literature of Hindu Mythology. It is grown all around the world under favorable environmental conditions and varies in shape, size and surface strips (facets) extending on its surface (popularly known as Mukhi). It is not only an element to hang in the neck of saints as garland. Roy (1993) found that Rudraksha beads possess inductive and electromagnetic properties and controls the human activities through direct action on central nervous system. Macro-nutrients available in Rudraksha beads are Carbon (50.024%), Hydrogen (17.798%), Oxygen (30.4531%) and Nitrogen (0.9461%) and many micronutrients in small proportions are also available in small proportions like Sodium, Alluminium, Potassium, Calcium, Magnesium, Iron, Cobalt, Nickel, Copper, Chlorine, Zinc etc. The multi-elemental composition of Rudraksha makes it suitable for undergoing through various physico-chemical processes to satisfy human requirements through various industries, research centers. Morphological characteristics changes [7]. Rudraksha beads are in the category of composite material because beads are composed of carbon, hydrogen, nitrogen, oxygen and some trace elements in combined form. The nuts was collected in huge quantities from the forest of uttarakhand. And compression testing was done upon it because The Rudraksha bead is brittle material because it experience compressive loads. The *Rudraksha* was taken out after peeling off the *pulp* and brushing it clean then the Rudraksha bead was ready for the testing. The collected rudrakhsa bead was dried at room temperature and dried in such a way there is no moisture contain in any form. And before it we have made a compression testing machine for finding the Rudraksha compression load [1]. For that we were purchased a electronic weighing machine of capacity upto 500 kg. which base is with load cell which display the calculated value on the display unit which is fixed above the weighing machine.

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The weighing machine is fixed as base of drilling machine on which the Rudraksha bead can be put gently in different plane which was crack by the pressing the handle gently in Which the drilling rod is replaced by the rod which diameter is approximately equal to the diameter of bead. The rod fixed in spindle is not in rotating form for compression testing. The rod can only move up and down to press the object [6].

II. MATERIALS AND METHODS

Ripe fruits of Rudraksh (Elaeocarpus ganitrus)have a stony endocarp, about 17 mm diameter, covered by fleshy blue mesocarp that extends fruit diameter to approximately 25 mm. Fruit weight with pulp and without pulp ranges 3.8 to 5.6 g and 2.0 to 3.4 g, respectively. Each fruit (nut) may contain 0-5 seeds. Ripe fruits were collected in 2016 from Uttarakhand, in North India. Nuts were cleaned in water physically after removing the pulp from fruit and dry at room temperature. The various nuts were cracked with compression testing machine and study over there. Rudraksha after calculation of all its dimensions given below is brought to the press machine which is designed for testing of compressive load of rudraksha vertically as well as horizontally. The machine consist of a base which is fitted with digital load cell which based on the principle of strain gauge, the force being sensed deforms a strain gauge. The strain gauge measures the deformation (strain) as a change in electrical resistance, which is a measure of the strain and hence the applied forces. A load cell usually consists of four strain gauges in a Wheatstone bridge configuration. The resistance values are extremely small and are relational to the stress or strain that the material load cell is undergoing at the time [1]. The change in resistance of the strain gauge provides an electrical value change that is calibrated to the load placed on the load cell.

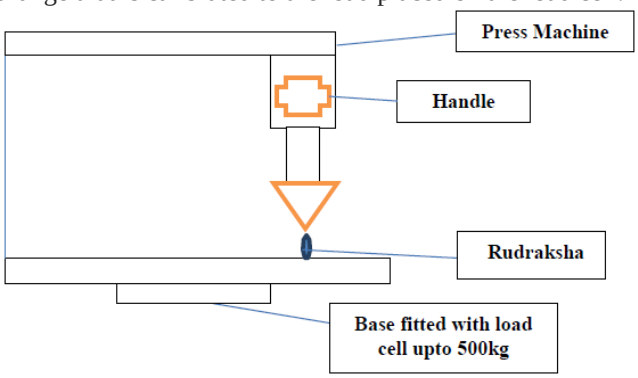

Fig. 1. Schematic Diagram of Mechanical Testing Unit

Strain gauge load cells convert the load acting on them into electrical signals. The gauges themselves are bonded onto a beam or structural member that deforms when weight is applied as shown in Figure. Two of the gauges are usually in tension, and two in compression, and are wired with compensation adjustments. When weight is applied, the strain changes the electrical resistance of the gauges in proportion to the load. Other load cells are fading into obscurity, it can sense a small load of 100gm to a max load of 500kg.The upper head consist of a handle for manually applying pressure on the rudraksh this handle is used to apply gradual load on specimen [1]. The load is applied on the specimen and its reading is shown in a digital meter which is connected to the load cell the reading is noted and the experiment is repeated on other specimen.

Fig. 2. Machine to Measure the Compressive Strength of Rudraksha Bead

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Table 1. Properties and Compressive Strength in Vertical Plane of Rudraksha bead Sample

S. No.	Mass (mg)	Length X (mm)	Diameter Y (mm)	Length Z (mm)	Total Volume ($x10^3$ mm^3)	Sphericity ± S.D.	Cortical Thickness of bead (mm) ± S.D.	Compressive Strength (vertical) (MPa) ± S.D.
1	25.1	20	16.3	19.2	6.25	0.92	6.5	0.78
2	25.3	20.65	16.85	19.2	6.71	0.9	6.2	0.76
3	25.7	21.4	17.4	18.37	6.84	0.88	7.55	0.68
4	26.1	20.7	16.67	17	5.89	0.86	6.53	0.36
5	27	21.31	15.6	18.1	6.01	0.85	6.11	0.56
6	27.3	21.35	17.07	18.24	6.64	0.88	6	0.73
7	28.8	22.27	16.38	18.32	6.68	0.84	6.13	0.68
8	30.2	22.4	17.32	19.32	7.49	0.87	6.06	0.8
Average	**27**	**21.3**	**16.7**	**18.46**	**6.56**	**0.88±0.1**	**6.34±0.10**	**0.67 ±0.3**

Table 2. Properties and Compressive Strength in Horizontal Plane of Rudraksha bead Samples

S. No.	Mass (mg)	Length X (mm)	Diameter Y (mm)	Length Z (mm)	Total Volume ($x10^3$ mm^3)	Sphericity ± S.D.	Cortical Thickness of bead (mm) ± S.D.	Compressive Strength (Horizontal) (MPa) ± S.D.
1	20.4	20.53	15.5	18.53	5.89	0.879	7	0.54
2	21.3	19.85	14.57	18.85	5.45	0.886	6.66	0.47
3	21.5	20.58	15.53	18.37	5.87	0.876	5	0.34
4	21.8	20.53	15.85	19	6.18	0.893	5.2	0.38
5	22.6	20.5	15.5	18.1	5.75	0.873	5.15	0.37
6	24.1	20.4	16.35	18.36	6.12	0.896	5	0.55
7	24.9	20.75	16.95	18.76	6.59	0.903	5.7	0.36
8	26.8	20.5	16.62	19.52	6.65	0.917	5.75	0.36
9	27.2	21.5	16.5	19.8	7.02	0.89	5.5	0.37
10	27.5	21.27	17.1	19.8	7.2	0.907	5.85	0.46
Average	**23.81**	**21.3**	**16.05**	**18.91**	**6.27**	**0.892**	**5.68**	**0.42**

III. TEXTURE

The texture of Rudraksha green fruit is smooth or plain. The kernel obtained after removal of uppermost layer resembles to vesicular and amygdaloidal texture of vesicular basalt rocks formed due to escape of gases from molten magma through due to volcanic eruptions. Similar to the rock vesicles are found all around the surface of Rudraksha kernel but these vesicles are empty compared to vesicular basalt rock in which vesicles are filled with minerals. So, the texture of Rudraksha kernel is said to be vesicular. Texture is very important property of a material which influences number of properties of a material. Surface roughness, coefficient of friction (static and dynamic friction), angle of repose etc which is used in design of storage structures (storage bins & silos), design of suitable hopper for feeding during milling and developing a conveyance system for movement of grains from one place to another place. The textural properties are analysed generally with the help of texture analyser which shows hardness of shell and magnitude of impact force to break the shell. The kernel is placed at impact platform in different orientation with varying dimensions. The beads of different shape and size are tested by applying increasing magnitude of forces and the magnitude of force should be noted carefully at the time of break.

Fig. 3. Micrograph of Rudraksha bead

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IV. TRI-AXIAL DIMENSIONAL AND SPHERICITY

To determine grain size distribution of green fruit of Rudraksha to know the range of green fruit size and find its sphericity used in design consideration of hopper and discharging chute due to its direct influence on frictional properties. Randomly selected fifteen samples of large, medium and small green fruit of Rudraksha from pile of freshly harvested Rudraksha green fruit. Tri -axial dimension is taken with the help of Vernier Caliper of sensitivity 0.01 mm. First of all largest dimension was designated as 'a', dimension perpendicular to it was designated as 'b' and dimension mutually perpendicular to a and b was designated as 'c'. Tri-axial dimensional analysis can also helps us for primary classification of green fruit as well as beed into large, medium and small for value addition during marketing, design of sieve orifice and design of suitable conveyance system for various stages of processing. The sphericity of material is calculated from the equation as shown below-

$$\text{Sphericity} = \frac{(a*b*c)^{\frac{1}{3}}}{a}$$

V. RESULTS AND DISCUSSION

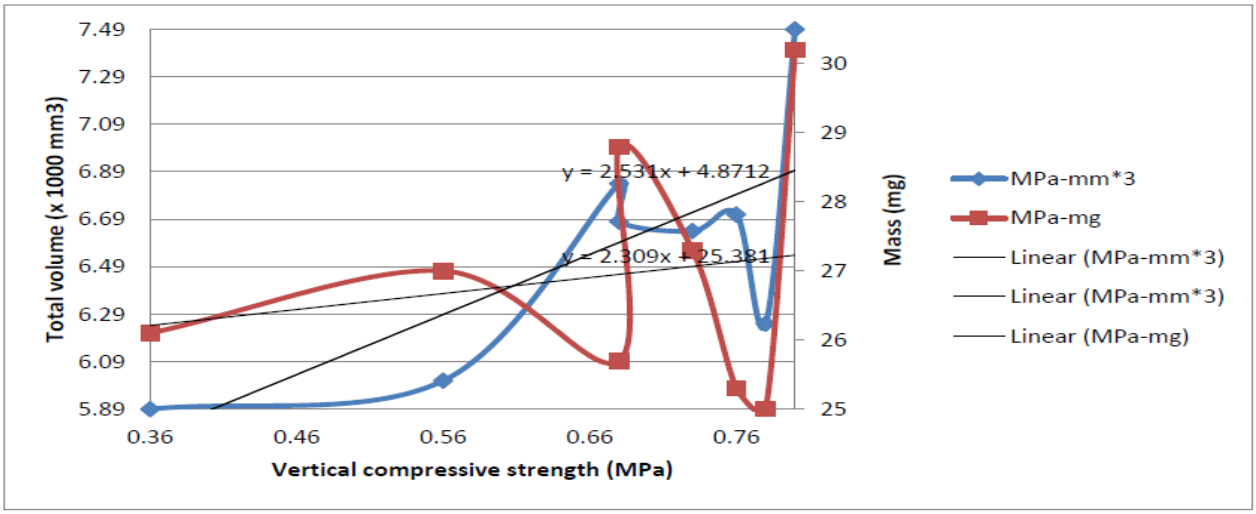

Fig. 3. Relationship between Vertical Compressive strength and Total Volume and Mass

The above show that the mass and total surface volume of bead is directly proportional to the compressive strength of Rudraksha bead. And in the above graph the red colour line is show the relationship between the mass of bead and compressive strength. Which give the positive slope. And the blue colour line show the relationship between the total surface volume and compressive strength of Rudraksha bead, which also give positive slope means if total surface volume is increases the compressive strength of bead will also increase. In both the case the slope is positive means the value of m is positive which shows that if value on the axis of x-axis increases then value on y-axis also increases. It is also indicate that the more total surface volume of bead have the more compressive strength. And if the weight of bead is more then the compressive strength is also more.

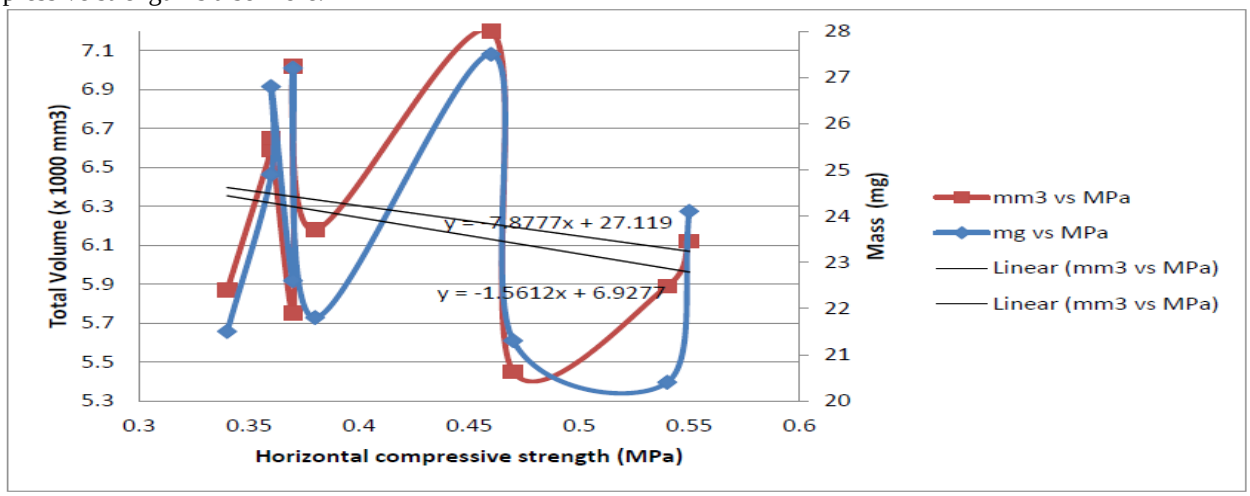

Fig. 3. Relationship between Total Volume &Horizontal Compressive Strength & Mass

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In the above graph as we can see that the both graph (total volume vs horizontal compressive strength and mass vs horizontal compressive strength) are more closely at several points. Which shows that the density is constant means if total volume of the surface is increases then mass will be also increase.

A. Textural Analysis

The study of texture provides us information regarding hardness or firmness of material. It characterizes compressive strength by application of impact force. The texture of Rudraksha green fruit is very soft and the texture of dry bead is very high. The hardness is increasing with increase in dimensions of bead [2].

B. Tri-Axial Dimensional Analysis

The diameter of freshly harvested Rudraksha green fruit varies from 16 mm to 32 mm. The variability in its dimension propels its classification into different classes on the basis of particle size distribution. So, based on observation from above tables, three classes are prepared on the basis of average of largest dimension. It will help us in value addition during marketing of raw harvested fruits. Above study is also helpful in developing a suitable manual or motorized grading unit to classify the fruit into various grades before undergoing to peeling and milling. It will be helpful in deciding clearance in milling machine. The average sphericity of fruits not varies largely from one another but they are showing variability from smaller to larger. Similarly the average diameters of large, medium and small beads of Rudraksha are found 23 mm, 20 mm and 18 mm.

Table 3.1 Dimension of Various Grades of Green Fruits of Rudraksha

Sl. No.	Class	Average Diameter(mm)
1	Small	< 22mm
2	Medium	22-26 mm
3	Large	> 26 mm

Table 3.2 Variation in Mean Thickness of Pulp Layer Over bead for Large, Medium and Small:-

Sl. No.	Mean Diameter of Large(mm)		Mean Diameter of Medium(mm)		Mean Diameter of Small(mm)	
	Green Fruit	Dried Bead	Green Fruit	Dried Bead	Green Fruit	Dried Bead
1	29	21.16	24.5	19.09	21.94	17.53
2	26.7	21.21	21.94	19.06	19.26	17.27
3	25.8	20.25	23.24	18.87	19.42	17.33
4	24.2	20.37	20.85	18.89	19.59	18.51
5	23.2	20.24	21.97	18.85	19.24	18.17
6	23.1	20.78	21.89	17.79	20.98	18.23
7	25.4	20.64	23.21	17.57	19.39	17.88
8	26	20.55	22.28	18.07	20.98	17.66
9	25.1	21.6	22.58	17.33	19.29	17.82
10	27.2	20.83	21.99	17.31	20.98	17.86
11	26.1	20.26	20.6	16.39	20.32	16.38
12	23.2	20.29	20.27	16.8	19.66	17.48

Above plot reveals that the mean diameter of green fruit is larger than the beed obtained on peeling the pulp significantly. The mean thickness of green layer is about 5.18 mm. The thickness of pulp layer ranges from 2.35 mm to 7.39 mm. The beed diameters are not directly proportional to corresponding green fruit diameters.

Above plot for medium green fruit and beed mean diameters reveals that the mean diameter of green fruit is larger than the beed obtained on peeling the pulp significantly in medium size also. The mean thickness of green layer is about 4.52 mm ranging from 1.96 to 6.86. The beed diameters are independent of corresponding green fruit diameters in medium size green fruit also [2].

The above plot reveals that the thickness of pulp layer around the beed is minimum for small size green fruit of Rudraksha. The mean thickness for pulp is 2.52 mm in small green fruit for a range of 1.07 mm to 4.41 mm.

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Table 3.2 Variation in sphericity of Green Fruits of Rudraksha

Sl. No.	Sphericity of Large	Sphericity of Medium	Sphericity of Small
1	0.9048	0.9074	0.914
2	0.9207	0.914	0.8676
3	0.9211	0.9294	0.8826
4	0.9296	0.8687	0.933
5	0.8921	0.955	0.8649
6	0.8566	0.9122	0.912
7	0.9083	0.9283	0.9235
8	0.8958	0.9282	0.912
9	0.9363	0.9031	0.8769
10	0.9082	0.8659	0.912
11	0.8992	0.8582	0.9238
12	0.9064	0.8445	0.9362

The shape of large green fruit of Rudraksha is more uniform compared to medium and small green fruits. As plot reveals the variability in shape of small green fruit is maximum whereas the mean sphericity for all three groups is almost same [2].

Table 3.2 Variation in Sphericity of DRIEd beads of all Grades

Sl. No.	Sphericity of large	Sphericity of medium	Sphericity of small
1	0.878	0.86	0.8988
2	0.8988	0.8666	0.8993
3	0.8882	0.8738	0.8667
4	0.8856	0.8664	0.873
5	0.8649	0.8728	0.8819
6	0.9275	0.8895	0.9023
7	0.8785	0.87	0.8637
8	0.8935	0.8989	0.901
9	0.8817	0.8667	0.9001
10	0.8699	0.9014	0.9208
11	0.8808	0.8908	0.9
12	0.8821	0.8797	0.8738

The mean sphericity in all three classes of dried beed has insignificant variability. The sphericity and variability of large beed is found highest individually. The mean sphericity is found maximum for small sized beed. The medium size beed is found more uniform and shows minimum variability.

VI. CONCLUSION

Following Conclusion has been Also Drawn:-

(i) This paper shows the comparison between Vertical as well as horizontal compressive strength of Rudraksha bead and we found that Rudraksha bead shows the elliptical property which means the compressive strength is more in the vertical plane and comparatively less in the horizontal plane. The data of compressive strength of Rudraksha bead is useful to design milling machine, grinding machine and crushing machine to mill/crush the Rudraksha bead to make a powder that is used for medicine purpose.

(ii) The texture of green fruit of Rudraksha is smooth or plain whereas the surface of dry bead is very undulating. Freshly harvested green fruit can be easily peeled with hand but the bead is not broken using hammer. It cannot be crushed easily using hammer. So, it undergoes either chemical treatment or thermal treatment before crushing.

(iii) The measurement of Rudraksha green natural product is running from 18 mm to 32 mm. The globules acquired on peeling green organic product likewise fluctuate in measurements. The variety in dimensional properties of Rudraksha impel us for reviewing of naturally reaped Rudraksha into three evaluations as introduced in table and it will prompt great stylish amid promoting and esteem expansion. In this way, there is have to create appropriate evaluating framework. The kind of reviewing framework will rely upon the measure of creation and accessibility of assets.

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