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Effect of Moisture Content on different Engineering Properties of Sweet Basil Seeds

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Abstract—*Sweet basil seed is the seed from the basil plant (Ocimum basilicum) which is a native plant of tropical regions. Basil seeds are a good source of fiber, proteins, micronutrients and antioxidants. Swollen basil seeds are commonly consumed in sharbat and falooda.The study diagnosed engineering properties of sweet basil seeds at four different moisture levels 8.35%, 10.80%, 13.65%, 16.20 % (w.b). The properties determined where 1000 seed weight, seed dimensions, arithmetic and geometric mean diameter, surface area, specific gravity, volume, sphericity, bulk density, true density, porosity, angle of repose and color. The result shows 1000 seed weight increased linearly with moisture content from 1.53 g to 1.80g. Likewise, the bulk and true density decreased as moisture content increased. It can be found that the mean bulk density of sweet basil seeds ranged from 0.748 to 0.689 g/ml and mean true density of sweet basil seeds ranged from 1.58 to 1 g/ml. The angle of repose increased as moisture content increased ranging from 12.02˚ to 19.93˚. Specific gravity also increased linearly with moisture content. The porosity decreased slightly but linearly with mean values ranging from 52.84% to 31.06% with increase in moisture content. In general, the values of L*, a*, b* & E* increased with moisture content. The knowledge of engineering properties of these seeds will serve as an important tool for designing agricultural machines and equipment for planting, harvesting, processing, packaging and storage as well as relevant to the design of the components of a planter such as the hopper, the seed plate and the delivery tube.*

1. INTRODUCTION

Basil (*Ocimum basilicum* L.) is native plant of tropical regions. It belongs to genus Ocimum which comprises between 50 and 150 species of herbs and shrubs [1]. Sweet basil seeds are known to treat dyspepsia, ulcer, diarrhea and other illness. They are used in Indian delicacies like sharbat and falooda[2]. Basil seeds swell in water to produce a gelatinous mass because poly saccharide layer is present on outer epidermis wall of seed [3]. Glucomannan (43%) and (1-4)-linked xylan (24.29%) and a minor fraction of glucan (2.31%) has been found in major fractions of poly saccharides [7]. Gum of basil seeds have been found to be suitable for model systems [4]. Essential oil extracted from basil leaves and seeds have antimicrobial and antioxidant properties. Physical and chemical composition of Indian and Iranian basil seeds has been reported [5, 6]. Basil seeds have been found to be a source of fiber, protein, minerals and phenolic compounds [8]. Basil seeds were used as thickening and stabilizing agent because of their high polysaccharide contents or these were usually processed into essential oil products in many studies [9]. Various physical properties of seeds are dependent on moisture content, and appear to be important in the design of planting, harvesting, handling operation, transportation, storing and processing equipment [12]. The physical properties of seed such as size, shape, axial dimensions, roundness and sphericity helps to determine the maximum size of the cup in the seed plate, the weight help in the material selection for the frame of the planter, the bulk density and moisture content helps to know the interaction between the seed and the material used for the hopper of the planter at maximum heat level [10]. The mechanical properties such as the angle of repose helps to ensure free flow of seed in the hopper [10]. Since currently used systems have been designed without taking these criteria into consideration, the resulting designs lead to inadequate applications. These cases result in a reduction in work efficiency and an increase in product losses. Therefore, determination and consideration of these properties play an important role in designing these equipments. [13]. Despite an extensive literature search, detailed information on the influence of moisture content on engineering properties of sweet basil seeds are not available.This necessitates the research work at varying moisture content: 8.35%, 10.80%, 13.65%, and 16.20 % (w.b) on indigenously grown sweet basil seeds.

2. MATERIAL AND METHOD

2.1 Sample preparation

The sweet basil seeds used for this study were collected from the local market of Gurugram, Haryana, India. The seeds were manually cleaned to remove all foreign matter, broken or immature seeds. Initial moisture contents of seeds were determined by oven drying method, in which the weight of pre-heated moisture dishes was took and then a fixed quantity of sample was put into them (replicate of 2), the weight of seeds+ moisture dishes were took using a sensitive digital balance up to 4 decimal places, then the samples were dried at 130 ± 1°C for 2 h [15] using a Digital Hot air oven (forced circulation type, company- Kasso,Model – GT8). The weight of sample after 2hr was noted down. The Moisture content of the seeds was calculated using the given formula-

$$MC_{wb} = \frac{W_i - W_f}{W_i} \text{x} 100 \quad (1)$$

MC_{wb} = moisture content wet basis

MC_{db} = Moisture content dry basis [%]

W_i = Initial weight & W_f = Final weight

Four levels of the moisture content of seeds were selected as 8.35%, 10.80%, 13.65% and 16.20 % (w.b), including the initial moisture content. The sweet basil seed samples at the desired moisture levels were prepared by spraying pre-calculated amounts of distilled water, which was calculated using the formula [27] –

$$Q = \frac{W_i(M_f - M_i)}{(100 + M_f)} \quad (2)$$

Where Q= amount of water needed in grams W_i= weight of sample in grams

M_f= desired moisture content (w.b %)

M_i= initial moisture content (w.b %)

The seeds were then thoroughly mixed and sealed in separate plastic bags. Samples were stored in a refrigerator at 5°C for a week to allow a homogeneous moisture distribution. Before starting a test, the required quantity of sample was taken out of the refrigerator and allowed to equilibrate at room temperature for at least 2 hours. The properties of sweet basil seeds were obtained at all four levels of the moisture content. All the properties were carried out with three replications [16].

2.2. Determination of 1000 seed mass

The samples prepared of 10.80%, 13.65%, & 16.20% were taken one ata time. The 1000 seed weight was calculated using 'Indosaw Computerized Automatic Seed Counter'. The machine counted 1000 seeds which were collected in a beaker and weighed, the weight of the beaker was subtracted to get the weight of the seeds. The same process was repeated thrice to get 3 different readings for each sample, the mean was taken and noted down [17, 18].

2.3 Bulk density

In order to determine the bulk density for sweet basil seeds, a container was taken and empty weight was noted (using Citizen Scales- Model: - CTG1202-1200), then filled with water till the brink from a measuring cylinder to determine the entire volume of the container. Then it was cleaned dry and sweet basil seeds were filled in excess. Excess seeds were removed using a flat ruler without compacting the seeds in any form.The container was weighed using an electronic balance (Citizen Scales- Model: - CTG1202- 1200) with a precision of 0.01 g. The weight of the seeds was obtained by a difference. The process was repeated thrice and the bulk density was calculated from the following relationship [17, 18, 23]:

$$\boldsymbol{\rho_b = \frac{m_p}{V}} \quad (3)$$

Where, m_p is the mass of seeds (weight of container with seeds- weight of empty container) and V is the Volume of container

2.4 True density

The true/ solid density was determined using the Toluene Displacement Method. The ratio of the weight of seeds to the total volume occupied by the seeds is true density. Seeds of known mass were lowered into a measuring cylinder containing toluene, filled up to a specific volume. The rise in volume after adding sweet basil seed was noted and the difference between the two levels is noted as Vt. The entire process was repeated thrice and the mean of all the observations was taken. Toluene was used instead of water because it has low absorptivity in seeds. In addition, the surface tension is low; such that it is capable to fill even shallow dips in a seed with low power dissolution. The ratio of mass to volume of the seeds was taken as true/ solid density as given [17, 19, 23]:

$$\rho_T = \frac{m}{V_t} \quad (4)$$

Where, m= Mass of sweet basil seeds,

V_t = Volume of toluene displaced

2.5 Specific Gravity

The specific gravity was measured using Specific Gravity Bottle- Pycnometer method. In this method first the weight of empty 25 ml pycnometer (Infusil calibrated at 250C) with stopper was taken using a digital weighing balance (Citizen Scale CTG 1202-1200), then it was filled with water and weighed again on the same weighing balance and the result was noted. After this step, water was poured out and the bottle was filled with toluene and weighed again. A measured amount of sweet basil seeds (Sabja Seeds) were taken and put in the pycnometer containing toluene, the stopper was placed such that the central capillary in the stopper was filled with toluene. Weight of pycnometer+toluene+seeds was noted. The entire process was repeated thrice and the mean of all the observations was taken as final result. Specific gravity was calculated using the formula-

$$s_g = \frac{\textbf{weight of sample}}{\textbf{weight of toluene displaced}} \text{ x } s_g \textbf{toluene} \quad (5)$$

2.6 Angle of Repose

The angle of repose is the angle with the horizontal at which the material will stand when piled. This was determined by using a glass measuring cylindrical with 50 ml volume.The cylinder was placed on a Graphite table, filled with the seeds and raised slowly until it formed a cone of seeds. The boundary of the cone thus formed was marked using pen and four different readings of the diameter of the cone was taken. Also, the height of the heap/ cone thus formed was calculated carefully using rulers (scale –15 cm). The angle of repose was calculated using the equation [20, 23]:

$$\varphi = \tan^{-1}\frac{2h}{d} \qquad (6)$$

2.7 Porosity

The porosity (ε) values were calculated from the values of true density and bulk density using the relationship given in equation 9 [21, 22, 17]:

$$\text{Porosity } (\varepsilon) = 1 - \frac{\rho_b}{\rho_t} \qquad (7)$$

2.8 Seed dimensions

Each seed was measured for its major diameter (a), minor diameter (b, also known as width) and the intermediate diameter (c, also known as thickness) using a Vernier calipers (Aerospace – 150mm reading to 0.02mm). Each seed was placed between the outside jaws of the calliper to measure the major diameter along the major axis of the seed. A total of 10 seeds were taken and their major, minor & intermediate diameter were taken. The minor diameter (b) was measured using a Micrometer/Screw gauge (Aerospace- 25mm, least count of 0.01mm) such that it was perpendicular to the major diameter of the seed while the intermediate diameter (c) was measured perpendicular to the major diameter and parallel to the intermediate diameter [23]. The mean of these values for a, b and c were taken and reported for each sample, which are given in the table 1 (all values in mm).

2.9 Color

The parameter of color values were measured using a hand held colorimeter (Konica Minolta- CR 400) which was calibrated using a white tile. The values of L*, a* & b* were obtained for all the four samples and the E* values was obtained for the three samples (10.80%, 13.65%, 16.20%) taking 8% as standard using the formula-

$$E^* = [(L-L^*)^2 + (a-a^*)^2 + (b-b^*)^2]^{0.5} \qquad (8)$$

Where L*, a* and b* are the L, a, b values of 8.35% sample.

2.10 Sphericity

Sphericity of the seeds were determined from the equation given below [19]:

$$\emptyset = \frac{(a.b.c)^{1/3}}{a} \qquad (9)$$

a= Major diameter/ length

b=intermediate diameter/length

c= minor diameter/length

3. RESULTS AND DISCUSSION

3.1. Determination of 1000 seed mass

There is a linear increase in thousand seed weight from 1.53 g to 1.80 g. The increase in weight gained due to increase in the amount of water contained in the seed as the moisture content increased could be a major factor [25].

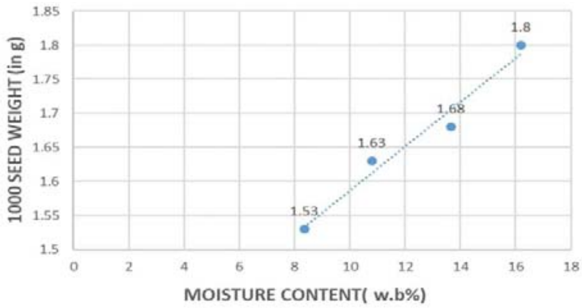

Figure 1. Variation of one thousand seed weight with moisture content

The variation of thousand seed weight with moisture content can be expressed mathematically by-

$W_{1000} = 0.0324Mc + 1.2626$ $(R^2 = 0.9712)$

Where, W_{1000}= 1000 seed weight &

Mc= moisture content (w.b %)

3.2 Bulk density

The bulk density decreased as moisture content increased. It can be found that the mean bulk density of sweet basil seeds ranged from 0.748 to 0.689 g/ml. Increase in size with moisture content gives rise to decrease in quantity of seeds occupying the same bulk volume which decrease bulk density [26].

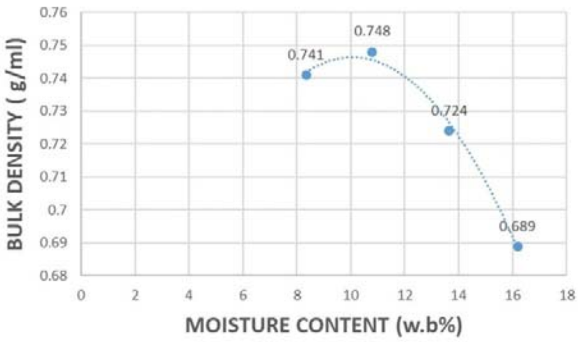

Figure 2. Bulk density of sweet basil seeds as a function of moisture content

The mathematical relationship between moisture content & bulk density can be obtained from the relationship –

y = -0.0015Mc² + 0.031Mc + 0.5907 (R^2= 0.9934)

$$y = -0.0015Mc^2 + 0.031Mc + 0.5907 \quad (R^2 = 0.9934)$$

Where, y = Bulk density,

Mc= Moisture content (w.b %)

3.3 True density

True density decreased as moisture content increased. Mean true density of sweet basil seeds ranged from 1.58 to 1 g/ml. Seed composition, decrease in water absorption caused by the oil globules and increase in swelling of the protein matrix with moisture content may have combined to cause the decrease in overall true density of seed[26].

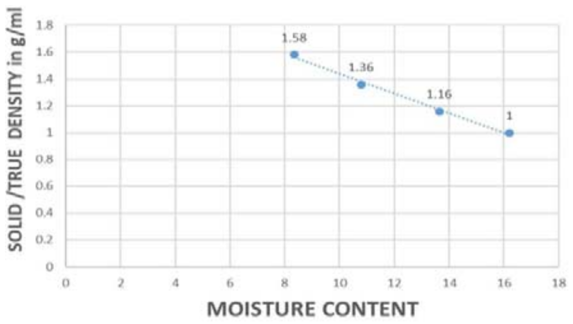

Figure 3. Change in bulk density as a function of moisture content

The mathematical relation between moisture content and solid/ true density can be given by the regression equation-

$$y = -0.0734Mc + 2.1742 \quad (R^2=.9937)$$

Where,

y= true/solid density

Mc= moisture content (w.b %)

3.4 Sphericity

Sphericity increased from 59.80% to 64.66%. The high value of sphericity of the seed indicates that it could be oval disc in shape [25].

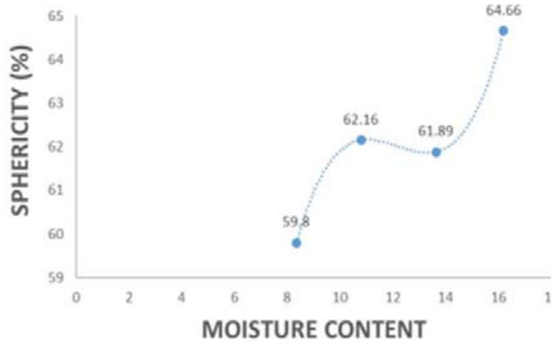

Figure 4. Variation of angle of sphericity with moisture content

The variation of sphericity with moisture content can be given by the equation-

$$\Phi = 0.0533x^3 - 1.9475x^2 + 23.522x - 31.843 \quad (R^2= 0.9918)$$

Where, y= Sphericity

x= Moisture Content (w,b%)

3.5Angle of Repose

There was an increase of angle of repose increased ranging from 12.02˚ to 19. 93˚.The angle of repose is the property of bulk material which indicates the cohesion among the individual units of the material. In this case, the higher the cohesion, the higher the angle of repose [24]. This indicates that increase in moisture content could have significant effect on the cohesion properties of sweet basil seeds.

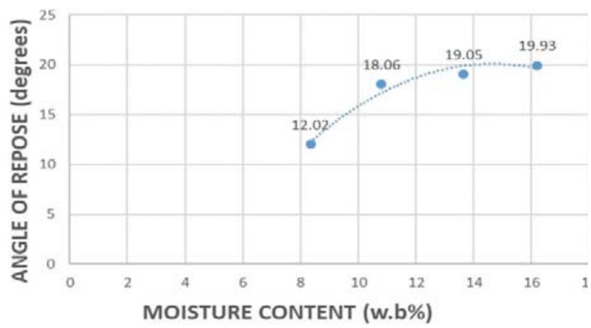

Figure 5. Variation of angle of repose with moisture content

The mathematical equation giving the relation between Angle of repose & Moisture content (w.b %) is given by-

$$\Theta = -0.195x^2 + 5.7167x - 21.796 \quad (R^2 = 0.9568)$$

Where, Θ = Angle of repose in degrees

x = Moisture Content

3.6 Specific Gravity

Specific gravity also increased linearly with moisture content.

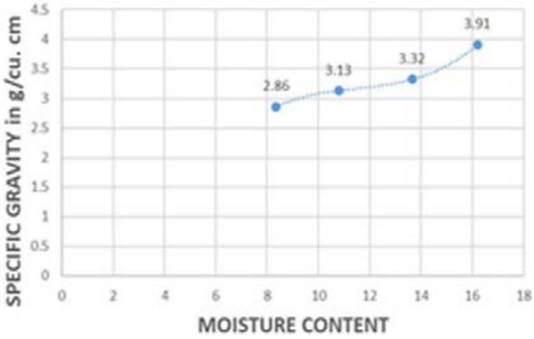

Figure 6. Specific gravity of sweet basil seeds as a function of moisture content

The equation showing the relationship of specific gravity & moisture content can be given by -

$y = 0.0049x^3 - 0.17x^2 + 2.0015x - 4.872$ ($R^2 = 0.9963$)

Where, y= Specific Gravity

x= Moisture content (w.b %)

3.7 Color

In general, the values of L, a* and b* increased with moisture content& E* value also increased with increase in moisture content meaning colors becoming brighter.

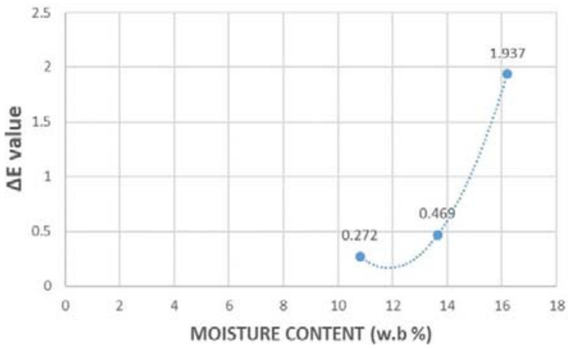

Figure 7. Effect of moisture content on color of sweet basil seeds

The rise in values of ΔE with moisture content can be determined by the

$\mathbf{y = 0.0938x^2 - 2.2257x + 13.364}$ (R^2= 0.9999)

Where y= ΔE value

x= Moisture content

3.8 Porosity

The porosity was found to decrease linearly from 52.84 % to 31.06 % due to significant increase in seed dimensions with increase in moisture content.

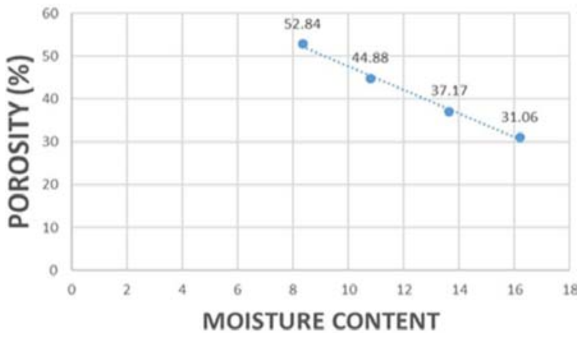

Figure 8. Effect of moisture content on color of sweet basil seeds

.Porosity and moisture content relationship can be determined as-

$\mathbf{\xi = -2.7649x + 75.358}$ (R^2= 0.9957)

Where, ξ = Porosity

x= Moisture Content (w.b %)

3.9 Seed dimensions

The dimensions of the seed increase uniformly in the three axes.

Table 1. Dimensional properties at varying moisture content

	MOISTURE CONTENT			
DIMENSIONS	8.35%	10.80%	13.65%	16.20%
L	0.268	0.232	0.241	0.241
B	0.153	0.127	0.134	0.147
T	0.095	0.096	0.097	0.101

4. CONCLUSION

The investigation of various engineering properties of sweet basil seeds revealed the following:

- As the moisture content increases, the dimensions of the seed increase uniformly in the three axes.
- The thousand seed weight increases linearly with moisture content.
- The true and bulk densities decrease with increase in moisture content.
- Porosity also decrease linearly with moisture content.
- The seed is described as being oval in shape.
- The dynamic angle of repose increases with moisture content and has a multiplicative relationship with it.

The knowledge of engineering properties of these seeds will serve as an important tool for designing agricultural machines and equipment for planting, harvesting, processing, packaging and storage as well as relevant to the design of the components of a planter such as the hopper, the seed plate and the delivery tube

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