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Note

Physical properties of cumin and caraway seeds

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A b s t r a c t. Physical properties of cumin and caraway seeds were measured and compared at constant moisture content of 7.5% w.b. The average thousand mass of grain, mean length, mean width, mean thickness, equivalent diameter, geometric mean diameter, surface area, volume, sphericity, aspect ratio, true density, bulk density and porosity were measured for cumin and caraway. There are significant differences (p<0.01) in most physical properties of cumin and caraway, except porosity and sphericity.

K e y w o r d s: physical properties, cumin seed, caraway seed, friction coefficient, angle of repose

INTRODUCTION

Cumin is one of the most important medicinal and spice plants in the world grown in Iran and other countries since many years ago. There are two types of cumin seeds. Cumin (*Cuminum cyminum*) called green cumin in Iran, is a small 15-50 cm high gramineous plant with long and thin roots, very thin leaves, and white or pink flowers. This plant is native to Egypt and Nile shores. Caraway (*Carum carrvi*) called black cumin in Iran, is a two-year 30-60 cm high plant having empty stems and thin light green leaves; it is native to a limited area of west Asia including the eastern regions of Iran. Due to their numerous applications in medicine and as food additives, the cultivation of these plants has been increased in recent years. Nowadays, Iran is one of the exporters of these products. Physical properties are very important factors in designing agricultural equipment such as dryers, aerators, cleaners, and conveyers. Measuring principal axial dimensions of grain is important in selecting grain separating sieves and removing foreign materials from the product. Furthermore, these dimensions are used in calculating surface area, volume, and sphericity of grain which are useful in designing postharvest equipmens.

For years, the physical properties of agricultural products have been of interest to many researchers. They have reported physical and mechanical properties of seeds, nuts, kernels and fruits such as arigo seeds (Davies, 2010), chick pea and lentil seeds (Ozturk *et al*., 2010), lentil seeds (Bagherpour *et al*., 2010), soybeans (Davies and El-Okene, 2009), ground nut (Davies, 2009), chia seeds (Ixtaina *et al*., 2008), rice (Correa *et al*., 2007), raw and parboiled paddy (Reddy and Chakravertyj, 2004), and hemp seeds (Sacilik *et al*., 2003; flaxseed (Singh *et al*., 2012) and corn seed (Babic *et al*., 2013).

As far as we know, no study has been reported on the physical properties of cumin and caraway. Therefore, our aim in this study was determine the physical properties of cumin and caraway seeds which provide the basic information for designing grain handling and processing machinery.

MATERIALS AND METHODS

In this study, cumin and caraway seeds were obtained from local shops. Before measuring the properties of grains, foreign matters such as dust, stones, straw, and chaff were removed manually from the rest of grains. The initial moisture content of seeds was determined using the standard method (Brusewitz, 1975). The average moisture content was 7.5% (w.b.), determined through an oven method at 105 ±3°C during 24 h according to Correa *et al*., (2007). The principal dimensions (length, width, thickness) of randomly selected cumin and caraway grains were measured using a digital micrometer having the accuracy of 0.001 mm.

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The geometric mean diameter, equivalent diameter, surface area, aspect ratio of the shape, sphericity, bulk density, and porosity were determined according to the standard methods (Jain and Bal, 1997; Mohsenin, 1980).

The filling or static angle of repose was measured with the topless and bottomless cylinder method (Mohsenin, 1980).

The static coefficient of friction was measured on different surfaces of wood, aluminium, and painted metal. For this purpose, a cylinder with a diameter and depth of 75 and 50 mm, respectively, was filled with grains. The cylinder was mounted on the surface and the slope of the surface was increased gradually. When the cylinder started sliding down, the angle was measured.

The internal friction angle for both cumin and caraway seeds was measured using a shear box tester (Mohsenin, 1980). Several specimens were tested at different normal vertical forces (F_n) to determine the angle of internal friction.

The result of the tests for each specimen considering the normal stress (σ_n) on x-axis and nominal shear stress (τ) on y-axis was plotted on a graph. The slope of the line represents the internal friction coefficient. In this test 1, 2 and 3 kg weights were applied for normal vertical force. The statistical data analysis was done using SPSS15 software.

RESULTS AND DISCUSSION

A summary of some physical properties of cumin and caraway is shown in Table 1. Statistical analysis showed that there were significant differences ($p<0.01$) in the length, width, and thickness of cumin and caraway seeds. The average length, width, and thickness for cumin were found to be 4.6, 1.2, and 0.8 mm, respectively, while 3.9, 1.0, and 0.6 mm were measured for black cumin. The correlation coefficient of seed dimensions for L/W, L/T, and W/T ratios were measured as 0.73, 0.73, 0.80 for cumin and 0.73, 0.74, 0.86 for black cumin, respectively. Based on these values, all dimensions of both cumin and caraway seeds were highly correlated to each other. The average sphericity of cumin and caraway was 0.362 and 0.346, respectively, which is in the range of 0.32-1.0 reported by Mohsenin (1980). The low value of sphericity in this case is caused by high differences between length and two other dimensions in both types of seed. Based on statistical analysis, there was no significant difference in the sphericity of cumin and caraway grains. The average of the equivalent diameter for cumin seeds was significantly higher than that for caraway seeds ($p<0.01$) with a value of 1.7 and 1.4 mm, respectively.

The geometric mean diameters were calculated to be 1.6 mm for cumin and 1.4 mm for caraway grain. There was a significant difference in the geometric mean diameters ($p<0.01$). The aspect ratio values are shown in Table 1. There was no significant difference in the aspect ratio of two types of cumin. The aspect ratio for the cumin seeds was lower than that for chia seeds (Ixtaina *et al*., 2008) and arigo seeds (Davies, 2010) and was in the range of rough rice grain varieties (Ghasemi Varnamkhasti *et al*., 2008).

There were significant differences in the grain volume and surface area of cumin and caraway ($p<0.01$) shown in Table 1. The ratio of volume per unit surface area was calculated to be 0.312 for cumin seeds and 0.256 for caraway

T a b l e 1. Some physical properties of cumin and caraway seeds

Property	No. observation	Cumin	Caraway
Length[a] (L) (mm)	30	4.6±0.7	3.9±0.6
Width[a] (W) (mm)	30	1.2±0.1	1.0±0.1
Thickness[a] (T) (mm)	30	0.82±0.1	0.6±0.05
Equivalent diameter[a] (mm)	30	1.7±0.2	1.4±0.1
Geometric mean diameter[a] (mm)	30	1.6±0.2	1.34±0.1
Sphericity[ns] (%)	30	36.2±3.8	34.64±3.7
Aspect ratio[ns]	30	0.3±0.05	0.3±0.05
Volume[a] (mm^3)	30	2.5±1.2	1.4±0.4
Surface area[a] (mm^2)	30	8.0±2.22	5.5±1.0
Bulk density[a] (kg m^{-3})	5	622.0±4.6	736.5±2.9
True density[a] (kg m^{-3})	5	1155.6±27.4	1294.1±14.4
Mass of thousand grains[a] (g)	5	2.91±0.01	1.583±0.01
Angle of repose[b] (°)	5	47.7±1.2	49.8±1.1

[a]1% probability, [b]5% probability, ns – no significant difference.

seeds. Any particle that has a smaller ratio of volume per unit surface has better conditions for rapid heat transfer (Stroshine and Hamann, 1994); this means that caraway seeds consume less time and energy during the drying process. The average bulk density of cumin and caraway seeds were calculated to be 622 and 736.5 kg m^{-3}, respectively. The significantly higher value of bulk density for caraway seeds ($p<0.01$) could be due to their lower volume compared to that of cumin. The bulk density of cumin seeds was in the range of the bulk density of sorrel seeds, while this value for black cumin seeds was higher than that for sorrel seeds (Omobuwajo *et al*., 2000) and was higher than that of rough rice (Ghasemi Varnamkhasti *et al*., 2008). As a result, with the same weight, caraway grains require less storage space. The values of true density for cumin and caraway grains are shown in Table 1, a significant difference ($p<0.01$) was observed. These values were higher than those mentioned for sunflower (Gupta and Das, 1997), safflower (Baumler *et al*., 2006), and arigo seeds (Davies, 2010).

There was a significant difference ($p<0.05$) between the mean angle of repose for cumin and caraway seeds, which were 47.7 and 49.8°, respectively. These values were much higher than those mentioned for oilbean seed (Oje and Ugbor, 1991), sunflower (Gupta and Das, 1997), Shea Kernel (Olajide *et al*., 2000), safflower (Baumler *et al*., 2006), rough rice grain (Ghasemi Varnamkhasti *et al*., 2008), and arigo seeds (Davies, 2010).

The static coefficient of friction of cumin and caraway seeds against three different structural surfaces were measured and they are shown in Table 2. Clearly, the plywood surface has the highest value of the static coefficient of friction while the aluminium sheet has the lowest static coefficient of friction. Statistical analysis showed a significant difference in the static coefficient of friction between cumin and caraway grains ($p<0.05$). These values were higher than those for rough rice (Ghasemi Varnamkhasti *et al*., 2008), much higher than for arigo seeds (Davies, 2010), and lower than that recorded for sorrel seeds (Omobuwajo *et al*., 2000). Charts related to the internal friction angle of cumin and caraway seeds are shown in Fig. 1. The slope of two lines showing the internal friction angle of cumin and caraway seeds are almost close together. Based on statistical analysis, there was no significant difference in the internal friction of cumin and caraway grains. The average of 1 000 grain mass of cumin and caraway seeds were 2.90 and 1.59 g, respectively, and are significantly different. The porosities of cumin and caraway were calculated to be 46 and 44%, respectively.

Finally, it can be concluded that the physical properties of cumin and caraway seeds are significantly different. Therefore, processing machines, sieves and storage equipment designed based on physical properties of cumin seeds cannot be used for caraway seeds.

Table 2. Static coefficient of friction for cumin and caraway seeds on different surfaces (number of observations – 3)

Surface	Cumin	Caraway
	Mean	
Plywood	0.57±0.02	0.54±0.01
Galvanized iron sheet	0.46±0.01	0.39±0.02
Aluminium sheet	0.31±0.01	0.28±0.01

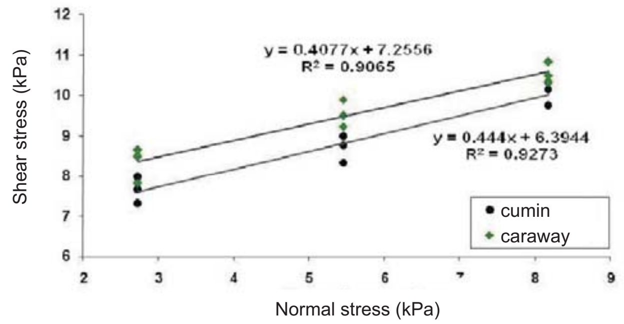

Fig. 1. Relation between shear and normal stress related to the internal friction angle of cumin and caraway seeds.

CONCLUSIONS

1. Significant differences were observed ($p<0.01$) in the most physical properties of cumin and caraway, except porosity and sphericity.

2. There were significant differences ($p<0.05$) in the angle of repose and static friction coefficient of cumin and caraway.

3. For cumin, the average static coefficient of friction varied from 0.312 on aluminium to 0.569 on plywood, while for caraway seeds the corresponding values varied from 0.277 to 0.535 on the same surfaces. The angle of repose for cumin and caraway seeds were 47.7 and 49.8°, respectively.

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