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PHYSICAL PROPERTIES OF MUSTARD SEEDS AND HOW THEY ARE INFLUENCED BY PACKAGING

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Abstract*: I paid attention to how mustard seeds interact with storage container for a period of 6 months. I examined some of the physical properties of these seeds such as: length L (mm), width W (mm), thickness T (mm), geometric mean diameter Dg (mm), sphericity Φ (%), porosity ε (%), volume V (mm^3), mass m (g), bulk density ρ_b (g/cm^3), true density ρ_{tr} (g/cm^3) before and after storage for six months at normal temperature and pressure. The samples were: sample 1 mustard seeds in a plastic bag and sample 2 mustard seeds in a plastic box with a top. The physical dimensions of the samples measured in three mutually perpendicular directions before storage had values between: for T minimum – 1.90 mm, maximum 2.61 mm, for W – minimum 1.87 mm, maximum 2.44 mm, for L – minimum 1.82 mm, maximum 2.58 mm. After the six months of storage at normal temperature and pressure in various packages, the physical dimensions of the mustard seeds varied the least for the seeds in sample 1.*

Keywords: *Mustard, seeds, physical properties.*

1. Introduction

Plants, including herbs and spices, have many phytochemicals which are a potential source of natural antioxidant, e.g., phenolic diterpenes, flavonoids, alkaloids, tannins and phenolic acids [1]-[4].
Many culinary herbs and spices were included in the category of medicinal plants such as cumin oil and seeds, cardamom seeds, cinnamon, cloves, dill seeds, fennel seeds and oil, garlic, ginger root, liquorice root, peppermint oil, onion, paprika, parsley root, oil and mint leaves, rosemary, sage, thyme, turmeric root, coriander seeds, mustard seeds [5].
Recently, the natural spices and herbs such as rosemary, oregano, and caraway have been used for the processing of meat products [1].
Most spices have been used for therapy of gastrointestinal, aphrodisiacs tonic and non-specific, some of them have antibacterial or antifungal effect, and some irritants were used for anti-inflammatory effect. Because they seem to have strong antioxidant effects, some claim to be able to prevent cancer. Most of the health benefits of more potent have not proven yet [6].
Mustard seeds are the small round seeds of various mustard plants. Mustard seeds may be colored from yellowish white to black. The seeds may come from three different plants: black mustard (*Brassica nigra*), brown Indian mustard (*B. juncea*), and white mustard (*B. hirta/Sinapis alba*) [6].
Mustard seeds have been used since 4000 years ago both in the kitchen for flavor and

also in medicine for its beneficial effects [6].
I have accorded the same attention to the bilberry and seabucktorn fruits, analyzing the behavior during the storage period, and in different packaging (plastic box with lid, jar package, double paper wrapper, plastic bag) [7]-[8].

The objective of this study was to investigate in which way the package influences the physical proprieties of mustard seeds *L (mm), W (mm), T (mm), Dg(mm), Φ(%), ε,(%), V(mm^3), m(g), ρ_b (kg/m^3), ρ_{tr} (kg/m^3)*.
All the information is important for designing the equipment, storage and packing to increase the work efficiency and decrease product loss.

Nomenclature	**T-thickness (mm)**
	V-single seed volume (mm^3)
Dg-geometric mean diameter (mm)	**W-width (mm)**
L-length (mm)	**ρ_b-bulk density, (g/cm^3)**
m-unit mass of the seed (g)	**ρ_{tr} –true density, (g/cm^3)**
m_{100}-100 seed mass (g)	**ε-porosity (%)**
S- seed surface (mm^2)	**Φ-sfericity, (%)**

2. Materials and methods

2.1 Sample preparation

The analyzed seeds have been bought from Suceava area, România.
I have randomly selected 10 seeds, using an electronic caliper with a precision of 0.01mm, I have measured the three major perpendicular dimensions of the fruits namely length L, width W and thickness T, after which I have packed them in:
Samples:

1. *Mustard seeds in plastic bag;*
2. *Mustard seeds in plastic box with a top.*

The samples were stored for 6 months under normal conditions of pressure and temperature and then re-measured.

2.2 Geometric mean diameter, sphericity, volume and surface area

The geometric mean diameter Dg and sphericity of seeds was calculated using the following relationship [9]:

$$Dg = (LWT)^{1/3} \quad (1);$$

$$\Phi = [(LWT)^{1/3}/L] \times 100 \quad (2);$$

for volume and seed surface was calculated by using the following relationship [10]:

$$V = \frac{\pi B^2 L^2}{6(2L-B)} \quad (3)$$

$$S = \frac{\pi B L^2}{2L-B} \quad (4)$$

Where B is:

$$B = (WT)^{0.5} \quad (5)$$

2.3. One hundred fruits weight and the unit mass

To obtain the unit mass of the seeds, the mass of 100 seeds were measured with an electronic balance with an accuracy of 0.0001g.

2.4. Bulk and true density

The bulk density is the ratio of mass sample of the seed to its total volume. It was determined by filling a 1000 mL container with seeds from a height of about 15 cm, the excess seeds were removed using a stick and then weighing the contents [11].
The true density was determined using liquid displacement method. The seeds were used to displace Toluene (C_7H_8) in a measuring cylinder after their masses had been measured. Toluene was used instead of water because it is absorbed by seeds to a lesser extent. The true density was found as an average of the ratio of their masses to the volume of Toluene displaced by seeds [11].

2.5. Porosity

The porosity is the fraction of space in the bulk seeds that is not occupied by the seeds [12].
The porosity ε of bulk mustard seed was calculated using the following relationship [9]:

$$\varepsilon = \frac{\rho_t - \rho_b}{\rho_t} x100 \qquad (6)$$

Where ρ_{tr} is true density in g/cm^3 and ρ_b is bulk density in g/cm^3.

3. Results and discussion

3.1. Seed size

The dimensions of the mustard seeds measured in three perpendicular directions, before storage had the values between two intervals: L – minimum 1.82 mm, maximum 2.58 mm, W - minimum 1.87, maximum 2.44 mm, T – minimum 1.90 mm, maximum 2.61 mm.
For the data analysis I have used ANOVA single factor.

In Table 1 are the medium values and the dimension variance of the seeds L(mm), W(mm), T(mm) before storage, for every sample, in Table 2 are the medium values and dimension variance of the same dimensions after 6 months of storage under normal conditions of pressure and temperature for both sample.

Table 1 The medium values and the dimension variance of the seeds L(mm), W(mm), T(mm) before storage.

SAMPLE	L (mm)		W (mm)		T (mm)	
	AVERAGE	VARIANCE	AVERAGE	VARIANCE	AVERAGE	VARIANCE
1	2.31	0.046	2.19	0.04	2.23	0.06
2	2.30	0.046	2.19	0.04	2.23	0.06

Tabel 2 The medium values and dimension variance of the same dimensions after 6 months of storage

SAMPLE	L (mm)		W (mm)		T (mm)	
	AVERAGE	VARIANCE	AVERAGE	VARIANCE	AVERAGE	VARIANCE
1	2.27	0.015	2.04	0.02	2.15	0.03
2	2.28	0.002	2.16	0.01	2.19	0.01

Because F (observed value) > F^{CV} (critical value) for T and W, we reject the null hypothesis.
To highlight more clearly how these dimensions of mustard seeds varies over time for each sample, we have represented the relative variation of L in Figure 1, the relative variation of W in Figure 2 and the relative variation of T in Figure 3.

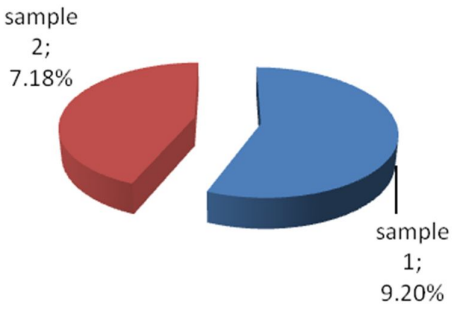


Figure 1 The relative variation of L(%)

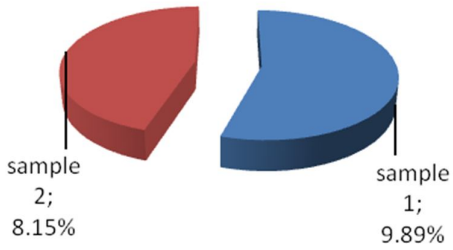


Figure 2 The relative variation of W(%)

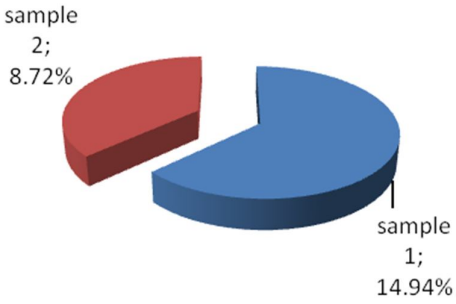


Figure 3 The relative variation of T(%)

As we can see, the variation of the all dimensions (L, W, or T) is greatest for the sample 1.

3.2 Geometric mean diameter, sphericity, volume and surface area.

To determinate the geometric diameter of the mustard seeds we have used Eq (1). The relative variations for each sample, after 6 month of storage are presented in Figure 4.

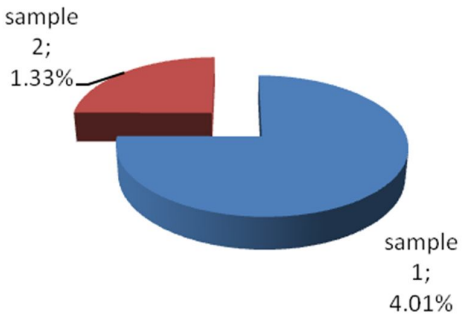
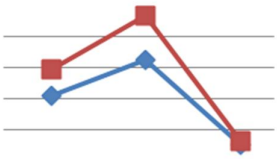


Figure 4 the relative variation of D_g (%)

To calculate sphericity, volume and surface of mustard seeds we used Eq (2), (3) and (4). The relative variations of sphericity, volume and surface of seeds, after 6 month storage, we represented in Figure 5.



	S(%)	V(%)	Φ(%)
SAMPLE 2	4,07%	6,92%	0,49%
SAMPLE 1	10,59%	16,26%	2,80%

Figure 5 The relative variation of S, V and Φ

As we can see, the variation of the sphericity, volume and surface of seeds, after 6 month storage, is greatest for sample 1.

3.3. One hundred mustard seeds weight.

The mass of 100 mustard seeds before storage was: $m_{100} = 0.7401g$, and after storage: for sample 1 was 0.6148g, for sample 2 was 0.6125 g.

Figure 6 The relative variation of m_{100} (%)

As shown in Figure 6, no significant differences of the relative variations of mustard seeds weight for each samples.

3.4. Bulk and true density

The relative variation of bulk density, for each sample, is presented in Figure 7 and the relative variation of true density for each sample, is presented in Figure 8.

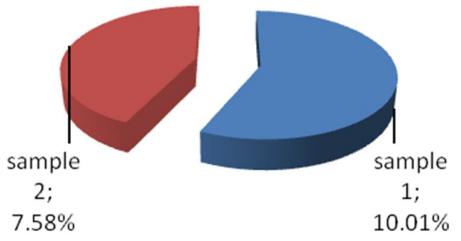


Figure 7 The relative variation of ρ_b(%)

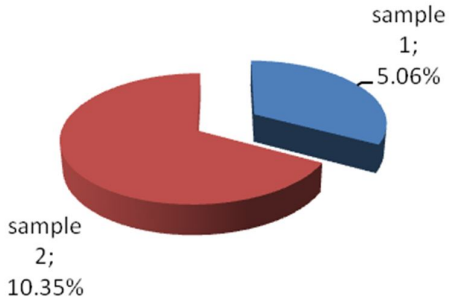


Figure 8 The relative variation of ρ_{tr}(%)

The relative variation of true density of the seeds was highest for the sample 1 10.1%, and the relative variation for bulk density was highest for sample 2 10.35%.

3.5. Porosity

The value of porosity were calculated with Eq (6) by using the data on bulk and true densities of seeds and the results obtained are presented in Figure 9.

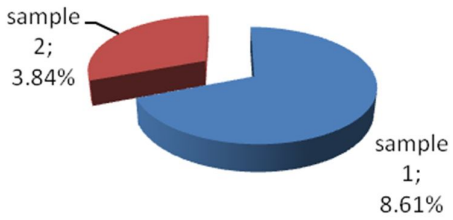


Figure 9 The relative variation of ε (%)

No significant variation of the porosity in none of the samples analyzed has been seen.

4. Conclusion

After the measurements made on physical properties of mustard seeds bought from Suceava area, Romania, before and after their storage for a period of six months at normal temperature and pressure in various packages, we drew the following conclusions:

1. The dimensions of the seeds measured by three perpendicular directions before storage had values between: for L – minimum 1.82 mm, maximum 2.58 mm, W - minimum 1.87, maximum 2.44 mm, T – minimum 1.90 mm, maximum 2.61 mm;
2. After the six months of storage at normal temperature and pressure in various packages, the dimensions of the mustard seeds suffer different modifications that depend on the nature of the package used for each sample.
3. As we can see, the variation of the physical dimensions was greatest for the sample 1, except the relative variation of true density that was higher for the sample 2 and for mass of 100 seeds which ranged roughly the same for both samples.

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