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THE ENERGY OF BEAN-POD OPENING AND THE METHOD OF DETERMINING AIR VOLUME THEREIN

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Summary. The thesis features the results of preliminary research on developing a simple method to determine air volume inside a pod. The research was carried out on bean-pods grown for dry seeds of the Narew, Nida and Warta varieties. Seven methods to determine air volume were compared (the picnometric one and six simple pod models).

There was a significant statistical dependency of air volume inside a pod and energy of opening on bean variety and the method to determine it. The volume of air and energy of the opening most similar to the ones determined by method 1 (accurate) were obtained for the Narew variety with method 5, for the Nida and Warta varieties – with method 7. The methods suggested make it much easier to determine air volume inside a bean pod, thus the energy needed to burst it open.

Key words: bean pod, energy of pod opening, air volume, measurement methods.

INTRODUCTION

The pod susceptibility to cracking is manifested by spilling seeds at harvest as a result of the operation of harvesting machine groups, mostly various cutting, plant-clipping, raking-up and gathering appliances. The feature is an important problem in pod plant farming as it contributes to generating significant seed loss [Furtak and Zaliwski 1986, Kuźniar and Sosnowski 2003, Szot and Tys 1979]. The pod susceptibility to cracking is conditioned by the content and structure of fibre in pod walls and their seams, which is a variety-related feature and depends on meteorological conditions during vegetation [Dorna and Duczmal 1994, Hejnowicz 1985, Kuźniar and Strobel 2000, Kuźniar and Sosnowski 2000, Tomaszewska 1954].

It is necessary to develop a method that would enable precise measurement in order to examine in detail the influence of various factors on the tendency of those fruits to burst open. A number of methods to measure pod durability features were developed which make it possible to characterise them objectively in relation to assessment of their susceptibility to cracking. The most accurate and objective of these methods were developed by Řezničk [1978], Szot and Tys [1987] Weeks and others [1975], and Szwed and others [1997, 2000]. Yet Řezničk's method is laborious and requires equipment which is expensive and uncomfortable to use. However, Weeks' method

interferes too much with pod tissue, as bursting a pod open with the use of arresting needles may damage its structure and change its mechanical parameters. Another disadvantage of these methods is that the results obtained should be compared with the size of fruits being examined. The faults of these methods are accounted for by the pressure method which makes it possible to assess pod resistance to bursting by inserting air into it and measuring the pressure which accompanies the cracking of seams. The measure of pod tendency to burst open is the energy of the opening [Kuźniar and Sosnowski 2006, Strobel 2003]; it is necessary to know not only the bursting pressure (relatively easy to measure) but also the air volume inside the pod to calculate it. The latter parameter, due to the irregular shape of that type of fruit, is hard to measure. Strobel [2003] defines air volume inside a pod as the subtraction of approximate pod volume and its seed volume. He calculates approximate pod volume as volume of a cylinder of the height equal to its length and of the diameter being the arithmetic mean of the width and thickness of the pod in its central part.

Exact volume of solids of irregular shape can be determined by a picnometer, yet it is time-consuming and requires relatively much work resulting from the need to measure first all of the pod and later its seeds and shells [Kuźniar and Sosnowski 2007].

The aim of this thesis was the analysis of ways to determine air volume inside a bean pod in a simplified way, and to assess the influence of a method determining that volume on the amount of energy needed to open a pod.

MATERIAL AND METHODS

The tests were carried out on pods of beans grown for dry seeds, Narew, Nida and Warta cultivars, which came from experimental field of the Agricultural and Food Production Engineering Department of the Rzeszow University. Refer to tab. 1 for the characteristics of tested pods of bean cultivars.

Tab. 1. Pod characteristics (average values) of tested bean cultivars

Specification	Narew	Nida	Warta
Dimension of pods [mm]:			
Length	100,7	92,0	101,9
Width	9,2	9,7	9,0
Thickness	8,9	8,9	8,7
Number of seeds in pod	4,6	4,4	5,2

In method 1, air volume inside a pod was determined exactly as subtraction of pod total volume and the volume of seeds therein and its shells volume. These volumes were determined by the picnometric method. However, that way to determine volume is quite laborious.

In method 2, air volume inside a pod was calculated as volume of a cylinder of the height equal to its length and the elliptical diameter of axes equal to the width and thickness in its central part.

In methods 3-7, air volume inside a pod was calculated as volume of a solid in its central part consisting of a cylinder and ended with two cones. The section of the cylinder and the base of cones is the ellipsis, like in method 2. The heights of the cylinder and the cone for these methods were put in tab. 2.

Tab. 2. The heights of the cylinder and the cone being a pod model in methods 3-7.

Method	Height of the cylinder	Height of the cone
3	0,75*l*	0,125*l*
4	0,5*l*	0,25*l*
5	0,4*l*	0,3*l*
6	0,3*l*	0,35*l*
7	0,2*l*	0,4*l*

l – length of the pod

The measurements were conducted on 20 pods of each variety, with the humidity of pods between 14.5 – 16%.

The given results underwent a statistical analysis.

RESULTS

Based on the analysis of the variance, there was a significant influence of bean variety and the method measuring air volume in the pod on the volume size and energy accompanying the opening of the pod.

For all methods used to determine air volume in pods, the Nida variety was characterized by the smallest volume, the Narew – by its biggest volume. Yet, the LSD test showed that greater volume in the Narew variety pods was statistically significant only for method 1.

The various methods used to determine air volume in a pod significantly differentiated that parameter. It is proved by the fact that the significance test due to mean air volumes in pods of the bean varieties tested distinguish six homogenous groups (tab. 3 – average A). Considering each variety as separate, the significance test showed slightly smaller differentiation, as air volumes constituted only five homogenous groups.

Out of the suggested simplified methods to determine air volume in a pod, the results most similar to the ones exactly determined by method 1 (picnometric) were obtained for the Narew pods with method 5, and for the Nida and Warta pods – with method 7. The significance test also showed the lack of statistically significant differences in volumes for the Narew variety pods with methods 4 and 6, and for the Nida and Warta pods – with method 6.

Tab. 3. The air volume in pods of tested bean cultivars [cm^3]

Methods	Narew	Nida	Warta	Average A
1	3,838 bc	2,963 a	2,967 a	3,256 ab
2	6,484 e	6,220 e	6,333 e	6,345 f
3	5,403 d	5,183 d	5,277 d	5,288 e
4	4,323 c	4,147 c	4,222 c	4,231 d
5	3,890 bc	3,732 bc	3,799 bc	3,807 c
6	3,449 ab	3,309 ab	3,369 ab	3,376 b
7	3,034 a	2,911 a	2,964 a	2,970 a
Average B	4,565	4,259	4,328	4,384

* different letters in column signify significant differences, as per LSD test (significance level of $\alpha = 0.05$)

For all methods used to determine air volume in pods, the smallest energy of the opening was characteristic for the Nida variety pods, the biggest – for the Narew ones. Based on the LSD test, it was concluded that, due to values of the energy of the opening determined by all methods applied, the tested bean varieties showed statistically significant differences.

The values of the energy of the opening pods were also significantly differentiated by the applied methods to determine air volume in a pod. It was proved by the fact that the significance test due to mean energy values distinguished four homogenous groups (tab. 4 – average A). Considering each variety tested separately, the significance test showed smaller differentiation, as the values of the energy of the opening now combined only three homogenous groups.

Tab. 4. Energy of pod opening [J]

Methods	Narew	Nida	Warta	Average A
1	0,2984 ab	0,0838 a	0,1596 a	0,1806 ab
2	0,5050 c	0,1705 c	0,3407 c	0,3387 d
3	0,4208 bc	0,1421 bc	0,2839 bc	0,2823 cd
4	0,3367 ab	0,1137 ab	0,2272 ab	0,2259 bc
5	0,3030 ab	0,1023 ab	0,2044 ab	0,2032 ab
6	0,2687 ab	0,0907 a	0,1813 a	0,1802 ab
7	0,2364 a	0,0798 a	0,1595 a	0,1586 a
Average B	0,3554	0,1172	0,2329	0,2242

* different letters in column signify significant differences, as per LSD test (significance level of $\alpha = 0.05$)

The values of the energy of the opening most similar to the ones determined by method 1 were obtained, just like with air volume, for the Narew pods with method 5, and for the Nida and Warta varieties – with methods 2 and 3.

CONCLUSIONS

1. Air volume inside a pod and the energy of the opening showed statistically significant dependence on pod variety and the method of determining volume.
2. With all methods applied, the Nida pods were characterised by smallest air volume and energy of the opening; the Narew pods – by greatest ones.
3. Method 1 (picnometric) was the most accurate of all methods used to determine volume.
4. Volume of air and energy of the opening most similar to the ones determined by method 1 were obtained for the Narew variety with method 5, for the Nida and Warta varieties – with method 7.
5. The methods suggested make it much easier to determine air volume inside a bean pod, thus the energy needed to burst it open.

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