DETERMINATION OF RAPESEED (*BRASSICA NAPUS)* DIMENSIONS AND SHAPE BY IMAGE ANALYSIS

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Abstract. This study is focused on determination of the dimensions and description of the shapes of rapeseeds (*Brassica napus*) using the image analysis with aid of trio ocular microscope. For the image analysis the ImageJ software was used utilizing the threshold method based on IsoData algorithm. The microscope was set up with a 4 x objective coupled to a cam with resolution 2592 x 1944. From determined dimensions the ball model based on the true seed area for description of the shape and dimensions of rapeseed was derived and verified. From the conducted study it follows that this derived ball model is more appropriate for description of true reality than models based on the arithmetic or geometric diameter determined from average measured diameters.

Keywords: model, ball, shape, dimension, diameter.

Introduction

For precision description of mechanical behaviour of rapeseeds as well as for design of the processing technology it is necessary to understand the shapes and dimensions of oilseeds [1-3]. There are lot of published studies related to the dimensions and shapes of rapeseeds [4-6] and from these studies it follows that with aid of determined dimensions the appropriate mathematical model could be derived. From already published studies it implies that the ball model is a suitable mathematical model for description of the shape of rapeseeds [4; 5; 7]. There are few theories for calculation of the model ball diameter which are based on the measured diameters [1; 2; 8], however, currently it is very well known that the model should be based on the true cross section area of oilseeds, which was verified in few FEM or DEM studies [9-12]. The ball model which respects the area of the seeds can be used more appropriate for accurate description and simulation of processing or transportation of seeds.

The aim of this study is to determine the diameter of the ball model, which is based on the measured areas of rapeseeds detected by the image analysis conducted by ocular microscope.

Materials and methods

Cleaned rapeseeds (*Brassica napus*) obtained from the Czech Republic were used for the experiment. The moisture content $M_c = (6.4 \pm 0.3)$ % d.b. of the samples was determined by the conventional method ASAE using a standard hot air oven with a temperature setting of 105 ºC and a drying time of 17 h (ASAE S410, 1998) [13].

For determination of the dimensions 20 pieces of rapeseeds were used. Dimensions of each seed, diameters D_A (mm), D_B (mm) and cross section areas S (mm^2) were determined by the digital image analyses using ImageJ software that uses java based image processing. The default threshold method based on IsoData algorithm was used in this experiment. The images were taken with aid of trio ocular microscope (Bresser BioScience Trino, Besser GmbH, Rhede, Germany) such as shown in Fig. 1, which was set up with a 4 x objective coupled to Bresser Mikrocam 10 MP with resolution 2592 x 1944.

Geometric mean diameter D_g (mm) of the ball model was calculated using the following equation:

$$D_g = \sqrt{\frac{4 \cdot S}{\pi}} \qquad (1)$$

Results and discussion

From the determined diameters, which are presented in Fig. 2, the average diameter D and average area S were calculated and they are shown together with their standard deviations in Table 1. From Table 1 as well as from Fig 2 it follows that the measured amounts of areas and diameters are consistent with already published studies focused on physical properties of rapeseeds [4-7].

Using the average cross section area S and equation (1) the ball model diameter D_g was calculated and it is presented in Table 1. From the statistical analysis, $t = 0.566$, $t_{crit} = 2.023$, which was done by

Student test for the level of significance 0.05 (t-test, n = 40, p > 0.05), it follows that the measured values of rapeseed diameters are statistically significant with the calculated ball model diameter and it is also clear from the graphical presentation in Fig. 2, where the ball model diameter is shown by a bold line and its standard deviations are also presented by a dashed line. From the histogram of rapeseed diameters for five groups of dimensions, which is shown in Fig. 3, it implies that the most represented group shows similarities with the determined ball model diameter. It is also evident that distribution of the diameter frequency confirms the conducted results of the statistical analysis for equality of the true diameters and the ball model diameter determined by equation (1). From the carried out study it implies that rapeseed areas determined by the image analysis can be used for calculation of the appropriate ball model diameter.

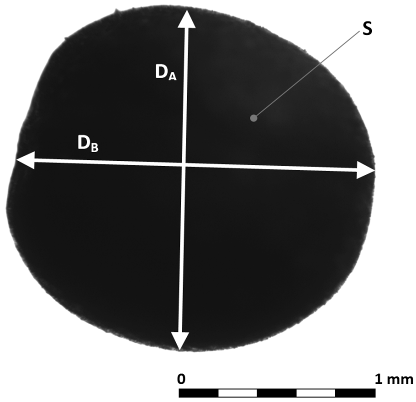

Fig. 1. **Image analysis of rapeseed**

Table 1

Determined dimensions of rapeseeds: values are presented with standard deviations

D, mm	S, mm^2	D_g, mm
2.06 ± 015	3.39 ± 0.32	2.08 ± 0.10

From the physical background of the seeds and also with regard to the modelling in virtual reality such as FEM or DEM methods [9-12] it follows that the derived ball model is more appropriate for description of true reality than the models based on the arithmetic or geometric diameter determined from the average measured diameter [4-6; 8]. This statement is also confirmed by already published studies from which it follows that the mathematical model should be based on the model with respect to the true cross section areas of the modelled seeds [9-11].

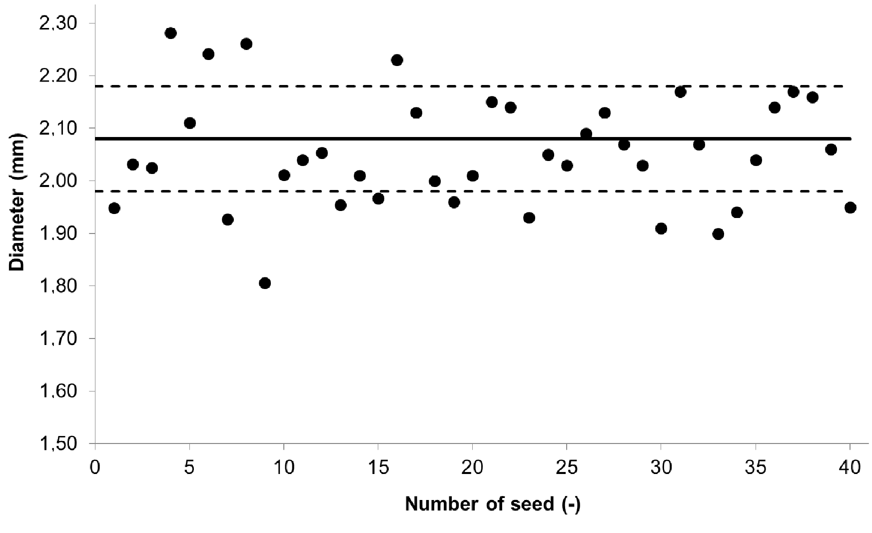

Fig. 2. **Determined diameters of rapeseeds: ball model diameter is shown by bold line and its standard deviations are presented by dashed line**

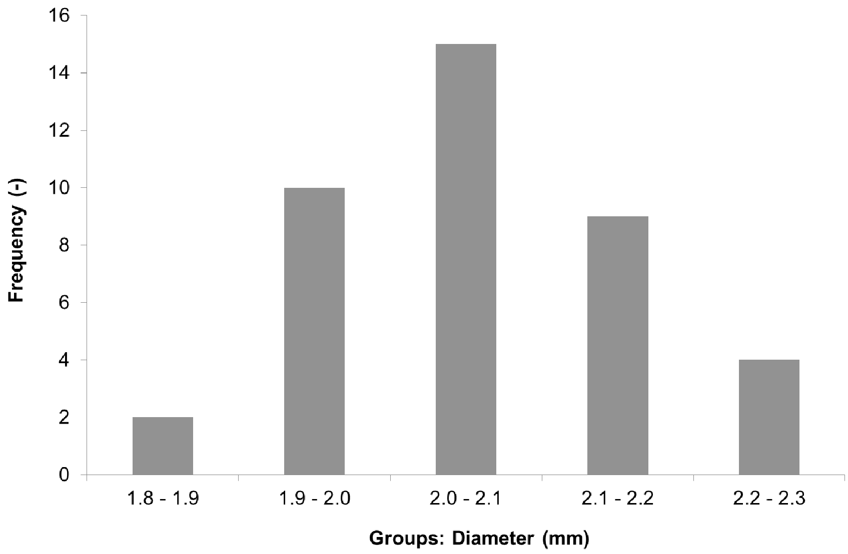

Fig. 3. **Histogram of measured rapeseed diameters**

The necessity of using the precision model for mathematical descriptions of mechanical behaviour has been already published by studies focused on virtual modelling of cereals [9-12; 14] and they confirm the determined results of this study. It implies that development of mathematical models based on an appropriate shape could be integral part of mathematical models describing behaviour of seeds or bulk seeds. From already conducted experiments [4; 5] it follows that the dimensions of this model must be dependent on the moisture content and temperature and this factor must be taken into account when a complex model will be created [9; 10; 12; 14]. Utilization of the ball model based on the true seed area can improve and specify general mathematical models for description of mechanical behaviour of rapeseeds as well as help design the appropriate processing technology. The ball model determined in this study should provide the basis for development of further models which will describe the shape and dimensions of oilseeds with aid of the image analysis.

Conclusions

1. Diameters, the average diameter D = (2.06 ± 015) mm, and cross section areas, average cross section area S = (3.39 ± 0.32) mm^2, of rapeseeds were determined using the image analysis with aid of trio ocular microscope and it was verified that the measured amounts are consistent with already published studies focused on physical properties of rapeseeds.
2. The ball model based on the true seed area for description of the shape and dimensions of rapeseed was derived and verified. The diameter of the ball model D_g = (2.08 ± 0.10) mm was determined.
3. From the conducted experiment and already published studies it is evident that the derived ball model is more appropriate for description of the true reality than the models based on the arithmetic or geometric diameter determined from the average measured diameter.

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