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Size properties of legume seeds of different varieties using image analysis

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ABSTRACT

Image analysis system was used to provide geometric parameters of legume seeds, which are important for designing of engineering processes such as drying, milling, germination etc. Measured features of bean and lentil seeds were projected area, equivalent diameter, MaxFeret, MinFeret and thickness. Three approximation models (an oblate spheroid, two sphere segments and a triaxial ellipsoid) were used to evaluate volume and surface area of lentil and bean seeds of various varieties. The best approximation model was found as the triaxial ellipsoid and the oblate spheroid for bean varieties and two sphere segments for lentil varieties. From the model data estimated specific surface area were ranged from 5.1–5.8 cm^2/g for bean varieties and 11.57–11.95 cm^2/g for lentil varieties. Image analysis system provided fast and accurate values of important technological properties of legume such as geometric parameters, volume and surface area.

1. Introduction

In general, legume is a source of complex carbohydrates, proteins and dietary fiber, having significant amounts of vitamins and minerals (Costa et al., 2006). In addition consumption of dry beans and lentils has been linked to reduced risk of heart disease (Anton et al., 2008).

Surface area and volume of legume seeds is an important physical characteristic in processes such as harvesting, cleaning, separation, handling, aeration, drying, storing, milling, cooking and germination (Igathinathane and Chattopadhyay, 1998; Hsieh et al., 1998). The size and shape are important in electrostatic separation from undesirable materials and in the development of sizing and grading machinery (Mohsenin, 1970). Geometric parameters of legume seeds are important for germination process as well, bigger bean seeds germinate faster than smaller and medium ones (Kelli, 2007). Large seeded cultivars of azuki beans exhibit slower water absorption than smaller ones. Cultivars of faba beans and chickpeas require longer cooking times than small seeded cultivars (Hsieh et al., 1998).

Owing to the irregularities and variation in shapes, surface profiles, and dimensions of specific food materials, it is very difficult to evaluate their actual surface areas. For food materials, such as seeds, grains, fruits or vegetables that are irregular in shape, a complete specification of shape requires an infinite number of measurements. The shapes of most natural food materials generally resemble some of the regular geometrical objects, and this feature is utilized in the theoretical estimation of the surface area utilizing certain numerical techniques. Often three measurements along the mutually perpendicular axes, namely, length, width, and thickness are used to specify the shape of the food material. The length, thickness and width of particles are generally measured using a calliper.

Digital image analysis enables size measurements faster and more accurately. Computer vision includes the capturing, processing and analyzing images, facilitating the objective and nondestructive assessment of visual quality characteristics in food products (Brosnan and Sun, 2004). Koc (2007) used image analysis system to estimate the volume of watermelon. Tahir et al. (2007) evaluated the variability in the colour, morphology and textural features of cereal grain due to the change in moisture content of the kernels by using image analysis. Yan et al. (2008) investigated the change of shape factor by image analysis system with moisture content changing during drying. Wang and Nguang (2007) aimed to design a low cost automatic sensor system for estimating the volume and surface area of axi-symmetric agricultural products. Tanska et al. (2005) tested the determination of the geometrical features of rapeseed, surface colour of seeds, and also identification impurities that are difficult to separate during the cleaning process. Kadlec et al. (2006) dealt with shape characterization of pea seeds using image analysis to determine the specific surface area of 0.60 m^2/kg for micro-wave drying.

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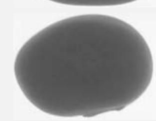
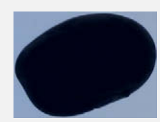
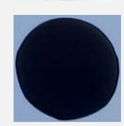
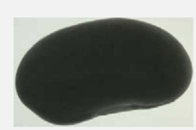
The objective of our research was to compare the seed sizes (projected area, equivalent diameter, length, width etc.) of bean and lentil varieties obtained from the Czech Republic and Turkey by using image analysis. To achieve this objective, by means of 2D visualization technique, completing height, the shape of a seed was practically as 3-D models. Geometrical shape was simulated as an oblate spheroid, two sphere segments, and a general ellipsoid for bean and lentil. According to these simulations, surface areas and volumes of the seeds of lentil and bean were calculated and verified with the volumes of seeds achieved by pycnometric measurements.

2. Materials and methods

2.1. Seed samples

The varieties of bean and lentil samples used in the study are given in Table 1. Tigar bean, white bean (Krajova), and white bean (ST513) were obtained from AGRITEC s.r.o. Šumperk, Gene Bank, and green lentil (Moench) was obtained from Crop Research Institute (CRI) Praha-Ruzyně, Gene Bank. The other seed cultivars were obtained from local market of Turkey and the Czech Republic.

Table 1
Bean and lentil samples used in this study.

Sample	Variety	Captured image
Czech Republic		
White bean (Krajova)	*Phaseolus vulgaris* L. cv. Krajova 477	
White bean (ST513)	*Phaseolus vulgaris* L. cv. ST513	
Tigar bean	*Phaseolus vulgaris* L. cv. Tigar	
White speckled red bean	*Phaseolus vulgaris* L. cv. Pinto	
Kidney bean	*Phaseolus vulgaris* L. cv. Kidney	
Green lentil (Moench)	*Lens esculenta* L. cv. Moench	
Green lentil (Medik)	*Lens culinaris* Medik	
Turkey		
White bean	*Phaseolus vulgaris* L. cv. Dermason	
White speckled red bean	*Phaseolus vulgaris* L. cv. Barbunia	
Green lentil	*Lens culinaris* Medik	
Red lentil	*Lens culinaris* Medik