THE STUDY OF BREAD VOLUME DETERMINATION USING THE PHOTOMETRIC METHOD

Petru Marian CÂRLESCU[1]

e-mail: pcarlescu@uaiasi.ro

Abstract

The external appearance of the bread is important both for the bread producer and especially for the consumer, it shows that the volume and shape of the bread are the parameters that must be studied with accuracy. Volume changes of bakery products, expansion and contraction occur in the bread making process as a result of transitions and changes that occur over time. The paper aims to determine the volume of three varieties of bread (white bread, black bread, whole meal bread) by the classical (gravimetric) method and the modern photometric method. The results of the determinations show that for white bread a volume difference of 70.34 cm^3 minus is obtained with the classic method, for black bread a volume difference of 151.37 cm^3 minus with the classic method, and for intermediate bread a difference of 122.93 cm^3 in minus with the classic method. From the experimental determinations, a high accuracy is found for the volumes determined by the photometric method compared to the classical method.

Key words: bakery, volume, physical parameters

Bread, as a basic product in human nutrition, is studied more and more to improve the physical properties of appearance and shape, nutritional and taste qualities, seeking to increase the yield and make the production, packaging, storage and transportation process more efficient (Serpil S., Servet G.S., 2006). Volume changes of bakery products, expansion and contraction occur in the bread making process as a result of some transitions and changes that occur over time (Mondal A., Datta A.K., 2008) Expansion or increase in volume is a characteristic feature of the baking of leavened bakery and pastry products (bread, cakes). During baking, the thermal expansion of carbon dioxide (produced by leavening agents) and water vapor present inside the porous structure deforms the dough, increasing its volume until starch gelatinization occurs (Lostie M. *et al*, 2002; Wagner M.J. *et al*, 2007). In addition, bread baking appears as a very special case in terms of volume change. During the process, the dough primarily undergoes an increase in volume due to the thermal expansion of carbon dioxide and water vapor (until the dough turns into bread), and then contraction occurs due to the final formation of the crust and setting, where reactions of reticulation (Scanlon M.G., Zghal M.C., 2001; Sommier A. *et al*, 2005; Vanin F.M. *et al*, 2009). While shrinkage is an inverse change observed during bread drying that occurs due to water loss and changes occurring in the porous structure of the bread when the volume of the product decreases (Mayor L., Sereno A.M., 2004). Since the external appearance of the bread is important both for the bread producer and especially for the consumer, it shows that the volume and shape of the bread are the parameters that must be studied with accuracy. This shows the producer new methods of improving the manufacturing technology and new forms of modeling the bread in order to obtain the most consistent volume, and for the consumer the volume is one of the criteria for choosing the respective product (Brennan J.G., 2011). The methods for determining the volume of bakery products are few and with low accuracy, but they have been used until now as well-known and sometimes standardized classical methods, but with the development of the technique, modern methods for determining the volume have appeared, which bring better accuracy and less time to get results. The present study aims to present a new, little-known method for determining the volume of bakery products using photometry. To demonstrate the accuracy of the method, it was compared with the classical method known for determining the volume of bread. present document is arranged so that it can be used as a model.

[1] Iasi University of Life Sciences, Romania

MATERIAL AND METHOD

For the experimental volume determinations, three types of bread were chosen as bakery products. They were made by hand from three types of flour: white flour (*figure 1a*), black flour (*figure 1b*) and whole wheat flour (*figure 1c*). All three varieties of bread had irregular shapes to see if shape is a factor influencing the results of volume determinations. Volume is an important factor in determining the quality of bakery products.

Figure 1 **Bread** a **white,** b **black,** c **whole**

The volume of solids can be determined using several methods: 1. Calculation of regularly shaped objects knowing the characteristic dimensions; 2. Experimental determination by displacing a known volume of liquid, gas or solid; 3. Photometric measurement using image processing. The image processing method has recently been developed to accurately measure volumes of food products with irregular shapes (e.g. braided bread).

The gravimetric method consists in determining the volume of the three types of bread using a laboratory apparatus (*figure 2a*) that reproduces the Fornet "*Bread Volume Meter 13300*" apparatus (*figure 2b*). Both operating on the classic principle of displacing a volume of rapeseed.

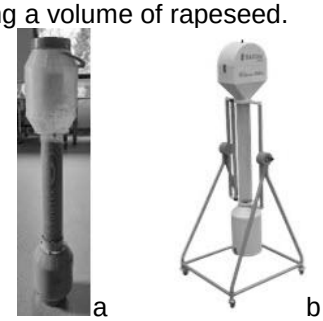

Figure 2 **Apparatus for determining volume** a **laboratory,** b **Bread Volume Meter 13300**

The experimental device for determining the volume of bread by the photometric method (*figure 3*) is composed of a box of parallelepiped shape with white walls, an LED projector with white light mounted on the top and a rotating support at the base. In the center of the rotating stand, the three types of bread were installed with a clamp, on which the bread will be fixed in order to be filmed at a 360-degree rotation for one minute (rotation of the rotating stand 1 rpm). The video was shot with a mobile phone camera (Samsung Galaxy A51) for one minute. The video camera used to record the video samples has a resolution of 48 MP and an aperture of f/2.0, it recorded the video sequences at a resolution of 3840x2160 pixels and 30 frames/s in .mp4 video format.

Figure 3 **The experimental device for photometric method**

For the initial calibration of the object from the obtained movie, two distinct points are marked on the surface of the bread at a measured distance of 5 cm (*figure 4*), this distance is later entered into the specific software for the final scaling of all images, after previously marking in each photo the control points for the accuracy of the final calculation of the volume of the bread.

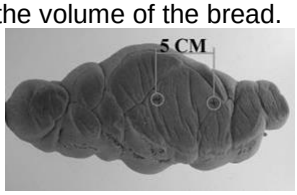

Figure 4 **Initial bread calibration through control points**

To determine the volume of a bakery product with irregular shapes, the video saved in .mp4 format was processed with the help of several software: VLC media player 3.0.8 for video sequencing of the movie, Topaz Gigapixel AI 4.1.1 for increasing the image resolution, NXPowerLite Desktop 8.0.4 which uses an algorithm for reducing the size of images while preserving their quality, Zephyr Aerial 3DF 4.300 for 3D reconstruction of the filmed object, final calibration (*figure 5a*) of the model, correction of the resulting imperfections and volume calculation (*figure 5b*).

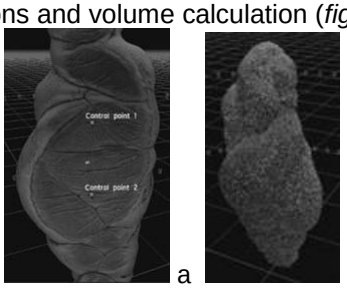

Figure 5 **Bread model** a **final model calibration,** b **3D volume model**

RESULTS AND DISCUSSIONS

The classic method used to determine the volume of the three types of bread, involves using the principle of displacing a volume of rapeseed. In the first stage of the experiment, the laboratory apparatus in Fig. 2a was calibrated using a non-deformable cylindrical box that has the following measured dimensions: r = 50 mm; h = 156 mm. The calculated volume of the cylindrical box is V_c = 1225.22 cm^3, and the average volume obtained

after 3 consecutive measurements by the classic method is V_m = 1220.10 cm^3. Through the difference, it follows that by the classical method a minus volume of 5.12 cm^3 is obtained.

The same work technique was used to determine the volume of bakery products. The white bread of irregular shape obtained by intertwining two strands of dough was introduced into the laboratory apparatus, after which three volume determinations were made by displacing the volume of rape seeds. The same was done with the irregularly shaped black bread obtained by intertwining three strands of dough, as well as with whole meal bread which had a shape similar to that of a cylinder. The results of the obtained volume are presented according to *figure 6*. This shows that the volume of white bread has the smallest volume of 700 cm^3, while the volume of whole meal bread is 860 cm^3.

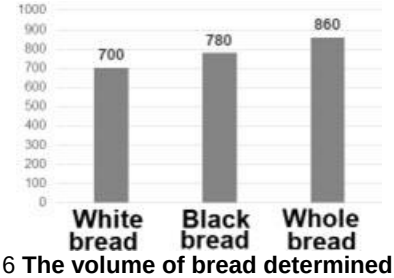

Figure 6 **The volume of bread determined by the classic method (cm^3)**

The experimental determination of the volume of the bakery products studied by the photometric method followed as a first step the calibration of the method with the same non-deformable cylindrical box used in the classic method. The calculated volume of the box is V_c = 1225.22 cm^3. For the photometric method of determining the volume, the box was measured and marked at the ends to be able to define the control points in the program. With the help of control points, the program scales the box to the actual dimensions, dimensions necessary to accurately determine the volume. The box was filmed from 3 different angles for 60 seconds to obtain a well-defined 3D object, *figure 7*.

Figure 7 **Non-deformable cylindrical box filmed from three different angles**

After processing the images and scaling the 3D object to the actual dimensions of the box r = 50 mm and h = 156 mm, a volume of V_f = 1223.74 cm^3 was obtained by photometric processing (*figure 8*). The difference between the calculated volume and the volume obtained by the photometric method was minus 1.48 cm^3, i.e. a deviation of 0.12%. From the technique of experimental measurements of volumes, it is known that a deviation below 0.3% is considered a determination with high accuracy.

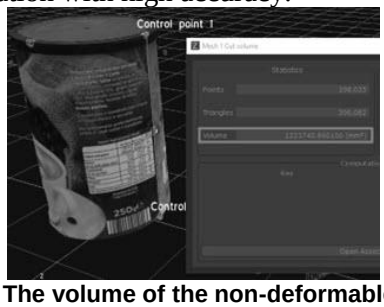

Figure 8 **The volume of the non-deformable box by the photometric method (mm^3)**

By the photometric method for determining the volume of bread, the following results were obtained (*figure 9*): White bread 629.66 cm^3; Black bread 628.63 cm^3; Whole meal bread 736.07 cm^3.

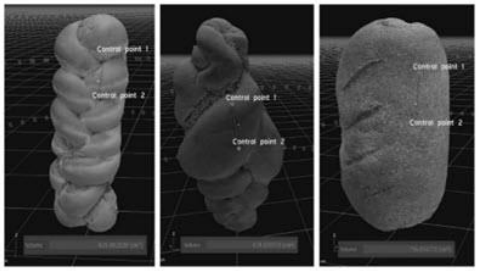

Figure 9 **The volume of bakery products obtained by the photometric method (cm^3)**

In summary, the results obtained for the volume of bakery products by the classical method and the photometric method using for comparison and a non-deformable cylinder of known dimensions are shown comparatively according to *figure 10.*

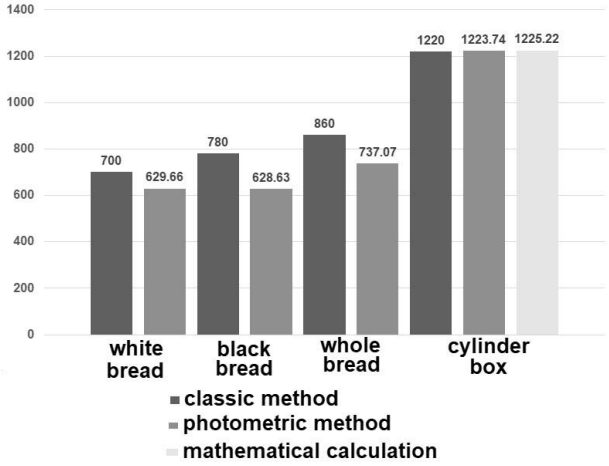

Figure 10 **The volume of bakery products determined by the classical and photometric methods (cm^3)**

It can be seen that the volume of bakery products determined by the photometric method is

much more accurate if we refer to the volume of the cylindrical box obtained by the same methods. Although the same bakery products were used for all determinations, the photometric method was proven to be accurate using complex calculation algorithms used in research programs. Of all the determinations made, the biggest difference appears when determining the volume of black bread with a minus of 151.37 cm^3, this is due to the irregular shape of the bread. Rapeseed seeds used for volume determination by the classical method do not cover all the gaps resulting from the overturning of the volume determination apparatus. Differences in volume determination appear for all three types of bread between the classical method and the photometric method.

CONCLUSIONS

Accurate volume measurement of bakery products and especially bread is important for both the bread maker and the consumer. The determination of the volume of three types of bread (white bread, black bread and whole meal bread) was carried out comparatively by two methods. The classical (gravimetric) method of determining the volume of bread was carried out with the help of a device that reproduces the "Bread Volume Meter 13300" Fornet device that uses the principle of displacement of a volume of rapeseed.

The photometric method (image processing) is a modern method for determining the volume of bread built with a device consisting of a white parallelepiped box, a white light LED projector, a rotating support and a video camera for recording images. Through the photometric method using a movie of the bakery product, a 3D volume of each analyzed assortment of bread is obtained through mathematical processing with the help of some software.

The results obtained by the two methods considered, show for a non-deformable cylindrical box with known dimensions a difference between the calculated volume and the volume determined by the photometric method of 0.12%, compared to 0.42% for the classical method. From the experimental technique in volume measurement, a deviation below 0.3% is considered a high accuracy determination. This shows that the photometric method is a much more accurate method compared to the classical method.

The results in the determination of the volume by the two methods for bread show that for white bread a volume difference of 70.34 cm^3 minus the classic method is obtained, for black bread a volume difference of 151.37 cm^3 minus the classic method, and for the intermediate bread a difference of 122.93 cm^3 minus the classic method. All these differences show the precision with which the volume is determined by the photometric method compared to the classical method.

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