A Volumeter for Breads Prepared from 10 Grams of Flour

S. VANHAMEL, L. VAN DEN ENDE, P. L. DARIUS, and J. A. DELCOUR[1]

ABSTRACT

Cereal Chem. 68(2):170–172

A displacement volumeter is described for bread loaves prepared from 10 g of flour. Standard deviations of loaf volume measurements by the instrument were significantly lower than those by a procedure published earlier. Other advantages of the new apparatus are that it is a closed system and that volume readings take significantly less time than with the method previously described. With the new volumeter and glass beads of 2 mm diameter, three independent readings gave a reasonable power to discriminate between items that differ in volume by at least 1 cm^3.

Shogren and Finney (1984) published an excellent method to evaluate the breadmaking potential of small samples of flour (10 g). Although at this laboratory we are pleased with the bread-baking procedure, we have found that the volumeter proposed by the authors has some disadvantages: 1) volume readings are time-consuming; 2) the procedure for scraping the metal cup surface to remove excess dwarf rapeseed must be highly standardized; 3) even when the scraping is standardized, the volume readings still have a high standard deviation; and finally, 4) the apparatus is an open system—minor faulty manipulations result in a loss of the rapeseed.

In view of the above, we tried to develop an alternative volumeter, i.e., a mini version of the National Manufacturing volumeter (TMCO, Lincoln, NE) for loaves prepared from 100 g of flour according to the procedure of Finney (1984). We here report on the construction of a new volumeter and on a comparison of the performances of the instrument described by Shogren and Finney (1984) (from here on termed volumeter I) and the new one (volumeter II).

MATERIALS AND METHODS

Bread Samples

Breads were baked from European flours of varied quality according to the procedure of Shogren and Finney (1984) to yield breads of varied volumes. The breads were placed on a grid after removal from the oven, and volumes were determined after about 2 hr.

Glass Beads and Wooden Calibration Blocks

Glass beads of 1.0-, 2.0-, and 3.0-mm diameter were purchased from Vel, Haasrode, Belgium. Wooden (oak) blocks had a surface area of 1,803 mm^2 (6.03 × 2.99 cm) and varied heights to yield volumes of 39.5, 51.3, 62.5, and 81.3 cm^3. The dimensions 6.03 and 2.99 cm correspond to the internal length and width dimensions of the top of the bread pans used in our laboratory.

Volumeter II

The volumeter II was constructed from stainless steel (1.0-mm thick) and Plexiglas (3.0 and 10.0 mm thick). Figure 1 shows the cut stainless steel plates with dimensions (in millimeters) and the number of each necessary to construct the apparatus. Not shown is a grid serving as a sieve, woven from stainless steel wire (27 × 40 mm) with 11 × 11 mm holes, and the two side walls (one for the volume readings) of Plexiglas (3.0 mm thick, 250 mm long, and 28 mm wide).

The central shaft from which volumes were read had two stainless steel walls and two walls of Plexiglas. To increase the accuracy of the volume measurements, the cross-sectional area of the shaft was reduced by lining the insides of the stainless steel walls with Plexiglas plates. These plates were 10.0 mm thick, 22.0 mm wide, and 250 mm long along the outside wall and 230 mm long on the inner surface; the shorter inside length resulted from 45 degree angles at both ends to allow for smooth passage of the glass beads. The cross-sectional area of the shaft (28 × 28 mm, internal dimensions) was therefore reduced by the two Plexiglas side walls (each 3 mm thick and 28 mm wide) as well as the two plates (2 × 10 × 22 mm^2). Because the resulting cross section of the shaft was only 176 mm^2, 1 cm^3 of bread volume corresponded to 5.7 mm of shaft height.

Volume Measurements

All volume measurements were made in the volumeter I, constructed and operated as described by Shogren and Finney (1984),

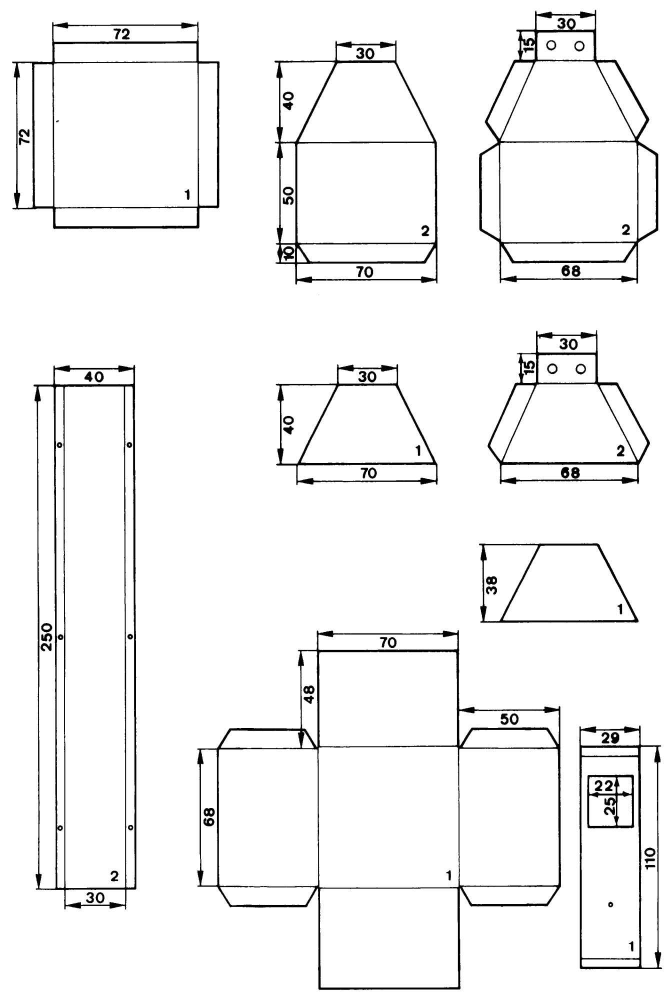

Fig. 1. Cut stainless steel plates with dimensions in millimeters indicated and the number of each necessary to construct the new volumeter.

[1]Research assistant, technical assistant, and research associates, respectively, Laboratorium voor Toegepaste Organische Scheikunde and Laboratorium voor Statistiek en Proeftechniek (P.L.D.), Katholieke Universiteit Leuven, Kardinaal Mercierlaan 92, B-3001 Heverlee, Belgium.

as well as in the volumeter II developed in this work. Both instruments were calibrated with the wooden blocks (constant height of 6.03 cm) described earlier.

The volumeter II was operated as follows. After initial calibration, the bread loaf was placed on end in the bottom chamber (grid side) of the volumeter, as also described for volumeter I. After closing the instrument, the horizontal plate (with the slit) at the end of the shaft was moved so that the glass beads or rapeseed could flow freely into the chamber. The volume was read from the height of beads or rapeseed in the shaft. The volumeter II was then turned upside down to allow the medium to leave the shaft and bottom chamber. The plate was closed, the volumeter was turned once more, and the loaf was placed on end again for the next volume determination.

Statistical analyses were made according to Winer (1962), and the average time necessary to evaluate bread volume by both procedures was determined.

RESULTS AND DISCUSSION

Construction of the Volumeter II

A dimetric projection view with dimensions and the insertion of the Plexiglas and the grid is presented in Figure 2. Front and side view scale drawings with the dimensions (in millimeters) are given in Figure 3. The instrument allows for volume readings within a 40 cm^3 range. At this laboratory it was calibrated to allow for volume determinations within a 40–80 cm^3 range, but it performed equally well when used for loaves within 60–100 or 80–120 cm^3.

Comparison of Volume Measurements by the Two Instruments

All volume readings were determined fivefold, and mean volumes and standard deviations were determined. Because we could envisage potential advantages in using the volumeters with glass beads instead of with dwarf rapeseed, we tested beads of 2.0- and 3.0-mm diameter. Initial experiments with 1.0-mm beads proved to be unsuccessful because such small beads adhered to small holes in the surface of the bread.

We first measured the volume of the wooden blocks by both methods with dwarf rapeseed (diameter 2 mm) or glass beads of 2.0- and 3.0-mm diameter. Figure 4 shows the 95% confidence interval for the mean (calculated from the five volume readings), together with the exact volume.

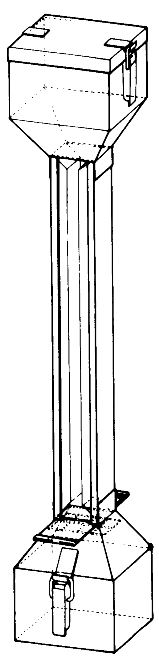

Fig. 2. Dimetric projection view of the loaf volumeter with the woven grid inserted.

The same work was then done with bread loaves of various volumes. The corresponding results are given in Figure 5. There was clearly a substantial difference with regard to both bias and accuracy between the different combinations of medium and volumeter. The glass beads of 2.0 mm in combination with the volumeter II gave the best results.

The analysis of variance on the volumeter readings (fivefold) with 2-mm glass beads for the six bread loaves and the four wooden blocks gave a mean squared error (based on 40 df) of 2.17 for the volumeter I and 0.06, which is significantly smaller ($P < 0.01$), for the volumeter II.

A conservative estimate (based on examination of the 95% confidence interval) of 0.1 for the variance of the measurement error was used to investigate the discriminating power of the volumeter II with 2-mm glass beads. The power of the usual t test (Winer 1962) for two groups (with a significance level of 0.05) with respect to an alternative hypothesis stating a difference of 1 cm^3, was found to be slightly larger than 0.80 for a group of three and greater than 0.94 for a group of four. Hence, with the volumeter II and 2-mm glass beads, three independent readings gave a reasonable power to discriminate between items that differed in volume by at least 1 cm^3.

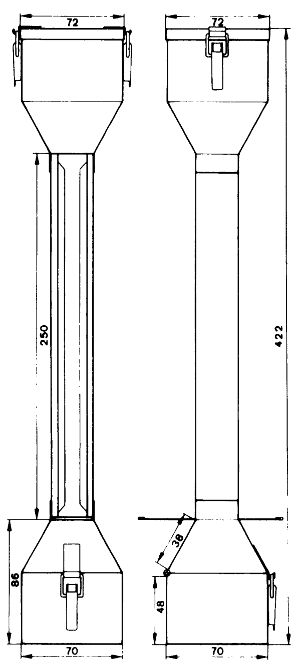

Fig. 3. Front and side view scale drawing of the loaf volumeter.

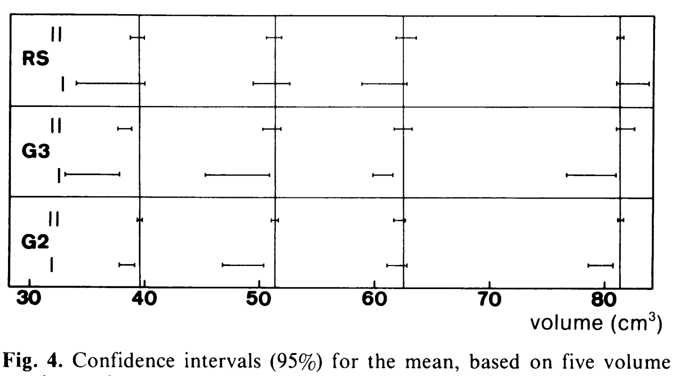

Fig. 4. Confidence intervals (95%) for the mean, based on five volume readings, of the wooden blocks measured with the two volumeters and the different displacement media. RS = rape seed; G2 and G3 = glass beads of 2.0 and 3.0 mm diameter; VII = volumeter II, developed in this study; VI = volumeter I, described by Shogren and Finney (1984). The vertical lines indicate the volumes of the wooden calibration blocks (i.e., 39.5, 51.3, 62.5, and 81.3 cm^3).

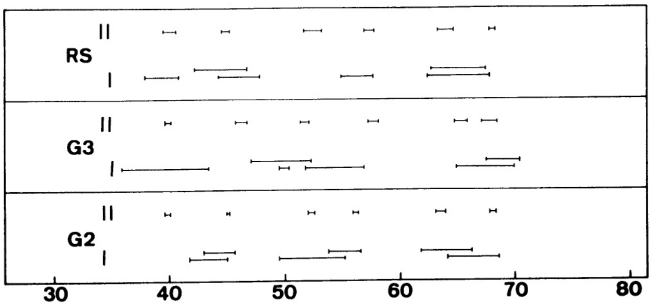

Fig. 5. Confidence intervals (95%) for the mean, based on five volume readings, of the bread loaves measured with the two volumeters and the different displacement media. RS = rape seed; G2 and G3 = glass beads of 2.0- and 3.0-mm diameter; II = volumeter II, developed in this study; I = volumeter I, described by Shogren and Finney (1984).

Finally, the average time necessary for five volume readings with the volumeter I was 350 sec, whereas that with the volumeter II was only 200 sec.

In general, the volumeter II has definite advantages over the volumeter I. Apart from the fact that it is a closed system, volume readings took considerably less time and were performed with less bias and greater accuracy.

Finally, the use of glass beads offers advantages over use of rapeseed of similar dimension. Indeed, there was less breakage with the glass beads, they were more uniform, and above all, they were significantly less subject to electrostatic interactions.

ACKNOWLEDGMENTS

Excellent technical assistance by H. Organe is gratefully acknowledged. Jan A. Delcour thanks the Nationaal Fonds voor Wetenschappelijk Onderzoek (Brussels, Belgium) for a research position as Bevoegdverklaard Navorser.

LITERATURE CITED

FINNEY, K. F. 1984. An optimized, straight-dough, bread-making method after 44 years. Cereal Chem. 61:20.

SHOGREN, M. D., and FINNEY, K. F. 1984. Bread-making test for 10 grams of flour. Cereal Chem. 61:418.

WINER, B. J. 1962. Statistical Principles in Experimental Design. McGraw Hill: London.

[Received April 3, 1990. Revision received September 28, 1990. Accepted October 1, 1990.]