Rapid Determination of Moisture in Masa with a Domestic Microwave Oven[1]

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Masa is a dough-like product prepared by grinding alkali-cooked corn. The moisture content of masa affects the texture of tortillas and other masa-based foods, e.g., corn chips and tacos (Khan et al 1982). Water is frequently added to corn during grinding if its moisture content, as determined subjectively by feel, is too low. Because of the time necessary for analysis, it is unrealistic to quantitatively assess masa moisture using a forced-air oven during corn grinding. More rapid moisture analysis tools, however, may involve additional expense not affordable by small operators.

Methods for rapid moisture analysis using microwave drying have been developed for various food and plant substances (Davis and Lai 1984, Farmer and Brusewitz 1980, Pieper et al 1977, Ueda 1980). Various types of ovens have been used: Davis and Lai (1984) used an inexpensive household microwave oven, but Farmer and Brusewitz (1980) used an expensive commercial microwave drying oven with an internal balance. Microwave ovens built for laboratory use usually have a uniform microwave energy field throughout the oven, and thus provide even drying of samples. Household microwave ovens, while considerably less expensive than commercial ovens, have a more variable microwave field, which can cause "cold spots" that result in uneven sample drying (Hayward and Kropf 1980). In addition, the magnetron (producer of microwave energy in household ovens) must be protected from excess microwave energy (overheating) developed by standing waves formed at the end of the drying cycle. Farmer and Brusewitz (1980) used an asbestos pad to absorb the energy, whereas Hayward and Kropf (1980) used a beaker of crushed ice covered with plastic wrap.

Moisture determinations using an ordinary household microwave oven might be inexpensive enough to allow small manufacturers of tortillas and other masa-based products to routinely monitor masa moisture. Because procedures so far developed for microwave drying vary greatly depending upon the oven type, oven radiation output, and the type and size of sample being dried, the feasibility of moisture determination for masa using an ordinary household microwave oven was evaluated.

MATERIALS AND METHODS

Masa from a fine-grind dry masa flour was prepared at different moisture contents. These freshly prepared masas were used to assess the suitability of microwave oven drying. Percent moisture was determined by drying 3-g samples at 130°C in a forced-air oven for 2.5 hr, when constant weight was obtained. Subsamples of this masa were also dried in the microwave oven.

A Sears Kenmore (model 564.88784, 1,400 W power consumption, 2,450 MHz) microwave oven was used for masa drying. This oven was outfitted with a food rotator (Nordic Ware Micro-Go-Round) to reduce uneven sample drying. Three grams of masa were pressed between two pieces of previously dried filter paper (Whatman No. 1, 12.5 cm) with a hand tortilla press and were placed on a microwave oven-safe plastic plate. The sample was positioned on the lip of the plate so that air could circulate under the sample. The food rotator was placed flush against the far right corner of the microwave oven to facilitate identical placement of masa samples before each drying operation. Then the plate was placed on the food rotator, slightly off-set from the center, which assured the sample would pass through as many areas of the oven as possible. Only one masa sample was dried at a time. Attempts to calibrate the microwave oven to allow determination of moisture equal to that determined by the forced-air oven were made on 100 and 70% power settings, with and without a beaker of ice to protect the magnetron. After the sample was dried, it was placed in a desiccator for 2 min prior to final weighing.

To calibrate the microwave oven, five masa subsamples at 55% moisture (as determined in the forced-air oven) were individually placed in the microwave oven as outlined above. Each sample was weighed after 30 sec of drying and was subsequently placed back in the oven. Weighing continued until 2 min after the microwave oven was "determined" to be at the same moisture as the forced air oven sample. The appropriate oven settings (calibration) were determined by plotting the average moisture of the masa versus the time used to dry the masa. A cut-off calibration line was drawn at the average percent moisture as determined by the forced-air oven. The time at which the drying curve intersected the forced-air oven moisture calibration line was taken as the appropriate microwave oven drying time.

To test the accuracy of the oven after calibration, 23 masa samples with a range of moisture contents (45–61% by forced-air oven) were prepared, and moisture was determined using both ovens. Three subsamples of each of the 23 masas were dried in each oven; means for moisture, coefficients of variation, standard deviations, and correlations between masa means for each oven were calculated using SAS version 5.08 (SAS 1983), and the SAS-Waller/Duncan procedure (Waller and Duncan 1969, Freund and Littell 1981) was used for mean separation (K ratio = 100, analogous to α 0.05).

RESULTS

The use of ice to protect the magnetron greatly slowed the drying process and was subsequently found unnecessary as long as 2 min elapsed between each test to allow the magnetron to cool. Likewise, the 70% power setting slowed drying sufficiently that other drying techniques would be almost as rapid as the microwave oven technique. In addition, it was found that the interior of the microwave oven (the walls, Micro-Go-Round, plastic plate, and glass bottom) all absorbed some heat. It was necessary, therefore, to preheat the oven before any samples were analyzed.

For our microwave oven, a calibration curve was developed (with masa containing 55% moisture) for rapid moisture analysis using the Hi (100%) setting for 2.5 min (Fig. 1); shortly after 2.5 min, the sample began to brown and subsequently burn. The average moisture contents of 23 masa samples dried in the microwave oven were not significantly different from the masa subsamples dried in the forced-air oven (Fig. 2). The forced-air and microwave oven drying methods were highly correlated ($r > 0.99$). The forced-air oven, however had a lower coefficient of variation (CV) than the microwave oven; the average CV for the 23 masa

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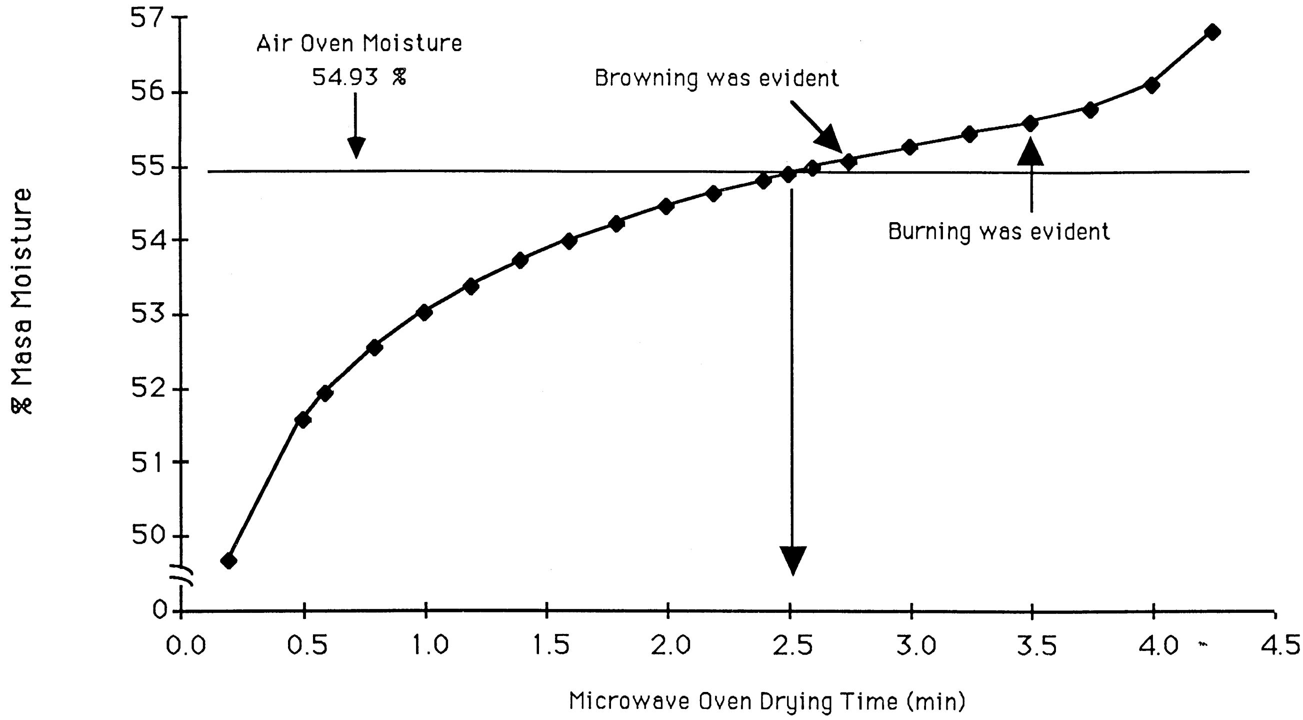

Fig. 1. Calibration/determination of microwave oven drying time for corn masa.

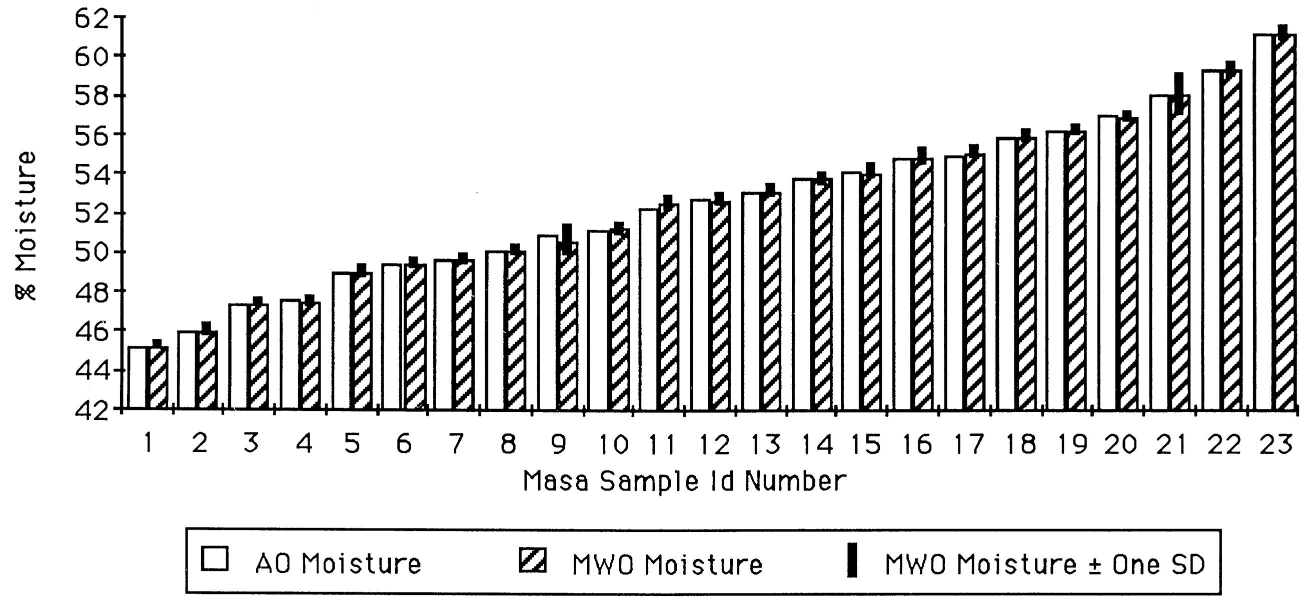

Fig. 2. Comparison of air-oven (130°C, 2.5 hr) and microwave oven drying (2.5 min, 100% power) procedures.

samples dried in the microwave oven was 0.29 (range 0.08–1.18), but the average CV for the forced-air oven dried samples was only 0.11 (range 0.03–0.22). Total analysis time from initial sample collection to final weighing averaged 10 min.

DISCUSSION

Because every household microwave oven produces different levels of microwave radiation, each must be calibrated. After calibration, however, these ovens can be used to provide moisture information to the masa producer. Although the average of three microwave oven sample replications was equivalent to the average percent moisture as determined by the forced-air oven, the coefficients of variation in the microwave oven method were greater. It is unlikely that the processor would have time to test more than one masa sample before deciding whether or not to add water, and thus although the microwave oven technique is rapid, an accuracy comparable to that obtained by forced-air oven drying four replicates could not be assured by microwave oven drying of one sample. The moisture determined by a properly calibrated oven, however, would not be more than one percent different from the forced-air oven moisture. Thus, the microwave oven technique, despite its limitations, could still prove valuable to tortilla and snack food manufacturers to inexpensively monitor their masa production to assure a more consistent product quality.

LITERATURE CITED

DAVIS, A. B., and LAI, C. S. 1984. Microwave utilization in the rapid determination of flour moisture. Cereal Chem. 61:1-4.

FARMER, G. S., and BRUSEWITZ, G. H. 1980. Use of home microwave oven for rapid determination of moisture in wet alfalfa. Trans. ASAE 23(1):170-172.

FREUND, R. J., and LITTELL, R. C. 1981. SAS for linear models. SAS Institute: Cary, NC.
HAYWARD, L. W., and KROPF, D. H. 1980. Sample position effects on moisture analysis by a microwave oven method. J. Food Prot. 43(8):656-657.
KHAN, M. N., DesROSIERS, M. C., ROONEY, L. W., MORGAN, R. G., and SWEAT, V. E. 1982. Corn tortillas: Evaluation of corn cooking procedures. Cereal Chem. 59:279-284.
PIEPER, H., STUART, J. A. Jr., and RENWICK, W. R. 1977. Microwave technique for rapid determination of moisture in cheese. J. Assoc. Off. Anal. Chem. 60(6):1392-1396.
SAS INSTITUTE. 1983. SAS Introductory Guide. SAS Institute, Inc. Cary, NC.
UEDA, M. 1980. Microwave oven procedure for moisture determination of pomace. Am. J. Enol. Vitic. 31(2):202.
WALLER, R. A., and DUNCAN, D. B. 1969. A Bayes rule for the symmetric multiple comparison problem. Am. Stat. Assoc. J. 64:1484-1499.

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ERRATUM

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On page 483, the formula in the caption to Figure 7 should read:

$$n \geqslant \frac{1.96^2\,[R(1-R) + P(1-P) - 4\,P(1-P)R(1-R)]}{[0.02(1-2\,P)]^2}$$

where n is the number of kernels, R is the percentage of total kernels that are soft expressed in decimal form, and P is the percentage overlap of texture of hard and soft wheat kernels.