

## Effect of Moisture Content on Popcorn Popping Volume for Oil and Hot-Air Popping<sup>1</sup>

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The practice of popping popcorn has been around for centuries. In 1948, archeologists found ears of popcorn in the Bat Cave in New Mexico dating back more than 5,600 years (Kusche 1977). Despite the long history of popcorn, the method of popping popcorn in oil has been around only since the mid-1880s (Kusche 1977), and only within the last decade has the hot-air popper been available to the public. It has been suggested by interested members of the popcorn industry that hot-air popping requires a higher initial moisture content to obtain its maximum popping volume. Only one study was found that measured the popping expansion characteristic for both hot-air popping and oil popping (Ashman 1979). The objective of Ashman's study was to measure popping expansion volume by using small samples (<150 g) instead of the entire ear. Using a small sample of approximately 40 g, he obtained satisfactory results for hot-air popping with the constant-volume-weight method. This method uses a constant volume of flakes and records a weight. No account was taken for popcorn moisture content during the study.

The objective of this experiment was to examine the effect of moisture content on popping volume and to determine what moisture contents produce maximum popping volume for both hot-air and oil popping.

### MATERIALS AND METHODS

An experiment was designed that would allow determination of popping volume over a range of popcorn moisture contents in both a hot-air popper and an oil popper.

#### Oil and Air Poppers

The oil popper was a modified West Bend "Stir Crazy" corn popper (model 5346, The West Bend Company, West Bend, WI). Specifications were: 5.7-L capacity, 120 V, 1,000 W, and approximately 190°C oil-popping temperature. The popper was equipped with a motor-driven stirrer. The modification consisted of extending support legs between the stirring motor and the heating element 10.2 cm. This allowed continuous use without overheating the motor.

The hot-air popper was a West Bend "The Poppery" hot-air corn popper (model no. 5459, The West Bend Company). Specifications before modification were: 120 V, 1,500 W, 2.8–3.8-L capacity, and approximately 230°C popping air temperature. Ashman (1979) reported a kernel blow-over problem. Kernel blow-over refers to unpopped kernels that are blown out of the popping chamber. Because of this problem, modifications to this machine were made, which consisted of extending the popping column 57 mm on the short side and 110 mm on the long side, fabricating a wire-mesh chute into which the popcorn was directed, and designing a wire-mesh retaining cap to stop loss of popcorn before popping begins. This design eliminated kernel blow-over.

#### Sample Preparation

One variety of yellow popcorn (A3004) was used in all the popping tests. A3004, a variety produced by the Ames Seed Farms, Inc., Ames, Iowa, was chosen because it consistently yields well in field tests and produces a larger popping volume than many other varieties. From an original 2.1-kg lot, seven sublots of approximately 300 g each were conditioned toward ideal target moisture contents of 8, 10, 12, 14, 16, 18, and 20% (wb), respectively. After an initial moisture content of 15.1% on a Motomco moisture meter was obtained, the samples that needed to lose moisture were placed in wire-mesh baskets at room temperature to dry. Samples were monitored until the desired weight was obtained. For the samples that needed to gain moisture, an appropriate amount of distilled water was added by using a paint spray gun while the popcorn tumbled in a rotating stainless steel drum. After the desired moisture was reached, samples were sealed in pint jars and allowed to equilibrate for a minimum of 30 days in a 3.3°C cooler. To assure equal moisture distribution throughout the sample, jars were inverted and shaken several times once each week. Ten days before popping, three 12–13-g samples were taken from each jar for moisture content determination. The final moisture content was determined using a slight variation of AACC method 44-15A (AACC 1983). This method uses 103°C for 72 hr. The variation consisted of weighing the samples immediately after removal from the oven instead of placement in a desiccator to cool to room temperature. Taraba (1979) reported that negligible error is introduced by not placing hot samples in a desiccator.

#### Popping Samples

Three replicate samples were popped at each moisture content in each popper. Sample weights were calculated so that each sample contained 26 g of dry matter.

#### Oil-Popping Method

Before data were recorded, three batches of a filler popcorn were popped to heat the machine thoroughly and to reduce variation among replications. The procedure used was similar to that used by the Agronomy Department at Iowa State University. The oil-popping procedure consisted of five steps: Ten milliliters of peanut oil and a sample (26 g of dry matter) of popcorn were combined into the oil popper. Heating was continued until popping was completed (count of five after the last kernel popped). Popped corn was poured into a 2,000-ml, 66-mm-diameter plastic graduated cylinder. The cylinder was inverted one time. The sample volume was recorded.

#### Air-Popping Method

Like oil popping, three samples of filler popcorn were popped to heat the machine. The air-popping procedure consisted of the following steps: The sample was added to the running machine. The retaining cap was lowered until the wire-mesh screen was covered with flakes. The screen was raised to allow flakes to flow freely over into the collection bucket. The volume measurement procedure was identical to that of the oil-popping method.

### RESULTS AND DISCUSSION

A total of 42 tests was performed (21 oil pops and 21 hot-air pops). Figure 1 is a graph of popping volume versus moisture content. Each point on the graph is the average of three

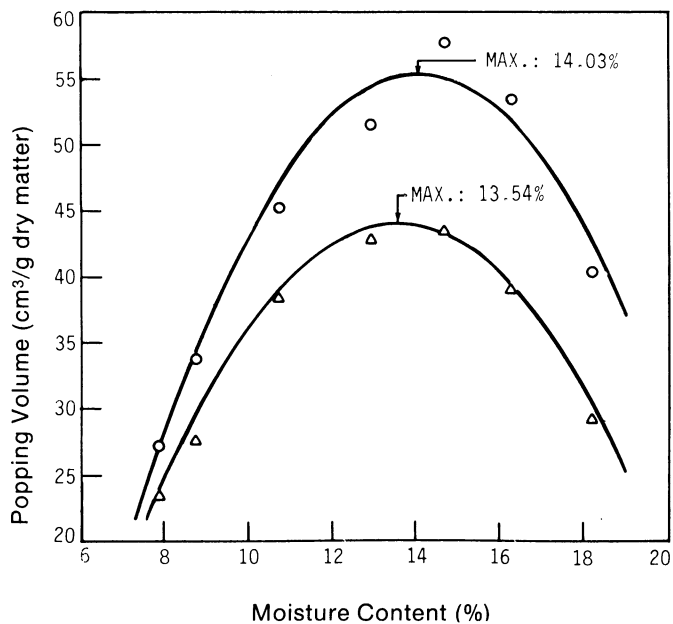
<sup>1</sup>Center for Crops Utilization Research, Iowa State University, Ames. Journal paper J-13174 of the Iowa Agriculture and Home Economics Experiment Station, Ames. Project 0178.

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**Fig. 1.** Popping volume versus moisture content. The least squares quadratic equation for air popping (○) was  $y = -94.8 + 21.4x - 0.761x^2$ ,  $R^2 = 0.97$ , SD  $2.33 \text{ cm}^3/\text{g}$ . The equation for oil popping (△) was  $y = -76.0 + 17.7x - 0.652x^2$ ,  $R^2 = 0.99$ , SD  $1.23 \text{ cm}^3/\text{g}$ .

replications. A least squares quadratic equation was fitted to the data. Maximum moisture contents were calculated by the first derivative of the least squares equation, equated to zero. The standard deviation of regression was  $2.33 \text{ cm}^3/\text{g}$  for air popping and  $1.23 \text{ cm}^3/\text{g}$  for oil popping.

#### Popping Volume

Oil popping produced a maximum volume of  $43.6 \text{ cm}^3/\text{g}$  of dry matter at a moisture content of 13.54%. Air popping produced a maximum volume of  $55.3 \text{ cm}^3/\text{g}$  of dry matter at a moisture content of 14.03%. This is 27% more than the oil-popped volume at their specific maximums. The graphic results of popping volume

versus moisture content show quite vividly that hot-air popping produced a larger popping volume than oil-popping over the entire moisture content range. The oil-popping data are consistent with earlier data reported in the literature. Lyerly (1940) observed that the maximum popping volume for oil-popping occurs in a moisture content range from 12 to 14%, depending upon the variety of popcorn. The moisture content range has since been narrowed to between 13 and 14.5% moisture, with the optimum being 13.5% (Ziegler et al 1985). There was no hot-air curve with which to compare results because no previous data were found for hot-air popping and direct volume measurement. Direct volume measurement refers to popping a recorded weight of popcorn and measuring the volume that results. The popping data obtained in this experiment confirm the belief that a greater moisture content is needed for hot-air popping. The unexpected result obtained was that the curve for hot-air popping was consistently above the oil-popping curve.

#### CONCLUSIONS

Popcorn variety A3004 attained a maximum popping volume of  $43.6 \text{ cm}^3/\text{g}$  dry matter at a moisture content of 13.5% in an oil popper. It attained a 27% greater maximum popping volume of  $55.3 \text{ cm}^3/\text{g}$  dry matter at a moisture content of 14.0% in a hot-air popper. Hot-air popping produced a larger popping volume than oil-popping over the entire moisture range of 7.89–18.19%.

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