Determination of Moisture Content in Sunflowers with Electronic Moisture Meters

D.C. ZIMMERMAN, ARS, USDA, North Dakota State University, Fargo, North Dakota

ABSTRACT

Accurate estimates of moisture content in sunflower seeds (achenes) with electronic moisture meters require that the sample be adequately equilibrated before testing. Seed which has undergone a rapid drying of the hull (pericarp) surface and is tested without sufficient equilibration time will indicate a moisture content that is 0.2-2.0 percentage points lower than the true moisture content. Seed can be properly equilibrated by placing them in a sealed container for 12 hr. Calibration curves based on quadratic equations provide a better estimate of sunflower seed moisture content over a greater range than do linear equations.

INTRODUCTION

During the past decade, sunflowers have changed from a limited acreage crop in the United States to one covering more than a million acres in 1975 (personal communication, Crop Reporting Service, USDA). Because of the recent introduction of hybrid varieties and their greater yield potential, the acreage will probably expand even further. As a result of expanded acreage, more and more country elevators are handling and processing sunflowers. In these elevators, the moisture content of the sunflowers is usually determined with an electronic moisture meter that is used for other grains. Recent experience has shown that sunflowers behave differently than cereal grains in this type of tester. A truckload of sunflowers may indicate 11% moisture when delivered, and a day later indicate 13% moisture. This has led to confusion and consternation among farmers, elevator operators, and processors. It has been claimed that certain brands of moisture testers do not show this effect and are better than other brands. Consequently, an effort was made to evaluate the response of sunflowers in several commercial testers and to make recommendations for their proper use.

EXPERIMENTAL PROCEDURES

Two types of sunflower seed were used: Peredovik, an oilseed variety, and Sundak, a nonoil variety. The moisture content of the original seed (ca. 9%) was adjusted by spraying 5, 10, 15, 20, 30, or 40 ml of distilled water on individual 250 g lots of seed. Each lot was placed in a sealed quart jar and allowed to equilibrate at 24 C for 6-8 days. There were four replications at each moisture level. Then, seed were removed from each jar, weighed, and analyzed with the moisture meters being tested. Temperature of each sample was determined with a mercury thermometer. Oven-dry moisture content was determined on two subsamples from the seed used in the moisture tester by drying for 3 hr at 130 C.

Each moisture meter was calibrated and oeprated according to its respective instruction manual. Meters tested were the Burroughs Model 700, Motomco Model 840, Motomco Model 919, Steinlite Model DM, and the Universal Moisture Tester. Individual scale readings were obtained from two dumps for each sample. The motomco 840 was calibrated at 53 for Peredovik and 23 for Sundak, and the Motomco 919 was calibrated at 73 for both types. Moisture content for the Motomco Model 919 was obtained by using the Motomco calibration chart S-1. The Burroughs and Steinlite instruments read out directly in percent moisture. The Universal Moisture Tester has a calculator dial on the instrument for converting meter reading and temperature to a moisture value which must then be multiplied by 0.6 to give percent moisture for sunflower, as recommended in the instruction manual.

Regression equations were prepared for each instrument based on least squares analysis of the data (dial readings versus moisture content by the oven-dried method).

A rapid surface dry of sunflower seed was simulated by spreading out 250 g seed on a 24 x 30 cm tray and placing it in an oven at 38 C for 30 min. This oven had forced air moving horizontally across the seed surface. Seed were removed, read in the moisture tester, then stored in a sealed jar and reread at several time intervals. Temperature of the seed was measured with a mercury thermometer just before it was placed in the moisture meter.

RESULTS AND DISCUSSION

The moisture meters were evaluated for their response with both oilseed sunflowers (Peredovik) and nonoil sunflowers (Sundak). Table I shows the results which were obtained with Peredovik samples on three of the meters. The readings from each meter were fit to a quadratic

TABLE I

Comparison of Moisture Contents for Peredovik Sunflowers

	Burroughs 700		Motomco 840	Motomco 919	
Oven dried[a] (%)	Indicated (%)	Regr. Eq.[b] (%)	Regr. Eq.[b] (%)	S-1[c] (%)	Regr. Eq.[b] (%)
9.09	10.35	9.37	9107	9.21	9.01
10.46	12.10	10.22	10.53	10.67	10.61
12.07	15.83	11.84	12.03	12.05	12.05
13.40	20.38	13.53	13.38	13.33	13.33
14.72	25.38	14.98	14.80	14.83	14.73
15.88	28.53	15.68	15.51	16.15	15.89
r[d]	0.9869	0.9933	0.9988	0.9976	0.9984

[a]Each value is the mean of four replications.

[b]Quadratic regression equation determined by least squares analysis.

[c]Calibration chart S-1, Motomco, Inc.

[d]Correlation coefficient between oven-dried values and meter values.

TABLE II

Comparison of Moisture Contents for Sundak Sunflowers

	Burroughs 700		Motomco 840	Motomco 919		Steinlite DM	
Oven dried[a] (%)	Indicated (%)	Regr. Eq.[b] (%)	Regr. Eq.[b] (%)	S-1[c] (%)	Regr. Eq.[b] (%)	Indicated (%)	Regr. Eq.[b] (%)
8.70	11.90	8.97	8.71	9.04	8.72	8.70	8.75
11.01	18.50	10.64	10.97	10.83	10.96	10.74	10.99
12.36	23.53	12.13	12.36	12.10	12.37	12.09	12.34
13.50	27.73	13.54	13.59	13.27	13.58	13.30	13.48
14.95	32.40	15.27	14.86	14.63	14.90	14.95	14.89
17.60	38.85	17.94	17.63	17.81	17.59	18.92	17.69
20.06	42.73	19.70	---	---	---	23.96	20.03
r^d =	0.9964	0.9963	0.9991	0.9956	0.9990	0.9916	0.9995

[a]Each value is the mean of four replications.

[b]Quadratic regression equation determined by least squares analysis.

[c]Calibration chart S-1, Motomco, Inc.

[d]Correlation coefficient between oven-dried values and meter values.

equation by regression analysis, and this equation was used to predict moisture contents for individual samples. Regression analysis was also used to fit the data to logarithmic, first order, and third order equations, but the quadratic equation always provided the best fit (highest correlation between predicted values and true values). Table I shows that the Burroughs 700, Motomco 840, and Motomco 919 each give excellent correlations with oven-dried values. Since there was no calibration chart for the Motomco 840, no direct comparisons could be made.

The indicated moisture contents with the Burroughs 700 were much larger than the oven-dried values. Although the instrument was set according to the calibration instructions and the indicated values were incorrect, the correlation (0.9869) was good. This indicated that the slope and intercept controls were improperly set. Setting them correctly by means of the two calibration dials on the control panel inside the instrument was impossible. However, when the indicated values were fit to a quadratic regression equation they agreed much better with the true moisture contents.

Similar results were obtained with Sundak seeds (Table II), where a slightly greater moisture content range (8.70-20.06%) and a Steinlite DM moisture meter were used. There is a much greater deviation from the oven-dried values at the higher moisture content levels. This is the area in which a linear calibration begins to deviate from linearity and a much better correlation is obtained with a quadratic regression equation (0.9995 vs. 0.9916 for the Steinlite DM) Fig. 1).

Table III shows the results obtained with the Universal Moisture Tester with Peredovik and Sundak seeds. The Universal operates differently than do the other moisture meters. It measures the conductance of a seed sample under a given amount of pressure, whereas the other meters measure the absorption of a high frequency radiowave of the whole seed in a condenser-type cell (1). With the Universal, the indicated moisture values were consistently higher than the oven-dried moisture contents for both varieties, although the differences were greater for Peredovik than Sundak. When quadratic regression equations were used, agreement between predicted moisture values and the oven-dried values was very close.

Tables I, II, and III show that each moisture meter can provide a reasonably accurate estimate of the moisture content in sunflower seed when properly calibrated. It should be noted that these results were obtained with seed which was thoroughly equilibrated, both with regard to temperature and moisture distribution within the seed sample. It is the proper equilibration of sunflower seed which is essential for accurate estimates with electronic moisture meters.

Sunflower seeds have a higher ratio of surface area to

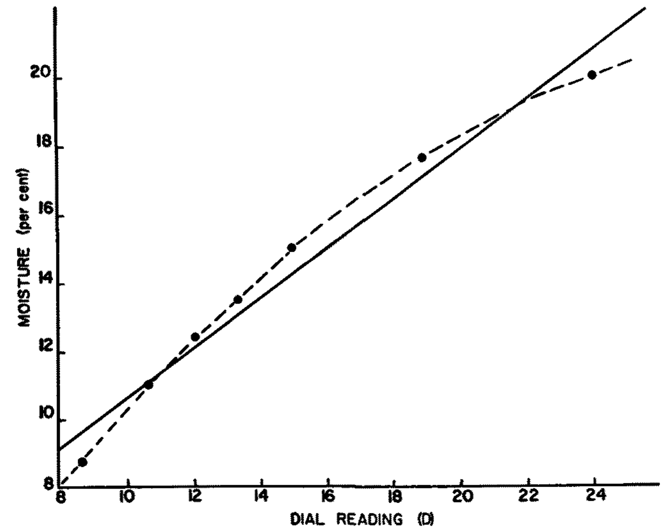

FIG. 1. Comparison of curves based on linear and quadratic regression analysis of data obtained with Sundak sunflowers on the Steinlite DM. • Mean of four replications. —— Line based on linear regression equation (percent moisture = 3.303 + 0.731 D; standard error of estimate = 0.64). – – – Curve based on quadratic regression equation (percent moisture = 1.619 D - 0.0269 D^2 - 3.294; standard error of estimate = 0.12).

internal volume than do cereal grains. Because of the large surface area of sunflower seed, it can lose moisture from the hull quite rapidly when subjected to warm temperatures or air moving rapidly over the hull surface. This rapid drying of the seed causes inaccurate moisture values when the seed is tested in an electronic moisture meter without adequate equilibration (Table IV). Both Peredovik and Sundak seeds were placed in a forced-air oven at 38 C for 30 min and their response in the Motomco 919 was measured. The results with both varieties showed that readings taken 10 min after the rapid drying treatment were lower than those taken later. Increasing the time allowed for the seeds to cool and for the moisture to redistribute itself within the seed lead to a more accurate response. The same type of response was observed with the Steinlite DM and Universal Tester. Table IV shows that a 4 hr equilibration time was sufficient for the laboratory rapid-drying treatment used in this study. However, adequate equilibration time will vary with the extent and severity of the drying conditions encountered, and it is felt that a minimum of 12 hr equilibration time in a sealed container would be a much better procedure for field use.

Temperature is an important factor in the operation of

TABLE III

Comparison of Moisture Contents for Peredovik and Sundak Sunflowers with the Universal Moisture Tester

Peredovik			Sundak		
Oven-dried[a] (%)	Indicated (%)	Regr. Eq.[b] (%)	Oven-dried[a] (%)	Indicated (%)	Regr. Eq.[b] (%)
6.75	8.37	6.80	8.61	8.93	8.62
9.01	11.10	8.92	10.18	10.67	10.21
10.75	13.23	10.72	11.52	12.04	11.47
13.43	16.40	13.64	12.92	13.59	12.94
15.11	17.79	14.97	14.36	15.09	14.40
r^c =	0.9954	0.9980	r^c =	0.9955	0.9957

[a]Each value is the mean of four replications.

[b]Quadratic regression equation obtained by least squares analysis.

[c]Correlation coefficient between oven-dried values and tester values.

TABLE IV

Effect of Rapid Drying on the Apparent Moisture Content of Sunflower Seeds

	Moisture content[a]		
Time (hr)	Sundak (%)	Peredovik (%)	Temperature (C)
Initial	13.69	15.12	24.0
0.17	7.50[b]	8.43[b]	31.7
2	8.16[c]	9.12[c]	26.1
4	8.34[d]	9.21[d]	25.6
6	8.37[d]	9.26[d]	25.0
8	8.36[d]	9.25[d]	25.0
12	8.41[d]	9.26[d]	24.4
24	8.45[d]	9.33[d]	23.9

[a]Each value is the mean of four replications, as determined with the Motomco 919.

[b,c,d] Values with the same superscript in each column were not significantly different at the 5% level from the 12 hr value.

electronic moisture meters. The change in instrument response with sample temperature can be compensated for, but it is important that these corrections be determined with seed that are completely equilibrated with regard to moisture. The compensation for different sample temperatures can be provided in chart form, e.g., Motomco, or incorporated into the operation of the instrument itself, e.g., Steinlite. If the seed sample temperature is not measured accurately or if all of the seeds are not at the same temperatures, errors will result. The Universal tester has a thermometer attached to the front of the instrument and is not in direct contact with the seed. If the seed are warmer than the temperature of the tester, the apparent moisture content will be greater than the correct value. This explains how improper temperature measurement can partially compensate for inadequate equilibration time. Unfortunately, these errors are not constant and cannot be corrected for in a standard procedure. While analyzing sunflower samples over a three month period, the difference between nonequilibrated and equilibrated samples has ranged from 0.2 to 2.0 percentage points.

Moisture contents of intact sunflower seeds can be accurately estimated with electronic moisture meters, if the following criteria are met: (a) the seed are allowed to equilibrate for 12 hr in a sealed container in a constant temperature environment, preferably near the moisture meter; (b) the temperature of the seed sample is accurately measured; and (c) the moisture meter was calibrated with equilibrated seed, and the calibration produced by means of a quadratic equation.

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