Comparison of methods for moisture content determination on soybeans

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Abstract

Moisture content (m.c.) is one of the most important factors affecting development of microorganisms in stored products. Therefore, m.c. monitoring is indispensable for maintenance of quality in stored seeds and grain. The m.c. of bulk soybean samples was determined by four methods: 1. oven-drying individual seeds using copper cups; 2. oven-drying 5 g samples; 3. oven-drying 10 g samples; and 4. a commercial electronic moisture meter (Motomco). The three oven-drying methods were carried out at 110°C for 20 hours. The mean m.c. results from the oven-drying methods did not differ significantly (P=0.01). The mean m.c. determined by the Motomco meter was significantly different (P=0.01) from the three oven methods in about 80% of the samples; it differed from 0.2 to 0.6 percentage points from the mean m.c. determined by the oven-drying individual seed method. The individual seed method proved to be reliable and gave consistent results when compared with the others. Even a small sample size might greatly increase the probability of detecting wet seeds within the sample, what helps to determine the potential risk of quality loss. It also helps to determine the safe storage time of lots or blends of lots of soybeans.

Introduction

The quantity of water present in grains and seeds, usually referred to as 'moisture content' (m.c.), and expressed on a 'wet weight basis', is important in storage management practices and marketing. Grain is bought and sold by weight, of which water usually makes up 10–15% of the total. In storage and transit, when high moisture content is observed, deleterious storage fungi may grow and reduce grain quality (Christensen and Sauer 1982; Christensen 1982; Christensen and Kaufmann 1982; Lazzari 1988).

In commerce, moisture content of grain is often determined by testing 'representative' samples with an electronic moisture meter. This suffices to determine how much water is present in the lot tested, but it does not evaluate storability or risk of spoilage, because moisture content may vary from place to place in the bulk or even from seed to seed. It may be considerably higher, in the case of soybeans, in accumulations of weed seeds, stems, pods and broken beans. Such contaminants are especially hazardous in storage silos because they tend to collect at the centre of bin, which is relatively inaccessible. Temperature differences within a grain bulk may cause a shift of moisture from place to place within the bulk (Booker et al. 1974; Christensen and Meronuck 1986; Christensen and Dorworth 1966; Dorworth and Christensen 1968).

In laboratory work, dealing with grain storage problems (including the effect of moisture content on growth of storage fungi and subsequent spoilage), moisture content in soybeans is usually determined by hot air oven-drying samples of 5-15 g for 72 hours at 103°C, which is widely used as a check method. It has been assumed that the values so obtained give precise information on the amount of water present throughout the sample and that the moisture is uniformly distributed from seed to seed. However, this assumption is questionable. (Christensen 1982).

It is important to know the range of moisture content of grains and seeds within the bin or silo, because this largely determines the storage risk. Also, the variation in moisture content from seed to seed may be of importance in evaluating the storability of grains and seeds (Christensen 1982; Hill et al. 1988; Lopez and Christensen 1967; Oxley 1948). The consistent and reliable method of individual seed moisture content determination can give the range of moisture content variation within a batch of grains or seeds.

The objective of this work was to compare the moisture content determined by oven-drying individual seeds with the results of conventional oven-drying methods and that of an electronic moisture meter.

Materials and Methods

Six random 2 kg samples of commercial soybeans, cultivar Hardin, were collected from a farm in Eden Prairie, Minnesota, USA. Three samples were collected from bins with soybeans from the 1988 crop and three with soybeans from the 1989 crop, following 1 year and 2 months in storage, respectively. Samples were collected with a deep probe at 1.5 m deep, near the centre and around the edges of the bins.

Sixty-two individual seeds were randomly collected from each sample for individual-seed moisture content determination. Copper cups (1 cm in diameter and 1 cm long), devised by D.B. Sauer, were used for this analysis. A single randomly collected soybean seed was put in each cup, covered and weighed at once. After drying in an hot-air oven at 110°C for 20 hours, the cups were covered immediately and weighed.

The other oven-drying methods consisted of four samples of 5 g and 10 g each, previously weighed and placed in small tins and dried in an air oven at 110°C for 20 hours. The samples were covered and weighed immediately after drying. For the moisture content determinations by the Motonco meter, one sample of 250 g was analysed four times, resulting in four replicates.

The samples analysed by the Motomco meter, the air-oven 5 g sample, and the air-oven 10 g sample, had an average of 1475, 31, and 61 seeds per replicate, respectively.

All moisture values obtained by the air-oven methods and Motomco meter were given on a wet weight basis. Data were analysed by t-test using the SPSS/PC+ V2.0 statistical package.

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Results

Table 1 gives the moisture content determined by the four methods.

The average moisture content determined by the air-oven drying individual seeds does not differ significantly (P = 0.01) from the 5 g and 10 g seed samples among the six samples collected from both crop seasons.

The mean moisture content obtained by the Motomco meter was significantly different (P = 0.01) from the three air-oven methods in five of six samples. The Motomco mean moisture content readings differed from 0.2-0.6% from the mean moisture content determined by the air-oven individual seed method.

Table 2 shows the mean moisture content and the range of values for the electronic moisture meter and the 5 and 10 g samples. For the individual seed method it shows the mean, high, low, and range of moisture contents.

The 5 and 10 g samples and the Motomco meter results did not have a range as wide as that obtained by the individual seed method. The range for individual seeds was obtained by comparing the moisture contents of the highest and lowest moisture seeds within a sample of 62 seeds, while the range for the other methods was obtained by comparing the replicate with the highest moisture with that with the lowest.

Table 3 compares the frequency distribution of moisture contents in six samples of soybeans determined by air-oven drying individual seeds. Samples with a low mean moisture content showed individual seeds distributed within a narrow moisture range, while samples with high mean moisture content had individual seeds distributed within a wide moisture range. Some seeds gave a moisture level unsafe for storage. In three bins holding soybeans from the 1989 crop, 35.5, 31.7, and 51.7 of the individual seeds had moisture contents above 13.0%, the level considered as safe for storage.

Discussion

The risk of spoilage of a grain batch might be dependent not only on its average moisture content, but also on the number of grains close to each other with moisture content high enough to create conditions favourable for growth of storage fungi.

Table 1. Mean moisture content of soybeans determined by four methods in St. Paul, MN, USA

Method	Moisture content (%)					
	Crop 1988[a]			Crop 1989[b]		
	Bin 1	Bin 2	Bin 3	Bin 1	Bin 2	Bin 3
Motomco[c]	8.7a	8.9a	10.6a	12.3a	12.4a	13.5a
Air oven 5 g[c]	8.3b	8.6b	10.7a	12.8b	12.9b	14.3b
Air oven 10 g[c]	8.4b	8.6b	10.8a	12.7b	12.9b	14.0b
Air oven, individual seeds[d]	8.7a	8.9a	10.6a	12.3a	12.4a	13.5a

[a]Soybean crop 1988 (seeds in storage for 1 year).
[b]Soybean crop 1989 (seeds in storage for 2 months).
[c] Mean of 4 replicates
[d] Mean of 62 seeds
Data followed by the same letters within a single column, are not significantly different at P=0.01

Table 2. Moisture values of soybeans obtained by four methods in St. Paul, MN, USA.

Method	Moisture content (%)					
	Crop 1988[a]			Crop 1989[b]		
	Bin 1	Bin 2	Bin 3	Bin 1	Bin 2	Bin 3
Motomco[c] (average 1475 seeds)						
Mean[c]	8.7	8.9	10.6	12.3	12.4	13.5
Range	0.1	0.1	0.2	0.2	0.2	0.3
Air oven 5 g (average 31 seeds)						
Mean[c]	8.3	8.6	10.7	12.8	12.9	14.3
Range	0.1	0.0	0.1	0.1	0.3	0.8
Air oven 10 g (average 61 seeds)						
Mean[c]	8.4	8.6	10.8	12.7	12.9	14.0
Range	0.1	0.1	0.2	0.2	0.2	0.3
Air oven, individual seeds (1 seed)						
Mean[d]	8.2	8.4	10.8	12.9	12.9	14.0
High MC	9.1	9.3	11.9	13.7	15.3	20.8
Low MC	7.5	7.1	9.7	11.5	12.0	9.8
Range	1.6	2.2	2.2	2.2	3.3	11.0

[a] Soybean crop 1988 (seeds in storage for 1 year).
[b] Soybean crop 1989 (seeds in storage for 2 months).
[c] Mean of 4 replicates
[d] Mean of 62 seeds

Table 3. Frequency distribution of individual seed moisture content of soybeans, St. Paul, MN, USA

Range in moisture content (%)	Crop 1988[a]			Crop 1989[b]		
	Bin 1	Bin 2	Bin 3	Bin 1	Bin 2	Bin 3
Mean (x)[c]	8.2	8.4	10.8	12.9	12.9	14.0
<10.0	100.0	100.0	1.6	-	-	8.1
10.1–10.5	-	-	38.7	-	-	16.1
10.6–11.0	-	-	17.7	-	-	6.5
11.1–11.5	-	-	33.9	1.6	-	8.1
11.6–12.0	-	-	8.1	-	-	1.6
12.1–12.5	-	-	-	17.7	37.1	8.1
12.6–13.0	-	-	-	45.2	30.6	-
--(13.0%)						
13.1–13.5	-	-	-	33.9	14.5	-
13.6–14.0	-	-	-	1.6	4.8	1.6
14.1–14.5	-	-	-	-	6.5	-
14.6–15.0	-	-	-	-	4.8	6.5
15.1–15.5	-	-	-	-	1.6	4.8
>15.6	-	-	-	-	-	38.7

[a] Soybean crop 1988 (seeds in storage for 1 year).
[b] Soybean crop 1989 (seeds in storage for 2 months).
c Mean of 62 seeds

There are many commercially used methods for measuring grain or seed moisture content but none of them measure the moisture content of individual seeds. Air-oven drying of a sample of individual seeds can determine the moisture content variation within a batch of soybeans and show the true condition of the grain. This information is important for management of stored seeds or grains.

Air-oven drying of individual seeds proved to be accurate and reliable for moisture determination when compared with the other air-oven methods. The mean moisture content determined by this method differed significantly from the mean moisture obtained by the Motomco meter. The measurement of individual seeds also resulted in a range of moisture content wider than that of the other methods. This method might help to determine the potential risk of quality loss and the allowable time for storage of single or mixed batches of soybeans or cereal grains before the occurrence of significant losses of quality and/or quantity. Under certain conditions, it may also be used to determine if dryer and wetter batches of seeds or cereal grains could be blended.

Further studies are needed to determine the number of individual seeds required to be oven dried for different soybean cultivars and/or blends at different moisture contents.

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