Bauer Mill Operation and Its Effect on the Percentage of Oil Found in Soybeans

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THE author has observed many times that a soybean seed sample may vary in apparent oil content when prepared for analysis by different chemists, though each is following the official method of the American Chemists' Society (1). This became very apparent during a study of the oil content of soybeans conducted cooperatively by the A. E. Staley Manufacturing Company, the Northern Regional Research Laboratory, and the U. S. Regional Soybean Laboratory. As a part of this study the writer ground with a Bauer Mill six samples of soybean meal representing three different lots of soybeans and sent aliquots to the other laboratories for similar preparation. All of the samples prepared by the author on one sampling day had higher oil contents (averaging 0.4% higher) than six duplicate samples prepared by each of the other two laboratories. The 0.4% higher oil percentages on meal ground by the author were confirmed by the other two laboratories, a fact which indicates a major difference in sample preparation. A resampling of these six lots by the Northern Regional Research Laboratory and several resamplings by the writer produced no more samples of abnormally high oil content.

Evidence of similar differences in apparent oil content of soybeans due to method of analysis was reported by R. T. Doughtie Jr. (3) on Commodity Credit Corporation check samples. Mr. Doughtie, as chairman of the subcommittee on oilseeds of the Smalley Committee of the American Oil Chemists' Society, assembles the analytical data each year on the oil and moisture determinations on 10 check samples of soybeans. Duplicate sets of 10 samples are analyzed by 20-25 different laboratories, and the results for each sampling nearly always spread over a range of about 1% of oil. Since the A.O.C.S. method (1) for determining oil in soybeans has been tested and found to be reproducible by ± 0.2% of oil, this range of 1% in oil means that a real difference in samples has been caused by some variation in preparation of the ground samples.

Some of the wide range in oil content of duplicate samples of soybeans found by different laboratories may have been caused by variation in mill temperature and rate of grinding of the samples. The writer has been able to produce samples of soybean meal with differences in apparent oil content ranging up to 0.8% by varying the feeding rate and operating temperature of a Bauer Mill.

Materials and Methods

This study of Bauer Mill operation was made on several duplicate sets of the 1948-49 series of check samples supplied through the courtesy of Mr. Doughtie. These samples are so well known and have been so thoroughly tested by so many laboratories, all using A.O.C.S. methods, that further description of these samples seems unnecessary. The Bauer Mill used in this study was a 5-h.p., 3,600-r.p.m., water-cooled type, official A.O.C.S. approved for use in grinding laboratory size samples of soybeans. All of these samples of soybeans were prepared and analyzed by A.O.C.S. approved methods and equipment. The Bauer Mill plates were set to .0015 to .0025 in. clearance with a blade-type of feeler gauge with the mill in normally warm condition. This setting becomes .008 to .009 in. when the mill cools to room temperature. For hot mill operation the cooling water was shut off and the mill heated by fast grinding of soybeans to bring the water in the cooling chamber to 170° to 180°F.

Test samples were ground in a hot mill with plate clearance (by feeler gauge) of .0015 to .0025 in. This very close setting of the hot mill becomes .012 to .014 in. when the mill cools to room temperature. Two methods of Bauer Mill operation were studied intensively although many variations of mill operation were also tried.

High Temperature Bauer Mill Operation. To establish a uniformly high temperature of the mill, four pounds of soybeans were ground at the fastest possible rate. This method of grinding soybeans causes and maintains a high temperature in the mill.

With the high temperature established and .0015 to .0025 in. plate setting the 10 check samples were ground at the fastest possible rate, using a minimum of time for cleaning the mill between samples.

Cool Bauer Mill Operation. In order to establish equilibrium temperature in the cool Bauer Mill, with cool water 20-25°C. flowing through the cooling chamber, about four pounds of soybeans were ground with a slow rate of feed. After checking the mill plate setting of .0015 to .0025 in. with a feeler gauge the 10 check samples were ground, using about ½ the fastest possible feed rate, thus taking about 10 seconds longer to grind each 60-g. of sample than when the samples were ground at the higher rate. This method of grinding maintains a relatively cool mill even with continuous operation, and one person operating the mill can grind 15 to 20 samples of soybeans of 60 g. each per hour.

Wiley Mill Ground Samples. To provide samples for a check and for comparison analyses duplicates of these 10 check samples were ground in an intermediate Wiley Mill, fitted with 1-mm. round hole screen.

Discussion

Results of analyses of these samples and the oil percentages as reported by 23 laboratories by Mr. Doughtie are given in Table I.

Table I shows clearly that operating a Bauer Mill at a high temperature, using a fast feed rate, results in an increased oil percentage for all 10 of these check samples in comparison with samples ground in a cool Bauer Mill with a slow feed rate. Oil percentages in samples ground in a cool Bauer Mill check very closely with those of duplicate samples ground in a Wiley

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TABLE I

Percentages of Oil in Soybeans as Affected by Mill Operations

Check samples[a]	Wiley Mill (1 mm.) screen, % oil	Cool Bauer Mill, slow feed rate, % oil	Hot Bauer Mill, fast feed rate, % oil	Analyses by 23 Laboratories,[b] % oil		
				Low	Average	High
1	17.82	17.90	18.35	17.4	17.9	18.5
2	16.50	16.40	17.00	16.2	16.7	17.0
3	18.50	18.46	18.71	18.2	18.7	19.4
4	17.52	17.20	17.94	17.2	17.7	18.1
5	17.34	17.28	17.64	16.9	17.5	18.2
6	17.67	17.56	18.03	17.5	17.9	18.3
7	17.39	17.27	17.76	17.2	17.6	18.4
8	19.32	19.27	19.56	19.1	19.4	20.0
9	16.80	16.68	17.35	16.2	16.8	17.3
10	17.86	17.72	18.07	17.6	18.0	18.0
Average	17.67	17.57	18.03	17.35	17.82	18.37

[a] Smalley Foundation Committee check samples, 1948-49, supplied by R. T. Doughtie Jr.
[b] Data supplied by Mr. Doughtie.

Mill. Methods of Bauer Mill operation vary widely between laboratories. Some of the range in percentages of oil reported by Mr. Doughtie may be due to differences of Bauer Mill operations since a high percentage of the laboratories used Bauer Mills in grinding these 10 samples of soybeans for analysis. Dull mill plates (plates that have ground 5,000-15,000 samples) might be expected to cause higher temperatures in the grinding process and might raise the oil content of samples more than sharp plates. However the sharp mill plates will grind at a faster rate so that the writer found no appreciable difference between a Bauer Mill equipped with new sharp plates and a mill equipped with plates that had ground 20,000 to 30,000 samples. When the mill becomes hot, fast feeding results in considerable darkening of the color (tan or brown) of the samples being ground, and results in a large increase (0.5% or more) in the petroleum ether-soluble content of these darkened samples.

Slow feeding of a hot mill causes only slight darkening of the samples and results in only slightly increased oil content. A Bauer Mill operated at slow feed rate remains reasonably cool in continuous operations and produces samples of soybeans that check closely in oil content with duplicate samples ground in a Wiley Mill.

Cool uniform mill operation and a mechanical feeding device to prevent a fast feeding rate seem desirable. A simple means of reducing the rate of flow of beans in the mill has been devised by the writer. The device is in constant use in the U. S. Regional Soybean Laboratory and has proven satisfactory for a wide range of sizes of soybeans.

In a previous publication (2) a modified feed throat for a Bauer Mill was explained. To overcome the necessity of hand-trickle feeding of the samples being ground, the feed regulator described below (Figure 1) was placed in the throat of the mill. The entire sample is poured into the mill, and the rate of feed is controlled by the operator. Rapid agitation of the wire is required in grinding large-size soybean seed and slight or no agitation of the wire for small soybean seed.

Plate E is drilled and tapped for a $\frac{5}{16}$-in. square-headed bolt cut to the proper length, and shims, F, added until the space between the bolt head and the mouth of the feed tube is decreased so that the beans cannot enter the grinding chamber at a rapid rate. The author used two $\frac{1}{16}$-in. washers and some paper for shims. The wire for agitation of the beans was made of $\frac{1}{8}$-in. mild steel welding rod fashioned to fit the feed tube and extend through a small hole in the throat of the mill. A slight movement of the wire is sufficient to agitate the beans and control the rate of feed into the grinding plates.

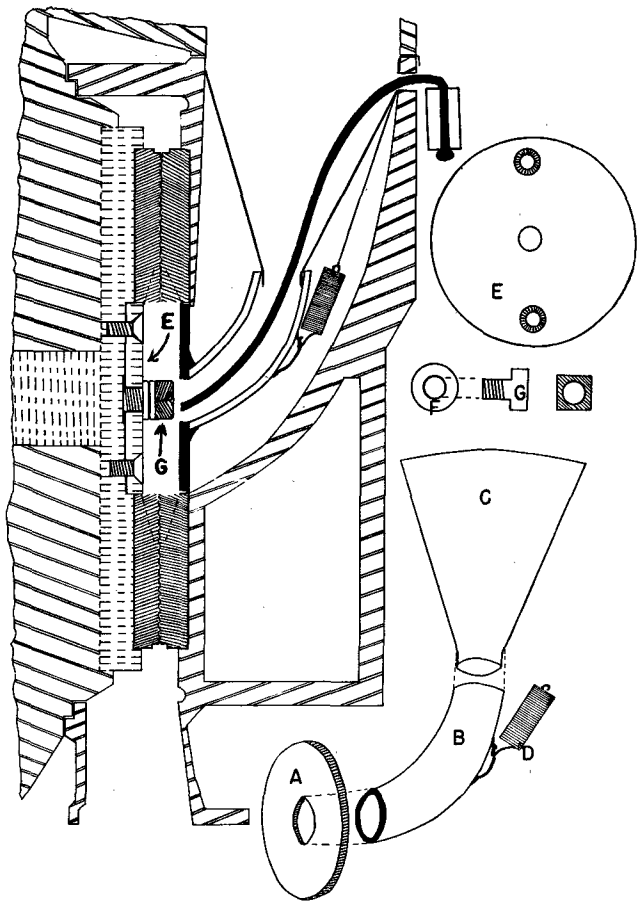

FIG. 1. Modified throat for Bauer Mill to control rate of feeding.

Summary and Conclusions

A Bauer Mill officially approved by the A.O.C.S. for grinding samples of soybeans to be used for oil determinations was used to grind duplicate series of the 10 check samples of soybeans sent out each year by the Smalley Foundation Committee. When the mill was operated at high temperature and forced to grind at its maximum rate, the 10 samples averaged 18.03% of oil. A duplicate series of 10 samples ground in a water-cooled mill at about one-half the maximum possible rate of grinding for the mill averaged 17.57% oil. Improper operation of a Bauer Mill when preparing soybean seed samples for analysis can cause abnormally high oil percentages. A simple mechanical device to reduce the rate of feed is suggested for use with the mill.

A Bauer Mill is satisfactory for use in grinding samples of soybeans for oil analysis when it is properly operated.

REFERENCES

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