Effect of Soybean Breakage on the Quality of Soybean Oil: Preliminary Study

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ABSTRACT

Soybean samples were separated into 4 fractions (whole beans, halves, pieces, and fines) according to physical damage, and all fractions but the fines were analyzed for oil quality. Free fatty acids were found to increase from 0.65% for whole beans to 1.79% for halves, 3.04% for pieces, and 9.46% for fines (by differences). Neutral oil loss of hexane-extracted oil from these fractions was 4.5% for whole beans, 4.62% for halves, and 6.08% for pieces. The results give a measure of the decrease in quality of soybean oil with increasing soybean breakage.

INTRODUCTION

Changes in quality of soybean products from breakage during transport are being studied jointly by several laboratories (1,2) of the U.S. Department of Agriculture, SEA, Agricultural Research. At the Seed Research Laboratory, we examined the effects of physical damage (breakage) of soybeans on oil quality as reflected in content of free fatty acids (FFA), an indicator of triglyceride deterioration, and neutral oil, a laboratory measure of the amount of refined oil obtainable. Neutral oil is that fraction of the unrefined oil that passes through a chromatographic column (i.e., the eluate), and "neutral oil loss" (a term used by industry) is that part of the unrefined oil, phospholipids, FFA and other saponifiables that remain on the column.

EXPERIMENTAL PROCEDURES

The samples used in this study were taken from 51,000 metric ton shipment of soybeans that arrived in Japan in February 1978. The 79 samples (500 g each) were sent by air to Beltsville where they were graded and analyzed for oil, protein, and free fatty acids (Whitten, M.E., unpublished data).

In this laboratory, we combined the 79 samples into composite samples in order to obtain sufficient broken beans for analysis. The entire shipment of 79 samples was, therefore, treated as 1 sample lot, and the 8 composite samples formed were subsamples of this lot. Seven composite samples contained 10 samples each, and 1 composite sample contained 9 samples.

The composite samples were sieved into 4 fractions (wholes, halves, pieces, and fines) with 3 sieves: a 11/64 x 3/4 in. slotted hole sieve for whole intact beans, a 15/64 in. round hole sieve for halves, and a 9/64 in. round hole sieve for pieces. The fraction passing through the 9/64 in. sieve was labeled fines and was not analyzed because of the large amount of extraneous material present in these fractions. After sieving, each fraction except the fines was handpicked to ensure uniformity of the fraction. The weights of each fraction were recorded and their percentages calculated.

Free fatty acid levels in petroleum ether extracts of unfractionated and fractionated beans were determined by AOCS official method Ac 5-41 and expressed as percent of crude (unrefined oil). Neutral oil contents were determined by AOCS official method Ca 9f-57 on oil extracted with hexane. The laboratory extract of oil with hexane was modeled by Whitten (manuscript in preparation) to duplicate the industrial extraction procedures, and oil yields of 97% are obtained when compared to the official oil procedure. First we dehulled the soybeans by drying, grinding coarsely in a Bauer mill, and removing the hulls by vacuum. We processed the coarsely ground beans into flakes by adjusting moisture, using heat and vacuum, to about 11%, then tempering with steam, removing excess moisture with heat and passing them through rollers to produce flakes about 0.012 in. thick. These flakes were added to hot hexane (60 C) and allowed to stand for 1 hr at 60 C. The hexane solution was filtered, and the hexane was evaporated on a steam bath. Residual hexane in the oil was removed in a vacuum oven at 80 C and 30 in. vacuum for 4 hr. We added this vacuum step to the procedure in order to ensure that the neutral oil loss of crude extracted oil was not a solvent loss.

TABLE I

Free Fatty Acid Contents (% of Crude Oil) of Soybean Fractions

		Fractions[a]			
Sample number	Whole sample (%)	Whole beans (%)	Halves (%)	Pieces (%)	Fines (%)
1	1.03	0.50	1.66	3.44	
2	1.40	0.59	1.59	2.93	
3	1.20	0.66	1.77	3.09	
4	1.38	0.54	1.87	3.14	
5	1.20	0.73	2.00	3.04	
6	1.39	0.80	1.86	2.96	
7	1.33	0.68	1.94	2.99	
8	1.21	0.72	1.67	2.78	
Average	1.26	0.65	1.79	3.04	[a]9.27
Ratio		1	2.75	5.2	14.13
%of[b] Total Sample	99.1	78.9	7.8	8.7	3.7
Adjusted FFA %	1.25	0.51	0.14	0.26	9.19

[a]Calculated by difference.

[b]Total sample contains an average of 0.9% non-soybean material.

TABLE II

Neutral Oil Loss (% Crude Oil) in Hexane-Extracted Soybean Oil

Sample number	Fraction		
	Whole beans	Halves	Pieces
1	4.68	4.53	6.27
2	4.38	4.70	5.89
Average	4.53	4.62	6.08

RESULTS AND DISCUSSION

The levels of FFA in composite samples before and after separation into wholes, halves, pieces, and fines are compared in Table I. Levels of FFA in the composite samples increased as breakage of the beans increased. Levels of FFA in bean halves were 2.8-fold those of whole beans; levels of pieces were 4.7-fold those of whole beans and levels of fines were 14.6-fold as calculated by difference. When the composite sample is analyzed before fractionation, its FFA content is intermediate to the values for wholes and halves since these two components make up about 87% of the sample.

Surprisingly, percentage of neutral oil loss in halves was similar to that of whole beans even though its FFA content was 2.8 times higher (Table II). The percentage of neutral oil loss in pieces (which are 8.7% of total sample weight) was 33% higher than that of whole beans (78.9% of total sample weight) or half beans (7.8% of total sample weight).

Thus, from examination of these preliminary results it is apparent that probable loss in oil quality is greatest in the broken pieces which are smaller than halves. In order to more accurately assess the oil quality in soybean samples, the amount of broken beans smaller than halves should be determined.

Because most of the soybean samples were used in other studies, we were only able to analyze 2 of the 8 composite samples for neutral oil content; therefore, these results should be viewed as fragmentary. Nevertheless, together with the FFA results, they have served to focus our attention on those fractions of broken soybeans in which the quality of oil is significantly affected. Plans have been made to monitor a greater number of shipments, at various world ports, so as to obtain a statistical correlation between breakage and oil quality during transport.

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