

# Extraction of Soybeans with Four Hydrocarbon Solvents

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## Abstract

Soybean flakes were extracted in glass extraction apparatus with four hydrocarbon solvents: hexane, isohexane, pentane, and isopentane. The amount of extracted oil was determined at 10 min intervals for 60 min. The extraction rates of the solvents increased in the following order: isopentane, pentane, isohexane, and hexane. Quality and fatty acid composition of the oils extracted by the four solvents showed no significant differences.

## Introduction

WHILE VARIOUS SOLVENTS have been studied and used commercially for the extraction of vegetable oils, the one most commonly used in the United States is the petroleum fraction, hexane. It varies in n-hexane content from 60–88%. A previous study in this laboratory (2) compared pure, "high purity" and "commercial" hexane with benzene as solvents for soybean and cottonseed oil. In the present investigation soybeans were extracted by hexane, pentane, isohexane, and isopentane to determine the extraction rates and the quality and fatty acid composition of the extracted oils.

## Experimental

Cracked soybeans containing 7–8% moisture were heated to 100F and rolled into flakes with an average thickness of 11 mils. The extractions were carried out in apparatus similar to that used in previous studies (3), except somewhat larger. The extraction chamber was 12 in. high by 2 in. in diameter allowing the use of 100g samples. The extraction chamber and the incoming solvent were heated to an average of 122F for the hexanes and 77F for the pentanes. The solvent passed through the flakes at a rate producing 10 ml of miscella per min. Samples were taken at 10 min intervals. The solvent was evaporated from each fraction under vacuum and the oil weighed. The residual oil content of each sample was determined in Soxhlet apparatus. The results are shown in Table I.

Composites of the oil aliquots from each complete extraction were examined for quality with the re-

TABLE I  
Extraction of Soybean Oil by Four Solvents

Extraction time, min	Residual extractable oil, percent of original <sup>a</sup>			
	Hexane	Isohexane	Pentane	Isopentane
10	74.6	73.2	77.1	77.4
20	54.0	53.1	60.3	59.5
30	37.3	38.2	46.1	46.4
40	24.4	26.9	34.4	36.0
50	15.5	18.1	26.5	28.0
60	9.7	16.7	20.1	21.9

<sup>a</sup> Original oil content of the flakes, 19.08% (dry basis).

TABLE II  
Quality of Oil Extracted by Four Solvents

Solvent used	Free fatty acid, %	Color	Neutral oil, %	Phospholipids, %	Saponification value	Iodine value
Hexane	0.5	6.1	96.3	3.5	192.0	137.0
Isohexane	0.4	4.9	96.4	3.2	191.5	136.8
Pentane	0.4	5.6	95.4	4.4	191.5	137.1
Isopentane	0.4	3.8	95.3	4.0	191.0	138.5

sults summarized in Table II. Free fatty acid content was determined by the AOCS Official Method. Color was determined by the AOCS tentative photometric method, saponification value and I.V. by AOCS method (1), and neutral oil and phospholipid content by the method of Choudhury and Arnold (4).

The fatty acid compositions of the oils were determined by gas liquid partition chromatography of the methyl esters. Each oil sample was saponified with a 4% solution of alcoholic sodium hydroxide, and the unsaponifiables were extracted with petroleum ether. Fatty acids were liberated by dilute sulfuric acid (1 part concentrated acid to 3 parts water). The fatty acids were then extracted with ethyl ether and dried over anhydrous sodium sulfate. The ether was evaporated off under vacuum. The fatty acids were esterified with methanol containing 3% by weight of hydrogen chloride. The esters were removed from the mixture with ethyl ether and analyzed by gas liquid chromatography. Results are shown in Table III.

TABLE III  
Fatty Acid Composition of Soybean Oil Extracted with Four Solvents

Solvent	Per cent fatty acid composition						
	Myristic	Palmitic	Palmitoleic	Stearic	Oleic	Linoleic	Linolenic
Hexane	0.4	10.5	1.0	2.8	20.8	56.5	8.0
Isohexane	0.3	11.1	0.8	2.9	21.2	55.2	8.5
Pentane	0.4	9.8	0.7	2.6	20.5	56.0	10.0
Isopentane	0.4	10.5	0.8	3.0	20.9	54.9	9.5

## Conclusions

The data (Table I) indicate that over the time intervals studied the hexane extracted the flakes to a lower residual than the other solvents. The residual—9.7% of the original oil (1.8% of the meal)—is higher than when secured by good commercial operation probably because of thicker flakes and lower extraction temperatures. It compares well with the 8.7% residual secured under otherwise identical conditions except an extraction temperature of 131F (2). The poorer extraction by pentane and isopentane may, in part, have resulted from the lower extraction temperature. The quality of the oils extracted by the various solvents was not significantly different except possibly the phospholipid content. It might be expected that extraction by pentane and isopentane which resulted in higher oil residuals than that by hexane might produce oils with less phospholipids. However such was not the case. The fatty acid composition of the various oils did not show much variation.

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