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Effect of Moisture on the Rate of Solvent Extraction of Soybeans and Cottonseed Meats

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THE effect of variation in the moisture content of oil-bearing seeds upon the rate at which oil is extracted from them by solvents has not been well established. Fan, Morris, and Wakeham (2) found in the extraction of peanuts with a hexane fraction (Skellysolve-B) that an increase from 10 to 22% in the moisture content decreased the extraction rate. Measamer (3), using trichloroethylene as a solvent, found very little difference in the extraction rate of soybean flakes containing zero moisture and 10% moisture. Yates (6) reported a decrease in the amount of oil extracted in a Sohxlet apparatus from soybean flakes by trichloroethylene with an increase in moisture content from 5.63 to 27.95%. Milner (4), in a study of the method for the determination of oil in soybeans, found that the amount of oil extracted with a mixture of approximately 80% hexane and 20% pentane increased with an increase in the moisture content from 3 to 12%. The beans had no heat treatment. Bull (1) in a similar study showed the amount of oil extracted from beans with moisture contents between 8.2 and 11.4% to be practically constant with a slight increase between 11.4 and 23.4%.

In the present study two solvents were used: extraction grade of trichloroethylene and a "hexane" fraction (Skellysolve-B) having a boiling point of 146° to 157°F. Two oil seeds were used: dehulled cottonseed meats and soybeans. Cottonseed meats and cracked soybeans containing 7 to 8% moisture were heated to 160°F. in a steam-jacketed tempering screw and rolled into flakes in a set of laboratory flaking rolls. Samples of flakes from a common batch were adjusted in moisture content by adding distilled water and leaving for two days in a closed container or by drying in a desiccator. The exact moisture content was determined at the time of extraction. The soybean flakes had an average thickness of 0.011 in. and the cottonseed flakes an average thickness of 0.016 in. The equipment used for measuring extraction rates was a jacketed glass extraction tube (Fig. 1) 1 in. in diameter connected to a 110°F. constant-temperature water bath.

The extraction procedure was as follows: The extraction tube was filled with a weighed quantity of cottonseed (equivalent to 18.4 g. on dry basis) or soybean (14.4 g.) flakes. The solvent was run into the bottom of the tube at such a rate that 10 milliliters per minute overflowed at the top. The miscella produced during each 5-minute interval was collected separately. The oil content of samples taken from these miscella increments was determined by evaporating the solvent and weighing the residue. The oil content at the end of the extraction was determined by Soxhlet extraction using hexane (Skellysolve-B) as a solvent. The sum of the amounts of oil in each of the miscella increments and in the residual meal was taken as the total oil content of the sample. The oil remaining in the flake sample after 5 minutes, or a multiple of 5 minutes as desired, was calculated by subtracting the total oil extracted in the given time interval from the total original oil. This was converted into percentage by dividing by the original oil content and multiplying by 100.

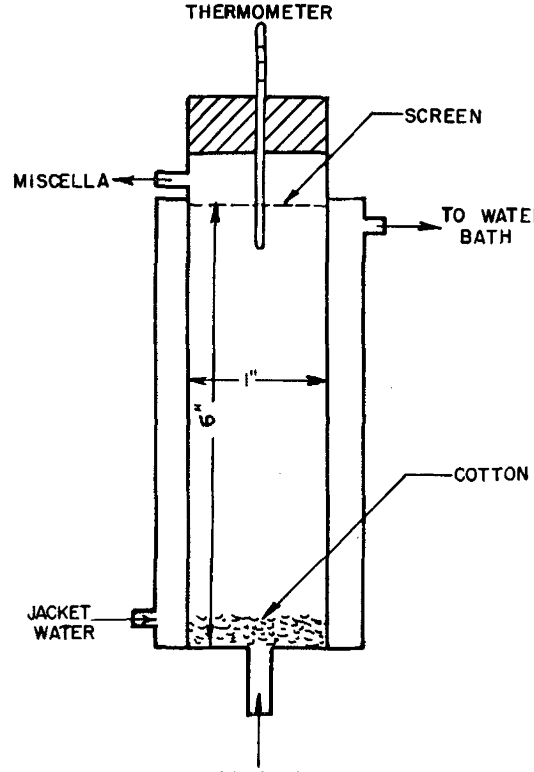

FIG. 1. Extraction rate apparatus.

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Typical extraction curves showing the relation between the logarithms of the percentages of the original oil remaining and the extraction time for each of the four combinations of seeds and solvents are shown in Figure 2. The effect of the variation in the amount of moisture upon the percentage of the original oil remaining in the flakes at the end of the various time intervals is shown as a family of curves for each solvent-seed combination in Figures 3 to 6. Both sets of

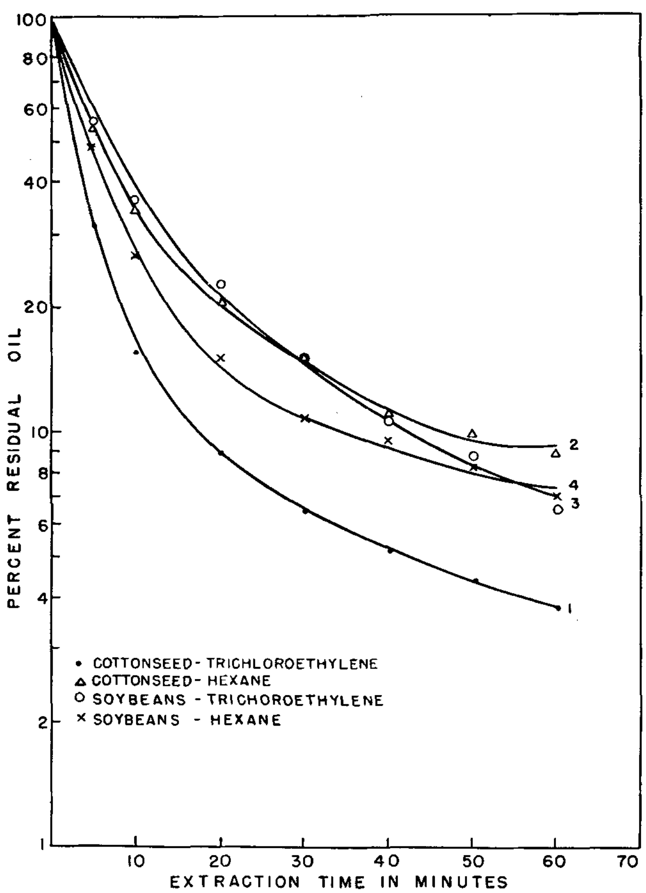

FIG. 2. Typical extraction rate curves.

curves for soybeans (Figures 3 and 4) are similar, showing maximum extraction at intermediate moisture contents. The lower extraction at high moisture in general agrees with the results of Fan, Morris, and Wakeham (2) with peanuts, and Yates (6) with soybeans, but not with Milner (4) and Bull (1). However the latter were using ground rather than flaked beans and were using a four-hour extraction time rather than a one-hour maximum.

It is possible that at higher moisture levels the protein of the soybeans is swollen sufficiently to restrict the size of the openings through which the diffusion of the solvent occurs. If this is true, the greater effect of high moisture on the extraction rate of hexane than on that of trichloroethylene is probably due in part at least to the higher viscosity of the former. Grinding and regrinding used in the analytical procedure together with longer extraction time may offset this.

The lower extraction at the low moisture levels may result from lower amounts of phosphatides being removed with the oil. Over the range of usual practical

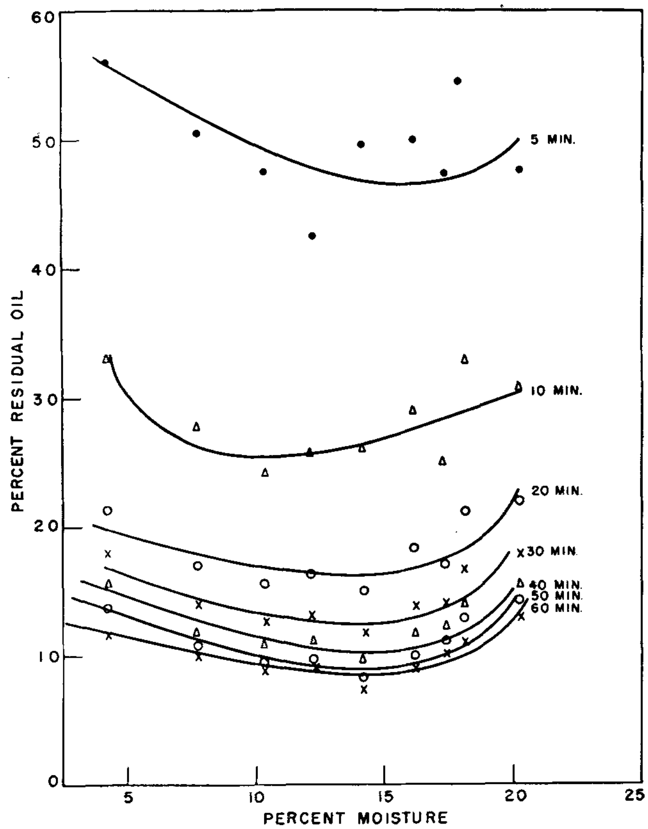

FIG. 3. Variation of residual oil content with moisture. Soybeans extracted with hexane.

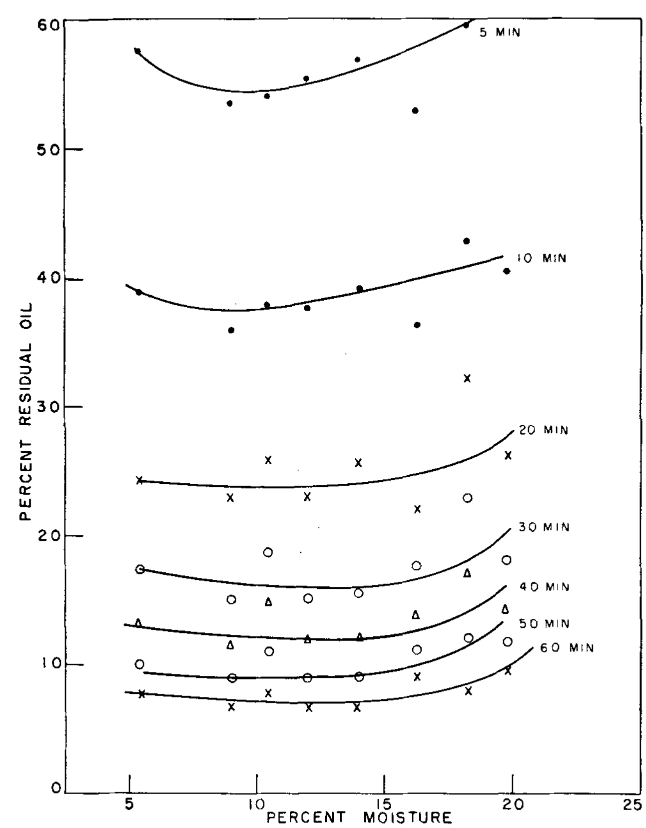

FIG. 4. Variation of residual oil content with moisture. Soybeans extracted with trichloroethylene.

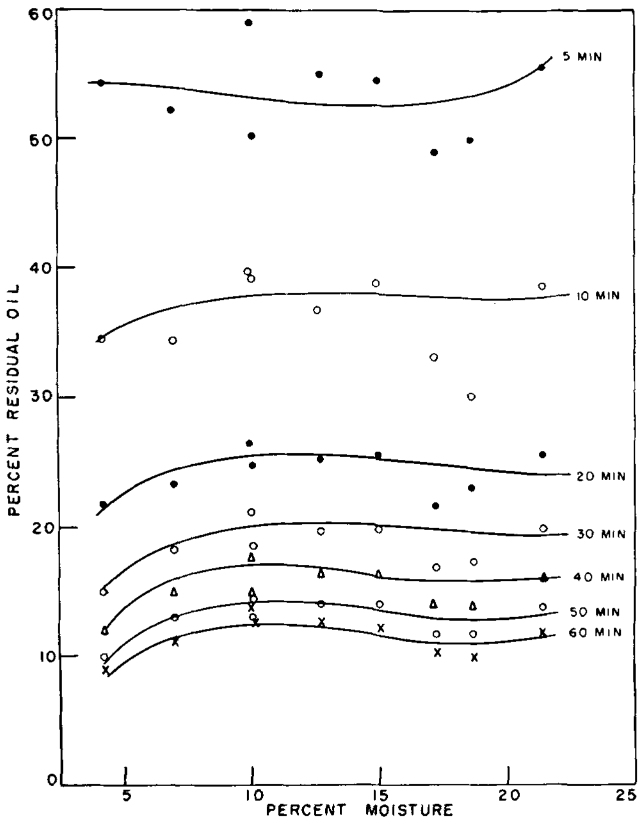

FIG. 5. Variation of residual oil content with moisture. Cottonseed meats extracted with hexane.

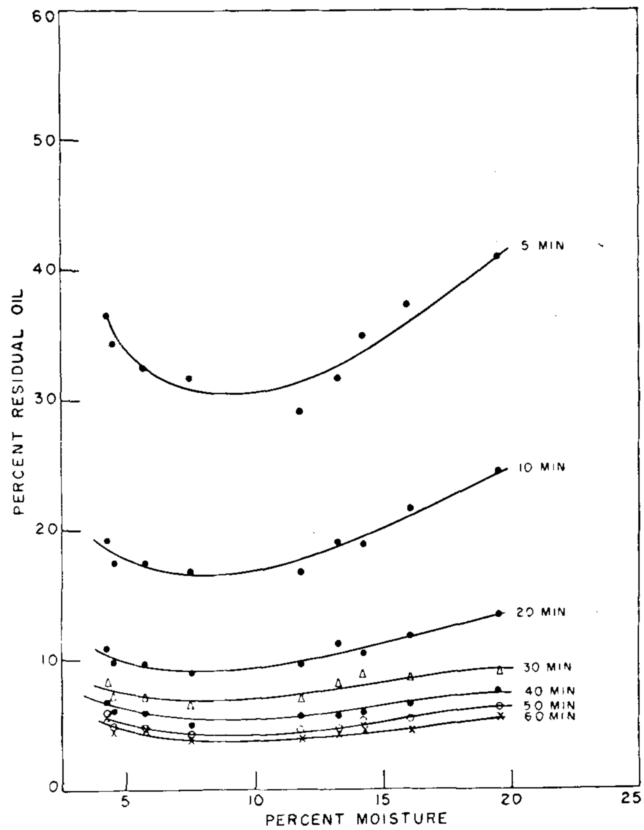

FIG. 6. Variation of residual oil content with moisture. Cottonseed meats extracted with trichloroethylene.

plant operating conditions the effect of moisture is small. Solvent extraction of soybeans is commonly carried out in the range of 8 to 12% moisture content. Over this range with hexane as a solvent the residual oil content varied about 1%, or on the basis of the beans, assuming 20% original oil, about 0.2%. With trichloroethylene as a solvent the variation is less.

In the extraction of cottonseed with hexane the best extraction occurred at the lowest moisture content used, 4.3%. With trichloroethylene, on the other hand, it occurred at 7.4%. Optimum moisture conditions for flaking cottonseed meats for extraction have been reported by Reuther, Westbrook, Hoffman, Vix, and Gastrock (5) to be from 9 to 10%. Work in this laboratory indicates 7 to 10 % as optimum. The variation in the amount of oil extracted by either solvent over either range was small. Some of the small variations with both soybeans and cottonseed may be due to experimental error such as unnoticed breakage of flakes during the handling incident to moisture adjustment or to slight differences in the packing of the flakes in the extraction tube.

Summary

While continuous *extraction* by *percolation* of flaked soybeans and cottonseed meats of different moisture contents by hexane and by trichloroethylene showed variations at the end of 60 minutes as great as 5.47% residual oil, the variations over the range of practical plant operation conditions are too small to be a significant factor. Moisture affects the *rate of extraction* of soybean flakes and cottonseed meat flakes by trichloroethylene less than the rate of extraction by hexane.

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