Key Operations in the Wet-Rendering of Peanut for the Isolation of Protein, Oil and Starch

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Abstract

Separation of oil and suspended solids from peanut slurry are two important interdependent operations in wet rendering of peanuts. A 3-way centrifuge cannot be used efficiently for the separation of the different phases due to the large volume of fibrous suspended solids in peanut slurry. Removal of suspended solids from the slurry by filtration is too slow and incomplete, as the fine particles tend to block the screen. The alternative method of centrifugal sedimentation of the suspended solids causes emulsification of the oil and results in the inefficient separation of the oil. It is shown in the paper that efficiency of the separation of oil and carbohydrate fraction from peanut by wet rendering method depends on careful conditioning of the seed.

Introduction

IN VIEW OF THE MANY food uses and industrial uses of peanut protein, attempts have been made by various workers (1–3) to isolate superior quality protein and oil in a single process from peanut kernel. Unlike the protein in peanut meal which was hitherto used as the raw material for the isolation of peanut protein, the kernel protein is undenatured and almost completely peptizable.

Subrahmanyan et al. (1) developed a process to separate and isolate peanut protein and oil by dispersing thoroughly ground peanut in alkaline water and centrifuging. The inefficient separation of oil and suspended solids from protein solution were the major problems encountered by the workers. Sugarmann (2) has taken a patent to separate protein and oil in a similar process as described above. As yet no published data regarding the efficiency of separation of oil and protein by the patented process are available. Chayen (3) has developed a shock wave process for the isolation of protein from oil seeds. In the shock wave process, peanut kernel suspended in water was passed through a high speed beater to produce a slurry. The slurry was passed through a 3-way centrifuge to separate fibrous solids, part of the oil and a liquid fraction rich in protein and oil. The pH of the latter fraction was adjusted and sedimented to separate a protein fraction containing about 30% oil on the dry basis. In this paper a process is described for the efficient separation of oil and protein from peanut kernel.

Key Operations of the Process

Removal of the solids and the separation of the oil from peanut slurry are the key operations in the isolation of protein. Separation of all the suspended solids in the slurry by screening is too slow and incomplete. It was observed (5) that removal of solids in a sedimentation centrifuge causes emulsification of the oil present in the slurry and results in the inefficient separation of oil from the protein solution. Preliminary experiments showed that simultaneous separation of solids and oil can be effected efficiently in a disc-type centrifuge. However, there was some difficulty in the operation of self-opening or the nozzle-type industrial model 3-way centrifuges for the continuous separation of oil, protein solution and solid residue from peanut slurry. The self-opening type 3-way centrifuge will have to open at very short intervals to discharge the solids (10% by volume in the peanut slurry) and this interferes with the separation efficiency. Solid content less than 3–4% is ideal for the efficient working of self-opening 3-way centrifuges. In the nozzle-type centrifuge, the nozzles tend to clog because of fibrous particles suspended in the slurry. Grinding peanut to fine particle size, small enough to pass through the nozzle, emulsifies the oil (6).

Separation of Solids from Slurry

Since the recovery of the oil is as important as the isolation of protein in the wet rendering process, it is essential to prevent the emulsification of oil while separating the suspended matter. Though the separation of the solids in the slurry by screening can be effected without causing emulsification of the oil, the operation is too slow since the fine particles tend to block the screen. The fine particles are formed as a result of fine grinding of dry peanut. It was considered that flaking of the peanut after the adjustment of moisture may prevent the breakdown of fiber structure.

Moisture content of the "roasted" and skinned peanut was adjusted to different extent and flaked to 0.1 mm thickness. Flakes so prepared were seperately extracted with seven times by weight of water at pH 10. The slurry in each case was filtered through 80-mesh screen and the solids passed through the screen were determined. The data are presented in Table I. When seeds were conditioned to a moisture content of 8% or more the fiber structure was found to be resistant to breakdown (Fig. 1). Slurry made out of the peanut flakes prepared from conditioned seeds (8.4–14.3% moisture) filtered at a fast rate and the solids passing through the screen were as low as 2.2%. The screened dispersion containing low suspended solids can be handled efficiently in continuous self-opening or nozzle type centrifuge. When seeds with less than 8% moisture content were flaked the fiber breakdown was high (Fig. 2); the slurry made out of it was filtered at a very slow rate and the

TABLE I
Effect of Moisture Variation of the Seed on the Suspended Solids Content of Size Less Than 80-Mesh

Moisture in the flakes %	Nature of the flakes	Solids passed through the 80-mesh screen— % on the seed (dry basis) by weight	Filtration
1.2	Powdery	14.5	Very slow
2.9	Powdery	5.7	Slow
5.0	Powdery	4.2	Good
8.4	Good	2.8	Good
10.8	Good	2.2	Fast
12.1	Good	2.2	Fast
14.3	Pasty	2.2	Fast

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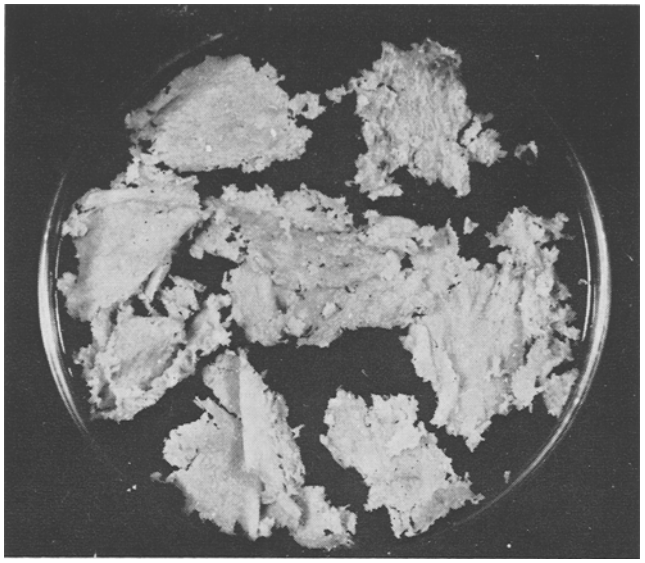

FIG. 1. Peanut conditioned to 10% moisture content and flaked.

solids passing through the screen were as high as 14.5%.

The roasting of the peanut was primarily carried out to loosen the skin for skinning. The effect of roasting was studied with respect to filtration rate and recovery of the protein. The seeds were roasted at different temperatures from 90C to 150C, skinned, conditioned to 10% moisture and flaked. The flakes were dispersed in alkaline water and filtered. The effect of roasting conditions on filtration rate and the viscosity pattern of the filtrate is presented in Table II. It can be observed from the table that dispersion made out of unroasted peanuts filter very slowly and the viscosity of the filtrate was also found to be very high. It can also be seen from the table that slurry from seeds roasted at temperatures above 140C filter at a comparatively slow rate.

As the protein solubility is adversely affected at high temperatures, protein recovery is dependent on the roasting temperature of the peanut. The effect of roasting conditions on the solubility and recovery of protein was determined by actual extraction. The results are presented in Figure 3. It can be observed from the graph that solubility of the protein in peanut was not affected appreciably up to a roasting temperature of 130C. As a result of poor filtration characteristics unroasted seeds and the seeds roasted above 140C gave poor yield of protein.

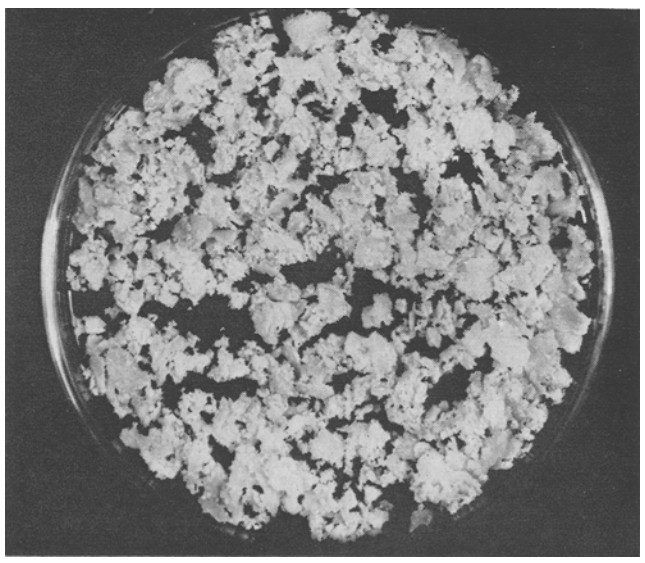

FIG. 2. Peanut with 4% moisture content flaked.

TABLE II

Effect of Roasting Conditions on Filtration Rate

Roasting temp. C	Filtration rate kg/hr/sq meter (2 in. filter bed)	Viscosity of the filtrate (centipoise)
Unroasted	1895	3.27
90	3260	2.57
100	3271	2.34
110	3388	2.34
120	3362	2.24
130	3284	2.36
140	3184	2.36
150	2038	2.51

Separation of Oil from Slurry

Grinding of the peanut in dry condition or suspended in water was found to cause emulsification of the oil. However, in the experiments carried out on conditioning of the seed to prevent fiber breakdown, it was found that oil could be separated easily from peanut dispersion by centrifugation. This observation indicated the presence of an optimum condition of peanut wherein no emulsification occurs.

It is possible to study the degree of emulsification by determining the average settling velocity of the oil in the slurry. With increase in emulsification, the average settling velocity of the oil globules is reduced and consequently the centrifugal separation becomes slow and hence less efficient. The equation:

$$Q = \frac{\Delta\rho\ D_2}{9}\ \frac{VW^2\ r}{s}$$

where

Q = feed rate to the centrifuge,
$\Delta\rho$ = density difference of the two phases,
D = diameter of the dispersed particle,
η = viscosity,
V = volume of the bowl,
W = angular velocity,
r = radius of the bowl,
s = distance through which particle has to travel before settling out,

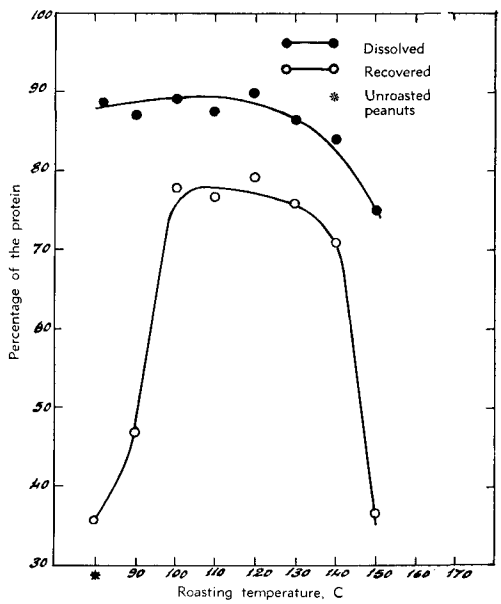

FIG. 3. Effect of roasting conditions on sulbility and recovery of protein.

derived by Ambler (7–9) for comparing the capacity of two centrifuges for a particular material in terms of area was used to determine the average settling velocity of oil globules in peanut slurry. The equation was derived for small particles which settle slowly.

$$\text{Velocity of settling under gravitational force} = V_g = \frac{\Delta\rho\ D^2 g}{18\eta}$$

$$\text{Area of a centrifuge in terms of simple gravitational tank of equivalent capacity} = \Sigma = \frac{V\ W^2 r}{gs}$$

The equation for flow rate Q, in a condition where settling velocity of an oil globule is average can be rewritten as follows:

$$Q = 2\ Vg\ \Sigma$$

or, average settling velocity Vg of the oil globule, $Vg = Q/2\Sigma$

Q was determined by experiment and Σ value of the centrifuge was calculated from its dimensions. Average settling velocity was calculated from the value of Q and Σ. The optimum condition for the efficient separation of oil was determined by studying the graph obtained by plotting the percentage of unseparated oil (in the dispersion after centrifugation) as ordinate against average settling velocity as abscissa on a logarithmic probability paper.

To study the effect of moisture content of the seed at the time of flaking, on the emulsification of the oil, seeds were adjusted from 2% to 36% moisture. The conditioned seeds were flaked to 0.05 mm thickness and dispersed in seven times their weight of alkaline water at pH 10. The slurry was filtered over 80-mesh screen and the filtrate was taken for the average settling velocity determination. Laboratory model tube centrifuge was used for average settling velocity determination. The Σ value of the centrifuge was calculated from the equation:

$$\Sigma = \frac{W^2\ V}{4.6\ g\ \log\left(\frac{(2\ r_2)}{r_1 + r_2}\right)}$$

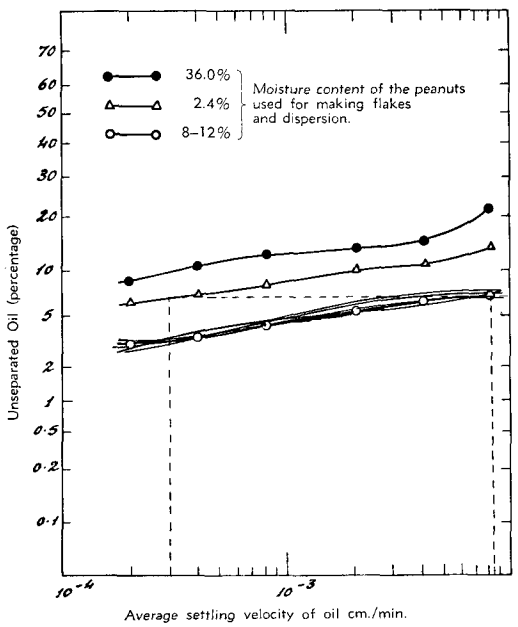

FIG. 4. Moisture content of the seeds and average settling velocity of the oil.

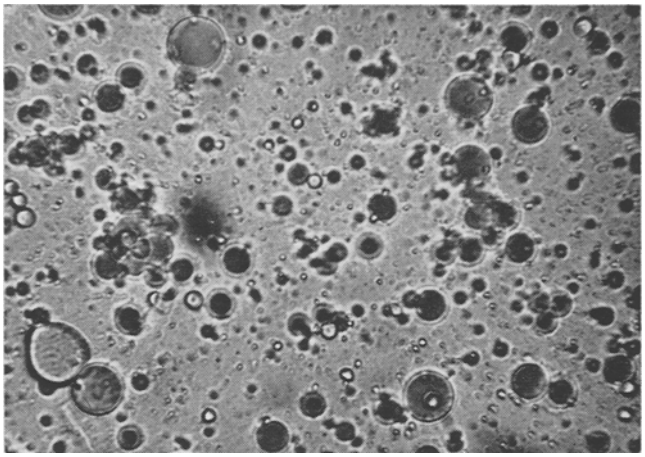

FIG. 5. Filtered dispersion from conditioned peanut flakes with 10% moisture content.

Fifty milliliters each of the filtered dispersion from the seeds conditioned to different moisture levels was taken in two centrifuge tubes. It was then centrifuged at varying feed rates (i.e., in this case, volume was kept constant and time varied to get the different feed rates), to get the different Q values in each experiment. At the end of the centrifugation 25 ml each of the middle layer from the two centrifuge tubes were pipetted out into a beaker and freeze dried. Fifty milliliters of the original dispersion was also freeze dried in a beaker. The former contains unseparated oil after centrifugation and the latter contains the total oil in the dispersion. Oil in the dried samples was determined by the acid hydrolysis method (10). Percentage of the unseparated oil was calculated in each case knowing the oil content of the dispersion before and after centrifugation. Average settling velocity calculated from Q and Σ value is plotted against unseparated oil in Figure 4. It can be observed from the figure that when peanut containing 8–12% moisture was used to make flakes and dispersion, oil globules settled with the highest velocity. When the moisture content of the peanut is more or less than this range the average settling velocity decreases very much. About 93% oil in the dispersion made from peanut with 8–12% moisture content, can be removed at an average settling velocity of 8.21×10^{-3} cm/min. Whereas, for the same separation of oil, in dispersion made from peanut with 2% moisture content

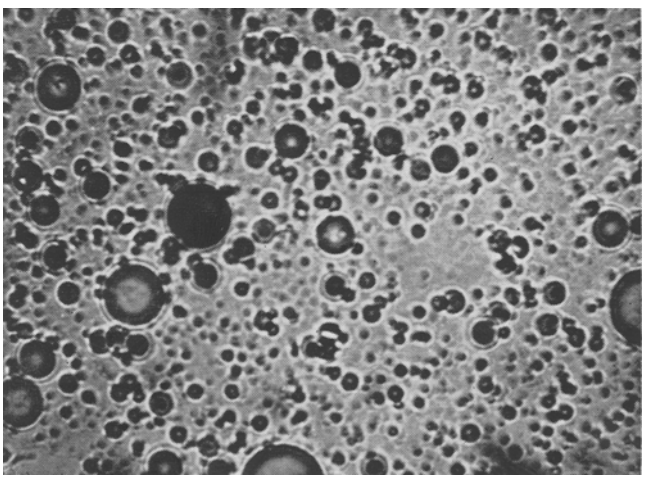

FIG. 6. Filtered dispersion from peanut flakes with 2% moisture content.

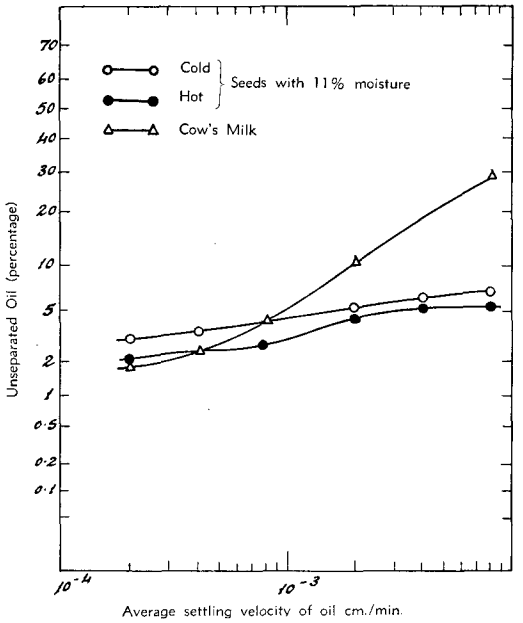

FIG. 7. Comparison of average settling velocity of oil in peanut dispersion (hot/cold) with cow's milk.

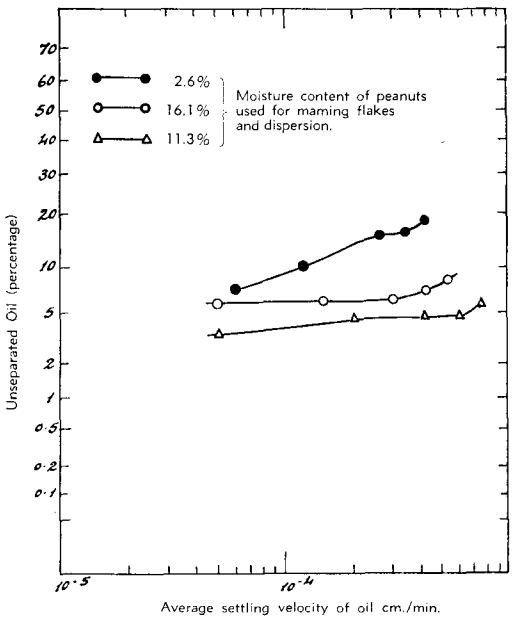

FIG. 8. Oil separation in cream separator.

the average settling velocity can be seen from the graph to be as low as 3.0×10^{-4} cm/sec. Average settling velocity is 27 times more in the former case and centrifuge will have 27 times more capacity than in the latter case for separating 93% of the oil from the dispersion. Microphotographs of the dispersion in the former case (Fig. 5) and the latter case (Fig. 6) are presented to show the comparative size distribution of oil globules. Average settling velocity of the oil in dispersion made from peanuts at higher moisture value is so low that it cannot be extrapolated for comparison with the oil in dispersion made with the seeds containing 8–12% moisture content.

Cow's milk is a protein-oil-water system like the peanut dispersion. As the milk fat separation is carried out on a commercial scale, it is of interest to compare the average settling velocity of the fat in milk with that of the oil-in-peanut dispersion. The average settling velocity of the milk-fat determined as described earlier is presented in Figure 7. It can be observed from the figure that fat globules present in milk fall under a narrower range than the oil globules in the peanut dispersion. Average settling velocity data collected by centrifuging hot (65C) peanut dispersion is also presented in the Figure 7. The last trace of oil in cold peanut dispersion was found to have a lower average settling velocity than the last traces of fat in cow's milk. It can be observed from the figure that when hot processing of the peanut was carried out the last trace of oil in the dispersion is also separable almost to the same extent as milk fat.

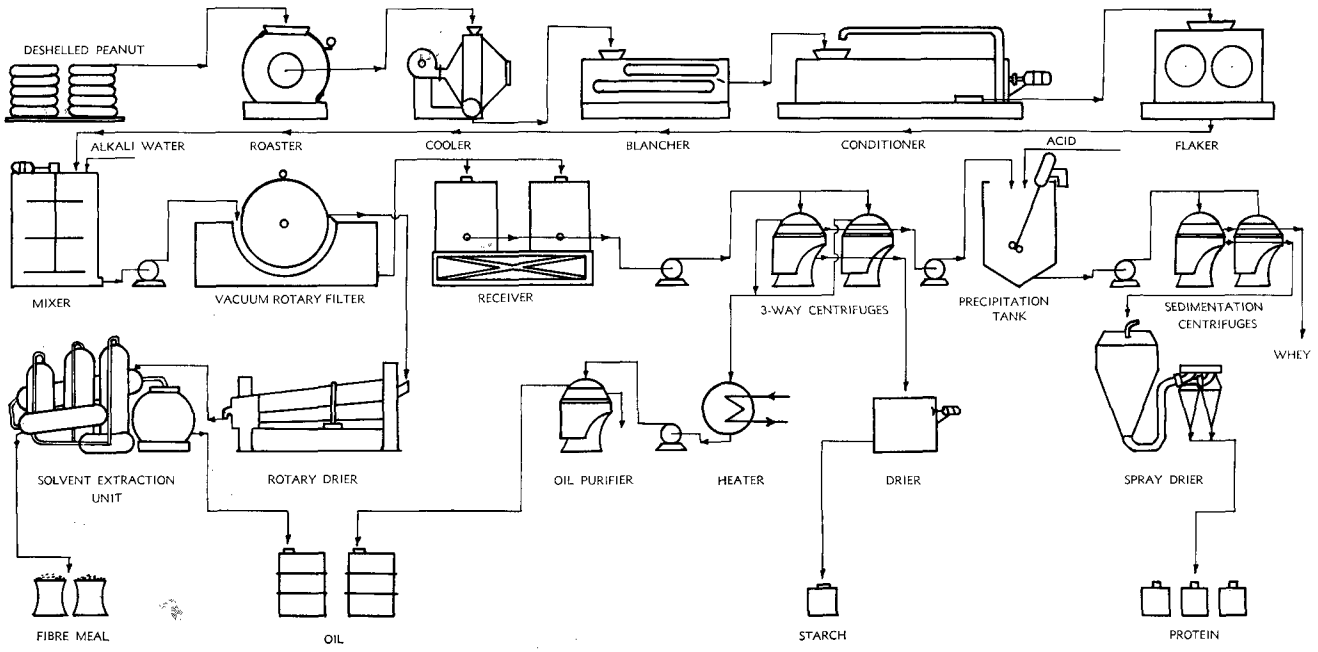

FIG. 9. Process flow sheet for isolation of protein and oil from peanut.

Trials were carried out with disc-type centrifuges to confirm the conclusions reached with tube type laboratory model centrifuge. For disc-type centrifuge Σ value is calculated by the equation:

$$\Sigma = \frac{2\ \pi n\ W^2\ (r_2^3 - r_1^3)}{3\ g\ C\ \tan\ Q}$$

Filtered dispersions made under identical conditions as described earlier were pumped with a centrifugal pump to the centrifuge at varying feed rates to get the required Q values. Percentage unsedimented oil is plotted against average settling velocity in Figure 8. As found in the experiments with the laboratory model tube centrifuge, when moisture content of the seed is outside the optimum level of 8–12%, the average settling velocity of the oil in the peanut dispersion was much reduced.

It may be concluded that oil may be efficiently separated from peanut by a wet rendering process, by conditioning the seeds to optimum moisture level (8–12%), flaking, dispersing in alkaline water, filtering and centrifuging. The general flow sheet for the wet-rendering of peanut for the isolation of protein, oil and carbohydrates is presented in Figure 9. A factory is being set up making use of the basic principle discussed in this paper, for the continuous wet rendering of peanut to isolate oil and protein.

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