Pilot Plant Preparation of Defatted Peanuts

J. POMINSKI, E. L. PATTON, and J. J. SPADARO, Southern Regional Research Laboratory,[1] New Orleans, Louisiana

Abstract

Interest in defatted peanuts is due to several factors: lower calorie value; possible increase in shelf-life by minimizing oil rancidity, possible use by hemophiliacs to control bleeding; and development of a new product to increase utilization of peanuts. Based on previously conducted laboratory work, pilot plant runs were conducted to prepare large amounts of materials for taste and appearance evaluation, to obtain pilot plant processing data for cost calculations, to investigate practical methods of desolventizing extracted peanuts, to develop a method for salting defatted peanuts, and to study packaging.

Fully-roasted and half-roasted batches of Virginia peanuts were extracted with hexane at room temperature for various periods of time, and oil losses determined. Fully-roasted peanuts with 81% of the oil removed had the best appearance, an acceptable taste, and require 120 hr extraction. Low rates of extraction indicate that large scale processing would be a batch method.

The extracted peanuts were desolventized for various periods of time and temperature in both forced draft and vacuum ovens. It was found that drying at a low initial temperature prior to a low initial temperature prior to a final high temperature appears to give a better tasting peanut, especially when a forced draft oven is used. Desolventizing peanuts in either a forced draft or vacuum oven requires from 9–10 hr drying time.

Defatted, desolventized peanuts were salted either by dipping in saturated salt solution at room temperature, or preferably by dipping in water and sprinkling with salt. The wet peanuts were oven dried.

Packaging of defatted peanuts (81% oil removed) in metal cans, in either vacuum or in an atmosphere of nitrogen containing less than 2% oxygen, proved satisfactory even after one year storage time. In flexible cellophane-type package, defatted peanuts tended to pick up excessive moisture within 30 days.

Introduction

INTEREST in the development of a commercial process for a low calorie peanut, primarily, resulted in planning and conducting a series of pilot plant investigations on the defatting and salting of peanuts. Other factors which helped initiate these investigations were: possible increase in shelf-life by minimizing oil rancidity; use of defatted peanuts by hemophiliacs to control bleeding; and an increased use of peanuts (1,2).

Previous work on a laboratory scale showed that oil can be removed from whole peanuts by simply soaking them in a suitable solvent and draining the resulting miscella; and also that rates of extraction depend on the moisture in the peanut, the solvent used, and the amount of oil to be removed (8). Rates of extraction to remove large amounts of oil are so slow that any such extraction on a commercial scale would probably use a batch process. Peanut oil is little affected by roasting (5).

Pilot plant runs reported were conducted to prepare large amounts of materials for taste and appearance evaluation, to obtain processing data for cost studies, to further investigate practical methods of desolventizing extracted peanuts, to develop a process for salting defatted peanuts, and to study methods and conditions of packaging.

Experimental

Material. Fully-roasted and half-roasted medium shelled Virginia peanuts were extracted. The fully-roasted peanuts contained 51.9% oil, 1.6% moisture; the half-roasted peanuts contained 48.5% oil, 4.2% moisture. The latter, which are designated commercially as half-roasted peanuts, are partially roasted peanuts. The fully-roasted peanuts were roasted at 580F for 8 min, cooled 24 hr, and blanched (skins removed). Fully-roasted and blanched peanuts contained 39% whole peanuts and weighed 39.8 lb per ft.[3] The half-roasted peanuts were roasted 8 min at 420F, cooled 24 hr, and blanched. Commercial hexane was the solvent used because of its general acceptance for processing foods, its availability, low cost, and because of the possibility of defatting peanuts in existing solvent extraction plants which use hexane (7).

Equipment and Methods. Batches of peanuts ranging from 15–200 lb were extracted on a pilot plant scale either in a stainless steel batch extractor or in small stainless steel tanks. The batch extractor, de-

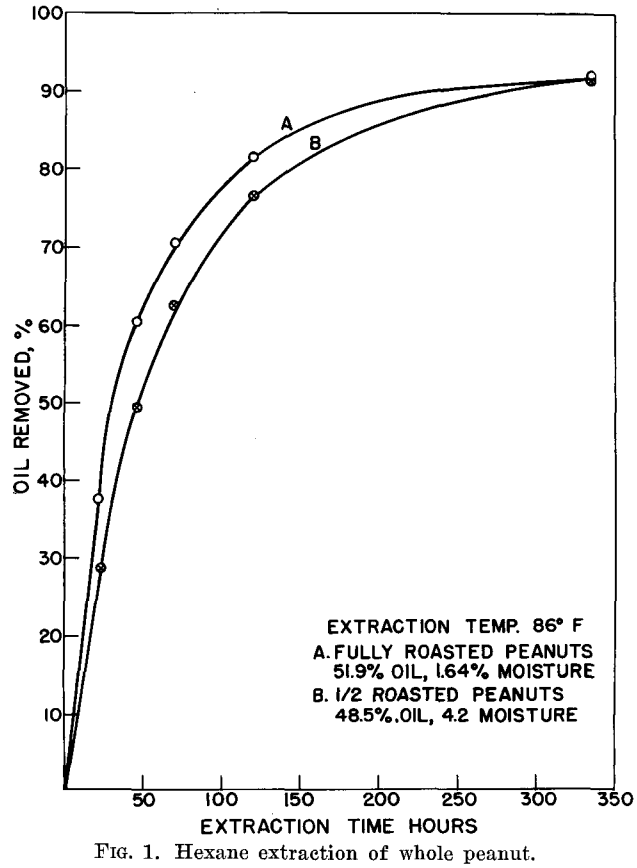

FIG. 1. Hexane extraction of whole peanut.

[1] S. Utiliz. Res. & Dev. Div., ARS, U.S.D.A.

TABLE I
Pilot Plant Extraction of Fully Roasted Peanuts

Extracted material	Extraction time—hr	Amt hexane used lb hexane/lb peanut	Wt lb/ft³	Analysis		Oil removed [a]
				Oil	Moisture	
				%	%	%
Original peanuts		.....	39.8	51.90	1.6	0
1	23	1.72	30.0	40.63	1.1	37.5
2	47	2.90	27.5	30.14	1.2	60.7
3	71	3.63	25.0	24.04	2.2	70.8
4	120	6.74	21.3	17.01	1.3	81.3
5	335	14.05	21.7	8.55	1.7	91.5

[a] Based on amount of oil in unextracted roasted peanut.

scribed in a previous publication, is a completely integrated explosion proof unit, equipped with pumps, extraction cells, filters, evaporator, condenser, storage tanks, heating facilities, and other accessories (6). In the extractor, solvent was circulated through the peanuts at room temp during working hours and left to soak during non-working hours. Long soaking times are permitted since the rate of extraction is not appreciably affected by the miscella concentration (8). The peanuts were extracted in stainless steel tanks by intermittent addition of solvent and removal of miscella. Portions of peanuts were periodically removed and analyzed for oil and moisture. Solvent was removed from extracted peanuts by air drying and drying in a forced draft oven, or directly drying in forced draft laboratory and pilot plant ovens, or directly drying in laboratory vacuum ovens evacuated to 27 in. of mercury. Defatted peanuts were salted at room temp by either dipping in saturated salt solution or by dipping in water and sprinkling with salt. The salted, wet peanuts were dried in forced draft ovens.

Defatted peanuts were packaged in metal cans in vacuum, and in an atmosphere of nitrogen. The peanuts were also packaged in flexible cellophane bags.

Results and Discussion

Extraction. Roasting peanuts prior to extraction has the following advantages: conventional roasting and blanching equipment can be used, and reduction in moisture content increases the extraction rate. In addition, peanuts with oil removed are difficult to roast, and may require special equipment.

Figure 1 shows the rate of oil extraction for fully-roasted and half-roasted peanuts. These peanuts were extracted at room temp of 86F in a stainless steel tank. To start the extraction, solvent was added in amounts equivalent to a solvent: peanut ratio of

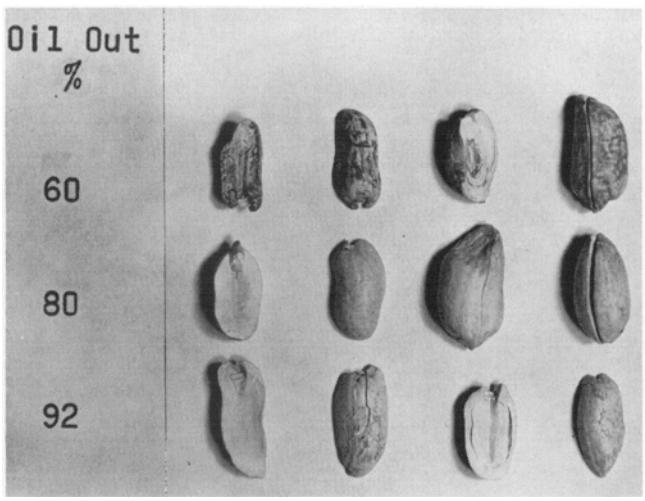

FIG. 2. Fully-roasted peanuts with different amounts of oil removed.

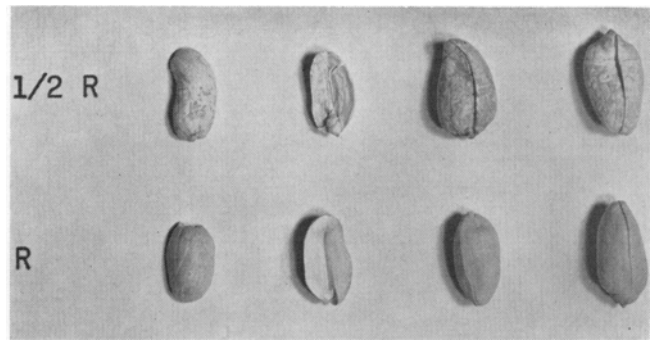

FIG. 3. Comparison of fully-roasted and half-roasted peanuts with approx. 80% oil removed.

0.44 : 1 by wt. Portions of peanuts were removed after extracting for 23,47,71,120, and 335 hr. Table I shows extraction times, solvent: peanut ratio, percentage of oil removed, and weights per ft³ of the various defatted products from fully-roasted peanuts. While Table I shows that a total solvent: peanut ratio of 6.74 : 1 removed 81.3% oil in 120 hr, subsequent experiments show that this amount of oil can be removed in the same length of time using a solvent to peanut ratio as low as 3.8 : 1.

Effects of the amount of oil removed on the appearance of the peanuts are shown in Figures 2 and 3. The fully roasted peanuts with 81.3% oil removed after 120 hr extraction have the best appearance. In Figure 2, fully-roasted peanuts with lesser amounts of oil removed have a mottled appearance due to unextracted spots of oil near and on the surface, which make them seem shriveled though the surface is smooth. The peanuts with 81.3% of the oil removed have a nice smooth even appearance with no unextracted oil spots on the surface. Peanuts with 91.5% of oil removed are cracked. Figure 3 shows that fully-roasted peanuts with 81.3% oil removed are superior in appearance to the half-roasted peanuts with 76.6% oil removed. The half-roasted defatted peanuts were split and cracked. Some causes of these effects may have been drying conditions in the field after harvesting or the methods of roasting. The original fully-roasted peanuts had 39% wholes and 61% halves. After processing the defatted peanuts (81.3% oil removed) had 20.5% wholes and 79.5% halves.

The slow rates of extraction eliminate any practical possibility for a continuous extraction process. Use of some low-boiling solvents (i.e. isopentane) reduce the time of extraction to possibly 72 hr, which is still too slow for a continuous process (8). In addition, such solvents would require pressure extraction equipment and refrigeration for cooling condenser water. These considerations would further increase the overall production costs for defatted peanuts.

A commercial batch extraction plant would probably consist of a battery of extractors operated in series in which solvent would be pumped into an extractor containing nearly exhausted material and the miscella formed, then pumped through the other extractors countercurrent to peanuts. In such an arrangement, total solvent to meal ratios would be considerably less than those shown in Table I.

Desolventization. Solvent wet, defatted peanuts containing 39% solvent can be desolventized in either a forced draft or a vacuum oven. Drying at a low initial temp appears to give better tasting defatted peanuts. For the forced draft oven, Table II, Section A, shows that a total drying time of 10.9 hr is needed

TABLE II
Drying Defatted Peanuts, 81.3% Oil Removed

A Forced draft oven			B Vacuum oven			C Forced draft oven			D Vacuum drying		
Temp	Drying time	Volatiles	Temp	Drying time	Volatiles	Temp	Drying time	Volatiles	Temp	Drying time	Volatiles
°F	hr	%	°F	hr	%	°F	hr	%	°F	hr	%
	0	39.0		0	39.0		0	39.0		0	39.0
150	4.4	3.8	167	1.00	26.0	212	1.00	13.7	212	1.67	15.5
212	6.9	1.4	212	3.08	2.7	212	3.33	5.5	212	3.00	5.1
212	8.9	1.2	212	4.75	1.3	212	5.33	1.3	212	5.00	1.0
212	10.9[a]	1.3	212	6.75	1.3	212	7.33	0.9	212	7.00	1.2
212	12.9	1.0	212	8.75[a]	0.8	212	9.33[a]	0.8	212	9.00[a]	1.0
			212	10.75	0.8				212	11.00	1.0

[a] Time last taste traces of hexane eliminated.

to eliminate the last taste traces of solvent (4½ hr at 150F, and 6.4 hr at 212F). For the vacuum oven, Table II, Section B shows a total drying time of 8.8 hr (1 hr at 167F and 7.8 hr at 212F). Satisfactory tasting peanuts were also obtained by air drying 6 hr, drying in a forced draft oven for 48 hr at 150F and then drying at 212F for one hr. Table II, Sections C and D, shows that there is little difference in rate of direct drying at 212F for the forced draft and vacuum ovens. In both cases, though a low level of 2% volatiles was reached in 4–5 hr, a total of 9 hr drying was required to eliminate taste traces of hexane. Excess drying time at 212F after solvent has been eliminated will degrade the taste and appearance of the peanuts.

Salting. Retail consumer tastes and demands require that peanuts be salted. Normally, shelled peanuts are salted after cooking in oil, by adding fine salt which adheres to the excess oil on the surface of the peanut. Unshelled peanuts can be salted by dipping in a saturated brine solution (4). Modified and new procedures were found to be necessary for salting defatted peanuts: In one method, defatted peanuts were salted by dipping in saturated brine solution at room temp for 5–10 min to gain 16–20% brine solution by weight, and then oven dried. In a second method, the defatted peanuts were dipped in water at room temp for 30 sec during which time 10–20% moisture was gained, sprinkled with salt (10% salt by wt of dry defatted peanuts is used, but only a portion adheres to the peanut) and then dried. The latter method is preferred since handling of brine would not be involved and it is closer to the present method for salting peanuts. Table III shows rates of moisture removal for peanuts with 81.3 and 37.5% oil removed respectively, by drying temp of 150 and 212F in a forced draft oven. Peanuts dried at 150F did not reach a moisture level as low as those dried at 212F. For peanuts with 81.3% oil removed, at 150F a moisture of 4% was reached in 4 hr and 3% in 10 hr; at 212F 1.7% was reached in 2 hr and 0.5% in 10 hr.

In an attempt to avoid the second drying step and to reduce costs, solvent wet peanuts were dipped in water, sprinkled with salt and then both solvent and water removed by drying at a low initial temp of 150F and then raising the temp to 212F. Both forced draft and vacuum oven drying were conducted. In both cases, taste and appearance were unsatisfactory. Shriveled nuts were obtained. This objectionable appearance was intensified by the vacuum drying. Apparently rapid evaporation of solvent and moisture cause the shriveling. Additional work to lower evaporation rates by using lower initial temp of drying may improve these conditions and should be investigated.

Commercially, defatted peanuts would probably be salted by spraying with water before being sprinkled with salt. Salting by spraying peanuts with saturated brine solution may also have practical possibilities.

Packaging. Defatted peanuts (81.3% oil removed) packaged in metal cans in an atmosphere of nitrogen containing less than 2% oxygen proved satisfactory after one year of storage. In the customary flexible cellophane-type package used for 5-cent packages of salted peanuts, defatted peanuts tended to gain excessive moisture. After 30 days, defatted peanuts with an initial moisture of 3% will have 5.75% moisture. Peanuts with 5.75% moisture are not sufficiently crisp and crunchy to be satisfactory.

Peanuts with 81.3% oil removed have a pleasing and acceptable appearance. Leaving more oil in the peanut improves the taste but the appearance may not be satisfactory. Color could probably be further improved by darkening the peanuts with food color or other means. Since the peanut flavor is probably associated with the oil, perhaps methods for recovering the flavor of roasted peanuts and adding it back to defatted peanuts could be developed. Other possibilities are uses of peanut flavor extenders. The taste of defatted salted peanuts is considered acceptable even though it differs considerably from the taste of original roasted peanuts.

A preliminary cost study based on data shown in this report shows that the volume of defatted peanuts equivalent to 1 lb of shelled naturally occurring peanuts costs 84¢, and the volume equivalent to the 14-oz pack popularly merchandized in 502 x 308 tins costs 74¢. Use of fully depreciated equipment would reduce the cost of the equivalent to the 14 oz pack to 61.5¢ (4).

TABLE III
Drying Salted Defatted Peanuts, Forced Draft Oven

Peanuts, 81.3% oil removed				Peanuts, 37.5% oil removed			
Temp 150°F		Temp 212°F		Temp 150°F		Temp 212°F	
Drying time	Volatiles	Drying time	Volatiles	Drying time	Volatiles	Drying time	Volatiles
hr	%	hr	%	hr	%	hr	%
0	16.8	0	16.8	0	10.0	0	10.0
1	7.6	1	3.4	1.09	4.9	1.00	2.5
2	5.0	2	1.6	2.58	3.4	2.09	1.8
3	4.4	3	1.3	3.58	3.1	3.09	1.3
4	4.0	4	1.3	4.58	2.9	4.09	1.1
5	3.7	10	0.7	5.58	2.7	5.09	0.9
10	3.1			10.58	2.20	10.09	0.6

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REFERENCES

1. Bailey, A. E., "Industrial Oil and Fat Products," Interscience Publishers, Inc., New York, 1945 (a) p. 40; (b) pp. 42–43.
2. Boudreaux, H. B., and V. L. Frampton, Nature *185*, 469–470 (1960).
3. Cecil, S. R., and J. G. Woodroof, Georgia Agr. Exp. Sta. Mimeo. Ser. N. S. 68 (Jan. 1959).
4. Molaison, L. J., K. M. Decossas, J. Pominski, and E. L. Patton, JAOCS, *39*, 473–476 (1962).
5. Pickett, T. A., Peanut J. and Nut World *26*, 27 (1947).
6. Pominski, J., L. J. Molaison, A. J. Crovetto, R. D. Westbrook, E. L. D'Aquin, and W. F. Guilbeau. Oil Mill Gaz. *51*, 33–39 (1947).
7. Rao, Y. K. Raghunatha, Oils and Oilseeds J. (Bombay) *14*, 11–12 (July, 1961).
8. Willich, R. K., and R. O. Feuge, Food Technol. *11*, 332–336 (1957).

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