dilute analytical reagents in the thousandth normal range. This method can replace the usual alkali titration with phenolphthalein on highly colored fat samples such as soap stock where visual end point detection is difficult or impossible. Additional suggested applications include the determination of hydroxyl value, carbonyl value, and other methods where a titration of acid is required. The titration of acids in aqueous media has been described by Taylor and Smith (1) and could be accomplished automatically with the same equipment as that described in this report.

Further improvements in precision can be effected by the use of purified or neutralized methanol in the solvent system. The resulting reduction in the blank and sample titration times, particularly for smaller samples, would improve precision of the "Titration-Blank" calculation. The method can be extended to even smaller samples, perhaps to less than 0.1 mg. of fatty acid, by reducing the electrolysis rate and sample volume with only a small increase in standard deviation. The ultimate limit of detection of the method is controlled by the solubility of silver chloride in the electrolyte solution.

The work reported here is part of a program now underway in our laboratories to examine the many aspects of coulometry and of amperometric and potentiometric end point detection.

TABLE II
Determination of Free Fatty Acid

Sample	% FFA as oleic				Difference
	Detn.	AOCS	Detn.	Coulometric	
					%
Tallow	1	1.67	2	1.62 ± .05	+0.05
Tallow	1	2.61	1	2.67	−0.06
HAVF	1	41.42	1	41.40	+0.02
Soybean	....	.....	....	.....	.....
Acidulated Foots	2	59.73 ± .24	2	59.25 ± 1.05	+0.48

Acknowledgment

The authors are indebted to R. E. Schmidt of this laboratory for his aid in designing and constructing the coulometric titrator.

REFERENCES

1. Taylor, J. K., and S. W. Smith, J. Research Nat. Bur. Standards *634*, 153 (1959).
2. Meyers, A. S., and C. M. Boyd, Anal. Chem., *31*, 215 (1959).
3. Strenuli, C. A., *Ibid 28*, 130 (1956).
4. Hanselman, R. B., and C. A. Strenuli, *Ibid 28*, 918 (1956).
5. Mather W. B., Jr., and F. C. Anson, Anal. Chim. Acta *21*, 468 (1959).
6. Fritz, J. S., and N. M. Lisicki, Anal. Chem. *23*, 589 (1951).
7. Van der Heijde, H. B., and E. A. M. F. Dahmen, Anal. Chim. Acta *16*, 378 (1957).

[Received November 1, 1961]

Defatted Peanuts: Preliminary Cost Study[1]

L. J. MOLAISON, K. M. DECOSSAS, J. POMINSKI, and E. L. PATTON, Southern Regional Research Laboratory,[2] New Orleans, Louisiana

Abstract

Defatted peanuts are high in protein and low in fat content. A preliminary cost study for defatting Virginia peanuts with hexane in three all-new hypothetical commercial plants indicates operating cost can be as low as 84 cents/lb of peanuts extracted when packaged in 502 x 308 tins. Cost in fully depreciated plants is as low as 61.5 cents for a volume of extracted peanuts equivalent to the amount of unextracted peanuts normally packaged in 502 x 308 tins. Process development shows promise for further reducing these costs which are based on limited exploratory pilot plant research.

Introduction

DEFATTED PEANUTS were first investigated by Willich and Feuge (1). This early work established general conditions of extraction, which were later used in the pilot plant at the Southern Regional Research Laboratory (2). Limited pilot plant research has established a basis of operation for producing a product having acceptable taste and appearance. It is expected that a quality product would appeal to those desiring lower-calorie diets. In addition, peanut meal prepared by extracting lightly roasted peanuts with hexane is already being included in the diet of hemophiliacs to obtain relief from bleeding (3).

This report describes a hypothetical commercial plant including processing, recovery, packaging, and storage facilities.

Process

The process is shown in Figure 1, and a material balance is given in Figure 2. It is a batch process consisting chiefly of extraction, desolventizing, salting, drying, and packaging. Fully roasted, shelled medium Virginia peanut kernels are extracted at ambient temp with commercial hexane in a battery of 5 extractors for 120 hr (5 days), for removal of 80% of the fat naturally occurring in them. The oil is recovered under 24" to 27" Hg. vacuum in a high-velocity, rising-film evaporator, and the solvent removed is condensed and reused. The extracted peanut kernels containing 35% solvent by wt are then desolventized in a forced draft dryer at 150F for 4½ hr and at 212F for an additional 6½ hr. An alternative to this is desolventization at 212F and 27" Hg. vacuum for 9 hr. Solvent removed is condensed and returned to solvent storage. The desolventized peanuts are salted on an oscillating feeder where they, on being sprayed, absorb 20% by wt of water. After this they are sprinkled with salt amounting to 10% of their dry defatted wt. The wet, salted, defatted peanut kernels are then dried in a forced draft dryer for 8 hr at 150F, vacuum and gas packed in a nitrogen atmosphere containing less than 2% oxygen in 502 x 308 tins, better known as the 1-lb coffee can, and packaged 12 cans to the case.

Plant

Three all-new hypothetical plants were studied. In the small plant each extractor has a capacity for 200 lb of unextracted peanut kernels; in the medium plant for 400 lb; and in the large plant for 600 lb. Operating 250 days, 24 hr per day, total annual processing rates are 50,000, 100,000, and 150,000 lb of unextracted peanuts, yielding 28,500, 57,000, and 85,500 lb of defatted peanuts, respectively.

The hypothetical plants include storage facilities, process and packaging equipment, piping, instrumen-

[1] Presented at the Peanut Utilization Research Conference, Jan. 15–16, 1962, New Orleans, La.
[2] One of the laboratories of the Southern Utilization Research and Development Division, Agricultural Research Service, U.S.D.A.

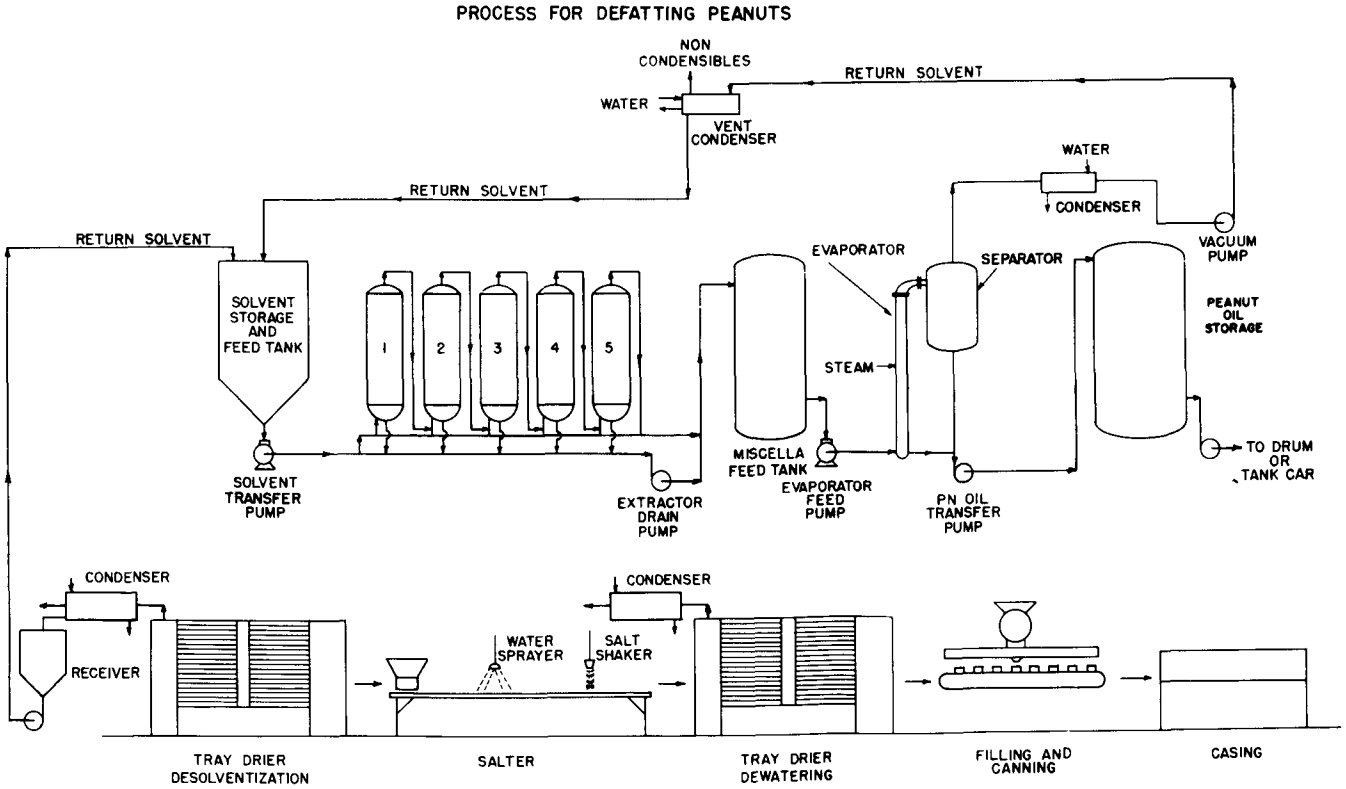

FIG. 1

tation, outside lines, steam boiler, and process and warehouse buildings, as listed in Tables I and II. All equipment surfaces coming into contact with the peanuts are of stainless steel construction to prevent contamination of the product.

Extractors, salting machine, dryer, and canning equipment are housed in a building of steel frame construction with corrugated metal covering, concrete floors, lighting, plumbing, and sprinklers, all costing $14 per sq ft of floor area. Also provided is warehouse area for one season's supply of 502 x 308 cans and one month's supply of product, at a cost of $8 per sq ft of floor area, as well as refrigerated storage for 9 months' supply of shelled roasted peanuts.

One of the 5 extractors is unloaded and reloaded each day, so that each extractor is reloaded once each week, and at the same time a daily supply of product is provided. Miscella is drained 3 times from the freshly loaded extractor during the first day of extraction, the last of the 3 drainings taking place after an overnight soak. During the remaining 4 days of extraction, miscella is displaced countercurrent to the peanuts twice daily from one extractor into the next in the series of extractors not loaded on those days. Total miscella drained and displaced daily into the miscella feed tank and evaporator has a volume

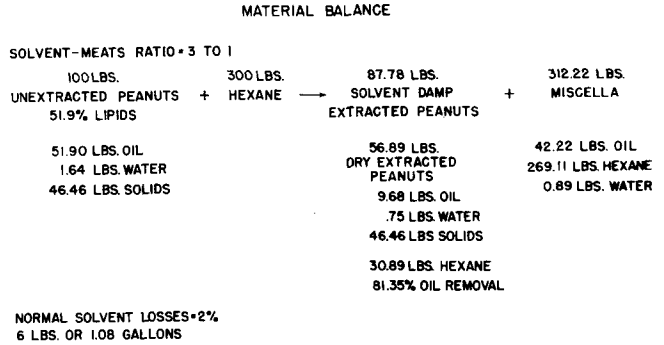

FIG. 2

equivalent to all 5 extractors. The most concentrated miscella is that from draining after the first overnight soak.

Investment Costs

Investment costs are tabulated in Tables I and II. Purchased equipment costs in Table I were obtained from equipment manufacturers. Total plant cost for an all-new installation is estimated at $88,000 for the 200-lb batch plant, $110,000 for the 400-lb batch plant, and $132,000 for the 600-lb batch plant. These costs would be reduced should a processor already have solvent extraction, handling, and recovery facilities. There is little difference in investment cost between plants using forced draft drying and those using vacuum drying. These costs do not include allowance for roasting and blanching equipment, but an allowance is made for cost of these operations in calculation of operating costs. Allowance of one cent per lb would be adequate for roasting and blanching by the seller or purchaser of the peanuts.

Operating Costs

Operating costs for the 3 plants, including the cost of shelled peanuts, are given in Table III for both atmospheric and vacuum drying conditions, and include direct, indirect and fixed costs, and general expenses excluding sales expense which has a wide variation and is dependent upon operations in a particular company, and channels of distribution used.

Raw materials cost including the cost of 100 lb of roasted medium shelled Virginias to yield 57 lb of defatted peanuts is given in Table IV. Price of shelled peanuts is average for the 1960–61 season.

Labor cost is based on a need for 1 operator and 2 laborers, 8 hr each in the small plant; 1 operator and 3 laborers in the medium plant; and 2 operators and 3 laborers in the large plant. Duties include unloading and loading extractors, operating solvent recovery equipment, loading and unloading dryers for

TABLE I
Defatted Peanut Plants Equipment Costs

Equipment Description	200-lb Batch Operation			400-lb Batch Operation			600-lb Batch Operation		
	Capacity each	Purchased cost, dollars	Installed cost, dollars	Capacity each	Purchased cost, dollars	Installed cost, dollars	Capacity each	Purchased cost, dollars	Installed cost, dollars
Process Equipment									
Solvent storage and feed tank, c.s., vertical above ground, 1 each	6,000 gal.	3,000	3,900	6,000 gal	3,000	3,900	6,000 gal	3,000	3,900
Extractors, s.s. shell, 5 each	5 cu ft	9,750	13,260	10 cu ft	11,680	15,880	15 cu ft	13,300	18,090
Miscella feed tank	150 gal.	160	220	300 gal	270	370	450 gal	330	450
Evaporator and separator, 304 s.s. tubes, 3¾" O.D., rising film high velocity type	8.8 sq ft	1,430	1,940	14.7 sq ft	1,950	2,650	20.6 sq ft	2,380	3,240
Condenser, s.s.	44 sq ft	670	770	103 sq ft	1,395	1,605	124 sq ft	1,590	1,830
Concentrated miscella storage tank, c.s.	350 gal	305	410	700 gal	375	510	1050 gal	520	710
Vacuum pump, bronze and cast iron, 22"–24" vac., w motor	½ gpm 1 hp	350	385	1.4 gpm 1½ hp	515	565	2.3 gpm 1½ hp	540	595
Dryer, atmospheric, 304 s.s. trays, steam heated, NEMA 7 equipped, w blower	83 sq ft 1½ hp	2,950	3,390	166 sq ft 1½ hp	4,250	4,890	200 sq ft 1½ hp	4,250	4,890
Condenser for atmospheric dryer, fin type	46.2 sq ft.	985	1,135	78.5 sq ft	1,500	1,725	117 sq ft	1,985	2,285
Dryer, vacuum, c.s., shelf type steam heated, 100 μ	66 sq ft	2,940	3,380	134.4 sq ft	5,135	5,910	195.5 sq ft	6,790	7,810
Condenser for vacuum dryer, s.s.	11 sq ft	300	345	24 sq ft	515	590	31.5 sq ft	615	705
Evaporator feed pump, all iron, rotary, w Class I, Group D motor, 1 each	⅓ gpm ¼ hp	115	125	⅔ gpm ¼ hp	115	125	1 gpm ¼ hp	120	130
Pumps, all iron, rotary, Class I, Group D motor, 3 each	5 gpm ⅓ hp	450	495	5 gpm ⅓ hp	450	495	5 gpm ⅓ hp	450	495
Oscillating feeder, s.s. with water sprays, salters, w 1 hp motor	.....	1,650	1,700	.....	1,650	1,700	.....	1,650	1,700
Canning equipment and assembly, clincher, closer, vacuum and gassing box, and vacuum pump	.....	7,230	7,530	.....	7,230	7,530	.....	7,230	7,530
Total installed equipment cost (atmospheric drying)	.....	.....	35,260	.....	.....	41,945	.....	.....	45,845
Total installed equipment cost (vacuum drying)	.....	.....	34,460	.....	.....	41,830	.....	.....	47,185
Auxiliary Facilities									
Steam boiler, equipped with feed pump and return tank, fully automatic	15 BHP	3,100	3,400	30 BHP	3,500	3,800	50 BHP	5,100	5,400

desolventizing and drying; feeding peanuts onto oscillating feeder for salting; canning and casing; and storage of raw materials, cans, and product. Wages allowed are $2.35/hr for operators, $1.10/hr for laborers, and 10% night differential when applicable.

Utilities costs include those for electricity, steam, process and cooling water. Electricity cost was estimated using industrial rates of the Alabama Power Co., applicable to the peanut processing area of that state. Cooling water cost was calculated on the basis of recycling cooling water through a cooling tower, with an allowance of 1 cent/1000 gals circulated. Process water was figured using Dothan, Ala., water rates. Steam was estimated at a cost of 50 cents/1000 lb, and refrigeration for peanut storage at a cost of 50 cents per ton-day.

Packaging costs include cans and cases. The cans are 502 x 308 Type A, of ¼-lb tin plate, and are better known as the 1-lb coffee can. Prices include 5 prints on white coating around can periphery and a single color on white coating on the top of the can. The cans are packaged 12 to the case. Cases are made of plain corrugated paperboard, 150 lb bursting strength with 2 panels having 2 colors.

Cost Analyses

Operating costs are plotted versus annual production in Figure 3. At a production of 28,500 lb of defatted peanuts, corresponding to processing one 200-lb batch daily, 250 days annually, operating cost is as much as $2.29/lb of product packaged in 502 x 308 tins. As production is doubled it is reduced to $1.62, and when tripled to as little as 85,000 lb it becomes $1.47/lb of product. Alternatively expressed, operating cost for processing 600-lb batches including the cost of roasted shelled peanuts is 84 cents/lb of peanuts extracted. The vol of defatted peanuts equivalent to 1 lb of shelled roasted peanuts costs 84 cents, and the vol of roasted, defatted salted peanuts equivalent to the 14-oz pack of roasted, salted, unextracted peanuts popularly merchandised in 502 x 308 tins costs 74 cents. (14 oz of unextracted peanuts is equivalent in vol to 8 oz of defatted peanuts.)

Using fully depreciated equipment which has been paid for reduces operating cost approx 25 cents/lb of product, and the equivalent of the 14-oz pack to 61.5 cents. This does not seem out of reason when it is considered that the 14-oz tin of salted roasted Jumbo Virginias retails for 69 cents in supermarkets in New Orleans. The processor usually allows only 20% profit on this type of product, the wholesaler allows 5% markup, and the retailer another 15% markup.

Higher productions were not investigated in this study because of the limitations and high labor costs

TABLE II
Defatted Peanut Plants
Total plant costs: 24 hr/day operation; 250 days/year operation.

Processing rate, lb unextracted peanuts/day	200		400		600	
Production rate, lb defatted peanuts/day	113.7		227.4		341.1	
	Atm.	Vac.	Atm.	Vac.	Atm.	Vac.
Investment costs:	$	$	$	$	$	$
a) Installed equipment	35,260	34,460	41,945	41,830	45,845	47,185
b) Process piping, 20% of a	7,050	6,890	8,390	8,365	9,170	9,435
c) Instrumentation, 5% of a	1,765	1,725	2,095	2,090	2,290	2,360
d) Outside lines, 5% of a	1,765	1,725	2,095	2,090	2,290	2,360
e) Auxiliary facilities	3,400	3,400	3,800	3,800	5,400	5,400
f) Buildings	18,360	18,360	26,360	26,360	36,675	36,675
g) Total physical plant cost	67,600	66,560	84,685	84,535	101,670	103,415
h) Engineering and construction, 20% of g	13,520	13,310	16,935	16,905	20,335	20,685
j) Contingencies, 10% of g	6,760	6,655	8,470	8,455	10,165	10,340
k) Total plant cost	87,880	86,525	110,090	109,895	132,170	134,440

TABLE III

Defatted Peanut Plants

Manufacturing Costs and General Expenses (cents/lb of product)
24 hr/day operation; 250 days/year operation

Processing rate, lb unextracted peanuts/day	200		400		600	
Production rate, lb defatted peanuts/day	113.7		227.4		341.1	
Type of drying operation	Atm.	Vacuum	Atm.	Vacuum	Atm.	Vacuum
k) Total plant cost, $	87,880	86,525	110.090	109,895	132,170	134,440
Manufacturing costs	¢/lb.	¢/lb.	¢/lb	¢/lb	¢/lb	¢/lb
l) Raw materials	29.53	29.53	29.53	29.53	29.53	29.53
m) Labor	35.15	35.15	21.62	21.62	20.19	20.19
n) Supervision, 15% of m	5.27	5.27	3.24	3.24	3.03	3.03
o) Maintenance, 6.5% of k	20.07	19.77	12.57	12.56	10.06	10.24
p) Plant supplies, 15% of o	3.01	2.97	1.89	1.88	1.51	1.53
q) Utilities	3.27	1.63	2.58	1.09	2.46	.93
r) Direct costs (¢/lb)	96.30	94.32	71.43	69.92	66.78	65.45
s) Payroll overhead, 15% of (m+n)	6.06	6.06	3.73	3.73	3.48	3.48
t) Gen. plant overhead, 50% of (m+n)	20.21	20.21	12.43	12.43	11.61	11.61
u) Control laboratory, 15% of (m+n)	6.06	6.06	3.73	3.73	3.48	3.48
v) Packaging	18.08	18.08	18.01	18.01	17.95	17.95
w) Indirect costs (¢/lb)	50.41	50.41	37.90	37.90	36.52	36.52
x) Insurance, 2% of k	6.18	6.08	3.87	3.86	3.10	3.15
y) Property taxes, 2% of k	6.18	6.08	3.87	3.86	3.10	3.15
z) Depreciation, 10% of k	30.89	30.41	19.35	19.31	15.49	15.75
aa) Fixed costs (¢/lb)	43.25	42.57	27.09	27.04	21.69	22.05
ab) Direct + Indirect + Fixed	189.96	187.30	136.42	134.85	124.99	124.02
ac) Contingencies, 5% of ab	9.50	9.37	6.82	6.74	6.25	6.20
ad) Manufacturing cost (¢/lb)	199.46	196.67	143.24	141.59	131.24	130.22
General Expenses						
Gen. adm. and off. overhead, 3% of ad	5.99	5.91	4.30	4.24	3.94	3.91
Financing 6% of (k + working capital)	23.18	22.85	14.99	14.95	12.41	12.54
General expenses (¢/lb)	29.17	28.76	19.29	19.19	16.35	16.45
Total cost (¢/lb product)	228.63	225.43	162.53	160.78	147.59	146.67
Total cost ($/lb product)	$2.29	$2.25	$1.63	$1.61	$1.48	$1.47

of batch operations. Lower bp solvents warrant investigation, because accelerated operations resulting from their use could lead to the development of a satisfactory continuous process which could carry with it the promise of higher production and lower cost. Process development indicates promise for reducing these costs, which are based on limited exploratory pilot plant research, even further. A quality product, high in protein, containing only 20% of the fat naturally occurring in peanuts, could have longer shelf-life, and an appeal for place in lower-calorie diets. In addition, peanut meal, prepared by extracting lightly roasted peanuts with hexane, is presently being included in the diets of hemophiliacs to relieve bleeding (3), and this could be another form for inclusion in such diets.

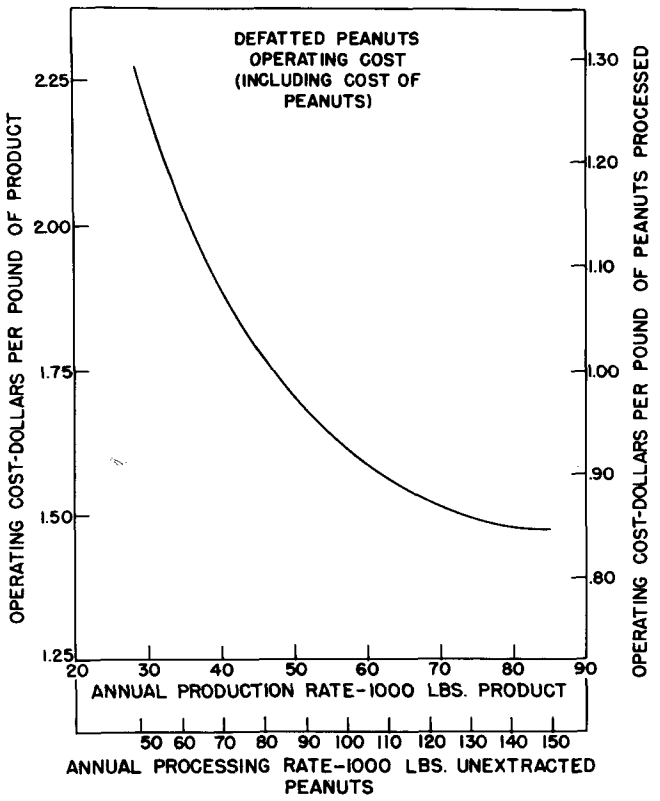

FIG. 3

TABLE IV

Raw Materials Cost for Defatting 100 lb of Roasted Medium Shelled Virginias to Yield 57 lb of Defatted Peanuts

Raw material	Quantity	Unit price	Cost, dollars
Shelled peanuts	100 lb.	21.7¢/lb	$21.70
Roasting	100 lb.	1¢/lb	1.00
Commercial hexane	1.2 gal[a]	19¢/gal	.23
Salt	5.7 lb	1.34¢/lb[b]	.07
			$23.00
Credit for extracted peanut oil	42.2 lb	14.7¢/lb[c]	6.20
			$16.80
$16.80/56.89 = 29.53¢/lb defatted peanuts			

[a] 2% solvent loss.
[b] Salt, table vacuum, common, fine, paper bags, c.l., 100 lb.
[c] Season average price Sept. 1960–Aug. 1961, crude, tank cars, f.o.b., S.E. mills.

Acknowledgment

The authors are indebted to J. P. Devine Manufacturing Co., Pittsburgh, Pa., and the F. J. Stokes Corporation, Philadelphia, Pa., for conducting vacuum drying tests. They also wish to thank G. I. Pittman for preparation of drawings, Alice deB. Kleppinger for preparation of tables, and Claire Weber for literature research.

REFERENCES

1. Willich, R. K., and R. O. Feuge, Food Technol. *11*, 332–336 (1957).
2. Pominski, J., E. L. Patton, and J. J. Spadaro, "Pilot Plant Preparation of Defatted Peanuts."
3. Boudreaux, H. B., and V. L. Frampton, Nature *185* (4711), 469–470, February 13, 1960.

[Received March 21, 1962]