Development and Use of Defatted Peanut Flours, Meals, and Grits

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Development and Use of Defatted Peanut Flours, Meals, and Grits[1]

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INTRODUCTION

THE PEANUT (*Arachis hypogaea* L.) is grown primarily for human food in the United States. In some other parts of the world it is used as animal feed, or only the oil is used for human food while the protein rich remainder is fed to animals or used as fertilizer. Peanuts are recognized as a valuable source of vegetable protein, but many of the countries of the world that have an abundance of peanuts, such as India, Senegal, and Nigeria, also have an urgent need for increased protein in the diet. This is largely the result of an almost complete lack of technology available for the best utilization of this protein food. A dairy cow returns 23 per cent of the protein fed to her as usable food for humans, a pig 12 per cent, and a beef animal 10 per cent *(1)*. Feeding a protein rich food such as peanuts, or even peanut meal, to animals would appear to be an inefficient process compared to using the peanuts or peanut meal for direct human consumption. If the oil is removed from peanuts under the proper sanitary conditions and without employing excessive heat, the remaining material can be ground into a flour which has good nutritional value. It has been shown that peanut protein, like most vegetable protein, is limited in some of the amino acids that are essential for its efficient utilization as food *(6)*. However, its biological value can

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be improved greatly by blending small amounts of animal protein with it *(9)*. When peanut flour is combined with cereal flours and milk solids and baked into breads or other staple items of the diet, the daily intake of protein can be raised considerably *(2,5)*. The peanut kernel from the runner-type peanut is about 26 per cent protein and 52 per cent oil. Thus, if most of the oil is extracted, the residue contains over 50 per cent protein. It is to the utilization of this defatted portion of the peanut that this bulletin is directed.

In the United States the 1969-70 peanut crop was valued at over 358 million dollars *(3)*. The total production from slightly less than 1.5 million acres was 2.8 billion pounds. Over half of these peanuts were grown in the Southeast, with Alabama's crop amounting to over 400 million pounds. Roughly 50 per cent of the crop is used in the manufacture of peanut butter and most of the remainder is used for direct consumption or as a source of vegetable oil.

The proportion of the peanut crop going to the vegetable oil industry in the United States varies from year to year depending largely on economic factors. In 1969-70, over one-fourth of the total shelled edible peanuts, or 437 million pounds, *(8)* were crushed for oil. This yielded almost 210 million pounds of low oil residue, or potentially over 105 million pounds of protein. The oil expeller and solvent extracter residue is ground into meal and used for livestock feed with a small proportion used for fertilizer. The 1971 average selling price for peanut meal was about $76.00 per ton *(7)* while that being sold for fertilizer brought $25.00 per ton. Therefore, only that meal condemned because of the presence of aflatoxin[3] is sold for fertilizer.

Perhaps the primary reason that peanut meal is not considered for human consumption in this country is the conditions prevailing in many of the peanut oil extraction plants. The meal is generally thought of as a byproduct, and since the oil is reprocessed and purified after extraction it does not have to be produced initially under strict sanitary conditions. Many of the buildings and some of the machinery used in the extraction process would require modification if the meal were to be used for human food. However, while much of the peanut supply used for oil produc-

[3] Aflatoxin is a poisonous substance (mycotoxin) sometimes produced in peanuts that have been contaminated with the mold *Aspergillus flavus* and kept under improper storage conditions.

tion is composed of oversize, broken, or immature kernels for economic reasons, the Commodity Credit Corporation releases considerable tonnage of high grade shelled peanuts to the oil industry every year. Although cake residues from the oil industry offer a valuable source of protein, little research has been done on its use in human foods.

METHODS AND MATERIALS[4]

Division of Work Between Departments

The research reported in this bulletin was conducted through coordinated studies in the Departments of Horticulture and Home Economics Research. Studies in the Horticulture Department were specifically concerned with: (1) the development of technology for processing peanuts to produce defatted flours, meals, and grits with different levels of residual oil and different amounts of roasting; (2) development of low oil peanut foods such as flakes, strips, chips, and pellets; and (3) determination of chemical and physical properties and shelf life of promising peanut flours and finished food items developed. Studies in the Department of Home Economics Research were concerned with: (1) the testing of the peanut flours, meals, and grits as protein supplements in various food items; and (2) making chemical determinations, shelf life studies, and quality evaluations of promising products.

Peanut Supply

Shelled, U.S. No. 1 grade, runner-type peanuts were used. They were obtained from 1964, 1965, and 1966 crops at the Wiregrass Substation, Headland, Alabama. All peanuts were hand sorted at the laboratory to remove visually defective kernels, packaged in friction-top cans (25 lb. each) sealed with tape, and held in 32-34° F. storage until processed.

Results of moisture and aflatoxin tests are presented in Table 1. The shipment of 1965 crop peanuts received in November contained 10.5 per cent moisture. Before going into storage they were dried in open trays for 48 hours at about 80° F. to lower their moisture to 7.1 per cent. All other peanut shipments went directly into storage.

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[4] Use of pictures of commercial equipment, or mention of such equipment by trade name does not constitute endorsement by the Ala. Agr. Expt. Sta., nor is criticism implied of similar equipment not mentioned.

TABLE 1. MOISTURE AND AFLATOXIN TESTS ON PEANUTS

Peanut crop	Quantity used	Moisture as stored	Aflatoxin tests[1]	
			Sorted stock	Pick-outs
	Lb.	*Pct.*	*p.p.b.*	*p.p.b.*
1964	500	8.9	None[4]	Trace[5]
1965[2]	500	7.1	Trace[5]	160
1965[3]	500	7.0	(1) None (2) 1.9	(1) 3.2 (2) 3.2
1966	1,000	6.8	------	------

[1] Aflatoxin tests were made by Urban L. Diener, Professor, Department of Botany and Microbiology.
[2] Received November 1965.
[3] Received February 1966.
[4] Samples held in 32 to 34° F. storage, tested December, 1965.
[5] Trace means less than 1 part per billion (p.p.b.).

Tests made on the 1965 crop peanuts received in February 1966 gave the following results: 53.2 per cent oil (dry basis); 2.8 meq. peroxide per 1,000 grams of oil; oleic acid content of 0.4 per cent; yeast and mold content of 100 per gram; coliform count of 10 per gram; and standard plate count of 1,000 per gram.

Code System

A code system was developed for use in specifying different flours, meals, and grits. The system was used in labeling products and in referring to products in shelf life studies, recipes, tables, and discussions. The code system is presented in Table 2.

TECHNOLOGY DEVELOPED FOR MAKING DEFATTED FLOURS, MEALS, AND GRITS

Deskinning the Peanuts

Conventional Methods. In the present peanut oil industry peanuts are pressed without removal of seed coats or "red skins." These skins remain in the cake residue. However, in processing peanuts for food uses such as peanut butter or roasted peanuts, skins are usually removed by a mechanical process referred to as blanching. This is accomplished by dry-heating peanuts and running them through a peanut blanching machine. It mildly crushes peanuts, separates kernels into halves, frees skins and germs from the half kernels, and removes skins by blowing and germs by screening. The mild crushing process results in very little breaking of halves.

TABLE 2. CODE SYSTEM FOR LABELING AND SPECIFYING FLOURS, MEALS, AND GRITS[1]

Symbol	Explanation	Specifications
		Approx. residual oil in cake
OE	Cake from oil expeller process	OE 1-7% OE 1.5-9.5% OE 2-12% OE 3-17% OE 4-22%
OS	Cake from solvent extraction process	OS 1—less than 1% residual oil OS 2—2 to 3% residual oil
S	Steam scrubbed to remove raw peanut flavor	S 10—steamed 10 minutes, etc.
DS	Steam scrubbed to desolventize product after air drying	DS 10—Steamed 10 minutes, etc.
R	Roasting treatment	R 1—product was not roasted R 2—partially roasted R 3—fully roasted
MO	Moisture in product	MO 6—6% moisture, etc.
DD	Cakes with high oil level drum dried to aid in grinding to flour	DD—product was coarsely ground, water added to form slurry, drum dried to approx. 3% moisture
F,M,G	Milling	F—flour (approx. 140 mesh) M—meal (20 to 30 mesh) G—grits (10 to 20 mesh)

[1] Examples: OE1-R3-FMO3.5 means expeller cake with approximately 7 per cent residual oil, fully roasted, ground to flour, 3.5 per cent moisture. OE1.5-OS1-DS10-R1-FMO7 means expeller cake with approximately 9.5 per cent oil, extracted with hexane to less than 1 per cent oil, steam scrubbed 10 minutes, peanuts not roasted, ground to flour 7 per cent moisture.

Effects of Skins in Defatted Flours. A preliminary test was made to determine the effects of skins in defatted peanut flours. Samples of flours were prepared with and without removal of skins. The skins appeared as objectional red specks in the flour and in finished products in which the flour was used. Flour made from deskinned peanuts was more attractive in appearance.

Deskinning was used as a standard treatment in the main studies reported in this bulletin.

Deskinning Peanuts for Screw Pressing. To deskin peanuts and leave them with suitable moisture content for screw press processing in an oil expeller required a study on deskinning technique. The conventional dry heating and mechanical blanching process resulted in too low a moisture content.

A boiling water dip treatment followed by dry heating in an oven and mechanical blanching proved to be satisfactory. This method left the peanuts with suitable moisture for screw pressing and proved to have other advantages. The hot water treatment helped to free skins from kernels, and any skins that remained in the product were less objectionable after having been leached of red pigments and bitter flavor by boiling water. Dry heat following the hot water dip was effective in conditioning the peanuts for mechanical blanching. A special laboratory oven used for dry heating treatments is illustrated in Figure 1.

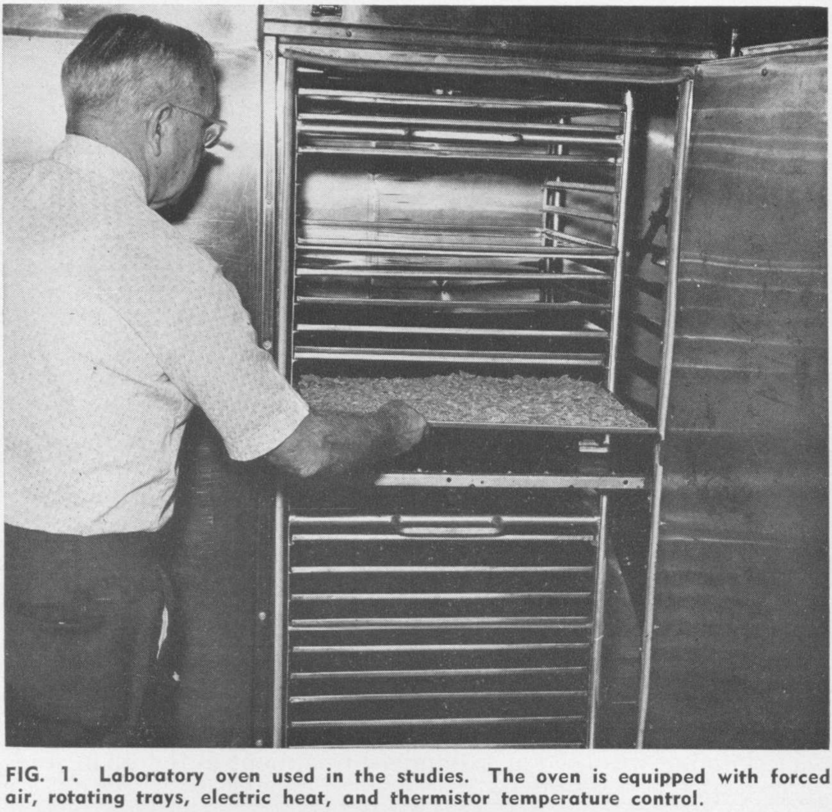

FIG. 1. Laboratory oven used in the studies. The oven is equipped with forced air, rotating trays, electric heat, and thermistor temperature control.

Peanuts dry heated for blanching without pre-treatment in boiling water could only be dried to a limited extent without bringing about changes in textural properties of peanuts which made them unsuitable for screw pressing even after rehydration and moisture equilibration. The amount of drying tolerated was insufficient to loosen the skins satisfactorily for mechanical deskinning.

Results of tests on the boiling water and oven drying method are presented in Table 3. These tests were made prior to delivery of a mechanical peanut blancher to the laboratory. Consequently, a laboratory model viner-type pea sheller with rubber screen (½-inch perforation) was used as a substitute machine for freeing skins from peanuts after heat treatment. The pea sheller treatment followed by air separation of skins from kernels proved to be fairly satisfactory for this operation. Percentages of skins removed by different treatments are presented in the table.

TABLE 3. BLANCHING PEANUTS FOR SCREW PRESSING BY BOILING WATER AND OVEN DRYING TREATMENTS[1]

Boiling water dip	Oven drying[2]	Weight 6-lb. samples after treatments[1]		Holding[3]	Moisture after drying and holding	Skins removed[4]	Moisture after water dipped, drained, and cooled
		Dipped, drained	Dried				
Sec.	*Min.* (250°F.)	*Lb.*	*Lb.*	*Hr.*	*Pct.*	*Pct.*	*Pct.*
45	52	6.52	5.81	15	5.4	87	20.0
45	42	6.55	5.84	15	6.0	84	------
45	39	6.52	5.87	15	6.4	77	------
45	35	6.51	5.90	15	6.5	83	------
45	30	6.53	5.93	15	7.4	74	------
45	27	6.56	5.96	15	7.4	82	------
45	23	6.56	5.98	15	7.6	78	------
20	20	6.52	5.93	1	8.1	76	19.4
0	10	6.00	5.93	1	7.3	61	------
	(300°F.)						
45	5	------	------	2	9.8	----	------
45	25	------	------	18	7.5	----	------
20	13	------	------	0	8.2	84[5]	------
20	15	------	------	0	8.2	79[5]	------
20	17	------	------	0	7.6	93[5]	------
20	19	------	------	0	6.7	85[5]	------
0	40	------	------	15	1.1	----	------

[1] 1964 crop Runner peanuts, 8.9 per cent moisture, directly from 32° F. storage.

[2] Forced air electric oven with rotating trays loaded at rate of 1.5 pounds per square foot.

[3] Blanched peanuts were held in friction top covered cans at approximately 80° F.

[4] Per cent skins removed in laboratory viner-type pea sheller after oven drying and cooling, and separating freed skins by blowing.

[5] Passed twice through the pea sheller.

Deskinning Peanuts by Lye Treatment. In preliminary tests, dipping the peanuts in a hot lye solution followed by washing in tap water resulted in 100 per cent removal of skins. However, a dark residue remained between the halves of some of the kernels. This residue was neutral in reaction and was present only in the small per cent of kernels that partially separated during the boiling water and lye treatments. Apparently it was caused by lye collecting in a partial vacuum that formed in the space between the halves when the peanuts were sprayed with cold water immediately after lye dipping. The lye was pulled in and trapped against removal by further washing. The problem was essentially eliminated by using a rinse treatment in 200° F. water immediately after the lye dip and before the final wash in cold water. The hot rinse removed most of the lye before the vacuum was formed.

Specific treatments and results of further tests on lye deskinning are presented in Table 4. Three variations of the lye treatment were compared with the boiling water and oven drying method. All of the lye treatments were effective in removing 100 per cent of the skins. Use of the 40-second boiling water dip followed by 20-second dip in boiling 10 per cent lye resulted in better color and less weight loss than was obtained by the 30-second dip in each of boiling water and lye.

The 40-20 timing in boiling water and lye resulted in 9.6 per cent weight loss from deskinning. By comparison the boiling water and oven drying method resulted in a weight loss of 5.6 per cent when the peanuts were deskinned in the pea sheller and in less than 3 per cent loss, Table 5, when deskinned in a peanut blancher. The comparatively high weight loss was apparently the most important disadvantage of lye blanching.

Advantages of the lye method were that 100 per cent of the peanuts were deskinned, the kernels had an attractive creamy appearance, and only a low per cent of the kernels were separated into halves. The free fatty acids were also decreased by approximately 50 per cent as compared with mechanically deskinned samples. Complete absence of bacteria, yeasts, and molds resulted from lye blanching while approximately 1,000 bacteria per gram of products were enumerated in the mechanically deskinned peanuts. No sodium hydroxide residue was detected on any of the samples subjected to the 40-20-second treatments followed by hot water rinse, tap water wash, and 1 per cent citric acid rinse.

Lye blanching did not cause any adverse effect on per cent oil in the peanuts or on flavor or other qualities of roasted peanuts. Samples of the chemically deskinned peanuts were satisfactorily screw pressed, and the resulting cake had properties

TABLE 4. EFFECTS OF BLANCHING METHODS ON DESKINNING AND QUALITIES OF PEANUTS[1]

Treatment			Wt. of 6 lb. sample dried blanched[2]	Loss from blanching	Deskinned	Evaluations on deskinned peanuts			
Blanching method	Boiling water	Boiling lye				Color[3]	Flavor[3]	Oil	FFA[4]
	Sec.	*Sec.*	*Lb.*	*Pct.*	*Pct.*			*Pct.*	
Boiling water-oven-drying pea sheller[5]	45	none	5.70	5.0	90	8.0	9	52.0	.22
	45	none	5.67	5.5	85	8.0	9	52.5	.22
	45	none	5.65	5.8	91	8.0	9	52.2	.20
	45	none	5.64	6.0	84	8.0	9	52.0	.22
Average			5.66	5.6	88	8.0	9	52.2	.215
Lye dip[6] (10% lye solution)	40	20	5.35	10.8	100	7.8	9	53.0	.14
	40	20	5.54	7.7	100	7.8	9	52.5	.14
	40	20	5.42	9.7	100	7.8	9	52.5	.12
	40	20	5.40	10.0	100	8.0	9	52.8	.14
Average			5.43	9.6	100	7.9	9	52.7	.135
Lye dip[6] (10% lye solution)	30	30	5.35	10.8	100	7.0			
	30	30	5.39	10.2	100	7.0			
	30	30	5.39	10.2	100	7.0			
	30	30	5.32	11.3	100	7.0			
Average			5.36	10.6	100	7.0			
Lye dip[6] (20% lye solution)	50	10	5.45	9.2	100	7.8			
	50	10	5.37	10.5	100	7.8			
Average			5.41	9.9	100	7.8			

[1] 1965 crop, Runner peanuts, 7.1 per cent moisture.

[2] All samples were dried on trays (1.5 pounds per square foot) for 28 min. in forced air oven at 250° F. This brought moisture to approximately 7 per cent.

[3] Based on 1 to 10 scale with 1 as very poor, 6 as fair, and 10 as excellent. Color ratings were on raw peanuts and flavor on roasted peanuts.

[4] Free fatty acid.

[5] Dipped in boiling water, dried in oven, cooled, run twice through pea sheller, blown.

[6] Boiling water and lye treatments as shown, rinsed in 200° F. water, thoroughly washed in rod washer with tap water, dipped 1 minute 1 per cent citric acid, dried.

essentially identical to those of cakes obtained from pressing mechanically deskinned peanuts.

Although the chemical method appeared to be promising as a method for blanching peanuts, it was not used as the standard method in preparing defatted products for uses reported in this bulletin. Rather, the boiling water dip treatment followed by oven drying and mechanical deskinning was used. The decision to use the boiling water method was based primarily on the premise that this method was a lesser departure from conventional dry heat blanching than that of the lye method of blanching. Also greater weight losses resulted from lye blanching than from the boiling water dip method.

TABLE 5. DESKINNING PEANUTS IN BAUER SPLIT NUT BLANCHER FOLLOWING BOILING WATER AND OVEN DRYING TREATMENTS[1]

Moisture in nuts	Feed rate[3]	Components after blanching			Removal of skins
		Half kernels	Germs	Skins	
Pct.[2]	*Lb./hr.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
7.2	3,650	94.6	3.0	2.5	95
7.2	2,920	94.6	3.1	2.4	95
7.2	2,420	94.4	3.0	2.5	95
7.2	2,670	94.4	3.2	2.5	95
7.2	2,550	94.5	3.0	2.5	95
6.4	1,290	94.6	3.3	2.6	98
8.2	1,200	93.6	3.5	2.8	97
7.9	1,230	93.7	2.7	2.9	85
8.5	1,120	94.7	2.5	2.7	81
5.9	--------	------	----	----	98

[1] 1966 Crop Runner Peanuts, 6.8 per cent moisture.
[2] Prior to deskinning, peanuts were dipped 45 seconds in boiling water, drained, dried in oven at 250° F., cooled. Drying time was varied (20 to 40 min.) to obtain different moisture levels.
[3] Rate of feeding peanuts into blancher.

Deskinning Tests in Mechanical Blancher. A Bauer split nut blanching machine was obtained in November of 1966 and all subsequent mechanical blanching was done in this machine. When roller separation, air circulation and velocity, and rate of feed of peanuts were properly adjusted, this machine was very effective in removing the skin and germ from peanuts that had been subjected to the boiling water and oven drying treatments. Results of tests on the machine are presented in Table 5.

Pre-treatment of the peanuts consisted of boiling water dip for 45 seconds followed by drying at 250° F. in the forced air oven. Dryness of the peanuts varied with the weight of the batch of peanuts under treatment as well as the drying temperature and air velocity. Using 12 trays with 6 pounds of nuts per tray, 1.5 pounds per square foot, and a temperature of 250° F., a drying time of 40 minutes produced a moisture of 5.9 to 6.4 per cent in the dried nuts. This moisture range was ideal for best skin removal. The moisture level of water blanched and oven dried peanuts was the most critical factor affecting skin removal by mechanical blanching. The machine easily handled pre-treated nuts at feed rates in excess of 2,500 pounds per hour.

Roasting Peanuts for Making Defatted Flours

To determine the effects of roasted peanut flavor in finished foods containing peanut flour, defatted flours with different degrees of roasting were produced. Different methods were tested for obtaining the roasted flavor in the flours.

Roasting Before Extraction of Oil. Dry roasting of peanuts prior to extraction of oil did not prove to be feasible in laboratory tests. When screw pressed, the roasted product formed a peanut butter-like mass that tended to extrude between the expeller bars without releasing the oil. In one expeller test on dry roasted peanuts without rehydration, the residual oil in the cake was 45 per cent. In eight additional tests in which the peanuts were screw pressed after dry roasting, rehydration, and equilibration of moisture, residual oil percentages in the cakes ranged from 12 to 38. In all cases, the expeller was adjusted for minimum residual oil in the cake without excessive extrusion of material between expeller bars. Complete data on the tests on dry roasted peanuts are given in the section on defatting the peanuts for making flours.

Roasting the Cake After Oil Extraction. Other methods were investigated for obtaining a roasted flavor in the defatted flour. Dry roasting the cake after oil extraction produced a roasted flavor in the product but also resulted in a hard cake that was somewhat difficult to grind. This cake could not be ground to flour fineness in a Wiley mill but was ground satisfactorily in a high speed stud mill. Good results were obtained by dry roasting expeller cakes as well as solvent extracted cakes in an oven at a temperature of 325° F. with forced air circulation. Uniform roasting was obtained in the laboratory oven, Figure 1, which was equipped for rotation of trays. Time required for a fully roasted flavor varied from 20 to 30 minutes depending on moisture level in the cake and other factors. The flours had a mild roasted peanut flavor which was more pronounced in flours from cakes with 12 to 20 per cent residual oil than in those of lower oil content. This method for obtaining roasted flavor in the defatted flour was used as the standard in the preparation of defatted flours for the shelf life and product development studies reported in this bulletin.

Steam heating of the cake prior to grinding also offered promise as a means of developing a roasted flavor in defatted flour. Results of flavor ratings on cakes subjected to different steam heat treatments are presented in Table 6.

Removal of Raw Peanut Flavor by Steam. The use of steam scrubbing as a method of removing hexane flavor from solvent extracted cake is reported in another section of this bulletin. An effect of a 10-minute steam scrubbing treatment, purely inde-

TABLE 6. FLAVOR SCORES ON PEANUT CAKE AFTER DIFFERENT STEAM TREATMENTS[1]

Judge	Score[2]					
	Cake steamed at 212° F., minutes					Cake steamed at 250° F. for 3 minutes
	0	2	4	6	10	
A	5	6	6	7	7	8
B	4	6	6	6	7	8
C	5	6	6	6	8	8
D	5	4	6	7	8	8.4
Average	4.8	5.5	6.0	6.5	7.5	8.1

[1] Cake from expeller test operation No. 36, 7.3 per cent oil. Evaluated as an ingredient.
[2] Scores based on range from 1 as very poor to 6 as fair to 10 as excellent.

pendent of desolventization, was complete removal of raw peanut flavor from the product. In earlier tests, flours made from raw peanut cake were considered unsatisfactory as food ingredients because of the persistence of raw peanut flavor in finished products. Flours made later from expeller cake both with and without solvent extraction, but with a 10-minute steam scrubbing treatment, were bland in flavor and were used satisfactorily as protein supplements in many food items.

Flours made from steam scrubbed cakes could not be described as raw, partially roasted, or full roasted. They were essentially raw, but were stripped of the objectionable raw flavor. These flours appeared to offer more promise than flours made from either raw or partially roasted cakes.

Methods Used in Defatting Peanuts for Making Flours

Preparation of different flours as specified in Table 2 required defatted peanut cakes with residual oil levels ranging from less than 1 to 22 per cent. Cakes with oil content of approximately 7 per cent or higher were produced by the expeller (screw press) process. Cakes with oil content ranging from 0.5 to 3 per cent were produced by solvent extraction as a second treatment of expeller cakes with relatively high residual oil content.

Although commercial methods for peanut oil production are well established, considerable experimentation and development were required to adapt the technology to laboratory operations suitable for the production of the wide variety of products required in this research. In commercial plants, screw pressing is done in large two-stage expellers using unblanched peanuts. They are fed continuously to the expeller through insulated heating and conditioning units. The expeller is adjusted for a high rate of production of a relatively thick cake with 9 to 12 per cent residual oil. The cake as produced does not meet the requirements for use as human food. By contrast, the screw pressing operations of this research were carried out on a batch basis in a small, single-stage laboratory expeller using pre-blanched peanuts. Cakes suitable for human food and with a wide range of oil levels were produced. Solvent extraction in commercial plants is carried out by a highly mechanized counter flow process. This was not feasible for the laboratory operations except as adapted on a simulated basis by experimentation and development.

A Hander Model 52 laboratory expeller was used for most of the screw pressing. For some of the earlier tests a V.D. Anderson Midget expeller was used. Special laboratory equipment was developed for solvent extraction. Analytical determinations included moisture and oil tests on the peanuts and cakes using methods described in the section on analytical studies. More details on equipment and methods are given in connection with specific studies.

Screw Pressing Studies

Screw Pressing Tests in the Anderson Midget Expeller. Difficulty was encountered in obtaining good cake formation with the Anderson expeller. Excessive amounts of fine material passing between the bars was also a problem. Seven tests were made on blanched peanuts with different amounts of roasting and with moisture percentages ranging from 2 to 9. Screw pressing with this expeller was ineffective when the moisture was less than 5.5 per cent. However, by heating the expeller with steam, good cake formation and residual oil as low as 6 per cent were obtained with the samples having approximately 8 per cent moisture.

The Hander Model 52 Expeller. The Hander Model 52 expeller, Figure 2, has an expeller barrel 2¼ inches inside diameter by 8 inches long. The barrel is composed of 16 expeller bars which are spaced with a clearance of 0.003 inch for the first 2⅛ inches of length from the feed hopper and "touching" for the remaining 5⅞ inches of length. The peanuts are subjected to progressively higher pressures as they are forced through the barrel by screw action. Oil is pressed out between the bars and caught in a pan while the cake is discharged through a conical aperture at the end of the barrel. Clearance on the aperture af-

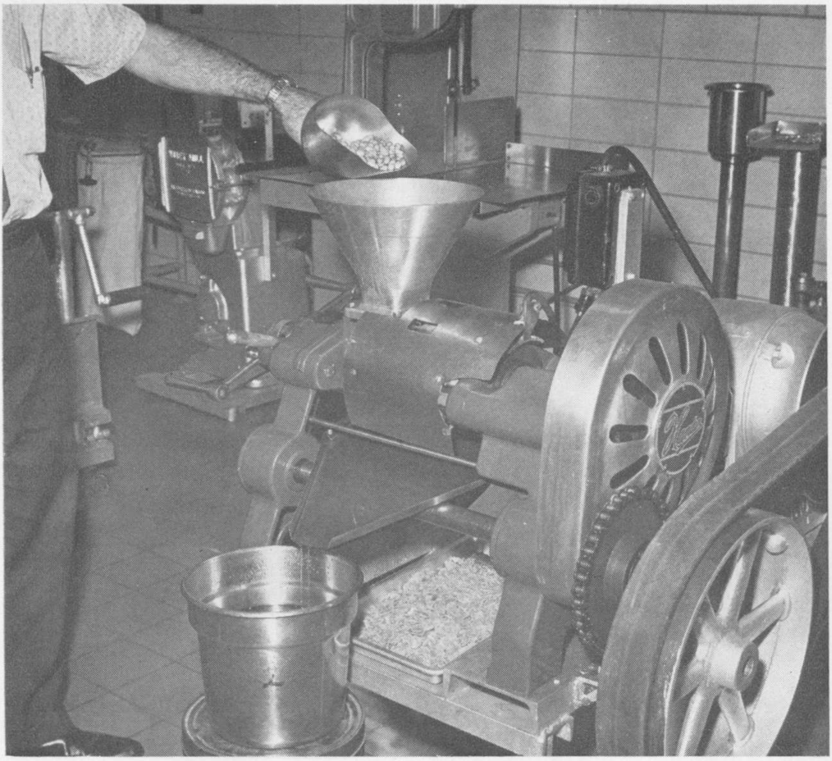

FIG. 2. Hander Model 52 laboratory oil expeller with 1,500-watt supplementary heat attachment that was used for most of the screw pressing operations.

fects the final pressure in the expeller barrel and, consequently, the residual oil of the cake. Clearance is adjusted by means of a manually operated crank which moves the main worm drive shaft axially and increases or decreases the aperture.

The Hander expeller was mounted on a stand and equipped with a 2 horsepower motor with variable speed drive. To study the effects of temperature on screw pressing, a 1500 watt electric heating unit was built as an attachment. This provided radiant heat to the outer surface of the expeller, which supplemented frictional heat inside the expeller barrel.

Establishing Technology for Screw Pressing. It became evident from results of earlier tests that expeller cakes with widely different oil levels could be produced with the Hander expeller but that considerable time would be required to establish exact screw pressing procedures that could be repeated under laboratory conditions with consistent results. Because of contract time limitation it was essential to begin production of the defatted flours for use in shelf life studies and for work to be initiated on uses of the flours. Therefore, most expeller operations were conducted with a two-fold objective of producing defatted cakes for further research while accumulating technology on screw pressing of peanuts on a laboratory basis. Variations were pre-pressing treatments, expeller aperture clearance, and other factors. Each test operation was assigned a number, and records kept on all variables. A total of 173 such tests was made in the Hander expeller. The resulting cakes were classified for further use in the research on the basis of residual oil as follows:

Class 1—approximately 7 per cent, range 5.8 to 8.0
Class 2—approximately 12 per cent, range 10.5 to 15.0
Class 3—approximately 17 per cent, range 15.1 to 21.0
Class 4—approximately 22 per cent, range 18 to 26.0

Procedure for Screw Pressing Tests in the Hander Expeller. Usually, series of tests were made in succession. In conducting these tests, batches of peanuts (6 to 12 lb.) were prepared using the pre-expulsion treatments to be studied. The expeller was preheated with steam and the special electric supplementary heater attached when it was to be used. Using a portion of the peanuts from the test sample, the operation was started with the expeller aperture open. The aperture was gradually closed until the oil flowed freely and a cake was formed, then fine adjustments were made until the operation was established as desired. At this time, the catch pans for oil and cake were changed, a time clock turned on, and the operation continued until nearly all of the sample was expelled. The time was then recorded, the catch pans changed, and the next sample started immediately behind the first. The expeller was readjusted, catch pans changed, and the clock started for the second test operation. Stopping the expeller between test operations was avoided in order to utilize to best advantage the pre-heated conditions of the expeller and to eliminate the need for complete readjustment from a fully-opened aperture. Combined weights of cake and oil were used as the sample weight for a given test operation.

Results of Screw Pressing Tests. Results of expeller tests reported in Table 7 show that moisture level was most important in conditioning peanuts for screw pressing to minimum residual oil

TABLE 7. EFFECTS OF MOISTURE LEVEL IN PEANUTS[1] ON SCREW PRESSING IN HANDER MODEL 52 EXPELLER

Moisture in peanuts	Tests	Oil in cake, dry basis		Moisture in cake	Expulsion rate
		Range	Mean		
Pct.	*No.*	*Pct.*	*Pct.*	*Pct.*	*Lb./hr.*
4.2	1	-------	30.3	4.9	54
4.5 to 5.0	5	7-18	12.3	----	60
5.3 to 5.5	3	8.8-11	9.6	8.8	43
5.8 to 6.0	5	7-8.8	7.7	9.2	33
6.1 to 6.5	5	7-9.8	8.3	10.1	35
6.6 to 7.0	6	6-9.7	7.6	8.9	35
7.1 to 7.5	4	5.7-8.7	7.3	10.3	30
7.8 to 8.5	3	8.2-9	8.6	11.3	54
9.3 to 9.8	3	10.9 to 19.3	14.3	11.4	71
10.8	1	-------	21.2	11.7	73
12.6	1	-------	33.1	11.7	34
13.9	1	-------	35.3	11.3	57

[1] Early Runner peanuts, deskinned by mechanical blanching following boiling water and oven drying treatment. Moisture equilibrated by holding in covered cans at 80° F. Expeller aperture adjusted for minimum residual oil in cake attainable without extruding cake between expeller bars.

in the cake. In the 38 tests reported, the main objective was to produce cakes with the minimum oil level attainable under the conditions of the tests. Nine of the tests resulted in cakes with oil content below 7.5 per cent. With one exception, these 9 tests were on peanuts with 5.8 to 7.5 per cent moisture. The cake oil content increased to 30 per cent when the moisture content of the peanuts was reduced to 4.2 per cent. The cake oil increased to 35 per cent when the moisture content of the peanuts was increased to 13.9 per cent. This relationship of moisture level to residual oil in the cake is shown graphically in Figure 3.

The effects of additional variables in screw pressing peanuts in the Hander expeller are shown in Table 8. Increasing the expeller aperture clearance was effective in increasing the level of residual oil in the cake (tests 113, 114, 121, and 122). This also resulted in a substantial increase in expulsion rate.

In all of the other tests reported in Table 8, the objective was to produce a cake with the minimum residual oil level attainable without extruding cake material between the expeller bars. Coarsely grinding the peanuts prior to pressing almost doubled the expulsion rate but also increased the level of residual oil in the cake (tests 139 and 142). Heating the peanuts to approximately 190° F. prior to pressing resulted in small increases in both expulsion rate and oil level in the cake (tests 138, 140, 141, 147, and 148). The pressing tests on dry roasted peanuts were generally

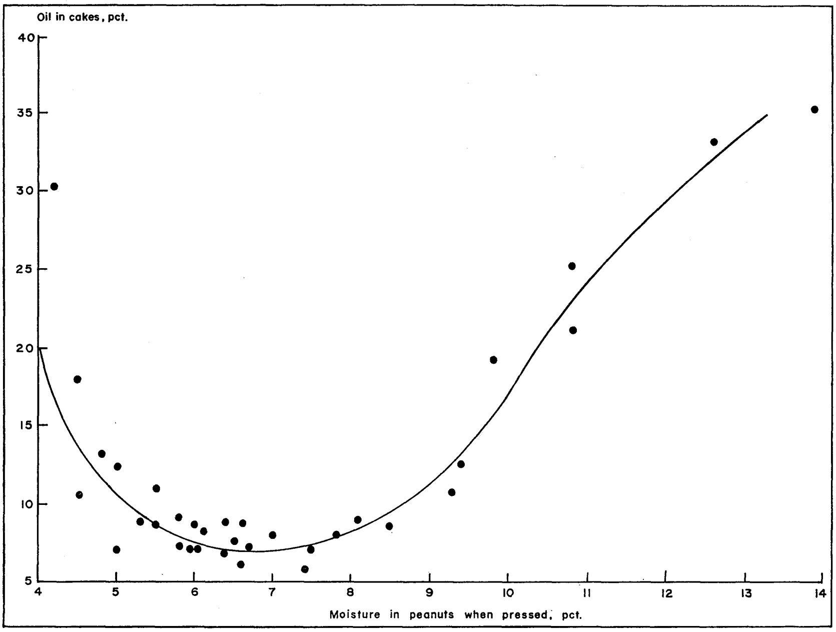

FIG. 3. Relationship of moisture level in peanuts to residual oil in cake when screw pressed with Hander Model 52 expeller. Early runner peanuts deskinned by boiling water, oven dried, and mechanically blanched were used.

unsuccessful (tests 63, 64, and 127-130). Pressing these peanuts without rehydration resulted in a cake with 45 per cent residual oil content. In three of the tests in which the peanuts were rehydrated, the cake oil content ranged from 33 to 38 per cent. In two tests, cakes with oil contents of approximately 12 per cent were obtained. In one of these the expulsion rate was very low, but in the other it was very high. The presence of the skins on the peanuts during pressing (tests 37, 149, and 150) or the use of the lye method for removing the skins prior to pressing (tests 91-93) did not appear to affect the screw pressing operation.

In additional pressing operations in the Hander expeller moisture equilibration of the peanuts prior to pressing appeared to be beneficial in obtaining a low oil level in the cake in some tests, but did not appear to have any effect in other tests. The operation of the expeller screw at speeds of 38 to 70 r.p.m. resulted in no detectable differences in the results of the tests. Operating the expeller screw at 22 r.p.m. as compared with 38 r.p.m. resulted in lower expulsion rate and higher residual oil in the cake.

TABLE 8. EFFECTS OF DIFFERENT VARIABLES IN SCREW PRESSING EARLY RUNNER PEANUTS IN HANDER MODEL 52 OIL EXPELLER[1]

Variable treatments	Expeller test no.	Moisture in peanuts	Pressing temp.	Expeller aperture clearance	Oil in cake, dry basis	Expulsion rate
		Pct.	°*F.*	*In.*	*Pct.*	*Lb./hr.*
Standard	146	5.3	184	.052	9.0	43
	137	6.6	184	.043	6.0	35
	36	7.5	------	.049	7.3	23
	43	8.5	------	.031	8.7	69
Expeller aperture opened to obtain high oil level in cake.	121	7.0	192	.063	18.0	37
	122	7.0	182	.069	19.0	41
	113	7.8	180	.063	17.2	47
	114	7.8	175	.069	20.0	63
Peanuts coarsely ground.[2]	142	5.5	194	.062	11.0	68
	139	6.5	214	.056	11.5	70
Peanuts heated to approximately 190° F. before expelling	148	4.5	194	.075	18.0	69
	147	4.8	198	.056	13.5	55
	140	5.0	197	.060	7.0	49
	141	5.5	197	.060	11.0	39
	138	6.1	209	.056	8.5	58
Peanuts dry roasted, rehydrated, and moisture equilibrated.[3]	64	1.1[3]	------	------	45.0	--
	129	5.5	165	.059	36.0	57
	130	5.5	170	.063	12.0	15
	63	6.0	------	.069	12.4	88
	127	6.5	165	.056	38.0	56
	128	6.5	150[4]	.056	33.0	39
Peanuts deskinned by lye method.	91	8.2	185	.044	10.6	51
	92	8.4	185	.044	10.8	56
	93	9.0	185	.044	10.0	56
Peanuts not deskinned.	150	5.7	182	.070	8.6	28
	149	7.2	170	.055	9.7	35
	37	7.5	------	.038	7.8	60

[1] Except as otherwise indicated, the peanuts were deskinned by standard treatment, expeller aperture was adjusted for minimum residual oil in cake attainable without extruding cake between expeller bars, and supplemental radiant heat was applied to external surface of expeller during pressing.
[2] Run through meat grinder with coarse plate (75 per cent of nuts broken into eighths or quarters).
[3] In test number 64, peanuts were not rehydrated.
[4] Frictional heat only.

These studies established that peanut cake with residual oil as low as 7.5 per cent can be produced from deskinned peanuts pressed in the Hander laboratory expeller provided the peanuts are not dry roasted prior to pressing. Further conditions required to produce this cake were:

(1) Peanuts deskinned by a method that did not reduce the moisture content below 5.5 per cent.
(2) Peanut moisture equilibrated to 5.8 to 7.0 per cent level.
(3) Expeller aperture adjusted carefully by starting the operation with ample aperture clearance and gradually closing until desired results were obtained.

(4) Expeller pre-heated before starting and supplementary heat used to maintain temperature of expeller barrel in 180° to 200° F. range.

(5) Expeller screw operated at approximately 40 r.p.m.

Cakes with residual oil higher than 7.5 per cent were produced by pressing peanuts with higher moisture content and/or using more clearance on the expeller aperture. Cake mixtures with specific oil levels were prepared by blending calculated quantities of cakes with different residual oil contents.

Solvent Extraction

General Methods. In commercial peanut oil operations the mechanical expeller is efficient in producing cakes with oil content of 9 to 12 per cent, but the efficiency of the expeller decreases sharply with further reduction in oil content of the cakes produced. To produce cakes with very low oil content a two-step process is employed using mechanical expulsion to bring the oil within the 9 to 12 per cent range and solvent extraction to further reduce the oil content to 1 per cent or less. Hexane is generally used as the solvent.

In these laboratory studies, an average of approximately 7.5 per cent oil in the cake was the minimum level that could be maintained with repeated tests in the Hander Model 52 expeller. At this level the capacity of the expeller was approximately 60 per cent of that attained when cakes with 9 to 12 per cent oil were produced, Table 7 and Figure 3. Flours with oil content within the range of 0.5 to 3.0 per cent were needed for some of the studies on uses of the flours. The two-step process of mechanical pressing followed by solvent extraction was employed to produce cakes for making these flours.

Preliminary Tests. Preliminary tests were made on hexane extraction using laboratory facilities already on hand. A sample of raw peanut cake with 28 per cent oil was ground into meal for use in the experiments. Extraction tests were made in a large Soxhlet extractor (2,200 milliliter sample chamber), in an Erlenmeyer flask with mechanical shaking followed by filtration, and in a Waring Blendor followed by filtration. With 20 to 30 mesh meal the Soxhlet extractor reduced the residual oil to 8 per cent in 2 hours. The mechanical shaking treatment reduced the oil to 8 per cent in 30 minutes and the Waring Blendor method reduced the oil level to 3 per cent in 30 minutes. With 40 to 50 mesh meal, the Waring Blendor treatment reduced the oil level to 1.3 per cent in 15 minutes and to 0.7 per cent in 30 minutes. In all of the tests, the meal was separated from the oil-solvent mixture (referred to in industry as "miscella") by suction filtration and rinsed with fresh hexane. From these tests, it was concluded that solvent extraction meeting the requirements of this research could be carried out under laboratory conditions, but that more adequate equipment was needed.

Solvent Extraction Equipment Developed. Laboratory facilities more suitable for the requirements of the research were developed. These included a unit for the extraction operation and a separate unit for hexane recovery by distillation, Figure 4. A conventional 6-gallon aluminum pressure cooker was utilized as the extraction chamber. It was equipped with a stainless steel stirring blade with the drive shaft passing through a seal in the cover. A variable-speed, air-powered motor was used to drive the blade. The distillation unit consisted of miscella reservoir, evaporator, condenser, and liquid receiver. A 10-gallon stainless steel pressure cooker was used as the miscella reservoir, and the evaporator, condenser, and receiver were constructed of 4-inch diameter stainless steel tubing. Compressed air supplied through a pressure regulator was used to force feed the miscella into the evaporator. Features of the evaporator included detachable heads for removal of fines and cleaning, a hot water or steam jacket on the bottom for heating, and an oil outlet tube passing through the heating jacket. The vaporized hexane rose into the condenser, which was cooled by tap water, and the condensed hexane flowed by gravity into the liquid receiver. Suitable valves were used for control of flow.

Solvent Extraction Operations in the Special Equipment. Tests were made in the extraction unit to determine efficiency and establish procedures. Peanut cakes produced by the Hander expeller were used. Technical grade hexane was used as the solvent. The objective was to establish procedures for extracting cakes to two oil levels: (1) 2 to 3 per cent and (2) less than 1 per cent. Preliminary tests in this extractor indicated that a single extraction treatment would reduce the cake oil to the 2 to 3 per cent level but that a three-step extraction treatment followed by a rinse in fresh hexane would be required to reduce the level to less than 1 per cent.

Results of tests using the three-step treatment are presented

FIG. 4. Solvent extraction and distillation unit.

in Table 9. In most of the tests the first extraction treatment was effective in reducing the oil content of expeller cakes to the 2 to 3 per cent level and the three-step treatment in reducing the oil level to less than 1 per cent. Similar results were obtained on expeller cakes with oil contents ranging from 9.1 to 18.0 per cent. A 15-minute extraction period was generally as effective as a 30-minute period. Rotation of the agitator blade in one direction at 50 r.p.m. was more effective than oscillating it 180 degrees at 26 cycles per minute. Use of the solvent on a simulated counter flow system, Figure 5, was as effective as using fresh hexane for each of the three-step runs.

The special distillation unit proved to be satisfactory for recovering the hexane from miscellas and obtaining oil samples from the solvent extraction operations.

Extracting Expeller Cake in a Jar-Roll Unit. Further study was

TABLE 9. HEXANE EXTRACTION OF PEANUT EXPELLER CAKES USING DIFFERENT THREE-STEP TREATMENTS IN SPECIAL LABORATORY EXTRACTOR[1]

Solvent	Weight of cake	Solvent to-cake ratio	Extraction time, each run[2]	Cake oil content by step-runs			
				Start	First	Second	Third[2]
	Lb.	*Lb.*	*Min.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Distilled hexane on all runs.	7.0	3 to 1	30	9.1	2.2	1.1	0.8
	7.0	3 to 1	15	9.1	2.4	1.4	0.8
	10.0	2 to 1	30	9.1	2.2	1.0	0.6
	10.0	2 to 1	15	9.1	2.3	1.4	0.7
Miscellas from second and third runs and rinse of previous tests used respectively as solvents for first, second, and third runs; and distilled hexane used for rinse. (See Fig. 5)	7.0	3 to 1	15	9.1	2.3	1.5	0.7
	10.0	2 to 1	15	9.1	3.2	1.8	1.1
	9.0	2 to 1	15[3]	9.1	3.9	3.0	2.2
	9.0	2 to 1	15	9.4	2.2	1.3	0.8
	9.0	2 to 1	30	9.4	2.4	1.2	0.6
	7.0	2 to 1	30	9.4	1.8	1.1	0.2
	7.0	2 to 1	15	9.4	2.6	1.5	1.0
	5.0	2 to 1	15	9.4	2.3	1.3	0.9
	9.0	2 to 1	22.5	9.4	2.2	1.0	0.6
	9.0	2 to 1	10-20-30	9.4	2.3	1.2	0.8
	9.0	2 to 1	7.5-15-30	9.4	3.0	1.9	1.1
	7.5	2 to 1	15	11.9	3.2	1.6	0.8
	5.3	2 to 1	15	18.0	3.6	0.9	0.5
	9.0	2 to 1	10-20-30	18.0	3.1	1.6	0.8

[1] Agitator blade operated at 50 r.p.m. except as indicated.
[2] Allowed to settle for 20 minutes after each run before changing solvent. Rinsed with fresh solvent after third run.
[3] Direction of agitator blade reversed after each 180 degree rotation, approximately 26 cycles per minute.

made to test a jar-roll technique as a laboratory method for solvent extraction, using a special machine designed to roll jars. One-gallon fruit jars equipped with Teflon® caps were used for the extraction containers. The jar-roll unit handled 4 of these jars at a time, rotating them at 50 r.p.m. Batches of 2.25 pounds of peanut cake and 4.50 pounds of solvent were run in each jar. Each batch was extracted with 3 runs (3 changes of solvent) with solvent changes being on a simulated counter flow basis, as shown in Figure 6. Extraction periods were 15 minutes each for the first and second runs on the cake and two 15-minute periods for the third run. With this procedure a full load (4 jars) was kept in the jar-roll unit. Solvents were changed rapidly between runs without allowing time for settling. Water was kept in the jar-roll unit to maintain a temperature of approximately 90° F. during extraction.

Fifty-six pounds of expeller cake with 14.3 per cent oil content were extracted in this manner. Percentages of residual oil after first, second, and third runs averaged 4.95, 2.35, and 1.00, respectively. On the basis of results, this method was considered

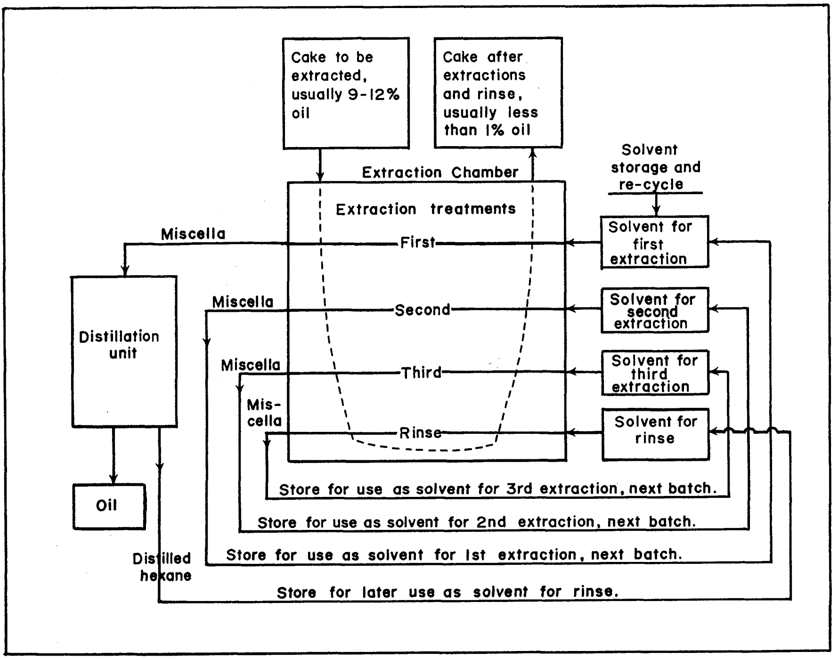

FIG. 5. Simulated counter-flow solvent extraction process in special laboratory unit using three-step extraction plus rinse.

to be most satisfactory for laboratory operation. Compared with the converted pressure cooker extractor described previously, the jar-roll method was faster, better adapted to simulated counter flow extraction, resulted in less breaking of the cake, and produced fewer fines in the miscella. However, the operation might be further improved by substituting suitable metal containers for the glass jars to permit higher extraction temperature with less hazard. Also, the second 15-minute run of the third extraction might be replaced with a fourth extraction in the counter flow process to further reduce the final oil content of the cake.

Direct Solvent Extraction of Peanuts. A test was made on direct solvent extraction of peanuts. Raw, partially roasted, and fully roasted samples were deskinned, chopped to a variety of particle sizes, and extracted with hexane in the converted pressure cooker.

Table 10 shows the percentages of residual oil in the extracted peanut samples chopped to various particle sizes. Seven pounds

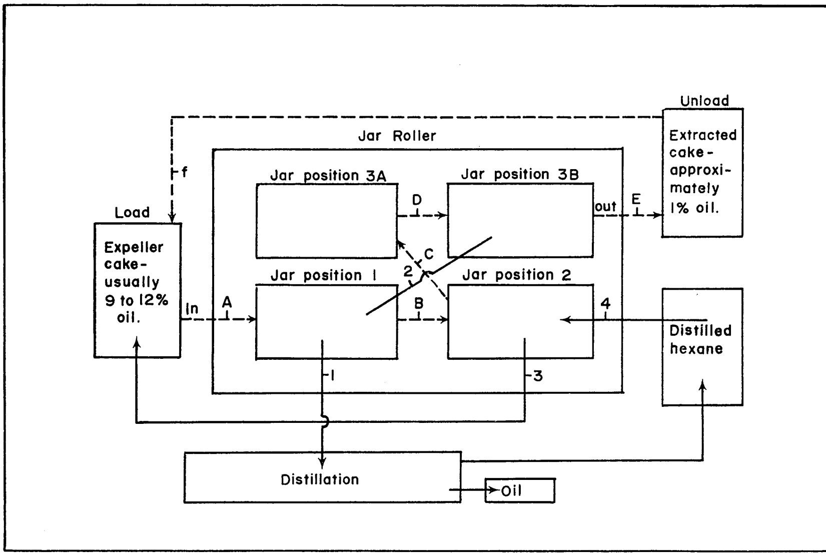

FIG. 6. Simulated counter-flow jar-roll extraction process. At end of roll period solvents advanced in order indicated by numbered lines, then jars advanced as indicated by lettered lines.

of chopped nuts were extracted 15 minutes with 14 pounds of hexane, and the process was repeated four times with each particle size. More nearly complete extraction of oil was accomplished with the more finely chopped nuts. Difficulty was experienced in separating the finer material from the hexane between runs. It was concluded that the two-step process of screw pressing followed by solvent extraction of the press cake was more efficient than direct extraction.

Desolventization of Extracted Cake. A detectable off-flavor that could be identified with hexane was noted in the extracted cakes after atmospheric drying. This was not completely removed by fully roasting the cake in an oven at 325° F. or by heating it at 158° F. under 29 inches vacuum for as long as 19 hours. The hexane-like off-flavor appeared to be more pronounced in flour made from dry roasted cake than in flour from raw cake that had only been dried at atmospheric pressure. No hexane residue was detected by gas chromatographic tests on samples dried in air for 1 hour at 180° F. or for 12 hours at 80° F.

The off-flavor was completely removed by scrubbing the cake with saturated or superheated steam at atmospheric pressure.

TABLE 10. DIRECT SOLVENT EXTRACTION OF RAW AND ROASTED PEANUTS IN SPECIAL LABORATORY EXTRACTOR

Particle size and roasting treatment	Residual oil in extracted cakes[1]		
	5 runs	4 runs	3 runs
	Pct.	*Pct.*	*Pct.*
Larger than #4 sieve, raw	33.8	------	------
#4 sieve only, raw	38.0	------	------
#6 sieve only, raw	29.4	------	------
#6 sieve only, raw	27.0	------	------
#8 sieve only, raw	19.7	------	------
#10 sieve only, raw	12.2	------	------
#4 sieve and smaller, raw	13.4	16.7	19.2
#4 sieve and smaller, partially roasted	6.9	9.5	20.4
#4 sieve and smaller, fully roasted	11.1	12.4	15.1

[1] Seven pounds of peanuts and 14 pounds of solvent per batch, 15-minute runs with 20-minute settling period between runs. Distilled hexane used for all runs.

From extensive tests using different steaming periods and different superheat temperatures, it was found that a 10-minute steaming with either source of steam was required for good results. Furthermore, it was found that 275° F. was a satisfactory superheat temperature and that superheating the steam was beneficial only in reducing the amount of moisture taken up by the cake. Regardless of the source of steam used, some drying of the cake was needed to bring the moisture to a suitable level for making flour.

Variation in intensity of off-flavor detected in air dried cakes from different sources was another aspect of desolventization. The off-flavor in cakes prepared with hexane that had been redistilled several times was not as pronounced as it was in cakes prepared from the first use of a batch of hexane. This suggested that the grade of hexane used (technical grade) had impurities that were removed by distillation and that these impurities were at least partially responsible for the flavor in question.

To obtain information on this, 5 gallons of fresh technical grade hexane were fed into the evaporator of the special distillation apparatus and all of the hexane boiled off except approximately 1 quart. This residue had a pronounced odor similar to that of the solvent extracted cake. With continued heating of this material, a small increase in boiling temperature was noted, but it was easily evaporated, leaving only a small amount of oil-like residue. When vacuum dried, this residue was essentially odorless and tasteless.

The extent to which hexane impurities with high or low boiling point were involved in the off-flavor was not clear, nor was there an answer to the question of bonding of hexane impurities with the peanut cake as a factor in the off-flavor. However, it was clear that steam scrubbing was effective in removing the flavor.

Drum Drying and Grinding Peanut Products

Drum Drying Peanut Products. The drum drying process was used in the preparation of several peanut products with unique properties. An interesting feature common to a number of products tested was the effect of drum drying on subsequent grinding. Peanut cakes or whole peanuts with high oil content that could not be ground to a flour without forming a paste were ground very satisfactorily after drum drying. Drum dried products with oil content as high as 24 per cent were satisfactorily ground to flour fineness in an Alpine mill, and drum dried products with oil content as high as 65 per cent were ground to a fairly fine flour in a Wiley mill.

In drum drying the products, whole or partially defatted peanuts were ground into a meal or paste, water added to adjust the total solids content to approximately 30 per cent, and the mixture agitated vigorously to emulsify the oil. The mixture was dried on a 6 x 8-inch double drum atmospheric dryer operated at 0.015 inch clearance, 60 p.s.i. steam pressure, and 1.5 r.p.m. Dried materials were crushed to form flakes then ground into flours.

Drum dried peanut flours made by this process were prepared with oil contents ranging from 7.6 to 65.0 per cent. Oil contents higher than that of whole peanuts were obtained by adding peanut oil to whole peanuts. Flours with oil content up to that of whole peanuts, approximately 52 per cent, were slightly oily in appearance. Drum-dried flours did not become gummy when water was added to them to form pastes. The pastes were fluffy.

Specific drum drying tests made and results obtained are presented in the following list. In each test very good sheet formation and release from drums resulted. Drum yield rates appeared to be high.

1. An expeller cake with 7.6 per cent oil produced an almost white drum-dried flour. The flavor was similar to that of the cake before drum drying.

2. The same cake as above heated for 10 minutes in steam at 15 p.s.i. pressure produced gold-colored drum-dried flour. The flavor was improved by the steam heat treatment.

3. An expeller cake from dry roasted peanuts, oil content of 12.4 per cent, produced light gold-colored drum-dried flour with flavor similar to that of whole dry roasted peanuts.

4. Whole dry roasted peanuts, 51 per cent oil, produced a bright gold-colored drum-dried flour with typical dry roasted peanut flavor.

5. Whole dry roasted peanuts with peanut oil added to increase oil content to 65 per cent produced a gold-colored drum-dried flour with a slightly oily appearance. The flavor was typical of roasted peanuts.

6. Two pounds of raw, deskinned peanuts mixed and ground with 3.5 pounds of cake having 7.6 per cent oil resulted in a stiff paste with 24 per cent oil and poor flavor. When water was added and the mixture drum-dried and ground, the flour was almost white and the flavor was similar to that of partially roasted peanuts.

7. When the above mixture in the paste form was heated in an oven before drum-drying and grinding, the flour was golden and had a typical roasted peanut flavor.

Grinding Peanut Products with Wiley Mill. Initially a Wiley mill was used for grinding operations in this research. The mill was equipped with new knives, set to minimum clearance, and 3 screens (15, 25, and 40 mesh). Rotary speed was 1,650 r.p.m.

Peanut cake ground through the 15 mesh screen and sifted with a 20 mesh sieve was classified as grits for the purpose of this research. Grinding the cake through the 25 mesh screen produced a product classified as meal without sifting. Grinding the cake through a 40 mesh screen produced flour which was not fine enough for the purposes of this project, and difficulty was encountered in the grinding operation. Usually the grinding rate was very low, heating of the product occurred, and in some cases the screen became clogged making it necessary to stop the operation and clean the screen. Products with low moisture content ground with some less difficulty than those with higher moisture.

Use of Alpine Grinding Mill. To provide more suitable grinding equipment for making flours, an Alpine impact stud mill, Figure 7, was purchased. The mill was equipped with a 3 horsepower, 3,500 r.p.m. motor and a drive mechanism to provide rotary speeds of 7,200, 9,400, 11,400, and 14,100 r.p.m. The Alpine impact stud mill was used extensively for grinding cakes

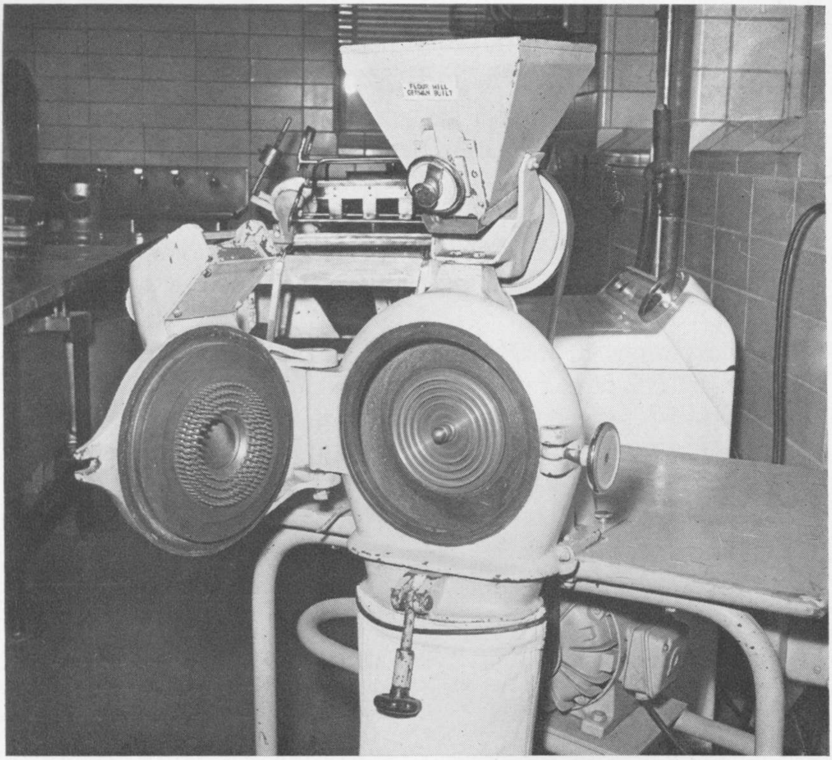

FIG. 7. Alpine stud mill with rotary speeds up to 14,100 r.p.m.

from different expeller operations as well as solvent extracted material. Cakes were crushed in the Wiley mill and then ground to a flour in the Alpine mill. A second processing through the Alpine mill was sometimes needed to reduce the product to a very fine flour.

The Alpine mill ground the product effectively when the oil content was 8 per cent or lower. However, there was a gradual buildup of material on the walls of the grinding chamber making it necessary to stop occasionally to remove the material. As the oil content of the cake increased, the material built up faster in the grinding chamber and temperature rose. Grinding to a flour was impossible when the oil was in excess of 16 per cent. The material formed a paste instead of a flour. However, cakes with oil content as high as 24 per cent were ground with moderate success in the Alpine mill by first drum-drying the product. Details on this technique are given in the section on drum-drying.

One grinding test in the alpine mill was on a sample of expeller cake with 13 per cent residual oil. The cake was crushed, water added, and the mixture drum-dried to 3.4 per cent moisture before grinding. As the material was discharged from the Alpine mill, it separated into two distinct components. The more finely ground particles collected as a soft cake on the interior walls of the grinding chamber and the less finely ground particles collected in the filter receiving bag provided for this purpose. The material collected in the mill tested 17 per cent oil as compared with 12 per cent in the material collected in the receiving bag. This type of separation occurred in other grinding tests; however, a satisfactory flour was obtained by grinding the material from the receiving bag a second time, pulverizing the soft cake from the mill walls, and mixing the two components.

Sieve Analysis. Sieve tests were made on the two components from the grinding test described and are presented in Table 11. It was not possible to sieve the product dry because of a tendency for the material to smear on the surface of the sieve rather than pass through. However, sieving was successful when the material was dispersed in water and then passed successively from coarser to finer sieves. Components collected on sieves were washed with water and the washings added to the next finer sieve. Materials remaining on sieves were carefully removed with a rubber spatula, vacuum dried, and weighed to determine percentages of original sample. Of the material collected in the filter receiving bag, 75.8 per cent passed through the 140 mesh sieve. Of the ma-

TABLE 11. SIEVE ANALYSIS OF PEANUT FLOUR MADE BY GRINDING EXPELLER CAKE IN ALPINE IMPACT STUD MILL[1]

Sieve size	Material collected in filter receiving bag of mill (12% oil)		Material collected on walls of grinding chamber (17% oil)	
	Retained on sieve	Passed through sieve	Retained on sieve	Passed through sieve
Mesh	*Pct.*	*Pct.*	*Pct.*	*Pct.*
40	Trace	------	----	------
60	2.6	97.4	Trace	------
80	9.0	88.4	0.9	99.1
100	6.0	82.4	2.1	97.0
120	2.8	79.6	5.0	92.0
140	3.8	75.8	0.6	91.4

[1] Peanut expeller cake with 13 per cent oil was crushed, water added, drum-dried, crushed, ground one time through Alpine mill operated at 14,100 r.p.m. with feed rate of 30 pounds per hour.

TABLE 12. GRINDING TESTS ON PEANUT CAKES FROM OIL EXPELLER OPERATIONS[1]

Expeller operation	Weight	Analysis of ground sample		
		Oil content	Moisture	Pass through 140 mesh sieve
Nos.	*Lb.*	*Pct.*	*Pct.*	*Pct.*
75, 76, 77 mixed	8.59	9.6	4.0	92.7
78, 79, 80 mixed	9.03	12.3	3.0	83.1
81, 82 mixed	9.28	14.2	2.0	89.5
83, 84, 85 mixed	7.81	8.9	3.2	76.3

[1] Expeller cakes were dry roasted to the fully roasted state (held on trays in forced air oven for 20 min. at 325° F.), crushed in Wiley mill, ground in Alpine mill at 14,100 r.p.m. Material from receiving bag was ground a second time. Feed rate was approximately 30 pounds per hour.

terial collected on the walls of the grinding chamber, 91.4 per cent passed through the 140 mesh sieve.

Results of grinding tests on cakes from expeller operation Nos. 75 to 85 are presented in Table 12. These samples were grouped for grinding according to oil content of the cakes.

Flow Chart on Preparation of Flours, Meals, and Grits

Laboratory procedures established for making the defatted flours, meals, and grits are summarized in the flow chart, Figure 8.

USES OF DEFATTED PEANUTS IN FOOD PRODUCTS

Investigations designed to develop foods containing the defatted peanut flours, meals, and grits were conducted over a 2½-year period. Eighteen different peanut flours, meals, and grits were incorporated into more than 100 food products. Panels were utilized to determine the degree of peanut flavor as well as acceptability of many products. Chemical tests were made to determine moisture, fat, protein, free fatty acids, and peroxide values. Shelf stability of peanut products under several conditions was studied.

Methods of sensory and chemical evaluations of products are presented in the section on analytical studies.

Problems Encountered in Using the Flours, Meals, and Grits

Peanut flours proved to be more useful in finished products than meals or grits, especially when the drum-drying treatment was not used prior to grinding. Products made from meals or grits ground without drum-drying usually contained hard parti-

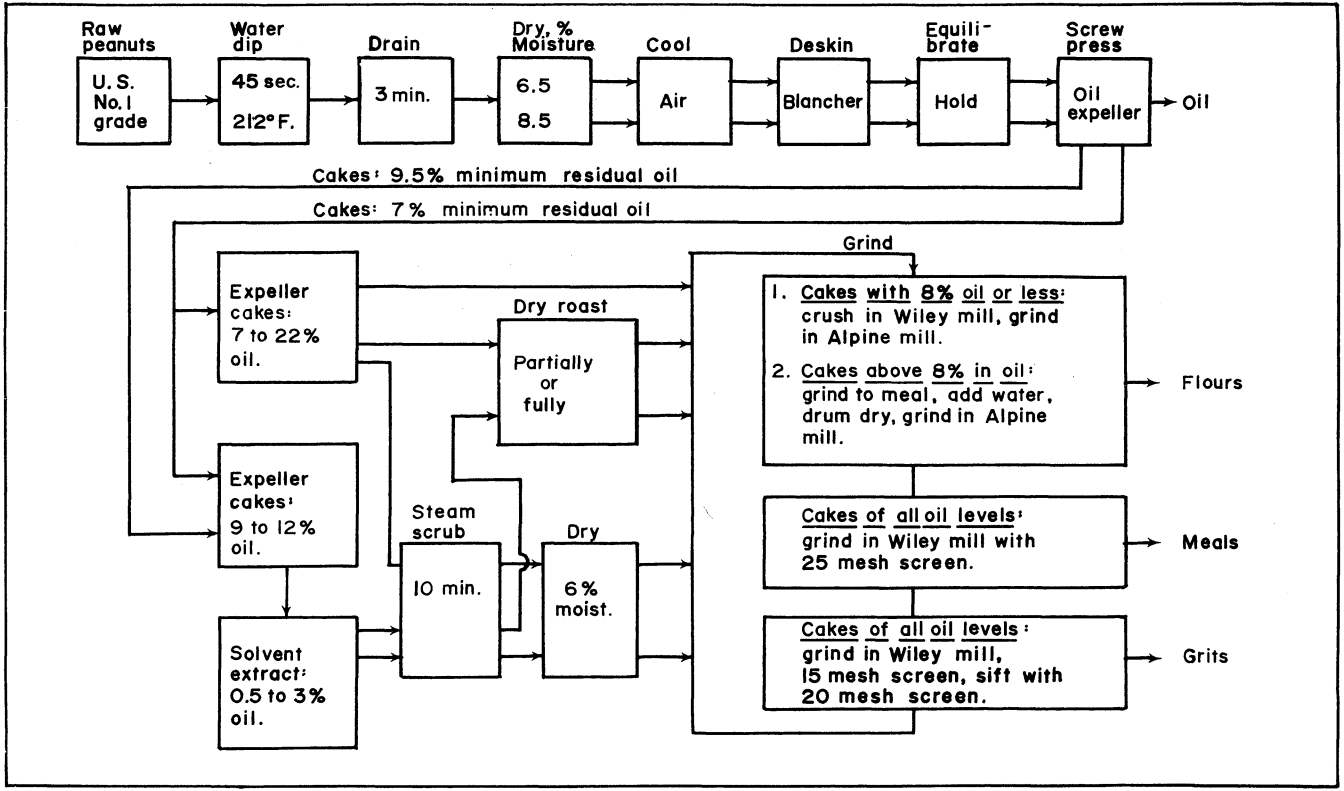

FIG. 8. Flow chart of laboratory procedures used in making defatted peanut flours, meals, and grits.

cles that were detected by taste panels and scored as undesirable. These meals and grits in the lower oil levels (OE1 and OE2) were found to be unacceptable in all products tested because they retained a mealy or gritty texture in spite of heat and moisture treatment. However, the meals in the two higher oil levels (OE3 and OE4) were used satisfactorily in some baked products, e.g., cookies, heavier cakes such as applesauce cake, and nut breads. Meals and grits made without drum-drying were unacceptable in all oil levels in such products as soups, gruels, dips, ice cream, puddings, etc. because some mealy or gritty texture was always retained. Drum-drying prior to grinding produced a lighter, finer meal that was much closer to a flour than the regular meal.

Because of the nature of the protein and carbohydrate content of peanut flour, the addition of large proportions to product formulations produced a heavy texture and frequently an undesirable dark color in the finished foods. This was especially true with the early flours with coarser texture. With refinement of the flours the opposite effect was noted—products were too dry and browning was delayed beyond the stage of doneness. Therefore, further adjustments in formulations were necessary.

Peanut flour did not have the thickening quality of wheat flour or corn starch and therefore could not be used as a thickening or emulsifying agent. Nor did peanut flour, which is high in protein, react in products as some other protein foods such as eggs. Total fat level of the flour was also an important consideration in formulations since equivalent fat content of the food was necessary for standardization of products.

Peanut products which proved acceptable and examples of food products prepared with them are shown in Table 13.

Food Formulation Investigations

Experimental food formulations were tested using peanut products to replace portions of wheat flour. Results of many of these tests are presented in Table 14. Included in the data are basic formulas, ratio of peanut product to wheat flour, calculated protein increase as a result of the peanut product, and panel scores on products. In many products 3 parts of peanut flour to 5 parts of wheat flour proved most acceptable. This increased the protein level in the flour mixture from approximately 10 to 25 per cent.

Using these investigations as a guide, a set of formulas was de-

TABLE 13. PEANUT PRODUCTS WHICH PROVED ACCEPTABLE AND EXAMPLES OF FOOD PRODUCTS PREPARED WITH THEM

Peanut product[1]	Food products tested
OE1-R2-F	Butterscotch oatmeal crispies, split pea soup, banana bread, butterscotch brownies.
OE1-R3-F	Chocolate cake, brownies, butterscotch brownies, peanut-onion dip, biscuits, chocolate cookies, yeast breads.
OE2-R3-F	Chocolate pudding, brown gravy, peanut butter fudge.
OE3-R3-F	Peanut-honey spread, scones, peanut-onion gruel.
OE4-R3-F	Banana-nut bread, tomato-onion soup, chocolate cookies.
OE1-S10-R1-F	One-egg cake, biscuits.
OE2-S10-R1-F	One-egg cake, biscuits.
OE3-S10-R1-F	One-egg cake, biscuits, yeast breads.
OE3-R3-M	Oatmeal-raisin cookies, apricot bread.
OE4-R3-M	Chocolate cookies, nut bread.
OE3-R3-DD-M	Apricot bread, butterscotch brownies.
OE4-R3-DD-M	Chocolate cookies, apricot bread.
OE1-R3-G	Peanut-honey spread, peanut-honey-raisin spread.
OE4-R3-G	Peanut chip cookies, ice cream, peanut-chocolate clusters, broiled peanut frosting.
OE1.5-OS1-DS10-R1-F	Banana loaf, one-egg cake.
OE1.5-OS1-DS10-R3-F	One-egg cake, brownies.
OE1.5-OS2-DS10-R1-F	One-egg cake, biscuits.
Peanut meal-applesauce	Applesauce cake.

[1] See Table 2 for explanation of symbols.

veloped for commercially prepared food mixes, Appendix I, and a set of recipes was developed for home use, Appendix II.

Examples of Experimental Product Investigations

Quick Breads, Muffins. A study to determine the extent to which each of four peanut flours, could be substituted for wheat flour in muffins included the following constant ingredients:

Baking powder	7.2 grams
Salt	3.2 grams
Whole milk	122.0 grams
Melted fat	20.7 grams
Egg	22.6 grams

The products were scored by a taste panel for four factors: external appearance, internal appearance, flavor, and overall quality. The results indicated that the flours OE1-R3-F (7 per cent oil), OE2-R3-F (12 per cent oil), and OE3-R3-F (17 per cent oil) could be substituted for wheat flour at levels up to 43.5 per cent by weight and still yield a desirable product, i.e., one with an overall quality score of 7.5 or higher on a 1 to 10 scale. The flour OE4-R3-F (22 per cent oil) could be used at levels up to 34 per cent.

Muffins made with 60.5 per cent OE1-R3-F were improved greatly in overall quality by increasing the whole milk to 244

TABLE 14. EXPERIMENTAL FOOD FORMULAS USING PEANUT PRODUCTS TO REPLACE PORTIONS OF WHEAT FLOUR

Product and basic formula[1]		Peanut ingredient		Calculated protein[2]	Panel scores[3]			
		Product	Ratio used[4]		Appearance Ext.	Appearance Int.	Flavor	Overall
				Pct.	*1-10*	*1-10*	*1-10*	*1-10*
Applesauce cake				3.4[6]				
1 t. soda	1 c. sugar	OE1-R2-F	1 to 5	4.4	8.6	8.5	8.8	8.6
½ c. oatmeal	1 c. applesauce		1 to 2	5.4	8.0	7.5	7.3	7.2
1 t. cinnamon	1 egg		1 to 1	6.3	6.6	6.8	6.9	6.6
¼ t. nutmeg	1½ c. wheat flour	OE1-R3-F	1 to 5	4.4	8.0	8.1	8.3	8.2
½ c. margarine			1 to 2	5.4	6.8	7.9	8.1	7.6
			1 to 1	6.3	6.3	6.3	7.3	6.6
Apricot bread								
3 T. baking powder	1 egg			3.2[6]				
½ t. soda	½ c. apricots, dried	OE1-R3-F	1 to 3	5.0	8.1	8.1	8.1	8.0
¾ t. salt	½ c. orange juice		3 to 5	5.8	6.7	6.3	7.1	6.9
3 T. margarine	2 c. wheat flour							
1 c. sugar								
				4.8[6]				
Banana bread		OE1-R2-F	1 to 5	6.7	7.9	8.4	7.9	8.1
3½ t. baking powder	1 egg		1 to 2	8.7	7.5	7.1	7.6	7.3
1 t. salt	1 c. banana, mashed		1 to 1	10.6	6.8	6.1	6.1	6.0
1 c. sugar	3 c. wheat flour	OE1-R3-F	1 to 5	6.7	8.4	8.5	7.9	8.0
2 T. margarine			1 to 2	8.7	7.3	7.0	6.9	6.6
			1 to 1	10.6	5.6	6.4	6.4	5.9
				4.5[6]				
Butterscotch brownies		OE1-R2-F	1 to 3	6.8	7.8	7.8	7.6	7.5
½ t. baking powder	1 egg & 1 yolk		1 to 1	9.3	7.8	7.6	7.2	7.2
½ t. salt	½ t. vanilla		3 to 1	11.8	7.3	7.1	6.8	6.8
¼ c. margarine	1 c. wheat flour	OE1-R3-F	1 to 3	6.8	7.9	6.9	7.6	7.1
½ c. brown sugar, packed			1 to 1	9.3	7.0	7.0	7.1	7.1
			3 to 1	11.8	6.8	6.4	5.8	5.9
Butterscotch oatmeal crispies				5.6[6]				
½ t. soda	1 egg	OE1-R2-F	4 to 5	8.2	8.6	8.8	9.0	8.7
½ t. salt	½ t. vanilla		2 to 1	9.6	8.5	8.8	7.8	8.0
½ c. margarine	1½ c. quick-cooking rolled oats	OE1-R3-F	4 to 5	8.2	8.6	8.5	8.9	8.7
½ c. sugar			2 to 1	9.6	8.8	8.6	8.8	8.7
½ c. brown sugar, packed	1⅛ c. wheat flour							

Butterscotch pudding 1 4-oz. pkg. butterscotch pudding mix	2 c. milk (whole, fluid) 1⅓ T. wheat flour			3.0[6]				
		OE1-R2-F	[5]	3.4	8.1	8.6	7.9	8.0
		OE1-R3-F	[5]	3.4	8.7	9.0	8.5	8.6
Butterscotch pudding 1 4-oz. pkg. butterscotch pudding mix	2 c. and 1⅓ T. of milk (whole, fluid) 2 T. wheat flour			3.0[6]				
		OE1-R2-F	[5]	3.7	8.4	8.5	8.1	8.0
		OE1-R3-F	[5]	3.7	8.8	8.5	8.1	8.2
Chocolate cake ½ t. soda ½ t. salt ⅝ c. sugar ¼ c. margarine 1 egg	1 oz. unsweetend chocolate ½ c. buttermilk ½ t. vanilla ⅞ c. wheat flour			3.9[6]				
		OE1-R2-F	1 to 6	4.7	7.8	7.6	5.9	6.3
			2 to 5	5.5	7.5	7.3	7.4	7.4
			3 to 4	6.4	7.5	6.8	7.3	7.0
		OE1-R3-F	1 to 6	4.7	8.1	8.1	8.3	8.1
			2 to 5	5.5	7.6	7.8	7.8	7.9
			3 to 4	6.4	7.8	6.9	7.3	7.1
Chocolate pudding 1 6-oz. pkg. chocolate pudding mix	3 c. milk (whole, fluid) 2 T. wheat flour			3.5[6]				
		OE1-R2-F	[5]	4.0	8.6	8.6	8.3	8.2
		OE1-R3-F	[5]	4.0	8.6	8.5	8.5	8.3
Chocolate pudding 1 6-oz. pkg. chocolate pudding mix	3⅛ c. milk (whole, fluid) 3 T. wheat flour			3.6[6]				
		OE1-R2-F	[5]	4.2	8.4	8.1	7.0	7.4
		OE1-R3-F	[5]	4.2	8.4	8.0	7.4	7.5
Peanut-honey spread ¼ c. wheat flour ½ c. water	½ c. honey ¼ c. margarine			1.0[6]				
		OE1-R3-G	[5]	3.1	----	7.5	7.1	7.1
Peanut-honey spread ½ c. wheat flour 1 c. water	½ c. honey ¼ c. margarine			1.3[6]				
		OE1-R3-G	[5]	4.4	----	7.0	6.4	6.2
Peanut-honey spread ¾ c. wheat flour 1½ c. water	½ c. honey ¼ c. margarine			1.6[6]				
		OE1-R3-G	[5]	5.1	----	6.5	6.1	5.9
Peanut-honey-raisin spread ¼ c. wheat flour ½ c. water ¼ c. raisins	½ c. honey ¼ c. margarine			1.2[6]				
		OE1-R3-G	[5]	3.0	----	7.9	7.7	7.5
Peanut-honey-raisin spread ½ c. wheat flour 1 c. water ¼ c. raisins	½ c. honey ¼ c. margarine			1.4[6]				
		OE1-R3-G	[5]	4.2	----	7.3	6.4	6.3

(Cont. next page)

TABLE 14 *continued*. EXPERIMENTAL FOOD FORMULAS USING PEANUT PRODUCTS TO REPLACE PORTIONS OF WHEAT FLOUR

Product and basic formula[1]		Peanut ingredient		Calculated protein[2]	Panel scores[3]			
					Appearance		Flavor	Overall
		Product	Ratio used[4]		Ext.	Int.		
				Pct.	*1-10*	*1-10*	*1-10*	*1-10*
Peanut-honey-raisin spread ¾ c. wheat flour 1½ c. water ¼ c. raisins	½ c. honey ¼ c. margarine	OE1-R3-G	[5]	1.5[6] 4.9	----	6.6	6.3	5.9
Peanut-onion dip 1 T. wheat flour 2 T. water	¼ c. sour cream 1 T. onion soup mix, dry	OE1-R3-G	[5]	2.3[6] 4.0	----	7.9	7.8	7.6
Peanut-onion dip 2 T. wheat flour 4 T. water	¼ c. sour cream 1 T. onion soup mix, dry	OE1-R3-G	[5]	2.2[6] 4.9	----	8.4	7.6	7.7
Peanut-onion dip 3 T. wheat flour 6 T. water	¼ c. sour cream 1 T. onion soup mix, dry	OE1-R3-G	[5]	2.2[6] 5.3	----	7.9	6.8	6.9
Split pea soup 2 T. margarine 1½ c. split peas, cooked	2½ c. milk (whole, fluid) 6 T. wheat flour	OE1-R2-F	2 to 1	5.0[6] 5.9	----	9.0	8.7	8.6
		OE1-R3-F	2 to 1	5.9	----	9.0	8.1	8.1

[1] Portions of wheat flour ingredient in basic formula were replaced with peanut ingredient (usually flour) as indicated in third column.

[2] Calculated protein content of blended ingredients, based on: "Composition of Foods" by B. K. Watt and A. L. Merrill, USDA Agr. Handbook No. 8, December 1963.

[3] Scores range from 1 as very poor, to 6 as fair, to 10 as excellent.

[4] Ratio by volume of peanut ingredient to wheat flour.

[5] All of wheat flour in basic formula replaced with peanut ingredient.

[6] Protein content of product made with wheat flour without peanut flour substitution.

grams. The addition of 25 to 45 grams of sugar and 25 grams of raisins further improved the muffins.

Peanut Yeast Breads. Extensive experimentation with peanut loaf bread using 1 part OE1-R3-F to 7.5 parts of all purpose wheat flour by weight resulted in a highly acceptable product. Seven levels of hydrogenated shortening were tested to establish a satisfactory proportion.

A honey-flavored loaf was developed with an excellent aroma and flavor, as judged by the taste panels; however, the texture was heavy and further adaptation of the formula would be necessary for a standard product.

A peanut-onion French bread mix was tested for shelf life. After 1 month of storage of this mix at room temperature (75° F.) the finished product did not produce a typical loaf shape when allowed to rise, although the flavor after baking was acceptable. Therefore, the study was terminated.

Breads containing candied orange rind with several variations were tested and found to be acceptable.

Commercial-Type Yeast Breads. Four desirable high-protein breads based on a commercial formula supplemented with different peanut flours were developed *(4)*.

Replacement of wheat flour with peanut flour at 13 per cent by weight increased the crude protein content of the bread from approximately 9 to 14 per cent. The taste panel rated the bread containing the roasted solvent-prepared flour as the most desirable.

Commercial-Type Ice Creams. Peanut flavored ice creams were prepared similarly to commercial products and packaged in individual cups for consumer-preference testing. Six formulas were tested in which defatted flours and other peanut products were used as additives in a basic commercial ice cream mix, Table 15. Coarsely ground (50 mesh) peanut flour was used in formulas I and II, whereas finely ground (140 mesh) peanut flour was used in the other formulas.

Of 66 panelists who compared formulas I and II, 97 per cent preferred formula II, containing the coarse flour and smooth peanut butter, over formula I, containing a higher rate of the coarse flour without peanut butter. A grainy texture caused by the coarse flour was objectionable to the panelists, but it was less objectionable in formula II than in formula I. Formula III contained fine flour and peanut grits whereas formula IV contained fine

TABLE 15. EXPERIMENTAL FORMULAS FOR ICE CREAM UTILIZING PEANUT PRODUCTS

Formula	Peanut additives[1]			
	Defatted flour or grit		Peanut butter or brittle	
	Product	Amount	Product	Amount
		Lb.		*Lb.*
I[2]	OE4-R3-F	4.0	None	----
II[2]	OE4-R3-F	2.6	Smooth peanut butter	2.6
III	OE2-R3-F	2.6	None	----
	OE4-R3-G	3.0		
IV	OE2-R3-F	2.6	Smooth peanut butter	2.0
V	OE2-R3-F	2.6	Crunchy peanut butter	2.0
VI	OE2-R3-F	2.6	Crushed peanut brittle	2.0

[1] Peanut products and amounts added to 5 gallons of commercial ice cream mix.
[2] Flour used in formulas I and II was coarsely ground (50 mesh). Flour used in other formulas was finely ground (140 mesh).

flour and smooth peanut butter. Of 69 panelists who tasted formula III, 51 per cent liked the product, 13 per cent disliked it, and 36 per cent did not express an opinion. Thirty-eight per cent stated that they would buy the product if it were on the market and 57 per cent indicated that they would not. Of 114 panelists who tasted formula IV, 79 per cent liked the product, 13 per cent disliked it, and 8 per cent did not indicate a like or dislike. Seventy-four per cent stated that they would buy the product if it were on the market and 21 per cent indicated that they would not.

Formulas V and VI were compared by 112 panelists. Forty-three per cent preferred formula V, containing the fine flour and crunchy peanut butter, 49 per cent preferred formula VI, containing the fine flour and crushed peanut brittle, and 8 per cent did not express a preference. Fifty-three per cent indicated that they would buy formula V, and 50 per cent indicated they would buy formula VI.

Uses of Defatted Flours in Breakfast Cereal Flakes

There is little published information on methods of cereal flake production. Most of the technology has been developed by commercial processing firms for private use.

The research reported in this bulletin includes use of defatted peanut flours in making a high protein, cooked breakfast cereal in flake form. The objectives were to establish formulas and processes for making such flakes with physical properties similar to those of flakes presently produced in the United States and to determine the effects of the peanut flour on acceptability. A total of 118 tests were made involving variations in the defatted peanut flours, rates used, formulations, and processes.

Drum-drying of dough formulations in a continuous sheet and then fragmenting the sheet did not produce desirably shaped flakes. When doughs were made into pellets and then drum-dryed there was a tendency for the flakes to split as the drums separated at the nip, producing two flakes, each with one smooth and one rough side. Splitting was prevented by air drying of the material for 3 minutes at 250° F. before drum-drying, but the flakes thus formed lacked textural qualities.

A further series of experiments were conducted to improve flake texture. The dry ingredient proportions were held constant and moisture levels, drying and heating treatments, and flake thicknesses were varied. One test resulted in a flake with improved texture and flavor. The formula for that test was:

Wheat flour, all purpose	300 grams
Peanut flour, fully roasted, 12% fat	200 grams
Water	400 grams
Molasses	25 grams
Corn syrup	25 grams
Sugar	32 grams
Salt	10 grams

The dough was extruded in cylindrical strips onto stainless steel trays and dried in a forced air oven at 250° F. for 3 minutes. After drying, the strips were cut into pellets and cold rolled into flake form on the drum dryer with a roller separation of 0.006 inch. The flakes had approximately 36 per cent moisture after rolling. The flakes were then spread out on wire screening and subjected to infrared rays for 30 seconds in a household toaster oven. This oven was equipped with top and bottom heating elements and mirrored interior surfaces. Flash heating caused blistering and puffing of the flakes and reduced the moisture content to approximately 13 per cent. The final step was drying in a forced air oven at 325° F. for 5 minutes to a moisture content of approximately 3 per cent.

Experiments were also conducted to determine the effect of the peanut flour per se on the flavor, color, and texture of the finished flake. Increasing the proportion of peanut flour to wheat flour resulted in higher acceptance up to a ratio of 3 parts peanut flour to 2 parts wheat flour, Table 16.

TABLE 16. EFFECTS OF INCREASING PROPORTIONS OF PEANUT FLOUR TO WHEAT FLOUR ON RELATIVE ACCEPTABILITY OF FLAKES

Formula	Ingredients[1]		Relative acceptance score[2]
	Wheat flour	Peanut flour	
	Grams	*Grams*	
50	250	0	5
51[3]	150	100	3
52	125	125	2
53	100	150	1
54	0	250	4

[1] In all formulas 200 grams of water, 12.5 of molasses, 12.5 of corn syrup, 16 of sugar, and 5 of salt were used.
[2] Scores are average evaluations by five trained panelists. Products were ranked in order of preference (1 most acceptable, 5 least acceptable).
[3] Same as formula 46.

Other experiments were conducted in the search for a flake with crisper texture, better flavor, color, and other properties which would compare more favorably with existing commercial flakes. Variations were made in ingredients, flake thickness, infrared drying, and dough handling method. Two trials resulted in flakes with texture, flavor, and color most nearly like those of commercial flakes. Formulas and processes for these trials are presented in Table 17.

TABLE 17. FORMULAS AND PROCESSES FOR BREAKFAST CEREAL FLAKES

Ingredient	Formula 97[1]	Formula 113[2]
	Grams	*Grams*
Peanut flour OE1.5-OS1-R3-F	200	------
Peanut flour OE1.5-S10-R1-F	------	200
Yellow corn flour	150	150
Whole wheat flour	100	100
Wheat germ ground to flour	50	50
Molasses	50	----
Malt syrup	----	[2]
Sucrose	30	75
Salt	15	15
Water	525	400

[1] Dough was autoclaved for 10 minutes at 20 p.s.i. steam pressure with a 15-minute pressure reducing period. After cooling, the dough was cold-rolled into flakes, approximately 0.002 inch thick. Rolled flakes were toasted in infrared rotisserie oven to about 3 per cent moisture.
[2] Dough was autoclaved for 10 minutes at 20 p.s.i. steam pressure with a 15-minute pressure reducing period. After cooling, 10 per cent by weight of malt syrup was blended with the dough and the mixture cold-rolled into flakes approximately 0.002 inch thick. Rolled flakes were toasted in infrared rotisserie oven to about 3 per cent moisture.

ANALYTICAL STUDIES

Chemical Procedures

Analyses for total protein, fat, and moisture as well as extensive shelf life studies were conducted on selected peanut flours, meals, and grits and on the finished products containing them.

Standard AOAC procedures were used for protein, fat, and moisture determinations. Free fatty acid percentages and peroxide values of the oils extracted from samples were used as indicators of hydrolytic and oxidative rancidity, respectively. Many of the off-flavors and odors produced during storage in foods containing oil have been traced to compounds formed in the oil as a result of rancidity. The higher the concentration of oil in the food, the more important these rancid off-flavors are in evaluation of storage stability or freshness of foods. In these studies, peanut products with oil concentrations from less than 1 per cent to greater than 20 per cent were evaluated by both chemical procedures and by taste panels.

Taste Panel Testing

Taste and odor characterization was accomplished by means of a small panel, usually five members, trained to detect small differences in flavor between peanut products differing in composition or storage history. A 1-10 scale was used with 1 as very poor, 6 as acceptable, and 10 as excellent fresh peanut flavor.

Taste tests on dry flours were complicated by the dusty nature of the product, the gummy effect in the mouth, and the fact that flours are not normally eaten by themselves but as an ingredient in finished foods. To overcome these complications a test formula was developed in which the flour was mixed with other ingredients to form a paste-like mixture more suitable for tasting than dry flour. Salt and sugar used in the mixture enhanced the overall flavor and made the panelists more alert to off-flavors in the peanut flour. The formula was as follows:

2 tablespoons peanut flour
2 teaspoons cane sugar
1/4 teaspoon salt
1 2/3 teaspoons water

Products containing peanut flours were tasted in the finished form.

Shelf Life Studies

Expeller Cake Products. Table 18 is an outline of a shelf life study on peanut flours, meals, and grits made from expeller cakes. Variables applied were storage temperature, packaging material, nitrogen versus air atmosphere in packages, and initial moisture and oil content of samples. At intervals sealed packages were removed from storage and chemical and organoleptic tests were carried out. Data were collected to determine the extent of changes in moisture, free-fatty acid, peroxide value, or flavor score. Samples from all treatments in the first storage study were evaluated after approximately 10 weeks, 20 weeks, and 32 weeks of storage as shown in Appendix III, Tables 1-4.

Table 19 is a summary of the data collected from the samples stored in air atmosphere, glass containers, at 75° F. After 10 weeks of storage there were essentially no changes in flavor scores or oil composition. Moisture changes were minor in products stored in glass containers and were probably due to initial variations in samples tested. Moisture gains in the Saran-packaged flours of low moisture content (2 and 3.5 per cent) were consistent, and slight losses of moisture occurred in the Saran-packaged flour of 8.5 per cent initial moisture. There was a marked increase in free fatty acid content in the higher moisture content roasted flours, product numbers 10, 11, 12 and in the applesauce peanut flour mixture, number 14. The applesauce peanut flour mixture also showed higher peroxide values.

The products were again examined after the second 10 weeks of storage. Moisture and total oil analyses were not carried out on the products packaged in glass since essentially no changes were found after the first 10 weeks of storage. Analyses on the Saran-packaged flours indicated a slight loss of moisture in the second 10 weeks of storage in the flours stored at 75° F. and essentially no change in the flours stored at 32° F. There were some gains and some small decreases in free fatty acid content of the flours during the second 10 weeks of storage but the changes were not consistent. The increases in peroxide values were more consistent but less than they were during the first 10 weeks of storage. There were no changes in flavor detectable by organoleptic means as indicated by the average flavor scores. Generally, there seemed to be less overall change in the flours during the second 10 weeks of storage than in the first as indi-

TABLE 18. OUTLINE OF SHELF LIFE STUDY ON PEANUT FLOURS, MEALS, AND GRITS MADE FROM OIL EXPELLER CAKES[1]

Processing treatments

Treatment no.	Product	Roasting[2]	Oil extraction[2]	Oil content	Moisture content	Other treatment
				Pct.	*Pct.*	
1	Flour	R1	OE1	7.8	8.0	None
2	Flour	R2	OE1	7.6	5.0	None
3	Flour	R3	OE1	7.8	3.5	None
4	Flour	R3	OE2	11.8	3.5	None
5	Flour	R3	OE3	16.6	3.5	Drum dried
6	Flour	R3	OE4	21.6	3.5	Drum dried
8	Flour	R3	OE1	7.8	2.0	Flour dried 2 hrs., 158°F. 29" vac.
9	Flour	R3	OE1	7.8	6.8	Flour held 24 hrs. above water in closed container, 80° F.
10	Flour	R3	OE1	7.8	8.5	Flour held 15 min. in saturated steam, 212° F.
11	Meal	R3	OE4	22.5	8.0	None
12	Grit	R3	OE4	22.0	8.0	None
13	Flour	R3	OE1	7.8	3.5	200 p.p.m. Tenox added when packaged.
14	Flour	R3	OE3	12.8	2.5	Applesauce-peanut combination, drum dried.

Packaging and storage conditions

Treatment no.	Container	Atmosphere	Storage temperature	Code
1-14	Glass	Air	75°F.	GA-75
1-14	Glass	Air	32°F.	GA-32
1-14	Glass	Nitrogen	75°F.	GN-75
1-14	Glass	Nitrogen	32°F.	GN-32
3,8,10	Saran	Air	75°F.	SA-75
3,8,10	Saran	Air	32°F.	SA-32
3,8,10	Saran	Nitrogen	75°F.	SN-75
3,8,10	Saran	Nitrogen	32°F.	SN-32

[1] Products were prepared from peanut supply purchased in February 1966. Study initiated May 26, 1966.
[2] See Table 2 for explanation of symbols.

cated by free fatty acid and peroxide values, and still no changes detectable by organoleptic means.

The fourth and final examination was made on the flours, meals, and grits after 32 weeks of storage. Results indicated substantial increases in both free fatty acid and peroxide values in many samples, and in most of these there was a corresponding decrease in flavor rating. Since the samples were prepared with varying moisture and oil levels, and with degrees of roasting from raw to fully

TABLE 19. SHELF LIFE STUDY RESULTS FROM PEANUT FLOURS, MEALS, AND GRITS FROM OIL EXPELLER CAKE[1]

Product treatment[5]	Flavor scores[2]				Free fatty acids[3]				Peroxide values[4]			
	Begin SL study	After 10 wk.	After 20 wk.	After 32 wk.	Begin SL study	After 10 wk.	After 20 wk.	After 32 wk.	Begin SL study	After 10 wk.	After 20 wk.	After 32 wk.
1	5.4	5.0	5.0	5.2	.40	.58	.62	.80	2.8	6.0	7.0	13.1
2	7.0	7.0	5.7	6.5	.42	.59	.54	.26	2.8	6.5	6.5	7.4
3	7.8	7.5	7.0	5.0	.58	.69	.66	.26	3.0	12.0	12.0	117.3
4	8.2	7.6	6.8	3.2	.60	.76	.63	.16	3.0	12.0	11.5	182.2
5	8.5	7.0	6.5	6.0	.60	.77	.60	.30	3.0	13.0	13.0	95.0
6	8.7	7.4	6.5	4.5	.60	.70	.79	.42	3.0	14.0	13.5	164.3
8	8.8	8.0	6.7	5.5	.58	.67	.62	.38	3.0	12.0	13.0	107.1
9	8.0	7.5	7.8	7.0	.58	.70	.62	.43	3.0	13.0	13.0	83.1
10	7.8	7.0	6.0	5.2	.58	.84	.92	.75	3.0	14.0	13.0	16.1
11	5.6	5.4	5.5	4.7	.58	.81	.90	1.20	3.0	13.0	13.5	12.8
12	6.1	6.0	6.7	5.0	.58	.82	.90	.62	3.0	13.0	14.0	37.2
13	7.8	7.5	8.0	6.1	.58	.70	.61	.25	3.0	13.0	13.0	73.2
14	8.9	8.5	8.5	4.0	.64	.84	.79	.31	4.0	18.0	17.0	24.2

[1] Products stored in darkness in sealed glass containers at 75° F.—no inert atmosphere used.
[2] Scores range from 1 as very poor, to 6 as fair, to 10 as excellent.
[3] Calculated as per cent oleic acid in the oil fraction.
[4] Milliequivelants of peroxide per kilogram of oil.
[5] See Table 18 for specific treatments.

roasted, it was difficult to compare flavor changes. In some cases, lack of correlation of flavor scores with peroxide or free fatty acid values may have resulted from strong roasted peanut flavors masking the rancid flavors. The following conclusions were drawn from this study: (1) refrigeration and nitrogen atmosphere help to retain the fresh odors and flavors of peanut flours, meals, and grits during storage, but adequate retention of freshness can be expected for at least 5 months if the flours are kept in sealed containers at 75° F. and protected from light; (2) the so-called induction period, or period of slow development for peroxides in the oils of peanut flours, meals, and grits, lasts for at least 5 months at 75° F. storage and ends sometime between the fifth and the eighth month; (3) moisture and oil levels within the limits normally to be expected in peanut flours, meals, and grits apparently do not greatly affect the rate of development of rancidity in those products.

Shelf Life Study on Solvent Extracted Flours. Since solvent extracted flours were not included in the first shelf life study, a subsequent study was initiated as outlined in Table 20. Objectives

TABLE 20. OUTLINE OF SHELF LIFE STUDY ON PEANUT FLOURS MADE FROM OIL EXPELLER CAKES FURTHER DEFATTED BY SOLVENT EXTRACTION

Storage inspection interval	Storage and treatment number	Flour specifications[1]
Three months	Glass-air, 32° F.	
	1	OE1.5-OS1-DS10-R1-F-MO4.6
	2	OE1.5-OS1-DS10-R3-F-MO1.5
	3	OE1.5-OS2-DS10-R1-F-MO4.7
	Glass-air, 75° F.	
	4	OE1.5-OS1-DS10-R1-F-MO4.6
	5	OE1.5-OS1-DS10-R3-F-MO1.5
	6	OE1.5-OS2-DS10-R1-F-MO4.7
Six months	Glass-air, 75° F.	
	7	OE1.5-OS1-DS10-R1-F-MO6.1
	8	OE1.5-OS1-DS10-R1-F-MO7.3
	9	OE1.5-OS1-DS10-R1-F-MO9.3
	10	OE1-S10-R1-F-MO5.2
	11	OE2-S10-R1-F-MO5.8
	12	OE3-S10-R1-F-MO4.0
	Glass-nitrogen, 75° F.	
	13	OE1.5-OS1-DS10-R1-F-MO4.6
	14	OE1.5-OS2-DS10-R1-F-MO4.7
One month	Glass-air, 104° F.	
	15	OE1.5-OS1-DS10-R1-F-MO4.6
	16	OE1.5-OS1-DS10-R3-F-MO1.5
	17	OE1.5-OS2-DS10-R1-F-MO4.7
	18	OE1-S10-R1-F-MO5.2
	19	OE2-S10-R1-F-MO5.8
	20	OE3-S10-R1-F-MO4.0

[1] For explanation of symbols see Table 2.

were to determine shelf life characteristics of peanut flours under the following conditions:

(1) Solvent extracted flours with two oil levels, two moisture levels at two storage temperatures, and with two degrees of roasting.
(2) Flours made from expeller cake without further oil extraction but with steam scrubbing to remove raw peanut flavor.
(3) Solvent extracted flours stored in nitrogen atmosphere.
(4) Flours stored at 104° F.

Table 21 shows results of the first and second examinations as compared with the initial determinations of free fatty acid, peroxide, and flavor ratings. After 3 months of storage there was essentially no change in flavor scores and very little development of rancidity as indicated by free fatty acid content and peroxide value. Up to this point the higher storage temperature of 104° F. did not seem to have increased rancidity over the 75° F. storage.

TABLE 21. RESULTS OF SHELF LIFE STUDY ON PEANUT FLOURS FROM OIL EXPELLER CAKES FURTHER DEFATTED BY SOLVENT EXTRACTION

Treatment no.[4]	Flavor score[1]			Free fatty acid[2]			Peroxide value[3]		
	Begin SL study	After 3 mos.	After 14 mos.	Begin SL study	After 3 mos.	After 14 mos.	Begin SL study	After 3 mos.	After 14 mos.
1	8.1	8.3	7.0	1.08	.28	----	7.9	12.4	15.2
2	6.8	7.8	8.0	.70	.20	----	9.5	14.9	19.2
3	8.3	7.8	7.0	.61	.20	----	10.4	12.0	43.5
4	8.1	8.2	7.0	1.08	.59	----	7.9	13.0	26.7
5	6.8	7.7	8.0	.70	.22	----	9.5	43.5	58.6
6	8.3	7.8	7.0	.61	.35	----	10.4	44.3	61.9
7	8.1	----	7.0	1.08	----	----	7.9	------	49.6
8	8.1	----	8.0	1.08	----	----	7.9	------	51.2
9	8.1	----	7.0	1.08	----	----	7.9	------	44.7
10	7.4	----	8.0	.38	----	----	26.7	------	91.9
11	8.3	----	7.0	.33	----	----	28.7	------	82.9
12	7.5	----	7.0	.23	----	----	25.8	------	56.2
13	8.1	----	7.0	1.08	----	----	7.9	------	97.2
14	8.3	----	7.0	.61	----	----	10.4	------	61.8
15	8.1	7.5	4.0	1.08	----	----	7.9	22.5	------
16	6.8	7.5	6.0	.70	.28	----	9.5	23.1	------
17	8.3	7.7	4.0	.61	.32	----	10.4	49.9	------
18	7.4	7.7	----	.38	.22	----	26.7	29.0	------
19	8.3	7.7	----	.33	.23	----	28.1	31.5	------
20	7.5	7.7	----	.23	.12	----	25.8	46.1	------

[1] Scores range from 1 as very poor to 6 as fair to 10 as excellent.
[2] Calculated as per cent oleic acid in oil fraction.
[3] Milliequivalents of peroxide per kilogram of oil.
[4] See Table 20 for specific treatments.

The second and final test was made after approximately 14 months of storage. There were no detectable differences in flavor scores on solvent extracted flours stored at 32° F. or 75° F. in air or nitrogen. All of these samples were still acceptable organoleptically. Furthermore, flours with three higher oil levels (treatment numbers 10, 11, and 12) made from steam scrubbed expeller cakes and stored in air at 75° F. were still acceptable on flavor score. All products stored at 104° F. were totally unacceptable and had strong off-flavors not identified as the usual rancid oil flavor.

Shelf Life Studies on Mixes. Six mixes were prepared in quantities sufficient for initial baking and subsequent preparation at six 8-week intervals. Mixes were packaged in pint jars and 5x9-inch Saran bags and stored at 75° F. and at 40° F. At intervals of 8 weeks mixes from each treatment were removed from storage and prepared in standard fashion for each baked product. The prepared products were examined organoleptically, and samples from each package were analyzed for free fatty acids and peroxides.

Tables 22 and 23 show the results of the chemical analyses through the six 8-week periods. Formulas for the mixes are included in Appendix I. Consistent increases in rancidity of the lipid fraction of all the mixes are indicated by free fatty acid and peroxide values. The data indicate some retardation of rancidity in glass over Saran packages and also at 40° F. versus 75° F. storage. However, all the products remained organoleptically acceptable throughout the storage test. While the date-muffin mix and plain muffin mixes did not change in character during the storage test, these mixes were not judged highly acceptable regarding general characteristics of good bakery products. The muffins were heavy in texture and the pronounced peanut odor was somewhat undesirable.

Effect of Peanut Flours on Protein Content

Total crude protein in bakery products was calculated on the basis of the analyses by the macro-Kjeldahl method and is shown in Table 24. Table 25 is an example of this type of calculation using the protein values from Table 24 to calculate the final crude protein of finished yeast breads.

SUMMARY

Peanut utilization research was conducted through coordinated efforts of the Departments of Horticulture and Home Economics Research. Shelled, U.S. No. 1 grade runner-type peanuts were

TABLE 22. FREE FATTY ACID OF SELECTED PRODUCTS CONTAINING PEANUT FLOUR STORED IN TWO TYPES OF CONTAINERS AND AT TWO TEMPERATURES DETERMINED AT 8-WEEK INTERVALS[1]

Food mix and storage treatment[2]	Weeks stored						
	0	1	2	3	4	5	6
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Applesauce cake							
Glass—75°F.	.61	.82	.95	.94	1.36	1.21	3.86
Glass—40°F.	.61	.64	.61	.58	.58	.79	.77
Saran—75°F.	.61	.74	.92	1.02	1.45	1.52	1.60
Saran—40°F.	.61	.63	.68	.67	.80	.78	.67
Butterscotch brownie mix							
Glass—75°F.	.25	.57	.69	.81	1.10	1.25	.83
Glass—40°F.	.25	.52	.45	.38	.58	.85	.60
Saran—75°F.	.25	.53	.58	.74	.92	1.01	1.00
Saran—40°F.	.25	.53	.40	.27	.61	.63	.47
Chocolate cake							
Glass—75°F.	.30	.39	.48	.43	.53	.59	.74
Glass—40°F.	.30	.42	.50	.43	.51	.47	.48
Saran—75°F.	.30	.38	.45	.48	.56	.55	.66
Saran—40°F.	.30	.39	.42	.40	.57	.53	.52
Muffins (with dates)							
Glass—75°F.	.21	.21	.29	.32	.29	.39	.35
Glass—40°F.	.21	.21	.23	.23	.31	.37	.31
Saran—75°F.	.21	.19	.19	.28	.36	.31	.31
Saran—40°F.	.21	.21	.22	.26	.38	.29	.30
Muffins (without dates)							
Glass—75°F.	.24	.23	.18	.39	.30	.55	.43
Glass—40°F.	.24	.21	.22	.71	.44	.37	.50
Saran—75°F.	.24	.20	.18	.72	.34	.30	.60
Saran—40°F.	.24	.17	.22	.33	.43	.39	.37
Oatmeal cookies							
Glass—75°F.	.21	.30	.42	.52	.73	.75	.86
Glass—40°F.	.21	.23	.33	.32	.38	.38	.45
Saran—75°F.	.21	.33	.37	.53	.65	.84	.89
Saran—40°F.	.21	.28	.31	.39	.38	.49	.39

[1] Calculated as per cent oleic acid in the oil fraction.
[2] Formulas for food mixes given in Appendix I.

used to make edible flours, meals, and grits with different levels of residual oil and different amounts of roasting. These were tested for shelf life and evaluated as ingredients in food products.

Screw-pressing studies were made using a Hander Model 52 oil expeller. Level and equilibration of moisture in peanuts, as well as processing temperature and expeller adjustments, greatly affected operations. A boiling water dip method was developed for conditioning peanuts for mechanical blanching. Conventional blanching equipment proved satisfactory for deskinning the conditioned peanuts. Moisture content ranging from 5.8 to 7 per cent was optimum for producing cakes with relatively low oil content (7 to 8 per cent). Cakes with higher residual oil (up to 26 per cent) were produced by pressing peanuts with higher moisture content

TABLE 23. PEROXIDE VALUES OF SELECTED PRODUCTS CONTAINING PEANUT FLOUR STORED IN TWO TYPES OF CONTAINERS AND AT TWO TEMPERATURES DETERMINED AT 8-WEEK INTERVALS[1]

Food mix and storage treatment[2]	Weeks stored						
	0	1	2	3	4	5	6
Applesauce cake							
Glass—75°F.	4.49	3.78	4.98	11.25	7.77	24.89	22.41
Glass—40°F.	4.49	3.99	4.73	8.19	6.16	18.64	8.55
Saran—75°F.	4.49	4.96	4.57	5.99	6.28	18.83	10.83
Saran—40°F.	4.49	4.61	5.83	7.35	5.69	18.99	12.42
Butterscotch brownies							
Glass—75°F.	1.71	2.41	6.04	10.06	28.39	10.20	13.89
Glass—40°F.	1.71	1.68	2.06	14.20	14.67	10.72	11.11
Saran—75°F.	1.71	3.95	9.58	17.27	23.10	12.30	16.22
Saran—40°F.	1.71	4.15	1.69	13.99	12.06	.98	10.61
Chocolate cake							
Glass—75°F.	1.29	4.61	3.74	18.02	12.23	17.63	12.29
Glass—40°F.	1.29	4.66	3.15	9.91	10.02	12.74	9.23
Saran—75°F.	1.29	2.74	7.89	11.06	13.64	24.58	10.58
Saran—40°F.	1.29	3.02	5.17	7.62	10.76	17.96	8.26
Muffins (with dates)							
Glass—75°F.	2.64	11.18	12.44	8.94	15.12	25.33	11.87
Glass—40°F.	2.64	11.35	12.97	7.47	11.79	24.53	13.89
Saran—75°F.	2.64	12.75	9.78	14.76	11.43	8.91	5.99
Saran—40°F.	2.64	10.54	8.83	36.70	13.79	13.19	16.12
Muffins (without dates)							
Glass—75°F.	3.22	7.55	16.41	19.16	34.99	14.91	21.68
Glass—40°F.	3.22	7.26	9.97	46.78	24.91	9.75	19.51
Saran—75°F.	3.22	6.52	13.23	63.20	39.27	13.39	25.89
Saran—40°F.	3.22	7.28	18.96	18.79	23.30	15.33	19.48
Oatmeal cookies							
Glass—75°F.	1.63	1.56	6.42	28.50	11.85	12.15	6.60
Glass—40°F.	1.63	1.32	3.96	27.01	5.01	8.16	7.51
Saran—75°F.	1.63	2.68	11.15	27.25	11.79	8.53	5.56
Saran—40°F.	1.63	2.06	1.54	7.58	3.72	7.99	11.10

[1] Milliequivelants of peroxide per kilogram of oil.
[2] Formulas for food mixes given in Appendix I.

and/or using more clearance on expeller aperture. Screw pressing fully roasted peanuts resulted in excessive extrusion of the cake between the expeller bars. Oil level in expeller cake was further reduced to less than 1 per cent by three-step hexane extraction involving either mechanical stirring or rolling in a container. The rolling method proved more satisfactory. Scrubbing with steam was effective in desolventizing the cake as well as in removing raw peanut flavor. Roasted flavors were obtained by steam or dry heat treatments of expeller or solvent extracted cakes. Intensity of roasted flavor increased with increase in cake oil content. An Alpine impact stud mill proved successful for grinding cakes to flour fineness when the oil content was less than 16 per cent. Cakes with higher oil content were ground successfully after subjecting them to a special drum-drying treatment.

TABLE 24. PROTEIN ANALYSIS PERCENTAGES USED IN CALCULATIONS OF PROTEIN INCREASES IN PEANUT PRODUCTS

Product	Protein content
	Pct.
OE1-R3-F	51.4
OE2-R3-F	50.0
OE3-R3-F	47.2
OE4-R3-F	44.8
Plain wheat flour	10.5
OE3-R3-M	42.4
OE3-M-DD	37.9
OE4-G	32.8
OE4-G-DD	36.9
OE4-M	41.6
OE1-R1-F	48.6
OE1-R2-F	50.8
Beatreme A	8.0
Applesauce—peanut flour	34.4
Beatreme CS	6.2
Beatreme 2255	4.5

TABLE 25. CRUDE PROTEIN CONTENT OF FOUR BREADS MADE WITH WHEAT AND PEANUT FLOURS (WET BASIS) *(4)*

Bread no.	Peanut flour		Wheat flour, amount used	Crude protein content
	Flour preparation	Amount used		
		Grams	*Grams*	*Pct.*
1	OE1-R3-F	60	400	11.4
2	OE1-R3-F	70	380	12.8
3	OE1-S10-R1-F	60	400	14.0
4	OE1-S10-R3-F	60	400	14.5
5	----	0	487	9.3

In shelf life studies, flours kept well for at least 5 months at 75° F. and for more than a year at 32° F.

The defatted products were used experimentally in more than 100 foods including bakery goods, spreads, dips, soups, meat dishes, confections, ice cream, yeast breads, breakfast cereal flakes, and snacks. The lower oil level flours and raw or partially roasted flours had slightly better mixing qualities than the flours with higher oil level or full roasting treatment. An unroasted flour, steam scrubbed to remove raw flavor, was preferred in many of the products.

The roasted peanut flavor of even the most highly flavored flours was not carried over into the cooked finished products. In all the bakery products, however, peanut flours contributed to a noticeable flavor character which was usually considered desirable. In uncooked products such as ice cream, the roasted peanut flavor contribution of the flours was highly desirable.

Many formulas were developed for use of the defatted peanut products in commercial mixes and home recipes.

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APPENDIX I

Prepared Food Mixes Containing Defatted Peanut Products

Applesauce Cake Mix

Mix ingredients

	Grams		*Grams*
Beatreme CS[1]	24	margarine	18
Beatreme 2255	18	spice mix[2]	4
wheat flour	110	sugar	196
soda	4	salt	5
quick-cooking rolled oats			44
peanut-applesauce flour-DD[3]			150

Finished product

When used, add 1 medium egg and 1¾ c. of water to mix and beat well. Pour in well greased loaf pan and bake at 375°F. for 75 min.

Chocolate Cake Mix

Mix ingredients

	Grams		*Grams*
sugar	216	soda	7
all-purpose flour	134	cocoa	32
OE1-R3-F	44	salt	1.4
Beatreme 2255	21	Beatreme CS	77
non-fat milk solids			15

Finished product

When used, add 1 medium egg, ⅔ c. of water, 2 t. vanilla and beat 1 min. Add 1 medium egg and ⅔ c. of water and beat 2 min. Pour into 2 greased and floured pans (8 x 8 inches) and bake at 350° F. for 25 to 30 min.

Biscuit Mix

Mix ingredients

	Grams		*Grams*
wheat flour	130	salt	4.8
OE1-R3-F[4]	115	Beatreme CS	90
baking powder	10.2	Beatreme 2255	30
non-fat milk solids			15

Finished product

When used, add 1 medium egg and ¾ c. water to mix (all at once), and stir until dough clings together. Knead lightly on floured surface 12 times. Roll out ½ inch thick. Bake at 425° F. for 12 to 15 min.

Scone Mix

Mix ingredients

	Grams		*Grams*
OE1-R3-F[5]	115	salt	6.5
baking powder	15	flour	130
Beatreme 2255	15	sugar	45
Beatreme CS	45		
non-fat milk solids			12

Finished product

When used, add 1 medium egg, slightly beaten and ½ c. of water. Stir in egg and water to make a soft dough. Knead gently on lightly floured surface about ½ min. Roll out ¼ inch thick and cut in diamonds or triangles. Brush with melted butter and sprinkle wtih sugar. Bake at 425° F. 10 to 12 min.

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[1] Beatreme furnished by Beatrice Foods Co., Chicago. Emulsifyer adjunct containing 60 to 73 per cent emulsified shortening with nonfat milk solids, mono and diglycerides and vegetable gum.

[2] Spice mix contains: 18 per cent ginger, 4 per cent nutmeg, and 78 per cent cinnamon.

[3] 3 parts OE3-R3-M to 1 part applesauce, water added to form slurry, then drum-dried to 3 per cent moisture.

[4] Acceptable mixes were also prepared and tested using OE2-R3-F or OE3-R3-F to replace the OE1-R3-F.

[5] Acceptable mixes were also prepared and tested using OE2-R3-F, OE3-R3-F or OE4-R3-F to replace the OE1-R3-F.

Nut Bread Mix

Mix ingredients

	Grams		Grams
OE4-R3-F	60	sugar	222
Beatreme 2255	8	flour	145
Beatreme CS	25	salt	3
baking powder	1.5	soda	2.5

Finished product[6]

When used, add 2 medium eggs, 1¾ c. water, 1½ t. vanilla, ½ c. chopped nuts, mix all ingredients well and bake in well greased, loaf pan 9 x 5 x 3 inches, at 350° F. for 90 min.

Date-Bran Muffin Mix

Mix ingredients

	Grams		Grams
OE1-R3-F[5]	20	chopped dates	90
light brown sugar	35	Beatreme CS	10
baking powder	4.5	all-bran cereal	30
all-purpose flour	30	salt	1.5

Finished product

When used, combine ½ c. milk with 1 medium egg, beaten, and add all at once to mix. Stir just until blended. Pour into 6 well greased muffin pans and bake at 400° F. 25 to 30 min.

Date Muffin Mix

Mix ingredients

	Grams		Grams
OE1-R3-F[5]	168	salt	6.4
Beatreme CS	20	sugar	50
non-fat milk solids	30	baking powder	14.5
all-purpose flour	110	dates, cut-up	100

Finished product

When used, combine 1 c. milk with 1 medium egg, beaten, and add all at once to mix. Stir just until blended. Pour into 12 well greased muffin cups and bake at 400° F. 25 to 30 min.

Date Nut Loaf Mix

Mix ingredients

	Grams		Grams
OE1-R3-F[4]	85	dates, cut-up	227
all-purpose flour	165	soda	8
light brown sugar	125	salt	3.5
		Beatreme CS	10

Finished product

When used, pour 1⅓ c. boiling water over dates. Cool. Add 1 medium egg, cooled dates, and water to mix and stir well. Pour in well greased loaf pan 9 x 5 x 3 inches and bake at 350° F. 60 min.

Butterscotch Brownie Mix

Mix ingredients

	Grams		Grams
Beatreme A	25	salt	3.5
Beatreme 2255	7	baking powder	0.8
brown sugar	210	flour	55
OE3-R3-M-DD[7]	45		

Finished product

When used, add 1 medium egg plus 1 yolk, ¼ c. water, and 1 t. vanilla. Mix well and pour into well greased square pan (8 x 8 inches). Bake at 350° F. 25 to 30 min.

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[6] To finish the product as banana nut bread include ½ c. of mashed ripe bananas with the added ingredients.

[7] An acceptable mix was also prepared and tested, using OE2-R3-F to replace the OE3-R3-M-DD.

Brownie Mix

Mix ingredients	Grams		Grams	Finished product
Beatreme CS	45	cocoa	40	When used, add 2 medium eggs, ¼ c. water, 1 t. vanilla and ½ c. chopped nuts. Mix well and bake at 350° F. 25 to 30 min.
Beatreme 2255	10	sugar	175	
OE3-R3-M	40	flour	45	
baking powder	0.6	salt	2	

Chocolate Cookies

Mix ingredients	Grams		Grams	Finished product
sugar	60	margarine	105	When used, mix all ingredients well and shape into roll. Chill. Slice ⅛ inch thick and bake at 350° F. 6 to 8 min.
flour	82	brown sugar	55	
soda	1	salt	1	
1 medium egg			40	
unsweetened chocolate			28	
OE1-R3-F[8]			70	

Peanut Chip Cookies

Mix ingredients	Grams		Grams	Finished product
margarine	76	brown sugar	55	When used, add 1 medium egg. Mix all ingredients thoroughly with hands. Shape into rolls of desired size. Chill several hours. Slice ⅛ inch thick. Bake at 400° F. for 6 to 8 min.
egg, 1 medium	40	vanilla	2	
sugar	50	flour	150	
cinnamon	1	salt	3	
soda	1	OE4-R3-G	65	

Peanut Butter Cookies

Mix ingredients	Grams		Grams	Finished product
Beatreme	30	margarine	60	When used, add 1 medium egg and 3 T. water. Mix well. Chill 2 hours. Shape into small balls, flatten with fork dipped in flour. Bake at 375° F. 10 to 12 minutes.
Beatreme 2255	8	egg, 1 medium	40	
baking powder	0.5	sugar	100	
OE4-R3-M	70	brown sugar	110	
peanut butter	60	flour	65	
soda	3	salt	0.5	

Oatmeal Cookie Mix

Mix ingredients	Grams		Grams	Finished product
Beatreme CS	95	spice mix	3.5	When used, add 1 medium egg, ¾ c. water, and ½ c. cut-up raisins. Mix well. Drop by teaspoonfuls onto greased cookie sheet. Bake at 325° F. 8 to 10 min.
all-purpose flour	90	sugar	150	
baking powder	3	OE3-R3-F	65	
non-fat milk		salt	1.5	
solids	15	margarine	55	
quick-cooking rolled oats			75	

[8] Acceptable mixes were also prepared and tested using OE2-R3-F, OE3-R3-F, OE4-R3-F, OE3-R3-M, OE3-R3-M-DD, OE4-R3-M, or OE4-R3-M-DD.

Peanut Maple Cookies

Mix ingredients

	Grams		*Grams*
all-purpose flour	110	soda	1
Beatreme CS	100	salt	0.5
OE3-R3-F	90	margarine	30
brown sugar	150		

Finished product

When used, add 2 eggs, beaten, ½ t. vanilla, ½ t. maple extract, ⅛ t. cinnamon and 3 T. water. Sift dry ingredients together. Cut in margarine. Add eggs, flavorings and water to mix and blend thoroughly. Chill 60 min. Shape into roll. Chill overnight before cutting. Slice ⅛ inch thick. Bake at 350° F. 8 to 12 min.

APPENDIX II

Recipes Developed for Home Use

Meat Loaf

1 lb. ground beef
2 T. instant chopped onion
1½ t. parsley flakes
1 T. non-fat dry milk solids
¾ T. salt
½ c. oatmeal
⅛ t. pepper
5 T. water
1 egg
½ c. OE4-R3-G or M

Procedure

Mix well. Place in lightly greased loaf pan and bake at 300° F. 45 min.

Peanut-Honey Twists

Basic dough

1½ t. dry active yeast
2 T. warm water
3 T. milk, scalded
1 T. margarine
2 t. sugar
¼ t. salt
1 T. egg, beaten
¼ c. OE2-R3-F
½-¾ c. all-purpose flour

Filling

⅓ c. peanut butter
3 T. honey

Procedure

Soften yeast in water. Combine next 4 ingredients, cool to lukewarm. Stir in egg and yeast. Gradually stir in flours, beat well. Knead dough until smooth and satiny. Place in buttered bowl, cover and allow to rise until double in bulk. Place on a floured board and roll dough into a rectangle. Blend peanut butter and honey, spread lengthwise over half the dough. Fold dough in half, lengthwise. Seal edges, cut crosswise in 1 inch strips. Loosely twist each, arrange in a baking dish. Let rise until double (about 1 hour). Bake at 375° F. about 20 min.
Yield: about 8 strips.

Peanut-Cinnamon Twists

Use the basic dough and procedure given in the Peanut-Honey Twist recipe. For the filling use 1½ t. cinnamon and 2⅔ T. sugar. Also brush the tops of the twists with margarine and just before baking, sprinkle the tops **generously** with a cinnamon-sugar mixture.

Caramel-Nut Twists

Use the basic dough and procedure given in the Peanut-Honey Twists recipe. For the filling, use 2 T. confectioner's sugar, ½ c. brown sugar, ½ c. ground nuts, ½ t. vanilla extract, and 2⅔ T. margarine. After the twists have baked, sprinkle them with confectioner's sugar.

Orange Brown and Serve Rolls

Basic dough

1½ t. dry active yeast
2 T. warm water
3 T. milk, scalded
1 T. margarine
2 t. sugar
¼ t. salt
1 T. egg, beaten
¼ c. OE2-R3-F
½-¾ c. all-purpose flour

Filling

¼ c. orange juice or ¼ c. orange marmalade
¼ c. sugar
¼ T. margarine
¼ t. grated orange rind

Procedure for dough

Sprinkle yeast over warm water, set aside. In a saucepan, scald milk, add margarine, sugar and salt. Stir until margarine melts and sugar dissolves. Pour into mixing bowl, cool to lukewarm. Stir in dissolved yeast, egg and orange extract. Add peanut flour and beat well. Gradually stir in enough white flour to make a soft dough. On floured surface, knead dough until smooth and satiny. Place in a buttered bowl, brush with melted margarine, cover and allow to stand in warm place until doubled in volume (about 1 hr.). Punch dough down and allow to rise a second time.

Procedures for filling and finished product

In a sauce pan combine orange juice (including pulp), sugar, margarine and orange rind. Cook over medium heat, stirring occasionally until mixture thickens (220° F.). Cool.

If orange marmalade is used, place it in a bowl and stir until it becomes thinner in consistency, and stir in other filling ingredients.

On lightly floured surface, roll dough into a rectangle. Spread with orange or marmalade filling. Roll lengthwise as for jelly roll. Cut in 1½ inch slices and place (cut side up) in buttered muffin cups (2½ inch in diameter). Brush with melted margarine. Cover and let stand in a warm place until double in bulk. Bake at 375° F. 10 to 12 min. Remove immediately to wire rack to cool. Store in freezer or refrigerator. To serve, reheat in oven at 375° F. until golden brown. Yield: 6 rolls.

Peanut-Cinnamon Rolls

Using the same basic dough and procedure as for the Orange Brown and Serve Rolls, substitute the following filling for the orange filling:

1½ t. cinnamon
2⅔ T. sugar

Sprinkle the top of the rolls generously with cinnamon-sugar mixture before baking.

Peanut Honey Orange Bread

1 pkg. active dry yeast
4½ T. warm water
6 T. honey
1½ T. shortening
½ c. milk, scalded
⅜ c. water, cold
1½ t. salt
1½ t. orange peel, grated
1 t. orange extract
3 T. candied orange peel, chopped
⅜ c. OE2-R3-F
2¼-2¾ c. all-purpose flour

Procedure

Soften yeast in warm water. In mixing bowl, blend honey, shortening, salt, and scalded milk until shortening is melted. Add cold water, cool to lukewarm. Stir in yeast, orange peel, orange extract and candied orange peel. Gradually add flours to form a stiff dough. Knead on floured surface until smooth and satiny, about 5 to 10 min. Place in greased bowl, turning to grease on all sides. Cover with foil or damp towel. Let rise in warm place until light and doubled in volume, about 2 hours. Punch down. Fold edges in and turn upside down. Let rise 30 min. Place on lightly floured surface and mold into ball. Cover, let set 15 min. Shape into loaf.. Place in well greased pan, 9 x 5 x 3 inches, and cover with damp towel. Let rise till dough fills pan and top of dough is well above pan edges (about 90 min.). Bake at 350° F. for 20 min., reduce heat to 300° F. and bake until done. Remove from pan immediately.

Biscuits I

1¼ c. flour
¾ c. OE1-R3-F
4 t. baking powder
¾ t. salt
¼ c. margarine
¾ c. milk

Procedure

Sift dry ingredients. Cut in margarine until particles are fine. Add milk all at once and stir until dough clings together. Knead lightly on floured surface 12 times. Roll out ½ inch thick. Bake at 425° F. 12 to 15 min.

Biscuits II

1¼ c. flour
¾ c. OE1-R3-F
4 t. baking powder
¾ t. salt
¼ c. margarine
⅔ c. milk
1 medium egg

Procedure

Sift dry ingredients. Cut in margarine until particles are fine. Add milk and egg all at once and stir until dough clings together. Knead lightly on floured surface 12 times. Roll out ½ inch thick. Bake at 425° F. 12 to 15 min.

Scones

1¼ c. flour
¾ c. OE1-R3-F
3 t. baking powder
1 t. salt
2 T. sugar
⅓ c. margarine
½ c. milk
1 medium egg, slightly beaten

Procedure

Sift flours, baking powder, salt and sugar. Cut margarine in finely. Stir in milk and egg to make soft dough. Knead lightly on floured surface about 30 seconds. Roll ¼ inch thick and cut in diamonds or triangles. Brush with melted margarine and sprinkle with sugar. Bake at 425° F. 10 to 12 min.

Banana Bread

1 c. sugar
2 T. margarine
1 medium egg
¾ c. milk
1 c. banana, mashed
1 t. vanilla
½ c. OE1-R2-F
3½ t. baking powder
2½ c. flour
1 t. salt

Procedure

Mix sugar, margarine, and egg thoroughly. Stir in milk, banana, and vanilla. Sift dry ingredients together and stir in. Pour into greased and floured loaf pan, 9 x 5 x 3 inches. Bake at 350° F. for 70 min.

Apricot Bread

1 c. sugar
2 T. margarine
2 medium eggs
¾ c. milk
¾ c. orange juice
1⅔ c. OE3-R3-M-DD
2 c. flour
4 t. baking powder
1 t. salt
¾ c. chopped nuts
1 c. dried apricots, very finely chopped

Procedure

Mix sugar, margarine, and eggs well. Stir in milk and orange juice. Sift dry ingredients together. Stir nuts and apricots into dry mixture to coat well. Add to sugar mixture and blend. Pour into well greased loaf pan, 9 x 5 x 3 inches. Let stand 20 min. Bake at 350° F. 70 min.

Date Bran Muffins

1 c. bran
1 c. milk (whole, fluid)
½ c. all-purpose flour, sifted
2 t. baking powder
½ c. OE1-R3-F
½ t. salt
1 c. dates, cut-up
¼ c. light brown sugar, packed
2 T. soft margarine
1 medium egg, beaten

Procedure

Soak bran in milk 5 min. Sift and mix dry ingredients except brown sugar. Add dates to dry ingredients. Beat brown sugar and margarine well together, gradually add egg, beat smooth. Stir in bran and milk. Add dry ingredients and dates. Stir just until mixed. Fill 10 to 12 greased muffin cups ⅔ full. Bake at 400° F. 25 to 30 min.

Date Nut Loaf

1½ c. dates, cut-up
1½ c. boiling water
½ c. brown sugar, packed
1 T. soft margarine
1 medium egg
1½ c. all-purpose flour
¾ c. OE1-R3-F
1½ t. soda
½ t. salt
1 c. nuts, broken

Procedure

Pour boiling water over dates. Let cool. Mix brown sugar, margarine and egg thoroughly. Stir in cooled dates and water. Sift dry ingredients and stir into date mixture. Blend in nuts. Pour into well greased loaf pan (9 x 5 x 3 inches). Let stand 20 min. Bake at 350° F. 60 to 70 min.

French-Onion Bread

1 pkg. active dry yeast
4 T. warm water
1 pkg. (1⅝ oz.) onion soup mix
3 t. sugar
3 t. shortening
1 c. boiling water
¾ c. cold water
½-1 c. OE1-R3-F
4-5 c. all-purpose flour
1 egg white, slightly beaten

Procedure

Soften yeast in warm water. In mixing bowl combine soup mix, sugar, shortening, and boiling water. Add cold water, cool to lukewarm. Stir in yeast. Add peanut flour. Gradually add all-purpose flour to form a stiff dough. Knead on floured surface until smooth and satiny, about 5 min. Place in greased bowl, turning to grease all sides. Cover. Let rise until doubled in volume about 90 min. Divide dough in half. On a floured surface roll to a rectangle (12 x 15 inches). Starting with 12 inch side roll jelly roll fashion, sealing dough with heels of hands after each roll. Pinch edges together to seal and pull to taper ends. Place seam down on greased cookie sheet. Let rise until double in volume, about 1 hour. Brush with egg white diluted with 1 T. water. With very sharp knife gently make 3-4 diagonal gashes ½ inch deep across top. Bake at 425° F. 15 to 30 min. until golden brown; then at 350° F. 30 min. until rich golden brown.

Tomato Onion Soup

2 T. instant chopped onion
2 T. cooking oil
½ c. and 1 T. OE3-R3-F
1½ t. salt
½ t. celery salt
2 T. peanut butter
2 c. milk
2 c. tomato juice

Procedure

Saute onion in oil till tender, but not browned. Add peanut flour and seasoning. Blend in peanut butter and add milk gradually, stirring to blend. Cook and stir till mixture comes to a boil and is thickened. Add tomato juice and bring just to a boil.

Split Pea Soup

2 T. margarine
¼ c. and 2 T. OE1-R3-F
2½ c. milk
1½ c. split peas, cooked

Procedure

Melt margarine in top of double boiler, blend in 2 T. peanut flour to make a smooth paste. Add milk gradually, stirring to blend. Add cooked peas and ¼ c. peanut flour. Bring to boil and cook a few min.

Peanut-Onion Gruel

1½ c. water
1 T. dehydrated minced onion
½ t. MSG
¼ t. celery salt
2 t. Beatreme 2255
¼ t. salt
¼ c. OE1-R3-F
2 T. non-fat milk solids

Procedure

Add water to dry ingredients and simmer 30 min. or until of desired consistency.

Peanut-Chocolate Malted Drink

2 t. instant chocolate malted drink
2 t. OE1-R3-F
½ c. milk (whole, fluid)

Procedure

Mix all ingredients well.

Brown Gravy

2 cubes beef bouillon
1½ c. water, boiling
3 T. margarine
1 slice onion
4 T. OE1-R3-F
1½ T. flour

Procedure

Dissolve bouillon cubes in boiling water. Melt margarine in heavy saucepan over low heat. Add onion and saute until golden. Remove onion and stir in flours until blended. Cook over low heat, stirring constantly, until flour is browned. Remove from heat and gradually stir in beef bouillon. Bring to boil, stirring constantly, and boil one min. Add salt and pepper to taste and a dash of worcestershire sauce, if desired.

Applesauce Cake

½ c. margarine
1 c. sugar
1 c. applesauce
1 c. flour
½ c. OE1-R2-F
1 t. soda
1 t. cinnamon
¼ t. nutmeg
½ c. quick-cooking oatmeal
1 medium egg

Procedure

Melt margarine. Add sugar, applesauce, flour (sifted), peanut flour, soda, spices, oatmeal, and egg. Mix well and pour into greased and floured loaf pan (9 x 5 x 3 inches). Bake at 350° F. for 75 min.

Chocolate Cake

½ c. OE1-R2-F
1¼ c. flour
1 t. soda
1 t. salt
1¼ c. sugar
½ c. margarine
2 medium eggs
2 sqs. unsweetened chocolate
1 c. buttermilk
1 t. vanilla

Procedure

Sift flour, peanut flour, soda, and salt together. Add sugar to margarine gradually and cream until light and fluffy. Add egg yolks and beat well. Add melted chocolate alternately with buttermilk and vanilla, beating well after each addition. Beat egg whites stiff and fold into batter. Pour into two lined pans (8 x 8 x 2 inches). Bake at 350° F., 25 min. Cool 15 min. and remove from pans.

Broiled Peanut Frosting

¼ c. smooth peanut butter
½ c. OE4-R3-G
½ c. brown sugar, packed
¼ c. margarine
¼ c. honey
¼ c. flaked coconut (optional)

Procedure

Blend all ingredients together and spread on cooled cake. Broil (4 to 5 inches from heat) till topping bubbles, about 3 min. Makes enough to frost a 9 x 13 inch cake or to fill a 3-layer 8 to 9 inch cake.

Peanut-Maple Frosting

1 c. confectioner's sugar, sifted
¼ c. OE1-R3-F
1 T. Beatreme A
2 t. Beatreme 2255
2 T. peanut butter
¼ t. maple flavoring
2-4 T. milk

Procedure

Combine sugar, flour, Beatreme A, Beatreme 2255, and cut in peanut butter. Add maple flavoring and milk to spreading consistency.

Butterscotch Pudding

⅔ c. brown sugar, packed
⅛ t. salt
2 T. cornstarch
2¼ c. milk
2 T. OE1-R3-F
1 T. peanut butter
1 medium egg, slightly beaten
1 T. margarine
1 t. vanilla

Procedure

Combine in saucepan, sugar, salt, and cornstarch. Add milk gradually. Cook over medium heat, stirring constantly, until mixture comes to a boil. Boil one min. Add peanut flour and peanut butter. Add small amount of hot mixture to egg and then add to remaining hot mixture. Cook, stirring constantly, until thickened. Remove from heat. Add margarine and vanilla. Beat with rotary beater until smooth. Cool slightly, then spoon into serving dishes.

Chocolate Pudding

1 c. sugar
¼ t. salt
2 T. cornstarch
2 c. milk
2 sqs. unsweetened chocolate
4 T. OE1-R3-F
2 T. peanut butter
2 medium eggs, slightly beaten
1 T. margarine
1 t. vanilla

Procedure

Combine in saucepan, sugar, salt, and cornstarch. Add milk gradually. Add chocolate and cook over medium heat, stirring constantly, until mixture comes to a boil and boil one min. Stir in peanut flour. Add small amount of hot mixture to eggs and add this to remaining mixture. Cook, stirring constantly, until it thickens, remove from heat. Add margarine and vanilla. Beat with rotary beater until smooth. Cool slightly and spoon into serving dishes.

Peanut-Onion Dip

1-2 T. OE2-R3-F
¼ c. sour cream
1 T. dehydrated minced onion
⅛ t. MSG
¼ t. celery salt

Procedure

Mix all ingredients well. Chill at least one hour to permit flavors to blend.

Peanut-Honey Spread

¾ c. OE1-R3-F
½ c. honey
¼ c. margarine
2 T. peanut butter

Procedure

Mix all ingredients well. Refrigerate.

Peanut-Honey-Raisin Spread

¾ c. OE1-R3-F
½ c. honey
¼ c. margarine
2 T. peanut butter
¾ c. raisins, cut-up

Procedure

Mix all ingredients well. Refrigerate.

Peanut Crunch Topping

1 T. smooth peanut butter
6 T. margarine
1 c. light brown sugar, packed
2 c. cornflakes, coarsely crushed
1 c. salted roasted peanuts
4 T. OE4-R3-G

Procedure

Combine peanut butter, margarine, and sugar in a saucepan. Stir over low heat until mixture bubbles, then cook 2 to 3 min. Remove from heat and stir in cornflakes and peanut products, mixing well. Spread on flat pan and allow to cool. Store in covered container.

Brownies

2 oz. unsweetened chocolate
¼ c. margarine
1 c. sugar
2 medium eggs
½ c. OE1-R2-F
½ t. salt
½ c. flour
½ t. baking powder
1 t. vanilla

Procedure

Melt chocolate and margarine together over hot water. Beat in sugar and eggs. Sift other dry ingredients together and stir in. Add vanilla. Spread in well greased pan (8 x 8 x 2 inches). Bake at 350° F. 30 to 35 min.

Butterscotch Brownies

¼ c. margarine
1 c. brown sugar, packed
1 medium egg & 1 yolk
1 t. vanilla
½ c. OE1-R2-F
½ t. salt
½ c. flour
½ t. baking powder

Procedure

Melt margarine in large saucepan. Remove from heat. Add brown sugar, stirring until dissolved. Cool, add egg yolk, egg, and vanilla. Beat well. Stir in sifted dry ingredients. Mix well. Spread in greased pan (9 x 9 x 2 inches). Bake at 350° F. 30 to 35 min. Cool and cut in squares.

Peanut Butter Brownies

¼ c. peanut butter
1 c. brown sugar, packed
1 medium egg
½ c. flour
½ c. OE1-R3-F
1 t. baking powder
½ t. salt
1 t. vanilla
½ c. chopped nuts (optional)

Procedure

Add sugar gradually to peanut butter, mixing well. Add egg and beat well. Sift dry ingredients together and stir into sugar mixture. Add vanilla and nuts. Spread in well greased 8 inch square pan. Bake at 350° F. 25 to 30 min.

Peanut-Maple Cookies

1 c. flour
1 c. OE1-R3-F
½ t. soda
¼ t. salt
½ c. margarine
1 c. brown sugar, packed
2 medium eggs
1 t. vanilla extract
1 t. maple flavoring

Procedure

Sift flours, soda, and salt together. Cream margarine and brown sugar, add eggs and flavorings and beat well. Add dry ingredients gradually, beating well. Chill. Form into balls about one inch in diameter and flatten with bottom of a glass that has been buttered and dipped in sugar. Bake at 350° F. 8 to 10 min.

Peanut Chip Cookies

⅓ c. margarine
¼ c. sugar
¼ c. brown sugar, packed
1 medium egg
¾ t. vanilla
1⅜ c. flour
¼ t. soda
1½ t. salt
½ t. cinnamon
½ c. OE4-R3-G

Procedure

Mix all ingredients thoroughly with hands. Shape into rolls of desired size. Chill several hours or overnight. Slice ⅛ inch thick. Bake at 400° F. 6 to 8 min.

Butterscotch Oatmeal Cookies

1½ c. OE1-R2-F
¾ c. flour
1 t. soda
1 t. salt
1 c. margarine
1 c. sugar
1 c. brown sugar, packed
2 medium eggs
1 t. vanilla
3 c. quick-cooking rolled oats

Procedure

Sift flours with soda and salt. Cream margarine. Add sugars gradually. Cream until light and fluffy. Add eggs and vanilla. Beat well. Blend in sifted dry ingredients gradually. Stir in rolled oats. Chill 1 hour. Shape into roll. Chill at least 2 hours. Slice ½ inch thick. Bake at 350° F. 10 to 12 min.

Oatmeal Crispies

½ c. shortening
½ c. brown sugar, packed
½ c. sugar
1 medium egg
½ t. vanilla
¼ c. flour
1 t. soda
½ t. salt
1½ c. three-min. oatmeal
¾ c. OE4-R3-G

Procedure

Thoroughly cream shortening and sugars. Add egg and vanilla and beat well. Sift in the flour, soda, and salt. Fold in oatmeal and grits. Mix. Drop by teaspoonfuls onto greased and floured pan. Flatten with fork. Bake at 350° F. 10 min., opening oven door a few times during cooking. Cool a few seconds before removing carefully from pan.

Chocolate Peanut Butter Fudge

1 sq. unsweetened chocolate
1 c. sugar
½ c. milk
1 T. corn syrup
⅛ t. salt
2 T. margarine
1 T. peanut
3 T. OE3-R3-F
½ t. vanilla

Procedure

Combine chocolate, sugar, milk, corn syrup, and salt together in a saucepan. Heat to 234° F. Stir occasionally to prevent sticking. Remove from heat and set pan in cold water. Add margarine, peanut butter, and peanut flour. Let mixture cool to lukewarm without stirring. Add vanilla and beat until mixture loses gloss. Pour into pan (8 x 8 x 2 inches).

Peanut Chocolate Clusters

¼ c. smooth peanut butter
¼-½ c. OE4-R3-G
1 c. semi-sweet chocolate
1 c. salted peanuts, whole

Procedure

Combine peanut butter, grits, and chocolate in top of double boiler and place over hot (not boiling) water until chocolate melts. Stir until blended. Add peanuts and stir to coat well. Drop by teaspoonfuls onto waxed, paperlined cooking sheet. Chill until set.

APPENDIX III

APPENDIX III, TABLE 1. PEANUT FLOUR SHELF LIFE STUDY—INITIAL DETERMINATIONS

Product treatment no.[1]	Flavor scores[2]	Oil content (dry basis)	Moisture	Free fatty acid[3]	Peroxide value[4]	Bacteriological data: SPC[5]	Bacteriological data: Coliforms	Bacteriological data: Yeasts and molds
		Pct.	Pct.					
1	5.4	7.8	8.0	0.40	2.8	15,000	6,000	100
2	7.0	7.6	5.0	0.42	2.8	5,000	3,000	20
3	7.8	7.8	3.5	0.58	3.0	200	0	0
4	8.2	11.8	3.5	0.60	3.0	300	10	0
5	8.5	16.6	3.5	0.60	3.0	0	0	0
6	8.7	21.6	3.5	0.60	3.0	150	0	0
7[6]	----	----	----	------	----	------	----	----
8	8.8	7.8	2.0	0.58	3.0	100	0	0
9	8.0	7.8	6.8	0.58	3.0	50	10	0
10	7.8	7.8	8.5	0.58	3.0	10	0	0
11	5.6	22.5	8.0	0.58	3.0	200	10	10
12	6.1	22.0	8.0	0.58	3.0	200	10	20
13	7.8	7.8	3.5	0.58	3.0	300	0	10
14	8.9	12.8	2.5	0.64	4.0	10	0	0

[1] See Table 18.

[2] Average scores by 5 judges based on 1 to 10 scale with 1 as very poor, 6 as fair and 10 as excellent.

[3] Expressed as per cent oleic acid in oil fraction of sample.

[4] Milliequivalents of peroxide per 1000 grams oil.

[5] Standard plate count.

[6] This product was included in the second shelf life study.

APPENDIX III, TABLE 2. PEANUT FLOUR SHELF LIFE STUDY—FIRST 10 WEEKS OF STORAGE

Treatment[1]	Flavor scores[2]	Moisture	FFA[3]	Peroxide value[4]	Treatment[1]	Flavor scores[2]	Moisture	FFA[3]	Peroxide value[4]
		Pct.	*Pct.*				*Pct.*	*Pct.*	
GA 75					GA 32				
1	5.0	8.8	.58	6.0	1	6.0	8.3	.54	5.0
2	7.0	5.5	.59	6.5	2	8.0	6.0	.54	6.5
3	7.5	3.0	.69	12.0	3	8.0	4.1	.65	7.0
4	7.6	4.5	.76	12.0	4	7.5	4.5	.72	7.0
5	7.0	4.5	.77	13.0	5	7.5	5.0	.72	7.0
6	7.4	4.0	.70	14.0	6	7.8	5.0	.65	7.5
8	8.0	3.5	.67	12.0	8	7.5	4.1	.62	7.0
9	7.5	7.0	.70	13.0	9	8.0	7.2	.64	7.0
10	7.0	8.1	.84	14.0	10	8.0	8.8	.80	7.0
11	5.4	8.5	.81	13.0	11	5.8	8.0	.77	6.0
12	6.0	8.4	.82	13.0	12	6.5	8.1	.78	6.0
13	7.5	4.3	.70	13.0	13	8.0	4.2	.65	6.5
14	8.5	3.5	.84	18.0	14	8.0	4.1	.79	9.0
GN 75					GN 32				
1	5.5	7.8	.57	5.0	1	6.5	9.1	.52	4.0
2	7.0	6.5	.57	5.5	2	7.0	6.9	.52	4.5
3	7.0	4.0	.64	8.0	3	7.0	5.0	.61	6.0
4	7.5	3.5	.73	8.0	4	7.0	4.8	.70	6.0
5	7.5	3.1	.74	8.0	5	7.8	6.0	.70	6.5
6	7.5	3.4	.68	9.0	6	8.0	5.4	.65	6.0
8	7.5	3.0	.65	8.0	8	8.0	5.0	.60	6.0
9	7.0	6.8	.65	8.0	9	8.5	6.8	.61	6.0
10	7.0	7.7	.78	9.0	10	7.5	8.1	.73	6.0
11	6.0	8.0	.76	8.0	11	6.6	8.6	.72	5.0
12	6.0	7.9	.80	8.0	12	7.0	7.8	.74	5.0
13	7.5	4.8	.68	8.0	13	8.0	4.9	.62	5.8
14	8.0	4.0	.83	13.0	14	8.5	3.8	.72	8.0
SA 75					SA 32				
3	7.0	5.0	.73	10.0	3	7.5	4.5	.71	7.5
8	7.0	4.2	.71	12.0	8	8.0	4.0	.70	8.5
10	7.0	8.0	.84	10.0	10	8.0	7.5	.81	7.0
SN 75					SN 32				
3	7.5	4.8	.72	6.5	3	7.0	4.5	.60	5.5
8	7.0	4.0	.59	7.0	8	8.0	4.4	.60	6.0
10	7.0	8.0	.81	6.0	10	8.0	7.7	.50	5.5

[1] For explanation of code see Table 18.

[2] Range of 1 as very poor to 6 as fair to 10 as excellent.

[3] Free fatty acid expressed as per cent oleic acid in oil fraction.

[4] Milliequivalents of peroxide per 1000 grams oil.

APPENDIX III, TABLE 3. PEANUT FLOUR SHELF LIFE STUDY—SECOND 10 WEEKS OF STORAGE

Treatment[1]	Flavor scores[2]	Moisture	FFA[3]	Peroxide value[4]	Treatment[1]	Flavor scores[2]	Moisture	FFA[3]	Peroxide value[4]
		Pct.	*Pct.*				*Pct.*		*Pct.*
GA 75					GA 32				
1	5.0	----	.62	7.0	1	5.7	----	.58	6.5
2	5.7	----	.54	6.5	2	6.8	----	.59	6.0
3	7.0	----	.66	12.0	3	7.0	----	.60	8.0
4	6.8	----	.63	11.5	4	6.7	----	.60	8.5
5	6.5	----	.60	13.0	5	6.7	----	.59	8.0
6	6.5	----	.79	13.5	6	6.1	----	.69	8.0
8	6.7	----	.62	13.0	8	7.4	----	.59	8.5
9	7.8	----	.62	13.0	9	7.2	----	.61	8.0
10	6.0	----	.92	13.0	10	5.6	----	.69	9.0
11	5.5	----	.90	13.5	11	5.4	----	.72	8.5
12	6.7	----	.90	14.0	12	----	----	.68	8.5
13	8.0	----	.61	13.0	13	7.6	----	.69	8.0
14	8.5	----	.79	17.0	14	7.7	----	.89	12.0
GN 75					GN 32				
1	5.2	----	.61	5.0	1	6.0	----	.58	4.5
2	5.8	----	.54	6.0	2	6.5	----	.58	4.5
3	6.8	----	.60	8.0	3	6.4	----	.65	6.5
4	7.0	----	.74	8.5	4	6.8	----	.70	6.5
5	7.0	----	.67	9.0	5	6.9	----	.68	7.0
6	6.0	----	.66	9.0	6	6.7	----	.63	7.5
8	7.0	----	.66	9.0	8	7.1	----	.65	7.0
9	6.8	----	.66	9.0	9	7.2	----	.62	7.5
10	6.0	----	.79	9.5	10	6.2	----	.69	8.0
11	6.3	----	.82	9.0	11	5.8	----	.78	8.5
12	6.8	----	.79	9.0	12	----	----	.76	9.0
13	7.8	----	.69	9.0	13	7.8	----	.65	9.0
14	9.0	----	.89	15.0	14	7.6	----	.80	11.5
SA 75					SA 32				
3	7.5	4.8	.78	11.5	3	7.4	4.8	.79	8.0
8	7.1	3.9	.79	12.0	8	7.2	4.1	.68	8.5
10	7.1	7.4	.91	11.0	10	6.2	7.8	.75	7.0
SN 75					SN 32				
3	7.6	4.6	.69	10.5	3	7.6	4.5	.71	7.5
8	7.2	4.1	.73	9.5	8	7.4	4.7	.79	7.0
10	7.1	6.7	.85	8.0	10	6.2	7.2	.85	7.0

[1] For explanation of code see Table 18.
[2] Range of 1 as very poor to 6 as fair to 10 as excellent.
[3] Free fatty acid expressed as per cent oleic acid in oil fraction.
[4] Milliequivalents of peroxide per 1000 grams oil.

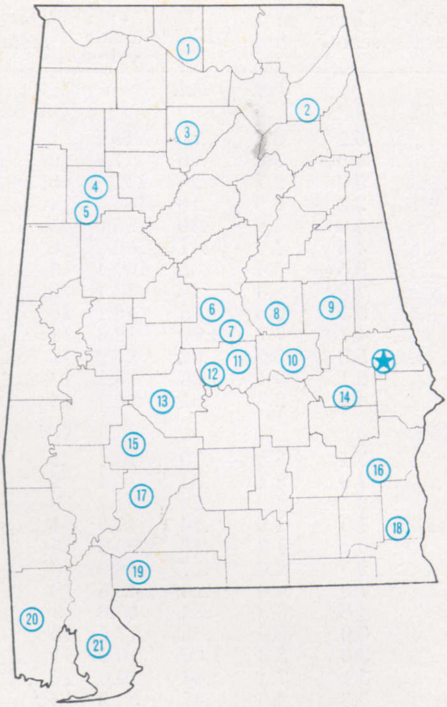
APPENDIX III, TABLE 4. PEANUT PRODUCT SHELF LIFE STUDY—FINAL EXAMINATION

Treatment[1]	Flavor scores[2]	Moisture	FFA[3]	Peroxide value[4]	Treatment[1]	Flavor scores[2]	Moisture	FFA[3]	Peroxide value[4]
		Pct.	*Pct.*				*Pct.*	*Pct.*	
GN 75					GA 32				
1	5.2	8.4	.80	13.1	1	5.4	9.3	.28	9.9
2	6.5	3.6	.26	7.4	2	4.9	7.1	.35	5.9
3	5.0	2.7	.26	117.3	3	7.5	4.2	.31	42.6
4	3.2	0.5	.16	182.2	4	----	----	----	----
5	6.0	1.6	.30	95.0	5	7.2	1.1	.19	15.2
6	4.5	1.9	.41	164.3	6	5.5	2.6	.17	59.8
8	5.5	3.4	.38	107.1	8	6.8	4.3	.32	31.5
9	7.0	3.4	.43	83.1	9	7.2	5.3	.25	46.5
10	5.2	6.5	.75	16.1	10	6.1	7.4	.32	16.3
11	4.7	7.7	1.20	12.8	11	6.0	8.8	.22	10.1
12	5.0	5.2	.62	37.2	12	5.2	8.7	.22	16.4
13	6.1	3.1	.25	73.2	13	7.2	7.1	.30	21.7
14	4.0	2.3	.31	24.2	14	3.0	5.8	.24	7.4
GN 75					GN 32				
1	5.1	8.8	.76	13.3	1	7.6	9.0	.33	3.5
2	4.9	5.1	.34	14.4	2	7.5	4.4	.28	20.9
3	6.4	4.2	.24	81.2	3	8.2	3.7	.42	38.3
4	7.5	1.9	.14	49.8	4	7.8	1.8	.18	68.9
5	6.1	1.3	.18	50.6	5	6.4	0.4	.18	20.2
6	2.5	2.6	.17	48.0	6	6.2	1.8	.15	55.9
8	7.8	4.0	.29	42.6	8	8.8	3.3	.23	50.7
9	4.6	5.0	.34	66.6	9	8.0	4.7	.26	30.5
10	6.0	6.9	.53	17.2	10	7.4	6.8	.35	7.8
11	3.6	8.8	1.06	10.9	11	7.4	8.8	.23	1.4
12	5.1	7.4	.84	20.0	12	6.8	7.2	.20	16.0
13	5.8	4.3	.41	52.8	13	7.8	4.2	.24	45.7
14	5.2	2.3	.26	35.0	14	6.2	1.4	.22	18.3
SA 75					SA 32				
3	5.0	5.5	.36	40.6	3	7.4	5.8	.20	31.2
8	6.2	5.0	.29	37.5	8	6.0	4.1	.26	42.2
10	5.9	6.1	.63	6.5	10	3.5	7.5	.68	7.0
SN 75					SN 32				
3	5.1	5.3	.28	39.0	3	4.2	6.2	.21	34.4
8	7.4	6.2	.31	45.1	8	6.6	4.8	.38	42.1
10	4.9	6.5	.66	28.1	10	3.2	7.4	.22	4.7

[1] For explanation of code see Table 18.
[2] Range of 1 as very poor to 6 as fair to 10 as excellent.
[3] Free fatty acid expressed as per cent oleic acid in oil fraction.
[4] Milliequivalents of peroxide per 1000 grams oil.

AGRICULTURAL EXPERIMENT STATION SYSTEM OF ALABAMA'S LAND-GRANT UNIVERSITY

With an agricultural research unit in every major soil area, Auburn University serves the needs of field crop, livestock, forestry, and horticultural producers in each region in Alabama. Every citizen of the State has a stake in this research program, since any advantage from new and more economical ways of producing and handling farm products directly benefits the consuming public.



Research Unit Identification

★ Main Agricultural Experiment Station, Auburn.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Forestry Unit, Fayette County.
6. Thorsby Foundation Seed Stocks Farm, Thorsby.
7. Chilton Area Horticulture Substation, Clanton.
8. Forestry Unit, Coosa County.
9. Piedmont Substation, Camp Hill.
10. Plant Breeding Unit, Tallassee.
11. Forestry Unit, Autauga County.
12. Prattville Experiment Field, Prattville.
13. Black Belt Substation, Marion Junction.
14. Tuskegee Experiment Field, Tuskegee.
15. Lower Coastal Plain Substation, Camden.
16. Forestry Unit, Barbour County.
17. Monroeville Experiment Field, Monroeville.
18. Wiregrass Substation, Headland.
19. Brewton Experiment Field, Brewton.
20. Ornamental Horticulture Field Station, Spring Hill.
21. Gulf Coast Substation, Fairhope.