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Peanut and Cowpea Meals as a Replacement for Wheat Flour in Cake-type Doughnuts

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ABSTRACT

Meals processed from partially defatted peanuts, untoasted and toasted, and from dry cowpeas were used to replace wheat flour at 10, 20, and 30% levels in cake-type buttermilk doughnuts. The legume meals were darker and larger in particle size than wheat flour and produced batters with a "grainy" appearance. With the exception of untoasted peanut meal at the 30% level which produced a sticky batter that was difficult to cut, the legume and 100% wheat flour control batters were well suited to mechanical cutting, dispensing, and frying. Legume meal batters produced fewer doughnuts per batch, of higher average weight, than control batters. Gardner color values of doughnuts were influenced more by the addition of toasted peanut meal than by the other test meals. Sensory quality scores for appearance, color, aroma, texture, and flavor were acceptable for control and test doughnuts, indicating that peanut and cowpea meals are compatible ingredients for use in this type of bakery product. Techniques to restrict excessive fat absorption during doughnut frying are needed, however.

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Investigations of the functionality of plant proteins as ingredients in bakery products have focused primarily upon bread as a test system because of its universal consumption and acceptability. These tests typically involve the replacement of wheat flour, nonfat dry milk, or eggs with a nonwheat protein product and then measuring certain physical properties of the dough (e.g., water absorption, mixing strength) as well as quality characteristics of the finished product (e.g., sensory acceptability, proximate composition, and objective measurements for volume, color, and tenderness). The compatibility of peanut and other oilseed flours with wheat flour for use in bread depends upon the type of oilseed, the method by which the protein product is processed, the type of baking system used, and the quality and quantity of wheat flour protein (6).

Although bread continues to be a staple in American homes, other baked goods, mostly rolls and sweet goods, are consumed by 95% of all households in the United States, as shown by USDA's 1977-78 Nationwide Food Consumption Survey of household spending patterns in the United States. Fresh sweetrolls, coffeecake, and doughnuts constitute 13.6% of U.S. weekly household expenditures for bakery products purchased as food consumed "at home," and households allocate a greater share of their at-home food dollar to bakery products as income increases (9). Thus, non-bread bakery products are potential candidates for utilizing peanut and other plant proteins, but information pertaining to their performance in these types of products is limited.

Harris et al. (5) developed several formulas for using defatted peanut flour as a wheat flour replacement in sweet baked goods. Lawhon et al. (7) evaluated the effects of using blends of peanut flour and wheat flour at three protein levels on the composition and sensory quality of cake doughnuts. The peanut flour was a commercial product which contained ground peanut skins and was less desirable for doughnut preparation than the other flours because of its high crude fiber content. A later study by Ayres and Davenport (2) used defatted peanut flour made from blanched peanuts as a total replacement for nonfat dry milk and a partial replacement for whole eggs in yeast-raised doughnuts; they reported that the resulting products had a rich crumb and surface color and resembled control doughnuts in flavor and appearance. These investigations (2, 5, 7) utilized bland peanut flours which contained very little oil (ca 1.0%).

Partially defatted peanut meal/flour is available commercially and has more of the flavor normally associated with raw or roasted peanuts than peanut meal/flour which has essentially all of the oil removed. The purpose of our study was to evaluate the performance of partially defatted peanut meal in untoasted and toasted form as a replacement for wheat flour in chemically-leavened doughnuts. A meal processed from dry cowpeas for use in another functionality study (8) was included for comparison.

Materials and Methods

Commercial peanut meals used in doughnut preparation were processed from partially defatted peanuts, untoasted and toasted, and were supplied by Pert Laboratories, Edenton, NC. The peanuts were partially defatted by a hydraulic pressing procedure developed by Vix et al. (10); the pressed nuts were either ground raw through a 6.3 mm screen to produce partially defatted, untoasted meal or toasted in hot air at 160 C for 15 min prior to grinding to produce partially defatted, toasted meal.

Cowpea meal was processed from whole, dry cowpeas grown in 1980 by the Department of Horticulture at Experiment, GA. The dixiecream cultivar was used since its white seed coat and lack of pigmentation in the hilum region (eye) allowed these peas to be milled without the necessity of removing the seed coats. The peas were milled in a hammer mill equipped with a 1.6 mm screen. Peanut and cowpea meals which passed through a sieve with 1.19 mm openings (14-mesh) were used for doughnut preparation.

Wheat flour, purchased in a local supermarket, and the legume meals were stored in glass jars and held at 1 C when not in use. The legume meals were darker and larger in particle size than bleached wheat flour, as shown in Figure 1. Untoasted peanut meal (B) and cowpea meal (D) were a cream-beige color; toasted peanut meal (C) was the color of lightly roasted peanuts and was the darkest test product used.

The legume meals were used to replace wheat flour at 10, 20, and 30% levels in cake-type buttermilk doughnuts; a 100% wheat flour formula served as the control. Formulations are shown in Table 1. For doughnut preparation, the eggs and sugar were beaten together for 60 sec at speed 6 in an Oster Kitchen Center mixer. The vegetable oil and vanilla were added to the egg mixture and mixed for 30 sec at speed 3. The beaters were scraped and mixing continued for 30 sec. The flour, baking powder, salt, and soda were stirred together and added alternately with the buttermilk to the egg mixture, beginning and ending with the dry ingredients, and beating just till blended after each addition. The beaters were scraped again and mixing continued for 30 sec. The batter was transferred to a Belshaw Donut Mini-Matic 110 where it was automatically cut, dispensed, and fried for 2 min in hydrogenated vegetable shortening at 191 C. The doughnuts were drained on absorbent paper, cooled, packaged in polyethylene bags, and frozen until sensory evaluations were conducted one week later.

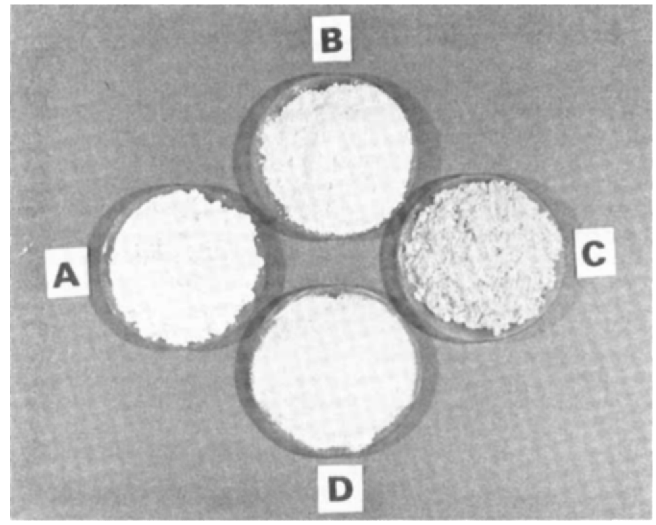

Fig. 1. Test products used in doughnut preparation: wheat flour (A), untoasted peanut meal (B), toasted peanut meal (C), and cowpea meal (D).

Table 1. Formulation of Cake-type Doughnuts for Replacement of Wheat Flour with Various Levels of Peanuts and Cowpea Meals.

	% Wheat Flour Replacement			
Ingredients	0 (g)	10 (g)	20 (g)	30 (g)
Wheat flour (plain, all purpose)	348.00	313.2	278.4	243.6
Peanut or cowpea meal	0	34.8	69.6	104.4
Baking powder (SAS)	11.10	→	→	→
Salt	3.42	→	→	→
Baking soda	0.75	→	→	→
Egg (whole, fresh)	75.00	→	→	→
Sugar (granulated, cane)	147.00	→	→	→
Vegetable oil	39.00	→	→	→
Buttermilk (fresh)	182.25	→	→	→
Vanilla	3/4 tsp.	→	→	→

For sensory evaluations, only one legume treatment consisting of doughnuts containing 0, 10, 20, or 30% of a particular meal was tested per day. Doughnuts were thawed overnight at room temperature in the packages, cut into halves, arranged in random order on white plates, overwrapped with polyethylene, warmed at 38 C for 2 hrs, and evaluated by panelists in individual booths under incandescent lighting. A volunteer panel of seven men and three women rated five quality attributes of doughnuts (appearance, color, aroma, texture, and flavor) on a scale of 9 to 1 (9 = excellent, 5 = borderline, 1 = very poor). These panelists were experienced in the use of sensory evaluation procedures and had demonstrated an ability to discern quality differences.

Moisture, oil, and protein levels of the legume meals were determined in triplicate. Three doughnuts from each batch were also analyzed in triplicate for moisture, oil, and protein content. The doughnuts were cut into small pieces in a Hobart cutter (model 84142) prior to analysis. Moisture content was determined by drying 5 g samples for 24 hrs in a vacuum oven at 70 C. Oil content was determined on moisture-free samples extracted for 24 hrs with Skelly F in a Soxhlet apparatus. Nitrogen content was determined by Kjeldahl procedure on 1 g samples of meals and 2.5 g samples of doughnuts. Factors used to convert nitrogen content to protein values (4) for the meals were 5.46 for peanut and 6.25 for cowpea. For the doughnuts, weighted conversion factors were calculated on the basis of the proportion of total protein provided by the protein-containing ingredients in the formula, i.e., wheat flour (N x 5.7), legume meal, egg (N x 6.25), and buttermilk (N x 6.25).

Ten doughnuts from each batch were weighed individually. Color differences in visual lightness (L), redness to greenness *(a)*, and yellowness to blueness *(b)* of the exterior of 10 doughnuts from each batch were measured with a Gardner Color Difference Meter Model C-4 (L), using an orifice size of 1.9 cm and an ivory standard placed over an optical glass cover plate. Reference values for the standard were L = 76.6, a = -1.1, and b = 24.2.

Doughnut weights, Gardner color values, and sensory quality scores were evaluated by standard procedures of analysis of variance and multiple range testing of the significance of mean differences using the Statistical Analysis System of Barr et al. (3).

Results and Discussion

The test meals differed substantially in compositional characteristics (Table 2). Toasted peanut meal had the lowest moisture content and cowpea meal the highest. The oil content of the partially defatted peanut meals was considerably higher than the inherent low oil content of cowpea meal and wheat flour. Protein levels of the peanut meals were almost twice that of cowpea meal and more than three times that of wheat flour.

Table 2. Moisture, Oil, and Protein Content of Peanut and Cowpea Meals[a].

Treatment	% Moisture	% Oil[b]	% Protein[b]
Peanut meal from partially defatted, untoasted peanuts	6.8	31.2	35.4
Peanut meal from partially defatted, toasted peanuts	3.2	36.3	34.2
Cowpea meal from full-fat, dry peas	14.2	1.0	19.5

[a]For comparison, all-purpose wheat flour contains 12.0% moisture, 1.0% fat, and 10.5% protein (11).

[b]Wet wt. basis.

Representative samples of doughnuts prepared from each legume meal are shown in Figure 2. No problems were encountered in cutting and dispensing the test batters except with untoasted peanut meal (A) used at the 30% wheat flour replacement level. This batter was extremely sticky, and the automatic cutting device could not completely cut away the doughnut center. This produced the closed doughnut center that can be seen with this treatment. For the most part, however, the legume meal batters were well suited to mechanical cutting, dispensing, and frying and would require no change in existing doughnut processing procedures. The legume meal batters had a "grainy" appearance, due to the particle size of the meals, and produced doughnuts with a coarser, more open-grained structure than the controls. This characteristic became increasingly apparent as meal level increased.

Compositional and physical characteristics of legume meal doughnuts are shown in Table 3. Increasing the level of each meal increased the percentage of protein in

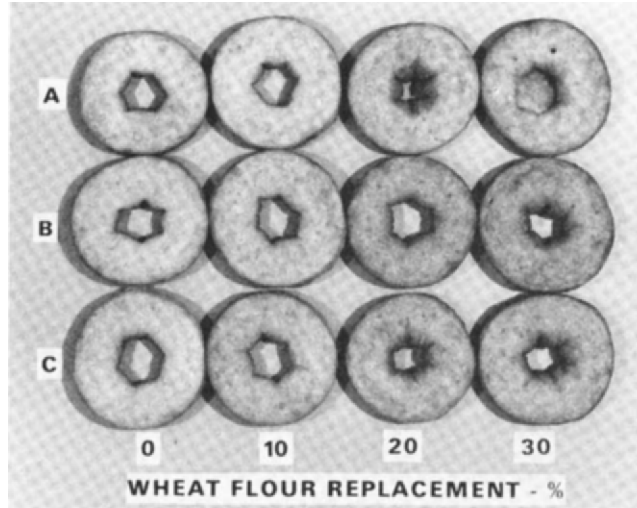

Fig. 2. Representative doughnuts prepared from untoasted peanut meal (A), toasted peanut meal (B), and cowpea meal (C) at various wheat flour replacement levels.

the fried products but also increased the oil content. The oil data results contrast with those reported by Lawhon et al. (7) with peanut flour containing 1.2% oil, but results obtained from the two studies are difficult to compare because of the substantial differences in particle size and initial oil content of the peanut ingredients. The increase in oil content was not totally unexpected with the peanut meals since they were only partially defatted at the outset but was somewhat surprising with the low-oil cowpea meal. Soy flour possesses the capacity to control fat absorption during frying and is added to doughnut formulations expressly for this purpose. Though the mechanism by which soy flour controls fat absorption during frying has not been explained, Wolf and Cowan (12) hypothesized that heat denaturation of the proteins may involve the formation of a fat resistant barrier at the doughnut surface. Intrinsic differences in the proteins of peanut and cowpea meals, the methods by which they were processed, and their particle size may have contributed to their inability to restrict fat absorption. Cake-type doughnuts should absorb some fat during frying to assure good organoleptic and keeping qualities, but excessive fat absorption should be avoided (1). Since controlled fat absorption during frying is essential for the production of high quality doughnuts, improvements in the performance of the legume meals evaluated in this study are needed. Areas which might be explored for this purpose include the use of finely-milled legume flours of high protein, low fat content; an increase in mixing time and/or floor time (rest period) between the mixing and cutting steps to allow the dry ingredients more time to take up water; and the addition of fat-controlling ingredients such as soy flour to the basic doughnut formula.

Legume meal batters produced fewer doughnuts per batch, of higher average weight, than control batters. Doughnut weights increased as the level of legume meal increased (Table 3).

Gardner color values of doughnuts prepared with various levels of peanut and cowpea meals are shown in Table 3. Increasing the level of untoasted peanut meal in doughnuts produced no significant reduction in lightness (L) except at the 30% wheat flour replacement level. Val-

Table 3. Compositional and Physical Characteristics of Doughnuts Prepared with Various Levels of Peanut and Cowpea Meals[a].

Treatment	% Wheat Flour Replacement	% Moisture	% Oil[b]	% Protein[b]	Batch Yield	Average Weight (g)	Gardner Color Values		
							L	a	b
Peanut meal	0	16.6	27.7	5.3	21	31.90c	50.8a	-4.5	20.4
from partially	10	17.3	28.4	6.2	18	39.39b	49.5a	-5.1	20.5
defatted, un-	20	14.8	34.0	7.0	18	40.22b	48.2a	-2.8	19.1
toasted peanuts	30	14.3	39.7	7.2	17	48.82a	44.8b	-3.3	18.1
	(probability)					(0.01)	(0.01)	(ns)	(ns)
Peanut meal	0	18.7	27.4	5.4	20	34.88c	50.5a	-7.9b	21.3a
from partially	10	17.5	29.9	6.0	19	38.23b	48.7a	-3.2a	19.6b
defatted,	20	13.7	40.1	6.3	20	40.26b	44.3b	-1.0a	17.3c
toasted peanuts	30	13.9	40.5	6.9	18	44.69a	43.3b	-0.7a	16.6c
	(probability)					(0.01)	(0.01)	(0.01)	(0.01)
Cowpea meal from	0	18.4	27.7	5.2	20	36.18c	52.5a	-1.5	19.2a
full-fat, dry	10	16.1	31.7	5.4	19	39.00b	49.9b	-0.5	18.0ab
peas	20	14.5	35.6	5.5	19	39.27b	46.4c	+0.4	16.9b
	30	16.0	34.6	6.1	17	43.86a	48.1bc	-0.6	18.0ab
	(probability)					(0.01)	(0.01)	(ns)	(0.05)

[a]For each meal, values having different letters within a column are significantly different at $P \leq 0.01$ or $P \leq 0.05$ as indicated; ns values are not significantly different.

[b]Wet wt. basis.

ues for *a* and *b* for control and test doughnuts containing untoasted peanut meal were not significantly different. In the toasted peanut meal set, control doughnuts and those made with the 10% level of this meal had similar lightness (L) values which were significantly higher than L values for doughnuts made with the 20 or 30% levels. Doughnuts containing 10, 20, or 30% toasted peanut meal had similar *a* values which were less intense than the control. Values for *b* (yellow when positive) decreased in intensity as the level of toasted peanut meal increased. For doughnuts made with cowpea meal, lightness (L) values were reduced whereas *a* values were not affected by the presence of the meal. Yellowness values (*b*) were variable and unordered, indicating that the differences should be discounted.

Sensory quality scores of doughnuts prepared with various levels of peanut and cowpea meals are shown in Table 4. The legume meal doughnuts were acceptable and scored favorably in comparisons with wheat flour controls. The only adverse comments noted by the sensory panelists were primarily in reference to the "coarse-grained, greasy texture" of doughnuts containing 20 to 30% of the legume meals. These doughnuts had an undesirably oily surface and visible fat penetration into the crumb. Some sensory panelists noted a "raw, beany flavor" in doughnuts made with 30% untoasted peanut meal and a "distinct roasted peanut flavor" in doughnuts containing 30% toasted peanut meal. The aroma of doughnuts made with 20 and 30% cowpea meal was described as "slightly beany," but this characteristic did not carry over to or adversely affect the flavor character of the doughnuts.

Results of this study indicate that peanut and cowpea meals are compatible ingredients for use in cake-type doughnuts. The legume meal batters had good machinability characteristics and produced doughnuts which compared favorably in sensory characteristics to wheat flour controls. Techniques to restrict excessive fat absorption during doughnut frying are needed, however. These might include the use of finely-milled legume flours of high protein, low fat content; increased reaction time among ingredients during and/or after mixing; and the addition of fat-controlling ingredients such as soy flour to the basic doughnut formula.

Table 4. Sensory Quality Scores of Doughnuts Containing Various Levels of Peanut and Cowpea Meals.

Treatment	% Wheat Flour Replacement	Sensory Quality Scores[a]				
		Appearance	Color	Aroma	Texture	Flavor
Peanut meal	0	8.3	8.1	8.1	7.6a	8.0a
from partially	10	8.3	7.9	7.9	7.7a	7.5ab
defatted, un-	20	8.2	8.1	7.6	7.6a	7.9a
toasted peanuts	30	7.6	7.8	7.3	6.6b	7.0b
	(probability)	(ns)	(ns)	(ns)	(0.05)	(0.05)
Peanut meal	0	7.8	7.5	8.1	7.9a	8.2a
from partially	10	8.0	7.8	8.0	7.8a	7.9ab
defatted,	20	7.5	7.9	7.3	6.9b	7.3bc
toasted peanuts	30	7.1	7.5	7.4	6.7b	7.1c
	(probability)	(ns)	(ns)	(ns)	(0.01)	(0.01)
Cowpea meal from	0	8.3	8.0	8.0a	7.9a	7.8
full-fat, dry	10	8.1	7.9	8.0a	7.7a	7.8
peas	20	7.8	7.8	7.4b	7.0b	7.4
	30	7.9	7.8	7.2b	7.0b	7.2
	(probability)	(ns)	(ns)	(0.01)	(0.05)	(ns)

[a]Scale of 9 to 1 where 9 = excellent, 5 = borderline, 1 = very poor. For each meal, values having different letters within a column are significantly different at $P \leq 0.01$ or $P \leq 0.05$ as indicated; ns values are not significantly different.

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Literature Cited

1. Anonymous. 1976. Doughnuts production handbook. The Pillsbury Co., Minneapolis, MN.
2. 'Ayres, J. L. and B. L. Davenport. 1977. Peanut protein: a versatile food ingredient. J. Amer. Oil Chem. Soc. 54:109A-111A.

3. Barr, A. J., J. H. Goodnight, J. P. Sall, and J. T. Helwig. 1976. A User's Guide to SAS 76. SAS Institute, Inc., Raleigh, NC, pp. 57-65.
4. FAO. 1970. Amino acid content of foods and biological data on proteins. Food and Agriculture Organization of the United Nations. Rome, Italy.
5. Harris, H., E. Y. Davis, M. S. Van de Mark, K. S. Rymal, and J. J. Spadaro. 1972. Development and use of defatted peanut flours, meals, and grits. Auburn Univ. Agric. Exper. Sta. Bull. 431.
6. Khan, M. N., D. Mulsow, K. C. Rhee, and L. W. Rooney. 1978. Bread making properties of peanut flour produced by direct solvent extraction procedure. J. Food Sci. 43:1334-1335.
7. Lawhon, J. T., C. M. Cater, and K. F. Mattil. 1975. Sensory, analytical evaluation of cake doughnuts fortified with protein from oilseed flours. Food Prod. Devel. 9(4):110-118.
8. McWatters, K. H. and B. B. Brantley. 1982. Characteristics of akara prepared from cowpea paste and meal. Food Technol. 36(1):66.
9. Salathe, L. E. 1979. Household expenditure patterns in the United States. U. S. Dept. Agric. Technical Bull. No. 1603.
10. Vix, H. L. E., J. Pominski, H. M. Pearce, Jr., and J. J. Spadaro. 1967. Development and potential of partially defatted peanuts. Peanut J. Nut World 46(3):10-11.
11. Watt, B. K. and A. L. Merrill. 1963. Composition of foods. Agric. Handbook No. 8. USDA, Washington, D.C.
12. Wolf, W. J. and J. C. Cowan. 1971. Soybeans as a food source. CRC Critical Reviews in Food Technol. 2(1):81-158.

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