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Quality Characteristics of Cake-type Doughnuts Containing Peanut, Cowpea, and Soybean Flours

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ABSTRACT

Ten percent of the wheat flour in cake-type buttermilk doughnuts was replaced with flours processed from prepress, solvent-extracted peanuts; partially defatted, untoasted peanuts; partially defatted, toasted peanuts; and dry cowpeas. The legume-supplemented doughnuts were prepared with and without soybean flour, which is frequently added to doughnut formulations to control fat absorption during frying. The quality of test doughnuts was assessed by comparison to wheat flour reference doughnuts. Good machinability and frying characteristics were observed in reference and test batters. Legume-supplemented doughnuts scored favorably in sensory comparisons with reference doughnuts and were similar in moisture content. Oil levels of legume flour-supplemented doughnuts were the same or less than that of reference doughnuts and were more acceptable than levels reported in an earlier study which utilized the legumes in the form of meal.

Key Words: Peanut flour, cowpea flour, soybean flour, legume flour doughnuts, legume flour:wheat flour blends.

Doughnuts and other sweet bakery goods are consumed widely in the United States (9) and are potential products for utilizing peanut and other legume protein products as ingredients (2, 4-8). In an earlier study (8), peanut and cowpea meals were used at various replacement levels for wheat flour in cake-type doughnuts; batters from the test products had good machinability and frying characteristics and produced doughnuts which compared favorably in sensory characteristics to wheat flour reference doughnuts. The only major adverse characteristic of the legume meal doughnuts was the excessive amount of fat which they absorbed during frying. It was not known if the inability of the legume meals to control fat absorption was related to their particle size or to some intrinsic characteristic of seed components.

In efforts to improve the quality of doughnuts containing legume-derived ingredients, two approaches were investigated to reduce excessive fat absorption during frying. These were (a) the use of legume flour instead of meal and (b) formula modification to include soybean flour, which has a demonstrated capacity to contol fat absorption during doughnut frying. The mechanism by which soy flour controls fat absorption is not known, but it has been hypothesized that heat denaturation of the proteins during frying may involve the formation of a fat resistant barrier at the doughnut surface (12).

The purpose of the present study was to evaluate the performance of peanut flour, both defatted and partially defatted, and cowpea flour in chemically-leavened doughnuts made with and without soybean flour.

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Materials and Methods

Defatted peanut flour was produced by a commercial prepress, solvent extraction procedure (1). Partially defatted peanut flour was commercially processed by a hydraulic pressing procedure developed by Vix et al. (10); the pressed peanuts were either ground raw to produce partially defatted, untoasted flour or toasted in hot air at 160 C for 15 min prior to grinding to produce partially defatted, toasted flour. Cowpea flour was prepared from 1981-crop dry cowpeas (*Vigna unguiculata* cv. Dixiecream) which were decorticated in an abrasive pearler, sieved to remove separated seed coats, cracked by passage through a Morehouse stone mill with the stones set at maximum distance apart (4.3 mm), air aspirated and sieved to remove separated seed coats, and milled in a Microjet 10 Ultracentrifugal mill equipped with a 0.2 mm screen and operated at 10,000 rpm. The soybean flour added to some of the doughnut formulations was a defatted, commercial product which was recommended by the manufacturer for use in doughnuts and breads. Wheat flour, purchased in a local supermarket, and the legume flours were stored in glass jars and held at 1 C when not in use.

Preliminary batches of doughnuts made with 20% and 15% levels of peanut or cowpea flour were quite sticky and difficult to cut. Therefore, these flours were used at a 10% wheat flour replacement level in cake-type buttermilk doughnuts. The legume-supplemented formulations were prepared with and without 3% soybean flour (based on the weight of wheat flour in the basic formula). A 100% wheat flour formula, which served as the reference, contained the following ingredients: 348 g wheat flour (plain, all-purpose), 11.1 g baking powder (SAS), 3.42 g salt, 0.75 g baking soda, 75 g egg (whole, fresh), 147 g sugar (granulated, cane), 39 g peanut oil, 183.75 g buttermilk (fresh), and 3/4 tsp. vanilla. A typical batch yielded 15 doughnuts. Mixing and frying procedures were the same as those described previously (8). The doughnuts were drained on absorbent paper, cooled, packaged in polyethylene bags, and frozen until sensory evaluations were conducted one week later.

For sensory evaluations, one set of doughnuts was evaluated per day and consisted of the following treatments: (1) 100% wheat flour, (2) 90% wheat flour + 10% peanut or cowpea flour, and (3) 90% wheat flour + 10% peanut or cowpea flour + soybean flour to increase the total flour content by 3%. Doughnuts were thawed overnight at room temperature in the packages, cut into halves, arranged in random order on white plates, and evaluated by panelists in individual booths under incandescent lighting. A volunteer panel consisting of eight men and two women rated five quality attributes (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, protein, and ash levels of the legume flours were determined in triplicate. Three doughnuts from each batch were analyzed in duplicate for moisture and oil content. Analytical procedures were the same as those described previously (8).

The texture (force required to shear) of eight doughnuts (halved) from each batch was determined with a Food Technology Corp. Shear Press (Model TP-1). Shear press operating conditions included a standard shear-compression cell, 136 kg transducer ring, downstroke speed of 30 sec, and recorder range setting of 50. Peak heights were measured and reported as kg force/g.

Sensory quality scores and shear values 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 legume flours differed substantially in composition (Table 1). The moisture content of the flours made from partially defatted peanuts was lower than the other flours because the processing of untoasted flour involved a spray drying step, and preparation of the toasted flour involved roasting the pressed nuts in hot air. The prepress, solvent extraction treatment produced a peanut flour which had practically all of the oil removed whereas the hydraulic pressing treatment produced peanut flours which were partially defatted. Cowpeas are inherently low in oil content. Protein levels were highest in the defatted peanut flour, intermediate in the partially defatted flours, and lowest in cowpea flour. Ash content was somewhat higher in the defatted peanut flour than in the other flours.

Table 1. Proximate Composition of Peanut and Cowpea Flours.[1]

Legume Source - Processing Treatment	% Moisture	% Oil	% Protein[2]	% Ash
Peanut - prepress, solvent extracted	7.2	0.9	54.4	5.1
- partially defatted, untoasted	2.4	34.5	34.9	3.2
- partially defatted, toasted	1.4	34.4	37.6	3.0
Cowpea flour	11.5	1.4	25.5	3.5

[1]Dry wt. basis. For comparison, all-purpose wheat flour contains 12% water and, on a dry wt. basis, 1% fat, 12% protein, and 0.5% ash (11).

[2]Conversion factor for peanut = N x 5.46, cowpea = N x 6.25.

Representative samples of doughnuts prepared from each legume flour are shown in Figure 1. No significant problems were encountered with mechanically cutting and dispensing the batters except with peanut flour from partially defatted, untoasted peanuts. This particular batter was sticky, and the automatic cutting/dispensing device could not completely cut away the doughnut center. This produced the closed doughnut center that can be seen with this treatment. The addition of soy flour facilitated the cutting and dispensing of this particular sample, though doughnut centers weren't as open as those of wheat flour reference doughnuts. Degree of browning was similar for reference and test doughnuts. The grain of legume flour-supplemented doughnuts was not as open and coarse as that of doughnuts made in an earlier study with legume meal (8).

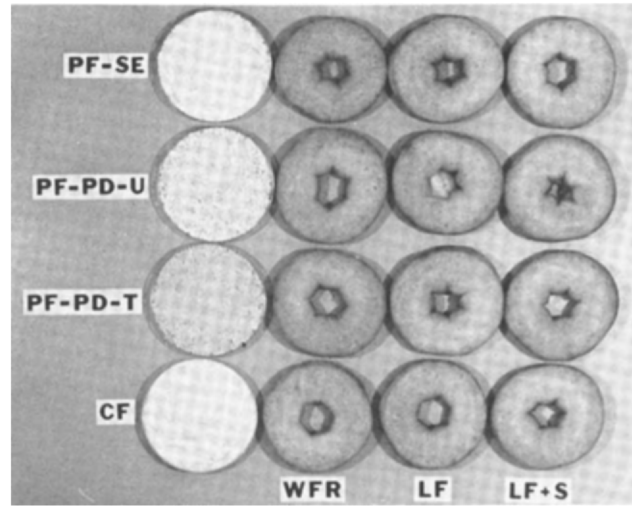

Fig. 1. Representative doughnuts prepared from peanut flour-solvent extracted (PF-SE), peanut flour-partially defatted-untoasted (PF-PD-U), peanut flour-partially defatted-toasted (PF-PD-T), and cowpea flour (CF). WFR = wheat flour reference, LF = 10% legume flour (peanut or cowpea), LF + S = 10% legume flour (peanut or cowpea) + 3% soybean flour.

Sensory quality scores of doughnuts prepared with the legume flours are shown in Table 2. The wheat flour reference and legume flour test products compared favorably in most sensory quality attributes (appearance, color, texture, and flavor). Aroma quality was reduced in some instances by the addition of peanut flour to doughnut formulations. The aroma of doughnuts containing 10% of the solvent extracted peanut flour, without soy flour, received an average rating of 6.6 ("fair"); the aroma was not objectionable to the sensory panelists but was described as being "bland" or "flat". Doughnuts containing 10% of the partially defatted, untoasted peanut flour and made without soy flour were described by panelists as having a "slightly beany" aroma. The aroma of doughnuts made with partially defatted, toasted peanut flour was described as "definitely peanutty." Doughnuts made with

Table 2. Sensory Quality Scores[1] of Doughnuts Prepared with Peanut, Cowpea, and Soybean Flours.

Treatment	Appearance	Color	Aroma	Texture	Flavor
Peanut flour					
Prepress, solvent extracted					
Wheat flour reference	8.0	7.9	8.0 a	7.6	7.9
10% peanut	8.0	7.8	6.6 b	7.1	7.2
10% peanut + 3% soy	8.1	8.0	7.7 a	7.7	7.5
(probability)	(ns)	(ns)	(0.05)	(ns)	(ns)
Partially defatted, untoasted					
Wheat flour reference	8.0	7.7	8.0 a	7.2	7.9
10% peanut	6.9	7.9	6.9 b	6.3	7.7
10% peanut + 3% soy	7.6	7.9	7.6 ab	7.2	7.8
(probability)	(ns)	(ns)	(0.05)	(ns)	(ns)
Partially defatted, toasted					
Wheat flour reference	8.4	8.2	8.1 a	7.3	8.0
10% peanut	8.0	8.0	6.2 b	6.4	6.5
10% peanut + 3% soy	7.9	8.0	6.4 b	6.7	6.7
(probability)	(ns)	(ns)	(0.05)	(ns)	(ns)
Cowpea flour					
Wheat flour reference	7.7	7.8	7.9	7.7	7.9
10% cowpea	7.9	8.1	7.2	7.6	6.8
10% cowpea + 3% soy	7.8	7.9	7.2	7.5	7.1
(probability)	(ns)	(ns)	(ns)	(ns)	(ns)

[1]Scale of 9 to 1 where 9 = excellent, 5 = borderline, 1 = very poor. For each flour, values within a column having no letter in common are significantly different at $P \leq 0.05$; ns values are not significantly different.

cowpea flour were similar to wheat flour reference doughnuts in all sensory attributes.

Wheat flour reference doughnuts contained about 21% water. The moisture content of legume flour-supplemented doughnuts was either about the same or 1-1 1/2% below or above this level. Wheat flour reference doughnuts contained about 30% oil (dry wt basis). The oil content of legume flour-supplemented doughnuts was either about the same or less than that of reference doughnuts. This was a definite improvement over the results obtained previously with legume meals (8). The addition of soy flour to some of the formulas provided no added benefit in controlling the amount of fat the doughnuts absorbed during frying. Batters containing legume products in the form of flour were not as open-grained in structure as batters made with legume meals (8), a factor which clearly contributed to the improved doughnut processing performance of the flours.

Values for the amount of force required to mechanically shear doughnuts are shown in Table 3. The shear value for wheat flour reference doughnuts was about 1.6 kg force/g. Values for legume flour-supplemented doughnuts and reference doughnuts were similar in most cases. The only exceptions were doughnuts made with partially defatted, untoasted peanut flour, with or without soy flour, and those made with partially defatted, toasted peanut flour without soy flour; these doughnuts required less force to shear than the other samples. Although shear values differed from some of the doughnuts, the textural differences were not apparent to the sensory panelists (Table 2).

Table 3. Shear Values for Doughnuts Containing Peanut, Cowpea, and Soybean Flours.

Treatment	kg force/gram[1]
Wheat flour reference	1.58 abc
Peanut flour - prepress, solvent extracted	1.45 c
- prepress, solvent extracted + soy	1.58 ab
- partially defatted, untoasted	1.16 e
- partially defatted, untoasted + soy	1.23 de
- partially defatted, toasted	1.31 d
- partially defatted, toasted + soy	1.46 bc
Cowpea flour	1.54 abc
Cowpea flour + soy	1.62 a

[1]Values having no letter in common are significantly different at $P \leq 0.05$.

Results of this study indicate that peanut and cowpea flours are compatible ingredients, in terms of processing performance and sensory quality, for use in cake-type doughnuts. Oil levels of legume flour-supplemented doughnuts were more acceptable than levels reported in an earlier study (8) which utilized the legumes in the form of meal. Doughnuts and other bakery goods which already enjoy widespread consumer acceptability are potential candidates for extending the utilization of legume proteins. Legume flour supplementation of bakery products also provides a means for improving the protein quality of wheat flour-based foods without sacrificing palatability.

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