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Supplementation of Bakery Items with High Protein Peanut Flour

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ABSTRACT

White skin peanuts were defatted with hexane to produce flours with 55-60% protein. The peanut flour was used to replace 12.5% of the wheat flour in bread, 100% of wheat flour in muffins, and 10, 15 or 50% of the wheat flour in cookies. At 12.5% levels of peanut flour, total solids, protein, moisture retention of bread after baking, and dietary fiber contents are increased without affecting loaf volume. Crust color of supplemented bakery items is darker brown, texture is coarse for bread and harder in cookies, but not enough to make them unacceptable. Peanut flour muffins with a net protein content of 33-40% can serve as a high protein snack food or bakery item, possibly for patients with celiac disease who cannot tolerate wheat flour. Moisture retention in supplemented products was greater than in nonsupplemented controls. Net increase of protein in baked items varied from 4% increase for 12.5% peanut flour bread to 30% for the all-peanut flour muffins. Other physical and chemical properties of these products are presented to support potential applications of peanut flour as a supplement for selected food products.

INTRODUCTION

Oilseed proteins are expected to play an increasing role in meeting the world's future needs for edible protein to replace decreasing or economically inaccessible supplies of animal protein, if they can be formulated into foods that look and taste like traditional foods. Fortifying bread with legume or oilseed proteins is one of the primary methods available for raising protein levels in human diets for economic and/or health reasons. Proper food and water are two of the most basic needs of all people, but religious, cultural and social habits frequently govern their eating habits. Even in today's affluent societies, there is a growing interest in "back to nature" or "natural" type foods in which dark breads or specialty breads are something of a status symbol, more so than the traditional wheat breads that have been enriched with vitamins and minerals for several decades (1). Four ounces of a protein-fortified bread can provide 20% of the US recommended daily allowance of protein for adults (2). For this reason there has been a great increase in research on the fortification of wheat bread with various types of protein, such as single cell protein (3), cottonseed, soybean, peanut and sunflower proteins (4,5), lentil, sunflower, faba bean, field pea and soy proteins (6-9), cowpea powder (10), potato protein (11), safflower protein (12), Great Northern Bean proteins (13), and fish protein concentrate and green algae (14). High protein flours and meals from red skin peanuts have been used in breads (4,5,15,16) but, unless the skins are removed before oil extraction, a flour darker than wheat flour is produced, which then yields darker bread color in fortified loaves (15).

Bread is not the only bakery item being fortified with oilseed and legume proteins. Because of a growing desire to raise the nutritional level of snack foods, various kinds of cookies (17-20), biscuits (21), and corn muffins (22) have been fortified with oilseed or legume proteins but none of these reports tested all-oilseed flour baked products, possibly because of the lower volume and heavier texture of such products compared to wheat flour products. Ranhotra et al. (20) and McWatters (19) reported that fortification of cookies with nutritionally significant levels of nonwheat proteins adversely affected their quality and acceptability. However, modification of formulation and processing technologies with flavors and dough conditioners improved product quality. To offset the adverse effects of soy flour on cookie spread while maintaining high levels of soy protein for its nutritional value, Ranhotra (23) substantially increased the level of shortening in the formula.

Bread is an ideal food for protein fortification since it is a major staple throughout the world, and peanuts can serve as a source of protein for fortification since they are already accepted as human food. Several years ago, studies were begun at the Southern Regional Research Center (SRRC) on white skin peanuts that did not have the typical peanut flavor/aroma after roasting, did not have to be blanched before oil removal (resulting in lower processing costs), produced a white high protein flour, had little or no flatus-causing sugars, and had a protein profile similar to red skin varieties (24,25). Defatted white skin peanut flour appears to be an ideal source of bland, white flour that should be comparable to other oilseed/legume proteins for fortification of baked goods. Data are presented on the chemical characteristics of two white skin peanut flours used in protein fortification of bread, cookies and muffins.

EXPERIMENTAL

The two varieties of white skin peanuts, PI288160 (SR57) and Spanwhite (C32W), were grown in experimental plots in Tifton, GA. After harvesting, drying, shelling and sorting, the seeds were shipped to the SRRC, New Orleans, LA, where they were flaked, deoiled by hexane solvent-extraction, dried, desolventized, and ground to a fine flour in the Engineering and Development Laboratory. Samples of the

TABLE I

Recipe for Standard White Wheat Bread

Ingredient	Quantity (standard recipe)	Quantity (metric, estimated)
Active dry yeast	2 pkg	20 g
Sugar	¼ cup	55 g
Salt	2 tsp	13.5 g
Vegetable oil, commercial brand	¼ cup	60 mL
Water	4 cups	946 mL
Wheat flour, white, (4-5 loaves)	12 cups	1.5 kg

TABLE II

Recipe for 100% Peanut Flour Muffins

Ingredient	Quantity (standard recipe)	Quantity (metric, estimated)
Eggs, well-beaten	2	140-150 g
Cream	½ cup	120 g
Butter	1 tbsp	20 g
Water	½ cup	125 g
Peanut flour[a]	1½ cups	150 g
Baking powder	2 tsp	20 g
(7-8 standard size muffins)		

[a]For peanut-flavored muffins, this was changed to 1 cup peanut flour (100 g) and ½ cup of a commercial freeze-dried peanut butter powder.

TABLE III

Proximate Composition of P_2O_5 Dried Breads with/without 12.5% Replacement of Wheat Flour by Peanut Flour

		Fortified breads	
Component	Control (wheat) (%)	C32W PN Flour (%)	SR-57 PN Flour (%)
Lipid extract	4.1	4.7	3.8
Protein, N X 6.25	11.1	13.9	14.2
Ash	3.5	3.1	3.2
Crude fiber	0.3	0.6	0.4
Carbohydrate	73.6	71.2	72.2
Moisture	7.4	6.5	6.2

TABLE IV

Proximate Composition of P_2O_5 Dried All-Peanut Flour Muffins

Component	Unflavored (%)	Flavored[a] (%)
Protein, N X 6.25	43.0	38.9
Lipid extract	22.1	30.5
Ash	6.9	5.2
Crude fiber	2.2	1.9
Carbohydrate	23.2	21.7
Moisture	2.6	1.8

[a]Flavor — a freeze-dried commercial peanut butter powder containing oil, protein and added starch as a stabilizer.

flour were analyzed in duplicate for aflatoxin contents, and microbial counts (Coliforms, Clostridium, Salmonella and thermophiles) by commercial laboratories.

All other ingredients for preparing the bread and muffins (bleached wheat flour, sugar, salt, yeast, milk, baking powder, vegetable oil) were purchased in local food stores. Recipe used to prepare the standard wheat bread is listed in Table I. To prepare 12.5% peanut flour-enriched bread, 1.5 cups (ca. 187 g) of unsifted wheat flour were replaced with an equal amount of either SR57 or C32W peanut flour and mixed in an electric dough mixer. Loaves (2 of each test sample) were baked in stainless steel 1-lb bread pans at 350 F (177C) for 30 min. Dough conditioners were not added to any of the formulations.

Ingredients used to produce 100% peanut flour muffins are given in Table II. Defatted flour prepared from SR-57 variety white skin peanuts was used to prepare the muffins. Dry ingredients were blended; the water, cream, and butter were mixed into the beaten eggs. The liquid mixture was then added to the dry ingredients and beaten by hand for 300-400 strokes. Muffins were baked in Teflon-lined aluminum muffin pans for 12-14 min at 450 F (230 C). To determine proximate composition (AOAC Methods) of the breads and muffins, duplicate samples were dried over P_2O_5 in a vacuum dessicator, without heat, with frequent changes of P_2O_5 until samples reached constant weight, then pulverized with a mortar and pestle to obtain homogeneous aliquots. Sample weights before and after P_2O_5 drying were used to determine water (moisture) contents of fresh products. Samples were analyzed for proximate composition by commercial laboratories according to AOAC methods. Moisture is the difference between total sample weight and % total solids (Tables III and IV).

Sugar, lemon drop, coconut drop, and high protein spice cookies were prepared and baked in duplicate sets at Universal Flavor Corp., Houston, TX using basic cookie recipes. Ingredients included all-purpose bleached wheat flour, vegetable oil or hydrogenated shortening, eggs, baking powder, sugar, salt, and flavors produced by Universal Flavors Corp. Sufficient defatted flour prepared from C32W variety white kin peanuts was used as a replacement for wheat flour so that protein contents increased from 4% (10% peanut flour) to 20% (50% peanut flour). One set of each type of cookies was forwarded to SRRC for evaluation.

RESULTS AND DISCUSSION

The peanut flours were free of aflatoxins and microbial counts were below the limits permissable for food uses or were completely absent.

The cross-sectional view in Figure 1 shows little or no decrease in loaf volume of 12.5% peanut flour-fortified breads compared to the all wheat flour control (W). Replacement of wheat flour with peanut flour at this level does not appear to have significant adverse effects on loaf volume or whiteness of the slices of bread. Khan et al. (16) reported no significant differences in breadmaking properties of one commercial and four experimental peanut flours at 10, 15 and 20% levels, but Tsen et al. (15) reported that more than 10% peanut flour impaired baking quality of wheat flour unless dough conditioners were added. With dough conditioners, acceptable bread was made with up to 15% peanut flour or 20% peanut meal as protein supplements. Fortification of bread with other legume flours had similar effects. Great Northern Bean flour at levels above 10% had adverse effects on dough and bread quality (13)

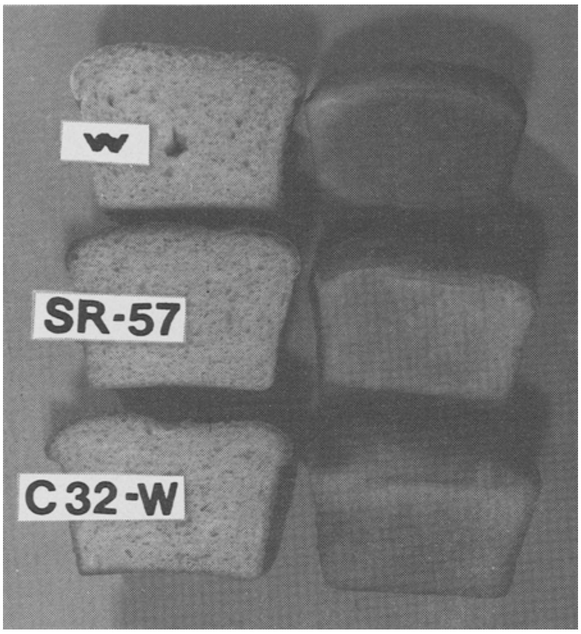

FIG. 1. Cross-sectional view of breads with and without peanut protein flour, to show loaf volume. W, control all wheat flour; SR-57, wheat flour plus 12.5% defatted peanut flour (white skin variety SR-57); C32-W, wheat flour plus 12.5% defatted peanut flour (white skin variety C32-W).

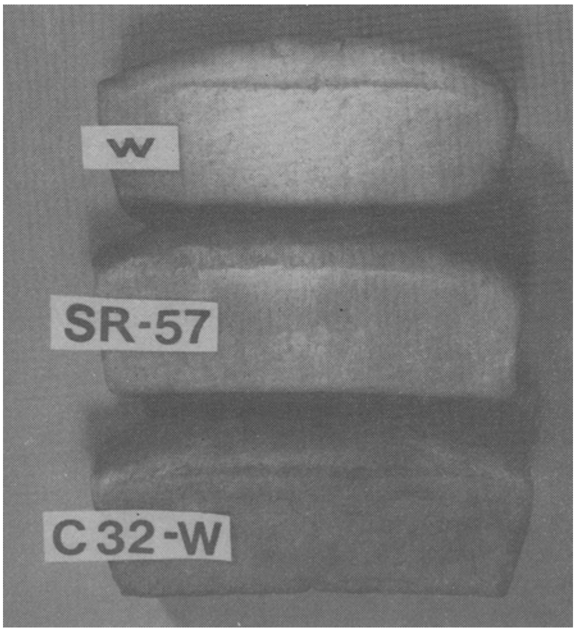

FIG. 2. End view of breads with and without peanut protein flour, to compare crust color (same designations as Fig. 1.)

and lentil flour produced progressive decreases in specific volume of the loaves as levels of lentil flour increased (8). The fortified breads, especially that containing C32W peanut flour, did have a darker brown crust than the all wheat control crust (Fig. 2), probably due to higher sucrose contents of the peanut flours, which can increase Maillard browning (24,25). Tsen et al. (15) using commercial red skin peanut flour or meal, observed more extensive browning reaction in fortified breads than in all wheat control

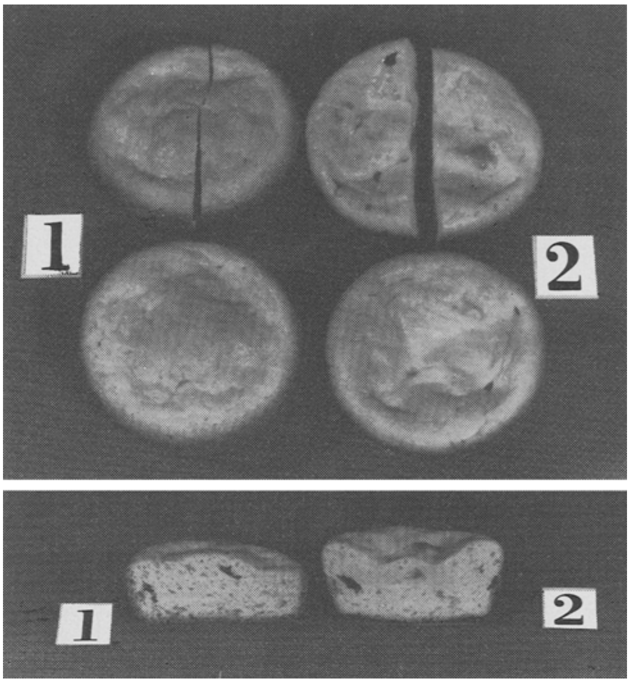

FIG. 3. Peanut flour muffins. (1) Unflavored control; (2) flavored. Top and middle rows, view of top surfaces; bottom row, cross-sectional view. Other conditions/composition described in Experimental.

breads. Peanut protein isolate at 8% substitution in Khan and Lawhon's study (5) contributed to better baking properties than did 8% cottonseed protein isolate or 4% soy protein isolate.

Crumb structure and pore sizes of the fortified breads were not visually different from the control. Fresh bread weights after baking were slightly heavier than the control because of increased water retention. The wheat control bread had 23.7% water (P_2O_5 dried), the C32W-fortified bread had 27.2%, and the SR-57-fortified bread had 27.8%.

Table III lists the proximate composition of the 3 breads after P_2O_5 drying to constant weight. Addition of peanut protein flour produced a slight increase of 1% in total solids (dry matter), 3% in total protein, and 0.1-0.3% in crude fiber of the breads.

Because of current interest in the benefits of dietary fiber, fiber-enriched breads containing wood pulp cellulose have been marketed in some parts of the country. Peanut skins have not been exploited as a source of fiber but, since the skins of these white skin peanuts are not removed during flour production, it was of interest to determine the neutral detergent fiber (NDF) contents of the skins. Crude fiber analysis (Table III) showed small increases for SR-57 and C32W-fortified breads with 10% added peanut flour. Since crude fiber is not a true indication of total dietary fiber, the skins were separated manually from flaked defatted peanuts before grinding and final preparation of flour, and the relative neutral detergent fiber (NDF) contents were determined. SR-57 peanut flour (plus skins) had 8.4% NDF, C32W peanut skins had 41.1%, and SR-57 peanut skins had 35.1%. Defatted skins of both varieties are high in fiber and should contribute some NDF to the total flour.

Top view of the 100% peanut flour muffins (Fig. 3) shows a graininess and external appearance similar to that for wheat flour muffins, but the gold to golden brown crust color was more like the color of yellow corn meal muffins. The cross-sectional view shows a grainy, dense internal structure of the muffins, not a light/fluffy appearance as expected for wheat flour muffins. Addition of baking powder probably caused the slight rise in volume, uniformity of cells and porous texture that is more evident in unflavored muffins (no. 1). Flavored muffins (no. 2) showed less rise in volume with no uniform cell structure and a gummy texture, despite the presence of baking powder in the formulation. This may be due to the type of flavoring used, a freeze-dried peanut butter powder that contained oil, protein, and added starch as a stabilizer. This powder seemed to inhibit rising of the dough but did not affect external appearance and potential acceptance of the muffins as a source of protein in muffins designed for people who are sensitive to wheat flour products.

Water retention in fresh peanut flour muffins before drying by P_2O_5 was quite high; 42.3% in both unflavored and flavored muffins. Table IV lists the composition of the dried muffins. The high protein content of these muffins (39-43%) would be 3-5 times higher than that for regular wheat flour muffins, based on results of Ahmed and Araujo (22) on fortified and unfortified corn muffins. This suggests that a peanut flour muffin could serve as a high protein food item snack/confection for those interested in nonwheat bakery items for health or other reasons.

Because of changing dietary habits and consumer interest in nutritional labeling and composition of foods, traditional wheat-based snacks, such as muffins and cookies, are also changing. Cookies, a popular snack food with good shelf-life, are ideal for protein fortification (19,20). The various types of cookies prepared for these studies were based upon wheat flour replacement by peanut flour (C32W variety). Like the fortified breads, all fortified cookies had increased protein contents ranging from 4 to 20%, depending upon the amount of peanut flour added, plus increased browning and darker color. Proximate compositions were similar to those reported by others (19,20) so they are not repeated here, but fortified cookies were harder than the controls, as judged by the tendency to break when pressed by the fingers. Spice cookies were much harder (more like ginger snap cookies) than the controls. The use of flavors, suggested by Ranhotra, et al. (20) does improve acceptability but, unless a high-protein snack is desired, the addition of such high levels of peanut flour to cookies may yield unacceptably hard texture. For such high levels it may be necessary to increase the addition of dough conditioners.

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