Replacement of Milk Protein with Protein from Cowpea and Field Pea Flours in Baking Powder Biscuits[1]

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ABSTRACT

Cereal Chem. 57(3):223-226

Baking and organoleptic qualities of baking powder biscuits made by replacing milk protein with cowpea (*Vigna unguiculata*) and field pea (*Pisum sativum*) protein were investigated. Flour from two varieties of cowpeas (G143, Dixie Cream) prepared by a dry milling process and from a flour and a protein concentrate prepared from field peas by pin-milling and air classification were included. Biscuits containing unheated and steamed (100° C, 30 min) pea products were compared to reference biscuits made with whole milk. Doughs containing the pea protein products were slightly less sticky than reference doughs. Sensory scores revealed that pea products in biscuits adversely influenced aroma and flavor qualities more than appearance, color, and textural attributes. Steam heating the pea protein products improved some biscuit quality attributes but not to the level of acceptability of the reference biscuits. Biscuits containing pea products browned less during baking and had lower weight/volume ratios than did the reference biscuits. The crust color of reference biscuits had lower L (lightness) and higher *b* (yellowness) Gardner values than did biscuits containing the pea products. The crumb color of reference biscuits and of those made from cowpea flours was lighter and less yellow than that of biscuits made from field pea products.

The use of plant proteins in foods is expected to increase substantially in the future as a means of meeting the worldwide demand for protein. The extent to which plant-derived proteins are successfully used will largely depend upon an understanding of the physical and functional qualities they impart to foods and of their acceptability to consumers. The use of pea protein in breads has focused primarily on yeast breads in which a portion of the wheat flour was replaced with pea flour (Anonymous 1974; Jeffers et al 1978; Okaka and Potter 1977, 1979b; and Sosulski and Fleming 1979). These workers indicated that pea protein produced beneficial effects in breads if used at low levels or in conjunction with dough conditioners to avoid adverse changes in breadmaking quality.

Another approach to investigating the performance of pea protein in bread is to use it as a replacement for the milk rather than for the wheat flour. To test the effects of using protein derived from cowpeas (*Vigna unguiculata*) and field peas (*Pisum sativum*) as a milk protein substitute, a quick bread (baking powder biscuit) rather than a yeast bread was selected for study because definite information about this application for pea protein was lacking. Unheated and steamed pea products were included for comparison.

MATERIALS AND METHODS

Flours

Two varieties, G143 and Dixie Cream, of 1978 crop dry cowpeas, grown by the Department of Horticulture of the University of Georgia Agricultural Experiment Station, were used to prepare cowpea flours. The peas were cracked by a pilot-scale stone mill (Morehouse Industries, model M-Ms-3) set at a stone clearance of 0.050 in. Following screening, the material that failed to pass a 100-mesh screen was reground in the Morehouse mill set at a stone clearance of 0.020 in. and screened again to separate seed coats. Material of 100-mesh to 140-mesh size was used for biscuit preparation. Field pea flour, #06520, and protein concentrate, #07520, were gifts of Pro-Star Mills, Ltd., Saskatoon, Saskatchewan. The flour was produced by dry pin-milling of dehulled field peas, and fractionated by air classification of the flour into protein concentrate and starch. Nitrogen content of the pea products used for biscuit preparation was determined by the Kjeldahl method (AOCS 1970) and converted to protein (N × 6.25). Protein contents ("as is" moisture basis) of unheated G143 cowpea flour, Dixie Cream cowpea flour, field pea flour, and field pea concentrate were 21.2, 21.1, 31.3, and 55.0%, respectively.

Moist Heat Treatment

One-pound samples of each pea product were spread in stainless steel pans at a depth of about 2 cm, placed in a temperature-controlled retort (Dixie RDTI-3), steamed at 100° C for 30 min, and transferred to a forced draft oven (Aminco G-3474) at 25 ° C for overnight drying. The product was pulverized with a mortar and pestle, reground in the Morehouse mill with the stone set at a clearance of 0.020 in., and screened. The material of 100-mesh to 140-mesh size was combined with the fines and used for biscuit preparation. The protein contents of heated G143 cowpea flour, Dixie Cream cowpea flour, field pea flour, and field pea concentrate were 22.7, 22.8, 30.9, and 55.5%, respectively. All flours, heated and unheated, were stored in glass jars at 1° C until used.

[1] Presented in part at the AACC 64th Annual Meeting, Washington, DC, October 1979.

0009-0352/80/03022304/$03.00/0

Biscuit Formulation and Preparation

The formula used for the control or reference biscuits contained 232 g of plain, all-purpose wheat flour, 6 g of salt, 14.8 g of baking powder (SAS-phosphate), 62.3 g of hydrogenated vegetable shortening, and 162.7 g of whole milk. The test biscuits were prepared by the same formula with pea flour and water substituted for the milk. A sufficient quantity of each test flour was used to supply protein equivalent to that provided by the whole milk, which was 6 g. The amount of tap water in the pea flour biscuit formulations, 142.2 g, was equivalent to the weight of water in 16.27 g of whole milk.

Biscuits were prepared by sifting the wheat flour and pea products together several times, sifting the flour mixture with the salt and baking powder into the mixer bowl, adding the shortening, which had been divided into several large pieces, and mixing at speed 1 (Hobart mixer, model N-50) for 1 min to cut in the shortening. The mixer was stopped and the bowl and beater scraped. The liquid was added all at once and mixed with the other ingredients for 45 sec. The dough was turned onto a lightly floured sheet of wax-coated freezer paper, kneaded by hand for 10 strokes, rolled between two sheets of wax-coated freezer paper to a uniform thickness of 8 mm, and cut to a diameter of 5.1 cm. Biscuits were placed about 2.5 cm apart on an ungreased aluminum cookie sheet and baked at 232° C (450 ° F) for 12 min in a preheated conventional household type of electric oven. Ten biscuits of each batch were selected at random, individually wrapped in aluminum foil, coded, and kept warm at 93° C for sensory quality evaluation.

Sensory Quality Evaluation

Several preliminary sessions were conducted to familiarize panelists with attributes contributing to biscuit quality. These included contour, browning characteristics, crumb moistness, evenness of grain, flakiness, tenderness, and flavor quality. Of these panelists, ten who could discern quality differences and who indicated that they liked and ate biscuits often participated in subsequent organoleptic evaluations. A scoring test and hedonic scale (Amerine et al 1965) were used to compare reference biscuits prepared with whole milk with experimental biscuits containing either heated or unheated pea products. Each sample was evaluated on its own merit for appearance, color, aroma, texture, and flavor quality. Two replications of each baking test were conducted.

TABLE I
Sensory Quality Scores of Baking Powder Biscuits Prepared with Heated and Unheated Pea Flours and Protein Concentrate[a,b]

Protein Source	Sensory Quality Scores[c]				
	Appearance	Color	Aroma	Texture	Flavor
G143 cowpea flour					
Reference (milk)	7.7	7.7 a	8.0 a	7.6	7.3 a
Heated flour	7.4	6.9 b	6.4 b	7.2	6.8 a
Unheated flour	7.4	7.4 a,b	5.5 c	7.3	5.7 b
(Probability)	(ns)	(0.05)	(0.01)	(ns)	(0.01)
Dixie Cream cowpea flour					
Reference (milk)	7.6	7.7	7.9 a	8.1 a	7.5 a
Heated flour	7.3	7.1	5.9 b	6.8 b	6.4 b
Unheated flour	7.3	7.3	5.2 b	7.1 b	5.5 c
(Probability)	(ns)	(ns)	(0.01)	(0.01)	(0.01)
Field pea flour					
Reference (milk)	7.7 a	7.6	8.0 a	7.8 a	7.6 a
Heated flour	7.2 b	7.4	6.8 b	7.0 b	6.7 b
Unheated flour	7.3 b	7.4	6.0 c	6.9 b	6.4 b
(Probability)	(0.05)	(ns)	(0.01)	(0.01)	(0.01)
Field pea protein concentrate					
Reference (milk)	7.8 a	7.7 a	8.0 a	8.0 a	7.4 a
Heated concentrate	7.2 b	6.8 b	6.9 b	7.1 b	6.8 b
Unheated concentrate	7.1 b	6.9 b	6.3 c	7.0 b	6.4 b
(Probability)	(0.05)	(0.01)	(0.01)	(0.01)	(0.01)

[a] For each set, 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] Each value is the average of 20 evaluations, 10 panelists having judged two replicates of each flour source.
[c] Scale of 9–1 where 9 = excellent, 5 = borderline, and 1 = very poor.

Density and Color Measurements

Separate batches from those used for sensory evaluations were prepared for objective density and color measurements; eight biscuits from each batch were randomly selected for these tests. Biscuits were weighed and their volume measured by seed displacement (Griswold 1962). Density of the biscuits was calculated as weight per unit volume. Color differences, including visual lightness (L), redness to greenness (a), and yellowness to blueness (b) of biscuits, were measured about 4 hr after baking with a Gardner Color Difference Meter model C-4(L), using an orifice size of 2.5 cm and set against a white standard. Reference values for the standard were $L = 93.9$, $a = -1.3$, $b = 2.5$. Single readings of L, a, and b values were obtained for the crusts and crumb of eight biscuits; crumb color was measured after cutting each biscuit in half horizontally to expose the entire crumb. Color differences of the heated and unheated pea flours and protein concentrate used in biscuit preparation were measured in triplicate by filling optical glass cups to a depth of about 3 cm; the same standard and orifice sizes were used.

Statistical Analysis

Sensory quality scores, color, and density measurements were evaluated by standard procedures of analysis of variance and multiple range testing of the significance of mean differences, using the Statistical Analysis System (SAS) of Barr et al (1976).

RESULTS AND DISCUSSION

Use of pea flours and protein concentrate to replace milk protein presented no difficulties in dough handling and biscuit preparation. The doughs containing the pea products were slightly less sticky than the reference doughs containing whole milk; this might be attributable to the absence of lactose, the carbohydrate of milk, in the pea product formulations or to the water binding ability of starches present in pea products.

Sensory Quality Evaluations

Sensory quality scores of reference and pea product biscuits are shown in Table I. Use of pea products adversely affected aroma and flavor qualities of biscuits more than appearance, color, and texture. Typical terms used by panelists in describing aroma and flavor of biscuits containing the pea products were "harsh," "beany," and "strong"; these traits were more pronounced in biscuits containing the unheated pea products. Steam heating the pea products improved some biscuit quality attributes but not to the level of acceptability of the reference biscuits. Pea product biscuits, which received significantly lower appearance and color scores than did reference biscuits, were described as "dull" and "less brown." Although the baking time in our tests was held constant, slightly longer baking may have been warranted to allow the crust color of pea product biscuits to develop more fully and to reduce the "doughy" and "slightly heavy" texture described by the panelists. These textural characteristics may also have been influenced by water retention properties exhibited by starch and protein components of the pea products.

Methods employed to reduce the harsh, bitter flavor of raw peas range from simple steam heat treatments (Austin and Austin 1967, McWatters and Heaton 1979) to more elaborate procedures involving soaking peas in acidified water, steam heating, and drum drying (Okaka and Potter 1979a). Results obtained from organoleptic evaluations in our study indicated that steaming alone was not sufficient to completely remove the bitterness of pea products for use in this particular quick bread application.

The most notable difference between cowpea products and field pea products was in aroma scores, which were higher for biscuits prepared with field pea products than for those with cowpea flours.

This may be attributable to the higher protein content of the field pea products; lower levels of these products than of the cowpea flours were needed to supply equivalent amounts of protein in the biscuits. These lower levels apparently made field pea products in biscuits less evident than cowpea flours were. Several panelists commented that the overall quality of biscuits prepared with the various pea products appeared to be comparable to many canned, refrigerated biscuits presently on the market.

Color and Density Measurements

The crust and crumb colors of reference and test biscuits are shown in Table II. Differences in crust color were significant for L and *b* values but not for *a* values. The pea product biscuits were lighter (had higher L values) and less yellow (had lower *b* values) in crust color than were the reference biscuits. Grouping the data according to heat treatment revealed that crust L values for biscuits made from heated pea products were not significantly different from those made from the unheated products. For crust *b* values, reference biscuits were the most yellow, biscuits made from unheated pea products intermediate, and those made from heated products the least yellow. Replacing milk protein with pea protein obviously altered the concentrations of reducing sugars and amino acids, thus causing the biscuits containing the pea products to brown less during baking than those made with milk.

Differences in L, *a*, and *b* crumb color values were highly significant. The crumb color of reference biscuits and those made from the cowpea flours was significantly lighter (had higher L values) and less yellow (had lower *b* values) than that of biscuits made from the field pea products. Biscuits prepared from the field pea protein concentrate had the highest *a* values. Grouping the data according to heat treatment revealed significant differences in crumb L and *b* values but not in *a* values. Reference biscuits had slightly higher crumb L values than did biscuits made with either heated or unheated pea products. Crumb *b* values of biscuits made with heated pea products were not significantly different from those of biscuits made with unheated products; biscuits made with both heated and unheated pea products had a more yellow crumb than did reference biscuits, however.

Density values for reference and pea product biscuits are also shown in Table II. All of the pea product biscuits lost less weight during baking and had larger volumes than did reference biscuits, thus accounting for their lower weight/volume ratios. Grouping the data according to heat treatment revealed that density values of biscuits prepared with the heated pea products were not significantly different from those made with the unheated products. In addition to weight and volume differences, we noted that the pea product biscuits rose more evenly during baking and had more uniform contours than did the reference biscuits.

Gardner color values of heated and unheated pea flours and protein concentrate used in biscuit preparation are shown in Table III. For each pea product, the steam heat treatment reduced lightness and increased the degree of redness and of yellowness. Color changes from moist heat treatment were more extensive in field pea products, particularly the protein concentrate, than in cowpea flours. These variations in pea product color were transferred to baked biscuit color, being particularly noticeable in the crumb.

Results of this study have shown that replacing milk protein with pea flour or protein concentrate in baking powder biscuits produced substantial changes in some sensory quality attributes, crust and crumb colors, and density. The "beany" aroma and flavor, which were the most objectionable sensory characteristics of biscuits made with unheated pea products, were lessened somewhat by preliminary steam treatment of the products. However, even the

TABLE II
Crust Color,[a] Crumb Color, and Density of Baking Powder Biscuits Prepared with Heated and Unheated Pea Flours and Protein Concentrate[b,c]

Sample	Crust Color			Crumb Color			Density, wt/vol
	L	*a*	*b*	L	*a*	*b*	
Reference	65.9 c	8.8	26.7 a	82.4 a,b	−0.7 c	12.9 e	0.602 a
G143 cowpea flour							
Heated	75.3 a	7.2	23.1 d	82.2 a,b	0.2 c	15.3 c	0.546 a,b,c
Unheated	75.5 a	6.2	24.0 b,c,d	82.8 a	0.5 b,c	14.3 d	0.515 b,c
Dixie Cream cowpea flour							
Heated	74.3 a	5.2	23.2 c,d	81.8 b	0.0 c	15.1 c	0.535 b,c
Unheated	73.6 a	5.4	24.6 b,c	82.1 a,b	−0.1 c	14.9 c	0.537 b,c
Field pea flour							
Heated	73.4 a	6.6	24.9 b	80.6 c,d	0.8 b,c	17.3 a,b	0.489 c
Unheated	70.7 b	7.5	25.3 b	81.0 c	0.5 b,c	16.8 b	0.556 a,b
Field pea protein concentrate							
Heated	74.1 a	6.4	23.0 d	79.1 e	2.1 a,b	17.3 a,b	0.511 b,c
Unheated	73.2 a	5.1	24.8 b,c	80.1 d	2.4 a	17.6 a	0.512 b,c
(Probability)	(0.01)	(ns)	(0.01)	(0.01)	(0.01)	(0.01)	(0.05)
Heat Treatment							
Reference	65.9 b	8.8	26.7 a	82.4 a	−0.7	12.9 b	0.602 a
Heated	74.3 a	6.3	23.5 c	80.9 b	0.8	16.2 a	0.520 b
Unheated	73.2 a	6.0	24.7 b	81.5 a,b	0.8	15.9 a	0.530 b
(Probability)	(0.01)	(ns)	(0.01)	(0.05)	(ns)	(0.01)	(0.01)

[a] Gardner color reference values: L, visual lightness = 93.9; *a*, redness to greenness = −1.3; *b*, yellowness to blueness = 2.5.
[b] 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.
[c] Each value is the average of eight measurements per treatment.

TABLE III
Gardner Color Values[a] of Heated and Unheated Pea Flours and Protein Concentrate Used in Biscuit Preparation

Sample	L		*a*		*b*	
	Unheated	Heated	Unheated	Heated	Unheated	Heated
G143 cowpea flour	89.9	86.9	1.1	1.9	10.6	13.4
Dixie Cream cowpea flour	88.4	86.5	1.4	2.0	11.5	13.3
Field pea flour	89.2	85.4	1.2	2.5	14.2	18.5
Field pea protein concentrate	87.0	79.5	1.0	4.2	14.9	20.3

[a] Reference values: L, visual lightness = 93.9; *a*, redness to greenness = −1.3; *b*, yellowness to blueness = 2.5.

heated flours produced biscuits less acceptable than reference biscuits. Future studies should be directed toward developing means of improving aroma and flavor characteristics of the flours, possibly by modifications in the processing methods. Slight alterations in formulation or baking procedure might also be warranted.

ACKNOWLEDGMENTS

We gratefully acknowledge the technical assistance of Margree Ector and Lucia Bledsoe and the statistical analysis by Len Moon.

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[Received August 30, 1979. Accepted January 30, 1980]