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Nutritional Characteristics of High-Protein Cookies

Gur S. Ranhotra,* Chul Lee, and Janette A. Gelroth

Cookies made with cake flour, defatted soy flour (50%, flour basis), and peanut butter (40%, flour basis) contained 15% protein (protein efficiency ratio, 1.4) and substantial amounts of important minerals and vitamins. A 2-oz serving (two cookies) provided 15% of the U.S. Recommended Daily Allowance for protein and Cu, 10% for P, Fe, and Mg, and between 4 and 8% for Ca, Zn, riboflavin, and niacin. Sensory scores revealed fair acceptance of the product which is likely to improve by the use of flavors and dough conditioners and by decreasing, somewhat, the level of soy and shortening in the formula.

Studies on the use of soy and other nonwheat proteins to improve the nutritional profile of wheat-based products have been directed mainly toward bread (Tsen et al., 1971; Ranhotra et al., 1974). Protein enrichment of other wheat-based staple or snack food items has received less attention.

Because of the impact of involved socioeconomic factors on our dietary habits, the consumption of wheat-based snack food items, such as cookies and crackers, has increased to the point that their traditional role in our diet needs reexamination. These food items can serve as important carriers of nutrients. Attempts to improve their nutritional profile, however, have often met with limited success. For example, at nutritionally significant levels, most nonwheat proteins adversely affect the quality of cookies (Fogg and Tinklin, 1972; Tsen et al., 1973; McWatters, 1978). Modification of formulation and processing technologies improves the product quality. In present studies, we attempted to maximize the addition of protein in cookies—a popular snack food with long shelf-life—and assess the nutritional and flavor characteristics.

MATERIALS AND METHODS

Cookies were made using commercially available cake flour (SWR), three different defatted soy flours, and peanut butter. Information on various other ingredients used, and on the cookie-making process, is given in Table I. Air-dried (2 days) cookies were weighed and their height and diameter measurements were taken by the method of AACC (1962). An eight-member panel (untrained) evaluated the sensory characters and overall acceptability of the cookies at 1, 2, and 16 weeks after baking (Table II).

The protein, fat, moisture, ash, and fiber contents of the cookies were determined by the standard methods of AACC (1962), as were the total phosphorus, thiamin, riboflavin, and niacin contents (Table III). Dietary (neutral-detergent) fiber was determined by the recently introduced AACC method. Calcium, magnesium, zinc, iron, and copper in the cookies were determined by atomic absorption spectrophotometry as described earlier (Ranhotra et al., 1978).

The standard AOAC (1975) method to determine the protein efficiency ratio (PER) was used to assess the quality of protein in the cookies (Table III). Because of the high level of fat in the cookies, all test diets were adjusted to contain 15% fat. The information in Table II (footnote) and the values for the U.S. Recommended Daily Allowance for various nutrients (NNC, 1975) were used to derive nutrition information per serving (Table IV). The data were subjected to appropriate statistical analysis.

Nutrition Research, American Institute of Baking, Manhattan, Kansas 66502.

Table I. Formulation of High-Protein Cookies[a] (g)

ingredients	cookies: high protein[a]	cookies: AACC formula
cake flour (Hi-ratio)	100	100
soy flour defatted[b]	50	
creamy peanut butter[c]	40	
shortening[d]	60	28
sucrose	50	58
dextrose	10	
honey	10	
baking soda	2	1.1
salt	1	0.9
water	112	21.8

[a] Hobart mixer at third speed; mixed soy and water (110 °F) with wire whip, 5 min; blended in sucrose and dextrose; mixed in shortening, 3 min; added peanut butter and mixed, 1 min; changed to paddle; added the remaining ingredients and mixed just long enough to incorporate; flattened the dough to uniform thickness (5 mm); cut to diameter of 60 mm; and baked in a gas-fired oven (375 °F, 11 min). [b] Three preparations tested (Table II). [c] Bonanza Brand, Sunstar Foods, IL. [d] Hydrogenated vegetable oil with mono- and diglycerides, and polysorbate 60 added (Penguin Brand, Swift & Co.).

RESULTS AND DISCUSSION

Sensory Quality of Cookies. Of the six commercial soy flours tested in preliminary test bakes, three performed satisfactorily and equally well (Tables I and II). To improve the cookie spread, and to maximize the addition of soy in cookies, the level of shortening in the cookie formula was increased substantially as compared to the standard AACC (1962) formula (Table I). Such an effect of shortening on cookies has also been shown by others (Tsen et al., 1973; McWatters, 1978). The level of sweeteners in the formula was also increased (and peanut butter added) to offset the undesirable flavor; this also improved the cookie spread. Sensory scores (Table II) revealed fair acceptability of the product. After 16 weeks, although color of the cookies improved, their overall acceptability declined somewhat as is normal. No food flavor was used to enhance acceptability. Such a use of flavor (citrus, butter, vanilla, etc.) and dough conditioners (Tsen et al., 1973) should improve acceptability appreciably. Acceptability is also likely to improve by reducing the level of soy and shortening, by using part of the formula sugar in the form of icing on the baked product, and by adding ingredients such as chocolate chips, nuts, and oatmeal. These various approaches were not attempted since efforts were centered more on developing a product by keeping the number of various ingredients to the minimum and assessing the nutritional profile.

Measurements. Test cookies weighed about an ounce on the average (Table II) and showed a good spread ratio

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Table II. Sensory Quality Scores and Measurements[a, b]

cookie[c]	week[d]	color	texture	flavor	aroma	general acceptability
A (9.4)	1	4.7 ± 0.8	3.7 ± 1.3	4.9 ± 0.9	4.6 ± 2.0	5.2 ± 1.1
	2	5.4 ± 1.2	4.0 ± 0.8	4.7 ± 1.2	4.5 ± 1.4	5.0 ± 1.2
B (9.4)	1	4.6 ± 0.8	3.6 ± 1.1	5.0 ± 1.3	4.2 ± 1.6	5.2 ± 1.5
	2	5.2 ± 1.6	4.4 ± 1.0	5.4 ± 1.3	4.3 ± 1.3	4.9 ± 1.3
C (9.3)	1	5.1 ± 1.9	4.1 ± 1.7	4.9 ± 1.0	4.3 ± 2.0	5.2 ± 1.3
	2	5.5 ± 1.6	4.5 ± 1.4	5.2 ± 1.5	4.5 ± 1.3	5.2 ± 1.5
combined	16	5.8 ± 1.2	4.4 ± 1.0	4.4 ± 1.4	3.4 ± 1.1	4.3 ± 0.9

[a] Values represent the mean ± SD of eight responses. Scale of 9 to 1, where 9 = very good, 4 = borderline, and 1 = very poor. [b] Measurements of cookies: thickness (mm), 12.7 ± 0.8; weight (g), 28.6 ± 2.7; diameter (mm), 80.4 ± 2.8; and spread ratio (diameter/thickness), 6.3 ± 0.2. [c] Soy source used: Soyfluff-Central Soya (A), Nutrisoy-ADM (B), and Bland 50 Soy-Staley (C). Values within parentheses are pHs. [d] After baking.

Table III. Nutritional Profile and Protein Efficiency Ratio of Cookies

	cookies[a]				
	A	B	C	mean	casein
proximate composition, %					
protein (N × 6.25)	15.2	15.2	15.0	15.1 (3.1)[d]	
ether extract	22.4	22.3	22.5	22.4	
moisture	4.7	4.5	4.9	4.7	
ash	2.4	2.4	2.4	2.4	
fiber (crude)	1.2 (1.5)[e]	1.2 (1.6)	1.0 (1.4)	1.1 (1.5)	
carbohydrates[b]	54.1	54.4	54.2	54.2	
micronutrients, mg/100 g					
calcium	48.6	52.2	46.4	49.1 (6.7)[d]	
phosphorus	179	186	181	182 (33.6)[d]	
magnesium	59.3	59.5	60.0	59.6 (8.6)[d]	
zinc	1.25	1.23	1.19	1.22 (0.23)[d]	
iron	2.78	2.81	2.69	2.76 (0.24)[d]	
copper	0.48	0.48	0.44	0.47 (0.05)[d]	
thiamin	0.02	0.02	0.02	0.02 (0.03)[d]	
riboflavin	0.26	0.23	0.19	0.23 (0.01)[d]	
niacin	2.60	2.60	2.60	2.60 (0.44)[d]	
protein efficiency ratio[c]					
weight gain, g	38.6 ± 5.8	36.3 ± 3.1	37.0 ± 4.5	37.3 ± 4.5	100.1 ± 9.3
food intake, g	215 ± 8	213 ± 12	236 ± 23	221 ± 14	330 ± 23
PER (measured)	1.8 ± 0.2	1.7 ± 0.1	1.6 ± 0.2	1.7 ± 0.2	3.0 ± 0.2
PER (corrected)	1.5 ± 0.2	1.4 ± 0.1	1.3 ± 0.1	1.4 ± 0.1	2.5 ± 0.2

[a] As in Table II. Energy content: 4.8 cal/g. [b] By subtraction. [c] Finely ground cookies were used to make test diets. Values represent the mean (10 rats/diet) ± SD. [d] From the amount of cake flour used in the formula (Table I); based on tabular values from Handbook 456. [e] Dietary (neutral-detergent) fiber.

Table IV. Nutrition Information per Serving[a]

per serving	2 oz (two cookies)
calories	274
protein	9 g
fat	13 g
carbohydrates	31 g
	% of U.S. RDA
protein	15
thiamin	*b*
riboflavin	8
niacin	8
calcium	4
phosphorus	10
iron	10
zinc	6
magnesium	10
copper	15

[a] Based on the mean values for cookies A–C (Table III). [b] Contains less than 2% of the U.S. RDA.

(over 6) for high-protein cookies. At soy levels between 30 and 48%, others (Tsen et al., 1973, McWatters, 1978) have reported values below 4. Preblending soy with water to satisfy its water-absorptive properties, using water at a higher level, and using extra amounts of leavening and shortening probably contributed to the good spread ratio.

Nutritional Profile. The protein content (15%, Table III) of cookies was about two–three times the level reported for flour-based or soy-fortified cookies (Tsen et al., 1973; McWatters, 1978). Test cookies were low in moisture (less than 5%) and contained about 22% fat and about 54% available carbohydrates. Although calculated dietary fiber (from flour, soy, and peanut butter) values showed a greater difference, determined values were only a little higher than crude fiber values. Apparently, the AACC method for dietary fiber performs less satisfactorily with cookies than it does with breads (Ranhotra et al., 1979). Calculated energy content of cookies was 4.8 cal/g.

In addition to protein, the use of soy and peanut butter also improved substantially the micronutrient profile of the cookies; values for these nutrients, except thiamin, were 5–23-fold higher as compared to those in the cake flour (Pyler, 1973; Adams, 1975). Prolonged exposure to heat, especially true for high-crust products such as cookies, and the use of baking soda (pH over 9, Table II) apparently caused excessive destruction of thiamin.

Protein quality, determined by the AOAC (1975) method, revealed a PER value of about 1.4. This represents a substantial improvement over the reported PER values of 0.7–0.9 for bread (Ranhotra et al., 1975, 1977) and related flour-based products which lend themselves to such a determination. Because of the low protein content, PER of unsupplemented (with protein) cookies cannot be determined by the AOAC method. Thus, the use of soy and peanut butter improved substantially not only the level but also the quality of protein in cookies.

Nutrition Information. Table IV lists information normally contained in a "nutrition label". A 2-oz serving (two cookies) provided 15% of the U.S. RDA for protein and copper, 10% for phosphorus, iron, and magnesium, 8% for riboflavin and niacin, 6% for zinc, and 4% for calcium. Contribution of nutrients not measured could also be substantial. Since no animal product was used in the cookie formula, presumably these cookies contained no cholesterol.

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α-Amylase Activity and Preharvest Sprouting Damage in Kansas Hard White Wheat

Grace Huang and E. Varriano-Marston*

α-Amylase activity, sprouting damage, and α-amylase gel electrophoretic patterns of two varieties of Kansas hard white wheat were compared with a standard hard red wheat. Varietal differences significantly ($P < 0.025$) affected the variables measured, with one white wheat (KS73256) showing significantly higher α-amylase activity and sprouting damage than the other varieties. Two methods for determining α-amylase activity were also studied. The falling number method was more highly correlated with sprouting damage than was α-amylase activity, as measured by the production of reducing sugars from a soluble starch substrate.

Work is currently being conducted on the feasibility of developing a variety of hard white wheat in Kansas. Such a wheat should have a higher price than hard red wheats do because of its higher yield of flour and increased marketability (Schruben, 1976). Past experiences with white wheat, however, indicate that they are more susceptible to preharvest sprouting than the red wheats (Everson and Hart, 1961; Greer and Hutchinson, 1945; Miyamoto and Everson, 1958; Miyamoto et al., 1961; McEwan, 1976).

Sprouting is associated with the synthesis and increased activity of a variety of enzymes. One particular enzyme, α-amylase, when present in excessive amounts in flour produces breads with a doughy crumb and poor eating quality (Reed and Thorn, 1971).

α-Amylase activity has been used extensively to estimate the degree of wheat sprouting in the field or in storage, and a close relationship between α-amylase activity and preharvest sprouting has been demonstrated by a number of authors (Bingham and Whitmore, 1966; Derera et al., 1976). Bingham and Whitmore (1966), in a study of fourteen wheat varieties, found that the varieties differed considerably in susceptibility to germination and that germination was always associated with increased α-amylase activity.

A study of Australian white-grained wheats by Derera et al. (1976) also showed that the varieties highly susceptible to sprouting were high in α-amylase activity. By selecting varieties that had low α-amylase activity, Persson (1976) was able to develop a new variety, OTELLO, which was resistant to preharvest sprouting.

In this study, α-amylase activity and preharvest sprouting damage in Kansas hard white wheats were compared with a standard hard red wheat grown under the same environmental conditions. During flowering we also subjected the samples to different levels of nitrogen fertilization in order to determine if this had an effect on amylase activity in the grain. In addition, two methods of measuring α-amylase activity were studied to determine which was the better predictor of sprouting damage.

MATERIALS AND METHODS

Materials. Three varieties of hard winter wheat were studied: Eagle (standard red) and Clark's Cream and KS73256 (white wheats). The wheats were sown at Hutchinson, KS, in October, 1976.

During the flowering stage, wheat in different plots received nitrogen in these amounts: 0, 30, 60, 90, and 120 lb/acre. Three replicates for each treatment were grown, and a split plot design (3 × 5 × 3) was used.

Department of Grain Science and Industry, Kansas State University, Manhattan, Kansas 66506.

