Rolled High-Lysine Barley in Breakfast Cereal, Cookies, and Bread[1]

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ABSTRACT

Hiproly barley, a hull-less, high-lysine variety, was rolled to form a product similar to rolled oats (oatmeal). The rolled barley (barleymeal) was compared with oatmeal for performance as a cooked breakfast cereal and as an alternative to oatmeal in bread and cookies. Organoleptic panels indicated no significant (5% level) difference between the breakfast cereals, although differences in texture and flavor were noted. Similarly, when 15% of the white flour in bread was replaced by either barleymeal or oatmeal, consumer panels indicated no significant difference in preference and rated both breads as acceptable as a 30% whole wheat bread. No preference between barleymeal and oatmeal was indicated in date-nut or chocolate chip cookies or in fudgenut bars. Oatmeal was preferred over barleymeal in a traditional oatmeal-raisin cookie, although the barleymeal cookie was scored well above the minimum acceptance level. The quantities of essential amino acids were similar in barleymeal and oatmeal, and both cereals at 15% flour replacement in bread provided higher amounts of essential amino acids than did whole wheat at the 30% flour replacement level.

Cereal proteins are characteristically low in lysine, methionine, valine and threonine—amino acids that, among others, must be preformed in the diets of monogastric animals. For about 15 years, an intensive search has been conducted for barleys with elevated levels of these amino acids, regardless of other characteristics. The ultimate objective is to breed those barleys so that they retain their desirable protein characteristic and lose their undersirable characteristics. Alternatively, the desirable amino acid compositions of the proteins might be bred into different varieties that are otherwise satisfactory agronomically.

In 1968 the first such barley, Hiproly, was found among the barleys of the USDA world barley collection (Munck et al 1970). Hiproly, which originated in Ethiopia, is a low-yielding, hull-less type with characteristically shriveled, hard kernels. Another high lysine variety Risø 1508, was obtained by treating the variety Bomi with the mutagenic reagent ethylenimine (Ingversen et al 1973). Risø 1508 is a hulled variety, however, and would not be suitable for human foods unless the hull were removed or finely milled. Recent reports describe hull-less, high-lysine crosses with markedly improved agronomic properties, for example, the absence of the shrunken endosperm character (Burger et al 1977); these are not yet available in substantial quantities, however. Because Hiproly is available in quantity, we have examined it as a prototype for its potential in human foods. This report describes its acceptability as a cooked cereal and as an ingredient in bread and cookies.

MATERIALS AND METHODS

Materials

Hiproly barley, grown in Idaho in 1976, was rolled by the Quaker Oats Co., Barrington, IL, to 0.020-in. thickness. The resulting barleymeal contained 19.5% protein (N × 6.25) and 2.2% ash.

Oatmeal (Quaker Old Fashioned, 0.011–0.019 in. thickness) purchased at a retail outlet contained 20.3% protein (N × 6.25) and 2.7% ash.

Thirty percent whole wheat flour for the control bread consisted of 30% ground whole wheat, which had 14.3% protein (N × 5.7) and 2.7% ash, blended with 70% of a commercial, baker's patent spring-wheat white flour, which had 13.4% protein (N × 5.7) and 0.45% ash.

All protein and ash values above are on a 14% moisture basis.

Ingredients for cookies were purchased from a retail outlet.

Food Preparation

Breakfast Cereal. Barleymeal (400 g) was added to 2,000 ml of boiling water containing 6 g of sodium chloride. The mixture was boiled vigorously for 1 min and simmered for 3.5 min. Oatmeal (340 g) was treated similarly with 1,900 ml of water and 6 g of sodium chloride, except that the mixture simmered for 5 min.

Bread. Physical dough properties were determined with the farinograph for 50 g of each flour in the 50-g bowl. The properties of flours with up to 20% flour replacement by oatmeal or barleymeal were examined so that the optimum level of flour replacement for organoleptic tests could be determined.

For the taste panels, 1-lb loaves of bread were produced by a straight-dough baking procedure with 2-hr fermentation. The baking formula, based on flour weight, was as follows: 2% salt, 5% sugar, 3% shortening, 3% nonfat dry milk, 3% compressed yeast, and varying amounts of water.

The 30% whole wheat flour (2,400 g, 14% moisture basis) was mixed with the remaining ingredients in a 20 qt Hobart mixer (The Hobart Mfg. Co., Troy, Oh) until the dough was properly developed.

Oatmeal and barleymeal were incorporated in the formula and replaced 15% of the white flour. The oatmeal and barleymeal were soaked in a portion of the required water for 5 min before the flour was mixed with remaining ingredients.

TABLE I
Cookie Formulations

Ingredients	Cookie Type		
	Raisin	Datenut	Chocolate Chip
	(g)		
Meal			
Oat	1,178	79	...
Barley	740	72	216
Brown sugar	1,750	...	80
Butter	983	...	112
Raisins	556	...	...
Vanilla	19	4	2
Baking soda	23	8	2
Salt	17	0.8	3
Eggs	570	114	57
Shortening	...	224	...
Granulated sugar	...	304	57
Flour			
Barleymeal recipe	1,725	228	72
Oatmeal recipe	1,285	228	72
Chopped almonds	...	70	...
Chopped dates	...	178	...
Semi-sweet chocolate chips	...	...	168

[1] Cooperative investigations of the Barley and Malt Laboratory with the North Dakota State University, Fargo, and the College of Agriculture and Life Sciences, University of Wisconsin, Madison.

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After a 2-hr fermentation, the dough mass was divided into 540-g portions. These were rounded and allowed to rest for 10 min before sheeting by machine and molding by hand. Loaves were proofed for 55 min at 43° C and baked at 221° C for 20 min. Loaf volume was measured 30 min after the bread was removed from the oven. The bread was sliced 2 hr after removal from the oven, placed in a plastic bag, and frozen until required for taste panel evaluation.

TABLE II
Formulation for Fudgenut Bars[a]

Ingredients	(g)
Crust	
Butter	224
Brown sugar	424
Egg	171
Oatmeal	216
Barleymeal	210
Flour	288
Salt	6
Filling	
Chocolate chips	450
Sweetened condensed milk	286
Butter	28
Salt	3
Chopped walnuts	119
Vanilla	8

[a] *Preparation.* Crust: Cream butter and sugar, blend in egg and vanilla. Stir in remaining ingredients. Press about 2/3 into a greased 15 × 11 in. jelly roll pan. Filling: Combine ingredients and heat until chocolate is melted. Spread filling on crust. Sprinkle remainder of crumbled crust mixture on top.

TABLE III
Frequency of Consumer Panelist Response

Product	N	Assigned Numerical Score[a] 7	6	5	4	3	2	1	Mean
Cooked oatmeal	197	25	70	56	23	16	5	2	5.21[b]
Cooked barleymeal	197	24	62	56	33	12	6	4	5.10[b]
Bread									
30% Whole wheat	199	24	67	66	29	9	3	1	5.28[b]
15% Barleymeal	199	23	68	62	31	12	2	1	5.25[b]
15% Oatmeal	199	21	62	61	36	11	4	4	5.09[b]
Cookies									
Barleymeal Raisin	200	23	76	66	21	9	4	1	5.33
Oatmeal raisin	200	46	87	46	16	4	1	0	5.76[c]

[a] Scale: 7 = like extremely, 6 = like very much, 5 = like moderately, 4 = like slightly, 3 = dislike slightly, 2 = dislike moderately, 1 = dislike very much.
[b] No significant difference at 5% level.
[c] Significantly different from the barleymeal raisin score at 5% level.

Cookies. The formulations for cookies are given in Tables I and II. Cookies were prepared by conventional procedures; baking temperatures were 176–190° C.

Organoleptic Evaluation

Cooked Breakfast Cereals. At the Department of Food Science, University of Wisconsin, 197 randomly selected consumer panelists were given the two cereal samples, two 17-ml containers of half-and-half cream, and two packets (4.3 g each) of sugar. Panelists were instructed to use the cream and sugar ad lib but to use the same quantities on both samples.

Bread and Cookies. Each of 199 randomly selected consumer panelists were presented with 1/4 slice of bread of each type and, for optional use, 28 g of butter. To evaluate barleymeal-raisin and oatmeal-raisin cookies, each of 200 panelists was given a cookie of each kind, about 6 cm in diameter and 1.5 cm thick. Panels of 30, 29, and 29 members evaluated datenut and chocolate chip cookies and fudgenut bars, respectively. These cookies were about the same size as the raisin cookies; the fudgenut bars were about 4 cm square.

Statistical Analyses

A traditional seven-point hedonic preference ballot (Amerine et al 1979) was used for evaluation. For statistical analyses, a scale of 1–7 was used as follows: "like extremely" was assigned a value of 7; "like very much," 6; "like moderately," 5; "like slightly," 4; "dislike slightly," 3; "dislike moderately," 2; and "dislike very much," 1. Mean scores, F-values, and least significant differences (LSDs) were calculated from these data (Steel and Torrie 1960). A score of 4 was chosen as minimum acceptability.

Chemical Analyses

Samples were analyzed for Kjeldahl nitrogen, crude fat, ash, and moisture (AACC 1962). For starch plus β-glucan, a 20-g sample was refluxed 4 hr in 1 *N* sulfuric acid (750 ml). The filtrate was neutralized with barium carbonate, and the glucose was assayed with an Aminex AG 50W-X4 column (Brobst et al 1973). The percentage of dietary fiber was calculated by subtracting the percentages of starch plus β-glucan, protein, crude fat, and ash from 100% (Brockmole and Zabik 1976).

RESULTS AND DISCUSSION

Cooked Breakfast Cereal

The overall preference score for barleymeal was 5.10 and for oatmeal 5.21, values that were not significantly different at the 5% level. The frequency data Table III demonstrate that the distributions of responses also were similar for the two cereals.

Voluntary comments by the panelists indicated that they noted distinct textural differences between the two cereals. The texture of the oatmeal sample was characterized by such terms as mushy, moist, sticky, smooth, and creamy (27 comments); and the barley sample was described as hard, dry, crunchy, rough, and grainy (14

TABLE IV
Farinograph Data for Flours

Source	White Flour Replaced (%)	Absorption[a] (%)	Dough Development Arrival Time (min)	Time (min)	Stability (min)
White flour	...	62.2	2.75	5.00	8.25
Whole wheat meal plus white flour	30	63.0	3.50	5.50	7.50
Oatmeal plus white flour	5	61.4	3.00	5.75	8.50
	10	62.2	3.75	6.75	9.00
	15	63.8	4.50	6.50	7.25
	20	65.2	5.00	7.25	7.00
Barleymeal plus white flour	5	63.4	5.50	8.00	8.00
	10	65.4	5.50	8.50	9.50
	15	66.8	7.00	9.00	6.50
	20	69.0	7.50	9.00	6.00

[a] Expressed on 14.0% moisture basis.

comments). The difference in the textural properties of the cereals was apparently an important determinant for preference; 18 panelists chose to comment on the desirability of the texture of each sample. (Six preferred the oatmeal texture, and 12 preferred the barley texture).

The flavor of the cooked barleymeal was described in general terms as more intense and richer-tasting than that of the oatmeal sample and as nutty, astringent, and bitter. Few comments were offered about the flavor of the cooked oats.

The flavor and texture differences between the two samples suggest that cooked barleymeal will appeal to a somewhat different market than the traditional oatmeal product does.

Bread

Increasing the barleymeal replacement of white flour resulted in a progressive increase in the farinograph absorption (Table IV). Particularly noteworthy was the increase in arrival time and dough development time as the level of barleymeal was increased. Apparently, the barleymeal hydrated at a much slower rate than the wheat meal in the 30% whole wheat flour. Increased amounts of oatmeal also showed increased absorption and arrival time but not to the same extent that the corresponding levels of barleymeal did. The stability values for the flour blends containing 15% and 20% oatmeal or barleymeal were lower than the value for the 30% whole wheat control flour or for the white flour (Table IV). The oatmeal and particularly the barleymeal had to be soaked in water before the dough was mixed; otherwise they did not adhere to the dough mass. Oatmeal, and particularly barleymeal, decreased the loaf volume relative to that of the 30% whole wheat loaf. Specific loaf volumes were 5.68, 5.11, and 5.98 cc/g, respectively.

In the consumer preference analysis, the breads containing 15% barleymeal or oatmeal were chosen as most appropriate for comparison with the 30% whole wheat bread. These three types of bread were similar in appearance. This level of the rolled cereals was chosen from consideration of the results of preliminary baking behavior and from visual and taste panel analyses and was believed to be practical because of the possible utilization of the barleymeal in standard oatmeal formulas. The mean overall preference scores are given in Table III and indicate no significant differences among the samples at the 5% level. The frequency distribution of the scores are also shown in Table III. The comments about flavor and texture did not indicate strong consumer differentiation among the samples. The 15% flour replacement level appears to be particularly appropriate for use of barleymeal in bread because the firm character of the rolled grain is not apparent.

Cookies

The mean overall preference scores for the barleymeal-raisin cookie and for the oatmeal-raisin cookie (Table III) differed significantly at the 5% level and showed that the oatmeal cookie was preferred over the barleymeal one. The mean score for the barleymeal cookie was, however, well above the minimum acceptability level. The frequency of panelist response in Table III shows twice as many scores of 7 for oatmeal-raisin. The main difference between the cookies appeared to be texture. The barleymeal-raisin cookie was frequently described as crunchy and coarse, while the oatmeal-raisin cookie was described as chewy and of good texture. Both the barley and the oatmeal sample were described as having good flavor.

Preliminary work had shown that the percentage of barleymeal in the formula should not be as high as that of oatmeal in the standard recipe. The barleymeal component was reduced to 30% of the dry cereal ingredients, compared with 48% for oatmeal, because this percentage of barleymeal was necessary for a product with a

TABLE V
Acceptability Scores for Datenut Cookies, Fudgenut Bars, and Chocolate Chip Cookies Containing Barleymeal

	N	Overall Preference Mean/Scores
Datenut Cookies	30	
Barleymeal		4.27[a]
Oatmeal		4.49
Fudgenut Bars	29	
Barleymeal		4.49[a]
Oatmeal		4.85
Chocolate Chip Cookies	29	
Barleymeal		4.56[a]
Standard		4.98

[a]No significant (5% level) difference from the corresponding oatmeal or standard product.

TABLE VI
Essential Amino Acids[a] in Flours,[b] Meals,[b] and Breads[c]

	Barleymeal	Cooked Barleymeal	Oatmeal	Whole Wheat	White Flour	30% Whole Wheat 70% White Flour	15% Barleymeal 85% White Flour	15% Oatmeal 85% White Flour
	(g/100 g dry basis)							
In Flour and Meal								
Lys	0.84	0.83	0.82	0.40	0.41	0.41	0.47	0.46
His	0.45	0.45	0.47	0.36	0.43	0.41	0.44	0.44
Arg	0.92	0.94	1.38	0.68	0.72	0.70	0.75	0.82
Thr	0.63	0.63	0.68	0.47	0.47	0.47	0.49	0.59
Val	1.09	1.08	1.16	0.76	0.88	0.85	0.91	0.92
Met	0.50	0.50	0.44	0.40	0.49	0.46	0.50	0.49
Ile	0.75	0.75	0.82	0.60	0.68	0.66	0.69	0.70
Leu	1.33	1.32	1.53	1.10	1.25	1.21	1.26	1.29
Phe	1.13	1.12	1.06	0.71	0.91	0.85	0.94	0.93
In Bread								
Lys	...	...	...	...	...	0.32	0.41	0.40
His	...	...	...	...	...	0.37	0.38	0.36
Arg	...	...	...	...	...	0.57	0.66	0.73
Thr	...	...	...	...	...	0.46	0.49	0.50
Val	...	...	...	...	...	0.77	0.91	0.85
Met	...	...	...	...	...	0.34	0.43	0.38
Ile	...	...	...	...	...	0.62	0.66	0.68
Leu	...	...	...	...	...	1.14	1.19	1.24
Phe	...	...	...	...	...	0.81	0.87	0.91

[a]Tryptophan was not analyzed.
[b]Values are means of three determinations.
[c]Values are means of five determinations.

rolled, whole-grain cereal-like identity even though its texural characteristics were different from those of the oatmeal cookie.

The overall preference scores for the date-nut cookie, fudgenut bar, and chocolate chip cookie made with barleymeal were not significantly different from those for the corresponding oatmeal or standard products (Table V). However, the chocolate chip cookie made with barleymeal was slightly darker and crisper than the standard chocolate chip cookie. Presumably, the presence of chocolate tended to mask the textural differences that might have influenced preference scores.

Generally, the experiments with cookies indicate that barleymeal is a suitable substitute for oatmeal in cookies, although the harder textural quality of rolled barley does not fulfill the consumer's expectation of the softer, chewier character of oatmeal.

Levels of Essential Amino Acids

The levels of essential amino acids in flours, meals, and breads are given in Table VI (tryptophan was not analyzed). Barleymeal and oatmeal were comparable except in arginine and leucine contents (which were somewhat higher in oatmeal) and in methionine content (which was higher in barleymeal). Both barleymeal and oatmeal had higher levels of essential amino acids than the whole wheat meal did. Cooking the breakfast cereal had no effect on the essential amino acid content of the barleymeal and presumably on that of the oatmeal.

The 15% oatmeal and barleymeal flours were higher than the 30% whole wheat flour in the essential amino acids, and this relationship was reflected in the breads produced from these flours. The high levels of essential amino acids are meaningful when the rolled grains are used in bread but are of less significance when the grains are consumed as breakfast cereals with milk or as cookies made with eggs.

The dietary fiber values are shown in Table VII. The Hiproly barleymeal contributed more dietary fiber than did the oatmeal or whole wheat meal—probably because of its shrunken endosperm character, which results in a low starch level (50%, compared with 53% for whole wheat meal and 61% for oatmeal). Lipid is characteristically high in oats and contributes to a lowered dietary fiber and undoubtedly to a caloric level that would be higher than that of barleymeal.

TABLE VII
Composition of Flours and Meals

	Protein[a]	Crude Fat	Ash	β-Glucan plus Starch	Dietary Fiber
Barleymeal	19.4	2.58	2.22	50.0	25.8
Oatmeal	20.3	6.62	2.73	60.9	9.3
Whole wheat meal	14.3	3.17	2.93	53.1	25.1
White flour	13.4	1.3	0.45	82.3	2.5
30% Whole wheat, 70% white flour	13.7	1.9	1.20	73.5	9.7
15% Barleymeal, 85% white flour	14.3	1.5	0.71	77.5	6.0
15% Oatmeal, 85% white flour	14.4	2.1	0.79	79.1	3.5

[a]Calculated as N × 5.7 for wheat protein and N × 6.25 for barley protein.

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