Consumer Acceptability of Baked Goods Containing Distillers' Dried Grains with Solubles from Soft White Winter Wheat

B. A. RASCO, S. E. DOWNEY, and F. M. DONG[1]

ABSTRACT

Cereal Chem. 64(3):139–143

Baked goods prepared from whole white wheat distillers' dried grains with solubles (DDGS) were rated by a consumer panel ($n = 387$). The experimental baked goods contained DDGS as a replacement for 30% (w/w) of the all-purpose flour. Using chi-square analysis, no significant differences ($P < 0.05$) were observed between ratings for experimental and control samples of chocolate chip cookies or banana bread. Both experimental and control products were rated as good to excellent. Panel ratings for white bread and whole wheat bread made with 30% DDGS were acceptable to good. The colors of experimental and control breads were significantly different ($P < 0.05$; Student's t test); however, the color of products containing DDGS did not appear to affect overall consumer preference.

Distillers' dried grains with solubles (DDGS) are the principal byproducts from the conversion of dry milled grain to ethanol. DDGS are generally sold as animal feed. At the present time, because it is sold at a higher cost than other cereal grains, wheat is not an economical choice as a fermentation substrate. Even with continuing government subsidies for fuel ethanol, the relatively high cost of the grain precludes economic viability unless DDGS can be sold as a value-added food product rather than as a feed. The sale of DDGS as a food component would dramatically improve the economic viability of manufacturing alcohol from cereal grains. DDGS has high dietary fiber and protein contents, approximately three times the concentration present in the grain used for fermentation (Waelti and Ebeling 1982, Wu et al 1984, Rasco et al 1987, Dong and Rasco 1987). Because of the high protein (30–40% dwb) and high dietary fiber content (30–40%) (San Buenaventura et al 1987), DDGS have the potential to enhance the nutritional value of food products, particularly baked goods.

[1]Institute for Food Science and Technology, HF-10, University of Washington, Seattle 98195.

Researchers report acceptable substitution levels of similar products, such as brewers' grains, at 15% (w/w) replacement of the all-purpose flour in biscuits (Hudson 1984), 15% in dark colored or highly flavored cookies (Tsen et al 1982), 6% in bread (Finley and Hanamoto 1980), and 10% in bread (Tsen et al 1983, Hudson 1984). Partial replacement of all-purpose flour with distillers' dried grain flour in light colored cookies was found not to be acceptable at 15 or 25% replacement levels because of dark color (Tsen et al 1982). Distillers' dried grains from white sorghum have been successfully incorporated at a replacement level of 25% in molasses cookies (Morad et al 1984). Delipidated distillers' dried grains (DDG) from barley used at a substitution level of 15% in oatmeal cookies were as acceptable as the controls. Defatting significantly improved the quality of DDG and bleached DDG from barley (Dawson et al 1984). White bread containing 6% brewers' grains flour was shown to have acceptable break and shred, grain, and texture but a slightly depressed loaf volume. A 12% substitution of brewers' spent grains for flour yielded an unacceptable product (Finley and Hanamoto 1980); decreased loaf volume and increased water absorption of brewers' grains or bran fraction from brewers' grains have been reported by others (Dreese and Hoseney 1982, Prentice and D'Appolonia 1977, Morad et al 1984).

The purpose of this study was to measure consumer acceptability and color of baked goods made with DDGS produced from soft white wheat at a higher level of replacement than previously reported. DDGS was substituted for 30% of the flour (by weight) in four different conventional formulations: chocolate chip cookies, banana bread, white pan bread, and whole wheat bread.

MATERIALS AND METHODS

Product Preparation

DDGS were produced from Hill 81, a variety of soft white winter wheat grown in Washington state. Previous studies (Rasco et al 1987, Dong and Rasco 1987) determined that DDGS used in this study had the following proximate composition: 6.9 ± 3.0% moisture, 7.1 ± 0.5% ash (dwb), 3.7 ± 0.3% crude lipid, 38.4 ± 2.5% protein based on Kjeldahl nitrogen values (% N × 5.7), 8.0 ± 0.4% crude fiber, neutral detergent fiber 31.3 ± 1.8%, acid detergent fiber 9.9 ± 0.2%, and lignin 3.0 ± 0.3%. Products were prepared according to the formulations outlined in Table I by a commercial baker under standard conditions (Larsen Brothers' Danish Bakery, Seattle, WA). Products were wrapped in plastic, sealed in cardboard boxes, stored frozen at −40°C for one day, transported frozen, and stored at −29°C for an additional one to three days until sensory evaluations were conducted. The product used for color measurements was kept frozen at −40°C for two weeks.

Color Parameters

Specific color parameters of the final baked goods and the flour constituents from which they were made were measured using a Hunterlab color meter model D25M-2, a standard tan color tile ($L = 78.3$, $a = -2.7$, $b = 21.6$), and standard light source, luminescence C, true to daylight. Visual lightness and luminous reflectance were measured. Color analyses of the flour constituents were conducted on a single sample of each flour or substituted flour from three separate batches of DDGS. The frozen baked products were thawed at room temperature immediately before color analysis. Slices from the centers of each type of bread and random samples from each set of cookies were obtained for color measurements. Color data for baked products are single readings from six loaves or six cookies.

Consumer Sensory Panel

Consumer acceptability was determined in a single blind test using a consumer panel ($n = 387$) composed of participants at a convention in Spokane, WA, December 8–12, 1985. Samples were distributed on three consecutive days from approximately 9 a.m. to 12 noon and from 1:30 to 5:00 p.m. Only the baked product required for each of six test sessions was thawed before that session. Products were thawed at room temperature (22–24°C). Baked goods were from two to five days old at time of serving. All products were served at room temperature as single 2-in. cookies or as approximately 3 × 2 × ¼-in. slices of bread. No condiments were provided. Drinking water was available. Samples were distributed from a booth in the lobby of the hotel (convention site) to volunteers. Coded questionnaires were provided. Consumer panelists were offered one product sample, either an experimental or control sample, for evaluation and were asked to rate the sample using an overall quality scale of 1 = very poor, 2 = poor, 3 = acceptable, 4 = good, or 5 = excellent (Schaefer 1979). In addition, panelists were instructed to compare the test product to products with which they were familiar. They were also asked whether they purchased bakery products and whether they would purchase the test product if it were available at the same price as similar products. Additional information on the panelist's age and gender was also obtained from the same survey. This information was used to ascertain whether these two factors had any noticeable effect on product acceptability.

Sensory data were analyzed using the chi-square test and instrumental color data using Student's t test (O'Mahony 1986).

RESULTS

The colors of all-purpose, whole wheat, and blended flours containing DDGS from soft white wheat at 15 and 30% (w/w)

TABLE I
Formulation for Baked Goods Containing Distillers' Dried Grains with Solubles (DDGS) from Soft White Winter Wheat[a]

	White Bread[b]		Whole Wheat Bread[b]		Chocolate Chip Cookies[c]		Banana Bread[b]	
Ingredient (g)	Control	Experimental	Control	Experimental	Control	Experimental	Control	Experimental
Flour								
All-purpose	1,365	955	910	500	1,362	664	1,175	822
Whole wheat	···	···	455	455	···	···	···	···
Pastry	···	···	···	···	965	965	···	···
DDGS[a]	···	410	···	410	···	698	···	353
Bisquick[d]	···	···	···	···	227	227	···	···
Sugar								
Granulated	113	113	113	113	1,362	1,362	987	987
Brown	···	···	···	···	1,476	1,476	···	···
Confectioners'	···	···	···	···	85	85	···	···
Invert[e]	···	···	···	···	255	255	···	···
Yeast, compressed	113	113	113	113	···	···	···	···
Baking powder	···	···	···	···	···	···	16	16
Salt	28	28	28	28	···	···	···	···
Dough conditioner[f]	28	28	28	28	···	···	···	···
Milk, whole	1,000	1,000	1,000	1,000	···	···	···	···
Egg, whole	···	···	···	···	900	900	500	500
Butter	114	114	114	114	1,900	1,900	756	756
Banana, fresh, mashed	···	···	···	···	···	···	1,400	1,400
Lemon juice	···	···	···	···	···	···	75	75
Vanilla extract	···	···	···	···	60	60	···	···
Chocolate chips	···	···	···	···	3,292	3,292	···	···
Pecans, shelled, chopped	···	···	···	···	2,156	2,156	···	···

[a] Distillers' dried grains with solubles (DDGS) produced from whole, ground Hill 81, a soft white winter wheat.
[b] Bread recipes are for six loaves.
[c] Cookie recipes are for 10 dozen 3-in. cookies.
[d] Bisquick is the trade name for a buttermilk baking mix manufactured by General Mills, Inc., Minneapolis, MN. Ingredients: enriched flour bleached (wheat flour, niacin, iron, thiamine mononitrate, riboflavin), animal and/or vegetable shortening (contains one or more of the following partially hydrogenated fats: soybean oil, cottonseed oil, palm oil, beef fat; and/or non-hydrogenated lard) with freshness preserved by BHA and BHT, leavening (baking soda, sodium aluminum phosphate, monocalcium phosphate), cultured buttermilk, salt, whey.
[e] Numoline, standard invert sugar; Liquid Sugar Specialty, Inc., Seattle, WA.
[f] Puratus, S500 developer, Sam Wylde Flour Co., Seattle, WA.

replacement levels are presented in Table II. Data for a lower level (15%) of substitution of DDGS in the blended flour were included for comparison. Data are presented in order of increasing color difference relative to all-purpose flour. Color difference (ΔE) was calculated as described by Clydesdale (1976). Color parameters in which a significant difference ($P < 0.05$) was found between the all-purpose flour control and either the whole wheat flours, DDGS, or blends of DDGS and all-purpose flour are listed under color characteristics. The 30% blended flour, like the DDGS, was found to be significantly darker, more red, and more yellow than the all-purpose flour control. Both of the whole wheat flours were darker and more green than the control. The Hill 81 was more yellow, and the commercial whole wheat flour was more blue than the control. The smallest number of color differences was found between the control and the 15% blended flour. The largest ΔE, a measure of overall color difference relative to the control, was found for 100% DDGS.

Color characteristics of the baked products are presented in Table III. There were no significant differences in color between the control and experimental chocolate chip cookies, but there were significant differences ($P < 0.05$) between the control and experimental banana bread. Both the whole wheat bread and white bread containing DDGS were substantially darker, more red, and more yellow than the control products.

Acceptability of products containing DDGS was found to be "good" by a consumer panel (Table IV). The mode for all experimental products was 4 (good) on a scale of 1–5. No significant differences between the ratings for the experimental and control products were found using the chi-square test ($P < 0.05$).

The distribution of the consumer panelists by age and gender

TABLE II
Color Values (*L*, *a*, *b*) for All-Purpose Flour, Blends of All-Purpose Flour, Hill 81 Soft White Winter Wheat, a Commercial Whole Wheat Flour, and DDGS[a]

Sample	n[b]	Parameter[c] *L*	*a*	*b*	Color Characteristic[d] Relative to Control	Color Difference from Control[e] (ΔE)
All-purpose flour[f] (control)	3	85.1 ± 1.6	0.5 ± 0.1	9.7 ± 0.5	···	···
15% DDGS, 85% all-purpose flour (w/w)	3	85.1 ± 0.5	0.6 ± 0.2	8.9 ± 0.6	···	0.8
Ground whole white winter wheat, Hill 81	3	81.3 ± 0.5	−0.6 ± 0.1	11.1 ± 0.3	Darker, more green, more yellow	4.2
30% DDGS, 70% all-purpose flour (w/w)	3	80.7 ± 0.6	1.2 ± 0.2	11.2 ± 0.8	Darker, more red, more yellow	4.7
Whole wheat flour[g]	3	76.8 ± 0.3	0.4 ± 0.1	9.4 ± 0.2	Darker, more green, more blue	8.3
DDGS	3	61.8 ± 1.2	3.8 ± 0.8	19.5 ± 1.5	Darker, more red, more yellow	24.6

[a] DDGS = distillers' dried grains with solubles; prepared from soft white winter wheat, Hill 81 cultivar.
[b] n = Number of samples. The average of duplicate readings for each sample was used to calculate the reported $\overline{X}$.
[c] Measured on a Hunterlab color meter model D25M-2, luminescence C true-to-daylight light sources and standard tan color tile ($L = 78.3$, $a = -1.7$, $b = 21.6$). Values are means ± standard deviations. L = Visual lightness, white/black; +100 = white, 0 = black tile. a = Luminous reflectance, red/green; +100 = red, −100 = green. b = Luminous reflectance, yellow/blue; +100 = yellow, −100 = blue.
[d] Color characteristics that were found to be significantly different from control using Student's t test ($P < 0.05$).
[e] Color differences calculated according to the method of Clydesdale (1976).
[f] All-purpose bleached flour, wheat flour enriched with niacin, thiamine concentrate, and riboflavin, Western Family Foods, Inc., Portland, OR.
[g] Stone-buhr whole wheat unbleached flour, Stone-Buhr Milling Co., Seattle, WA.

TABLE III
Color Values (*L*, *a*, *b*) for Bakery Products Containing 30% DDGS[a] from Soft White Winter Wheat as a Replacement for All-Purpose Flour

Sample[b]	n[c]	Parameter[d] *L*	*a*	*b*	Color Characteristics[e]	Color Difference from Control[f] (ΔE)
White bread						
Control	6	74.7 ± 0.5	−3.2 ± 0.2	16.7 ± 0.1	···	
Experimental	6	49.1 ± 1.3	2.4 ± 0.2	24.1 ± 1.3	Darker, more red, more yellow	27.0
Whole wheat bread						
Control	6	64.1 ± 0.5	1.1 ± 0.1	17.6 ± 0.1	···	
Experimental	6	48.7 ± 0.5	2.6 ± 0.2	23.7 ± 0.5	Darker, more red, more yellow	16.0
Banana bread						
Control	6	47.8 ± 1.9	−0.3 ± 0.6	14.2 ± 0.5	···	
Experimental	6	40.7 ± 1.7	0.5 ± 0.1	15.1 ± 0.3	Darker, more red, more yellow	7.2
Chocolate chip cookies						
Control	6	39.2 ± 2.2	1.1 ± 0.3	14.9 ± 0.7	···	
Experimental	6	41.6 ± 0.9	1.7 ± 0.4	15.4 ± 0.4	···	2.5

[a] DDGS = distillers' dried grains with solubles; from soft white winter wheat, Hill 81 cultivar.
[b] Product formulations are presented in Table I.
[c] n = Number of samples. Single readings for each sample were used to calculate the reported $\overline{X}$ ± SD.
[d] Measured using a Hunterlab color meter model D25M-2. L (100 = white, 0 = black), a (+red, −green), b (+yellow, −blue).
[e] Color characteristics that were found to be significantly different from control by Student's t test ($P < 0.05$).
[f] Calculated according to method of Clydesdale (1976).

was determined for each of the experimental products. Depending on the experimental product evaluated, 53–74% of the panelists were male. Between 29 and 50% of the panelists were 35 years of age or older.

Additional information on the panelists regarding their buying habits and readiness to purchase baked goods containing DDGS was collected (Table V). Of the consumers that purchase white (57%) or whole wheat bread (39%) from bakeries, 92 and 85%, respectively, indicated they would purchase those products made with 30% DDGS if they were available at the same price as white and whole wheat breads. Approximately 75% of the consumers who evaluated the chocolate chip cookies buy those products from bakeries, and 98% of the panelists who tested cookies indicated they would purchase the DDGS product. Similar results were obtained for the banana bread; 87% of those polled purchase bakery quick breads, and 98% of these people said they would purchase the product containing DDGS.

The large amount of butter, whole milk, and eggs contained in cookies and banana bread outweighed any calorie-diluting effect of the high fiber in DDGS (Table VI). Reduction in calories for the formulations containing DDGS in Table I was 4% or less for quick bread and cookies and approximately 10% for white or whole wheat bread. However, based on food composition data (Pennington and Church 1985) and calculated calorie contents of these products, the caloric content of conventional breads that contain no milk or that substitute skim milk for whole milk can be reduced by 15% or more at a replacement level of 30% DDGS.

DISCUSSION

The color of blended flours containing 15% DDGS from soft white wheat was not found to be significantly different from that of commercial all-purpose flour (Table II). This is an important characteristic to note when developing formulations for wheat DDGS products; products containing DDGS could be formulated that may not be substantially darker than products containing only all-purpose flour. The 30% blended flour was darker, more red, and more yellow than all-purpose flour. However, the ΔE value for the 30% blended flour was less than that for whole wheat flour. This suggests that products made with up to 30% DDGS from white wheat should be lighter in color than comparable whole wheat products.

Although statistically significant differences occurred in all three color parameters (L, a, and b) for experimental and control banana bread, white bread, and whole wheat bread, no significant difference between the color of experimental and control chocolate chip cookies was found. The differences in color in the experimental breads did not appear to significantly affect the overall acceptability of the DDGS products.

All the baked products were rated well, and no significant differences ($P<0.05$) were found using a chi-square test in overall acceptability when the experimental and control products were compared. Even though there was a definite bias in our sample population towards men and towards people over 35 years of age, other studies using consumer panels to evaluate products made with DDGS have shown no bias in the data for overall acceptability according to panelist gender and minor or no differences by panelist age (Dawson et al 1984, Downey et al 1987).

The success of incorporating DDGS at higher replacement levels than have been previously reported resulted in part from using wheat rather than another cereal product for the fermentation. It is reasonable to expect that DDGS from other cereal grains or cereal blends would be less acceptable than a comparable wheat product as an ingredient in wheat-based food products. Additional advantages of DDGS from white wheat include the product's light color and fine, flaky texture.

This soft white wheat product was dried using an atmospheric drum drier. Conventional drying methods for DDGS manufacture include steam tube and tunnel drying, both of which produce coarse, hard DDGS particles with a dark color. Preliminary investigations suggest that DDGS dried using harsh heat treatments are less suitable than drum-dried products in bakery goods.

TABLE IV
Panel Ratings for Bakery Products Containing Distillers' Dried Grains with Solubles from Soft White Winter Wheat at a 30% Replacement Level for All-Purpose Flour in Conventional Formulations

Product[a]	n[b]	$\overline{X} \pm SD$	Rating Mode[c]
White bread	91	3.8 ± 0.7	4
Whole wheat bread	99	3.7 ± 0.9	4
Chocolate chip cookies	96	4.3 ± 0.8	4
Banana bread	101	4.3 ± 0.6	4

[a] Product formulations are presented in Table I.
[b] n = Number of consumer panelists.
[c] Ratings: 1 = unacceptable, 2 = poor, 3 = acceptable, 4 = good, 5 = excellent (Schaefer 1979).

TABLE V
Percentage of Consumer Panelists Who Purchase Bakery Products and Would Purchase Sample Products Containing Wheat Distillers' Dried Grains with Solubles (DDGS)[a]

Sample	Panelists[b] (n)	Bakery Goods Purchasers[c] (n)	Purchasers Who Would Buy Sample Products[d] (%)
Whole wheat bread	99	39	92
White bread	91	52	85
Chocolate chip cookies	96	75	98
Banana bread	101	67	98

[a] These results were from a single blind test. Panelists were unaware that the product they were evaluating contained DDGS from soft white winter wheat.
[b] n Refers to number of consumer panelists who tested product containing 30% DDGS from Hill 81 soft white winter wheat and completed questionnaire.
[c] n Refers to number of consumer panelists who tested experimental sample and who purchase similar bakery products.
[d] Percent of those who purchase similar bakery products who would purchase the sample they evaluated.

TABLE VI
Comparison of Nutrient Contents of Bakery Products Containing Distillers' Dried Grains with Solubles (DDGS) from Soft White Winter Wheat Versus Controls

Nutrient[a] (per oz)	White Bread	White Bread w/30% DDGS	Whole Wheat Bread	Whole Wheat Bread w/DDGS	Banana Bread	Banana Bread w/DDGS	Chocolate Chip Cookies	Chocolate Chip Cookies w/DDGS
Calories (kcal)	70.0	63.5	69.4	62.1	88.5	85.0	132	129
Protein (g)	1.96	2.99	2.11	3.13	1.20	1.50	1.22	1.56
Lipid (g)	1.44	1.60	1.48	1.38	3.92	4.20	8.34	8.41
Crude fiber (g)	0.041	0.35	0.13	0.34	0.06	0.18	0.19	0.30
Dietary fiber (g)[b]	0.4	1.8	0.9	2.2	0.3	1.0	0.1	0.6

[a] The nutrient contents of ingredients listed in Table I were obtained from Pennington and Church (1985). The calories, protein, lipid, crude fiber, and dietary fiber contents of DDGS were calculated from data reported in previous studies (Rasco et al 1987, Dong and Rasco 1987).
[b] Estimates based on total dietary fiber values reported for wheat by Prosky et al (1984) and for DDGS by Dong and Rasco (1987).

The major nutritional advantage of supplementing baked goods formulations with DDGS from soft white winter wheat is an increased level of dietary fiber and protein. The protein and crude and dietary fiber contents of products containing DDGS were significantly higher than those of control products containing only all-purpose flour or a combination of all-purpose flour and whole wheat flour per 1-oz serving (Table VI). Relative to control products, the DDGS products contained more protein; the protein content was 30% greater in experimental chocolate chip cookies and banana bread and 50% greater in the experimental yeast breads.

Dietary fiber content increased in experimental products by 500% in chocolate chip cookies, 140% in whole wheat bread, 350% in white bread, and 230% in banana bread. A 1-oz slice of whole wheat bread containing DDGS at a 30% replacement level provides 2.2 g of dietary fiber, or 9% of the recommended intake of 25 g of dietary fiber/day. Even for an exceptionally high-fat chocolate chip cookie containing only 5% DDGS based on the formulation weight, the level of dietary fiber was almost five times higher than in the product without DDGS. DDGS from soft white wheat has approximately 34% total dietary fiber (San Buenaventura et al 1987). The lipid and caloric contents were relatively unchanged for baked goods listed in Table I.

CONCLUSIONS

Chocolate chip cookies and banana bread made with DDGS from soft white wheat at a replacement level of 30% for all-purpose flour were rated as well as control products that contained no DDGS. The consumer panelists rated the banana bread as good to excellent in spite of statistically significant differences in color measurements of the finished product compared to the control. Whole wheat bread and white pan bread, both containing DDGS, were rated as acceptable to good.

There is a definite potential for the development of bakery products using DDGS from soft white wheat. DDGS would be a useful material to enrich baked goods with dietary fiber and protein.

ACKNOWLEDGMENTS

This research was sponsored in part by the Washington, Oregon, and Idaho Wheat Commissions. The authors thank Orville Mayer of St. John Grain Growers, St. John, WA, for the donation of white wheat; Paul Larsen of Larsen Brothers' Danish Bakery for providing baked products; and Joyce Ostrander, Margery Einstein, and William McBurney for technical advice and assistance.

LITERATURE CITED

CLYDESDALE, F. M. 1976. Instrumental techniques for color measurements of foods. Food Technol. 30:52.

DAWSON, K. R., O'PALKA, I., HETHER, N. W., JACKSON, L., and GRAS, P. N. 1984. Taste panel preference correlated with lipid composition of barley dried distillers' grains. J. Food Sci. 49:787.

DONG, F. M., and RASCO, B. A. 1986. The neutral detergent, acid detergent, crude fiber and lignin content of distillers' dried grains with solubles. J. Food Sci. 52:403.

DOWNEY, S. E., RASCO, B. A., DONG, F. M., and OSTRANDER, J. 1987. Consumer acceptability and color of deep-fried fish batter made with distillers' dried grains with solubles (DDGS) from wheat and corn. J. Food Sci. In press.

DREESE, V. G., and HOSENEY, R. C. 1982. Baking properties of the bran fraction from brewer's spent grains. Cereal Chem. 59:89.

FINLEY, L. W., and HANAMOTO, M. M. 1980. Milling and baking properties of dried brewer's spent grains. Cereal Chem. 57:166.

HUDSON, D. 1984. Making biscuits and bread from spent grain. Brew. Distil. Int. 14:42.

MORAD, M. M., DOHERTY, C. A., and ROONEY, L. W. 1984. Utilization of dried distillers' grain from sorghum in baked food systems. Cereal Chem. 61:409.

O'MAHONY, M. 1986. Pages 91-115 in: Sensory Evaluation of Food. Statistical Methods and Procedures. Marcel Dekker, Inc.: NY.

PENNINGTON, J. A. T., and CHURCH, H. N. 1985. Bowes and Church's Food Values of Portions Commonly Used. J. D. Lippincott Co.: Philadelphia, PA.

PRENTICE, N., and D'APPOLONIA, B. L. 1977. High-fiber bread containing brewer's spent grains. Cereal Chem. 54:1084.

PROSKY, L., ASP, N.-G., FURDU, I., DEVRIES, J. W., SCHWEITZER, J. F., and HARLAND, B. F. 1984. Determination of total dietary fiber in foods and food products: Collaborative study. J. Assoc. Off. Anal. Chem. 68:677.

RASCO, B. A., DONG, F. M., HASHISAKA, A. E., GAZZAZ, S. S., DOWNEY, S. E., and SAN BUENAVENTURA, M. L. 1987. Chemical composition of distillers' dried grains with solubles (DDGS) from soft white wheat, hard red wheat, and corn. J. Food Sci. 52:236.

SAN BUENAVENTURA, M. L., DONG, F. M., and RASCO, B. A. 1987. The total dietary fiber content of distillers' dried grains with solubles. Cereal Chem. 64:135.

SCHAEFER, E. E., ed. 1979. Page 39 in: ASTM Manual on Consumer Sensory Evaluation. No. 682. American Society of Testing Materials: Washington, DC.

TSEN, C. C., EYESTONE, W., and WEBER, J. L. 1982. Evaluation of the quality of cookies supplemented with distillers' dried grain flour. J. Food Sci. 47:684.

TSEN, C. C., WEBER, J. L., and EYESTONE, W. 1983. Evaluation of distillers' dried grain flour as a bread ingredient. Cereal Chem. 60:295.

WAELTI, H., and EBELING, J. M. 1982. Fuel Alcohol. Distillers' Dried Grain Nutritional Value. AE 108. Cooperative Extension Services, Washington State University: Pullman, WA.

WU, Y. V., SEXTON, K. R., and LAGODA, A. A. 1984. Protein-rich residue from wheat alcohol distillation: Fractionation and characterization. Cereal Chem. 61:423.

[Received July 21, 1986. Revision received November 14, 1986. Accepted November 22, 1986.]