Evaluation of Spaghetti Supplemented with Corn Distillers' Dried Grains

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ABSTRACT

Spaghettis were prepared supplemented at 5, 10, and 15% levels with corn distillers' grains (CDG) or with CDG extracted with hexane-ethanol azeotrope. Spaghetti containing 10% CDG or 10% extracted CDG had 12–14% more protein and several times the dietary fiber of control spaghetti. Cooked weight, cooking loss, and firmness of supplemented spaghettis were acceptable. Spaghettis supplemented with 5 or 10% CDG or extracted CDG had fair flavor and texture quality, but spaghetti containing 15% CDG was unacceptable. These studies demonstrated that acceptable spaghetti can be prepared with up to 10% CDG, thereby improving its nutritional value while providing an additional market for CDG.

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Corn is the major cereal grain fermented to ethanol (Morris 1983). Stillage, the residue remaining after ethanol is distilled, can be separated into solid and soluble fractions. The soluble fraction is usually concentrated and combined with wet solids, which are then dried to produce corn distillers' dried grains with solubles (CDGS). Some corn distillers' dried grains (CDG) and corn distillers' dried solubles (CDS) are also produced. Distillers' dried grain flours have been incorporated into cookies (Tsen et al 1982) and bread (Tsen et al 1983), and CDG has been evaluated in blended foods for overseas distribution (Wall et al 1984, Bookwalter et al 1984). CDG is rich in protein and dietary fiber (Wu and Stringfellow 1986) but has an undesirable flavor; flavor can be improved by extracting with hexane-ethanol azeotrope (Bookwalter et al 1984). Thus, CDG supplementation has the potential of improving the nutritive value of spaghetti by enriching its protein and dietary fiber contents and could expand the use of this by-product from ethanol fermentation. For these reasons, we evaluated the cooking qualities and flavor of spaghetti supplemented with CDG fractions of various protein and fiber contents and azeotrope-extracted CDG.

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MATERIALS AND METHODS

CDG, supplied by Brown-Forman Distillers Corp. (Louisville, KY), was sieved without moisture adjustment through 18-, 24-, and 35-mesh U.S. standard screens (0.98, 0.678, and 0.447 mm openings, respectively). CDG and its fractions were ground in an Alpine model 160Z pin mill to pass a 35-mesh screen or in a hammermill through a 0.595-mm sieve. Some untreated CDG and CDG fractions were extracted 10 times with hexane-ethanol

(82:18, v/v) azeotrope at a solvent-to-solid weight ratio of 2.67, and the solvent was removed by air-drying overnight followed by oven drying at 88° C for 1 hr.

Durakota, a durum semolina marketed by the North Dakota Mill, Grand Forks, was used as a control. To make dough, 310 g of H_2O and 1,000 g of semolina were mixed and passed batchwise through a DeMaco laboratory extruder as described by Walsh et al (1971). Spaghetti was dried in air for 30 min, then at 40° C for 18 hr at a relative humidity decreasing linearly from 95% to room humidity. To prepare supplemented spaghetti, 5, 10, or 15% of the semolina weight was replaced by CDG or one of its fractions. Diameter of extruded spaghetti was 1.6 mm.

Cooking Quality

To evaluate cooking quality, 10 g of spaghetti was boiled with 300 ml of water for 12 min. Cooked weight was determined after draining the cooked spaghetti. Cooking loss was determined from the quantity of residue in the cooking water, expressed as percent of original spaghetti weight. Work (g-cm) required to cut a cooked strand of spaghetti was measured with an Instron universal testing instrument (Canton, MA) equipped with a special plastic cutting edge (Walsh 1971). A relative firmness value was calculated from work required.

Sensory Evaluations

Spaghetti with and without CDG was evaluated for flavor quality and texture by a 15-member panel experienced in tasting cereal products and CDG samples. Flavor quality was rated on a 10-point scale from excellent (10) to bad (1); a control with no CDG was rated as having good quality (score = 8). Off-flavors were rated on an intensity scale from none (0) to strong (10). Texture was rated for both firmness (soft = 1, firm = 10) and grittiness (smooth = 1, gritty = 10). Before each panel session, testers were given the control to use as a basis from which to rate samples containing CDG. In general, flavor quality scores below 5.0 were considered unacceptable.

Analyses

Protein, fat, and ash contents were determined by AACC methods (1983). Moisture was measured by heating samples at 100° C to constant weight. Protein content (nitrogen × 6.25 for CDG and nitrogen × 5.7 for spaghetti, Watt and Merrill 1963) was calculated from quadruplicate micro-Kjeldahl analyses. Dietary fiber (cellulose, lignin, and water-insoluble hemicellulose) was determined in duplicate by the neutral detergent method (McQueen and Nicholson 1979). Amino acid analyses were carried out with a Glenco MM-100 amino acid analyzer (Glenco Scientific Inc., Houston, TX) or a Dionex D300 amino acid analyzer (Dionex Corp., Sunnyvale, CA). Each sample was hydrolyzed for 24 hr under reflux in 6*N* hydrochloric acid. The hydrolyzed sample was evaporated to dryness in a rotoevaporator, and the residue was dissolved in pH 2.2 citrate buffer. The sulfur amino acids were determined after oxidation of the sample with performic acid (Moore 1963). The data were computed by the method of Cavins and Friedman (1968).

RESULTS AND DISCUSSION

Composition

Protein, fat, ash, and dietary fiber contents of CDG fractions and spaghetti are listed in Table I. CDG contained about double the protein and ash contents, 40 times the dietary fiber, and significantly more fat than spaghetti. CDG retained by a 35-mesh screen had lower protein but slightly higher dietary fiber than untreated CDG, whereas CDG smaller than 35-mesh had higher protein but lower dietary fiber than untreated CDG. CDG extracted with hexane-ethanol azeotrope contained higher protein and dietary fiber but less fat than untreated CDG. Spaghetti with 10% CDG or with 10% azeotrope-extracted CDG had 12–14% more protein and about five times the dietary fiber of control spaghetti.

Cooking Quality

Upon cooking 10 g of spaghetti, the cooked weight (26.52–28.79 g) was within the expected range of 28 ± 2 g (Table II). Cooking loss that is undesirable should not exceed 8% of dry weight. Generally, the cooking loss increased as CDG fraction content increased, and all samples with 15% CDG did exceed 8%. The firmness value (6.31) for the cooked spaghetti control was fairly good, although a value of 7 would be more acceptable; extremely high (8.5 too firm) or low (3.5–4.0 mushy) firmness values are not acceptable. Firmness values for spaghetti with CDG additives were similar to scores for spaghettis made from semolinas milled from older varieties of durum that have weak gluten. Firmness scores

TABLE I
Composition of Corn Distillers' Dried Grains (CDG) Fractions and Spaghetti (dry basis)

	Content, %			
Material	Protein[a]	Fat	Ash	Neutral Detergent Fiber
CDG	31.4 (0.2)	7.8 (0.0)	1.7 (0.1)	58.2 (0.3)
CDG on 18 mesh	26.6 (0.2)	8.3	1.9	60.5 (0.4)
CDG 18–24 mesh	22.7 (0.1)	8.5	1.8	64.3 (0.8)
CDG on 35 mesh	24.9 (0.2)	8.8 (0.1)	1.7	61.7 (0.4)
CDG through 35 mesh	41.0 (0.5)	6.9 (0.1)	1.5	53.7 (1.1)
Azeotrope-extracted CDG	35.3 (0.1)	0.18 (0.02)	1.7 (0.0)	63.0 (1.2)
Azeotrope-extracted CDG on 35 mesh	24.1 (0.3)	0.12 (0.04)	1.8 (0.1)	74.0 (0.1)
Spaghetti	14.5 (0.1)	0.10 (0.03)	0.7	1.5 (0.1)
Spaghetti + 10% azeotrope-extracted CDG[b]	16.6	0.11	0.8	7.7
Spaghetti + 10% CDG[b]	16.2	0.87	0.8	7.2

[a] Protein = N × 6.25 for CDG and fractions, protein = N × 5.7 for spaghetti. Values in parentheses are standard error of mean = $s/n^{1/2}$, where s is standard deviation and n is number of measurement.
[b] Calculated from the sum of individual components.

TABLE II
Cooking Quality[a] of Spaghetti Supplemented with Corn Distillers' Dried Grain (CDG)

CDG Fraction	Percent CDG Fraction Added	Cooked Weight (g)	Cooking Loss (%)	Firmness
None	0	28.67	6.7	6.31
CDG	5	27.94	7.7	5.10
	10	27.16	8.1	4.56
	15	26.82	9.4	4.47
On 18 mesh	5	27.78	8.3	5.16
	10	27.84	8.4	4.95
	15	26.52	8.6	4.21
18–24 mesh	5	27.81	7.4	5.21
	10	28.20	7.2	4.56
	15	27.37	9.1	3.97
Through 35 mesh	5	28.79	7.0	5.62
	10	28.54	7.1	5.46
	15	27.82	8.4	4.95
Azeotrope-extracted	5	27.82	7.6	5.05
	10	27.77	7.2	5.44
	15	26.65	9.0	4.47
Azeotrope-extracted on 35 mesh	5	27.93	7.6	5.64
	10	27.89	8.6	5.40
	15	27.41	8.1	4.95

[a] These analyses were done on 10-g samples, single analysis for each.

TABLE III
Sensory Evaluation of Spaghetti Supplemented with Different Levels of Corn Distillers' Grains (CDG)

Parameters	Control	% CDG in Spaghetti[a]				
		Azeotrope-Extracted		Untreated		
		5	10	5	10	15
Overall flavor quality[b]	8.0	5.8	5.7	5.9	5.6	4.1
Fermented off-flavor intensity[c]	0	2.0	2.0	3.8	4.6	4.8
Firmness[d]	6.4	5.7	5.6	5.1	5.0	6.2
Grittiness[e]	2.2	4.9	5.3	5.2	5.3	6.3

[a] LSD = 1.0 (95% confidence level).
[b] 1 = Bad; 10 = excellent; < 5 = poor quality.
[c] 0 = None; 10 = strong.
[d] 1 = Soft texture; 10 = firm.
[e] 1 = Smooth texture; 10 = gritty.

TABLE IV
Amino Acid Composition of Corn Distillers' Grains (CDG) Fractions and Spaghetti[a]

Amino Acid	CDG				Spaghetti[b]
	Whole	On 18 Mesh	18-24 Mesh	Through 35 Mesh	
Aspartic	6.6	7.1	7.6	6.2	3.1
Threonine	3.9	4.1	4.5	3.7	2.2
Serine	4.9	5.5	5.4	4.8	4.0
Glutamic	20.5	18.1	20.1	21.8	27.7
Proline	8.0	9.6	9.8	8.8	8.0
Glycine	4.0	4.4	5.0	3.6	2.3
Alanine	7.4	11.6	7.7	7.8	2.2
Valine	5.1	5.2	5.8	4.9	3.2
Cystine	3.2	2.2	1.9	2.5	1.2
Methionine	3.4	1.9	2.2	3.0	1.2
Isolecuine	3.7	3.1	3.8	3.7	2.5
Leucine	13.1	8.8	12.5	14.5	8.8
Tyrosine	4.0	3.6	4.1	4.9	0.7
Phenylalanine	5.1	4.2	5.3	5.3	3.6
Lysine	3.2	3.6	2.6	2.7	1.5
Histidine	2.8	2.5	2.1	2.7	2.0
Arginine	5.9	6.2	4.9	5.3	2.9

[a] Data reported as grams of amino acid per 16 g of nitrogen recovered. Tryptophan not determined. Single analysis except spaghetti in triplicate.
[b] Bahnassey et al 1986.

generally decrease as percent additive increases. Cooked weight, cooking loss and firmness of spaghetti showed no correlation with protein, dietary fiber, or fat content of CDG fractions, but the cooking quality is dependent on the percent of CDG fractions added.

Sensory Evaluation

Flavor and texture of spaghetti with CDG (Table III) differed significantly from those for the control. Overall flavor quality scores of spaghetti with CDG and with azeotrope-extracted CDG at the 5 and 10% addition levels were similar. However, the score for the spaghetti containing 15% CDG was significantly lower and was unacceptable. The predominant off-flavor was the fermented flavor characteristic of CDG. Fermented off-flavor intensity was significantly higher for the samples with untreated CDG than for those with azeotrope-extracted CDG. Firmness scores of spaghetti with 5 and 10% untreated CDG were significantly lower than the control. Grittiness scores of spaghetti with azeotrope-extracted or untreated CDG were significantly higher (more gritty) than the control. This increase in grittiness was a result of the larger particle size of CDG compared with semolina.

Amino Acid Composition

The amino acid compositions of CDG and its fractions, in general, did not differ greatly (Table IV). However, the amino acid composition of CDG differed greatly from that of spaghetti. CDG had higher histidine, isoleucine, leucine, lysine, methionine + cystine, phenylalanine + tyrosine, threonine, and valine—the essential amino acids. Whole CDG had twice the lysine content (in grams of amino acid per 16 g of nitrogen) of spaghetti, where lysine is the first limiting amino acid. The supplementation of spaghetti with 10% CDG would increase the contents of lysine per 100 g spaghetti by 22% and result in a more nutritious product.

CONCLUSION

CDG fractions with various protein, dietary fiber, and fat contents were incorporated at 5, 10, and 15% levels to increase protein and dietary fiber of spaghetti. Cooked weight, cooking loss, and firmness of spaghetti showed no correlation with protein, dietary fiber, or fat content of the CDG fractions, but cooked weight, cooking loss, and firmness depended on the percentage of CDG fractions added. Spaghetti containing up to 10% CDG or azeotrope-extracted CDG had acceptable flavor, texture, and cooking quality (although not quite as good as control) as well as enhanced protein, dietary fiber and essential amino acids contents.

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