Sensory Analysis of Brownies Fortified with Corn Gluten Meal

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ABSTRACT

Corn gluten meal is a high-protein product from wet milling of corn. Substitution of 15% of the flour weight by corn gluten meal increased protein content of brownies from 6.3 to 8.0%. Sensory evaluation of brownies with 0, 10, and 15% corn gluten meal, with and without an added masking agent, showed addition of corn gluten meal to brownies did not have any detrimental effect as judged by trained sensory panelists.

Corn gluten meal (CGM) has a minimum of 60% protein and is a coproduct of the wet-milling process. Increased production of fuel ethanol and high-fructose corn syrup results in higher demand for starch, which in turn results in more CGM being produced. The unpleasant flavor of CGM (Wu et al 1994) is a major limitation for use in food. Approaches to overcome this problem include reducing the unpleasant flavor by extracting CGM with ethyl acetate-aliphatic alcohol and water (Phillips 1977), with ethyl acetate (Neumann et al 1984), or with supercritical carbon dioxide (Wu et al 1994).

Another approach to utilize CGM in food is to mask the unpleasant flavor by natural ingredients in a recipe or by the addition of a masking agent. Brownies are a widely consumed food and contain chocolate, which may mask subtle off-flavors. Substitution of part of the flour in brownies by CGM can increase protein content. This study used CGM as a substitute for up to 15% of wheat flour in brownies.

MATERIALS AND METHODS

Sample Preparation

Corn gluten meal (CGM) was supplied by Williams Ethanol (Pekin, IL). A 3^3 factorial design was used for the CGM study. CGM was substituted for a certain percentage of the flour content in a recipe for brownies (Better Homes and Gardens 1979). The ingredients consisted of 3/4 cup of butter or margarine, 57 g of unsweetened chocolate, 1 and 1/3 cups of sugar, 3 eggs, 1 cup of all-purpose flour, 1 tsp of baking power, and 1/2 tsp of salt. Three masking agents were tried in a preliminary experiment. Prosweet MM50 and MM55 (Virginia Dare, Brooklyn, NY) performed better and were chosen for subsequent experiments. Formulations consisted of a 0, 10, and 15% substitution, with or without 0.5% Prosweet MM50 or MM55, flavor additives that could mask the yeasty attribute associated with CGM. MM50 contained 90–99% dextrose and 1–10% flavoring ingredients; MM55 contained 90–99% dextrose, 1–10% natural flavoring ingredients, and <1% modified food starch. Brownies were baked in 23 × 33 cm Teflon-coated baking pans (Echo) in 177°C ovens (Jenn-Air, Maytag Cleveland Cooking Products, Cleveland, TN) a day before analysis. After baking, brownies were allowed to cool for a 0.5 hr, then 1 cm of the perimeter was removed using a stainless steel knife. Brownies were cut into sample size rectangles of 2.5 × 5.1 cm, stored by treatment in 1-gal freezer bags (Ziploc), then refrigerated at 0°C until analysis. Each sample was placed in a covered petri dish (100 × 20 mm) for 1 hr before analysis, and allowed to reach room temperature before presentation to the panel.

Sensory Analysis

Twelve sensory panelists trained in descriptive analysis techniques as described by Johnsen (1994) evaluated the flavor quality of brownies. A linear universal intensity scale (0–10, where 0 is not detectable) based on the sensory spectrum descriptive method (Meilgaard et al 1999) was used to assess brownie flavor intensity. The study consisted of seven sessions in which a standard (a brownie without experimental treatments) and a maximum of four test samples were presented in random order for sensory evaluation. The standard was basically served as a warm-up sample and a means of calibration for sensory panelists. Samples were presented at 10-min intervals and assessed under red light to discourage evaluations based on preconceptions associated with food coloration. There was no visible difference in color of brownies when CGM was added. Panelists were instructed to smell the samples initially to evaluate aromatics before proceeding with an oral assessment of flavors. An average score of the panel and session was recorded for those flavor descriptors in which a varying range of intensity was noted during evaluation. Purified water obtained from a reverse osmosis filtering system (Hydrotechnology, Valencia, CA) was used to cleanse the palate between samples. All samples were replicated a minimum of three times. Brownie descriptors and definitions are listed in Fig. 1.

Analysis

Nitrogen was measured by the micro-Kjeldahl method, and moisture was measured from weight loss after oven drying at 130°C for 1 hr by Approved Methods (AACC 2000). Protein was calculated as N × 6.25. Samples for amino acid analyses were hydrolyzed at 145°C for 4 hr (Gehrke et al 1987), and methionine and cystine were oxidized with performic acid before hydrolysis (Moore 1963). Amino acids were determined in a amino acid analyzer (6300, Beckman Instruments, San Ramon, CA) by cation-exchange chromatography. Tryptophan was measured by colorimetric method after enzymatic hydrolysis by pronase (Spies and Chambers 1949; Holz 1972).

Statistical Analysis

The experimental design was a factorial mixed effects model, completely random design (Neter et al 1990). It was analyzed as a three-factor analysis of variance (ANOVA). Treatment effects were CGM, additive, and CGM × additive; degrees of freedom were 2, 2, and 4, respectively. Random effects were panel, CGM × panel, additive × panel, and CGM × additive × panel; degrees of freedom depended on the number of panelists in a session and the number of treatments in a session. The rating scale for panelists was 0–10 for a variety of flavor characteristics, each analyzed separately. When a significant *F*-value was obtained from analysis, least square mean

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differences were examined using conservative $P < 0.02$ values for mean comparison significance (SAS Institute, Cary, NC). For protein content and amino acid composition, means were compared by *t*-tests of pairs of least square means using $P < 0.05$ as significant difference.

DESCRIPTOR	DEFINITION
Aromatics	
Chocolate	Aromatic associated with roasted or ground cocoa beans. Examples are milk/dark/semi-sweet/imitation chocolate and cocoa.
Sugary/Sweet Aromatic	Aromatic associated with materials that have a sweet smell such as caramelized sugar, molasses, cane syrup, saccharin, and caramel.
Grain/Bran	Aromatics derived from various grains such as oat, corn, or wheat. These aromatics may have a light, dusty impression.
Buttery/Oily	The aroma and flavor notes reminiscent of fresh butter or vegetable oil. These aromatics are commonly associated with fat-based shortening agents used in baking.
Nutty	Aromatic associated with nuts or nut meats.
Eggy	Aromatic associated with freshly boiled eggs or custard pudding.
Rancid/Painty/ Cardboardy	Aromatic associated with oxidized fats and oils.
Chemical	A general term associated with many different types of compounds such as solvents, cleaning compounds, and hydrocarbons.
Tobacco	Aromatic associated with tobacco leaves.
Burnt	Aromatic associated with blackened/acrid carbohydrates.
Soured Yeasty/ Fermented	Aromatics associated with fermented grains, activated yeast, and lactic or spoilage bacteria as in soured milk, soured meat, or sourdough.
Tastes	
Sweet	The taste on the tongue associated with sugars.
Salty	The taste on the tongue associated with sodium salt, especially sodium chloride.
Bitter	The taste on the tongue associated with caffeine.
Mouthfeel	
Astringent	The chemical feeling factor on the tongue described as puckering/dry and associated with strong tea.

Fig. 1. Brownie descriptors and definitions.

RESULTS AND DISCUSSION

Protein content and amino acid composition of brownies with and without 15% CGM are shown in Table I. There was a large increase in protein content from 6.3 to 8.0% when 15% of flour was substituted with CGM in brownies. There was a significant increase ($P < 0.05$) in all amino acids except tryptophan when CGM was substituted for 15% of flour in brownies. Higher protein content and higher amino acid composition gave a more nutritious brownie when CGM was added.

Brownies had a strong sweet taste (6.2–6.6 intensity scale) and weak salty, bitter, and astringent descriptors (intensity scale of ≤1.5) (Table II). There was no statistical difference between 0, 10, and 15% CGM or between MM50, MM55, and no additive for sweet, salty, bitter, and astringent descriptor intensities.

TABLE I
Protein Content and Amino Acid Composition of Brownies and Brownies with 15% Corn Gluten Meal (% dry basis)

	Brownies	Brownies with 15% Corn Gluten Meal
Protein content	6.3b[a]	8.0a
Aspartic acid	0.54b	0.64a
Threonine	0.26b	0.31a
Serine	0.37b	0.43a
Glutamic acid	1.36b	1.64a
Proline	0.40b	0.54a
Glycine	0.24b	0.28a
Alanine	0.31b	0.45a
Half-cystine	0.17b	0.21a
Valine	0.39b	0.45a
Methionine	0.16b	0.20a
Isoleucine	0.29b	0.35a
Leucine	0.52b	0.79a
Tyrosine	0.19b	0.26a
Phenylalanine	0.34b	0.44a
Histidine	0.15b	0.18a
Lysine	0.31b	0.35a
Arginine	0.36b	0.41a
Tryptophan	0.078a	0.083a

[a] Values followed by the same letter in the same row are not significantly different ($P < 0.05$).

TABLE II
Intensity of Sweet, Salty, Bitter, and Astringent Descriptors Independent of Corn Gluten Meal (CGM) and Additive ($P < 0.02$)

Descriptor	Effect	CGM, %	Additive	Intensity
Sweet	CGM	0		6.36 (0.31)[a]
	CGM	10		6.33 (0.31)
	CGM	15		6.57 (0.32)
	Additive		MM50	6.24 (0.32)
	Additive		MM55	6.42 (0.32)
	Additive		None	6.61 (0.32)
Salty	CGM	0		1.37 (0.11)
	CGM	10		1.50 (0.11)
	CGM	15		1.40 (0.11)
	Additive		MM50	1.40 (0.11)
	Additive		MM55	1.43 (0.11)
	Additive		None	1.43 (0.11)
Bitter	CGM	0		0.84 (0.22)
	CGM	10		0.82 (0.22)
	CGM	15		0.72 (0.22)
	Additive		MM50	0.81 (0.22)
	Additive		MM55	0.79 (0.22)
	Additive		None	0.77 (0.22)
Astringent	CGM	0		0.96 (0.20)
	CGM	10		0.88 (0.20)
	CGM	15		0.91 (0.20)
	Additive		MM50	0.91 (0.20)
	Additive		MM55	0.94 (0.20)
	Additive		None	0.90 (0.20)

[a] Means (standard deviation around panelists and sessions) of descriptor intensity; 0 = not detectable, 10 = highest for this work.

TABLE III
Intensity of Aromatic Descriptors Independent of Corn Gluten Meal (CGM) and Additive (*P* < 0.02)

Descriptor	Effect	CGM, %	Additive	Intensity
Chocolate	CGM	0		4.21 (0.30)[a]
	CGM	10		4.47 (0.31)
	CGM	15		4.36 (0.31)
	Additive		MM50	4.29 (0.31)
	Additive		MM55	4.38 (0.31)
	Additive		None	4.38 (0.31)
Sugary/Sweet Aromatic	CGM	0		1.74 (0.41)
	CGM	10		1.91 (0.41)
	CGM	15		1.88 (0.41)
	Additive		MM50	1.84 (0.41)
	Additive		MM55	1.75 (0.41)
	Additive		None	1.93 (0.41)
Grain/Bran	CGM	0		2.42 (0.50)
	CGM	10		2.31 (0.50)
	CGM	15		2.42 (0.50)
	Additive		MM50	2.38 (0.50)
	Additive		MM55	2.32 (0.50)
	Additive		None	2.45 (0.50)
Burnt	CGM	0		1.87 (0.28)
	CGM	10		1.87 (0.28)
	CGM	15		1.84 (0.28)
	Additive		MM50	1.89 (0.28)
	Additive		MM55	1.83 (0.28)
	Additive		None	1.87 (0.28)

[a] Means (standard deviation around panelists and sessions) of descriptor intensity. 0 = not detectable, 10 = highest for this work.

TABLE III (continued)
Intensity of Aromatic Descriptors Independent of Corn Gluten Meal (CGM) and Additive (*P* < 0.02)

Descriptor	Effect	CGM, %	Additive	Intensity
Soured/Yeasty /Fermented	CGM	0		1.50 (0.24)
	CGM	10		1.48 (0.24)
	CGM	15		1.46 (0.24)
	Additive		MM50	1.48 (0.24)
	Additive		MM55	1.45 (0.24)
	Additive		None	1.50 (0.24)
Nutty	CGM	0		0.09 (0.04)
	CGM	10		0.06 (0.04)
	CGM	15		0.06 (0.04)
	Additive		MM50	0.07 (0.04)
	Additive		MM55	0.07 (0.04)
	Additive		None	0.06 (0.04)
Eggy	CGM	0		0.87 (0.18)
	CGM	10		0.84 (0.18)
	CGM	15		0.79 (0.18)
	Additive		MM50	0.87 (0.18)
	Additive		MM55	0.74 (0.18)
	Additive		None	0.89 (0.18)
Chemical	CGM	0		0.29 (0.17)
	CGM	10		0.28 (0.17)
	CGM	15		0.27 (0.17)
	Additive		MM50	0.27 (0.17)
	Additive		MM55	0.28 (0.17)
	Additive		None	0.30 (0.17)

[a] Means (standard deviation around panelists and sessions) of descriptor intensity; 0 = not detectable, 10 = highest for this work.

TABLE IV
Intensity of Aromatic Descriptors Dependent on Corn Gluten Meal (CGM) or Corn Gluten Meal and Additive Interaction

Descriptor	Effect	Pr > *F*	CGM, %	Additive	Intensity[a]
Buttery/Oily	CGM × Additive	0.0096			
	CGM × Additive		0	MM50	2.18 (0.16)a
	CGM × Additive		0	MM55	1.78 (0.16) b
	CGM × Additive		0	None	1.93 (0.16)ab
	CGM × Additive		10	MM50	1.86 (0.17)ab
	CGM × Additive		10	MM55	1.82 (0.17)ab
	CGM × Additive		10	None	2.14 (0.17)a
	CGM × Additive		15	MM50	2.20 (0.17)a
	CGM × Additive		15	MM55	2.15 (0.17)a
	CGM × Additive		15	None	1.83 (0.17)ab
Rancid/Painty/Cardboardy	CGM × Additive	0.0458			
	CGM × Additive		0	MM50	0.45 (0.22)ab
	CGM × Additive		0	MM55	0.37 (0.22)ab
	CGM × Additive		0	None	0.44 (0.22)ab
	CGM × Additive		10	MM50	0.19 (0.22)b
	CGM × Additive		10	MM55	0.64 (0.22)a
	CGM × Additive		10	None	0.25 (0.22)b
	CGM × Additive		15	MM50	0.21 (0.22)b
	CGM × Additive		15	MM55	0.46 (0.22)ab
	CGM × Additive		15	None	0.34 (0.22)ab
Tobacco	CGM	0.0207			
	CGM		0		0.40 (0.09)a
	CGM		10		0.38 (0.09)a
	CGM		15		0.18 (0.09)b

[a] Means (standard deviation) of intensity values followed by different letters for each descriptor were significantly different (*P* < 0.05) as determined by least square means comparisons; 0 = not detectable, 10 = highest for this work.

Brownies had a moderate chocolate intensity (4.2–4.5), weaker sugary/sweet aromatic, grain/bran, burnt, soured/yeasty/fermented intensity, and weak nutty, eggy, and chemical descriptor intensities (Table III). All descriptor intensities in Table III were independent of CGM (0, 10, and 15%) and additive (MM50, MM55, or none).

Intensity of the tobacco descriptor was significantly lower (*P* < 0.05) for 15% CGM brownies compared with 0 and 10% CGM brownies (Table IV). Intensity of the buttery/oily descriptor was significantly lower (*P* < 0.05) for MM55 than MM50 additive without CGM. Intensity of the rancid/painty/cardboardy descriptor was significantly higher (*P* < 0.05) for the MM55 additive compared with no additive or MM50 additive with 10% CGM. MM50 and MM55 were chosen after preliminary experiments indicated they performed better than another masking agent. Earlier study of CGM from four different producers showed no large difference in composition (Wu 2001), the producer of CGM for this study was chosen because of close proximity to our location.

CONCLUSIONS

Brownies formulated with 10 and 15% substitution of flour by CGM showed no difference in sensory analysis compared with brownies without CGM. Also, flavor masking agents did not significantly affect the sensory descriptors of brownies with 0, 10, and

15% CGM. The difference in intensity of the tobacco descriptor between brownies with 15% CGM and 0 and 10% CGM was not considered of practical significance, although it was statistically significant ($P < 0.05$) because it was very low in intensity, and the higher concentration of CGM was lowest in tobacco flavor. Additives MM50 and MM55 did not change intensity of sensory descriptors of brownies, except MM55 gave a lower buttery/oily intensity than MM50 without CGM ($P < 0.05$) and MM55 gave higher rancid/painty/cardboardy intensity than MM50 with 10% CGM ($P < 0.05$). Likewise, the statistical difference between MM50 and MM55 is not considered of practical significance because no trend is apparent. It is possible a substitution of >15% flour by CGM can result in an acceptable brownie with an increased protein content.

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