Alternative Systems for Sweetening Layer Cakes Using Aspartame With and Without Fructose[1,2]

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ABSTRACT

Layer cakes sweetened with aspartame, alone or in combination with low levels of fructose, were evaluated for texture and flavor by trained sensory panels and by physical measurements. The Instron Universal Testing Machine with a specially designed attachment was used for texture evaluation of cakes. Lemon, orange, spice, and chocolate layer cakes were baked in microwave and conventional ovens. No differences in sweetness and crumb bitterness were found between orange and spice cakes; lemon cakes were considered sweeter than spice cakes and had the most bitter crust. The chocolate cakes were judged to be similar in overall eating quality, and were sweeter, more bitter, less uniform in cell structure, less tender, and drier than the other three cakes. Cakes cooked in the microwave oven were generally sweeter than conventionally cooked cakes and were rated lower for sensory tenderness and moistness. Low levels of fructose enhanced sweetness and tenderness of layer cakes sweetened with aspartame.

Aspartame, the high-potency dipeptide sweetener L-aspartyl-L-phenylalanine methyl ester, was approved for use in dry food products in July, 1981. Aspartame is said by the manufacturer to be virtually indistinguishable in taste from sugar. In previous research and sensory testing of aspartame, no one failed to perceive sweetness, and no one reported an aftertaste; some tasters indicated they preferred aspartame to sucrose (Beck 1974). Untrained tasters could not detect changes in sweetness between beverages containing either half or double concentrations of aspartame (Mazur and Ripper 1979). Baldwin and Korschgen (1979) reported an intensification of fruit flavors in orange- and cherry-flavored noncarbonated beverages containing 0.065% aspartame.

When subjected to extremes of temperature and pH, aspartame decomposes to diketopiperazine, which results in a loss of sweetness. Thus, aspartame generally is considered unsuitable in foods requiring prolonged heating (Beck 1978, McCormick 1975). Studies by the manufacturer have indicated a substantial but not total loss of sweetness in baked products prepared with aspartame (Beck 1978).

Four flavors of aspartame-sweetened cakes, each with two levels of additional aspartame or of fructose, were compared in this study. Two methods of baking using microwave and conventional ovens were evaluated for the effect their differing rates of heating have on the loss of sweetening ability of aspartame.

MATERIALS AND METHODS

Cake Preparation

Preliminary evaluations of numerous high-ratio, medium-ratio, and low-ratio cake formulations with varying egg, shortening, and leavening levels resulted in the selection of the following basic formula for the lemon, orange, and spice cakes prepared in this study. Twenty-one percent bulked aspartame (G. D. Searle), 50% hydrogenated shortening (Crisco), 8% double-acting baking powder (Calumet), 1.6% salt (Good Value brand), 60% fresh whole egg, and 110% fresh whole milk were used based on 100% soft-wheat patent flour (10.31% protein, 14% moisture basis). The aspartame was granulated and spray-dried with maltodextrin to substitute volume to volume for sugar.

Preliminary testing indicated that the same formulation was not appropriate for chocolate-flavored cakes. A formula containing fresh buttermilk rather than whole milk at a lower level (78%) and higher levels of the aspartame, salt, shortening, eggs, and leavening agents (23.5, 1.7, 66, 100, and 10%, respectively) than the formula for the other flavors gave cakes of similar overall eating quality. We added, to all formulations, the emulsifier sodium-stearoyl-2-lactylate at the 0.01% level to decrease the size of air bubbles and to improve textural quality. Xanthan gum, a hydrophilic colloid, was added at the 0.01% level to enhance water-binding ability and sweetness.

In some treatments, fructose (Sigma Chemicals), 18.5 or 25.0%, flour weight basis (fwb) (22.3 or 30.1% for chocolate cakes) was added, as Roche (1980) suggested, for reduced-calorie cakes and cake mixes. In other treatments, additional nonbulked aspartame was added at the 0.5 or 1.0% levels, fwb (0.6 or 1.2% for chocolate cakes). Lemon, orange, and spice cakes were prepared using 1% lemon extract; 2.5% fresh orange peel; or 1.4% cinnamon, 0.5% allspice, and 0.375% mace, respectively. The chocolate cakes contained 18% cocoa (Hershey's brand) and 1% vanilla for flavoring. Whenever possible, the ingredients were procured in sufficient quantities for the entire project. Oranges, eggs, whole milk, and buttermilk were obtained fresh weekly.

The preparation method is shown in Table I. During the conventional baking, the internal temperature of the cakes was recorded at 1-min intervals using a Honeywell potentiometer. Probes were positioned at the center, and at 2.54 and 3.81 cm from the center. The internal temperature of the microwave cakes at similar positions was taken 1 min after removal from the oven.

Physical Measurements

To determine pH, 25 g of batter or crumb was slurried with 100 ml of distilled water. Specific gravity of batters was determined gravimetrically, and the volume index was determined using an adaptation of AACC method 10-91 (1976) for 6-in. cakes.

A specially designed incisor and molar attachment (Prusa et al 1982) was used on the Instron Universal Testing Machine (IUTM), model 1122, to measure textural characteristics. A 0.1-kg setting (full-scale load) with a crosshead speed of 50 mm/min and a chart speed of 200 mm/min was used. Three representative 2.54-cm cubes from the top (bottom crust removed) were evaluated, and four measurements were made on each of the force-distance curves obtained for our cakes (Fig. 1).

Sensory Analysis

Cell uniformity, moistness, tenderness, sweetness, and overall eating quality were assessed using five-point descriptive-quality rating scales (with 5.0 considered highest and 1.0 considered lowest quality). Bitterness of crust and of crumb was evaluated, with 5.0 considered least bitter and 1.0 most bitter.

Sample Preparation and Presentation. Cakes were stored 18–24 hr in plastic bags at room temperature. Cubes (2.54-cm) were cut from the center of the cake, and 2.54-cm squares were cut from the

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top crust just before panel evaluation. Samples were placed on white plates coded with three-digit random numbers and covered with plastic wrap to prevent drying. Two sets of four cakes were evaluated with 15 min between sets at mid-morning and mid-afternoon sessions by two separate panels.

Panel Selection and Training. One panel consisted of five panelists, referred to as nondiabetics, who apparently were in good health and had no known carbohydrate or metabolic diseases. They were graduate students studying foods and related areas at Kansas State University. The participants for the second panel, six townspeople and students in the Manhattan, KS community who had conditions of abnormal carbohydrate metabolism such as diabetes mellitus or hypoglycemia, were selected by a series of screening tests. Those panelists were likely to be potential users of nonsucrose-sweetened cakes. In training sessions, panelists were familiarized with basic sensory techniques, basic taste sensations, characteristics of high-quality layer cakes, and the five-point descriptive rating scales used in this study.

TABLE I
Mixing Method for Cakes

Mixing Steps	Speed Setting[a]	Time (min)
Cream shortening.[b] Scrape.	7	1.0
Gradually add xanthan gum, sodium-stearoyl-2-lactylate, aspartame.[c,d] Scrape.	6	1.0
Cream the above ingredients. Scrape.	6	2.0
Gradually add egg. Scrape.	8	1.0
Cream all the ingredients. Scrape.	8	1.0
Add one third of sifted dry ingredients[e] and one third of milk[f]. Scrape.	1	0.25
Add one third of sifted dry ingredients[e] and one third of milk.[f] Scrape.	1	0.25
Add remaining ingredients. Scrape.	1	0.25
Mix all ingredients.	1	0.25
Weigh 300 g of batter into a greased and papered metal pan and bake at 350° F for 30 min. in a conventional oven.[g]		
Weigh 250 g of batter into a greased and papered glass dish and bake at full power in a microwave oven[h] for 2 min.		

[a] Hobart mixer, model K5.
[b] Orange peel, when used, added.
[c] Cocoa, when used, sifted into the sweetener mixture.
[d] Fructose, when used, premixed with sodium stearoyl-2-lactylate, xanthan gum, and aspartame.
[e] Cinnamon, allspice, and mace, when used, presifted with flour, salt, and baking powder.
[f] Lemon or vanilla extract, when used, premixed with the milk.
[g] Rotary Hearth oven, model 280C.
[h] Amana Radarange®, model RR-7DA.

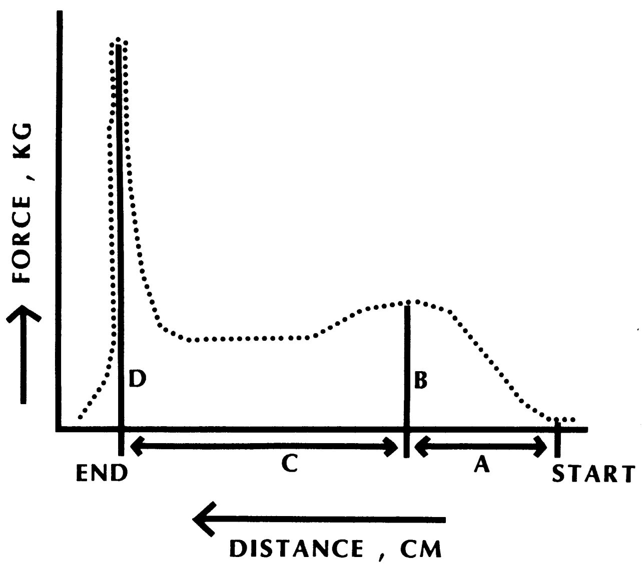

Fig. 1. Typical force-distance curve obtained by compression of nonsucrose-sweetened cakes. Scale load = 0.1 kg, crosshead speed = 50 mm/min, chart speed = 200 mm/min. The gap between upper and lower incisors was 1 mm. A, resistance of top crust and crumb during compression; B, crumb strength; C, breakdown of crumb structure related to the grain; D, maximum force exerted on cakes.

Experimental Design and Statistical Analysis

Three replications of eight treatments (four levels of sweetener—two with aspartame, and two with fructose, baked by conventional and microwave methods) for four cake flavors were compared by the two types of sensory panels using a randomized complete block design, blocked on flavor. All treatments of a flavor were evaluated randomly at the two sessions in a day. Physical measurements were compared separately. All data were analyzed using analysis of variance procedures of the Statistical Analysis System (SAS Institute 1979). Least significant differences were used for multiple mean comparison tests.

TABLE II
Comparison of Some Sensory and Physical Attributes[a] for Four Flavors of Cakes

Measurement	Cake Flavor				
	Chocolate	Lemon	Orange	Spice	LSD[b]
Sensory characteristics[c]					
Moistness[d]	2.47 a	3.15 C	3.07 bc	2.99 b	0.13
Sweetness[d]	2.57 a	2.35 b	2.31 b	2.28 b	0.07
Crumb bitterness[e]	4.00 a	4.15 b	4.20 b	4.21 b	0.07
Crust bitterness[e]	3.67 a	3.77 b	3.98 c	3.96 c	0.09
Physical measurements[c]					
Batter pH[f]	6.86	6.72	6.78	6.87	NS[h]
Crumb pH[g]	6.33 a	7.04 b	7.09 b	6.99 b	0.21
Batter specific gravity[f]	0.7586 ab	0.7703 b	0.7454 ab	0.7316 a	0.0356

[a] Mean values for three replications, eight treatments, two panels (total, 48 observations).
[b] Least significant difference: $P \leqslant 0.05$.
[c] Mean values in same row with same letter are not significantly different at $P = 0.05$.
[d] Five-point scale: 5.0 = highest, 1.0 = lowest.
[e] Five-point scale: 5.0 = lowest, 1.0 = highest.
[f] Three replications, four treatments (12 observations total).
[g] Three replications, eight treatments (24 observations total).
[h] NS = not significant.

TABLE III
Comparison of Instrumental Texture Measurements[a] for Four Flavors of Cakes

Texture Measurements[b]	Cake Flavors			
	Chocolate	Lemon	Orange	Spice
Resistance (distance to the first peak, cm)	40.32 a	38.59 a	34.11 a	27.43 b
Crumb strength (force required for first peak, kg)	194.55 a	136.71 b	132.17 bc	114.38 c
Breakdown of crumb structure (distance between the peaks, cm)	62.08 a	62.21 a	67.56 ab	74.83 b
Maximum force (force required for the final break, kg)	82.67 a	49.47 b	40.85 b	57.62 b

[a] Mean values for three replications; Instron Universal Testing Machine, model 1122. Values have been pooled for all eight treatments.
[b] Mean values in the same row with the same letter are not significantly different at $P = 0.05$. Least significant difference values are different for the measurements; ranges are 5.19–5.37, 9.43–9.64, and 27.73–28.35 for resistance and crumb strength, for breakdown of crumb structure, and for maximum force, respectively.

RESULTS AND DISCUSSION

Effect of Cake Flavor

Significant differences were found among the four flavors for the sensory characteristics of moistness, sweetness, and crumb and crust bitterness. Crumb pH and specific gravity also were significantly different for the four flavors studied. The means obtained for each of those attributes, pooled for all treatments and for panels for the sensory measurements, are shown in Table II. Chocolate cakes were not different from other cakes in overall eating quality according to analysis of variance, which confirmed our preliminary observations. Panelists found chocolate cakes different from all other cakes for sweetness and crumb and crust bitterness as well as for moistness, indicating panelists' sensitivity to the higher levels of sweetening and leavening agents and to the cocoa used in the chocolate formulation. Lemon cakes had the most bitter crust of the other flavors that had the same basic formulation, and they were rated more moist than the spice cakes.

Comparisons (Table II) of batter specific gravities for all flavors indicated spice cake batters had the lowest specific gravity, and lemon cake batters had the highest. The IUTM measurements for the four flavors are shown in Table III. Chocolate cakes were the least tender of the four flavors according to the crumb strength and maximum force required.

Flavor by treatment interactions were significant for cell uniformity, sensory tenderness, overall eating quality, and standing heights. Means are given for the flavors of each treatment for those characteristics in Table IV. Generally, conventionally baked, aspartame-sweetened chocolate cakes were judged by the panelists to be less tender than the other three flavors, which agrees with the data obtained from the IUTM. When fructose was used, the chocolate cakes were similar in tenderness to the other three flavors totally sweetened with aspartame. Few differences in tenderness for

TABLE IV
Mean Values[a] for Sensory Measurements of Overall Eating Quality, Standing Height Measurement, Tenderness, and Cell Uniformity of Layer Cakes

Treatment[b]	Cake Flavors			
	Chocolate	Lemon	Orange	Spice
		Overall Eating Quality[b]		
Conventionally-baked[c]				
0.5% Nonbulked aspartame	2.54 cde	2.25 ab	2.49 cd	2.14 a
1.0% Nonbulked aspartame	2.16 a	2.41 bc	2.51 cd	2.59 cde
18.5% Fructose	2.80 fgh	2.72 defg	2.72 defg	2.80 fgh
25.0% Fructose	2.87 gh	3.02 hi	3.13 i	2.76 efg
Microwave-baked[c]				
0.5% Nonbulked aspartame	2.49 cde	2.08 a	2.16 ab	2.16 ab
1.0% Nonbulked aspartame	2.36 bc	2.09 a	2.04 a	2.47 cd
18.5% Fructose	2.53 cdef	2.43 cd	2.45 cd	2.71 ef
25.0% Fructose	2.39 bc	2.76 f	2.63 def	2.50 cde
		Standing Heights[d]		
Conventionally-baked[c]				
0.5% Nonbulked aspartame	4.32 abc	4.11 abc	4.03 ab	4.08 ab
1.0% Nonbulked aspartame	4.01 ab	3.95 a	4.07 ab	4.15 abc
18.5% Fructose	4.37 bc	4.05 ab	4.15 abc	4.17 abc
25.0% Fructose	4.49 c	4.07 ab	4.19 abc	4.07 ab
Microwave-baked[c]				
0.5% Nonbulked aspartame	4.21 d	3.41 abc	3.55 bc	3.29 ab
1.0% Nonbulked aspartame	4.19 d	3.49 abc	3.13 a	3.37 abc
18.5% Fructose	4.31 d	3.54 abc	3.59 bc	3.55 bc
25.0% Fructose	4.34 d	3.50 abc	3.58 bc	3.76 c
		Tenderness		
Conventionally baked[c]				
0.5% Nonbulked aspartame	3.28 a	3.79 bc	3.97 cd	4.14 de
1.0% Nonbulked aspartame	3.25 a	3.64 b	4.00 cde	4.07 de
18.5% Fructose	3.63 b	4.08 de	4.17 def	3.99 cde
25.0% Fructose	3.72 b	3.98 cde	4.37 f	4.20 ef
Microwave-baked[c]				
0.5% Nonbulked aspartame	3.43 cde	3.29 bc	3.36 cd	3.06 a
1.0% Nonbulked aspartame	3.49 cde	3.37 cd	3.08 ab	3.50 cdef
18.5% Fructose	3.56 defg	3.61 efg	3.58 defg	3.70 fgh
25.0% Fructose	3.88 h	3.74 gh	3.72 fgh	3.61 efg
		Cell Uniformity		
Conventionally-baked[c]				
0.5% Nonbulked aspartame	2.64 a	3.16 bcd	3.67 g	3.09 bc
1.0% Nonbulked aspartame	2.76 a	3.55 efg	3.20 bcd	3.04 b
18.5% Fructose	2.82 a	3.38 def	3.34 cde	3.33 cd
25.0% Fructose	3.24 bcd	3.64 fg	3.37 cdef	3.44 defg
Microwave-baked[c]				
0.5% Nonbulked aspartame	3.12 ab	3.44 cd	3.26 bc	3.13 ab
1.0% Nonbulked aspartame	2.92 a	3.57 de	3.08 ab	3.53 cde
18.5% Fructose	2.94 a	3.49 cde	3.61 de	3.53 cde
25.0% Fructose	3.34 bcd	3.77 e	3.43 cd	3.48 cd

[a] Three replications, two panels (six observations total).
[b] Levels of sweetener used with chocolate-flavored cakes were 0.6 and 1.2% for aspartame and 22.3 and 30.1% for fructose.
[c] For this cake attribute by this baking method, mean values in same row or column with the same letter are not significantly different at $P = 0.05$; least significant difference values are 0.22 for tenderness and 0.28 for cell uniformity.
[d] Three replications.

the four flavors were found in the microwave-baked cakes (Table IV).

Cell uniformity (Table IV) was low for microwave- or conventionally baked chocolate cakes sweetened with aspartame or prepared with the lower of the two levels of fructose as compared to all other treatments. The cakes with the most uniform cell structure were the conventionally baked lemon and spice cakes with the high level of fructose, and orange cakes with the low level of aspartame. Microwave-baked cakes having the most uniform cells were the lemon-flavored cakes with the high level of aspartame and both levels of fructose, orange cakes with the low level of fructose, and spice cakes with the high level of aspartame or low level of fructose.

All microwave-baked chocolate cakes had significantly higher standing heights (Table IV) than the other flavors. Generally, few differences among the flavors were noted in the standing heights of conventionally baked cakes. The overall eating quality for the treatments studied was judged to be highest for the conventionally baked lemon and orange cakes sweetened with the higher level of fructose and the aspartame. Lowest overall eating quality was for those same flavors microwave-baked and sweetened totally with aspartame as well as for the microwave-baked spice cake with the lower of the two levels of additional aspartame.

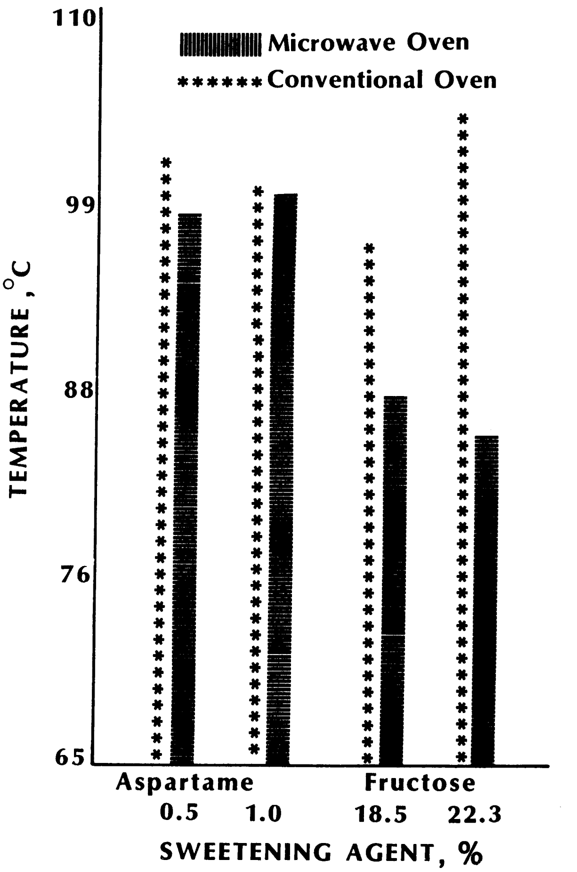

Fig. 2. Final internal temperatures of center of spice cakes prepared in microwave and conventional ovens. Similar trends were noted at other locations for each of the flavors of cakes prepared.

Effect of Preparation Treatments

Cooking Method. Microwave-cooked cakes were judged to be significantly less moist (Table V) than conventionally baked cakes. Street and Surratt (1961) and Neuzil and Baldwin (1962) also found moisture to be less when microwave cooking was used, measured both by sensory methods and by moisture losses by weight. Neuzil and Baldwin (1962) found that conventional baking produced slightly lower volume with some cakes, and Hill and Reagan (1982) found no difference in volume of yellow butter cakes baked in conventional or microwave ovens. However, in this study, standing heights were used as an index to volume and were significantly higher (Table VI) for the conventionally baked cakes compared to the microwave-cooked cakes. Microwave-baked cakes generally were less tender and had more uniform cell structure than cakes baked in a conventional oven (Table IV). Street and Surratt (1961) found that an increase in liquid level gave microwave-cooked cakes cell distribution, moisture content, and volume similar to those in conventionally baked cakes. In this study, liquid levels were not adjusted.

The microwave-cooked cakes containing either 0.5 or 1.0% aspartame were significantly sweeter (Table V) than corresponding cakes with 0.5 or 1.0% aspartame, respectively, which were baked in the conventional oven, as was expected because of the shorter time they were exposed to heat. Internal temperature of the microwave-cooked cakes was lower than for the corresponding treatments of conventionally baked cakes (Fig. 2). Cakes prepared with 25.0% fructose were evaluated as sweetest. Cakes with aspartame baked in the microwave oven were sweeter than the conventionally baked counterpart. Microwave-baked cakes also had the lowest final temperature of the cakes evaluated.

Sweetener. Panelists' scores for textural and taste characteristics generally were higher for cakes with added fructose than for those with only aspartame. Regardless of the cooking method, cakes with added fructose in all but one instance were judged more tender than similarly baked cakes with only aspartame (Table IV). Microwave-baked chocolate and lemon cakes with the highest level of fructose were evaluated similar or more tender than conventionally baked cakes with aspartame (Table V). The effects of fructose on starch gelatinization and protein gel strength contributed more than aspartame to tenderness of cakes.

Comparing cakes baked by the same method, those made with

TABLE V
Comparisons of Sensory Characteristics[a] for Conventionally and Microwave-Baked Cakes, Each with Two Levels of Additional Aspartame or Fructose

	Cake Treatment								
	Conventionally Baked				Microwave Baked				
Measurement	0.5% APM[b]	1.0% APM[b]	18.5% Fructose	25.0% Fructose	0.5% APM[b]	1.0% APM[b]	18.5% Fructose[b]	25.0% Fructose[b]	LSD[c]
Sensory characteristic[d]									
Moistness[e]	3.32 ab	3.23 a	3.32 ab	3.45 bc	2.51 d	2.58 d	2.48 d	2.51 d	0.13
Sweetness[e]	2.08 a	2.33 bc	2.30 bc	2.57 e	2.25 b	2.46 d	2.39 cd	2.65 e	0.10
Crust bitterness[f]	3.62 a	3.47 b	3.89 d	3.81 cd	3.81 cd	3.73 ac	4.29 e	4.17 e	0.14
Crumb bitterness[f]	3.99 a	3.84 b	4.33 c	4.36 c	3.98 a	3.94 ab	4.33 c	4.35 c	0.11

[a] Three replications, four flavors, two panels (24 observations total).
[b] Nonbulked aspartame; levels of sweetener were 0.6 and 1.2% for APM and 22.3 and 30.0% for fructose for chocolate cakes.
[c] Least significant difference: $P \leq 0.05$.
[d] Mean values in same row with same letter are not significantly different at $P = 0.05$.
[e] Five-point scale: 5.0 = highest, 1.0 = lowest.
[f] Five-point scale: 5.0 = lowest, 1.0 = highest.

TABLE VI
Comparisons of Physical Measurements[a] for Conventionally and Microwave-Baked Cakes, Each with Two Levels of Additional Aspartame or Fructose

Measurement	Type and Level of Sweetening Agent[b]				LSD[c]
	Nonbulked Aspartame (0.5%)	Nonbulked Aspartame (1.0%)	Fructose (18.5%)	Fructose (25.0%)	
Batter[d]					
pH batter	6.59	6.87	6.87	6.91	NS
Specific gravity	0.755 ab	0.772 b	0.743 ab	0.735 a	0.036
Microwave-baked cakes					
pH crumb[e]	6.80 b	6.96 c	7.17 d	7.15 d	0.15
Volume index, cm[f]	3.61 ab	3.54 a	3.75 bc	3.80 c	0.20
Conventionally-baked cakes					
pH crumb[e]	6.72 ab	6.62 a	6.79 b	6.73 ab	0.15
Volume index, cm[f]	4.14 d	4.05 d	4.18 d	4.21 d	0.20

[a] Three replications and four flavors (12 observations total).
[b] Levels of sweetener used for chocolate cakes were 0.6 and 1.2% for non-bulked aspartame and 22.3 and 30.0% for fructose.
[c] Least significant difference: $P \leq 0.05$.
[d] Mean values in same row with same letter are not significantly different at $P = 0.05$.
[e] Mean values in these rows for microwave and for conventionally baked cakes with same letter are not significantly different at $P = 0.05$.
[f] Mean values in these rows for microwave and for conventionally baked cakes with same letter are not significantly different at $P = 0.05$.

fructose had a less bitter ($P < 0.05$) crust and crumb than did those cakes made with aspartame (Table V). The highest level of added fructose (25.0%) gave significantly sweeter cakes. With the exception of microwave-baked chocolate cakes, cakes made with fructose and baked in either oven possessed a higher overall eating quality than did cakes made with aspartame (Table IV). Cakes containing some fructose generally had a less acidic crumb and greater volume than the cakes cooked by the same method with only aspartame (Table VI). Those differences, however, were not always significant.

None of the IUTM measurements for texture were significantly different for the treatments used in this study, with the exception of force required for the final peak. For this measurement, cakes prepared with the highest level of fructose and cakes that were conventionally baked required the least force (109.2 kg) of all cakes studied. This was significantly less $P \leq 0.05$ than for the microwave-cooked cakes made with either level of aspartame (157.8 kg and 180.5 kg for 0.5 and 1.0%, respectively) or for the lowest level of fructose (159.3 kg). Microwave-cooked cakes with the highest aspartame level required the greatest force—180.5 kg. This was significantly higher ($P \leq 0.05$) than for all conventionally baked cakes, the values of which ranged from 109.2 to 141.4 kg. Both microwave cooking and use of aspartame generally increased the force required.

CONCLUSIONS

Our results indicated that the chocolate-flavored cake formulation judged similar in overall eating quality was the lowest in textural quality and the most bitter, but was the sweetest of the four flavors of cakes evaluated. Cakes cooked by microwaves were sweeter but less tender and less moist than cakes baked in the conventional oven. Adding fructose generally improved the tenderness and cell uniformity, adding 25% fructose enhanced the sweetness of the aspartame-sweetened cakes to a greater extent than did higher levels of aspartame.

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