

Invisible Fats: Sensory Assessment of Sugar/Fat Mixtures

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Fifty normal-weight college females tasted and rated 15 stimuli resembling cake frostings and composed of sucrose (20–77% weight/weight), butter (15–35% weight/weight), polydextrose and distilled water. Sweetness intensity ratings rose as a function of sucrose levels. In contrast, ratings of fat content were only poorly related to stimulus fat. Rather, the perception of fat depended on stimulus texture and was a combined function of fat, polydextrose and water. Increasing sucrose levels suppressed fatness ratings: sweeter stimuli were judged to be lower in fat content. The finding that sugar masks the sensory assessment of fats in some solid foods may help explain why so many sweet, high-fat desserts are commonly viewed as carbohydrate-rich foods. The acceptability of the frostings was a combined function of both sucrose and fat levels. Hedonic response profiles to sucrose solutions in water predicted sensory preferences for sweet frostings containing 15% fat, but not those containing 35% fat.

INTRODUCTION

Increasing prevalence of obesity in Western societies has been linked to elevated consumption of refined sugars and fat. Nutritional surveys estimate that added sugars contribute approximately 13% of calories to the American diet, and that a further 37% of calories are derived from oils and fats (Glinsman *et al.*, 1986; Joint Nutrition Monitoring Evaluation Committee, 1986). Growing concern with nutrition and health has spurred the development of artificial sweeteners and fat replacement products, intended to minimize calories while preserving the palatability of the diet.

Laboratory studies have only recently focused on the role of fats in determining food acceptance (Drewnowski & Greenwood, 1983; Drewnowski *et al.*, 1987; Tuorila, 1987). Fats and fat-soluble molecules are responsible for the characteristic texture, flavor and aroma of many foods and play a major role in determining the overall palatability of the diet. However, it is not always clear what oral sensations contribute to the perception of fat in foods. Sensory evaluation studies of liquid dairy products have shown that the perception of fat content depends on stimulus mouthfeel and texture and to a lesser degree on olfaction (Pangborn & Dunkley, 1964; Drewnowski, 1987a). For liquid milk and cream, where fat is contained in emulsified globules, the

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principal sensory cue for fat content is stimulus smoothness, thickness or viscosity (Drewnowski, 1987a; Cooper, 1987; Mela, 1988). Accordingly, the illusion of elevated fat content can be created by gelling heavy cream (e.g. Devonshire cream) or by the use of gelatin-based stabilizers or hydrocolloid thickeners (Cooper, 1987).

The assessment of fat content in solid foods is more problematic. Fats can be an inherent part of the food itself (e.g. meat, nuts, avocados) or can be added during food processing (e.g. potato chips). Fats provide olfactory input in the form of volatile fat-soluble molecules and can endow foods with a variety of textural characteristics ranging from crispness or crunchiness to adhesiveness, creaminess or smoothness. Consequently no single textural attribute can be unambiguously associated with fat content. The General Foods Texture Profile (Brandt *et al.*, 1963) distinguished between mechanical and geometrical qualities of foods, focusing on such food attributes as hardness, adhesiveness or fracturability. In contrast, only two adjectives: oily and greasy addressed the oral perception of fat content during mastication and swallowing.

Fats in the diet are often described as "visible" or "invisible" fats (Hamilton & Whitney, 1982). Visible fats are table spreads, and salad and cooking oils, while invisible fats include meat, dairy products, and a wide range of processed foods (Schneeman, 1986). Although invisible fats may be difficult to detect by sensory means, they often play a decisive role in determining food acceptance. For example, premium quality as opposed to standard ice creams are invariably those that are high in butterfat content (16–18% as opposed to 10% weight/weight). Consumers appreciate the richness, smoothness or creaminess of the premium product, without necessarily being aware of its elevated fat content.

Indeed, the fat content of some sweet high-fat foods can be so effectively concealed that many sweet desserts are often referred to as "carbohydrate-rich" foods, despite deriving the bulk of their calories from fat. Several investigators have characterized chocolate candy, cakes, pastries and even such desserts as ice cream sundaes with whipped cream as high-carbohydrate foods (Wurtman *et al.*, 1981; Lieberman *et al.*, 1986; Chiodo & Latimer, 1986). Or course, these highly palatable items typically derive the bulk of their calories from two principal ingredients—sugar and fat (Watt & Merrill, 1975; Drewnowski, 1987b, 1988).

The pervasive belief that sweet, high-fat desserts are carbohydrate-rich foods suggests there may be difficulties in the oral assessment of fat content in some sugar/fat mixtures. In previous studies with liquid dairy products (Drewnowski & Greenwood, 1983; Mela, 1988), changes in stimulus viscosity were the principal sensory cue for elevated stimulus fat content. In contrast, when stimulus consistency was held constant by the use of solid foods (Drewnowski *et al.*, 1989), the perception of fatness was impaired, while the acceptability of high-fat stimuli remained high. It may be that under some circumstances, fats are an 'invisible' component of sweet, high-fat foods.

A further issue concerns the existence of the so-called sweet tooth. It is generally believed that taste preferences for sweet solutions are indicative of sensory preferences for sweetened solid foods (Desor *et al.*, 1975). Hedonic response profiles to sweet solutions have been linked to dietary restraint, distance from set-point, and a variety of hormonal and metabolic variables (Cabanac & Duclaux, 1970; Johnson *et al.*, 1979). The question remains whether individual responsiveness to sweet taste can tell us anything about the individual, his or her physiological or nutritional status, or the likely patterns of food selection (Mattes, 1985).

For the present study, we designed a set of stimuli resembling cake frostings that were composed of sucrose, unsalted butter, polydextrose and distilled water. Cakes,

cake frostings, frozen pastries and other desserts are usually mentioned in the literature on carbohydrate craving and in anecdotal reports of a sweet tooth (Drewnowski, 1987b). Although the sweet taste of sugar is clearly the dominant attribute of many sweet desserts, it is often fat that provides the bulk of concealed calories. The question arises whether sucrose affects the perception of fat in sweetened foods, either by making sweetness the most salient food attribute or by altering the textural characteristics of the food product. A further question is whether taste responsiveness to sweet solutions can predict sensory preferences for mixtures of sugar and fat.

METHODS

Subjects

Fifty college females were recruited by advertisements in the campus newspaper and took part in the study in return for a \$5.00 payment. The subjects were 18–24 years of age, of normal weight, non-smokers and not on medication. All subjects were weighed and measured in the laboratory. Measurements of waist, hips and mid-arm circumference were obtained in duplicate, while triceps and subscapular skinfold measures were obtained in triplicate. Subject characteristics are summarized in Table 1. The subjects' mean weight (60.3 kg) corresponded to the mean weight of 18–24-year-old females (60.7 kg) in the NHANES II data set (Najjar, 1987). Mean values of body mass index were also comparable to those in the NHANES II data (22.4 vs. 22.6). Median arm circumference (26.1 cm) equalled the median value of 26.0 cm obtained for 21-year-old females (Frisancho, 1974).

The present sample included both dieters and non-dieters as ascertained on the basis of scores on the Restraint Scale (Herman, 1978). Restraint scores ranged from 4 to 30, with a median score of 17. Eleven of 50 subjects (22%) reported dieting to lose weight at the time of the study.

Sensory Stimuli

Sensory stimuli created to resemble cake frostings were 15 different mixtures of powdered confectionery sugar, unsalted butter, polydextrose and distilled water. The function of polydextrose—a bland, partially absorbable starch polymer (Pfizer)—was to maintain stimulus consistency while permitting broad orthogonal manipulations of sucrose and fat levels. Polydextrose is reported to have no sweetness or flavor and serves as a bulking or texturizing agent, supplying appropriate texture and mouthfeel qualities normally provided by sugar and fat (Torres & Thomas, 1981; Smiles, 1982). It has been used as a partial substitute for either sugar or fat in reduced calorie food products, notably frozen desserts, puddings and cake frostings (Torres & Thomas, 1981).

The proportions of stimulus ingredients are summarized in Table 2. To prepare the frosting, butter was first creamed in a ten-speed Kitchen-Aid mixer (setting nine or ten) for 10 min. The dry ingredients were stirred and mixed together. Since polydextrose in solution has low pH, stimuli containing polydextrose also contained between 0.5 and 1.5 g of baking soda. The dry ingredients and water were alternately added to creamed

TABLE 1
Summary of subject characteristics. The data are means and standard deviations (in parentheses).

	<i>X</i>	<i>SD</i>
Age (years)	20.2	(1.7)
Height (cm)	163.8	(6.3)
Weight (kg)	60.3	(7.8)
BMI (weight/height ²)	22.4	(2.2)
Circumference measures		
Waist (cm)	67.7	(5.1)
Hip (cm)	98.0	(5.3)
Arm (cm)	26.3	(2.5)
Skinfold measures		
Triceps (mm)	19.0	(5.2)
Subscapular (mm)	12.8	(4.0)
Sum of skinfolds	31.8	(8.4)
Restraint score	16.4	(6.1)

TABLE 2
Summary of stimulus ingredients

Sample Number	Sugar	Butter	Poly-dextrose	Water	Sugar % weight/weight	Fat % weight/weight
1	200	90	150	60	40	15
2	250	90	100	60	50	15
3	300	90	50	60	60	15
4	350	90	0	60	70	15
5	350	90	0	10	77	15
6	150	150	100	100	30	25
7	200	150	75	75	40	25
8	250	150	50	50	50	25
9	300	150	0	50	60	25
10	350	150	0	0	70	25
11	100	210	75	115	20	35
12	150	210	50	90	30	35
13	200	210	50	40	40	35
14	250	210	0	40	50	35
15	300	210	0	0	60	35

butter, and the mixture was blended at low speed (setting two) until homogeneous. Finally, the frosting was whipped for 8–10 min at speed eight.

Fat content of the stimuli varied from 15 to 35% weight/weight, while sucrose levels varied from 20 to 77% weight/weight. Ingredient composition of the stimuli as compared to some commercial frostings is summarized in Figure 1. Typical commercial products are relatively high in sugar (>50% weight/weight) and contain between 15 and 25% fat weight/weight. The present 15 stimuli used three levels of fat and five levels of sucrose and spanned a wide range of possible formulations. The 3 × 5 arrangement came close to a full orthogonal design without compromising the textural integrity of the final product.

Testing Procedures

The subjects first tasted and rated four sucrose solutions in distilled water (concentration range: 2, 8, 16 and 32% weight/weight), presented at room temperature and in a random order. The subjects then tasted 15 sweet “frostings”, also presented at room temperature and in a random order. The stimuli, presented in small opaque plastic cups with lids, were not identified by the experimenters other than by code numbers. The subjects previously instructed on the standard sip-and-spit procedure tasted each numbered item in turn, expectorated each sample into a disposable carton with plastic funnel and rinsed their mouths with water. The experimenter asked the subjects to wait a minimum of 3 min between tasting successive items, and measured the interval with a stopwatch. Subjects were instructed not to swallow the stimuli in the course of tasting. In addition to rating perceived stimulus sweetness and acceptability, the subjects rated perceived fat content of the stimuli.

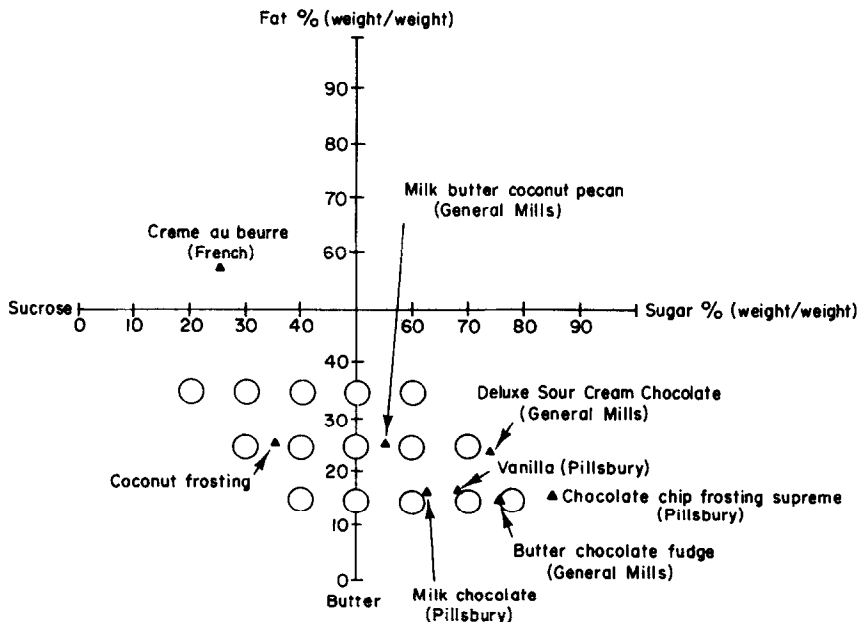


FIGURE 1. Schematic diagram showing sucrose and fat content of 15 sugar/fat stimuli (open circles) as compared to commercially available cake frostings.

For the scaling of sweetness intensity, the subjects used a unipolar nine-point category scale with extremes marked as "not at all sweet" and "extremely sweet". For the scaling of fat content, the scales were anchored at each end with "extremely low in fat" and "extremely high in fat". For the scaling of stimulus acceptability, the subjects used a standard nine-point hedonic preference scale (Peryam & Pilgrim, 1957), ranging from "dislike extremely" to "like extremely".

Data Analyses

Perceived sweetness, fat content and acceptability ratings for the 15 'frostings' were first analyzed using BMDP Anovas for repeated measures, with sucrose and fat as independent variables. Two sets of analyses were conducted: a 3×3 Anova for 15, 25 and 35% fat weight/weight and those levels of sucrose (40, 50 and 60%) that were crossed with each level of fat, and a full 3×5 Anova for the three fat levels and all five sucrose levels. Since identical results were obtained in both analyses, only data from 3×3 Anova are presented below.

The subjects' responses were also modelled using a multivariate analytical technique—the Response Surface Method (Drewnowski & Greenwood, 1983; Drewnowski *et al.*, 1987). This procedure uses empirical data to predict the shape of a three-dimensional response surface as a function of ingredient levels (Drewnowski *et al.*, 1987).

Given that the present stimulus system contained a total of four ingredients, multiple regression analyses were also used to assess the relative contributions of sucrose, butter, polydextrose and water to sweetness intensity, fat content and acceptability ratings. Although bland polydextrose was not expected to influence stimulus sweetness, its function as a bulking agent was expected to influence stimulus texture and therefore the perception of fat content. The amount of water was expected to influence the perception of sweetness through differential distribution of sucrose between the aqueous and the lipid phases of the stimulus. Finally, since polydextrose does not crystallize and has different water binding capacity from sucrose, the relative proportions of fat, polydextrose and distilled water might determine stimulus smoothness or creaminess and so affect the perception of fat content.

In the multiple regression analysis, the three dependent variables were regressed in turn on the concentrations of the four ingredients (i.e. sugar, butter, polydextrose and water). This was done separately for each of the 50 respondents, and the regression coefficients for each of these analyses were saved. Treating these regression coefficients as data, it was possible to calculate the mean coefficient for each independent variable across the 50 subjects, and to test the null hypothesis that the mean coefficient was equal to zero.

RESULTS

Sweetness and Fat Content

Sweetness intensity ratings are summarized in Figure 2 as a function of sucrose levels. Sweetness intensity scores rose sharply with increasing sucrose [$F(2, 98) = 35.03$, $p < 0.01$]. Fat also contributed to sweetness scores, and high-fat stimuli (35% fat) were

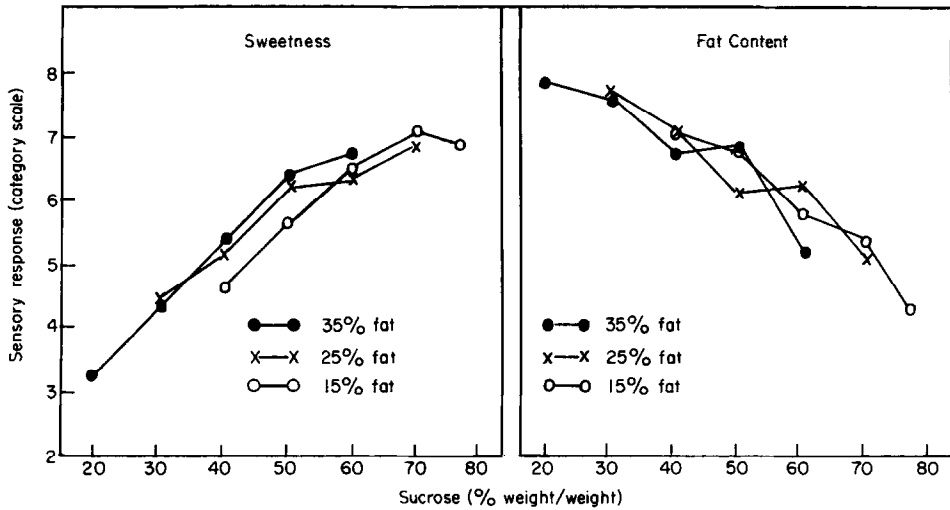


FIGURE 2. Ratings of perceived sweetness intensity (left panel) and fat content (right panel) as a function of stimulus sucrose and fat levels.

judged as sweeter. The main effect of fat was low but significant [$F(2, 98)=4.89$, $p<0.05$].

The ratings of fat content (Figure 2) demonstrate that the perception of fatness was almost independent of stimulus fat content. The main effect of fat was not significant [$F(2, 98)=1.89$]. The effect of sucrose was much stronger, and the ratings of fat content declined sharply with increasing sucrose levels (see Figure 2). The main effect of sucrose [$F(2, 98)=28.29$, $p<0.01$], and the fat by sucrose interaction [$F(4, 196)=5.15$, $p<0.01$], were both significant.

The sensory response to stimulus sweetness and fat content is better visualized through three-dimensional projections of the response surface. The subjects' evaluations were analyzed further using the Response Surface Methodology or RSM (Drewnowski & Greenwood, 1983). Data in Figure 3 show predicted values for perceived sweetness and fat content, simultaneously as a function of increasing sucrose (x -axis) and fat levels (y -axis), both expressed as log percent weight/weight.

The model preserves the key features of the data, as shown in the two panels of Figure 2 and confirmed by analyses of variance. Perceptions of sweetness (left panel) increased sharply with sucrose and to a lesser degree with fat. Perception of fatness (right panel) was virtually unaffected by stimulus fat content, but dropped sharply with increasing sucrose levels.

Acceptability of Sugar and Fat

Hedonic preference ratings are summarized in Figure 4, separately as a function of increasing sucrose (left panel) and fat levels (right panel). Stimulus acceptability increased as a function of both sucrose and fat. The main effects of sucrose [$F(2, 98)=21.54$, $p<0.01$], and fat [$F(2, 98)=13.05$, $p<0.01$], were significant, as was the fat by sucrose interaction [$F(4, 196)=2.76$, $p<0.05$].

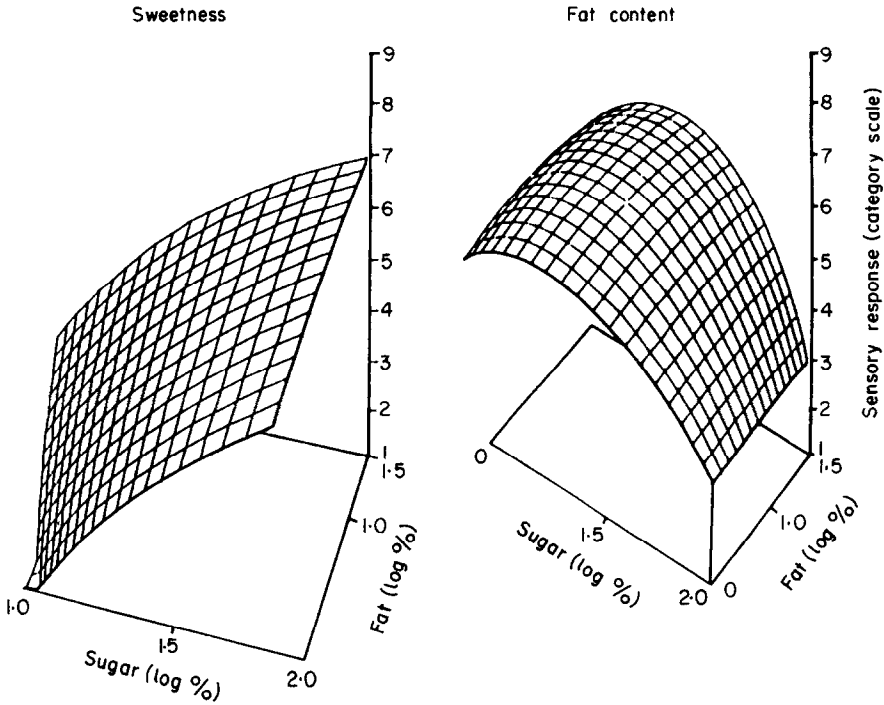


FIGURE 3. Three-dimensional projections of response surface for perceived sweetness intensity and fat content of taste stimuli as a function of sucrose and fat levels (expressed as log % weight/weight).

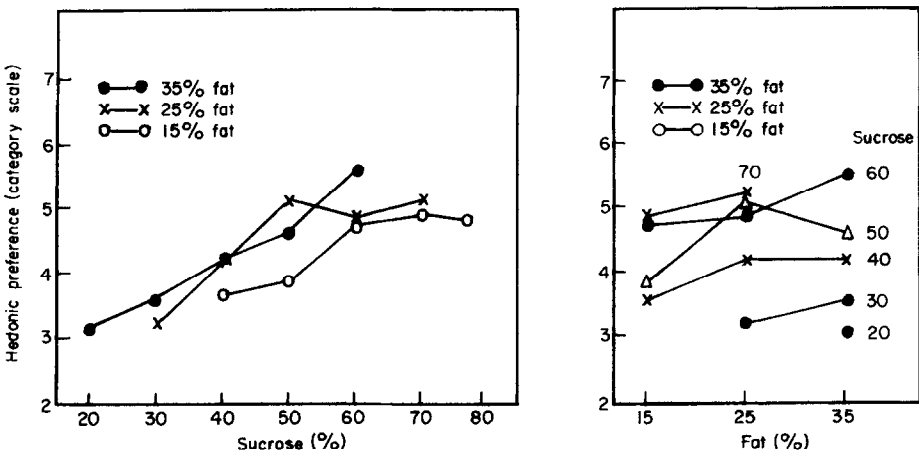


FIGURE 4. Ratings of stimulus acceptability as a function of sucrose (left panel) and fat levels (right panel).

Assessment of Fat Content

The sensation of “fatness” was influenced to a greater degree by stimulus sweetness and texture than by the actual stimulus fat content. Clearly, the assessment of fat content must be modulated to some degree by the remaining stimulus ingredients.

All four ingredients are likely to influence stimulus texture. In the present set of stimuli, polydextrose varied inversely with sucrose, so that the sweeter stimuli were generally lower in polydextrose and *vice versa*. However, it should be noted that sucrose suppressed the perception of fat content even in those stimuli that contained no polydextrose. Unlike sucrose, polydextrose does not crystallize and tends to produce smoother, taffy-like frostings. Increasing polydextrose at constant fat levels enhanced the perception of fat content as summarized in Figure 5.

The relative contributions of stimulus ingredients to sweetness, fat content and overall acceptability ratings are summarized in Table 3. For sweetness intensity scores, only the mean coefficient for sucrose was significantly different from zero. In contrast, fat, polydextrose and water all contributed to the perception of stimulus fat content: the three coefficients were all significantly different from zero. The observation that sucrose did not significantly contribute to fatness ratings suggests that reduction in perceived fat content of stimuli may be largely mediated by changes in texture rather than increased sweetness intensity of the stimuli.

Existence of Sweet Tooth

Mean hedonic preference scores for sucrose solutions in water showed the conventional breakpoint at 8% sucrose (Moskowitz *et al.*, 1974). However, it is well

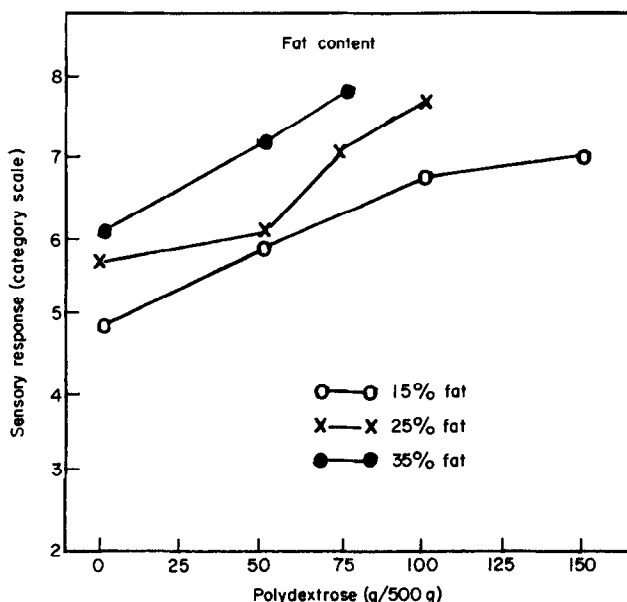


FIGURE 5. Ratings of perceived fat content as a function of polydextrose and fat levels.

TABLE 3
Results of regression analyses

Measure	Independent variables			
	Sugar	Butter	Water	Polydextrose
Sweetness				
Mean coefficient	8.07	2.38	0.32	0.46
T-statistic	2.93	0.94	0.11	0.16
Significance	<0.01	—	—	—
Fat content				
Mean coefficient	2.36	6.66	10.74	7.13
T-statistic	0.71	2.19	2.74	2.24
Significance	—	<0.03	<0.01	<0.03
Acceptability				
Mean coefficient	8.88	6.47	2.70	4.33
T-statistic	4.14	3.51	1.30	1.87
Significance	<0.01	<0.01	—	—

known that some subjects like while others dislike sucrose solutions of increasing sweetness. Following criteria previously employed by Thompson *et al.* (1976) we defined Type I response as increased preferences with increasing sweetness, while Type II response was a rise in preference followed by a decline. The 50 subjects were then separated into Type I ($n=18$) and Type II ($n=32$) respondents, as shown in Figure 6. Confirmatory Anova of hedonic preference scores showed a significant main effect of group [$F(1, 48)=22.7, p<0.01$], and a group by sucrose interaction [$F(3, 144)=27.3, p<0.01$]. Sweetness intensity ratings also showed a main effect of sucrose [$F(3, 144)=128.9, p<0.01$], as well as a main effect of subject group. Type II respondents who liked sucrose solutions less also tended to rate them as more intensely sweet [$F(1, 48)=15.6, p<0.01$].

Hedonic responsiveness to sucrose solutions in water was not linked to any of the physical variables measured. The two groups of subjects had virtually identical body weights, BMI values, and skinfold and circumference measures. Mean dietary restraint scores were 16.3 for Type I and 16.4 for Type II respondents.

Type I and II respondents did not differ in rating sweetness intensity of the 15 frostings. A 3×3 Anova of sweetness ratings showed no effect of subject group. The only main effects observed were those of sugar [$F(4, 192)=62.82, p<0.01$], and fat [$F(2, 96)=62.82; p<0.01$], and there were no group-related interactions

The two groups did differ in their acceptability ratings for the frostings, as summarized in Figure 7. Analysis of variance showed a main effect of sugar [$F(4, 192)=36.79, p<0.01$], and the expected fat by sugar interaction [$F(8, 384)=3.41, p<0.01$]. The main effect of group [$F(1, 48)=4.35, p<0.01$], and a group by sugar interaction [$F(4, 192)=2.95, p<0.05$], suggested that preferences for sweetness in water solution may predict preferences for sweet taste in another food system. In contrast, the absence of a group by fat interaction suggested that responsiveness to sweet taste does not necessarily predict preferences for food stimuli with an elevated fat content.

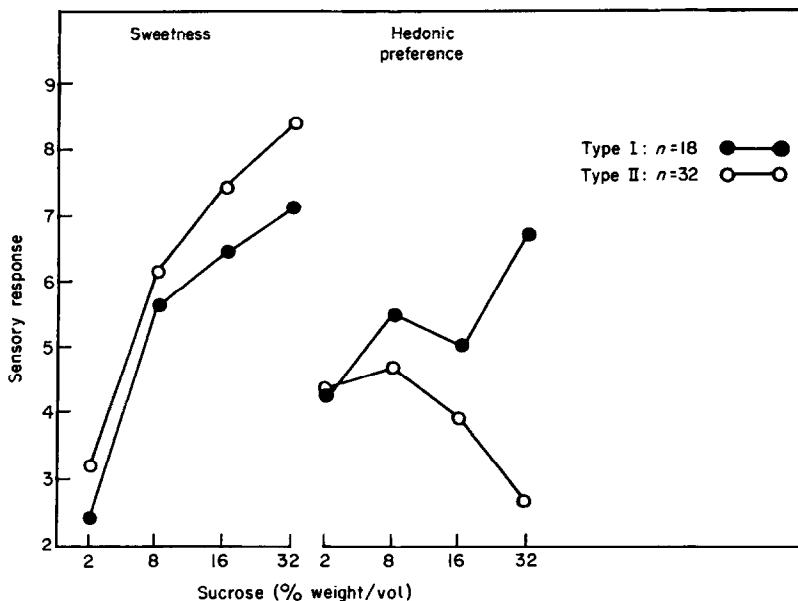


FIGURE 6. Sweetness intensity ratings (left panel) and hedonic preferences (right panel) for sucrose solutions in water. Subjects were divided into Type I ($n=18$) and Type II ($n=32$) respondents according to criteria of Thompson *et al.* (1976).

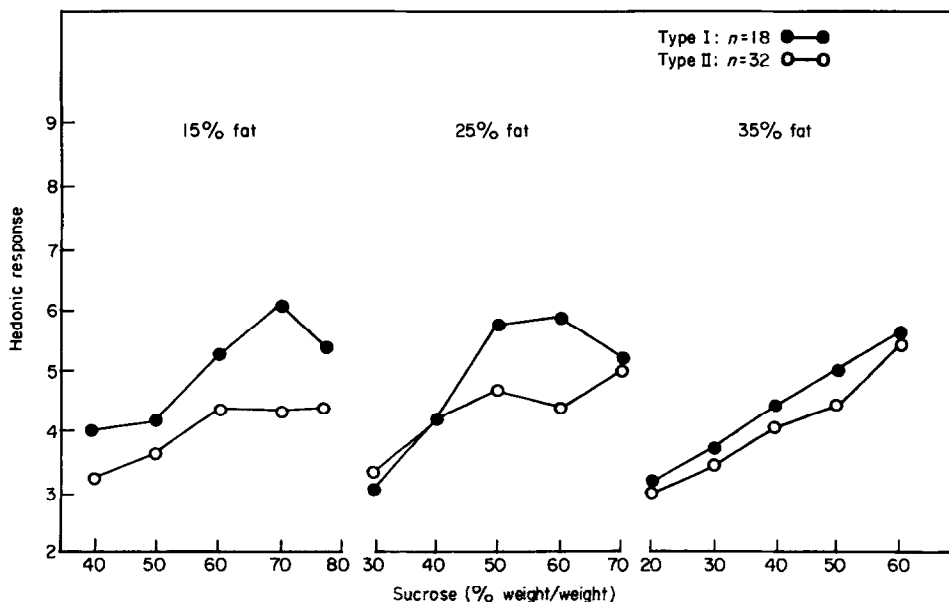


FIGURE 7. Acceptability ratings for sugar/fat stimuli for Type I and Type II respondents as a function of stimulus sucrose and fat levels.

DISCUSSION

Oral assessment of fats in solid foods was strongly influenced by stimulus texture. In the present study, the perception of fat content in frosting-like stimuli was a combined function of fat, polydextrose and water. While the perception of sweetness intensity was a direct function of sucrose levels, the perception of fatness was largely independent of stimulus fat content.

Increasing sucrose levels suppressed the oral perception of stimulus fatness. The sweetest stimuli were also perceived as lowest in fat. One hypothesis was that oral assessment of fat was masked by the increasing intensity and therefore greater salience of stimulus sweetness. However, the addition of sucrose also affected stimulus texture, removing sensory cues commonly associated with the perception of fat in foods. Specifically, the crystalline nature of sucrose makes for denser and less creamy frostings. In contrast, polydextrose, a water-soluble starch polymer does not crystallize, resulting in a smoother and more viscous product (Torres & Thomas, 1981). If the presence of fat in solid foods is assessed on the basis of stimulus texture, the sensation of fatness would be expected to be diminished by the removal of polydextrose and the addition of sucrose.

The principal sensory cues for the perception of fat in liquid dairy products are stimulus thickness, smoothness and viscosity. The illusion of increased creaminess or fat content can be achieved by adding sucrose to skim milk (Drewnowski & Greenwood, 1983), or by the addition of gels, stabilizers or thickeners to milk or heavy cream (Cooper, 1987; Mela, 1988). In contrast, the addition of sucrose to the present frostings created the illusion of reduced fat content. The sweeter and denser stimuli were perceived as lower in fat, despite the fact that the actual amount of fat remained constant. If this perceptual illusion of invisible fats can be created with a relatively simple model system of only four ingredients, many more instances of similar phenomena would be expected with real foods.

As the current literature on carbohydrate craving amply demonstrates, many sweet fat-rich desserts are persistently viewed as carbohydrate-rich foods. For example, most obese individuals (Wurtman *et al.*, 1981), some bulimics (Chiodo & Latimer, 1986) and many patients suffering from the seasonal affective disorder (Rosenthal *et al.*, 1987) have been reported to exhibit selective cravings for carbohydrate-rich snacks. Clinical observations have also listed carbohydrate craving and weight gain as side effects of treatment with tricyclic antidepressants (Paykel *et al.*, 1973; Berken *et al.*, 1984).

Carbohydrate snacks are reported to serve as a form of self-medication since they improve mood states and relieve depression and fatigue (Lieberman *et al.*, 1986). Although their sensory aspects have been dismissed as unimportant (Wurtman & Lieberman, 1987), the "carbohydrates" used in most studies were almost without exception mixtures of sugar and fat. Among the stimuli were chocolate candy, including Snickers and M&M's, chocolate cupcakes and chocolate chip cookies (Lieberman *et al.*, 1986). In other studies, cakes, frozen pastries and other desserts (Paykel *et al.*, 1973; Wurtman *et al.*, 1981) and even ice cream sundaes with whipped cream (Chiodo & Latimer, 1986) were described as carbohydrate-rich foods. Despite the fact that many of these foods derive the bulk of their calories from fat, most of the attention seems to focus on their sugar content. The present data provide a sensory rationale for this common misconception: elevated sugar content in at least some sugar/fat mixtures may mask the presence of dietary fat.

Although many subjects are unable to accurately assess the fat content of solid foods, hedonic ratings are surprisingly sensitive to stimulus fat content. Elevated preferences for fat-rich solid foods (Drewnowski *et al.*, 1989) suggest that acceptability ratings need not be analytical in nature and need not depend on conscious perception of food constituents. Preferences for high-fat foods need not be linked to conscious realization that the given food is rich in fat. In fact, consumers may select certain foods under the impression that the food has a low fat content.

The present findings have several implications for the use of fat replacements in reduced calorie food products. Among potential approaches to fat replacement are the use of casein-starch microglobules, water soluble starch polymers and non-absorbable zero calorie fats. While sensory studies have focused on the ability of such products to mimic the texture and mouthfeel of fat (Torres & Thomas, 1981; Smiles, 1982), hedonic evaluations of the final product may turn out to be even more important (Tuorila & Pangborn, 1988). It remains to be seen whether the resulting lower-calorie food products are fully acceptable to the consumer.

The final point concerns the reality of the "sweet tooth" phenomenon. The present study examined sensory responsiveness to sucrose solutions and to sugar/fat mixtures in the same group of 50 young women. The type of hedonic response to sucrose solutions (Type I or II) predicted the relative acceptability of sweet frostings containing 15% fat but not to frostings containing 35% fat.

These data are consistent with a study by Conner & Booth (1988) showing that ideal points for sugar in lime drink, tea and coffee were reliably associated with each other and with a choice of some sugared solid foods. Similarly, a recent report by Drewnowski *et al.* (1989) showed comparable levels of optimal sweetness in both liquid and solid foods. However, sensory preferences for sucrose solutions do not predict preferences for all sweet foods. Stimulus fat content may be a critical variable. In one previous study (Olson & Gemmill, 1981) children's preferences for sucrose solutions correlated with preferences for sweetened apple juice but not with preferences for sweetened peanut butter—another mixture of sugar and fat. Similarly, the present results indicate that preferences for sucrose solutions failed to predict individual preferences for sweet frostings that also contained a substantial proportion of fat.

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