Sweet taste and intake of sweet foods in normal pregnancy and pregnancy complicated by gestational diabetes mellitus

Beverly J Tepper and Annie C Seldner

ABSTRACT

Background: Dietary compliance in gestational diabetes mellitus (GDM) is poor. Changes in sweet taste perception might alter food preferences in GDM, making dietary compliance difficult to achieve. These indexes have never been studied in GDM.

Objectives: This study documented changes in sweet taste perception and dietary intakes in pregnant women with and without GDM and determined whether these differences persisted postpartum.

Design: Subjects were 30 pregnant women without GDM, 25 pregnant women with recently diagnosed GDM, and 12 nonpregnant control subjects. Pregnant women were tested at 28–32 wk gestation and retested 12 wk postpartum. Subjects evaluated the taste of strawberry-flavored milks with different sucrose (0–10%) and fat (0–10%) contents and glucose solutions (10–160 mmol/L).

Results: Women with GDM showed no differences in liking for the milk samples across test sessions and their liking ratings were not significantly different from those of nonpregnant control subjects. Women without GDM liked the 10% sucrose-sweetened milk samples less during pregnancy than at 12 wk postpartum (P ≤ 0.01), at which time their ratings were not significantly different from those of nonpregnant control subjects. In women with GDM, plasma glucose after a 50-g glucose load was correlated with both increased liking for the taste of glucose (r = 0.64, P ≤ 0.001) and higher consumption of fruit and fruit juices (r = 0.45, P ≤ 0.02).

Conclusions: Normal pregnancy was associated with a lower preference for 10% sucrose-sweetened milk samples late in gestation than postpartum, whereas GDM was associated with no such differences. Plasma glucose in women with GDM was significantly different from those of nonpregnant control subjects. Women without GDM liked the 10% sucrose-sweetened milk samples less during pregnancy than at 12 wk postpartum (P ≤ 0.01), at which time their ratings were not significantly different from those of nonpregnant control subjects.

KEY WORDS Gestational diabetes mellitus, taste, diet, pregnancy, sweetness, oral-glucose-tolerance test, women

INTRODUCTION

Gestational diabetes mellitus (GDM) is a form of carbohydrate intolerance of variable severity that is first recognized during pregnancy (1). The metabolic profile and management of GDM is similar to that of type 2 diabetes (2). GDM affects ≈4% of all pregnancies in the United States, although prevalence rates in minority populations can reach as high as 14% (3). If untreated, GDM can result in significant perinatal morbidity and mortality, including increased risk of hypoglycemia, macrosomia, and respiratory distress (4). Women with GDM have a disproportionately high risk of preeclampsia and cesarean delivery (4–6). Many women who develop GDM are obese before pregnancy and recurrence rates for GDM in subsequent pregnancies are substantially higher for these women (7). Women who have had GDM are also at greater risk of developing impaired glucose tolerance or type 2 diabetes later in life (8, 9).

Dietary strategies specifically designed for pregnant women with GDM are ill defined (10, 11). Dietary management of pregnant women with GDM is complicated by considerations for the developing fetus and there is little consensus regarding proper dietary management, particularly when the mother is obese (10, 11). Low-energy diets have been used with some success, but are controversial because of safety concerns for the developing infant (10, 11). A pregnancy complicated by GDM is highly stressful and compliance with traditional diet strategies is likely to be low (11). To be effective, nutritional interventions must consider personal food preferences and eating habits (11, 12). It is possible that women with GDM experience taste changes that could influence food preferences and make dietary compliance difficult to achieve.

It is well known that other forms of diabetes (types 1 and 2) affect taste perception, with sweet taste being the most vulnerable (see reference 13 for a review). Taste perception is reduced for certain simple sugars (eg, glucose and sucrose), which could increase the preference for sweet foods in individuals with diabetes (14, 15). Indeed, in a previous study involving subjects with type 2 diabetes, a positive correlation was obtained between liking for a sweetened fruit beverage and dietary intake of sweet foods (16). The relation between sweet taste and dietary intake has never been examined in women with GDM. Additionally, as
many as 85% of women experience food cravings during pregnancy (17), which are especially acute for sweet foods such as ice cream, cakes, pies, and fruit and fruit juices (17–20). Whether women with GDM experience more frequent or intense cravings for sweet foods than do pregnant women without GDM is not known.

The objectives of this study were to 1) examine taste perception, taste preferences, and dietary intakes in women with recently diagnosed GDM (28–32 wk gestational age) compared with those in pregnant women without GDM; and 2) retest these same women 12 wk postpartum when plasma glucose concentrations return to normal limits. Therefore, the study was designed to document changes in taste associated with GDM that are distinct from those of normal pregnancy and to determine whether these changes persist after delivery.

SUBJECTS AND METHODS

Subjects

Subjects were recruited from the Women’s Ambulatory Clinic, St Peter’s Medical Center, New Brunswick, NJ, where all women are universally screened for GDM at 24–28 wk gestation with a 50-g glucose load (1). Women with a positive result underwent a 100-g oral-glucose-tolerance test (OGTT). Blood samples were collected 1 h after the 50-g glucose load and 0, 1, 2, and 3 h after the 100-g OGTT. Those with ≥2 positive results from the OGTT received a diagnosis of GDM (1). Twenty-five women with GDM and 30 women without GDM between the ages of 18 and 42 y participated in the study. Except for GDM, all subjects were healthy and free from chronic diseases. Because insulin treatment influences taste perception (21), only women who were treated by diet alone participated. Twelve nonpregnant women attending the clinic for other reasons were recruited as control subjects to test for possible changes in taste perception due to pregnancy. All subjects gave written consent and received monetary compensation for their participation. The study was approved by the Institutional Review Boards of Rutgers University and St Peter’s Medical Center.

Taste stimuli

Many of the foods that are craved during pregnancy are both sweet and high in fat, suggesting that changes in fat preference might also be an underlying feature of food cravings during pregnancy. Increased body weight is also associated with a higher preference for fat (22, 23). Given the close association between GDM and obesity, it seemed relevant to investigate this aspect of taste perception in the target population. The taste stimuli used in this study were glucose solutions and strawberry-flavored milk mixtures that varied in sweetness and fat. Glucose solutions have been used in numerous taste studies in diabetes (13).

Strawberry-flavored milk samples were prepared by using procedures developed in this laboratory and described previously (24). The starting material was nonfat dry milk (Grand Union Co, Wayne, NJ) reconstituted with deionized water according to package directions. Nine samples were prepared by adding 0%, 5%, or 10% (wt:vol) vegetable oil (Hunt-Wesson Inc, Fullerton, CA) and 0%, 5%, or 10% (wt:vol) sucrose (Fisher Scientific, Fairlawn, NJ) to the nonfat milk. Strawberry flavor (0.2–0.4% Bell Flavors & Fragrances Inc, Northbrook, IL) and red food coloring (0.3 mL; McCormick & Co, Inc, Hunt Valley, MD) were added to enhance acceptability. The samples were mixed in a blender until homogenized. Previous studies showed that these samples are well suited for sensory testing because they are visually similar but perceptually different in flavor and texture (24). Five glucose solutions (10–160 mmol/L) were prepared by dissolving dextrose (Fisher Scientific) in deionized water. All taste stimuli were prepared on the day before use and stored at 5°C.

Taste ballots

The strawberry-flavored milk samples were evaluated for sweetness, creaminess, and overall flavor by using 9-point category scales. The category scales had end anchors of 1 (none) and 9 (very strong) for intensity and 1 (dislike extremely) and 9 (like extremely) for liking. Intensity of sweetness and liking of glucose solutions were rated by using 15-cm line scales with end anchors of 0 (no sweetness) and 15 (very sweet) and 0 (dislike extremely) and 15 (like extremely). Glucose solutions were evaluated with line scales because taste perception changes in diabetes generally occur when the glucose concentration of the solution is low and line scales are more likely to capture these subtle effects than are category scales.

Dietary questionnaires

Subjects completed a 1-d dietary recall, a 141-item food-frequency questionnaire (25), and a food-craving questionnaire (26). The food-frequency questionnaire was developed previously in our laboratory and was used in a previous study (25). Estimated energy intakes calculated from the food-frequency questionnaire were validated against those obtained from 3-d diet records (r = 0.87, P ≤ 0.01; BJ Tepper, unpublished observations, 1996). The food-craving questionnaire asked subjects to list the types of foods craved and the frequency of the craving (cravings/mo). An experienced dietitian assisted with the dietary recall and reviewed all questionnaires with the subjects probing for inaccurate and omitted responses. Foods specific to the Hispanic culture were added to the food-frequency questionnaire and all ballots and questionnaires were translated into Spanish for Spanish-speaking subjects.

Body weight

Body mass index (BMI; in kg/m²) was calculated by using heights and weights obtained from the medical charts and measured at 28 wk of pregnancy and 12 wk postpartum. Prepregnancy body weights were self reported.

Procedures

Pregnant subjects were recruited into the study as soon as their GDM status was known. Every effort was made to test subjects with GDM before dietary counseling was initiated. Subjects completed 2 tasting sessions during the prenatal period (28–32 wk gestation) and 2 sessions at 12 wk postpartum. The postpartum test sessions were a repeat of the initial protocol. The control group did not repeat the protocol.

During session 1, subjects tasted and rated the strawberry-flavored milk samples, completed the food-cravings questionnaires, and the dietary recalls. During session 2, they evaluated the glucose solutions and completed the food-frequency questionnaires. Twenty milliliters of the samples were presented in soufflé cups labeled with 3-digit code numbers and served to the subjects in a random order. Subjects were asked to refrain from eating or drinking for 1 h before testing.
TABLE 1
Characteristics of women with and without gestational diabetes mellitus (GDM)

<table>
<thead>
<tr>
<th></th>
<th>With GDM</th>
<th>Without GDM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number pregnant</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>Number postpartum</td>
<td>18</td>
<td>22</td>
</tr>
<tr>
<td>Number breastfeeding</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Age (y)</td>
<td>28.7 ± 1.0</td>
<td>24.9 ± 1.0</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td></td>
<td></td>
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<tr>
<td>Prepregnancy</td>
<td>27.3 ± 0.8</td>
<td>24.6 ± 0.7</td>
</tr>
<tr>
<td>28 wk gestation</td>
<td>30.7 ± 0.9</td>
<td>27.8 ± 0.8</td>
</tr>
<tr>
<td>12 wk postpartum</td>
<td>28.9 ± 1.1</td>
<td>26.0 ± 1.0</td>
</tr>
<tr>
<td>Pregnancy weight gain (kg)</td>
<td>14.8 ± 1.0</td>
<td>16.7 ± 0.9</td>
</tr>
<tr>
<td>Plasma glucose (mmol/L)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50-g Glucose screening</td>
<td>10.0 ± 0.2</td>
<td>6.5 ± 0.2</td>
</tr>
<tr>
<td>Oral-glucose-tolerance test</td>
<td></td>
<td></td>
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<tr>
<td>Fasting</td>
<td>5.5 ± 0.1</td>
<td></td>
</tr>
<tr>
<td>1 h</td>
<td>10.6 ± 0.6</td>
<td></td>
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<tr>
<td>2 h</td>
<td>9.1 ± 0.4</td>
<td></td>
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<tr>
<td>3 h</td>
<td>8.1 ± 0.3</td>
<td></td>
</tr>
<tr>
<td>Ethnicity (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>28</td>
<td>44</td>
</tr>
<tr>
<td>Black</td>
<td>20</td>
<td>23</td>
</tr>
<tr>
<td>Hispanic</td>
<td>32</td>
<td>23</td>
</tr>
<tr>
<td>Asian</td>
<td>20</td>
<td>10</td>
</tr>
</tbody>
</table>

*P < 0.01, ‡P < 0.05, †P < 0.001.

Statistical analysis

Taste data were analyzed by using two-factor analysis of variance (ANOVA) for diabetes status (GDM or no GDM) and pregnancy status (pregnant, postpartum, or nonpregnant control subject). Initially, a repeated-measures design was used to assess the effects of increasing sucrose and fat concentrations on the liking ratings of strawberry-flavored milk. Because no interactions were observed between sucrose or fat contents and diabetes or pregnancy status, data were averaged across fat concentrations and separate analyses were performed on the 0%, 5%, and 10% sucrose-containing samples. A total of 9 ANOVAs were performed for intensity of strawberry-flavored milk, 1 for each of the 3 attributes (creaminess, sweetness, and flavor) at 0%, 5%, and 10% sucrose contents. A similar set of analyses was performed on the liking ratings. Data for the glucose solutions were averaged across concentrations and 2 ANOVAs were performed (1 for intensity and 1 for liking). Post hoc comparisons were made by using the least-significant-difference test when main effects or their interactions were statistically significant.

Dietary-recall data were analyzed by using NUTRITIONIST IV software (N-Squared Computing, Salem, OR) for total energy and percentages of energy from carbohydrate, protein, and fat. Consumption of simple sugars (the sum of fructose, sucrose, glucose, and maltose in grams) was examined as a percentage of energy intake and as a percentage of total carbohydrate intake. Foods from the food-frequency questionnaire were grouped into the following categories: bread, noodles, and grains; fruit and fruit juices; vegetables; dairy products; meats; combination oils; salty snacks; desserts; and dietetic foods. The frequency of consumption (servings/d) of each food group was calculated. A two-factor ANOVA design (GDM and pregnancy) was also used to examine group differences in the dietary variables. Because control subjects did not provide dietary data, this group was not included in these analyses.

Relations between plasma glucose concentrations and selected taste and diet measures were analyzed by using the Pearson product-moment correlation coefficient. Correlations were performed by using the following variables: plasma glucose during the 50-g glucose screening (for all pregnant subjects); fasting and 1-, 2-, and 3-h plasma glucose concentrations during the 100-g OGTT (GDM subjects only); mean liking ratings for the glucose solutions and strawberry-flavored milk; daily consumption of fruit and fruit juices and desserts. None of the correlations involving taste ratings for the strawberry-flavored milk samples or desserts were significant and are not reported. Statistical analyses were conducted by using SAS (version 6.09; SAS Institute Inc, Cary, NC) and P values ≤ 0.05 with all tests were considered significant.

RESULTS

Subject characteristics

Eighteen of the 25 women with GDM and 22 of the 30 women without GDM were available for postpartum testing and completed all test sessions. Subject characteristics are shown in Table 1. Women with GDM were 3.8 y older and had a significantly higher prepregnancy BMI than women without GDM. Total weight gain during pregnancy was not significantly different between the 2 groups. However, weight gain in women with GDM exceeded that recommended for women with a prepregnancy BMI ≥ 26 (27). Women with GDM also maintained a higher postpartum BMI than did women without GDM. A greater proportion of women with GDM (56% compared with 23%) breast-fed their infants (P < 0.05).

As expected, women with GDM had significantly higher plasma glucose concentrations after the 50-g glucose screening than did women without GDM. Plasma glucose concentrations measured during the OGTT were elevated in women with GDM on the basis of standard diagnostic criteria (1). During the postpartum period, glucose tolerance in women with GDM returned to normal limits, ie, a plasma glucose concentration of 7.5 ± 0.1 mmol/L 2 h after a 75-glucose load (1). Lastly, a greater proportion of the women with GDM (72%) than those without GDM (56%) were from minority groups. In general, participants in the present study had characteristics typical of women with GDM, ie, those characteristics mentioned above (3).

Taste ratings

Strawberry-flavored milk

Liking ratings for sweetness, creaminess, and overall flavor in strawberry-flavored milk are shown in Figure 1. Data were averaged across fat concentrations and are shown separately for the 0%, 5% and 10% sucrose-sweetened samples. Results showed a significant interaction between pregnancy and GDM for liking of creaminess in 5% sucrose-sweetened strawberry-flavored milk and liking of sweetness, creaminess, and overall flavor in 10% sucrose-sweetened strawberry-flavored milk. These differences were due to the finding that women without GDM liked these samples significantly less during pregnancy than they did during the postpartum period. After delivery, liking ratings of women without GDM were not significantly different from those of nonpregnant control subjects. One exception to this finding was noted: women
without GDM liked the creaminess of 10% sucrose-sweetened milk significantly more during the postpartum period than did nonpregnant control subjects. In contrast, there were no significant differences in liking ratings for the strawberry-flavored milks in women with GDM when tested during pregnancy and postpartum, and these ratings at both test periods were not significantly different from those of nonpregnant control subjects. Comparisons between the 2 groups of pregnant women showed that women without GDM liked the sweetness, creaminess, and overall flavor of the 10% sucrose sample less during pregnancy than during the postpartum period. Means with different lowercase letters are significantly different, $P \leq 0.05$ (least-significant-difference test).

Intensity ratings for the milk samples showed the same general pattern as for the liking ratings. However, the only significant difference was in women without GDM, who perceived a lower overall flavor intensity in the 10% sucrose-sweetened milks during pregnancy than they did postpartum (GDM × pregnancy interaction: $P \leq 0.01$, ANOVA; subsequent post hoc test: $P \leq 0.05$) (data not shown).

Glucose solutions

Liking and intensity ratings for sweetness in the glucose solutions are shown in Figure 2. Neither pregnancy nor having GDM influenced the liking ratings, although there was a trend for women with GDM to like glucose more before delivery than after delivery. All pregnant women tended to give lower sweetness intensity ratings to the glucose solutions than did nonpregnant control subjects, but this difference was not significant ($P \leq 0.06$).

Dietary intake

Estimated dietary intakes calculated from the 24-h dietary recalls of women with and without GDM are shown in Table 2. All subjects reportedly consumed significantly more energy dur-
ing pregnancy than postpartum. However, women with GDM reported that they consumed significantly less energy during gestation than did women without GDM. After delivery, women with GDM consumed a significantly higher percentage of their carbohydrate intake from dietary sugars than did women without GDM. A similar trend, although not significant, was observed for intake of carbohydrate as a percentage of energy intake.

Analysis of the food-frequency questionnaires showed that all pregnant women reportedly consumed more breads, noodles, and grains than they did after delivery (6.2 ± 0.5 compared with 4.5 ± 0.6 servings/d; P ≤ 0.003) and more fruit and fruit juices than they did after delivery (3.9 ± 0.4 compared with 2.5 ± 0.3 servings/d; P ≤ 0.004). Pregnant women with GDM also reported consuming significantly fewer desserts (0.6 ± 0.1 servings/d) than did pregnant women without GDM (1.2 ± 0.1 servings/d): GDM × pregnancy interaction, P ≤ 0.002. No other significant differences in food choice were noted between pregnant women with or without GDM.

There were no significant group differences in the types or amounts of foods craved by women during pregnancy. During pregnancy, the most frequently craved foods were fruit and fruit juices (17.6 ± 9.3 times/mo); desserts (13.0 ± 4.5 times/mo); breads, noodles, and grains (10.8 ± 5.8 times/mo); salty snacks (10.1 ± 4.3 times/mo); ice (8.1 ± 5.6 times/mo); and seafood (6.7 ± 3.9 times/mo). There was a trend for salty snacks to be craved more during pregnancy than during the postpartum period (P ≤ 0.09).

Relations between plasma glucose and taste perception and dietary measures

As illustrated in Figure 3, women with GDM showed a positive correlation between plasma glucose measured 1 h after the 50-g glucose screening and I) the overall mean hedonic ratings of the glucose solutions (r = 0.64, P ≤ 0.001) and 2) daily servings of fruit and fruit juices (r = 0.45, P ≤ 0.02). Four women with more severe GDM (plasma glucose concentration > 10 mmol/L) subsequently received insulin to control their disease. Liking ratings for glucose were twice as high in these women (10.8 ± 1.3) than in the rest of the women with GDM (5.3 ± 0.8). In addition, consumption of fruit and fruit juices was marginally higher in these women (4.5 ± 0.9 servings/d) than in the rest of the women with GDM (3.2 ± 0.8 servings/d). No positive correlations involving these measures were observed in women without GDM (r = 0.09 and 0.02, NS). Additionally, no positive correlations were observed between plasma glucose at any time point during the OGTT and liking of the glucose solutions or daily consumption of fruit and fruit juices (r = 0.13–0.30, NS; data not shown). However, several women with severe GDM on the basis of the 50-g glucose screening did not undergo the 100-g OGTT and therefore were not included in these analyses.

DISCUSSION

The purpose of this study was to investigate changes in taste perception and dietary indexes in women with and without GDM and to determine whether these changes persisted after delivery. Contrary to expectations, women with GDM showed no differences in liking for sucrose-sweetened milk samples when their pregnancy ratings were compared with their postpartum ratings. In addition, postpartum ratings of women with GDM were not significantly different from those of a separate group of nonpregnant control subjects. In contrast, women without GDM liked the 10% sucrose-sweetened samples less during pregnancy than they did 12 wk postpartum, at which time their ratings were not significantly different from those of nonpregnant control subjects. Thus, differences observed between women with and without GDM during pregnancy were due to the finding that women without GDM liked the 10% sucrose-sweetened milk samples less than did women with GDM. These observations suggest that pregnancy and GDM may have complex effects on preferences for sweet high-fat foods that are not yet well understood. The findings in women without GDM indicate that these women have fewer cravings for sweet foods during the third trimester of pregnancy than during the second trimester (17) and a lower preference for sweet foods (determined under laboratory conditions) during late pregnancy than during early pregnancy (20).

The present study also found no effect of GDM on taste intensity ratings or liking of glucose solutions. These results contrast with those of previous studies that reported impaired sweet taste perception in subjects with type 1 and type 2 diabetes (13–15). It is unlikely that these other forms of diabetes are associated with changes in sweet taste perception, but GDM was shown not to be associated with such changes. The more likely explanation is that the present study used a line scale to assess sweetness perception in the weak-to-moderate range (ie, at concentrations that might reasonably be found in food), whereas most other studies used threshold testing methods (13–15). Threshold methods are useful for defining small differences in perception at barely detectable concentrations, but have little relevance for predicting food preferences and dietary behavior (28).
Correlation analyses indicated important relations between glycemic status in women with GDM and their taste perception and dietary behavior. Plasma glucose concentrations 1 h after the 50-g glucose screening in women with GDM were positively related to increased liking for the taste of glucose and also to higher consumption of predominantly sweet foods such as fruit and fruit juices (Figure 3). Four women with GDM who subsequently received insulin to control their disease were among those with the highest liking ratings for the taste of glucose and the highest intake of fruit and fruit juices. These results agree with the findings of our previous study in individuals with type 2 diabetes (16) in which an increased liking of a sucrose-sweetened fruit beverage was related to higher dietary intakes of sweet foods in individuals with diabetes, but not in control subjects. Together, the results of these studies suggest that a high preference for a sweet taste could serve as a convenient marker for GDM. Further examination of this potentially important relation seems warranted.

None of the plasma glucose values obtained during the OGTT were correlated with the taste perception or diet measures. However, GDM was diagnosed on the basis of a glucose screening alone (ie, no OGTT was conducted) in several women with GDM (16) in which an increased liking of a sucrose-sweetened fruit beverage was related to higher dietary intakes of sweet foods in individuals with diabetes, but not in control subjects. Together, the results of these studies suggest that a high preference for a sweet taste could serve as a convenient marker for GDM. Further examination of this potentially important relation seems warranted.

Food cravings are a common feature of pregnancy (17–20) and are reported to be most frequent and intense during the second trimester and to decline thereafter (17). Sweet foods are generally preferred during the second trimester, whereas salty foods are preferred during the third trimester (20). Surprisingly, the frequency of cravings was similar in women with GDM (52%) and women without GDM (57%). This frequency was somewhat lower than anticipated in women with GDM, but might reflect the general decline in food cravings observed during late pregnancy (17, 20). The types of foods craved included fruit and fruit juices; pastries; breads, noodles, and grains; salty snacks; ice; and seafood, and were similar to those reported previously (17–20). 

Pregnant women attending the Women’s Ambulatory Clinic are generally prescribed a diet providing 8.4–10.0 MJ (2000–2400 kcal). Although reported energy intakes in women with GDM were slightly below this range, maternal weight gain exceeded the guidelines of the National Academy of Sciences (ie, 7–11.5 kg) for women with a prepregnancy BMI of 26–29 (27). However, none of the women with GDM developed obstetric or perinatal complications and most (84%) successfully controlled their disease by diet alone. On the basis of these general criteria, compliance was satisfactory among women with GDM.

The present study had several limitations. First, more women with GDM were from minority groups and ethnic differences could have contributed to group differences in food cravings, food consumption frequency, dietary intakes, and liking responses (29). Nevertheless, when minority women with GDM (n = 18) were compared with white women with GDM (n = 7), no reliable differences in taste perception ratings or food consumption were found (data not shown). Perhaps our subject population was too small to reliably capture these differences. Second, we used a 1-d dietary recall to assess dietary intake to minimize the burden on subjects. Longer assessment periods provide better estimates of dietary intake (30) and will be necessary to confirm the present findings. The extent to which subjects might have underreported their food intake is unknown (31). We are aware of no other dietary studies of women with GDM in which no dietary manipulations were used. Third, the women with GDM were overweight before pregnancy, which is typical of women with this disease (3). Because preferences for high-fat foods are positively related to body weight (23), it is unclear whether the present results reflect the effects of GDM, increased adiposity, or the interaction of these variables. This confounding factor needs to be considered in future studies. Last, exogenous insulin is thought to influence taste perception (21). Thus, women with GDM who were being treated with insulin at the time of the study were prohibited from participating. Because insulin treatment is recommended for diabetic women with severe symptoms or for those who cannot control their disease by diet alone (10), it would be important to include these women in future investigations.

In summary, we found that normal pregnant women liked 10% sucrose-sweetened milks less during the third trimester than they did postpartum, at which time liking was not significantly different from that of nonpregnant control subjects. No significant differences were observed in women with GDM. In women with GDM, the higher the plasma glucose concentration after the 50-g glucose screening, the higher the liking ratings for glucose and

TABLE 2
Dietary intakes of women with and without gestational diabetes mellitus (GDM) during pregnancy and postpartum based on a 1-d dietary recall

<table>
<thead>
<tr>
<th></th>
<th>With GDM</th>
<th>Without GDM</th>
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<tbody>
<tr>
<td></td>
<td>Pregnancy (n = 25)</td>
<td>Postpartum (n = 18)</td>
</tr>
<tr>
<td>Energy (kJ/d)</td>
<td>7937 ± 334–3</td>
<td>6933 ± 398</td>
</tr>
<tr>
<td>Protein (% of energy)</td>
<td>19.1</td>
<td>17.9 ± 1.0</td>
</tr>
<tr>
<td>Fat (% of energy)</td>
<td>26.8 ± 1.7</td>
<td>30.1 ± 2.0</td>
</tr>
<tr>
<td>Carbohydrate (% of energy)</td>
<td>54.0 ± 1.9</td>
<td>51.6 ± 2.3</td>
</tr>
<tr>
<td>Simple sugars (% of energy)</td>
<td>16.5 ± 1.1</td>
<td>19.8 ± 1.9</td>
</tr>
<tr>
<td>Simple sugars (% of carbohydrate)</td>
<td>31.2 ± 2.8</td>
<td>38.5 ± 3.3</td>
</tr>
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</table>

1± SEM.
2Significantly different from women without GDM during pregnancy (GDM × pregnancy interaction: P ≤ 0.0001, ANOVA; subsequent post hoc test: P ≤ 0.05).
3Significantly different from postpartum, P ≤ 0.0001.
4Simple sugars include fructose, sucrose, glucose, and maltose.
5Significantly different from women with GDM postpartum (GDM × pregnancy interaction: P ≤ 0.02, ANOVA; subsequent post hoc test: P ≤ 0.05).
the higher the consumption of simple sugars as fruit and fruit juices. The mechanisms responsible for these findings are not well understood and invite future investigation. For example, the gestational hormones estrogen and progesterone are thought to play a role in sweet taste (32, 33) and short-term appetite regulation (34) and may be involved in taste changes during pregnancy. Taste changes in GDM could reflect either direct or indirect effects of impaired glucose homeostasis or lipid metabolism (35). A direct effect of glucose on taste cells or pancreatic β-cells has been proposed as a possible mechanism for taste perception changes in other types of diabetes in humans (13) and the db/db mouse (36). Finally, the present observations have important clinical implications. Dietary guidelines for individuals with diabetes are designed for nonpregnant populations and may not be optimal for pregnant women (37). Current guidelines allow flexibility in the consumption of carbohydrates on the basis of individual needs and treatment objectives (ie, 80–90% of total energy from carbohydrate and fat with no specific restriction on simple sugars) (2). Our data suggest that some women with GDM may experience difficulty avoiding sweet foods, which could compromise their glycemlc control and undermine their weight-management goals. More restrictive diets may be warranted in these cases. There is a critical need for more data relating taste perception and dietary indexes to methods for managing normal pregnancies and to treatment outcomes in pregnancy complicated by GDM. The present observations serve as a starting point for addressing these objectives.

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