

# Taste, Enjoyment, and Desire of Flavors Change After Sleeve Gastrectomy-Short Term Results

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## Abstract

**Background** Laparoscopic sleeve gastrectomy (LSG) incidence continues to increase worldwide because of its efficacy and low surgical risks. This study aimed to investigate satisfaction with eating and the change in taste perception, desire, and enjoyment of flavor changes and associations with extent of percentage excess weight loss (%excess weight loss (EWL)) post-LSG.

**Methods** One hundred six participants completed an online questionnaire 4 to 6 weeks as well as 6 to 8 months post-LSG bariatric surgery. The questionnaire included study-specific questions about changes in taste, desire, and enjoyment of eight major categories of flavor, as well as the Suter Quality of Alimentation Questionnaire to measure satisfaction with eating.

**Results** The majority of participants reported a post-surgery increase in the intensity of the flavor of sweet (60, 55%) and fatty (57, 70%) at both time points, respectively. Participants also reported a decreased enjoyment for sweet (77, 61%) and

fatty (77, 83%) flavors and decreased desire for fatty (83, 84%) and sweet (82, 68%) flavors at both time periods. This study found an increase in intensity of flavor of all eight taste modalities and a decrease in desire and enjoyment of all taste modalities except salty and savory flavors following surgery. Participants reported an increased acuity of spicy flavors and fatty tastes over time, and the desire and enjoyment of sweet, bitter, and metallic flavors increased over time. Changes in savory enjoyment over a 6- to 8-month period post-LSG were weakly associated with extent of % EWL at 6 months post-surgery. The participants reported average (40, 37%), good (33, 42%), and excellent (15, 11%) satisfaction with eating at both time points.

**Conclusion** This preliminary study indicates that subjective changes in taste, desire, and enjoyment of flavors of eight taste modalities are very common after LSG.

**Keywords** Sleeve gastrectomy · Taste changes · Satisfaction with eating · Flavor · Desire · Enjoyment

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Laparoscopic sleeve gastrectomy (LSG) is a restrictive single-stage procedure and is relatively new in the field of bariatric surgery but has already proven its efficacy in weight loss with low surgical risks [1]. Success is generally defined as an initial loss >50% of excess weight loss (EWL) over 12–24 months [2]. Many authors have reported that LSG produces an excess weight loss of 50 and 63% on average by 6 and 12 months post-operatively and the majority of the weight loss after LSG takes place during the first 6 months post-surgery [3, 4]. Success in maintaining weight loss after bariatric surgery requires the ability to implement long-term changes in eating habits [4]. However, patient-reported outcome measures in the LSG patient cohort, such as taste changes and satisfaction with eating that may impact on food preferences and, thus, long-

term weight loss, have received little attention in the literature. Studies in Roux-en-Y gastric bypass (RYGB) have indicated that patient-reported outcomes such as subjective changes in appetite, taste, and smell are very common after RYGB [5]. Moreover, in a study of 110 RYGB patients, majority of the patients believed that taste is important to the enjoyment of food, and RYGB patients (82%) reported a change in the taste of food or beverages after surgery [6]. Further, most patients (83% of RYGB) agreed that the loss of taste resulted in better weight loss outcome and those who experienced food aversions had more post-operative weight loss compared to their counterparts without such dislikes [6].

Taste is an important factor governing eating behavior as it contributes to food preference, and it is thought that it can modulate appetite and caloric intake [7]. Taste-related food reward has been separated into the psychological and neural components of liking (enjoyment), wanting (desire), and learning [7]. Patients struggling with obesity report higher hedonic hunger and higher enjoyment for sweetness and fatty tastes compared with normal weight subjects [8]. In contrast, very little is known of any relations between the perception of savory tastes and obesity and eating behavior [9]. However, patients post-RYGB have a preference for low-fat and low-sweet foods and report finding specific types of food less enjoyable. These changes in RYGB in food preferences and taste perception have been strongly attributed to changes in taste and hedonic enjoyment [10]. In a recent qualitative study, the participants reported an inability to experience satisfaction with eating behaviors post-revisional bariatric surgery due to taste changes which, in turn, increased their negative affect and perpetuated the maladaptive eating cycle [11]. A pilot study ( $n = 15$ ) assessed food preference changes before and 6 weeks after vertical sleeve gastrectomy (VSG) and concluded that VSG reduced preference for calorie-dense foods high in sugar, sugar, and complex carbohydrate and that the changes may contribute to weight loss with VSG [12]. Limited published data however exist on food preferences, hedonic enjoyment, and taste changes in LSG patients.

The aim of this study was therefore to investigate the patient-reported outcomes of changes in taste, enjoyment, and desire of foods following LSG (at 4 to 6 weeks and at 6 to 8 months) and to examine the impact of these changes on the early weight loss trajectory over a 6- to 8-month post-LSG follow-up period. It is hypothesized that the perception of taste, desire, and enjoyment of flavors will change and may be associated with the extent of % EWL at 6 months post-LSG. Further, it is expected that the changes over a 6- to 8-month period to the taste, desire, and enjoyment of flavors are associated with extent of % EWL. A secondary aim was to examine quality of alimentation, in particular satisfaction with eating, as it is hypothesized that the perception of taste and desire of flavors at 6 to 8 months post-surgery are related to quality of alimentation.

## Methods

The dietitians, nurses, or surgeons at four bariatric clinics gave information leaflets to patients during 2014, if they were older than 18 years and were considering a primary bariatric procedure. Participants who were interested in the study contacted the researcher, had the study explained to them, and were then emailed the URL for the online questionnaires to complete it in their own time. The same participants were contacted 6 months later to complete the second set of questionnaires. Participants were mailed an AU \$20 movie voucher after the completion of both questionnaires as a token of appreciation for their participation. Although 132 participants initially took part in the study, 114 participants completed the survey at both times. Eight participants were excluded as they had primary laparoscopic adjustable gastric band (LAGB) or RYGB. These participants were excluded to ensure all participants underwent the same bariatric procedure given the differences in the mechanisms of the bariatric procedures and the differences in the rate of weight loss.

## Measures

Self-reported details, including age, sex, height, pre-operative weight, type of surgery, occupation, marital status, and level of education, were obtained. Participants consented to self-report their weight in kilograms (kg) at 6 months post-surgery. Body mass index (BMI) was calculated for all participants, and percentage excess weight loss (% EWL) was calculated at 6 months post-LSG surgery. % EWL was calculated as pre-operative weight, minus ideal body weight lost (ideal weight is that at a BMI of  $25 \text{ kg m}^2$ ), divided by excess body weight (see Table 1). Further, data were collected regarding patient satisfaction on the quality of alimentation and changes in taste, desire, and enjoyment of food.

### Taste Desire and Enjoyment Change Questionnaire

The Taste Desire and Enjoyment Change Questionnaire (TDECQ) is a study-specific questionnaire consisting of 24 questions with a Likert scale that ranges from 1 to 5 (Fig. 1). The TDECQ provides an indication of the degree of extent the tastes, desires, and enjoyment for certain foods or liquids have changed or stayed the same since undergoing bariatric surgery. Prior to the start of study, the TDECQ was reviewed by educational and health professionals for content and readability. The revised questionnaire was pilot tested with a sample of 10 bariatric patients to test for content validity to ensure that the developed questionnaire assessed the specific constructs of interest.

**Table 1:** Participant characteristics

Characteristic	Value
Patients ( <i>n</i> )	106
Mean age (year)	42 ( <i>SD</i> 10.72)
Female (%)	81
Mean BMI at date of surgery (kg/m <sup>2</sup> )	44 ( <i>SD</i> 7.35)
Mean % EWL at 6 months	64 ( <i>SD</i> 21)
Mean % TWL at 6 months	26 ( <i>SD</i> 5.88)
Mean BMI (kg/m <sup>2</sup> ) at 6 months	33( <i>SD</i> 6.7)
Working status (%)	
Employed	80
Not working	20
Level of education (%)	
High school	30
Post high school	27
University	42
Marital status (%)	
Married	42
De facto/in a relationship	27
Single	19
Divorced	4
Widowed	3

Data presented as mean with standard deviation, unless noted otherwise  
*BMI* body mass index, % *EWL* percentage of excess weight loss, % *TWL* percentage of total weight loss

### Quality of Alimentation Questionnaire

The Suter Quality of Alimentation questionnaire is a recognized tool for assessing food tolerance in bariatric patients to evaluate the overall patient satisfaction regarding the quality of alimentation [13]. Section 1 assesses satisfaction with current ability to consume food, with a score range from 1 (*very poor*) up to 5 (*excellent*).

### Data Analysis

In 2014, 132 participants (113 female) from four sites completed questionnaires at 4 to 6 weeks post-bariatric surgery and with 114 of these participants completing the same measures again at 6 to 8 months (*N* = 114) indicating a follow-up response rate of 88.4%. Participants completing both sets of measures predominantly underwent LSG (*N* = 106), three participants underwent laparoscopic adjustable band (LAGB), and five underwent Roux-en-Y gastric bypass (RYGB). Results of the 106 (92 female) LSG participants who completed questionnaires at both times are reported.

Analysis was performed using SPSS 23 software. Missing data were excluded. A response of zero in the taste perception items indicated no change in taste perception, and therefore, a series of one-sample *t* tests were used to test if the responses

were significantly different from zero. A two-tailed, paired sample *t* test with an alpha level of 0.05 was used to compare the change in flavor at both times. A series of bivariate correlations were completed with extent of % EWL and changes in the perception of taste, desire, and enjoyment of flavors at time 1; satisfaction score and changes in the perception of taste and desire of flavors at time 2; and % EWL and change in flavor, desire, and enjoyment over time (*T2* – *T1*). Multiple regression was used when there were multiple independent variables associated with a dependent variable.

### Results

The results at the two time points were varied, with an average of 52% (*SD* = 13.71) and 47% (*SD* = 16.07) participants respectively reporting unchanged tastes, 40% (*SD* = 12.55) and 44% of participants (*SD* = 12.98) respectively reporting increased intensity of taste of flavors, and 7.35% (*SD* 2.78) and 10% (*SD* = 8.99) respectively reporting reduced intensity of taste of flavors across the eight taste modalities. More specifically, the majority of participants reported an increase in the intensity of the flavor of sweet (60, 55%) and fatty (57, 70%) tastes, at 4–6 weeks (time 1) and 6–8 months (time 2), respectively.

### Intensity of Flavor Change

Figure 2 shows the means and 95% confidence intervals of changes in the intensity of flavor in eight taste perception modalities at both 4 to 6 weeks (time 1) and again at 6 to 8 months (time 2) post-LSG surgery. These results indicated statistically significant increases in the intensity of perception of all flavors at both time points, with greatest increases shown in sweet, fatty, and metallic flavors at time 1 and fatty, spicy, and sweet flavors at time 2. A series of paired sample *t* tests were used to examine the difference of change in intensity of flavor between both time points. The change in intensity of flavor was significantly different for fatty flavor, *t* (105) = −2.57, *p* = .012, and spicy flavor, *t* (105) = −3.09, *p* = .003, between both time points, and the change in intensity of fatty and spicy flavors was stronger at time 2 than at time 1. There was no significant difference in change in the intensity of the other six flavors across time.

### Intensity of Desire Change

Figure 3 shows the means and 95% confidence intervals of changes in intensity of desire in eight taste perception modalities at both time points. These results indicated a significant change in intensity of desire in all taste modalities at both time points (*p* < .001), except for change in salty desire, at time 1, *t* (105) = 1.52, *p* = .132, and time 2, *t* (104) = 1.08, *p* = .281, and

**Fig. 1.** Taste Desire and Enjoyment Change Questionnaire (TDECQ)

**Taste Desire and Enjoyment Change Questionnaire (TDECQ)**

The questions below relate to the extent your tastes and desires for certain foods or liquids have changed or stayed the same since undergoing bariatric surgery. Please circle the number that best represents the extent of any changes in taste and the extent of change of desires/cravings for certain foods or liquids.

\*(foods refers to all types of foods and liquids)

The rating scale is as follows:

- 1- Much weaker flavour/taste;
- 2- Weaker flavour/taste
- 3- No change in strength of flavour/taste
- 4- Stronger flavour /taste
- 5- Much stronger flavour/taste

1. I noticed that the taste of salty foods has changed	1	2	3	4	5
2. I noticed that the of taste of sugar /sweet foods has changed	1	2	3	4	5
3. I noticed that the taste of fatty/oily foods has changed	1	2	3	4	5
4. I noticed that the taste of sour/tart foods has changed	1	2	3	4	5
5. I noticed that the taste of savoury foods has changed	1	2	3	4	5
6. I noticed that the taste of spicy or piquant foods has changed	1	2	3	4	5
7. I noticed that the taste of bitter foods has changed	1	2	3	4	5
8. I noticed that foods and liquids have a metallic taste	1	2	3	4	5

The rating scale is as follows:

- 1- Much weaker desire/enjoyment
- 2- Weaker desire/enjoyment
- 3- No change in desire/enjoyment
- 4- Stronger desire/enjoyment
- 5- Much stronger desire/enjoyment

9. I noticed that the desire for salty foods has changed	1	2	3	4	5
10. I noticed that the desire for sugar/sweet foods has changed	1	2	3	4	5
11. I noticed that the desire for fatty/oily foods has changed	1	2	3	4	5
12. I noticed that the desire for sour/tart foods has changed	1	2	3	4	5
13. I noticed that the desire for spicy/piquant foods has changed	1	2	3	4	5
14. I noticed that the desire for bitter foods has changed	1	2	3	4	5
15. I noticed that the desire for metallic tasting foods has changed	1	2	3	4	5
16. I noticed that the desire for savoury foods has changed	1	2	3	4	5
17. I noticed that the enjoyment of salty foods has changed	1	2	3	4	5
18. I noticed that the enjoyment of sweet foods has changed	1	2	3	4	5
19. I noticed that the enjoyment of fatty /oily foods has changed	1	2	3	4	5
20. I noticed that the enjoyment of sour/tart foods has changed	1	2	3	4	5
21. I noticed that the enjoyment of spicy/piquant foods has changed	1	2	3	4	5
22. I noticed that the enjoyment of bitter foods has changed	1	2	3	4	5
23. I noticed that the enjoyment of savoury foods has changed	1	2	3	4	5
24. I noticed that the enjoyment of metallic tasting foods has changed	1	2	3	4	5

change in savory desire at time 1,  $t(104) = 1.60, p = .104$ , and time 2,  $t(103) = 2.12, p = .036$ , with greatest decreases seen in sweet and fatty flavor desire. A series of paired sample  $t$  tests examined the difference in change in desire between both time points. The change in intensity in desire between both time points was significantly different for sweet flavor,  $t(105) = -3.65, p < .001$ , bitter flavor,  $t(98) = -2.76, p = .007$ , and metallic flavor,  $t(105) = -2.86, p = .005$ , with these flavors showing the greatest increase in intensity in desire back to pre-surgery levels.

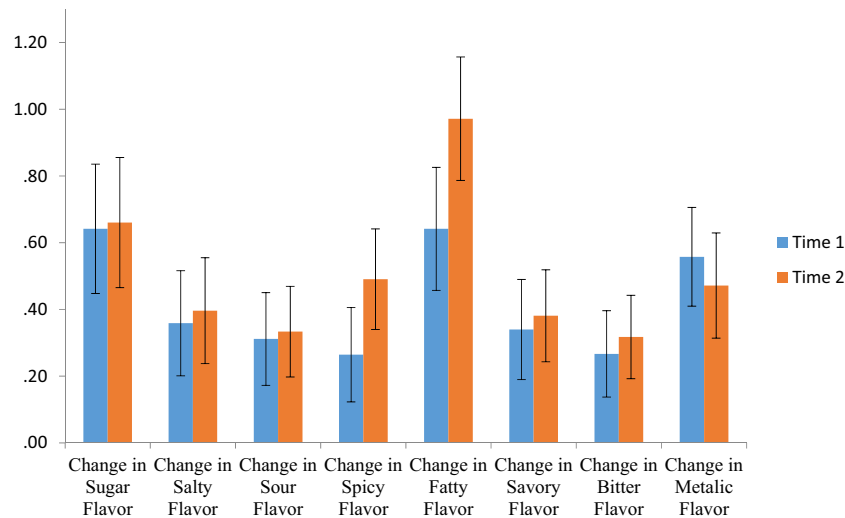
### Intensity of Enjoyment Change

Figure 4 shows the means and 95% confidence intervals of changes in intensity of enjoyment in eight taste perception modalities at both time points. These results indicated statistically significant decreases in intensity in enjoyment in sweet, sour,

spicy, fatty bitter, and metallic tastes at both time points, but no change in salty and savory enjoyment. A series of paired sample  $t$  tests was used to examine differences in change in intensity of enjoyment between both time points. The change in intensity in enjoyment was significantly different for sweet,  $t(105) = -3.25, p = .002$ , bitter,  $t(104) = -2.34, p = .021$ , and metallic taste,  $t(103) = -2.31, p = .023$ . These results indicated decreases in the intensity in enjoyment of sweet, bitter, and metallic tastes over time.

### Quality of Alimentation Questionnaire

Participants reported mean scores of  $3.46 \pm 0.82$  at time 1 and  $3.54 \pm 0.95$  at time 2, in section 1, indicating that they were satisfied with their eating behavior and there was no statistically significant change over time. Results are detailed in Fig. 5.



**Fig. 2.** Means and 95% confidence intervals of changes in intensity in flavor in eight taste perception modalities at time 1 and time 2. Note: time 1 = 4–6 weeks, time 2 = 6–8 months post-LSG. The *t* values for time 1 measures were as follows: sweet flavor,  $t(105) = 6.56^{***}$ , salty flavor,  $t(105) = 4.51^{***}$ , sour flavor,  $t(105) = 4.44^{***}$ , spicy flavor,  $t(105) = 3.70^{***}$ , fatty flavor,  $t(105) = 6.89^{***}$ , savory flavor,  $t(105) = 4.49^{***}$ , bitter flavor,  $t(104) = 4.09^{***}$ , and metallic flavor,

$t(103) = 7.47^{***}$ . The *t* values for time 2 measures were as follows: sweet flavor,  $t(105) = 6.71^{***}$ , salty flavor,  $t(105) = 4.95^{***}$ , sour flavor,  $t(104) = 4.86^{***}$ , spicy flavor,  $t(105) = 6.45^{***}$ , fatty flavor,  $t(105) = 10.41^{***}$ , savory flavor,  $t(104) = 5.48^{***}$ , bitter flavor,  $t(103) = 5.04^{***}$ , and metallic flavor,  $t(105) = 5.93^{***}$ . \* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$

### Association with Extent of % Excess Weight Loss and Satisfaction with Quality of Alimentation

#### Time 1 Variables

There was a statistically significant but weak association of changes in savory enjoyment at 4 to 6 weeks post-LSG and extent of % EWL at 6 months post-surgery,  $r(104) = -.229$ ,  $p < .05$ . This result indicates that the greater the decrease in enjoyment of savory flavor, the greater the subsequent increase in extent of % EWL.

#### Time 2 Variables

There were significant but weak associations between satisfaction with eating at 6 to 8 months and change of the intensity of the following flavors at 6 to 8 months post-surgery (i.e., perception of change from pre-surgery to 6–8 months of follow-up): change in sweet flavor,  $r(106) = .268$ ,  $p < .05$ , change in sour flavor,  $r(105) = .231$ ,  $p < .05$ , change in savory flavor,  $r(105) = .208$ ,  $p < .05$ , change in bitter flavor  $r(104) = .237$ ,  $p < .05$ , and change in metallic flavor,  $r(106) = .257$ ,  $p < .05$ .

Multiple regression was used to examine the association between satisfaction with eating at 6 to 8 months and change in bitter, sugar, sour, savory, and metallic flavor at 6 to 8 months post-LSG. Although the model was significant,  $F(5, 96) = 2.74$ ,  $p = .023$ , with 12.5% variance in satisfaction

explained, none of the five flavor variables were uniquely associated with satisfaction with eating ( $p > .05$ ).

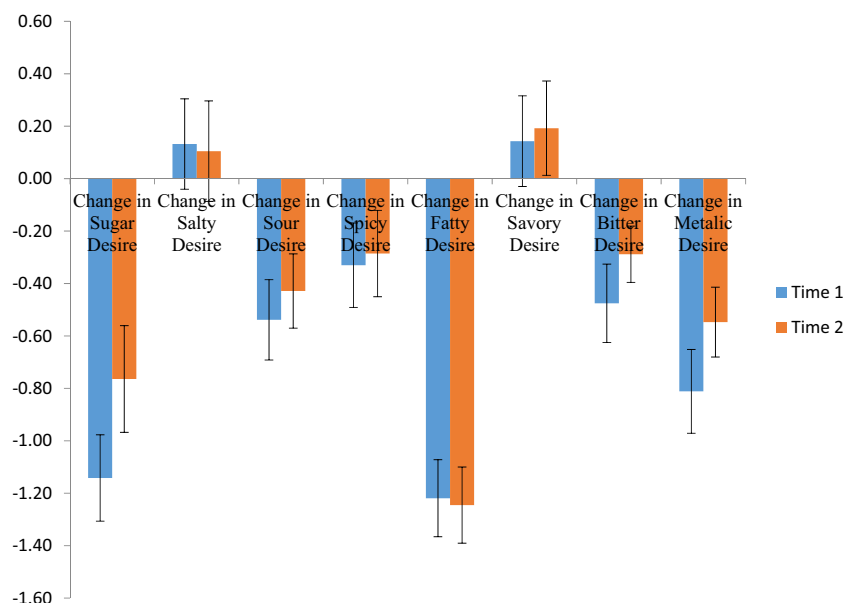
There were significant but weak bivariate associations between satisfaction with eating at 6 to 8 months post-surgery and change in salty desire at 6–8 months post-surgery,  $r(106) = -.201$ ,  $p < .05$ , and change in savory desire,  $r(104) = -.201$ ,  $p < .05$ . This result indicates that the greater the satisfaction with eating, the greater the subsequent increase in salty and savory desire.

Multiple regression was used to examine the association between satisfaction with eating at 6 to 8 months and change in salty and savory desire at 6 to 8 months post-LSG. The overall model was non-significant,  $F(2, 100) = 2.62$ ,  $p = .078$ , and both changes in salty desire ( $b = -.09$ ,  $SE = 0.09$ ,  $p = .346$ ) and savory desire ( $b = -.14$ ,  $SE = 0.10$ ,  $p = .147$ ) were not uniquely associated with satisfaction with eating.

#### Change from time 1 to time 2

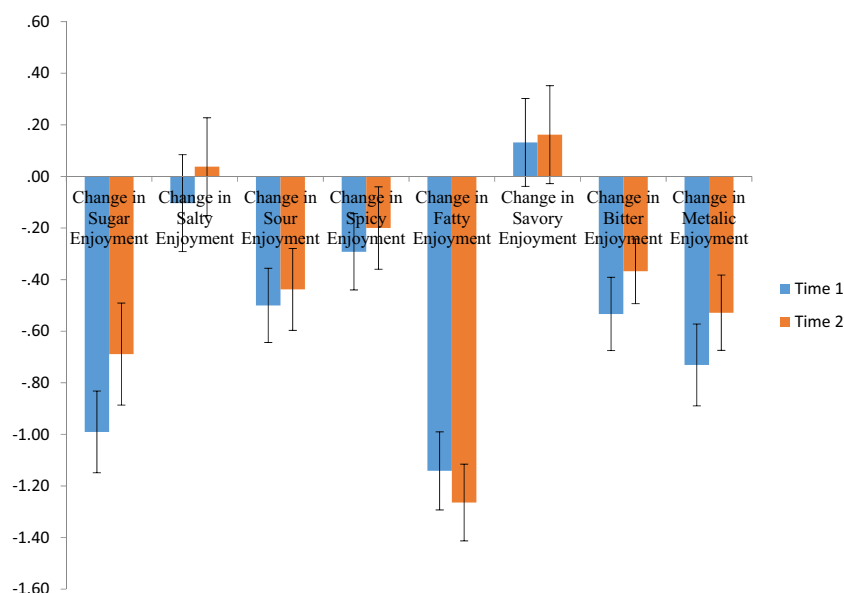
There were statistically significant bivariate associations between change over time in perception of savory enjoyment (time 2 – time 1) and extent of % EWL at 6 months post-surgery, but this association is also weak in terms of the strength of the association,  $r(105) = .248$ ,  $p < .05$ . This result indicates that the greater the increase over time in perception of savory enjoyment, the greater the subsequent increase in extent of % EWL.





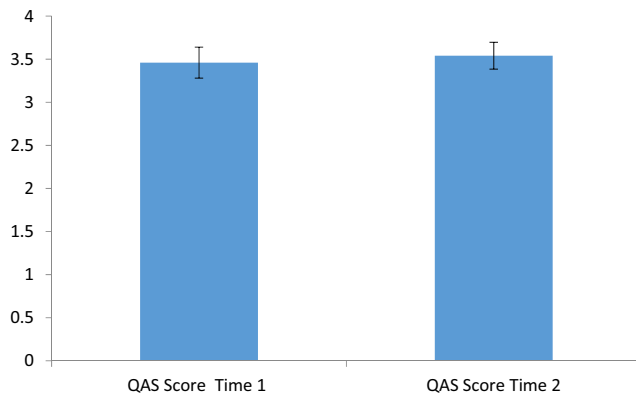
**Fig. 3.** Means and 95% confidence intervals of changes in intensity of desire of flavor in eight taste perception modalities at time 1 and time 2. Note: time 1 = 4–6 weeks, time 2 = 6–8 months post-LSG. The *t* values for time 1 measures were as follows: sweet desire,  $t(105) = 13.74^{***}$ , salty desire,  $t(105) = 1.52$ , sour desire,  $t(103) = 6.98^{***}$ , spicy desire,  $t(105) = 4.07^{***}$ , fatty desire,  $t(104) = 16.45^{***}$ , savory desire,  $t(104) = 1.64$ , bitter desire,  $t(100) = 6.32^{***}$ , and metallic desire,

$t(105) = 10.07^{***}$ . The *t* values for time 2 measures were as follows: sweet desire,  $t(105) = 7.45^{***}$ , salty desire,  $t(104) = 1.05$ , sour desire,  $t(104) = 6.00^{***}$ , spicy desire,  $t(104) = 3.44^{***}$ , fatty desire,  $t(105) = 17.01^{***}$ , savory desire,  $t(103) = 2.12^*$ , bitter desire,  $t(103) = 5.33^{***}$ , and metallic desire,  $t(105) = 8.14^{***}$ .  $^*p < .05$ ;  $^{**}p < .01$ ;  $^{***}p < .001$



**Fig. 4.** Means and 95% confidence intervals of changes in intensity of enjoyment of flavor in eight taste perception modalities at time 1 and time 2. Note: time 1 = 4–6 weeks, time 2 = 6–8 months post-LSG. The *t* values for time 1 measures were as follows: sweet enjoyment,  $t(105) = 12.40^{***}$ , salty enjoyment,  $t(105) = 1.10$ , sour enjoyment,  $t(105) = 6.89^{***}$ , spicy enjoyment,  $t(105) = 3.92^{***}$ , fatty enjoyment,  $t(105) = 14.95^{***}$ , savory enjoyment,  $t(105) = 1.54$ , bitter enjoyment,  $t(104) = 7.44^{***}$ , and

metallic enjoyment,  $t(103) = 9.14^{***}$ . The *t* values for time 2 measures were as follows: sweet enjoyment,  $t(105) = 6.91^{***}$ , salty enjoyment,  $t(105) = 0.39$ , sour enjoyment,  $t(104) = 5.48^{***}$ , spicy enjoyment,  $t(104) = 2.48^*$ , fatty enjoyment,  $t(105) = 16.86^{***}$ , savory enjoyment,  $t(104) = 1.69$ , bitter enjoyment,  $t(105) = 5.81^{***}$ , and metallic enjoyment,  $t(105) = 7.17^{***}$ .  $^*p < .05$ ;  $^{**}p < .01$ ;  $^{***}p < .001$



**Fig. 5.** Means and 95% confidence intervals of satisfaction with eating at time 1 and time 2. *Note:* time 1 = 4–6 weeks post-LSG, time 2 = 6–8 months post-LSG. *Quality of alimentation satisfaction score (QAS score)*

## Discussion

This preliminary study investigated the patient-reported outcomes of satisfaction with eating and changes in taste, enjoyment, and desire of foods at 4 to 6 weeks and 6 to 8 months post-LSG. It was predicted that LSG patients' perception of taste, desire, and enjoyment of foods would change post-LSG. This hypothesis was confirmed.

The majority of participants reported an increase in the intensity of the flavor of sweet (60, 55%) and fatty (57, 70%), at both time points compared with their recollection of the intensity of these flavors prior to surgery. Thus, these results show an increase in intensity of flavor of high calorie-dense sweet foods and fatty foods initially for the majority of participants post-LSG. This finding is consistent with studies showing food preferences in rodents after sleeve gastrectomy increased for low-fat and less calorically dense foods [14]. This study also demonstrated a decreased enjoyment for fatty (77, 83%) and sweet (77, 61%) flavors and decreased desire for fatty (83, 84%) and sweet (82, 68%) flavors at both time points following LSG. These findings are similar to those reported by Himpens et al. [15] who found a loss of craving for sweet flavors post-LSG procedure as well as a decrease in desire for both sweet and fatty flavors post-LSG. Miras and Le Roux [16] offer an explanation for this occurrence in other bariatric surgery patients such as RYGBP patients, by reporting an increase in the sweet taste acuity which, in turn, leads to a decreased desire to consume such foods. The results of this study supports this notion as there was an increase in taste acuity in all eight taste modalities and a decrease in the desire and enjoyment of all taste modalities except change in salty and savory flavors and change in savory enjoyment. Additionally, the desire and enjoyment for sweet, bitter, and metallic tastes increased over time. Participants reported an increased intensity of spicy flavors and fatty tastes over time. The changes in taste sensitivity and the decreased desire and

enjoyment of specific foods may translate into long-term changes in food preferences.

We also predicted that changes in LSG patients' perception of taste, desire, and enjoyment of foods post-surgery would be associated with extent of % EWL over a 6-month period. This hypothesis was partially confirmed. Specifically, we found that only changes to the perception of savory enjoyment at 4 to 6 weeks post-surgery and further changes from 4 to 6 weeks to 6 to 8 months were weakly associated with extent of % EWL at 6 months post-surgery. It is suggested that this increase in savory taste enjoyment over time may be associated with the consumption of protein-rich foods and therefore greater satiation. Prior studies have found that protein is more satiating than either carbohydrate [17, 18] or fat [19].

While weight loss is one measure of change and is an important parameter to consider, satisfaction with eating is an important patient-reported outcome as it impacts on satisfaction with the surgery outcome. The majority of the participants in this study were satisfied with their quality of alimentation post-LSG. Other studies have found similar results in LSG patients [20, 21]. The findings confirmed the hypothesis that changes in the perception of taste and desire of flavors at 6 to 8 months post-surgery are related to quality of alimentation. There were significant bivariate associations in that satisfaction with eating was weakly associated with changes in taste, with a greater satisfaction of eating behaviors being associated with increased change of intensity from 4 to 6 weeks to 6 to 8 months of sweet, sour, savory, bitter, and metallic flavors. Additionally, satisfaction with eating at 6–8 months was weakly associated for salty and savory flavors from 4 to 6 weeks to 6 to 8 months, with greater satisfaction being associated at 6–8 months having a decreased desire for salty and savory flavors from 4 to 6 weeks to 6 to 8 months. However, when these independent variables were added to a multiple regression, they did not have any unique associations with the dependent variable, satisfaction with eating. While this may be partly associated with the sample size, it may also be that there is too much shared variance among the independent variables for any unique predictors of the dependent variable to emerge as significant in the analysis.

## Limitations

There are limitations to the current study: the short-term follow-up, self-reported BMI, perceived perception of flavor change over 4 to 6 weeks and 6 to 8 months, use of a not yet validated flavor questionnaire (TDESQ), and all participants coming from the same ethnic group. The power analysis for a dependent sample *t* test was conducted to determine a sufficient sample size using an alpha of 0.05, a power of 0.80, and one tail. Based on the aforementioned assumptions and an effect size of 0.248, the desired sample size required was 96

participants for the primary outcome measure. However, in the secondary outcome measures based upon the smallest significant effect size of 0.208, the required sample size required was 149. Consequently, a further limitation of this study was the relatively small sample size for the secondary outcome measures. Therefore, these findings need to be replicated in a larger sample size. In this study, 18 participants were lost to follow-up and their outcomes are unknown.

## Conclusion

In conclusion, changes in taste perception, desire, and enjoyment of flavors occur for a majority of participants post-LSG which may have important implications on food preferences and satisfaction with eating behaviors post-surgery. In addition, the results indicated that increases in the perception of savory enjoyment post-LSG are weakly associated with extent of % EWL. Furthermore, the perception of changes in taste and desire of flavors post-surgery is related to quality of alimentation. This preliminary study suggests that LSG patients should be made cognizant of taste changes as part of the informed consent process for bariatric surgery. Additionally, taste changes post-LSG may be an opportunity for intervention in changing eating behavior and food preferences.

**Acknowledgements** We thank the participants for partaking in this study and the bariatric surgeons for allowing access to their patients for this research study.

## Compliance with Ethical Standards

**Ethical Considerations** Ethics approval was obtained from the university's Human Research Ethics Committee.

**Conflict of Interest** The authors declare that they have no conflict of interest.

**Funding** This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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