

## Reduction of Oral Malodor by Oxidizing Lozenges\*

Ronit Bar-Ness Greenstein, Sarit Goldberg, Sharon Marku-Cohen, Nir Sterer, and Mel Rosenberg

THE MAIN PURPOSE OF THE STUDY was to examine the anti-malodor properties of oxidizing lozenges, as compared to breath mints and chewing gum. Healthy, young adult volunteers (N = 123; mean age 24.5 years) were measured for oral malodor-related parameters (whole mouth odor measured by 2 judges; tongue dorsum posterior odor using the spoon test; volatile sulphide levels; salivary levels of cadaverine and putrescine; and 2 versions of an oral rinse test) on the first afternoon of the study. They were then assigned randomly to one of 6 groups (2 brands of breath mints, chewing gum with no active ingredients, regular and full-strength oxidizing lozenges, and a no-treatment control), and instructed to employ the treatment before bedtime, the next morning, and in the early afternoon 3 hours prior to measurements, which were carried out 24 hours following baseline measurements. Volunteers also estimated the level of their own whole mouth and tongue odors at baseline and post-treatment. The data showed that, among treatments, only the full-strength oxidizing lozenge significantly reduced tongue dorsum malodor, as determined by the spoon test. The full-strength lozenge also yielded a significant increase in the modified oral rinse test, presumably due, at least in part, to residual oxidizing activity retained in the oral cavity. Self-estimations of whole mouth and tongue malodor by volunteers were significantly correlated with corresponding-judge assessments, suggesting some degree of objectivity in assessing one's own oral malodor. *J Periodontol* 1997;68:1176-1181.

**Key Words:** Halitosis/drug therapy.

Bad breath (halitosis, fetor ex ore) is a common complaint dating back to ancient times.<sup>1,2</sup> In most cases, breath odors originate within the oral cavity itself.<sup>1-9</sup> Bad breath is considered to result from production of sulphur-containing<sup>1</sup> and other gases,<sup>4,5</sup> by Gram-negative bacteria,<sup>5-8</sup> generally under anaerobic conditions.<sup>5</sup> In healthy persons, bad breath often derives from the posterior part of the tongue dorsum.<sup>4,9</sup> In many<sup>6,8,10-15</sup> but not all<sup>7,16</sup> studies, periodontal disease-related parameters have been found to be associated with bad breath levels. Other oral causes of bad breath include faulty restorations (e.g., overhanging restorations and leaking crowns) and sites of food impaction.<sup>2</sup>

Previous investigations have addressed the antimalodor properties of various mouth rinses, including those containing zinc compounds, essential oils, cetylpyridinium chloride, chlorhexidine, and 2-phase oil:water mouthwashes.<sup>10,17,18</sup> Few studies have addressed other oral products. In the present report, 123 young adults were tested

for oral malodor parameters prior to and following sucking of various candies and lozenges, as well as chewing gum, as compared with a control group (no treatment). The data show that sucking of a full-strength lozenge with oxidizing properties reduces tongue dorsum malodor for 3 hours following use.

### MATERIALS AND METHODS

The experiment consisted of a randomized clinical trial of 123 healthy volunteers (mean age 24.5 ± 3 years; 71 females) who were recruited by newspaper and university advertisements. Subjects who took antibiotics within 1 month prior to study, smokers, or those who had partial or complete dentures were excluded. The experiment was conducted according to an approved human subjects protocol and participants signed an informed consent form.

Subjects were split randomly into one of 6 groups: chewing gum (N = 22; chewing gum with no active ingredients);<sup>1</sup> breath mint 1<sup>2</sup> (N = 22); breath mint 2<sup>3</sup> (N =

\*The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel-Aviv University, Ramat-Aviv, Israel.

<sup>1</sup>Warner Lambert, Morris Plains, NJ.

<sup>2</sup>Tic Tac, Ferrero Frankfurt/M, Germany.

<sup>3</sup>O'dol Nice, Linger Fischer, Buhl, Germany.

Table 1. Experimental Protocol

Initial Measurement	Treatment	Treatment	Treatment	Final Measurement
4 p.m.-7 p.m.	bedtime	early morning	early afternoon	4 p.m.-7 p.m.
DAY 1		DAY 2		

19); oxidizing lozenge, regular strength (N = 21); oxidizing lozenge,<sup>1</sup> full strength (N = 19); as well as a control group (N = 20; no treatment). Subjects were tested in random order, with researchers and odor judges blinded to group affiliation throughout.

The protocol of the experiment was similar to that previously used to compare mouth rinses.<sup>18</sup> Pre-treatment measurements were conducted between 4 p.m. and 7 p.m. of the afternoon of day 1. Subjects were instructed to reappear at the clinic at the same time on the next afternoon for post-treatment measurements. They were randomly assigned to 1 of the 6 groups. Those assigned to the lozenge/breath mint groups were asked to suck 1 lozenge/mint directly before bedtime on the same day (day 1); 1 in the early morning of the next day (day 2); and 1 in the early afternoon of day 2, 3 hours prior to their examination. Subjects in the chewing gum group were instructed to chew 1 piece of gum for 5 minutes directly before bedtime on the same day (day 1); 1 piece in the early morning of the next day (day 2); and 1 piece in the early afternoon of day 2, 3 hours prior to their examination. All subjects were instructed to continue their regular oral hygiene regimen, but to refrain from any oral hygiene activities, including toothbrushing, flossing, and rinsing, 3 hours before measurements. They were instructed to refrain from eating and drinking for at least 2 hours before measurements. The protocol of the experiment is summarized in Table 1.

#### Measurement Parameters

**Volatilé sulfur compounds (VSC).** Determination of intraoral headspace VSC was carried out using a sulphide monitor.\* Measurement was carried out essentially as previously reported,<sup>8,10,15,19</sup> using disposable straws, rather than teflon tubing. Participants were asked to refrain from talking for 5 minutes prior to measurement. The monitor was zeroed on ambient air, and measurement performed by inserting a disposable one-quarter inch plastic straw approximately 4 cm into the partially open oral cavity. Subjects were asked to breathe through their nose during measurement. Results were recorded as peak ppb sulphide equivalents.

**Oxygen depletion in expectorated milk rinse.** Oxygen depletion in expectorated milk rinse was determined using the oratest oral rinse procedure,<sup>20</sup> as well as a modified version. Previous studies have shown that oratest scores are sensitive to changes in microbial counts and clinical parameters.<sup>10,18,20,21</sup> Briefly, volunteers rinsed vigorously for 30 seconds with 14 ml of sterile milk. Following expectoration, 3 ml of the sample was added to test tubes containing 0.12 ml of methylene blue solution (0.1%), and the time required for a blue-to-white color change over a 6 mm diameter at the bottom of the test tube was recorded. The oratest was performed directly following the judges' organoleptic measurements.

In the modified oratest, a 10 ml sample of the same milk expectorate was poured into a plastic disposable conic tube (12 cm height × 1.5 cm diameter)\*\* and the extent (height in mm) of color change was recorded following 30 minutes' incubation at room temperature as above.

**Organoleptic measurements.** Organoleptic measurements of whole mouth malodor were performed by 2 judges, both with previous experience in assessing oral malodor (AG and EL). For judge scoring of whole mouth malodor, subjects were instructed to exhale briefly through the mouth, at a distance of approximately 10 cm from the nose of the 2 judges, sequentially. For self-assessment of whole mouth malodor, subjects were instructed to smell the odor emanating from their entire mouth by cupping their hands over mouth and nose, exhaling through the mouth and breathing in through the nose.<sup>15</sup> Odor measurements to assess the odor emanating from the posterior tongue dorsum were performed by one judge (EL), using a plastic spoon to scrape and scoop material from the far back region of the tongue dorsum.<sup>2</sup> Five seconds later, both the odor judge and subject assessed the spoon odor at a distance of approximately 5 cm. Results of all malodor assessments were independently rated in semi-integer intervals on a scale of 0 to 5<sup>19</sup> with description as follows: 0, no appreciable odor; 1, barely noticeable odor; 2, slight, but clearly noticeable odor; 3, moderate odor; 4, strong odor; 5, extremely foul odor. Judges and subjects were blinded from one another's scores throughout.

\*Desaquick extra fresh, Roland Arzneimittel, Hamburg, Germany.

<sup>1</sup>Desaquick forte, Roland Arzneimittel, Hamburg, Germany.

\*\*Model 1170, Intersean Corp., Chatsworth, CA.

<sup>2</sup>Mimplast, Ein Shemer, Israel.

Table 2. Mean Baseline Values for the Various Parameters

Parameter	Mean ± Standard Deviation
Whole mouth (Judge AG)*	1.95 ± 1.44
Whole mouth (Judge EL)*	1.20 ± 0.92
Whole mouth (Judges' mean)*	1.57 ± 0.98
Whole mouth (self-assessment)*	1.79 ± 1.07
Spoon test (Judge EL)*	1.95 ± 0.88
Spoon test (self-assessment)*	2.43 ± 1.19
Ln volatile sulphides <sup>†</sup>	4.26 ± 0.40
Ln oratest <sup>‡</sup>	4.93 ± 0.60
Modified oratest <sup>‡</sup>	1.21 ± 1.29
Ln cadaverine	1.10 ± 1.49
Ln putrescine	2.14 ± 1.06

\*On a semi-integer 0 to 5 scale.

<sup>†</sup>In ppb sulphide equivalents.<sup>‡</sup>In minutes for color change on bottom of tube.

\*Millimeters height color change after 30 minutes.

In peak ppm diamine.

**Diamine analysis.** Cadaverine and putrescine levels were determined in unstimulated whole saliva using high performance liquid chromatography (HPLC) as described previously.<sup>10,22</sup>

**Statistical analysis.** Comparisons between the various groups of the study were carried out using ANOVA, followed by Bonferroni's multiple comparisons. Several of the parameters (peak volatile sulphide levels, oratest, putrescine, cadaverine) were ln transformed in order to approximate normal distributions.

Comparisons between self-assessments and judges' scores were performed using paired *t*-tests. Associations between the various parameters were assessed by Pearson correlations. Multiple regression was applied in order to test the contribution of some of the post-treatment parameters (ln [cadaverine], ln [sulphide levels], and modified

oratest) to the prediction of post-treatment mean judge score.

## RESULTS

Mean baseline values of the various parameters for the entire subject group are summarized in Table 2. No differences in any of the parameters among the 6 treatment groups were detected at baseline ( $P > 0.05$ , ANOVA). Following treatment, significant differences among treatment groups were noted for 2 parameters: tongue dorsum posterior odor judge scores ( $P = 0.025$ , ANOVA) and modified oratest ( $P = 0.018$ , ANOVA).

The mean changes in each group following the various treatments are summarized in Table 3. Among the various treatments, only the full-strength oxidizing lozenge was found to significantly reduce tongue dorsum posterior malodor. This reduction was significant not only with respect to the no-treatment control ( $P = 0.009$ ), but also with respect to the chewing gum group ( $P = 0.002$ ), breath mints 1 and 2 ( $P = 0.023$  and  $P = 0.016$ , respectively), and the regular-strength oxidizing lozenge group ( $P = 0.003$ ).

The full-strength oxidizing lozenge also yielded the largest improvements (decreases) in self-assessment whole mouth and self-assessment tongue posterior odor scores, as well as whole mouth odor scores (judge EL), but these did not reach significant levels.

With respect to the modified oratest, use of the full-strength oxidizing lozenge was found to be associated with significant increases in the extent of oxygen consumption in the rinsed milk samples. This increase was significant not only with respect to the no-treatment control ( $P = 0.0025$ ), but also with respect to the chewing

Table 3. Changes From Baseline Means

Tested Parameter	Chewing Gum	Breath Mint 1	Breath Mint 2	Regular Oxidizing Lozenge	Full-Strength Oxidizing Lozenge	Control (No Treatment)
Whole mouth (Judge AG)*	-0.54 ± 1.28	-0.54 ± 1.17	-1.47 ± 1.58	-1.40 ± 1.75	-1.29 ± 1.32	-1.00 ± 1.60
Whole mouth (Judge EL)*	0.02 ± 1.25	-0.07 ± 0.76	-0.08 ± 1.31	0.02 ± 0.77	-0.29 ± 0.89	-0.10 ± 0.84
Whole mouth (Judges' mean)*	-0.26 ± 0.95	-0.31 ± 0.78	-0.78 ± 1.17	-0.69 ± 1.03	-0.79 ± 0.77	-0.55 ± 0.84
Whole mouth (self-assessment)*	0.14 ± 0.77	-0.09 ± 1.11	-0.21 ± 1.18	-0.17 ± 1.06	-0.36 ± 1.13	0.27 ± 0.79
Spoon test (Judge EL)*	0.20 ± 0.93	-0.07 ± 0.82	0.00 ± 0.88	0.14 ± 0.74	-0.74 ± 0.99*	0.05 ± 1.15
Spoon test (self-assessment)*	0.02 ± 1.12	-0.29 ± 1.23	-0.39 ± 1.65	0.10 ± 1.29 <sup>‡</sup>	-0.82 ± 0.99	-0.12 ± 0.65
Ln volatile sulphides <sup>†</sup>	0.003 ± 0.25	-0.02 ± 0.35	-0.09 ± 0.34	0.03 ± 0.41	-0.09 ± 0.23	-0.06 ± 0.38
Ln oratest <sup>‡</sup>	-0.03 ± 0.53	-0.03 ± 0.69	0.16 ± 0.58	-0.20 ± 0.68	-0.20 ± 0.61	0.05 ± 0.59
Modified oratest <sup>‡</sup>	-0.14 ± 1.16	-0.23 ± 1.35	-0.74 ± 1.49	0.09 ± 1.65	0.82 ± 1.85*	-0.62 ± 1.16
Ln cadaverine	0.06 ± 1.02	-0.42 ± 0.85	-0.16 ± 0.65	-0.53 ± 0.86	0.31 ± 1.34	-0.34 ± 0.70
Ln putrescine	-0.19 ± 0.75	-0.28 ± 1.04	-0.45 ± 0.67	-0.29 ± 0.73	-0.39 ± 0.78	-0.32 ± 0.64

\*On a semi-integer 0 to 5 scale.

<sup>†</sup>In ppb sulphide equivalents.<sup>‡</sup>In minutes for color change on bottom of tube.

\*Millimeters height color change after 30 minutes.

In peak ppm diamine.

<sup>†</sup>Significant difference among groups,  $P = 0.0254$  (ANOVA); full-strength oxidizing lozenge scores differed significantly from 1) chewing gum group,  $P = 0.0015$ ; 2) breath mint 1 group,  $P = 0.0228$ ; 3) breath mint 2 group,  $P = 0.0156$ ; 4) regular oxidizing lozenge,  $P = 0.0033$ ; and 5) no treatment control group,  $P = 0.0091$ .

<sup>‡</sup>Significant difference among groups,  $P = 0.0184$  (ANOVA); full-strength oxidizing lozenge scores differed significantly from 1) chewing gum group,  $P = 0.0389$ ; 2) breath mint 1 group,  $P = 0.024$ ; 3) breath mint 2 group,  $P = 0.0013$ ; and 4) no treatment control group,  $P = 0.0025$ .

gum group ( $P = 0.0389$ ), as well as breath mints 1 and 2 ( $P = 0.024$  and  $P = 0.0013$ , respectively). Modified oratest levels following use of regular versus full-strength oxidizing lozenges were not significantly different from one another. Similar trends to those found for the modified oratest were observed with the original oratest procedure, but differences among groups were not significant.

The increase in the modified oratest scores following use of the full-strength oxidizing lozenges appears anomalous, since it would ostensibly indicate an increase, rather than decrease, in microbial activity.<sup>10,18,20,21</sup> However, since the efficacy of the lozenges is based on oxidizing activity, we guessed that the observed increase was due, at least in part, to the depletion of oxygen brought about by active components of the lozenge. Indeed, *in vitro* experiments in which lozenges were mixed with sterile saliva and added to sterile milk containing methylene blue yielded rapid color change indicative of oxygen depletion, whereas control tubes containing sterile saliva and milk alone did not yield color change (data not shown). Future research is necessary to determine whether the oxidizing agents of the lozenge indeed show retentivity on the tongue surface for 3 hours following use.

Pearson correlation coefficients were used to compare associations among the various parameters. At baseline and following treatment, both judge's scores of whole mouth malodor were moderately associated with one another ( $r = 0.35$ ,  $P < 0.001$ ). Both judges' initial whole mouth malodor scores were related to volatile sulphide levels, yielding  $r$  values of 0.27 ( $P = 0.003$ ) and 0.39 ( $P < 0.001$ ) for judges AG and EL, respectively. However, neither of the initial odor judge scores was significantly related to cadaverine levels ( $P > 0.05$ ). Following treatment, correlations between odor judge scores and volatile sulphide levels were significant for judge AG ( $r = 0.27$ ,  $P = 0.003$ ), but not for judge EL ( $r = 0.16$ ,  $P = 0.072$ ). Conversely, EL post-treatment scores were highly associated with cadaverine ( $r = 0.31$ ,  $P = 0.001$ ), whereas AG post-treatment whole mouth scores were not ( $r = 0.16$ ,  $P = 0.09$ ). Multiple regression analysis of post-treatment results showed that both cadaverine and volatile sulphides factored equally in accounting for mean whole mouth odor judge scores ( $P = 0.01$  for both parameters), yielding a multiple  $r$  of 0.36 ( $P < 0.001$ ). In contrast, only volatile sulphide scores factored into the regression equation accounting for baseline mean odor judge scores, yielding a multiple  $r$  of 0.39 ( $P < 0.001$ ).

If-assessments of whole mouth malodor were not significantly different from the corresponding mean judge scores at baseline ( $P = 0.073$ , paired  $t$ -test), but were significantly higher than corresponding mean judge scores post-treatment ( $P < 0.001$ , paired  $t$ -test). Self-assessment of spoon scores (indicative of odor on the tongue dorsum posterior) was higher than corresponding judge scores

both prior to, and following treatment ( $P < 0.001$  and  $P = 0.006$ , respectively; paired  $t$ -test). Self-assessments of whole mouth, pre- versus post-treatment, were highly associated with one another ( $r = 0.52$ ,  $P < 0.001$ ), as were self scores of the spoon odor prior to versus following treatment ( $r = 0.49$ ,  $P < 0.0001$ ). Corresponding pre- versus post-treatment odor judge scores were less strongly associated with one another ( $r = 0.33$ ,  $P < 0.001$ ; and  $r = 0.35$ ,  $P < 0.001$  for whole mouth scores of AG and EL, respectively; and  $r = 0.40$ ,  $P < 0.001$  for spoon scores of judge EL).

Interestingly, self-assessments of whole mouth were significantly associated with corresponding mean judge scores, both at baseline ( $r = 0.20$ ,  $P = 0.024$ ) and post-treatment ( $r = 0.23$ ,  $P = 0.009$ ). Furthermore, self-scoring of spoon odor versus corresponding judge (EL) scores yielded highly significant correlations of  $r = 0.25$ ,  $P = 0.005$  (baseline) and  $r = 0.35$ ,  $P < 0.001$  (post-treatment), respectively. Self spoon scores were also significantly correlated with volatile sulphide scores, both pre- and post-treatment ( $r = 0.20$ ,  $P = 0.03$ ; and  $r = 0.25$ ,  $P = 0.005$ , respectively), but not with levels of salivary cadaverine ( $P > 0.05$ ).

Salivary cadaverine concentrations were marginally associated with sulphide levels both before and following treatment ( $r = 0.20$ ,  $P = 0.03$ ; and  $r = 0.19$ ,  $P = 0.043$ , respectively). In contrast, putrescine levels were not related to sulphide levels ( $P > 0.2$ ).

Correlations between the modified oratest and the previous oratest technique were high, both at baseline and following treatment ( $r = -0.61$ ,  $P < 0.001$ ; and  $r = -0.68$ ,  $P < 0.001$ , respectively).

## DISCUSSION

Although mouth rinses have been tested for their effectiveness in reducing oral malodor parameters in a variety of studies,<sup>10,17,18</sup> few investigations have been conducted using other kinds of oral products. In the present study, we compared the efficacy of breath mints, oxidizing lozenges, and chewing gum in reducing oral malodor over a 3-hour period.

Among the various treatments, only the full-strength oxidizing lozenge was effective in reducing tongue malodor, as determined by the spoon test. Furthermore, this decrease was significant, as compared to all other treatment groups ( $P$  values ranging from 0.025 to 0.009). Although the full-strength oxidizing lozenge also yielded the largest improvements (decreases) in other parameters; i.e., self-assessment scores (whole mouth and tongue dorsum posterior), and whole mouth odor scores (judge EL), these did not reach significant levels. To our knowledge, this is the first report demonstrating a 3-hour anti-malodor effect of any lozenge. More recent findings (unpublished) have demonstrated a 90-minute effect for the regular-strength oxidizing lozenge in reducing posterior tongue malodor.

The anti-malodor effect may be due to the activity of dehydroascorbic acid, which is generated by peroxide-mediated oxidation of ascorbate present in the lozenges. Indeed, *in vitro* malodor reduction by mixtures containing oxidizing agents and ascorbic acid has been previously demonstrated.<sup>22</sup>

Although gum chewing *per se* is considered to be helpful in reducing bad breath during the day by stimulating saliva flow and mechanical cleansing,<sup>4</sup> the chewing gum employed in this study, devoid of active ingredients, was not effective in reducing malodor parameters 3 hours following use.

Gentle scraping of the back of the tongue with a plastic spoon, as performed here, has been used successfully for several years in our clinical assessment of the source of oral malodor.<sup>4</sup> We have recently begun to employ this test as a measurement parameter in research protocols.<sup>10</sup> In addition to its ability to distinguish anti-malodor activity among the groups, the "spoon test" appears to have potential in self-assessment. Subjects' scores of the spoon malodor, both at baseline and post-treatment, correlated significantly with corresponding odor judge scores, as well as with volatile sulphide measurements.

As in previous studies, odor judge scores were significantly associated with sulphide monitor results, although the correlation coefficients obtained were not as high as those found elsewhere.<sup>1</sup> Furthermore, changes following treatment were slight and not significant. Similarly, although cadaverine was marginally related to volatile sulphide scores, and factored significantly (together with sulphide levels) in explaining post-treatment odor judge scores, the relationships between this diamine and other malodor-associated parameters were weaker than those found in a previous investigation.<sup>23</sup> One reason for the lower degree of association may be the relatively young age and good health of the subjects studied here.

This is the first study to employ the modified oratest. Its main advantage is that the color change is not followed continuously, but rather at a fixed interval (30 minutes). The modified oratest was highly associated with the previous oratest technique, and was more sensitive to differences among groups than the previous test. Although the oratest was originally devised as a test of oxygen consumption by the expectorated oral microbiota, the results presented here suggest the potential of the modified oratest in monitoring substantivity of oxidizing agents in the oral cavity.

Correlations between the 2 judges, although significant, were moderate, even though both judges had previously participated in clinical malodor studies. In a previous study, we compared inter-examiner scores among 7 judges and found that the Pearson correlation coefficients ranged from 0.14 ( $P = 0.135$ ) to 0.49 ( $P < 0.001$ ).<sup>24</sup> One potential factor in accounting for inter-examiner variability is that each judge exhibits a different sensitivity to-

wards different "notes" of oral malodor. The post-treatment odor judge scores presented here provide initial support for such a hypothesis. Whereas judge EL's post-treatment scores were highly associated with cadaverine ( $P = 0.001$ ) but not volatile sulphides ( $P = 0.072$ ), judge AG's post-treatment scores were associated with volatile sulphides ( $P = 0.003$ ), but not with cadaverine ( $P = 0.087$ ). When the molecular compositions of the various kinds of oral malodor become better characterized, it should be possible to test this hypothesis more thoroughly.

In a recent study, we addressed the question of whether people can objectively gauge their own bad breath, in a group of 52 subjects, most of whom had a complaint of bad breath. Subjects were asked to rate the odor emanating from their mouths in the same manner as described here (i.e., by cupping hands over mouth). In the previous study, no correlation was found between self-estimation of whole mouth malodor and objective measurements. However, in the present investigation, significant associations were found comparing self-scoring of malodor with odor judge scores, as well as with volatile sulphide levels. One possible explanation for this discrepancy is that the group of subjects in the previous study were concerned about having bad breath and exhibited elevated psychopathological scores as compared with a normal population.<sup>25</sup> In contrast, the subjects studied here were healthy young adults who had no specific complaint regarding bad breath and were recruited based on financial remuneration. As with whole mouth odor, self-estimation of spoon scores was also significantly associated with odor judge scores and sulphide levels, both pre- and post-treatment. These data raise the possibility that in the general population, some degree of objective self-evaluation regarding oral odor is possible. This objectivity, however, may still be mitigated by personal sensitivity to one's own odor. As found in the previous investigations,<sup>24,25</sup> subjects in the present study tended to score their own tongue odor more severely than the corresponding odor judge scores, both prior to and following treatment. Moreover, subjects' baseline and post-treatment self-scores were more highly associated with one another than corresponding odor judge scores.

#### Acknowledgments

We thank Jeff Neal for help with the *in vitro* oxidation reduction experiments and Ilana Gelernter for statistical guidance. This study was supported by a grant from Roland Arzneimittel, Hamburg, Germany; the chewing gum was provided by Warner-Lambert, Morris Plains, NJ.

#### REFERENCES

1. Geist H. Halitosis in ancient literature. *Dent Abstr* 1957;2:417-418.
2. Rosenberg M. Introduction. In: Rosenberg M, ed. *Bad Breath: Research Perspectives*, 2nd ed. Tel Aviv: Ramot Publishing-Tel Aviv University; 1997:1-12.

3. Tonzetich J. Production and origin of oral malodor: A review of mechanisms and methods of analysis. *J Periodontol* 1977;48:13-20.
4. Rosenberg M. Clinical assessment of bad breath: Current concepts. *J Am Dent Assoc* 1996;127:475-482.
5. Kleinberg I, Codipilly M. The biological basis of oral malodor formation. In: Rosenberg M, ed. *Bad Breath: Research Perspectives*. 2nd ed. Tel Aviv: Ramot Publishing-Tel Aviv University; 1997:13-39.
6. De Boever EH, De Uzeda M, Loesche WJ. Relationship between volatile sulfur compounds, BANA-hydrolyzing bacteria and gingival health in patients with and without complaints of oral malodor. *J Clin Dent* 1994;4:114-119.
7. De Boever EH, Loesche WJ. Assessing the contribution of anaerobic microflora of the tongue to oral malodor. *J Am Dent Assoc* 1995;126:1384-1393.
8. Kozlovsky A, Gordon D, Gelernter I, Loesche WJ, Rosenberg M. Correlation between the BANA test and oral malodor parameters. *J Dent Res* 1994;73:1036-1042.
9. Grapp GL. Fetor oris (halitosis). A medical and dental responsibility. *Northwest Med* 1933;32:375-380.
10. Kozlovsky A, Goldberg S, Natour I, Rogatky-Gat A, Gelernter I, Rosenberg M. Efficacy of a 2-phase oil:water mouthrinse in controlling oral malodor, gingivitis, and plaque. *J Periodontol* 1996;67:577-582.
11. Sulser GF, Brening RH, Fosdick LS. Some conditions that affect the odor concentration of breath. *J Dent Res* 1939;18:355-359.
12. Berg M, Fosdick LS. Studies in periodontal disease. II. Putrefactive organisms in the mouth. *J Dent Res* 1946;25:73-81.  
Miyazaki H, Sakao S, Katoh Y, Takehara T. Oral malodor in the general population of Japan. In: Rosenberg M, ed. *Bad Breath: Research Perspectives*. 2nd ed. Tel Aviv: Ramot Publishing-Tel Aviv University; 1997:119-136.
14. Yaegaki K, Sanada K. Volatile sulphur compounds in mouth air from clinically healthy subjects and patients with periodontal disease. *J Periodont Res* 1992;27:233-238.
15. Rosenberg M, Kulkarni GV, Bony A, McCulloch CA. Reproducibility and sensitivity of oral malodor measurements with a portable sulphide monitor. *J Dent Res* 1991;70:1436-1440.
16. Bony A, Kulkarni GV, Rosenberg M, McCulloch CAG. Relationship of oral malodor to periodontitis: Evidence of independence in discrete subpopulations. *J Periodontol* 1994;65:37-46.
17. Niles HP, Gaffar A. Advances in mouth odor research. In: Rosenberg M, ed. *Bad Breath: Research Perspectives*. 2nd ed. Tel Aviv: Ramot Publishing-Tel Aviv University; 1997:55-69.
18. Rosenberg M, Gelernter I, Barki M, Bar-Ness R. Daylong reduction of oral malodor by a 2-phase oil:water mouthrinse, as compared to chlorhexidine and placebo rinses. *J Periodontol* 1992;63:39-43.
19. Rosenberg M, Septon I, Eli I, Bar-Ness R, Gelernter I, Brenner S, Gabbay J. Halitosis measurement by an industrial sulphide monitor. *J Periodontol* 1991;62:487-489.
20. Rosenberg M, Barki M, Portnoy S. A simple method for estimating oral microbial levels. *J Microbiol Methods* 1989;9:253-256.
21. Tal H, Rosenberg M. Estimation of dental plaque levels and gingival inflammation using a simple oral rinse technique. *J Periodontol* 1990;61:339-342.
22. Larsson BT, Widmark G. A gas chromatographic method for analysis of volatiles in saliva samples. *Acta Pharmaceutica Suecica* 1969;6:479-488.
23. Goldberg S, Kozlovsky A, Gordon D, Gelernter I, Sintov A, Rosenberg M. Cadaverine as a putative component of oral malodor. *J Dent Res* 1994;73:1168-1172.
24. Rosenberg M, Kozlovsky A, Gelernter I, et al. Self estimation of oral malodor. *J Dent Res* 1995;74:1577-1582.
25. Eli I, Baht R, Kozlovsky A, Rosenberg M. The complaint of oral malodor—possible psychopathologic aspects. *Psychosomatic Med* 1996;58:156-159.

Send reprint requests to: Dr. Mel Rosenberg, Maurice and Gabriela Goldschleger School of Dental Medicine, Tel-Aviv University, Ramat-Aviv, Israel 69978.

Accepted for publication April 14, 1997.