Short Communication

The effect of zinc-containing chewing gum on volatile sulfur-containing compounds in the oral cavity

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Volatile sulfur-containing compounds (VSC) are known to constitute the major component of halitosis. Aqueous solutions of zinc salts have been shown to reduce the levels of VSC produced orally. The aim of the present study was to examine whether zinc could be made available in the oral cavity and inhibit VSC production when delivered by a chewing gum. VSC measurements were carried out on the 'morning breath' of 11 test subjects and re-examined after the use of test solutions containing 0.02% zinc chloride, 0.2% chlorhexidine, or water or the use of chewing gums containing 2 mg, 0.5 mg, or 0 mg zinc acetate. The results showed that similar amounts of zinc in mouthrinses or chewing gum had the same effect, with a reduction of the oral VSC of 45%. Chewing gum thus seems to be a viable alternative for delivering zinc to reduce VSC levels in the oral cavity. □ *Halitosis; metal salt; oral administration; sulfur volatiles*

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It is generally accepted that volatile sulfur-containing compounds (VSC) constitute the major component of halitosis or bad breath originating from the oral cavity (1, 2). It has also been shown that it is the anaerobic, mainly Gram-negative bacteria that are responsible for this odor production (3–5). All oral conditions that favor the retention of such a flora predispose for the formation of VSC and thereby contribute to the development of halitosis. In addition to interdental areas and periodontal pockets, the main retentive site is the dorsum of the tongue, with its large surface area (6–8). As substrates for odor production, the bacteria mainly utilize the amino acids methionine and cysteine in proteins from the diet, desquamated epithelial cells, and saliva (9, 10). These amino acids contain sulfur and are metabolized by the anaerobic bacteria to yield the volatile sulfur-containing compounds hydrogen sulfide and methyl-mercaptan (11, 12). These substances have an unpleasant odor even in extremely low concentrations (6).

It is well known that aqueous solutions of zinc salts used as mouthrinses reduce and inhibit VSC formation in the oral cavity (13, 14). It is assumed that zinc ions form stable mercaptides with the substrate, with precursors of VSC or with the VSC directly, since zinc has an affinity for sulfur and oxidizes sulfhydryl groups (15). The aim of the present study was to examine whether, and to what extent, a chewing gum can be used as a vehicle for zinc ions as an alternative to mouthwashes, as this would provide a more convenient and more practical delivery system.

Materials and methods

Eleven test subjects (age, 8–45 years) volunteered for the study. All test subjects had clinically healthy gingival and periodontal conditions. Measurements of VSC levels were carried out on 'morning breath'; the test subjects were instructed not to brush their teeth on the morning of testing and to brush with water the night before testing. On the morning of testing they were not allowed to eat, drink, smoke, or perform any kind of oral hygiene before testing. The measurements were carried out using a portable sulfide monitor (Halimeter RH17E, Interscan, USA). Base-line readings were first carried out on the test panel, then the allocated test substance was applied, and subsequently further VSC readings performed. The chewing gums tested were non-commercial, especially made for the experiment, and contained 2 mg, 0.5 mg, or 0 mg zinc acetate. The chewing gum was not coated, and the zinc was added to the gum base. One piece of gum was chewed for 5 min. No flavoring oils were included in the gums, since these may interfere with the analysis by this sulfide monitor. The test solutions applied were 0.02% zinc chloride or 0.2% chlorhexidine in aqueous solutions. Water was used as a negative control. Ten milliliters were used as a rinse for 1 min. Only one single rinse or chewing period was performed in the present study. All subjects used all test regimens in a double-blind design. Statistical analysis was carried out using a one-tailed Student's *t* test.

Table 1. Reduction (means and standard deviations, *s*, in percentage) of volatile sulfur-containing compounds by the different chewing gums and solutions measured in 11 subjects

	Mean	*s*
Chewing gum containing 2 mg zinc acetate	45	25
Chewing gum containing 0.5 mg zinc acetate	16	14
Chewing gum containing 0 mg zinc acetate (placebo)	14	20
Aqueous solution of 0.02% zinc chloride	45	24
Aqueous solution of 0.2% chlorhexidine gluconate	7	23
Water (negative control)	7	14

Results

The results in Table 1, given as mean percentage reduction in VSC levels, showed that the chewing gum that contained 2 mg Zn-acetate reduced VSC levels by 45%. This effect was significantly better than the chewing gum containing no zinc ($P = 0.003$), which showed a reduction of 14%. The chewing gum containing 0.5 mg zinc had less effect in reducing VSC levels (16%) and was not significantly better than the placebo gum ($P = 0.757$). The effect of the placebo gum was not significantly better than the negative water control ($P = 0.260$), which had an effect of 7%. The zinc-containing mouthwash gave a reduction of 45%, not statistically different from 2 mg gum ($P = 0.990$), both significantly different from the water control ($P = 0.000$). The chlorhexidine rinse showed an effect of 7%, which is significantly less effective than the zinc-containing solution ($P = 0.000$) but not different from the water control ($P = 0.971$).

Discussion

Various attempts have been made to develop instrumental approaches to measuring bad breath. These include the osmoscope (16), gas chromatography (17), and, more recently, portable sulfide monitors such as the Halimeter used in the present experiment (18). The most reliable method of evaluation, however, has been claimed to be the human nose. The reliability of evaluating bad breath with a portable sulfide monitor has been investigated in several studies and has shown a positive correlation between sulfide levels measured with the Halimeter and organoleptic odor assessments (18–22), which appears to justify the use of this instrument in the present study.

The results showed clearly that zinc applied in chewing gum can reduce the VSC levels to the same extent as when applied in a mouthrinse. This is not self-evident, because the zinc was included in the gum base and could thus be unavailable for effect. Furthermore, the zinc in a gum will be more slowly released than from a rinse, in which the zinc ions will be available instantly. Furthermore, the study showed that zinc has to be present in a certain amount, since the addition of 0.5 mg zinc acetate showed no significant effect. The small effect of the placebo gum is probably related to the chewing per se, since this will stimulate salivary flow to a considerable extent (23, 24), thereby increasing the oral clearance of available substrate and metabolites for odor production.

In the mouthwash the zinc was added in the form of zinc chloride, whereas the chewing gum contained zinc acetate. The reason for using a zinc chloride solution was that several previous studies on VSC inhibition with mouthrinses have been performed with this salt (13, 14, 25), and its use thus makes direct comparison possible. The results of this study supports these previous findings. Organic zinc salts have less metallic taste, and zinc acetate was therefore used in the chewing gum. Stoichiometric considerations show that the mouthrinse contained slightly more zinc than the gum. That a comparable effect was observed further supports the conclusion that the zinc is bioavailable when supplied in a chewing gum.

The chlorhexidine rinse was included in the study as a comparison because it is known to be a potent antibacterial substance. Studies have reported a favorable effect of mouthrinses with chlorhexidine on VSC production in the oral cavity (25, 26). The lack of effect in the present study was probably due to the fact that only a single rinse was performed and that the bacteria in their protected retention sites were not affected by the rinse. A prolonged application of chlorhexidine would probably have given better results. This experiment showed clearly that the mechanism of the effect is quite different for zinc ions compared with chlorhexidine. The antibacterial activity of zinc as such is probably not an important aspect of the observed effect on VSC by zinc.

Conclusion

Chewing gum seems to be a suitable vehicle for zinc in order to reduce VSC levels in the oral cavity. The effect of chewing without zinc was negligible.

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