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The erosive potential of jawbreakers, a type of hard candy

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Abstract: *Objectives:* To explore the consumption pattern of a specific type of acidic solid candy, the so-called jawbreakers, by primary school children and determine the erosive potential of this type of candy *in vivo*. *Methods:* A questionnaire about jawbreaker consumption was distributed among 10–12 year-old-children (n = 302). Subsequently, 19 healthy volunteers tested four different jawbreakers *in vivo*. Whole saliva was collected 5 min before, 3 min during and 11 min after consumption. Salivary flow rate and pH were determined. *Results:* Two-thirds of the children reported a history of jawbreaker consumption, 18% during the last week. More than half of the children estimated their average time for consumption of one jawbreaker to be more than 15 min. *In vivo*, the jawbreakers induced 8.6–13.9-fold increase in salivary flow rate. Sucking on sour, jumbo and strawberry jawbreakers induced a drop in salivary pH to values below pH 5.5. During consumption of fireball jawbreakers, the intra-oral pH hardly changed. *Conclusions:* Jawbreakers are frequently used by children, who keep this candy in their mouth for a long time. Jawbreakers differ considerable in erosive potential, with sour and jumbo jawbreakers > strawberry jawbreaker >> fireball jawbreaker. This information is of use for dental hygienists counselling juvenile patients with dental erosion.

Key words: acidic candy; dental erosion; erosion potential; flow rate; saliva

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Introduction

Dental erosion is a pathologic, chronic localized loss of dental hard tissue due to chemical dissolution of the tooth surface by acid and/or chelating agents without bacterial involvement (1). In well developed countries in the World, the prevalence of dental erosion is high in children and young adolescents, and the prevalence seems to be increasing (2–8).

The aetiology of dental erosion is multifactorial, but it is assumed that dietary sources of acids are the major risk factor in this age group. Several studies have shown a strong relation between the presence of dental erosion and a high level of consumption of cola-type and other flavoured carbonated beverages (4, 5, 9, 10). Soft drinks contain acids such as phosphoric, citric and other acids as ingredients, and their pH is often less than 4.0 (11–13).

Solid acidic candies also contain organic acids such as citric acid and malic acid to develop the characteristic sour flavour, and therefore are potentially erosive. Homogenized sour sweets dissolved in water decreased the pH to values ranging from 2.3 to 3.1 (14). Incubation of human enamel in these acid solutions *in vitro* for 1 h induced significant loss of surface enamel (14). Sucking this type of acidic candies decreased the pH of whole-mouth saliva to approximately 4.5 (15, 16), well below the pH-value of 5.5 that has generally been adopted as the critical value below which hydroxyapatite dissolves (17, 18). It was found that the Knoop surface micro-hardness of human enamel decreased *in situ*, sucking an acidic sugar-free lozenge (19). Taken together, this suggests that consumption of acidic candies can contribute to the development of dental erosion, especially in individuals with low salivary flow rates and low salivary buffer capacity (19).

Jawbreakers consist of several hard layers of candy around a bubble gum centre. They are usually round with a diameter between 1 and 3 cm. As their name suggests, they are difficult to bite, and therefore usually consumed by sucking or licking. Jawbreakers are mainly consumed by primary school children. As jawbreakers dissolve slowly, the children will keep them in the mouth for a relatively long time. The aim of the present study was twofold. Firstly, to explore the frequency and characteristics of jawbreaker consumption among school children. Secondly, to examine the erosive potential of a number of commercially available jawbreakers *in vivo* by measuring their effect on saliva pH during and after consumption.

Material and methods

A written questionnaire was distributed in October 2008 among schoolchildren between 10 and 12 years of age from three different primary schools in Rotterdam, the Netherlands. The questionnaire included questions with regard to age, gender, whether the child had ever consumed a jawbreaker, jawbreaker consumption during the previous week, and the way and estimated time jawbreakers were kept in the mouth. Participation was on a voluntary base, and the questionnaire was returned by 302 children (143 boys, 148 girls, 11 children did not report their gender).

The effects of jawbreaker on saliva secretion rate and pH were investigated in 19 healthy volunteers between 20 and 25 years of age, because the Medical Ethical Committee prohibited use of individuals under the age of 18 years. All volunteers were dental student with an optimal level of oral hygiene, fully dentate (≥28 teeth), without active caries and not suffering from xerostomia, taste or masticatory dysfunctions. The protocol was approved by the Medical Ethical Committee of the Vrije Universiteit of Amsterdam, the Netherlands. Prior to the experiment all volunteers gave informed consent. The volunteers were instructed to abstain from smoking, eating, drinking and tooth brushing at least 1 h before the experiments (20).

Four different jawbreakers (Table 1) were tested by each volunteer in randomized order on different days. Each experimental session consisted of an initial collection of unstimulated whole saliva for 5 min (21). Subsequently, a jawbreaker was placed in the mouth and whole saliva was collected in 1 min intervals for a total period of 3 min while the volunteer sucked on the jawbreaker. Subsequently, the jawbreaker was removed from the mouth and saliva was collected at 1 or 2 min intervals for an additional 11 min (post-stimulus). The preferences for the different jawbreakers were assessed with a 100 mm visual analogue scale (VAS, nasty to delicious) (22). Saliva secretion rates were determined gravimetrically (assuming 1 g = 1 ml). The salivary pH was determined with an electronic pH meter (PHM 240 Sentron 1001; Radiometer, Copenhagen, Denmark), calibrated each morning with reference buffers of pH 4.00 and pH 7.00 (Sigma-Aldrich, St. Louis, MO, USA).

Statistics

Gender effects on jawbreaker consumption were explored with Chi-squared tests. Differences in preferences, salivary pH and secretion rate between experimental conditions were explored with analysis of variance (ANOVA) for repeated measures. The statistical analysis was performed using the statistical software package SPSS version 15.0.1 (SPSS Inc., Chicago, IL, USA). All levels of significance were set at $P < 0.05$.

Results

Two hundred of the 302 children (66.2%) reported a history of jawbreaker consumption. A history of jawbreakers consumption was significantly more frequently reported by boys than by girls (72.7% versus 60.1%, $P = 0.023$). Eighteen percent of the children reported that they had used one or more jawbreakers during previous week. For consumption during the previous week, no gender effect was observed (18.5% for boys versus 17.4% for girls).

During consumption, children usually place the jawbreakers in the buccal pouch (52.3% of the children with a history of jawbreaker consumption) or suck on it (50.3%). Licking the jawbreaker (8.8%) or biting it into pieces (13.5%) was much less frequently reported. A gender effect was only observed for

Table 1. **Characteristics of the tested jawbreakers and the type of acid mentioned on the product label**

Product	Weight (g)	Diameter (mm)	Acid	Manufacturer
Strawberry jawbreaker	8.6	24	Citric acid	Zed Candy, Dublin, Ireland
Jumbo jawbreaker	21.1	31	Citric acid	Zed Candy, Dublin, Ireland
Fireball jawbreaker	8.6	23	Citric acid	Zed Candy, Dublin, Ireland
Sour jawbreaker	8.3	23	Citric acid	Zed Candy, Dublin, Ireland

Weight and diameter are the mean of five different jawbreakers.

licking jawbreakers, which was more frequently reported by girls than by boys (14.6% versus 3.8%, $P = 0.009$). More than half of the children estimated their mean time for consumption of a jawbreaker to be more than 15 min (Fig. 1). About 10.6% of the children who consumed jawbreakers reported that they sometimes play a game with other kids to keep the jawbreaker in the mouth as long as possible. These games were more often reported by boys (12.7%) than by girls (7.9%) but this difference did not reach statistical significance.

In vivo, sucking on a jawbreaker induced an immediate increase in salivary flow rate (Fig. 2). This increase in salivary flow rate varied between 8.6- and 13.9-fold during the first minute, and remained significantly increased during the whole period of 3 min while the jawbreaker was present in the mouth. During the first minute, the sour jawbreaker induced significantly more stimulation of the salivary flow than other three jawbreakers.

With the exception of the fire jawbreaker, all jawbreakers induced a significant decrease of the salivary pH within 1 min, which remained constant till the jawbreaker was removed from the mouth (Fig. 3). For the Jumbo and sour jawbreaker, the salivary pH dropped to values far below pH 5.0. The strawberry jawbreaker induced a smaller drop in salivary pH to values around 5.3.

For each jawbreaker, the salivary flow rate dropped considerable within several minutes after it was removed from the mouth, but still remained significantly increased during the whole post-stimulus period when compared to the baseline values. After removal of the strawberry, jumbo and sour jawbreakers from the mouth, the salivary pH values returned to baseline values within 1 min. After removal of the fireball jawbreaker a small but significant transient increase in salivary pH above the baseline values was observed. The fireball jawbreaker was appreciated less than the other jawbreakers, but this difference did not reach statistical significance (Table 2).

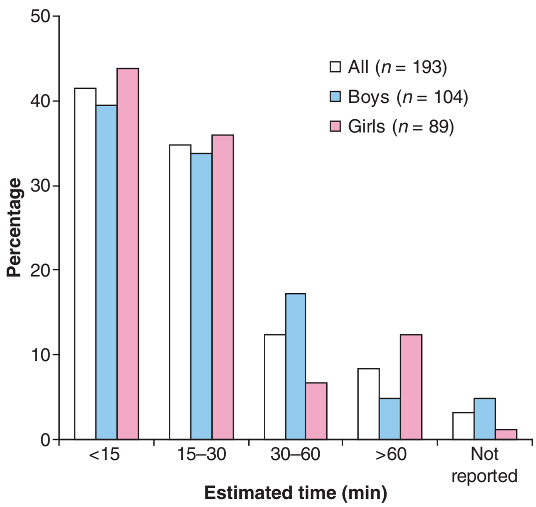

Fig. 1. Estimated time for consumption of a jawbreaker by children (10–12 years).

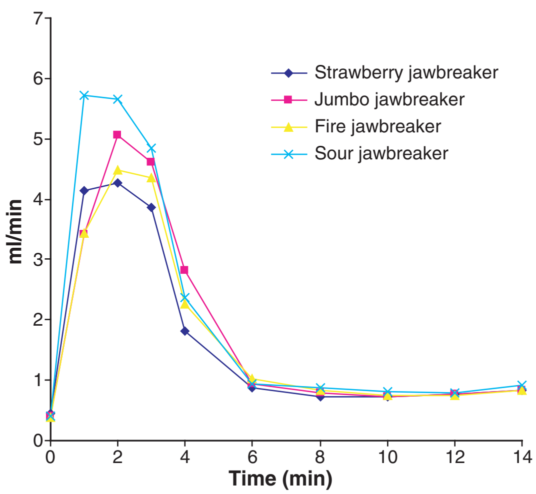

Fig. 2. Mean salivary flow rate before, during and after use of four different jawbreakers ($n = 19$). The jawbreakers were actively sucked during the period 0–3 min and then removed from the mouth.

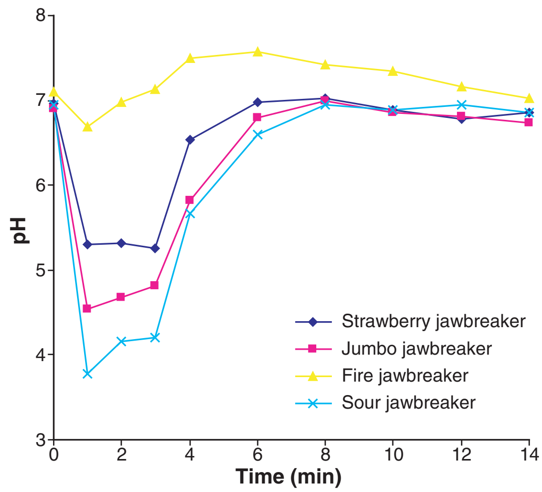

Fig. 3. Mean salivary pH before, during and after use of four different jawbreakers ($n = 19$). The jawbreakers were actively sucked during the period 0–3 min and then removed from the mouth.

Table 2. **Appreciation of four different jawbreakers by healthy volunteers, assessed with a 100 mm VAS (nasty to delicious)**

	VAS-score (mm)
Strawberry jawbreaker	62.5 ± 21.7
Jumbo jawbreaker	57.7 ± 23.5
Fireball jawbreaker	44.6 ± 34.5
Sour jawbreaker	64.1 ± 25.3

VAS, visual analogue scale.
Data are expressed as mean ± SD ($n = 19$).

Discussion

The results from this study show that primary school children frequently use jawbreakers. They keep this type of hard candy in their mouth for prolonged times, and some kids even compete with other children to keep a jawbreaker in the mouth as long as possible.

Immediately after the jawbreakers were introduced into the mouth, each tested variant stimulated the salivary flow rate (Fig. 2), to a comparable extent as acidic candies or lollipops (16, 23). In spite of the protective effects of saliva (buffering and dilution) (14, 15, 24), the jumbo jawbreaker and the sour jawbreaker decreased the intra-oral pH values considerably below the pH-value of 5.5, the value that has generally been adopted as the critical value below which hydroxyapatite dissolves (17, 18), indicating the erosive potential of these jawbreakers *in vivo*. This is in agreement with similar studies showing the erosive potential of other solid acidic candies (14–16, 19, 23, 25).

The strawberry jawbreaker gave a smaller decrease in intra-oral pH, suggesting a smaller erosive potential. This is not a general characteristic for strawberry-flavoured candy. Previously it has been reported that strawberry-flavoured lollipops have similar erosive potential *in vivo* than lollipops with other flavours (23). After intra-oral application of a single dose of candy spray, the lowest pH values were observed for two strawberry-flavoured variants (26).

According to the product label, all tested jawbreakers contained citric acid. However, the observed large differences in decrease of intra-oral pH during consumption suggest considerable differences in concentration of citric acid. Citric acid is a complex organic acid. At low pH values, it provides protons which directly attack dental enamel. At higher pH levels around pH 7.0, the citrate anion may draw calcium away from the enamel by chelation. This means that the demineralising effect of citric acid is exceptionally great and may even continue after the pH at the tooth surface has normalized (11, 24, 27).

The present *in vivo* study is based on the use of jawbreakers by young adult volunteers. However, jawbreakers are mainly used by children and the volume of saliva in children is smaller than in adults (28, 29). Therefore, in children the same jawbreaker may result in even lower salivary pH values. The size of the jawbreaker will also determine its erosive potential, because the mass of acidic lozenges was related to the level of enamel softening *in situ* (19). The use of acidic jawbreakers for a long period of may exacerbate their erosive potential, as the longer the teeth are exposed to acid, the longer the period of time for erosion to occur and the less time for remineralisation (12, 13). In this respect, it seems disturbing that a sour jawbreaker is available in an approximately 80 g version with a diameter of 48 mm, which is advertised as ‘do you dare take the 8 h-challenge’ (30).

Differences seem to exist in susceptibility of deciduous and permanent dentition to erosion by low pH drinks and solid acidic candy (14, 31, 32). In general, erosion of enamel was greater in the deciduous tissue, especially with increased frequency of consumption. In combination with the smaller dimensions, this makes the deciduous dentition more susceptible to the long-term acid attack by jawbreakers.

When the outer layers of hard candy are finally dissolved, the child will start chewing the bubble gum centre, presenting an additional threat to the enamel surface. The long-term exposure to acid will have softened the dental enamel, making it more prone for mechanical tooth wear due to attrition by the subsequent chewing of gum. It is well-recognized that such interactions between erosion and attrition can have a synergistic effect on the risk of tooth wear (33, 34).

In summary, our study shows that jawbreakers are frequently used by schoolchildren, who keep this type of candy in their mouth for a long time. The tested jawbreakers differed considerable in erosive potential, with jumbo and sour jawbreakers having a relatively high risk for developing dental erosion. Dental hygienists must be aware of this erosive potential and should inform juvenile patients and their parents that (excessive) use of jawbreakers may cause tooth wear.

References

1 Ten Cate JM, Imfeld T. Dental erosion, summary. *Eur J Oral Sci* 1996; **104:** 241–244.

2 Deery C, Wagner ML, Longbottom C, Simon R, Nugent ZJ. The prevalence of dental erosion in a United Sates and a United Kingdom sample of adolescents. *Pediatr Dent* 2000; **22:** 505–510.

3 Linnett V, Seow WK. Dental erosion in children: a literature review. *Pediatr Dent* 2001; **23:** 37–43.

4 Nunn JH, Gordon PH, Morris AJ, Pine CM, Walker A. Dental erosion – changing prevalence? A review of British National childrens’ surveys. *Int J Paediatr Dent* 2003; **13:** 98–105.

5 Dugmore CR, Rock WP. A multifactorial analysis of factors associated with dental erosion. *Br Dent J* 2004; **196:** 283–286.

6 Jaeggi T, Lussi A. Prevalence, incidence and distribution of erosion. *Monogr Oral Sci* 2006; **20:** 44–65.

7 Kazoullis S, Seow WK, Holcombe T, Newman B, Ford D. Common dental conditions associated with dental erosion in schoolchildren in Australia. *Pediatr Dent* 2007; **29:** 33–39.

8 El Aidi H, Bronkhorst EM, Truin GJ. A longitudinal study of tooth erosion in adolescents. *J Dent Res* 2008; **87:** 731–735.

9 Al-Dlaigan YH, Shaw L, Smith A. Dental erosion in a group of British 14-year-old school children. Part II: influence of dietary intake. *Br Dent J* 2001; **190:** 258–261.

10 Jensdottir T, Arnadottir IB, Thorsdottir I *et al.* Relationship between dental erosion, soft drink consumption, and gastroesophagealreflux among Icelanders. *Clin Oral Investig* 2004; **8:** 91–96.

11 Järvinen VK, Rytömaa II, Heinonen OP. Risk factors in dental erosion. *J Dent Res* 1990; **70:** 942–947.

12 Lussi A, Jaeggi T, Zero D. The role of diet in the aetiology of dental erosion. *Caries Res* 2004; **38(suppl 1):** 34–44.

13 Moynihan PJ. Dietary advice in dental practice. *Br Dent J* 2002; **193:** 563–568.

14 Davies R, Hunter L, Loyn T, Rees J. Sour sweet a new type of erosive challenge. *Br Dent J* 2008; **204:** E3.

15 Jensdottir T, Nauntofte B, Buchwald C, Bardow A. Effects of sucking acidic candy on the whole-mouth saliva composition. *Caries Res* 2005; **39:** 468–474.

16 Jensdottir T, Nauntofte B, Buchwald C, Bardow A. Effects of calcium on the erosive potential of acidic candies in saliva. *Caries Res* 2007; **41:** 68–73.

17 Ericsson Y. Enamel apatite solubility. *Acta Odontol Scand* 1949; **8(suppl 3):** 1–139.

18 Larsen MJ, Pearce EIF. Saturation of human saliva with respect to calcium salts. *Arch Oral Biol* 2003; **48:** 317–322.

19 Lussi A, Portman P, Burhop B. Erosion on abraded dental hard tissues by acidic lozenges: an in situ study. *Clin Oral Investig* 1997; **1:** 191–194.

20 Hoek GH, Brand HS, Veerman ECI, Nieuw Amerongen AV. Toothbrushing affects the protein composition of whole saliva. *Eur J Oral Sci* 2002; **110:** 480–481.

21 Bosch JA, Brand HS, Ligtenberg TJ, Bermond B, Hoogstraten J, Nieuw Amerongen AV. Psychological stress as a determinant of protein levels and salivary-induced aggregation of *Streptococcus gordonii* in human whole saliva. *Psychosom Med* 1996; **58:** 374–382.

22 Bots CP, Brand HS, Veerman ECI, van Amerongen BM, Nieuw Amerongen AV. Preferences and saliva stimulation of eight different chewing gums. *Int Dent J* 2004; **54:** 143–148.

23 Brand HS, Gambon DL, Paap A, Bulthuis MS, Veerman ECI, Nieuw Amerongen AV. The erosive potential of lollipops. *Int Dent J* 2009; **59:** 358–362.

24 Hunter ML, Patel R, Loyn T, Morgan MZ, Fairchild R, Rees JS. The effect of dilution on the *in vitro* erosive potential of a range of dilutable fruit drinks. *Int J Paediatr Dent* 2008; **18:** 251–255.

25 Bibby BG, Mundorff SA. Enamel demineralization by snack foods. *J Dent Res* 1975; **54:** 461–470.

26 Gambon DL, Brand HS, Nieuw Amerongen AV. The erosive potential of candy sprays. *Br Dent J* 2009; **206:** E20.

27 Lussi A, Jaeggi I. Erosion – diagnosis and risk factors. *Clin Oral Investig* 2008; **129(suppl 1):** S5–S13.

28 Crossner CG. Salivary flow rate in children and adolescents. *Swed Dent J* 1984; **8:** 271–276.

29 Watanabe S, Dawes C. Salivary flow rates and salivary film thickness in five-year-old children. *J Dent Res* 1990; **69:** 1150–1153.

30 http://www.zedcandy.com/Sour-Mammouth-Jawbreaker-!WZ4017-prod.html [accessed December 14, 2009].

31 Hunter ML, West NX, Hughes JA, Newcombe RG, Addy M. Erosion of deciduous and permanent dental hard tissue in the oral environment. *J Dent* 2000; **28:** 257–263.

32 Hunter ML, West NX, Hughes JA, Newcombe RG, Addy M. Relative susceptibility of deciduous and permanent dental hard tissues to erosion by a low pH fruit drink *in vitro*. *J Dent* 2000; **28:** 265–270.

33 Litonjua LA, Andreana S, Bush PJ, Cohen RE. Tooth wear: attrition, erosion and abrasion. *Quintessence Int* 2003; **34:** 435–446.

34 Addy M, Shellis RP. Interaction between attrition, abrasion and erosion in tooth wear. *Monogr Oral Sci* 2006; **20:** 17–31.