Provides a background about the link between acidic barrages and dental erosion.

Provide better understanding of the criteria of novelty sweet and potential risk of developing dental erosion upon the frequent consumption of this type of sweet.

The data obtained in this study would provide good understanding of various erosive factors of the acidic food.

This study provides a scientific information used by dental personnel in counselling patients who consume this type of sweet or at risk of developing dental erosion.

The data obtained in this study would also help in the prevention strategy of dental erosion early in childhood.

Investigation of the erosive potential of sour novelty sweets

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Background The expansion of the novelty sweets market in the UK has major potential public health implications in children and young adults as they may cause dental erosion. **Objective** To investigate the erosive potential of the novelty sweets in term of their physiochemical properties and amount of enamel loss. **Subjects and methods** Novelty sweets were tested *in vitro* for pH using a pH meter and neutralisable acidity by titrating the sweets against 0.1M NaOH. The viscosity of the novelty sweets was measured using a rotational viscometer. The wettability of enamel by each sweet was measured using dynamic contact angle analyser. Enamel loss was assessed using contact profilometry. **Results** The pH ranged from 1.8-3.2,

the neutralisable acidity ranged from 9-201ml of 0.1 NaOH. The viscosity of the novelty sweets that come in liquid form ranged from 2-594 mPa-s. The surface enamel erosion ranged from 1.95-15.77 μm and from 2.5–17.6 μm with and without immersing in saliva for 1 hour before immersing in acidic solution respectively. The amount of subsurface enamel loss was ranged from 0.75 to 2.3 μm following ultrasonication at 0 min of acidic attack and from 0.23 to 0.85 μm at 60 minutes of acidic attack while immersed in saliva. The contact angle between enamel surface and four sweet was less than the angle formed between the orange juice and the enamel which caused more wettability of enamel. **Conclusion** The pH is lower than the critical value for enamel erosion (5.5), high neutralisable acidity and high sugar content strongly suggest that these sweets may cause significant amount of dental erosion clinically. In addition, the degree of wettability of enamel by solution is an important factor to consider in determining the enamel loss caused by acidic solution. Immediate tooth brushing would cause further enamel loss as a result of the mechanical removal of softened enamel. However, it has been suggested that postponing brushing after erosive attack should be reconsidered.

INTRODUCTION

Epidemiological studies have highlighted that frequent consumption of acidic foods and/or drinks can lead to the development of dental erosion which is the most common type of tooth surface loss (TSL).[1–3] The development of TSL at an early age in deciduous and mixed dentition is becoming an increasing concern for the dental profession with erosion being the primary cause. The most recent National Child Dental Health Survey reported an increase tooth surface loss (TSL) for all age-groups taking part between 2003 and 2013. For example, in 12 year olds TSL in incisors increased from 12% to 24% and from 30% to 38% in buccal and lingual surfaces

respectively; the increase in molar teeth was from 19% to 25%.[3]

Over the last decade sour and novelty sweets have continued to gain popularity in the UK.[4] Sour sweets were first introduced in the late 1970s by adding a sour flavoured coating which contained a mixture of simple organic acids such as citric, malic and tartaric, to the surface of the sweet. Sour sweets, incorporating novelty sweets, a more recent development, have grown in market share and social acceptability. For example in the UK, in 2015 Haribo™ was the leading social brand food company according to their Fast Moving Consumer Goods ranking.[5] Novelty sweets are characterised by being sold in resealable packages, both sweet and sour tasting, are usually brightly coloured, resemble or can be used as toys and are sold at pocket money prices. The marketing of novelty sweets is mainly directed towards children who are the primary consumers of sweet confectionery in the UK.[6]

Novelty sweets are of particular concern because they contain both high levels of free sugars and acids. Furthermore, their unusual product design facilitates regular frequency of consumption as many are available in resealable packages. Consequently, they have the potential to cause dental caries and dental erosion[7–11] and for children to consume extra "empty calories" which could lead to the development of overweight or obesity.[12–14] It is because of these concerns relating to oral and general health that it is important to address free sugar, including confectionary consumption, as a part of an overall health promotion programme.[15,16]

Many properties of the acidic solutions emanating from food and drink consumption influence the amount of enamel and dentine loss. These factors include pH and buffering capacity[17], wettability of enamel surface by the solution[18], viscosity of the acidic solution[19] and temperature.[20]

To date, studies on the health implications of novelty sweets are limited, addressing only the pH, neutralisable acidity and enamel loss associated with their consumption and their general availability to children.[16,21–26]

The objective of this study was to give more detailed information about the erosive potential of novelty sweets and to build on existing research which has assessed the erosive potential of novelty sweets in terms of pH, neutralisable acidity and surface enamel loss. In this study, in addition to the previously investigated factors, wettability of enamel surface by these sweets, measurements of the viscosity of these sweets and subsurface enamel loss with and without initial treatment were assessed.

This study is a part of series of studies undertaken to identify the most commonly available novelty sweets by Aljawad *et al.*[27]. The most commonly available sweets from a recent scoping study is shown in Table 1 below. The study hypothesis is that novelty sweet consumption has major potential public health implications in children as they may cause dental erosion.

MATERIALS AND METHODS

The ten selected sweets plus distilled water as a negative control and orange juice (Tropicana smooth) as a positive control were tested. Sweets which had solid and syrup components were tested separately. This applied to two products, Juicy Drop Pop and Big Baby Pop. The remaining sweets which were presented as hard boiled sweets were ground up using a pestle and mortar. 10g of powder was dissolved in 20ml of water following the method of Davies *et al.*[21] This applied to five products, Juicy Drop Pop, Big Baby Pop, Push Pop, Toxic Waste, Brain Blasterz.

pH

The pH of each novelty sweet was assessed using an electronic pH meter on a magnetic stirrer (HANNA pH meter HI 2210, HANNA instruments, Michigan, USA). The pH meter was calibrated before each use using pH 7 and 4.01 buffering solutions and the probe was washed using distilled water between each use to remove any remaining residues. The pH of each sweet was measured using ten samples and mean and standard deviations calculated. pH was measured at room and body temperature in a temperature controlled room.

Neutralisable acidity

The neutralisable acidity was tested by placing 20ml of each liquid sweet and each prepared hard boiled sweet in a glass beaker on a magnetic stirrer and 0.1M sodium hydroxide was gradually added until neutrality was reached[21]. Sweets presented as hard boiled were ground up using a pestle and mortar then prepared by dissolving 10g of powder in 20ml of water following the method of Davies *et al.*[21]

The amount of sodium hydroxide needed to increase the pH to 7 was noted. Each sweet was tested using ten samples and the mean and standard deviations were calculated.

Contact angle measurement (wettability)

Specimens of human enamel were sourced from recently extracted permanent teeth following informed consent and ethical approval from South East Research Ethics Committee, Cardiff, UK (Ref. 12/WA/0289).

Measurement of the contact angle required the preparation of crowns with a flat enamel surface for each side (buccal, lingual, mesial and distal). Sectioning of teeth was undertaken

using a low speed machinery saw with a water soluble coolant (Model 650 low speed diamond wheel saw, South Bay Technology, US). Samples were surface polished using 600 grit then 1200 grit abrasive discs on an automatic polishing machine (Kemet International Limited, Maidstone, UK) under water cooling to give a flat surface to allow the contact angle analyser to measure the contact angle between each novelty sweet solution and enamel surface. Enamel crowns were randomly allocated to each test groups (10 samples for each group) using a random allocation software (RAS, v 2.0) (Saghaei, Asfahan, Iran) (Schulz and Grimes 2002; Dettori 2010). Enamel samples were labelled by permanent marker from 1 to 140 to allow the software to randomly allocate 10 samples for 14 groups.

A dynamic contact analyser (model 312; Thermo Cahn, Madison, Wisconsin, USA) linked to a computer was used to measure the contact angle.

This angle reflects the wettability of surface enamel by each type of solutions which in turn may reflect the potential enamel loss by acidic solution[19].

The methodology used to measure the contact angle included the following.

40 ml of sweet solution was placed in a glass beaker and placed on a movable table of the contact angle analyser.

Each enamel specimen was attached to an electrobalance holder above the glass beaker which was placed on the movable table. The table gradually moved with the glass beaker upward towards the enamel sample once activated by the computer while the wetting medium scanned along at a constant speed via a computer-controlled stage.

The enamel sample was then pulled up by the downward movement of the table once the appropriate depth in the solution was reached.

For each test group, 10 enamel specimens were used at room temperature.

The enamel specimen was immersed and emersed. This allowed for measurement of wetting tensions which was subsequently used to calculate the contact angles by the software in the computer linked to the contact angle analyser.

The mean contact angle and standard deviation of the ten measurements of each sweet were calculated.

Measuring the viscosity using the rotational viscometer

The viscosity of the novelty sweets which came in liquid forms in addition to orange juice (Tropicana smooth) and water as positive and negative control solutions was measured using a rotational viscometer (Cole-Parmer, London, UK). This was applied to Vimto Candy Spray, Tango Candy Spray, Mega Mouth, Juicy Drop Pop, Brain Licker and Lickedy Lips. The rotational viscometer measures the viscosity proportional to the motor torque that is required for turning the spindle against the fluid's viscous forces. This is called the Searle principle.[28]

The test material was placed in a beaker with an amount enough to immerse the spindle to be in the centre of the glass beaker. The required spindle was attached to the lower shaft of the viscometer. The lower shaft was held in one hand and the spindle screwed clockwise. The speed (shear rate) was selected to be fixed at 100 RPM.

The readings were taken 3 times for each material and a mean and SD calculated. The Viscosity readings were given in centipoises (mPa-s). Between each measurement, the spindle was removed and washed out by water to remove the test material. All the measurements were taken at room temperature and all measurement were made on the same day.

Erosion test

Crowns used for the contact angle measurement were sectioned using a low speed machinery saw with a water soluble coolant to obtain 280 enamel specimens. Enamel specimens were embedding in low exothermic epoxy resin (Stycast 1266, Emerson & Cuming, Nijverheidsstraat, 2431 Westerlo, Belgium). Three baseline readings were taken using a contact profilometer (Mitutoyo, surftest-SV2000, Mitutoyo America, USA) for each sample using the method of West *et. al.*[29] were recorded for each enamel sample before undertaking the enamel surface loss. Samples with a stylus deflection to baseline of less than 0.30 μm were used in the study. A 2x2mm window of enamel sample of enamel sample was exposed to 70ml of stirred solution for one hour at body temperature and the other part was covered using PVC tape (Henleys Medical supplies, Hertfordshire, UK) to assess the difference in the readings between the exposed and un-exposed part of the enamel sample.

Samples were randomly divided into 14 groups using a random allocation software v 2.0 (RAS, v 2.0,Saghaei, Asfahan, Iran) with 10 samples in each group (12 test solutions, one positive control using orange and one negative control using water).

Surface enamel loss

To assess the effect of saliva on amount of enamel loss, stimulated neutral saliva was collected from the researcher (34 years old) using paraffin wax provided in the saliva-check kit (GC Europe N.V., Leuven, Belgium). The saliva sample was collected in the morning between 10:00am and 12:00pm. The collected saliva samples were stored in a water bath at body temperature. The salivary pH and buffer capacity of the collected saliva was checked using the saliva-check kit. The pH of the saliva used was 7.6 while the buffer capacity was normal/high.

Ten enamel specimens were immersed in natural saliva (collected from the researcher) for 1 hour in a water bath set at 37°C before immersing them in each sweet solution for 1 hour (group A) to assess the effect of saliva on the amount of enamel loss. Another ten enamel specimens were immersed in a glass beaker in each type of solution set at 37° C and exposed to 70ml of each sweet solution for one hour, for example, with no immersion in saliva (group B). Ten samples were immersed in orange juice as a positive control group and another ten samples in water as a negative control group.

Following exposure, samples were washed with distilled water, dried and surface profiles of the exposed surface measured using surface profilometery and compared to pre-exposure measurements. The value measured by the profilometry is the average of both erosion depth and roughness of exposed surface[21].

When enamel is exposed to dietary acid this causes a shift in the normal mineral dynamic ionic exchange between the enamel and the plaque fluid, mostly from the sub-surface enamel as microradiographs of white spot lesion. The extent of the softening can be assessed by ultrasonicating the enamel specimens after exposure to the test liquid following the method of Eisenburger et. al.[30]

For the subsurface softening part of this study, the enamel specimens were treated as above but following exposure to the test solution they were ultrasonicated at 37°C in water for 30 seconds using 100W at 38 kHz. Following ultrasonication, enamel loss will be assessed using contact profilometry as above.

The ten enamel specimens in group A placed in natural saliva for 1 hour immediately after measuring the amount of enamel loss using the contact surfometer to assess the effect of saliva

on the sub-surface enamel loss. Then, they were placed in the ultrasonic bath at 37°C for 30 seconds. Then, the amount of subsurface loss was measured using the contact surfometer.

The other ten enamel specimens in group B were placed in the ultrasonic bath at 37°C for 30 seconds immediately after immersing them in the sweet solution and measuring the amount of enamel loss using the contact surfometer without placement in saliva. Then, the amount of subsurface loss was measured using the contact surfometer.

STATISTICAL ANALYSIS

Results of pH, neutralisable acidity and enamel loss for each group of samples were analysed using SPSS (IBM Corporation, Chicago, USA) analysis of variance followed by Tukey's test was performed with statistical significance set at $p < 0.05$.

RESULTS

pH

The pH of the tested novelty sweets ranged from 1.8-3.2 at body temperature (Table 2). Toxic waste had the lowest pH value (1.8) while Big Baby Pop lollipop had the highest pH value (3.2).

The pH of eight sweets (at both room temperature and body temperature) was also statistically significantly lower than the pH of the orange juice (3.7) used as a control ($p<0.05$). These sweets, with appropriate pH were Brian Licker (1.92), Toxic Waste (1.83), Lickedy Lips (1.9), Vimto Candy Spray (2.43), Brain Blasterz (2.3), Big Baby Powder (2.3), Mega Mouth (1.83) and Juicy Drop Syrup (2.24).

Neutralisable acidity

The values of neutralisable acidity ranged from 201 ml of 0.1M NaOH for the Juicy Drop Syrup

to 9 ml for Push Pop (Table 3). The mean neutralisable acidity of seven of the novelty sweets was statistically significantly higher than the neutralisable acidity of the orange juice (28.4 ml NaOH) ($p<0.05$). These sweets, with relevant neutralisable acidity's were; Toxic Waste (93.6 ml), Lickedy Lips (40.2 ml), Vimto Candy Spray (70 ml), Tango Candy Spray (41.6 ml), Brain Licker (49 ml), Juicy Drop Syrup (201 ml) and Mega Mouth (95 ml).

Contact angle

The results show that the widest contact angle was formed between enamel surface and the Juicy drop syrup with 105° surface while the narrowest contact was between the enamel surface and the Vimto solution with 75.22° which caused the highest wettability of the enamel surface (Table 4). The contact angle between enamel surface and orange juice (Tropicana smooth) and between enamel surface and water were 75.74° and 74.55° respectively.

The contact angle between four types of the selected novelty sweets and enamel surface were smaller than the contact angle between the orange juice and enamel surface. These sweets were Brain Blasterz (75.4°), Tango Candy Spray (75.43°), Toxic Waste (75.4°) and Vimto Candy Spray (75.22°).

Viscosity of the novelty sweets

Viscosity could only be tested on the sweets and control solutions that were in liquid form. The results show that the sweet with the highest viscosity was the Juicy Drop Syrup with 594 mPa-s and the lowest is the Vimto spray with 1.7 mPa-s in comparison to the orange juice (Tropicana smooth) with 3 mPa-s and water with 1 mPa-s (Table 5). There was a statistical significant difference in viscosity between four types of the selected novelty sweets and orange juice

(p<0.05). These novelty sweets were Mega Mouth (12.85 mPa-s), Lickedy Lips (78.82 mPa-s), Brain Licker (66.90 mPa-s) and Juicy Drop Syrup (594.81 mPa-s).

Erosion tests

Surface enamel loss

Surface enamel loss caused by novelty sweets ranged from 2.5–17.64 μm (Table 6 and Figure 1). The erosion caused by six novelty sweets (in both Group A and Group B) was statistically significantly higher than the erosion caused by orange juice (positive control) (P<0.05). These novelty sweets were Toxic Waste, Vimto Candy Spray, Tango Candy Spray, Brain Blasterz, Big Baby Pop, Juicy Drop Pop. Surface enamel loss caused by novelty sweets after initial placement of enamel specimens in saliva (1h) then in the sweet solution (1h) were slightly lower and ranged from 1.95-15.77 μm. A pre-treatment cycle using saliva reduced surface enamel loss by 0.34-1.87 μm.

Furthermore, there was no statistical significant difference between the amount of surface enamel loss with enamel samples initially placed in saliva for one hour and amount of surface enamel loss without immersing the samples in the saliva for all groups (p>0.05).

Sub-surface enamel softening

The amount of subsurface enamel loss caused by the tested novelty sweets after 1 hour together with immersing in saliva before ultrasonication for 30 seconds ranged from 0.23-0.85 μm (Group A). The amount of subsurface enamel loss caused by the novelty sweets with immediate ultrasonication (without immersing in saliva) ranged from 0.75-2.3 μm.

The mean subsurface enamel loss in Group A and Group B caused by six test sweet were

statistically significantly higher than the mean subsurface enamel loss caused by the orange juice ($p<0.05$). These novelty sweets were Brain Blasterz, Juicy Drop Pop, Toxic Waste, Mega Mouth, Tango and Vimto.

Furthermore, the amount of subsurface enamel loss caused by the tested novelty sweets in group A was a statistically significantly lower than the amount of subsurface enamel loss in Group B ($p< 0.05$). The results of the two groups of sub-surface enamel loss are presented in Table 7 and Figure 2.

DISCUSSION

This study found that the pH of the most common novelty sweets ranged from 1.83-3.20. At pH of 5.5, the ionic exchange shifts increasingly towards net mineral loss from the enamel.[31]

It was found that the pH of eight tested novelty sweets' solutions was significantly lower than the pH of the orange juice when tested at room temperature (20^0 C) and body temperature (37^0 C).

These findings were comparable to the result of the study by Beeley[22] who found that the pH of the novelty sweet tested (Brain Licker, Juicy Drop Pop, Mega mouth and Big Baby Pop) ranged from 1.7-3.4. The results were also similar to the findings of Davies et. al.[21] who found that the pH of the novelty sweets ranged from 2.3-3.14 (Brain Licker, Juicy Drop Pop and Mega Mouth were common with this study).

The findings of this study show no statistically significant differences in pH between the selected novelty sweets at room and body temperature ($p>0.05$) which is consistent with the findings of Amaechi et. al.[32] who found that a difference in temperature did not affect the pH of measured variety of acidic solutions, an important consideration in determining if these

sweets have erosive potential.

The erosive potential does not exclusively depend on the pH of the novelty sweets, but it also depends on their neutralisable acidity. The greater the neutralisable acidity, the longer it takes for the saliva to neutralise it.[33] The data from the present study shows that the neutralisable acidity of Toxic Waste, Lickedy lips, Vimto candy spray, Tango candy spray, Brain Licker, Juicy drop (Syrup) and Mega Mouth was significantly higher than the neutralisable acidity of the orange juice when tested at room temperature and body temperature.

These findings are largely comparable to the result of the study of Davies et. al.[21] which found that the neutralisable acidity of the tested novelty sweets range from 9.78–77ml of 0.1 NaOH and the neutralisable acidity of orange juice was 37.1 ml of 0.1 NaOH.

The resulting range of neutralisable acidity values suggests strongly that most of the novelty sweets tested can potentially cause a drop in intra-oral pH considerably more than the orange juice which could cause clinically significant erosion.[34]

The viscosity and contact angle between of the selected novelty sweets and enamel surface were measured to assess the wettability of enamel and subsequent diffusion into the enamel surface and cause enamel dissolution.[18,19] The findings of this study showed that the higher the contact angle values of the novelty sweets, the lower the wettability of enamel surface and therefore potentially the less amount of enamel loss. For example, the contact angle between the Juicy Drop Syrup and enamel surface was 105 degrees (higher than orange juice at 75.7 degrees) and the viscosity was 594 mPa-s (higher than orange juice at 3 mPa-s), but caused significantly less amount of surface enamel loss 3.3 μm (compared to orange juice at 4.75 μm). The pH of the Juice Drop Syrup was 2.24 (lower than the orange juice 3.7) and the neutralisable

acidity was 201 ml NaOH (higher than orange juice 28.3 ml NaOH).

These findings showed that the viscosity of novelty sweets' solutions and the contact angle with enamel surface by these sweets may be potentially important determinants of the amount of enamel loss. This finding is consistent with the finding of Aykut-Yetkiner *et al.*[19] who found that the amount of enamel loss was dependent on the viscosity of the acidic solutions, not only its chemical properties. This finding is also consistent with the finding of Ireland *et al.*[18] who found that the wettability of the enamel surface directly affected the amount of enamel loss which resulted in longer enamel exposure to acidic solutions.

The results of the surface erosion tests showed that the mean amount of surface enamel removed by orange juice was 4.75 μm. The greatest amount of enamel removed was by Toxic Waste at 17.64 μm, while the least amount of surface enamel removed was by Brain Licker at 2.5 μm.

These findings were consistent with the findings of a previous study[21] where the amount of surface enamel loss caused by Juicy Drop Pop, Mega Mouth and Brain Licker in the present study is comparable to the amount of enamel loss caused by the same sweet in the study of Davies *et al.*[21]

The results of this study show that the amount of enamel loss caused by the orange juice was 4.75 μm. This was close to previous findings 5.27μm[35] 3.23 μm[36]], 5.2 μm[37] and 5.3 μm[21].

The results of this study also showed that there was no significant effect of saliva on the amount of surface enamel loss ($p>0.05$), but it did significantly reduce the subsurface enamel loss ($p<0.05$). Thus, the findings of this study also showed that the saliva confers a protective function against the subsurface dental erosion and that delayed tooth brushing for 1 hour may

allow the softened subsurface enamel to remineralise as demonstrated by Jaeggi and Lussi[38]. However, a recent study of Lussi et. al.[39] suggested that postponing brushing after erosive attack should be reconsidered.

The result of this study also showed that there was no significant difference between the amount of surface enamel loss caused by novelty sweets with initial placement of enamel samples in saliva for one hour and without placement ($p>0.05$). This finding may be explained by the possibility that the acquired pellicle or the formed pellicle was thin and did not make a significant protection from surface enamel loss consistent with Nekrashevych *et al.*[40].

CONCLUSIONS

The results of this study examining the physical and chemical properties of the novelty sweets provide further understanding of the potential effects of these sweets on dental tissues.

Although the erosive potential of these sweets varies, all can be considered as potentially erosive.

Clinicians need to counsel young patients about the potential development of dental erosion to avoid the frequent consumption of acidic food including novelty sweets. Additionally, it is important to inform patients who consume these sweets to avoid any physical challenge such as tooth brushing after the acidic challenge and delay this by about an hour.

Those personnel involved in delivering dental and wider health education or health promotion also need to be aware of the potential effect of consumption of novelty sweets on dental and general health. Parents and children also need to be informed about the possible implications of the frequent use of such type of sweets.

Table 1 The most commonly available novelty sweets identified by Aljawad et al. (2016).

Sweet	***Name***	***Contents***
	Brain Licker	glucose-fructose syrup, acidifiers, citric acid, lactic acid, malic acid
	Lickedy Lips	glucose-fructose syrup, acidifiers, citric acid, lactic acid, malic acid
	Push Pop	Sugar, glucose syrup, lactic acid
	Vimto	Sugar, malic acid, citric acid, acid regulator (sodium citrate)
	Tango	Sugar, malic acid, citric acid, acid regulator (sodium citrate)
	Juicy Drop Pop	Sugar, glucose syrup, fructose syrup, citric acid, malic acid
	Toxic Waste	Sugar, glucose syrup, citric acid, malic acid
	Big Baby Pop	Sugar, glucose syrup, citric, lactic acid

	Mega Mouth	Sugar, citric acid
	Brain Blasterz	Sugar, acidity regulator

Table 2 H of tested novelty sweets at room and body temperature (standard deviation in parentheses). Values in red are statistically significantly lower than the pH of orange juice (p<0.05).

Product	***Mean pH at room temperature***	***Mean pH at body temperature***
Big Baby Pop	3.22 (0.043)	3.18 (0.033)
Big Baby Pop (powder)	2.3 (0.011)	2.37 (0.02)
Brain Blasterz	2.3 (0.01)	2.3 (0.008)
Brain Licker	1.92 (0.02)	2.05 (0.033)
Juicy Drop Pop	3.12 (0.018)	3.16 (0.021)
Juicy Drop (Syrup)	2.24 (0.007)	2.33 (0.02)
Lickedy Lips	1.9 (0.017)	2 (0.041)
Mega Mouth	1.83 (0.043)	1.93 (0.033)
Push Pop	3.11 (0.023)	3.15 (0.011)
Tango	3.18 (0.022)	3.21 (0.021)
Toxic Waste	1.83 (0.026)	1.93 (0.035)
Vimto	2.43 (0.016)	2.46 (0.015)
Orange Juice (Tropicana smooth)	3.7 (0.02)	3.81 (0.01)

Table 3 Neutralisable acidity of tested novelty sweets at room temperature and body temperature (standard deviation in parentheses). Values in red are statistically significantly higher than the orange juice (p<0.05).

Product	***Mean Titratable Acidity at room temperature in ml***	***Mean Titratable Acidity at body temperature in ml***
Big Baby Pop (pop)	10.1 (0.16)	10.4 (0.14)
Big Baby Pop (powder)	10.4 (0.11)	10.6 (0.2)
Brain Blasterz	29 (0.15)	29.5 (0.34)
Brain Licker	49 (0.43)	48.5 (0.13)
Juicy Drop (pop)	9.9 (0.17)	10.2 (0.24)
Juicy Drop (Syrup)	201.3	202 (0.43)
Lickedy Lips	40.2 (0.23)	40.7 (0.42)
Mega Mouth	95 (0.16)	95.3 (0.14)
Push Pop	9 (0.083)	9.2 (0.11)
Tango	41.65 (0.45)	41.6 (0.42)
Toxic Waste	93.6 (0.71)	94.1 (0.43)
Vimto	69.7 (0.36)	70.7 (0.42)
Orange Juice (Tropicana smooth)	28.3 (0.46)	28.4 (0.42)

Table 4 Contact angles measured between the tested novelty sweets and enamel surface (standard deviation in parentheses).

Product	***Average contact Angle***
Big Baby (Pop)	76.9° (2.93)
Big Baby (Powder)	84.3° (3.14)
Brain Blasterz	75.4° (2.9)
Brain Licker	96.25° (2.06)
Juicy Drop (Pop)	77.14° (2.42)
Juicy Drop (Syrup)	105° (3.04)
Lickedy Lips	97.4° (2.58)

Mega Mouth	86.5° (1.8)
Push Pop	83.6° (2.81)
Tango	75.43° (0.7)
Toxic Waste	75.4° (2.34)
Vimto	75.22° (2.15)
Water	74.55° (2.6)
Orange Juice	75.745° (2.9)

Table 5 The viscosity of novelty sweets, orange juice and water (standard deviation in parentheses). Values in red are statistically significantly higher than the viscosity of orange juice.

Material	***Spindle size***	***Viscosity (mPa-s) (n=10)***
Brain Licker	L2	66.90 (0.13)
Juicy Drop Syrup	L3	594.81 (0.10)
Lickedy Lips	L2	78.82 (0.13)
Mega Mouth	L1	12.85 (0.13)
Tango	L1	2.00 (0.03)
Vimto	L1	1.78 (0.04)
Water	L1	1.00 (0.02)
Orange Juice (Tropicana smooth)	L1	3.00 (0.54)

Table 6. Total surface enamel loss with initial placement in saliva (Group A) and without initial placement in saliva (Group B) in μm (standard deviation in parentheses). Values in red are enamel loss statistically significantly more than the amount removed by orange juice ($p<0.05$).

Product	***Surface E loss with initial placement in saliva for 1 hour Group A (in µm)***	***Surface E loss without Initial placement in Saliva for 1 hour: Group B (in µm)***
Big Baby (Pop)	7.85 (0.52)	8.78 (0.90)
Big Baby (powder)	4.30 (0.40)	4.92 (0.86)
Brain Blasterz	12.56 (0.42)	13.75 (1.15)
Brain Licker	2.71 (0.065)	3.06 (0.54)
Juicy drop (Pop)	7.12 (0.48)	7.84 (0.55)
Juicy drop (Syrup)	2.68 (0.47)	3.30 (0.57)
Lickedy Lips	1.95 (0.30)	2.50 (0.40)
Mega Mouth	4.84 (0.05)	5.90 (0.05)
Push Pop	2.80 (0.26)	3.65 (0.67)
Tango	7.63 (0.48)	8.96 (0.07)
Toxic Waste	15.77 (0.84)	17.64 (1.46)
Vimto	9.30 (0.45)	10.46 (0.10)
Water	0.017 (0.03)	0.03 (0.06)
Orange Juice	3.62 (0.04)	4.75 (0.05)

Table 7. Total subsurface enamel loss with saliva (Group A) and without saliva (group B). Values in red are enamel loss statistically significantly more than the amount removed by orange juice ($p<0.05$).

Material	***Subsurface E loss with saliva***	***Subsurface E loss w/o saliva***
Big Baby (Pop)	0.34	1.21
Big Baby (Powder)	0.34	1.14
Brain Blasterz	0.81	2.15
Brain Licker	0.43	1.157
Juicy drop (Pop)	0.48	1.96
Juicy Drop (Syrup)	0.28	0.91
Lickedy Lips	0.3	0.94
Mega Mouth	0.4	1.6
Push Pop	0.23	0.75
Tango	0.39	1.72

Toxic Waste	0.85	2.3
Vimto	0.55	1.84
Water	0.027	0.028
Orange Juice	0.35	1.29

Figure 1. Total surface enamel loss with initial placement in saliva (Group A) and without initial placement in saliva (Group B).

Figure 2. Total subsurface enamel loss with initial placement in saliva before the ultrasonication (Group A) and immediate ultrasonication without placement saliva (Group B).