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## **Erosive potential of vitamin and vitamin+mineral effervescent tablets**

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## Erosive potential of vitamin and vitamin+mineral effervescent tablets

#### KEYWORDS

effervescent tablet,  
 erosion,  
 enamel loss

#### SUMMARY

The extrinsic sources for erosion-causing acids are primarily acidic beverages and foodstuffs. Effervescent tablets also contain organic acids (e.g. citric, tartaric, malic) in order to form carbon dioxide by contact with water – with the help of the carbonate salts of the tablets. To adequately inform patients about the possible erosive potential of effervescent tablets, this study was undertaken in order to investigate the erosive potential of effervescent tablets (ET), containing either a combination of vitamins and minerals or vitamins only, commercially available in Switzerland.

One hundred and ninety-two bovine enamel samples were prepared and allocated to 16 groups (A–H and 1–8; n = 12/group). Samples were eroded (120 s/erosive cycle) in freshly prepared solutions (200 ml/12 samples) comprised of tap water and a supplement as follows: none (control groups, A and 1); vitamin+mineral ET: Qualité & Prix (B), Optisana (C), Well&Active (D),

Actilife All in One (E), Berocca (F), Isostar (G) and Qualité & Prix Mg + Vit C (H); vitamin ET: Actilife–Multivitamin (2), Sunlife Vitamin C (3), Optisana Vitamin C (4), Optisana Multivitamin (5), Well&Active Multivitamin (6), Kneipp Vitamin C+Zink (7) and Sunlife Multivitamin (8). Enamel loss was measured using profilometry after 10 and 20 erosive cycles.

For the vitamin+mineral ET, no loss was observed in groups B–E. Significantly highest enamel loss (mean ± SD) after 20 cycles was observed for Isostar (5.26 ± 0.76 µm) and Qualité & Prix Mg + Vit C (5.12 ± 0.67 µm). All vitamin ET showed erosive enamel loss. Significantly highest loss was observed for Sunlife Multivitamin (8.45 ± 1.08 µm), while the lowest loss was observed for Actilife–Multivitamin (5.61 ± 1.08 µm) after 20 cycles. Some of the tested effervescent tablets showed a considerable erosive potential and patients should be informed accordingly.

## Introduction

Both the prevalence and incidence of dental erosion, defined as non-carious dental substance loss induced by direct impact of extrinsic or intrinsic acids or chelating agents (SCHLUETER ET AL. 2012, GANSS 2014), have increased considerably (LUSSI & CARVALHO 2014).

Enamel erosion is a process characterized by initial softening (hardness loss) of the enamel surface and followed by a continuous layer-by-layer dissolution of enamel crystals, which leads to a permanent loss of tooth volume, with a softened layer at the surface of the remaining tissue (LUSSI ET AL. 2011, SCHLUETER ET AL. 2012). In the initial stage of the enamel erosion process, repair (remineralization) is in theory still possible, as the remaining tissue could act as a scaffold. In the second, more advanced stage, in which the minerals of the outer enamel are totally lost, repair is not possible. Only the remaining softened enamel still present after the loss of superficial hard tissue is able to be remineralized (LUSSI ET AL. 2004).

The principal extrinsic factors of dental erosion are dietary acids (SCHWEIZER-HIRT ET AL. 1978), with a trend toward increased consumption (CAVADINI ET AL. 2000). In the past several decades, many studies investigating the erosive potential of different dietary substances have been performed and a wide range of drinks and foods, such as soft drinks, sports drinks, juices, salad dressings, candies, herbal teas, alcoholic drinks, vinegar, etc., have been identified as contributing factors in the observed increase in erosion (LUSSI ET AL. 2012). Several studies also investigated the erosive potential of some effervescent tablets, especially as effervescent medication or vitamin C preparations (MEURMAN & MURTOMAA 1986, NUNN ET AL. 2001, LUSSI ET AL. 2012).

The pursuit of a healthier lifestyle, paradoxically, can lead to dental health problems in the form of dental erosion. This lifestyle often involves diets rich in acidic food and beverages and regular exercise. While acidic drinks and foods stimulate salivary flow, exercise tends to decrease salivary flow and often results in the consumption of low-pH sugar-containing beverages, such as acidic sports drinks, fruit juices and other carbonated and uncarbonated acidic beverages (BARBOUR & LUSSI 2014). Furthermore, it is conceivable that effervescent tablets containing minerals and/or vitamins may be used by these patients on a daily basis. Health conscious individuals also tend to have better than average oral hygiene. However, the frequent tooth brushing with abrasive oral hygiene products has been suggested as a cause for increased tooth wear in patients consuming erosive beverages, as the softened enamel and dentine is more susceptible to abrasion (DAVIS & WINTER 1980). The susceptibility of eroded dental hard tissue to abrasion remains raised, even after an enhanced waiting period between the erosive attack and tooth brushing (LUSSI & CARVALHO 2014).

Effervescent tablets containing various vitamins and or minerals, often used as a dietary supplement, contain a soluble organic acid (e.g. citric, tartaric, malic, fumaric, adipic acid) and an alkali metal carbonate salt (e.g. sodium bicarbonate/carbonate, potassium bicarbonate/carbonate) (STAHL 2003). These ingredients form carbon dioxide when they come into contact with water, hence the effervescent effect. Given this acid content, these tablets are possible erosive agents.

Therefore, the aim of the present study was to investigate the erosive potential of effervescent tablets which are consumed as dietary supplements. Effervescent tablets commercially avail-

able in Switzerland, containing either vitamins alone or a combination of vitamins and minerals, were investigated.

Two null hypotheses were proposed: (1) effervescent tablets would not have any erosive character and (2) no differences of erosive potential between different effervescent tablets exist.

## Materials and methods

### Sample preparation and allocation

For this study, 192 enamel samples were prepared from freshly extracted bovine lower incisors. After removing the organic tissue and cleaning the teeth, the crowns were sectioned from the roots at the cemento-enamel junction with a water-cooled diamond disc. The pulp tissue was then removed with endodontic files and the crowns were stored in 0.5% thymol solution until required.

Enamel cylinders (3 mm in diameter) were drilled out from the labial surface of the crowns using a trephine mill. The enamel cylinders were then placed centrally in sample moulds (6 mm in diameter) with the labial surface down and embedded in acrylic resin (Paladur, Heraeus Kulzer, Hanau, Germany). After curing of the acrylic resin by means of a heat-pressure polymerization system, the samples were removed from the moulds. The enamel surfaces of the samples were then ground flat and polished with water-cooled carborundum discs (1200, 2400, 4000 grit) (Water Proof Silicon Carbide Paper, Struers, Erkrath, Germany). During the sample preparation process, the enamel cylinders and later the embedded samples were numbered according to the tooth from which they originated, for use during later sample allocation.

Finally, the samples were randomly allocated to 16 groups (A-H and 1-8; n=12;) and stored in tap water until use. During the allocation process, care was taken to ensure that each group did not contain more than one sample from any single tooth.

Samples of groups A-H were used in part one of the study and samples of groups 1-8 were used in part two.

### Erosion procedure

Prior to beginning the erosion procedure, the samples were ultrasonically cleaned in water from possible impurities.

For an erosive cycle, samples were stored for 2 min in the respective solutions, followed by a tap water rinse. The solutions for the respective groups were prepared as follows:

#### Part one

Vitamin+mineral effervescent tablets (groups A-H)

Composition of the solutions and the manufacturer of the effervescent tablets are provided in Table I.

#### Part two

Vitamin effervescent tablets (groups 1-8)

Composition of the solutions and the manufacturer of the effervescent tablets are provided in Table II.

The tap water volume per effervescent tablet for the preparation of each solution is based on the manufacturer's recommendation for the respective product.

For each cycle, fresh solutions were prepared and the twelve samples per group were simultaneously immersed in 200 ml of the respective solutions, at 23 °C, while gently being stirred (30 rpm) for the test period.

**Tab. I** Allocation of vitamin+mineral effervescent tablets to groups A–H and amount of tap water in which one tablet was diluted

Group	Effervescent tablet (main compounds) and its manufacturer	Water (ml) per tablet
A	– (tap water, control)	–
B	Qualité & Prix (vitamin D + calcium) Coop, Basel, Switzerland	300
C	Optisana (vitamin D3 + calcium) Krüger GmbH & Co. KG, Bergisch Gladbach, for Lidl Schweiz, Weinfelden, Switzerland	200
D	Well&Active (vitamin D3 + calcium) Aldi Suisse AG, Schwarzenbach, Switzerland	250
E	Actilife All in One (different vitamins + calcium + magnesium + zinc) Migros-Genossenschafts-Bund, Zurich, Switzerland	200
F	Berocca (different vitamins + calcium + magnesium + zinc) Bayer AG, Zurich, Switzerland	300
G	Isostar (different vitamins + calcium + magnesium) Wander AG, Neuenegg, Switzerland	250
H	Qualité & Prix Mg + Vit C (vitamin C + magnesium) Coop, Basel, Switzerland	300

**Tab. II** Allocation of vitamin effervescent tablets to groups 1–8 and amount of tap water in which one tablet was diluted

Group	Effervescent tablet (main compounds) and its manufacturer	Water (ml) per tablet
1	– (tap water, control)	–
2	Actilife-Multivitamin (different vitamins) Migros-Genossenschafts-Bund, Zurich, Switzerland	200
3	Sunlife Vitamin C (vitamin C) Sunlife, Hövelhof (Germany), for SPAR Switzerland, Gossau, Switzerland	250
4	Optisana Vitamin C (vitamin C) Krüger GmbH & Co. KG, Bergisch Gladbach (Germany), for Lidl Schweiz, Weinfelden, Switzerland	200
5	Optisana Multivitamin (different vitamins) Krüger GmbH & Co. KG, Bergisch Gladbach (Germany), for Lidl Schweiz, Weinfelden, Switzerland	200
6	Well&Active Multivitamin (different vitamins) Aldi Suisse AG, Schwarzenbach, Switzerland	250
7	Kneipp Vitamin C+Zink (vitamin C + zinc) Kneipp Werke (Germany) for Migros-Genossenschafts-Bund, Zurich, Switzerland	200
8	Sunlife Multivitamin (different vitamins) Sunlife, Hövelhof (Germany), for SPAR Switzerland, Gossau, Switzerland	250

### Measurement of erosive enamel loss

From each sample five baseline profiles were recorded with a stylus profilometer (Perthometer Concept, Mahr, Göttingen, Germany) with a distance of 250 µm between each profile. After 10 and 20 erosive cycles, new profiles were recorded. To ensure an exact repositioning of the samples, the profilometer and the samples were equipped with a jig. The erosive enamel loss was calculated with a custom-made software allowing an automated superimposition of the baseline profiles with the respective profiles after 10 and 20 cycles. If the calculated loss per profile was below the measurement limit of the profilometer of 0.105 µm (ATTIN ET AL. 2009), the value for this profile was set as 0.000 µm.

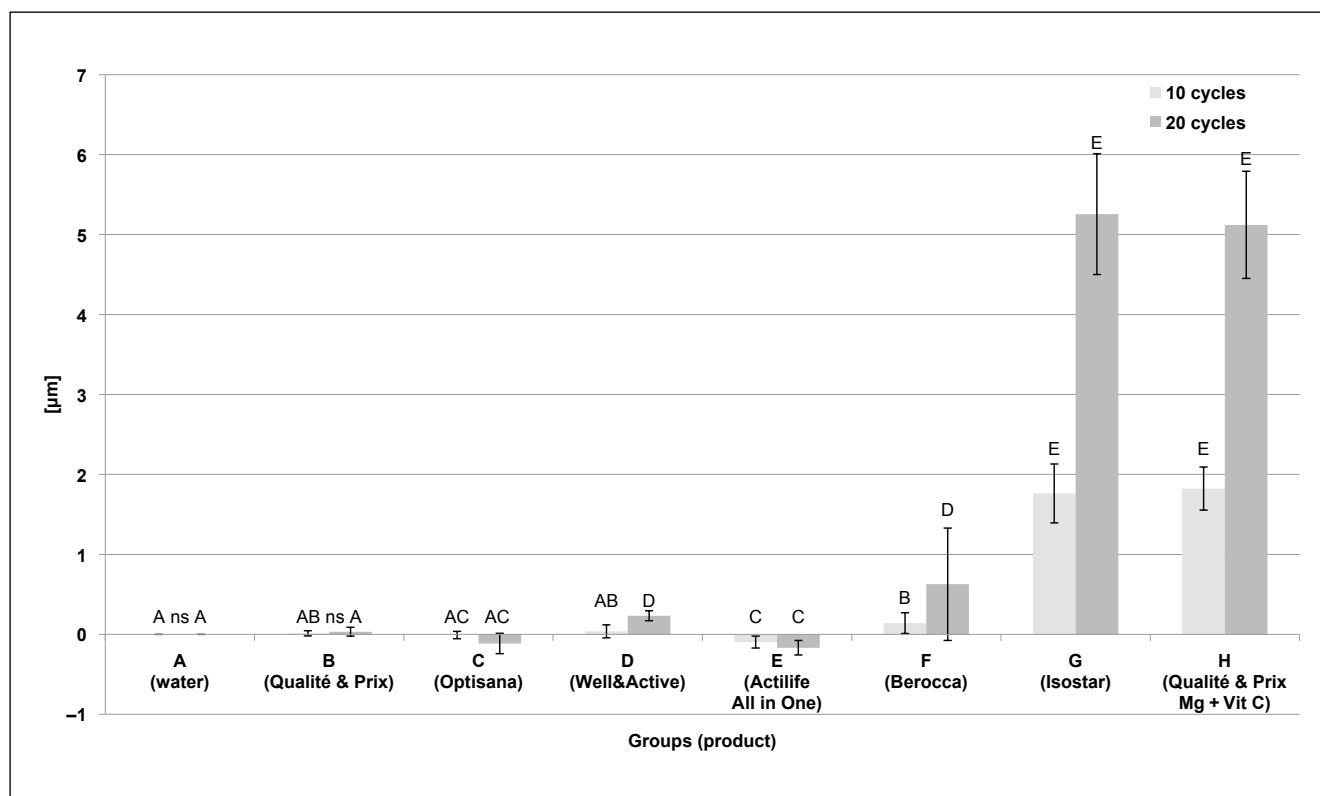
Per sample, enamel loss was calculated by averaging the values of the five respective profiles. Per group, the respective values were calculated by averaging the values of the twelve samples of the respective group.

### Characterization of the solutions

In order to check the product composition and description, and to study the erosive potential of effervescent tablets, the following properties were determined:

For each type of effervescent tablet the average weight was evaluated with an electronic analytical balance (Mettler AT261

Delta Range, Mettler-Toledo GmbH, Greifensee, Switzerland). The pH of the solutions were then determined with a potentiometer (Titroprocessor 686, Metrohm Swiss made, Herisau, Switzerland). The determination of fluoride (F) concentration was performed with an ion-selective electrode (Orion fluoride ion-selective electrode Type 94-04, Orion Research, Cambridge, USA) after mixing 1 ml of the decarbonated solutions with 1 ml TISAB following the methodology presented by Bushee et al. (BUSHEE ET AL. 1971). By means of enzymatic tests, the concentration of citric acid (Citric acid Test kit, Roche Diagnostics GmbH, Mannheim, Germany), malic acid (L-Malic acid Test kit, Roche Diagnostics GmbH, Mannheim, Germany) and ascorbic acid (L-Ascorbic acid Test kit, Roche Diagnostics GmbH, Mannheim, Germany) were determined. To determine the carbon dioxide (CO<sub>2</sub>) concentration, a CO<sub>2</sub> meter (CarboQC, Anton Paar® GmbH, Graz, Austria) was used. This measurement was performed 1 min after the respective tablet was totally dissolved. The concentration of calcium (Ca), magnesium (Mg), sodium (Na) and zinc (Zn) ions was measured using atomic absorption spectrometry (2380 Atomic Absorption Spectropho-



**Fig. 1** Enamel loss and SD [ $\mu\text{m}$ ] in the groups A–H after 10 and 20 cycles of erosion. Values within the same number of cycles which are not statistically significantly different are marked with same capital letters. Values within the same group which are not statistically significantly different are marked with ns.

tometer, Perkin-Elmer, Schwerzenbach, Switzerland). The concentration of inorganic phosphate ( $P_i$ ) was measured following the methodology presented by Fiske & Subbarow (FISKE & SUBBAROW 1925) using a spectrophotometer (Spectrophotometer U-2010, Hitachi High-Technologies Corporation, Tokyo, Japan).

For each type of effervescent tablet, two solutions were prepared and from each solution two samples were tested, for a total of four test samples.

For all tested solutions, the degree of saturation with respect to hydroxyapatite (HA), octacalciumphosphate (OCP) and calcium fluoride ( $\text{CaF}_2$ ) was calculated before the samples were immersed in the solutions. The calculation was performed with the computer program IONPRODUCT (SHELLIS 1988). The temperature assumed in the ion speciation calculations was  $23^\circ\text{C}$ , as this was the solution temperature just prior to immersion of the samples.

The ion concentration and calculated degrees of saturation with respect to the different kinds of apatite and  $\text{CaF}_2$  are provided in Tables III (groups A–H) and IV (groups 1–8).

### Statistical analysis

The enamel loss data were encoded into a Microsoft Excel file. The statistical analysis was then performed using the software program IBM® SPSS® Statistics Version 22 (International Business Machines Corp., Armonk, New York, United States).

Mean, standard deviation, median, interquartile range and 95% confidence intervals were calculated.

As the data of part one (groups A–H) were not normally distributed, according to the Kolmogorov-Smirnov and Shapiro-Wilk tests, the non-parametrical Kruskal-Wallis and Mann-Whitney tests were used to disclose differences

between the enamel loss in the different groups at 10 and 20 cycles of erosion. As 28 tests were conducted on the data at the respective time points (10 and 20 cycles), the Bonferroni correction was applied and resulted in a  $p$ -value of  $p < 0.00179$  for those tests.

To compare the enamel loss at 10 and 20 cycles within the same group, the Wilcoxon test was used and level of significance set at  $p \leq 0.05$ .

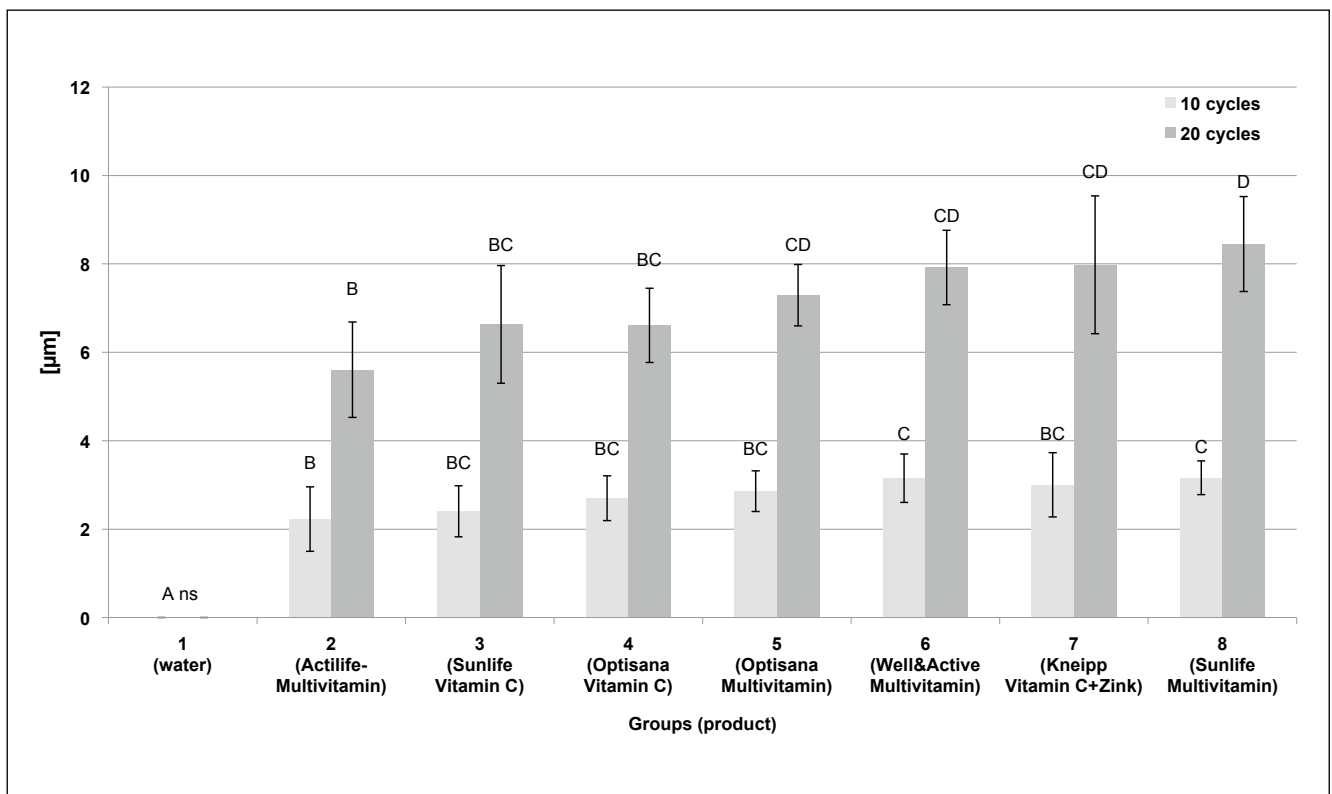
The data of part two (groups 1–8) were normally distributed, according to the Kolmogorov-Smirnov and Shapiro-Wilk tests. Therefore, the data was analysed by ANOVA and Scheffe's post hoc tests ( $p \leq 0.05$ ).

## Results

### Vitamin+mineral effervescent tablets (groups A–H)

Enamel loss (mean  $\pm$  SD) after 10 and 20 cycles for the different groups is provided in Figure 1.

After 10 and 20 cycles, no enamel loss was observed for group A (water, control). No significant enamel loss or gain was observed in group B (Qualité & Prix), group C (Optisana) (after 10 and 20 cycles) and group D (Well&Active) (after 10 cycles). Significantly highest enamel loss after 10 and 20 cycles was observed for group G (Isostar fast hydration powertabs) ( $1.76 \pm 0.37 \mu\text{m}$  and  $5.26 \pm 0.76 \mu\text{m}$ , respectively) and group H (Qualité & Prix Mg + Vit C) ( $1.82 \pm 0.27 \mu\text{m}$  and  $5.12 \pm 0.67 \mu\text{m}$ , respectively), while for group E (Actilife All in One) a significant gain was observed ( $0.10 \pm 0.07 \mu\text{m}$  and  $0.17 \pm 0.09 \mu\text{m}$ , respectively). The enamel loss in groups G and H was not significantly different at the respective numbers of cycles. In all groups, except A and B, the enamel loss or gain after 20 cycles was significantly higher compared to that after 10 cycles ( $p < 0.05$ , respectively).



**Fig. 2** Enamel loss and SD [ $\mu\text{m}$ ] in the groups 1–8 after 10 and 20 cycles of erosion. Values within the same number of cycles which are not statistically significantly different are marked with same capital letters. Values within the same group which are not statistically significantly different are marked with ns.

### Vitamin effervescent tablets (groups 1–8)

Enamel loss (mean  $\pm$  SD) after 10 and 20 cycles for the different groups is provided in Figure 2.

After 10 and 20 cycles, no enamel loss was observed for the water control group. In all other groups, a significant erosive enamel loss was recorded as compared to control. At 10 cycles, the enamel loss for Actilife-Multivitamin, Sunlife Vitamin C, Optisana Vitamin C, Optisana Multivitamin and Kneipp Vitamin C+Zink was not significantly different. Furthermore, no significant difference in the enamel loss of groups 3–8 (Sunlife Multivitamin) was observed at 10 cycles. At 10 cycles, the enamel loss of group 2 was significantly lower compared with the enamel loss of groups 6 and 8.

After 20 cycles, the enamel loss of groups 2, 3 and 4 was not significantly different. Also at 20 cycles, no significant difference in the enamel loss of groups 3–7 was observed. Furthermore, the enamel loss of groups 5, 6, 7 and 8 was not significantly different.

In all groups, except the water control group, the enamel loss after 20 cycles was significantly higher compared to that after 10 cycles ( $p < 0.05$ , respectively).

### Discussion

In the present study, the samples were prepared from bovine enamel. Due to genetic, environmental and dietary differences, bovine and human enamel are not identical (LAURANCE-YOUNG ET AL. 2011). However, the studies using bovine enamel for dental erosion experiments are numerous (RIOS ET AL. 2006A, KATO ET AL. 2010, ATTIN ET AL. 2013) and the reasons are many. First of all, bovine teeth are easier to obtain in large quantities than human teeth (OESTERLE ET AL. 1998). Moreover bovine teeth are in better condition and with a more uniform composition (YASSEN ET AL.

2011) when extracted for study purposes. Bovine teeth often stem from cattle from the same region with similar environmental and nutrition factors. Furthermore, they do not have caries lesions, other defects or a history of fluoridation measures that might influence the outcomes of dental erosion. Another reason for the use of bovine teeth is their larger size, which facilitates their handling and allows the preparation of more samples from the same tooth, resulting in a reduction of differences between the samples (LAURANCE-YOUNG ET AL. 2011). A study performed by Attin and coworkers (ATTIN ET AL. 2007) showed that erosion alone and erosion-abrasion caused higher enamel loss in cattle's teeth than in human wisdom teeth. Therefore, one might assume that the enamel loss seen in this study, due to contact with the solutions prepared from the different effervescent tablets, might be overestimated. However, we assume that a slight overestimation is more acceptable than an underestimation, as there is no reliable data about the frequency of consumption of these products. Furthermore, under real-life conditions it is imaginable that patients consume these products and later brush their teeth, resulting in a much higher erosive/abrasive wear (BARTLETT 2005).

As in several other studies evaluating the erosive potential of acidic substances, the enamel loss was measured by contact profilometry. This method can be performed reliably, has been thoroughly validated and is therefore addressed as a "gold standard" (BARBOUR & REES 2004, SCHLUETER ET AL. 2005). However, contact profilometry has the disadvantage that the stylus can penetrate the eroded enamel surface and, consequently, can cause surface damages and lead to an overestimation of early erosion depth (SCHLUETER ET AL. 2011).

The exposure time of the samples in the solutions during a single erosive cycle was set to 120 s, as used in a previous study

**Tab. III** The ion concentration (mM) and degree of saturation values with respect to the different kinds of apatite (hydroxyapatite [HA] and octacalciumphosphate [OCP]) and calcium fluoride (CaF<sub>2</sub>) for the vitamin+mineral effervescent tablets (groups A–H)

Group	Composition	Concentration of ions (mM)				
		Ca	P <sub>i</sub>	F	Mg	Na
A	Water (control)	1.20	<0.00	<0.01	0.30	0.20
B	Water + Qualité & Prix tablet	33.30	<0.00	<0.01	0.00	0.00
C	Water + Optisana tablet	50.01	<0.00	<0.01	0.00	0.00
D	Water + Well&Active tablet	27.20	<0.00	<0.01	0.00	0.00
E	Water + Actilife All in One tablet	12.40	<0.00	<0.01	21.80	0.00
F	Water + Berocca calcium tablet	8.30	<0.00	<0.01	16.00	0.00
G	Water + Isostar tablet	3.40	0.40	<0.01	3.80	0.00
H	Water + Qualité & Prix Mg + Vit C tablet	<0.00	<0.00	<0.01	38.70	0.00

**Tab. IV** The ion concentration (mM) and degree of saturation values with respect to the different kinds of apatite (hydroxyapatite [HA] and octacalciumphosphate [OCP]) and calcium fluoride (CaF<sub>2</sub>) for the vitamin effervescent tablets (groups 1–8)

Group	Composition	Concentration of ions (mM)				
		Ca	P <sub>i</sub>	F	Mg	Na
1	Water (control)	1.20	<0.00	<0.01	0.30	0.20
2	Water + Actilife–Multivitamin tablet	<0.00	<0.00	<0.01	0.00	0.00
3	Water + Sunlife Vitamin C tablet	<0.00	<0.00	<0.01	0.00	0.00
4	Water + Optisana Vitamin C tablet	<0.00	<0.00	<0.01	0.00	0.00
5	Water + Optisana Multivitamin tablet	<0.00	<0.00	<0.01	0.00	0.00
6	Water + Well&Active Multivitamin tablet	<0.00	<0.00	<0.01	0.00	0.00
7	Water + Kneipp Vitamin C+Zink tablet	<0.00	<0.00	<0.01	0.00	0.00
8	Water + Sunlife Multivitamin tablet	<0.00	<0.00	<0.01	0.00	0.00

(WEGEHAUPT ET AL. 2011) and as recommended by Wiegand and Attin (WIEGAND & ATTIN 2011). This duration seems to be representative of a rapid consumption of an acidic beverage (MEURMAN ET AL. 1987).

A limitation of the present study might be that the chosen *in vitro* model did not completely reflect the intraoral situation, where numerous other factors, such as saliva (RIOS ET AL. 2006B, LUSSI ET AL. 2011), acquired pellicle (HANNIG & BALZ 1999, WIEGAND ET AL. 2008A) and abrasive attacks (HOOPER ET AL. 2003, LUSSI & HELLWIG 2006) influence the potential enamel loss.

Both null hypotheses of this study have to be partially rejected. The first null hypothesis has to be partially rejected as the results of this study showed that effervescent tablets, depending on their chemical composition, will cause more or less pronounced erosive enamel loss. However, there were some tablets that presented no erosive enamel loss (groups A–C and E). Within the tested vitamin+mineral solutions, there were in fact groups that showed high enamel loss (groups G and H), low enamel loss (groups D and F), no significant enamel loss (groups A–C) and even something that could be interpreted

as “enamel gain” (group E). This fact leads to the rejection of the second null hypothesis.

Comparing the results with the chemical characteristics of the solutions (Tab. III), the pH seems to be not the only reason for the different erosive potentials of the tested effervescent tablets. All solutions of the tested vitamin+mineral effervescent tablets had an erosive pH (in the range from 3.82 to 4.30), which was much lower than the pH of the water control group (8.20). However, only the groups G and H after 10 and 20 cycles of erosion and the groups D and F after 20 cycles of erosion showed significantly higher enamel loss compared with the water control (group A). The groups B and C instead presented no significant difference with respect to the water control (group A).

Within the tested vitamin solutions, all groups (2–8) presented erosive enamel loss compared with the water control (group 1). This fact supports the rejection of the second hypothesis. In comparison with the solutions prepared from the vitamin+mineral effervescent tablets, the solutions prepared from the vitamin effervescent tablets (Tab. IV) showed a slightly higher pH (in the range from 4.14 to 4.49).

Values marked as “-” were not possible to calculate due to the low phosphate concentrations.

					pH	Calculated saturation		
Zn	CO <sub>2</sub>	Malic	Ascorbic	Citrate		HA	OCP	CaF <sub>2</sub>
0.00	0.91	0.00	0.00	0.26	8.20	-	-	-
0.00	49.18	6.71	0.00	28.94	4.10	-	-	-
0.00	71.57	14.92	0.00	42.16	3.93	-	-	-
0.00	58.17	0.00	0.00	46.01	4.02	-	-	-
4.10	52.26	0.00	1.60	33.83	4.06	-	-	-
3.70	45.40	0.00	6.37	33.10	4.14	-	-	-
0.00	32.72	0.00	0.35	22.90	3.82	0.03	0.01	-
0.00	37.83	0.00	1.64	29.46	4.30	-	-	-

Values marked as “-” were not possible to calculate due to the low phosphate concentrations.

					pH	Calculated saturation		
Zn	CO <sub>2</sub>	Malic	Ascorbic	Citrate		HA	OCP	CaF <sub>2</sub>
0.00	0.91	0.00	0.00	0.26	8.20	-	-	-
0.00	80.66	0.00	4.00	59.33	4.49	-	-	-
0.00	74.53	0.00	4.10	29.15	4.42	-	-	-
0.00	81.80	0.00	4.99	33.31	4.38	-	-	-
0.00	88.62	0.00	2.10	47.10	4.31	-	-	-
0.00	58.17	0.00	1.77	33.10	4.14	-	-	-
5.20	72.71	0.00	1.85	37.47	4.33	-	-	-
0.00	67.26	0.00	1.32	38.72	4.20	-	-	-

Calcium concentration seems to be the factor that, beside the pH value of the solutions, has the strongest influence on the erosive potential of the investigated effervescent tablets. It was observed that effervescent tablets with a higher calcium concentration (group C) induced less enamel loss than effervescent tablets with a similar pH, but lower calcium concentration (group G). This finding was particularly evident in the comparison of group B with group H. While group B, which has a low pH (4.10) and a high calcium concentration (33.3 mM), showed no erosive enamel loss, group H, which has a higher pH (4.30) but contains no calcium, presented one of the highest enamel losses within the vitamin+mineral effervescent tablets. In other words, calcium seems to have an anti-erosive potential. If a solution contains no calcium, like all solutions prepared from the vitamin effervescent tablets, its erosive potential mainly depends upon, and can be determined by, its pH value.

These findings correlate well with the literature. Various studies demonstrate in fact that the addition of calcium to acidic beverages can decrease their erosive potential (WEST ET AL. 1999, WEGEHAUPT ET AL. 2011). Hara and Zero (HARA & ZERO 2008)

summarised that calcium-ion content, as well as pH, were good predictors of the erosive potential of beverages.

Furthermore, foods with a naturally high calcium content, such as yoghurt, show a low or no erosive potential despite their low pH (LUSSI ET AL. 2004, LUSSI ET AL. 2012).

Based on the results of this study, especially individuals at high risk for dental erosion and those with active erosion should select vitamin and mineral supplements in a non-effervescent tablet form or at least avoid effervescent tablets with no or little calcium. If this is not possible, when consuming effervescent tablets (as well as other foods and drinks) with a high erosive potential, some preventive measures should be taken into consideration. For example, it is advisable not to hold and swish the erosive solution in the mouth (JOHANSSON ET AL. 2004) and to avoid tooth brushing immediately after the intake (ATTIN ET AL. 2001). Additionally, the time needed to “rearden” the softened, eroded enamel, so that abrasive actions cause no or only little additional tooth wear, is discussed controversially in the literature. Some authors found that a time-lapse of at least 60 min between the erosion and the later tooth brushing (ATTIN



ET AL. 2001) is needed, while other studies showed that even a duration of two hours does not have an effect on the reduction of the erosive/abrasive tooth wear (GANSS ET AL. 2007). To overcome this problem, Wiegand and coworkers (WIEGAND ET AL. 2008B) suggested that when patients anticipate an erosive attack (such as when consuming any of the effervescent tablets tested in this study), they should perform tooth brushing prior to the acid challenge, rather than afterwards. This could minimize the enamel and dentin wear. Additionally, neutralization of the low intraoral pH with fluoride-/calcium-/phosphate-containing products, sugar-free chewing gums or water might also be recommended (WIEGAND ET AL. 2008C, LUSSI ET AL. 2009).

## Conclusion

Given the findings of the present study, and within its limitations, it can be concluded that all tested vitamin and some of the vitamin+mineral effervescent tablets show an erosive potential. Although the general public considers effervescent tablets to be a health supplement, patients should be informed about this risk factor regarding dental erosion and possible preventive approaches to counteract this risk.

## Résumé

### Introduction

Les boissons ou les aliments acides sont les principales sources extrinsèques causant des érosions dentaires. Les comprimés effervescents contiennent également des acides organiques comme par exemple l'acide citrique, tartrique ou malique qui, au contact de l'eau, forment, avec les sels de carbonate contenus dans les comprimés, du dioxyde de carbone. Cette étude devait déterminer le potentiel érosif des comprimés disponibles sur le marché suisse. Plus particulièrement des comprimés contenant des vitamines ou des vitamines combinées à des minéraux afin d'en informer adéquatement les patients.

### Matériaux et méthodes

192 échantillons d'émail d'origine bovine ont été préparés et divisés en 16 groupes (A-H et 1-8; n=12). Les échantillons ont été stockés pendant 120 s par cycle dans des solutions fraîchement préparées (200 ml/12 échantillons). Les solutions ont été préparées avec de l'eau et les comprimés effervescents suivants: pas d'adjuvant pour le groupe témoin (A et 1), des comprimés effervescents de vitamines combinées avec des minéraux: Qualité & Prix (B), Optisana (C), Well&Active (D), Actilife All in One (E), Berocca (F), Isostar (G) et Qualité & Prix Mg + Vit C (H) et des comprimés effervescents vitaminés: Actilife-Multivitamin (2), Sunlife Vitamin C (3), Optisana Vitamin C (4), Optisana Multivitamin (5) Well&Active Multivitamin (6), Kneipp Vitamin C+Zink (7) et Sunlife Multivitamin (8). La perte d'émail a été déterminée après 10 et 20 cycles érosifs à l'aide d'un profilomètre de contact.

### Résultats et discussion

Pour les groupes A et 1 (contrôle avec l'eau), aucun potentiel érosif n'a été observé. Pour les comprimés effervescents contenant des vitamines combinées à des minéraux (B-E) également, aucune érosion d'émail n'a pu être observée. La perte d'émail la plus élevée (moyenne  $\pm$  écart-type) a été trouvée pour Isostar ( $5,26 \pm 0,76 \mu\text{m}$ ) et Qualité & Prix Mg + Vit C ( $5,12 \pm 0,67 \mu\text{m}$ ) après 20 cycles érosifs.

En revanche, tous les comprimés effervescents vitaminés ont démontré un potentiel érosif. Après 20 cycles érosifs, la perte d'émail la nettement plus élevée a été observée dans le groupe

Sunlife Multivitamin ( $8,45 \pm 1,08 \mu\text{m}$ ), alors que la perte d'émail la plus basse a été trouvée dans le groupe Actilife-Multivitamin ( $5,61 \pm 1,08 \mu\text{m}$ ).

Bien que les comprimés effervescents soient considérés par la population comme bons pour la santé, ils peuvent être nuisibles à la structure de la dent. Certains de ces comprimés effervescents testés montrent un potentiel érosif significatif. Les patients doivent être informés de ce risque.

## Zusammenfassung

### Einleitung

Saure Getränke oder Lebensmittel sind hauptsächlich extrinsische Quellen für Erosionen verursachende Säuren. Auch Brausetabletten enthalten organische Säuren (z. B. Zitronen-, Wein- oder Apfelsäure), um mit den Karbonatsalzen der Tabletten, bei Kontakt mit Wasser, Kohlendioxid zu bilden. Um Patienten adäquat über ein mögliches erosives Potenzial solcher Brausetabletten zu informieren, war es das Ziel der vorliegenden Studie, das erosive Potenzial von in der Schweiz kommerziell erhältlichen Brausetabletten zu bestimmen. Es sollten Brausetabletten untersucht werden, die entweder Vitamine oder Kombinationen aus Vitaminen und Mineralien enthalten.

### Material und Methoden

Es wurden 192 bovine Schmelzproben hergestellt und auf 16 Gruppen (A-H und 1-8; n=12) aufgeteilt. Die Proben wurden für 120 s je Zyklus in frisch hergestellten Lösungen (200 ml/12 Proben) gelagert. Die Lösungen wurden aus Hahnenwasser und den folgenden Brausetabletten hergestellt: kein Zusatz (Kontrollgruppe, A und 1); Brausetabletten mit Vitaminen und Mineralien: Qualität & Preis (B), Optisana (C), Well&Active (D), Actilife All in One (E), Berocca (F), Isostar (G) und Qualität & Preis Mg + Vit C (H); Vitamin-Brausetabletten: Actilife-Multivitamin (2), Sunlife Vitamin C (3), Optisana Vitamin C (4), Optisana Multivitamin (5), Well&Active Multivitamin (6), Kneipp Vitamin C+Zink (7) und Sunlife-Multivitamin (8). Der Schmelzverlust wurde nach 10 und nach 20 erosiven Zyklen mit einem Kontaktprofilometer bestimmt.

### Resultate und Diskussion

Für die Gruppen A und 1 (Wasserkontrollen) wurde kein erosives Potenzial beobachtet. Auch für die Brausetabletten mit Vitaminen und Mineralien B-E konnte kein erosiver Schmelzverlust beobachtet werden. Nach 20 erosiven Zyklen wurde der signifikant höchste Schmelzverlust (Mittelwert  $\pm$  Standardabweichung) für Isostar ( $5,26 \pm 0,76 \mu\text{m}$ ) und Qualität & Preis Mg + Vit C ( $5,12 \pm 0,67 \mu\text{m}$ ) beobachtet.

Im Gegensatz dazu zeigten alle Vitamin-Brausetabletten ein erosives Potenzial. Nach 20 erosiven Zyklen wurde der signifikant höchste Schmelzverlust in der Gruppe Sunlife Multivitamin ( $8,45 \pm 1,08 \mu\text{m}$ ) beobachtet, während der Schmelzverlust der Gruppe Actilife-Multivitamin ( $5,61 \pm 1,08 \mu\text{m}$ ) am geringsten ausfiel.

Auch wenn Brausetabletten von der Bevölkerung als gesund erachtet werden, können sie für Zahnhartsubstanzen schädlich sein. Manche der getesteten Brausetabletten zeigen ein deutliches erosives Potenzial. Patienten sollten über dieses Risiko entsprechend informiert werden.

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