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RESEARCH ARTICLE

Erosive Effect of Salad Dressing on Flowable Composite Resin Surfaces

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Background: The purpose of this study was to investigate the effect of salad dressings on the flowable composite resin surface and the erosion-inhibitory effect of calcium.

Methods: The experiment included six groups: oriental dressing, balsamic dressing, lemon-garlic dressing, lemon-garlic dressing supplemented with 3% calcium, mineral water as a negative control group, and orange juice as a positive control group. pH and titratable acidity were measured. The prepared specimens were immersed in the experimental solutions for 1, 3, 5, 15, and 30 minutes. The surface microhardness was measured using the Vickers hardness number before and after the treatment, and the surface of the specimens was observed using a scanning electron microscope (SEM).

Results: The pH values of the experimental groups in increasing order were as follows: lemon-garlic dressing (2.49±0.03), balsamic dressing (3.12±0.06), lemon-garlic dressing +3% calcium (3.27±0.09), oriental dressing (3.75±0.03), orange juice (3.82±0.02), and mineral water (7.32±0.16). The largest surface hardness reduction value was shown in lemon-garlic dressing (−9.61±1.16), followed by balsamic dressing (−9.17±1.63), oriental dressing (−8.62±1.09), orange juice (−8.19±1.36), lemon-garlic dressing +3% calcium (−6.76±1.23), and mineral water (−1.63±2.47). According to the SEM findings, the experimental and positive control groups showed rough surfaces and micropores, whereas the negative control group showed a smooth surface. Moreover, the lemon-garlic dressing with +3% calcium showed fewer micropores and a smoother surface than the lemon-garlic dressing.

Conclusion: The intake of salad dressings at a low pH could weaken the surface microhardness of the flowable composite resin. However, adding calcium to these salad dressings can reduce the risk of microhardness reduction on the flowable composite resin surface.

Key Words: Calcium, Composite resins, Hardness, Salad dressing, Scanning electron microscopy

Introduction

1. Background

Due to recent lifestyle changes, there has been an increased interest in external factors, such as physical health and beauty, leading to a growing interest in the diet. As a result, domestic salad consumption continues to expand and the demand for salad dressing is also on the rise[1].

The pH level that causes enamel dissolution is 5.5, and foods below 4.0 can cause dental erosion[2]. Attin et al.[3] reported that a low pH could cause tooth enamel erosion, which increases the risk of dental erosion. Dental erosion is irreversible damage to hard tissue due to a chemical reaction caused by an external acidic factor without the involvement of bacteria[4]. Hartz et al.[5] reported that the average pH of balsamic dressing is 3.55, a vinegar-based product that could affect dental erosion. Moreover, Linkosalo and Markkanen[6] found that lacto-vegetarians experienced greater dental erosion than non-vegetarians. Dental erosion among lacto-vegetarians was related to the intake of

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vinegar, berries, and pickles. It was assumed that vinegar was consumed as an ingredient in salad dressings rather than consumed alone. Many studies have reported the effects of energy, carbonated, and hangover drinks on teeth and composite resins[7-9], but there are insufficient studies on the effects of salad dressing on the surface of composite resin.

Dental erosion is the loss of tooth hard tissue due to chemical dissolution and is divided into intrinsic and extrinsic factors. Intrinsic factors cause dental erosion due to direct contact with teeth, such as gastric acid and reflux disease caused by vomiting, while extrinsic factors are caused by exposure to an acidic work environment, acidic food intake, and taking medications[10]. Extrinsic acid consumption is the leading cause of dental erosion in most cases. In the early stages of the erosion process, protons released by the acid react with the carbonate or phosphoric acid of hydroxyapatite to form unstable enamel crystals and cause dissolution of the tooth surface[5]. Beverages with a low pH are one of the leading causes of dental erosion[11], and many studies have been conducted on the prevention of dental erosion. Lee et al.[9] confirmed that calcium-added beverages have a preventive effect on dental erosion and that as the calcium concentration increases, the amount of change in enamel surface microhardness decreases. Larsen and Nyvad[12] confirmed that dental erosion did not occur after immersing the tooth specimen in orange juice containing calcium and phosphorus for a week. Jensdottir et al.[13] also confirmed the suppression of dental erosion by soft drinks containing calcium and phosphorus. Hara and Zero[14] found that when teeth were exposed to both calcium- and non-calcium-containing beverages, enamel demineralization was inhibited in the calcium-containing beverages. Moreover, Beiraghi et al.[15] found that adding 5% calcium lactate to cola inhibited dental erosion.

Composite resin is one of the most widely used dental materials in the dental clinical field owing to its advantages, such as excellent bonding with teeth, high mechanical strength, and excellent esthetic properties[11]. It has been reported that the preference for and usage of composite resins are continuously growing. As the use of light-curing composite resin to treat dental caries in children under the age of 12 is ensured, the demand for the composite resin is expected to rise[16]. However, studies have reported that composite resins are greatly affected by the oral environment, along with enamel. Han et al.[17] confirmed that low pH significantly affects the durability and lifespan of composite resin restorations, and Valinoti et al.[18] confirmed that pH cycling and immersion in acidic chemicals cause surface degradation of composite resins.

2. Objectives

In this study, based on a previous study reporting that the pH of salad dressings is low, it was thought that there is a possibility of erosion; therefore, the effect on the surface of the flowable composite resin was evaluated. Furthermore, it is to confirm the erosion-inhibitory effect by adding calcium to the salad dressing. The study thereby provides an efficient salad dressing intake method and proposes basic data for the effective oral health management of consumers.

Materials and Methods

1. Ethic statement

This article does not require institutional review board screening because human participation was not involved.

2. Materials

1) Salad dressings

Among the salad dressings on the market in Korea, five dressings were purchased in the order of the highest market sales, and the pH was measured. Among them, lemon-garlic, balsamic, and oriental dressings were selected in order of their lowest pH. In addition, to confirm the effect of calcium addition on the surface of the composite resin, 3% calcium was added to the salad dressing with the lowest pH value among the three salad dressings, and it was selected as an experimental group. Orange juice was used as a positive control group, and Jeju Samdasoo was used as a negative control group. All products were used with an expiration date of more than 1 year. The control and experimental groups used in this study comprised six groups, and their characteristics are as follows (Table 1).

Table 1. Characteristics of the Experimental Materials Used in This Study

Group	Brand name	Ingredients	Manufacture
Samdasoo (negative control)	Jeju Samdasoo	Natural mineral water	JPDC, Jeju, Korea
Orange juice (positive control)	Minute maid	Purified water, Spanish orange concentrated nectar, calcium gluconate, Calcium Lactate, vitamin C, citric acid, steviol glycoside, natural flavoring	Coca-Cola Beverage Co., Yeoju, Korea
Oriental dressing	Pulmuone	Purified water, fermented vinegar (spirit vinegar, apple juice concentrate [China/apple 100%], glucose, brewed soy sauce 13% [USA/milk, soybean, refined salt], seasoned base [vegetable soy sauce, India], brewed soy sauce [India], fructose, HVP-B, crude oil), sugar, corn oil, condiment A (herbal liquor, fructose, glucose, sugar, yeast extract), glucose, sesame oil 1.94%, lemon concentrate, garlic 1%, onion concentrate extract, stir-fried sesame 0.85%, amino base-P, dense decomposition extract, caramel pigment, lemon concentrate 2, xanthan gum, citric acid, apple acid, redpepper powder, black pepper powder	Sias corp., Cheongju, Korea
Balsamic dressing	Fontana	Purified water, Balsamic vinegar (Italy/wine vinegar, cooked grape must, caramel color, antioxidant [sulfur dioxide]), Canola oil (Australia), other fructose, glucose, sugar, refined salt (Korea), onion, extra virgin olive oil, prepared mustard, lemon concentrate, red grape juice concentrate, yondu-light, garlic, mustard seed, xanthan gum, tamarind gum, synthetic fragrance (balsamic scent), white wine, basil, yeast, basil powder, thyme, oregano powder, thyme powder, black pepper powder, contain soybean	Dongwon Home Food Co., Asan, Korea
Lemon-garlic dressing	Pulmuone	Purified water, other fructose, fermented vinegar (spirit vinegar, malt extract, fermented nutrient), glucose, Lemon extract 5.9% (Israel/mixed content lemon 100%), refined salt (Korea), concentrated apple extract (apple:Korea), lemon 1.5% (USA), Onion, frozen red bell pepper, garlic 0.8% (Korea), concoction (Food Starch Modified, Maltodextrin), dextrin, dry garlic pieces 0.5% (garlic100%:Korea), Natural fragrance (lemon scent), Xanthan Gum, parsley flakes, aminobase P, decomposed wheat extract, oregano, Gardenia Yellow	Sias corp.
Lemon-garlic dressing +3% Ca	-		

2) Composite resin

Among the flowable composite resins, those with the highest market share and sales volume (Filtek Z350 XT Flowable; 3M ESPE, Saint Paul, MN, USA) were selected.

3) Calcium

Calcium lactate (Calcium Lactate Pentahydrate; Galactic S.A., Brussels, Belgium) was selected as a food additive for the addition of calcium to the salad dressing.

3. Study design

1) pH and buffer capacity

To measure pH under the same temperature conditions, the salad dressings were left at room temperature 25°C for 6 hours, opened immediately before measurement, and 10 ml were dispensed into the same container. An experimental group to which 3% calcium lactate was added was measured after stirring at 200 rpm for 1 hour in order to dissolve the calcium thoroughly. The pH of the salad dressing was measured using a pH meter (S20K pH meter; Mettler-Toledo, Greifensee, Switzerland) after calibration with buffer calibration solution (pH 4.0 and 7.0). The average value was calculated thrice in the same manner.

For titratable acidity, 0.05 ml of 1 M NaOH was added to 50 g of salad dressing, and the amount of 1 M NaOH added was measured until the pH reached 5.5 and 7.0. All measurements were performed thrice in the same manner, and the average values were calculated.

2) Specimen preparation

(1) Preparation of a resin specimen

After making a circular space with a diameter of 5 mm and a height of 2 mm in acrylic (15 mm×15 mm×15 mm), the specimen was filled with composite resin (Filtek^{TM} Z350 XT Flowable; 3M ESPE) and light-cured using a wireless light-curing machine (L1660679D; Guilin Woodpecker Medical Instrument, Guilin, China) for 20 seconds. Then, to make the surface smooth, it was polished step-by-step using Sic-paper #1200, #1500, #2000, and #4000 with a polishing machine (Struers LaboPol-5, Type 05206133; Struers, Ballerup, Denmark). A total of 72 polished specimens with a surface microhardness value of 46±5 Vickers hardness number (VHN) were selected and then divided into six groups, with 12 specimens assigned to each of the control and experimental groups.

(2) Specimen surface hardness measurements

To measure the surface microhardness of the polished specimen, the top, bottom, left, and right areas of the specimen were placed perpendicular to the stamping direction. Stamped with a load of 200 g for 10 seconds, and the VHN was measured at a magnification of 400 times of the measuring microscope to calculate the average value of four areas. Additionally, the collected specimens were washed with distilled water for 30 seconds after 1, 3, 5, 15, and 30 minutes of immersion in the salad dressing and measured using the same method as before immersion in the adjacent area.

3) Immersion in salad dressing

After dispensing 50 g of each in the same container for the experimental and control groups, 12 specimens per group were immersed in each container. The immersion times were 1, 3, 5, 10, 15, and 30 minutes, after which the samples were collected and washed with distilled water for 30 seconds.

4) Scanning electron microscopy

To observe the morphological changes of the composite resin surface, one specimen was selected after each group was immersed for 30 minutes. The treated specimens were dehydrated in order of increasing alcohol concentration and then dried using a critical point dryer (HCP-2; Hitachi, Tokyo, Japan). It was then fixed to an aluminum stub and coated with gold-palladium to a thickness of 200 nm using an ion sputter (E-1030; Hitachi). It was observed under a scanning electron microscope (SEM; S-4700; Hitachi) at an accelerating voltage of 10 KV and a magnification of 3,000×.

4. Data analysis

A paired t-test was used to compare the surface microhardness of the specimens before and after immersion in salad dressing for 30 minutes. To compare the surface microhardness of the composite resins between groups, a one-way analysis of variance (ANOVA) was used, followed by a post hoc test using Tukey's test. A repeated measures ANOVA was used to compare the microhardness of the composite resin surface by immersion time for each group, and Tukey's honestly significant difference was used as a post hoc test. The Statistical Package for the Social Science (SPSS), version 28.0.1.1 (IBM Corp., Armonk, NY, USA), was used for the statistical analysis.

Results

1. pH and buffer capacity

The pH of the experimental group used in this experiment was the lowest in lemon-garlic dressing (2.49±0.03), followed by balsamic dressing (3.12±0.06), lemon-garlic dressing +3% calcium (3.27±0.09), oriental dressing (3.75±0.03), the positive control group (3.82±0.02), and the negative control group (7.32±0.16). The titratable acidity at pH 5.5 was the lowest in orange juice (0.60±0.04), followed by oriental dressing (1.21±0.11), balsamic dressing (1.23±0.10), lemon-garlic dressing (2.14±0.04), and lemon-garlic dressing +3% calcium (3.00±0.16). The titratable acidity at pH 7.0 was the lowest in orange juice (0.81±0.01), followed by oriental dressing (1.42±0.16), balsamic dressing (2.42±0.12), lemon-garlic dressing (2.42±0.11), and lemon-garlic dressing +3% calcium (3.25±0.17) ($p<0.05$, Table 2).

Table 2. pH and Titratable Acidity of Test Groups

Group	pH	Titratable acidity (ml)	
		pH 5.5	pH 7.0
Samdasoo	7.32±0.16	-	-
Orange juice	3.82±0.02	0.60±0.04	0.81±0.01
Oriental dressing	3.75±0.03	1.21±0.11	1.42±0.16
Balsamic dressing	3.12±0.06	1.23±0.10	2.42±0.12
Lemon-garlic dressing	2.49±0.03	2.14±0.04	2.42±0.11
Lemon-garlic dressing +3% Ca	3.27±0.09	3.00±0.16	3.25±0.17

Values are presented as mean±standard deviation.

Table 3. Microhardness Change on Composite Resin Surface after Treatment for 30 Minutes (Unit: VHN)

Group	n	Treatment		Difference**
		Before (0 min)	After (30 min)	
Samdasoo*	12	46.53±1.36	44.90±2.09	−1.63±2.47[a]
Orange juice*	12	45.71±2.88	37.52±1.72	−8.19±1.36[c]
Oriental dressing*	12	45.64±2.33	37.02±2.97	−8.62±1.09[c]
Balsamic dressing*	12	46.37±3.53	37.20±2.31	−9.17±1.63[c]
Lemon-garlic dressing*	12	45.86±2.67	36.25±2.53	−9.61±1.16[c]
Lemon-garlic dressing +3% Ca*	12	47.23±1.10	40.47±2.18	−6.76±1.23[b]

Values are presented as mean±standard deviation.
The same letter indicates no significant difference by Tukey's test at α=0.05.
*$p<0.05$, by paired t-test. **$p<0.05$, by one-way ANOVA.

2. Changes in surface microhardness of composite resin after immersion in salad dressing

As a result of measuring the surface microhardness of the composite resin before and after immersion in salad dressing, a significant difference was observed between the groups ($p<0.05$, Table 3). Regarding surface microhardness difference (△VHN) before and after 30 minutes immersion, lemon-garlic dressing (−9.61±1.16) was the highest, followed by balsamic dressing (−9.17±1.63), oriental dressing (−8.62±1.09), the positive control group orange juice (−8.19±1.36), lemon-garlic dressing +3% calcium (−6.76±1.23), and the negative control group (−1.63±2.47). There was also a significant difference in surface microhardness according to immersion time ($p<0.05$), compared to Samdasoo and lemon-garlic dressing +3% calcium, orange juice, balsamic dressing, and lemon-garlic dressing decreased by immersion time ($p<0.05$, Table 4).

3. SEM results after the treatment with salad dressings

Observation of the surface of the composite resin using a SEM revealed surface changes in all groups after 30 minutes of immersion, except for Samdasoo. The negative control Samdasoo had a soft and smooth surface. The positive control, orange juice, had a rough surface due to the loss of resin crystals, and micropores with a size ≤0.5 μm were observed in some parts. In the experimental group, the surface was rough overall in the oriental dressing; micropores of 0.5 to 1 μm were observed in some parts; and the surface of the balsamic dressing was rough overall; micropores of approximately 0.5 μm were observed in some parts. The lemon-garlic dressing was partially rough on the surface, and a micropore approximately 1 μm in size was observed in some parts. In the case of the lemon-garlic dressing with 3% calcium, a smooth surface was observed as a whole, and fewer micropores were observed compared with the lemon-garlic dressing without calcium (Fig. 1).

Table 4. Microhardness Change of Composite Resin by Treatment Time (Unit: VHN)

Group	Treatment (min)					
	Before	1	3	5	15	30
Samdasoo[a]	46.53±1.36	47.31±1.56	45.32±1.94	45.06±2.27	45.62±1.30	44.90±2.09
Orange juice[c]	45.71±2.88	40.25±1.44	39.50±3.17	38.64±4.41	38.31±1.33	37.52±1.72
Oriental dressing[c]	45.64±2.33	44.00±2.99	39.86±2.97	39.44±1.49	37.55±3.11	37.02±2.97
Balsamic dressing[c]	46.37±3.53	40.41±1.67	38.14±1.25	37.59±1.28	37.49±1.79	37.20±2.31
Lemon-garlic dressing[c]	45.86±2.67	38.79±1.50	38.59±1.52	37.79±1.33	36.44±2.66	36.25±2.53
Lemon-garlic dressing +3% Ca[b]	47.23±1.10	42.68±1.75	41.62±2.35	41.04±1.46	40.80±1.16	40.47±2.18

All values are mean±standard deviation.
The same letter indicates no significant difference by Tukey's test at $\alpha=0.05$.

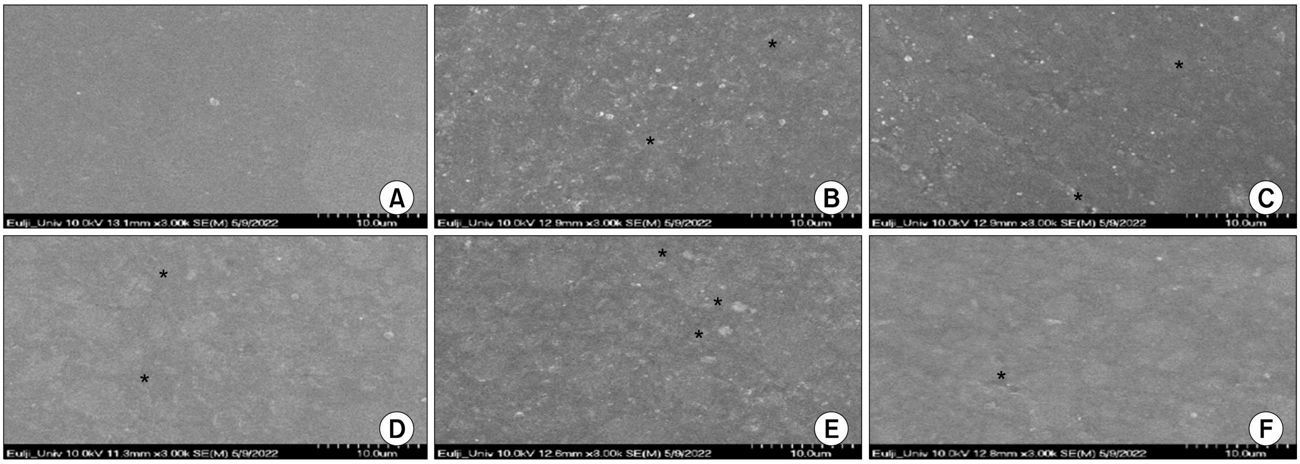

Fig. 1. Scanning electron microscope (SEM) image of a composite resin surface 30 minutes after the treatment. This demineralization pattern was observed in all samples except the negative control group, Samdasoo. In particular, erosion appeared severely in the positive control group Orange juice, and Oriental dressing, Balsamic dressing, Lemon-garlic dressing, an experimental group. (A) Samdasoo; (B) Orange juice; (C) Oriental dressing; (D) Balsamic dressing; (E) Lemon-garlic dressing; (F) Lemon-garlic dressing +3% calcium. All magnification is ×3,000. *: micropore.

Discussion

1. Interpretation

When adding a specific ingredient to reduce the effect of food causing dental erosion, it is difficult to select a certain additive or adjust its concentration. According to previous studies, calcium can be safely added to food to prevent dental erosion[19-21]. Accordingly, several calcium compounds are used as food additives, of which calcium lactate is the most common representative[22]. Calcium lactate is well soluble in water, and is colorless and odorless; therefore, it is widely used as a supplement for calcium in foods. Studies by Kashket and Yaskell[23,24] have confirmed that enamel demineralization is inhibited when calcium lactate is added to sweets or beverages containing sugar. A study by Kim et al.[25] showed that demineralization was suppressed in the Oranssi calamansi group treated with 3% calcium lactate. Therefore, the calcium lactate contained in the beverage helps prevent dental erosion.

Therefore, this study used the research method of Kim et al.[11], which confirmed that the addition of calcium to fermented milk reduced the weakening of the surface microhardness of the composite resin. The purpose was to confirm the change in surface hardness owing to the effect of salad dressing with calcium lactate added to the composite resin. Lee et al.[9] reported that a 3% calcium concentration most effectively inhibits erosion while being lower than 5%, considering that the lowest observed adverse effect level of calcium is 5.0 g per day. Accordingly, 3%

calcium lactate was added to the lemon-garlic dressing, which has the lowest acidity among salad dressings.

Dental erosion is primarily caused by the consumption of extrinsic acids. It is usually caused by foods such as citrus fruits, fruit juices, and sports drinks[26]. Among the extrinsic factors, a study by Oh and Lee[27] related to beverages explained that the surface microhardness decreased as a result of treating the teeth with a low-pH beverage for 30 minutes. Therefore, based on previous studies, it can be inferred that salad dressings made with low-acidity ingredients, such as fruits and vinegar, are also major causes of dental erosion.

2. Key results and comparison with the results of previous studies

In many previous studies, a pH of 5.5 or lower is the critical pH for enamel dissolution, and in particular, erosion-inducing properties of pH below 4.0 have been reported[28]. As a result of this study, except for Samdasoo, the average pH of the three salad dressings was 3.12±0.04. Lemon-garlic dressing showed the lowest pH at 2.49±0.03, followed by balsamic dressing at 3.12±0.06 and oriental dressing at 3.75±0.03. Orange juice, the positive control group, showed 3.82±0.02. A study by Lee et al.[29] showed an average pH of 2.49～3.82, which is below 4 on average, confirming the high risk of dental erosion. In addition, it was confirmed that the pH of the salad dressing increased from 2.49±0.03 to 3.27±0.09 when 3% calcium lactate was added to the lemon-garlic dressing. According to a study by Franklin et al.[30], calcium chelates acidic ions present in the juice, reducing the content of active acids and limiting the pH drop. This is also why pH increased when 3% calcium lactate was added to the lemon-garlic dressing in this study. Furthermore, it was reported that when the oral pH decreased by one step (pH 1.0) from 6.5, tooth solubility increased 7～8 times. As such, it is believed that the calcium added to the salad dressing not only inhibits enamel dissolution but also increases the pH of the salad dressing, resulting in an erosion-inhibitory effect.

Along with the pH of the beverage, titratable acidity is also a factor that affects dental erosion. The titratable acidity plays a role in neutralizing acids and exhibits the properties of acidic drinks that resist pH changes[31]. In this study, the titratable acidity was calculated by the amount of 1 M NaOH needed to reach a pH between 5.5 and 7.0 of the salad dressing. As a result of the study, the buffering capacity at pH 5.5 was the lowest in the positive control group at 0.60±0.04; and in the experimental group, lemon-garlic dressing ＋3% calcium showed the highest value at 3.00±0.16, followed by lemon-garlic dressing at 2.14±0.04, balsamic dressing at 1.23±0.10, and oriental dressing at 1.21±0.11. At pH 7.0 in the positive control group, orange juice showed the lowest buffering capacity at 0.81±0.01, and in the experimental group, lemon-garlic dressing ＋3% calcium showed the highest at 3.25±0.17, followed by lemon-garlic dressing at 2.42±0.11, balsamic dressing at 2.42± 0.12, and oriental dressing at 1.42±0.16. Unlike the study by Larsen and Nyvad[12], which found that higher titratable acidity causes more erosion, in this study, titratable acidity was higher in the lemon-garlic dressing with calcium lactate added than in the lemon-garlic dressing. It is possible that calcium, an inorganic ingredient, interfered with diluting NaOH in salad dressing, and the same results can be seen in other studies[32], indicating that pH is more related to erosion than titratable acidity.

To confirm the surface changes of the composite resin, the surface microhardness was measured, and the surface morphological changes of the composite resin were observed after exposure to salad dressing using a SEM. The results of this study showed that, although there were differences between each group of salad dressings, they all reduced the surface microhardness of the composite resin. After 30 minutes of immersion in salad dressing, the surface microhardness was significantly reduced in all groups. Lemon-garlic dressing (－9.61±1.16) was the highest in surface microhardness difference before and after immersion in salad dressing, followed by balsamic dressing (－9.17±1.63), oriental dressing (－8.62±1.09), orange juice (－8.19±1.36), lemon-garlic dressing ＋3% calcium (－6.76±1.23), and Samdasoo (－1.63±2.47). Changes in the surface microhardness over time also showed similar patterns.

In this study, surface microhardness before and after immersion showed a small difference in the negative control group but a large difference in both the positive control and experimental groups. In a study by Martos et al.[33], when the composite resin specimens were stored in distilled water, the surface became rough, showed a porous structure, and the surface microhardness decreased compared with the specimens not stored in distilled water. Therefore, in this study, it is presumed that the surface microhardness of the composite resin specimens immersed in Samdasoo, the negative control group, decreases. De Witte et al.[34] reported that the surface decomposition of composite resin could facilitate the wear and adhesion of dental plaque, reducing the lifespan of composite resin and increasing the risk of dental caries. Accordingly, the surface erosion of composite resin is not limited to the reduction of the mechanical and chemical properties of dental materials but is considered a factor that affects dental caries and overall oral health. Thus, it is important to prevent erosion.

The pH difference between the lemon-garlic dressing and the lemon-garlic dressing +3% calcium was 0.78. The difference in surface microhardness before and after immersion was −2.85 △VHN, and it was confirmed that there was an erosion-inhibitory effect on the composite resin, as reported by Kim et al.[11]. In addition to calcium, various studies have been conducted to prevent dental erosion in acidic drinks, including the addition of specific ingredients. Calcium, fluoride, and xylitol have been added to carbonated, orange juice, and hangover drinks to inhibit erosion. Therefore, it is thought that study that adds not only calcium but also fluoride and xylitol to salad dressing is necessary.

When observing the surface of the composite resin using a SEM, the negative control group showed a smooth surface pattern. Oriental dressing, balsamic dressing, and lemon-garlic dressing showed a rough surface, as did orange juice in the positive control group. These results confirm that the salad dressing affects the composite resin surface. In addition, the lemon-garlic dressing with 3% calcium showed relatively fewer micropores than the lemon-garlic dressing without calcium, confirming the erosion-inhibitory effect of calcium.

3. Suggestions

Based on the results of this study, it is necessary to consider a method of adding calcium to salad dressings. This reduces the weakening of surface microhardness due to salad dressing intake in the oral environment where flowable composite resins exist. Furthermore, oral health experts should make consumers aware of the relationship between the erosion of composite resin and salad dressing through continuous oral health education. It is recommended that consumers take care of themselves by rinsing with water instead of brushing immediately after eating salad dressings to reduce the residual acid in the oral cavity.

4. Limitations

A limitation of this study is that the effect of saliva, which always exists in the oral cavity and has a buffering effect, cannot be reproduced. To address this limitation, it is recommended that further studies be conducted under similar conditions to the oral cavity for a better understanding of the observed effect.

Notes

Conflict of interest

No potential conflict of interest relevant to this article was reported.

Ethical approval

This article does not require IRB screening because human participation was not involved.

Author contributions

Conceptualization: Ye-Jin Kim, Im-Hee Jung, and Do-Seon Lim. Data acquisition: Ye-Jin Kim, Hyun-Woong Jeong, Na-Sun Jung, Na-Hyun Kwon, and Jin-Yeong Lee. Formal analysis: Na-Hyun Kwon, Jin-Yeong Lee, and Na-Sun Jung. Supervision: Do-Seon Lim and Im-Hee Jung. Writing–original draft: Ye-Jin Kim, Na-Hyun Kwon, Na-Sun Jung, Jin-Yeong Lee, and Hyun-Woong Jeong. Writing–review & editing: Do-Seon Lim and Im-Hee Jung.

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Data availability

The supporting data of this study are available from the corresponding author upon reasonable request.

References

1. Kukmin Ilbo: Clean taste and balance. Retrieved October 4, 2021, from http://news.kmib.co.kr/article/view.asp?arcid=0924130179&code=11151600&cp=nv (2020, March 29).
2. Rytömaa I, Meurman JH, Koskinen J, Laakso T, Gharazi L, Turunen R: In vitro erosion of bovine enamel caused by acidic drinks and other foodstuffs. Scand J Dent Res 96: 324-333, 1988. https://doi.org/10.1111/j.1600-0722.1988.tb01563.x
3. Attin T, Weiss K, Becker K, Buchalla W, Wiegand A: Impact of modified acidic soft drinks on enamel erosion. Oral Dis 11: 7-12, 2005. https://doi.org/10.1111/j.1601-0825.2004.01056.x
4. Cairns AM, Watson M, Creanor SL, Foye RH: The pH and titratable acidity of a range of diluting drinks and their potential effect on dental erosion. J Dent 30: 313-317, 2002. https://doi.org/10.1016/s0300-5712(02)00044-1
5. Hartz JJ, Procopio A, Attin T, Wegehaupt FJ: Erosive potential of bottled salad dressings. Oral Health Prev Dent 19: 51-57, 2021. https://doi.org/10.3290/j.ohpd.b898955
6. Linkosalo E, Markkanen H: Dental erosions in relation to lactovegetarian diet. Scand J Dent Res 93: 436-441, 1985. https://doi.org/10.1111/j.1600-0722.1985.tb01336.x
7. Kim SY, Park JH, Kim GC, Choi YC: Scanning electron microscopic study of the effect of acidic drink on enamel erosion: a case report. J Korean Acad Pediatr Dent 35: 509-515, 2008.
8. Kim MY, Lim HJ, Kim HE, et al.: Effect of liquefied digestive medicine on the surface of composite resin. J Dent Hyg Sci 22: 20-29, 2022. https://doi.org/10.17135/jdhs.2022.22.1.20
9. Lee HJ, Oh HN, Hong SJ, Choi CH: Effect of hangover beverage containing fluoride and calcium on enamel erosion. J Korean Acad Oral Health 36: 177-184, 2012.
10. Al-Dlaigan YH, Shaw L, Smith A: Dental erosion in a group of British 14-year-old, school children. Part I: prevalence and influence of differing socioeconomic backgrounds. Br Dent J 190: 145-149, 2001. https://doi.org/10.1038/sj.bdj.4800908
11. Kim YS, Kim JE, Chung KH, Choi CH: Effect of fermented milk product on composite resin surface. J Korean Acad Oral Health 45: 138-144, 2021. https://doi.org/10.11149/jkaoh.2021.45.3.138
12. Larsen MJ, Nyvad B: Enamel erosion by some soft drinks and orange juices relative to their pH, buffering effect and contents of calcium phosphate. Caries Res 33: 81-87, 1999. https://doi.org/10.1159/000016499
13. Jensdottir T, Bardow A, Holbrook P: Properties and modification of soft drinks in relation to their erosive potential in vitro. J Dent 33: 569-575, 2005. https://doi.org/10.1016/j.jdent.2004.12.002
14. Hara AT, Zero DT: Analysis of the erosive potential of calcium-containing acidic beverages. Eur J Oral Sci 116: 60-65, 2008. https://doi.org/10.1111/j.1600-0722.2007.00513.x
15. Beiraghi S, Atkins S, Rosen S, Wilson S, Odom J, Beck M: Effect of calcium lactate in erosion and S. mutans in rats when added to Coca-Cola. Pediatr Dent 11: 312-315, 1989.
16. Ryu JI, Jung SH, Han DH, Lee SR, Jeon JE: Financial estimate of light-curing composite resin treatment after National Health Insurance Service coverage. J Korean Acad Oral Health 43: 136-141, 2019. https://doi.org/10.11149/jkaoh.2019.43.3.136
17. Han L, Okamoto A, Fukushima M, Okiji T: Evaluation of flowable resin composite surfaces eroded by acidic and alcoholic drinks. Dent Mater J 27: 455-465, 2008.
18. Valinoti AC, Neves BG, da Silva EM, Maia LC: Surface degradation of composite resins by acidic medicines and pH-cycling. J Appl Oral Sci 16: 257-265, 2008. https://doi.org/10.1590/s1678-77572008000400006
19. Grenby TH: Lessening dental erosive potential by product modification. Eur J Oral Sci 104(2 (Pt 2)): 221-228, 1996. https://doi.org/10.1111/j.1600-0722.1996.tb00071.x
20. West NX, Hughes JA, Parker DM, Newcombe RG, Addy M: Development and evaluation of a low erosive blackcurrant juice drink. 2. Comparison with a conventional blackcurrant

juice drink and orange juice. J Dent 27: 341-344, 1999. https://doi.org/10.1016/s0300-5712(98)00070-0
21. Hughes JA, West NX, Parker DM, Newcombe RG, Addy M: Development and evaluation of a low erosive blackcurrant juice drink. 3. Final drink and concentrate, formulae comparisons in situ and overview of the concept. J Dent 27: 345-350, 1999. https://doi.org/10.1016/s0300-5712(98)00068-2
22. Song IG, Lee KH, Kim DE, Yang YS: Effect of citric acid and calcium on dental erosion. J Korean Acad Pediatr Dent 32: 454-460, 2005.
23. Kashket S, Yaskell T: Effect of timing of administered calcium lactate on the sucrose-induced intraoral demineralization of bovine enamel. Arch Oral Biol 37: 187-191, 1992. https://doi.org/10.1016/0003-9969(92)90088-p
24. Kashket S, Yaskell T: Effectiveness of calcium lactate added to food in reducing intraoral demineralization of enamel. Caries Res 31: 429-433, 1997. https://doi.org/10.1159/000262434
25. Kim EK, Park HR, Chung KY, Choi CH, Jeong SS: Effects of some commercial calamansi-containing beverages on the enamel surface. J Korean Acad Oral Health 44: 7-12, 2020. https://doi.org/10.11149/jkaoh.2020.44.1.7
26. ten Cate JM, Imfeld T: Dental erosion, summary. Eur J Oral Sci 104(2 (Pt 2)): 241-244, 1996. https://doi.org/10.1111/j.1600-0722.1996.tb00073.x
27. Oh HN, Lee HJ: The effect of energy drink on enamel erosion. J Dent Hyg Sci 15: 419-423, 2015. https://doi.org/10.17135/jdhs.2015.15.4.419
28. Mahoney EK, Kilpatrick NM: Dental erosion: part 1. Aetiology and prevalence of dental erosion. N Z Dent J 99: 33-41, 2003.
29. Lee HJ, Hong SJ, Choi CH: Erosive effect of hangover-curing beverages on enamel surface. J Korean Acad Oral Health 37: 119-125, 2013. https://doi.org/10.11149/jkaoh.2013.37.3.119
30. Franklin S, Masih S, Thomas AM: An in-vitro assessment of erosive potential of a calcium-fortified fruit juice. Eur Arch Paediatr Dent 15: 407-411, 2014. https://doi.org/10.1007/s40368-014-0130-3
31. Rugg-Gunn AJ, Maguire A, Gordon PH, McCabe JF, Stephenson G: Comparison of erosion of dental enamel by four drinks using an intra-oral applicance. Caries Res 32: 337-343, 1998. https://doi.org/10.1159/000016469
32. Kim KH, Kim DE, Kim AO, Shin AR, Jeong SS, Choi CH: A study of dental erosion prevention by calcium contents of fermented milk. J Korean Soc Dent Hyg 17: 969-981, 2017. https://doi.org/10.13065/jksdh.2017.17.06.969
33. Martos J, Osinaga PWR, de Oliveira E, de Castro LAS: Hydrolytic degradation of composite resins: effects on the microhardness. Mat Res 6: 599-604, 2003. https://doi.org/10.1590/S1516-14392003000400029
34. De Witte AM, De Maeyer EA, Verbeeck RM: Surface roughening of glass ionomer cements by neutral NaF solutions. Biomaterials 24: 1995-2000, 2003. https://doi.org/10.1016/s0142-9612(02)00617-8