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Original Article

Effects of sour curry temperature with fermented shrimp paste on surface hardness of tooth enamel

Pojjanut Benjakul[1], Paruhat Prommontri[4], Chanya Chuenarrom[1,2]*, and Ureporn Leggat[3]

[1] *Department of Prosthetic Dentistry, Faculty of Dentistry,*

[2] *Dental Materials Research Unit, Faculty of Dentistry,*

[3] *Department of Oral Biology and Occlusion, Faculty of Dentistry,*
Prince of Songkla University, Songkhla, Thailand

[4] *Phuket Smile Dental Clinic, Phuket, Thailand.*

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Abstract

The aim of this study was to evaluate the effect of temperature of Thai sour curry with and without fermented shrimp paste (Kapi) on enamel hardness. The pH and the titratable acidity of the assigned food were determined for Kangsom with Kapi and Kangsom without Kapi at 25°C, 37°C and 55°C. Thirty six enamel specimens were randomly assigned into 6 groups. Each group was exposed to the assigned foods at 25°C, 37°C and 55°C at 15 min interval for 3 periods and the last intervals at 60 min. The enamel surface hardness was evaluated by a Vickers microhardness tester. Increasing the temperature of the food resulted in a decreasing pH and a slightly increased titratable acidity content. The hardness values of enamel exposure for Kangsom with Kapi and Kangsom without Kapi were significantly different for all temperatures. The hardness value of enamel exposure for Kangsom with Kapi at 55°C was higher than that for exposure at 25°C and 37°C. In contrast, the hardness value of enamel exposure for Kangsom without Kapi at 55°C was significant lower than that for exposure at 25°C and 37°C. The temperature of Kangsom had an effect on enamel softening and Kangsom without Kapi had higher erosive potential than Kangsom with Kapi.

Keywords: enamel softening, fermented shrimp paste, Kangsom, microhardness, temperature

1. Introduction

Acidic foods and drinks which taste sour are an important factor of dental erosion (Chuajedong *et al.*, 2002; Kunzel *et al.*, 2000). Foods and drinks with pH value lower than the critical point (pH 5.5) and with high quantitation acid (titratable acidity) are more progressive in dental erosion (Tahmassebi *et al.*, 2006). However, there are other factors correlated with dental erosion, such as different kinds of acids (citric, malic, tartaric etc. cause different progressions of dental erosion) (Zero, 1996), and food temperature (West *et al.*, 2000). Some minerals in foods, for example phosphate and fluoride are able to decrease the progression of dental erosion (Lussi *et al.*, 1993).

Amaechi *et al.* (1999) found that the immersed tooth specimens in orange juice at higher temperature showed a greater degree of erosion than at lower temperatures. Thienthananurak (2004) studied the effect of temperature in Thai food on dental erosion and found that higher temperatures of orange juice and pickled grapes had greater effect on dental erosion. This result is in contrast to the finding with Kangsom (Thai spicy sour curry). When tooth specimens

* Corresponding author.
Email address: chanya.ch@psu.ac.th

were immersed in higher temperatures of Kangsom there was less progression of dental erosion.

Kangsom is a commonly consumed food in Thailand. This curry has a spicy and sour taste. The ingredients of Kangsom sauce includes herbs such as chilli, shallot, garlic, turmeric, tamarind or lemon juice, Kapi (fermented shrimp paste), and salt. The ingredients of Kangsom have varied chemical composition and acid-base, and may affect the relationship between composition and the level of effect dental erosion. Another recent work investigated the effect of Kapi in tamarind juice on loss of tooth enamel, in which it was found that Kapi could reduce the erosive potential of tamarind juice (Chuenarrom and Benjakul, 2010). Kapi is a salty fermented shrimp paste produced from small shrimps or silver shrimps, and is salted, fermented, and dried until it breaks down into a paste. It has a strong salty taste and an extreme smell. Kapi is used as a general condiment in south-east Asian and southern Chinese food. It is rich in protein, calcium, vitamins and various extractable compounds (Heu *et al.*, 2003). One teaspoon of Kapi contains 73 milligram of calcium or up to 1565 milligram of calcium per 100 gram of Kapi (Bunjong *et al.*, 1995).

The pH range is 3.38-3.90 for Kangsom (Tiantananurak, 2004) which is lower than the critical point for eroding dental enamel (Cairns *et al.*, 2002). Kangsom is consumed at room temperature or taken hot, so the finding that the level of dental erosion is inversely related to its temperature is particularly interesting. The aim of this study was to investigate the effect of Kapi in Kangsom on enamel hardness change and compare the erosive potential of Kangsom with Kapi and Kangsom without Kapi at different temperatures. The results of this study will serve on a guideline for examination of enamel erosion from Kangsom, which is a popular dish for Thai people.

2. Materials and Methods

2.1 The acidity of Kangsom sauce and ingredients

The Kangsom sauce recipe comprises curry paste and tamarind juice. The curry paste is prepared from crushed chilli, garlic, turmeric, kapi and salt in tamarind juice. The recipe of the assigned foods used in the present study is presented in Table 1.

The pH value of the assigned food at 25°C, 37°C and 50°C were determined using pH meter (520A, Orion, Orion Research Inc., USA). Next, 20 ml of each assigned food was titrated with 1 N NaOH to raise the pH from the original pH to pH of 7. The volume (ml) of 1 N NaOH used in the titration was recorded to be the titratable acidity content (TA).

2.2 Specimen preparation

Unerupted human third molar teeth were immersed in NaCl for preserving the teeth. Eighteen teeth were selected and soaked in 0.05% NaClO for disinfecting. The remaining debris was removed by scrubbing and the tooth was washed in distilled water. Specimens were sectioned into buccal and lingual side, embedded in acrylic resin blocks, then minimally ground with silicon carbide abrasive paper with grit No.400, 600 and 1,200 under tap water to produce an optically flat area of enamel, 3x3 mm^2 in dimension. All specimens were measured for initial hardness using a Vickers microhardness tester (Buehler, Micromet II, Buehled Ltd., USA) under a load of 100 g for 10 s.

2.3 Erosion regimes

The 36 specimens were randomly assigned to 6 groups, and then immersed in Kangsom without Kapi or Kangsom with Kapi at 25°C, 37°C or 50°C. Each group was exposed to 20 ml of the assigned foods at 15 min interval for 3 periods (totalling 45 min). Next, specimens were exposed to the last interval for 60 min. At each interval, specimens were rinsed in running tap water, dried and the hardness of enamel surfaces measured with the microhardness tester under a load of 100g for 10s.

The percentage of surface microhardness value (% SMH) was calculated based on the initial Vickers hardness number (VHN_0) and Vickers hardness number after exposure in agents (VHN_1) as follows: $\%SMH = (VHN_1 / VHN_0) \times 100$.

Table 1. The composition of assigned foods used in the study for their acidity properties.

Assigned food	temperature						Composition in water (%weight)
	25°C		37°C		55°C		
	pH	TA	pH	TA	pH	TA	
Tamarind juice	2.69	0.59	2.43	0.67	2.21	0.66	2.7% tamarind paste
Kapi	7.38	-	7.32	-	6.98	-	1.0% kapi paste
Kangsom without Kapi	2.97	1.16	2.81	1.17	2.44	1.22	2.7% tamarind paste, 1.7% chilli, 0.8% garlic, 0.3% turmeric, 0.1% salt
Kangsom with Kapi	4.06	0.72	3.93	1.0	3.65	0.94	2.7% tamarind paste, 1.7% chilli, 1.0% kapi, 0.8% garlic, 0.3% turmeric, 0.1% salt

2.4 Statistical analysis

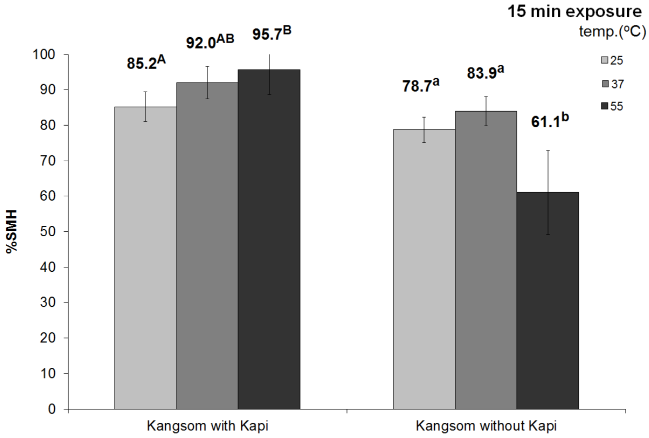
Analysis of variance was performed on the results and Tukey's significant difference was used to evaluate the multiple comparisons.

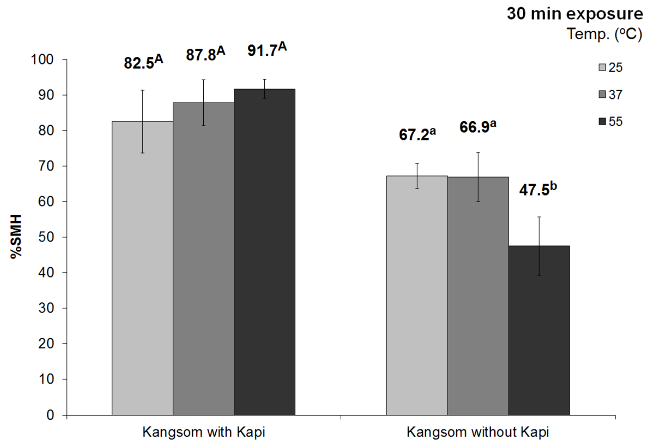
3. Results

The pH and titratable acidity of tamarind juice, Kapi, Kangsom without Kapi, and Kangsom with Kapi at different temperatures are shown in Table 1. Increasing food temperature resulted in decreasing their pH and slightly increasing the titratable acidity content. Tamarind juice was a strong acid while Kapi sauce was neutral. Therefore, Kangsom with Kapi had a higher pH than Kangsom without Kapi.

The average initial Vickers hardness value of 36 specimens was 361.8±13.8 kg/mm^2. The percentage for surface hardness value of the treatment groups showed that each group had a different erosive potential on the enamel surface (Figures 1 to 4). At the same temperature, specimens exposed in Kangsom without kapi had a lower hardness value than Kangsom with kapi ($p<0.05$).

An effect of the temperature on enamel hardness was also seen. At 55°C, for exposure in Kangsom with Kapi, the enamel hardness value was higher than at 25°C and 37°C. In contrast, the hardness value of enamel exposure for Kangsom without Kapi at 55°C was significantly lower than that at 25°C and 37°C.

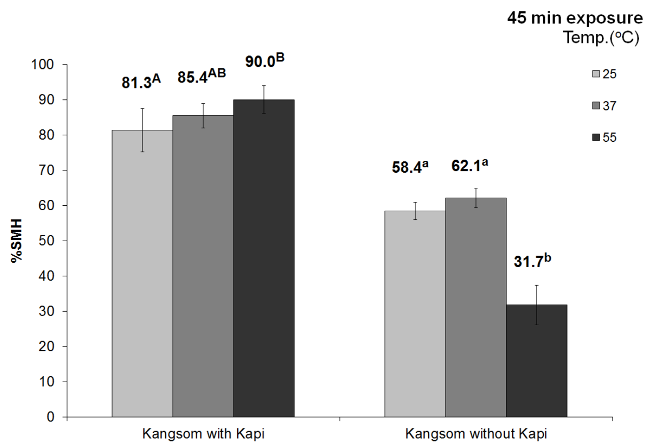


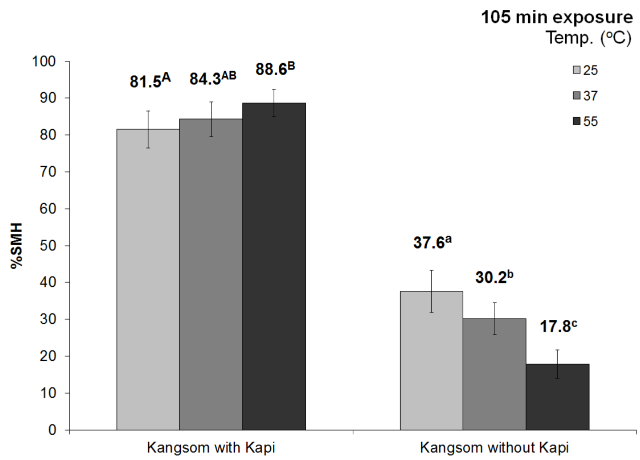


Means identified with the same letter are not signiûcantly different at the $p < .05$ level.

Figure 1. %SMH of enamel after exposure to assigned agents for 15 min at different temperatures.

Figure 2. %SMH of enamel after exposure to assigned agents for 30 min at different temperatures.





Means identified with the same letter are not signiûcantly different at the $p < .05$ level.

Figure 3. %SMH of enamel after exposure to assigned agents for 45 min at different temperatures.

Figure 4. %SMH of enamel after exposure to assigned agents for 105 min at different temperatures.

4. Discussion

The microhardness test is the accepted method for investigating the early stage of enamel dissolution (Maupome *et al.*, 1998; Seow and Thong, 2005; Wongkhantee *et al.*, 2006; Zero *et al.*, 1990). In this study, Vickers microhardness number (VHN) for enamel surface after flat polishing ranged from 321 to 389 kg/mm^2. These values are similar to other previous studies (Lupi-Pegurier *et al.*, 2003; Maupome *et al.*, 1998). After exposure to assigned agents, the results showed different softening of enamel surface in each group.

Kangsom was chosen because it is a frequently consumed dish in the southern area of Thailand. Although there are several ingredients in Kangsom sauce, each which different chemical properties, our pilot study found that the ingredients in Kangsom sauce other than tamarind juice and Kapi did not affect the acidity value of Kangsom. This study looked at these 2 main ingredients; tamarind juice produces a sour taste and Kapi is rich in calcium. Both tamarind juice and Kapi had an effect on the pH value of Kangsom. Table 1 shows that tamarind juice is an acid, while Kapi is neutral, so when adding Kapi to Kangsom it assists in decreasing the acidity of Kangsom. The results clearly demonstrate that the difference in the erosive potential of Kangsom can be attributed to the adding of Kapi. This result is consistent with previous reports. Hooper *et al.* (2004) demonstrated that calcium addition can be applied to a range of drink types to reduce erosion of enamel. Barbour *et al.* (2006) demonstrated that sufficient calcium concentration in drinks is one of the factors that assists in the reduction of the rate of hydroxyapatite dissolution. A recent study has found that Kapi could delay enamel loss due to tamarind juice (Chuenarrom and Benjakul, 2010). Calcium can reduce enamel erosion as follows; calcium ions can interact with the carboxyl group of tartaric acid to create calcium salt, hence the number of available carboxyl groups of tartaric acid would decrease and calcium would be extracted from the enamel surface at a lower rate. In addition, when the acid typically dissolves the surface of enamel until a calcium saturated solution is reached, the saturated solution prevents further dissolution or erosion. Therefore, addition of sufficient calcium to the initial solution can saturate the initial solution and prevent subsequent dissolution (Featherstone and Lussi, 2006).

The pH of all tested food in Table 1 decreased noticeably with increase in temperature and there was a slight variation in the titratable acidity. Heat is used as a catalyst to speed up the chemical reaction between acidic food and hydroxyapatite which results in tooth enamel loss. The effect of the temperature on the pH and the erosive potential of Kangsom without Kapi was consistent with the explanation above. It can be seen in Figures 1 to 4 that there was a significant decrease in surface hardness of enamel when the temperature was increased from 37°C to 55°C.

Kangsom with Kapi, by contrast, saw a decrease in the pH and the erosive potential even when the temperature was increased, whereas other sour foods saw the opposite expected result. Interestingly, the decrease in the pH afforded by the increase in temperature results in a decrease of the erosive potential of Kangsom with Kapi. Kangsom with Kapi at 25°C and 37°C, with a pH of 4.06 and pH of 3.93 respectively, caused a greater reduction in the hardness of enamel than Kangsom with Kapi at 55°C (pH of 3.65). The reduction in hardness was small and independent of the temperature which has been confirmed in a previous study on juice drink with high calcium concentration (Barbour *et al.*, 2006). This is likely to be due to the relatively high concentration of calcium in the drink which compensates for the decrease in pH. In the present study, this effect can also be explained as it is possible that Kangsom with Kapi at higher temperatures had higher concentrations of free Ca^{2+} from the Kapi and this would increase ion activity of the solution and reduce the solubility of hydroxyapatites.

In practice, Kangsom is consumed with rice, holding Kangsom in the mouth while chewing before swallowing is a risk factor for tooth softening or erosion. Our results indicated that Kapi is an important ingredient in Kangsom for reducing erosive potentials, and so consumers should eat Kangsom hot. However, the hardness changing results obtained in this *in vitro* study must be interpreted with regard to the *in vivo* situation. The interpretation is that the enamel softening effect of Kangsom in vivo conditions will be less than in vitro studies because of the formation of pellicles as well as the buffer capacity, pH and flow rate of oral fluid (Lussi *et al.*, 1995).

5. Conclusion

Under the experimental conditions of this study, the results showed that adding Kapi to Kangsom resulted in a reduction of enamel softening. It is clear that the association between enamel softening and the temperature of Kangsom without Kapi differed from that of Kangsom with Kapi. For Kangsom without Kapi, an increase in temperature resulted in an increase in enamel softening. While for Kangsom with Kapi, an increase in temperature resulted in a decrease in enamel softening.

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