Comparative study on animal and vegetable fat as effective palate cleanser of spiciness

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Abstract. Fat based palate cleanser used to overcome spicy intensity on the tongue papillae TRPV1 receptor. In this study, the effectiveness of milk as an animal fat-based palate cleanser was compared to vegetable fat based palate cleansers such as coconut milk and soymilk. Temporal dominance of sensations (TDS) was applied to monitor the effectiveness of palate cleanser (milk, coconut milk, and soymilk) on three different concentrations of chili powder (0.2%; 0.4%, and 0.6%). The study involved 12 intensively trained panellists. It was observed that coconut milk tended to be more effective than those of milk and soy milk in 0.2% and 0.4% chili powder concentration (P-value < 0.05). Further confirmation suggests that at a lower concentration of spiciness, protein involves cleansing sensation, while at higher concentration, it is more dominant by fat in conjunction with protein contribution.

1. Introduction
Traditionally, Indonesia has many spicy foods which are mostly stimulated by the usage of chili. In fact, Indonesia’s national consumption growth per capita is about 1.7% per year [1]. Even though the spicy foods are popular among Indonesian, only a few people can stand the sensation of chili spiciness. The spicy sensation is mostly affected by the reaction between chili capsaicin and TRPV1 receptor (high temperature receptor) in tongue papillae. The contact between capsaicin (irritant) and mouth cavity has the same effect when we eat high-temperature food (burning sensation mouthfeel) [2]. Many ways collected to resolve the high-intensity spiciness of chili based food. One of them is the usage of a palate cleanser. A palate cleanser is any food material that can be used to clean and neutralize the oral cavity [3].

In this current study, fat based palate cleansers were used to overcome the spiciness of chili. The fats were chosen considering their similar polarity as capsaicin. Thus it was expected that the capsaicin will be dissolved by the fats and therefore minimizing the contact with the TRPV1 receptor [4]. Furthermore, it was also reported that fat-based palate cleansers such as milk, may replace burning sensation by enhancing sweetness [5]. The usage of milk, as an animal fat-based palate cleanser, has been reported in many similar studies. However, to date, there is no comprehensive study comparing the effectiveness of animal and vegetable fat based palate cleansers in neutralizing the effect of chili capsaicin. Therefore this current study was aimed to compare the effectiveness of milk, representing
animal fat-based palate cleanser, to coconut milk and soy milk, representing vegetable fat-based palate cleanser. It was expected that the difference between fat content and structure may affect the polarity and thus cleanser effectiveness.

A sensorial approach was used to evaluate the effectiveness of oral cleansing. Temporal Dominance Sensation (TDS) test was applied to evaluate the duration of spicy (burning) dominance sensations and to determine possible any other sensory attribute that may suppress the spiciness. TDS is a descriptive test often used in profiling the dynamic (changing) oral sensory attribute [6]. In this current study, the changing of burning sensation and its duration in the mouth will be evaluated to find the most effective palate cleansers for chili spiciness.

2. Materials and Method

2.1. Materials
This study uses commercial milk, coconut milk, and soy milk that is processed in ultra-high temperature (UHT) as a spicy (burning) sensation palate cleanser. In addition, chili powder is used as a spicy stimulant and water as a solvent for chili powder. Water is also used to make coconut milk and milk solution with 1% fat content.

2.2. Method
The method used in this study was the Temporal Dominance of Sensations (TDS). This method provides information on the dominance sensory attribute in the mouth cavity [6] and the ending time (second) of spicy (burning) dominance sensations. The results of the dominant sensory attributes will be discussed descriptively (using the TDS curve) and the ending time of spicy (burning) sensation dominance will further be analyzed by analysis of variance (ANOVA) General Linear Model (GLM).

Panelists will evaluate the palate cleanser sample in removing spicy sensations that are preceded by stimulation of spicy sensations. Three concentrations of chili powder solved in water (chili concentration) are used to stimulate the spicy sensation (spicy stimulant) [5] which will then be tested by a palate cleanser. The difference in chili concentration used aims to discover whether the amount of capsaicin (in chili) yields the same or different palate cleansing effect. Only 0.4% chili concentration was used to describe the sensory development of each palate cleanser. The palate cleanser used is divided into 2 groups namely based on the type of palate cleanser (in the whole form) and based on the type of fat (fat content of 1%).

Table 1. Research design of spicy sensation palate cleanser.

| Factor                              | Chili concentration (%) |
|-------------------------------------|-------------------------|
| Type of palate cleanser (whole)     | 0.2%                    |
| (dairy milk, coconut milk, and soy milk) | 0.4%                  |
| Fat type of palate cleanser (fat content of 1%) | 0.2%                  |
| (dairy milk solution, coconut milk solution, and soy milk) | 0.4%                  |
|                                     | 0.6%                    |
2.3. Sample preparation

Samples (milk, coconut milk, and soy milk) were first tested for their fat content. It was found that the lowest fat content was found in soy milk which is 1%. This fat content will be used as a standard concentration level of fat for making milk and coconut milk standard solution. Standard solution samples are made by dissolving each ingredient (milk and coconut milk) into the water. For the palate cleanser type factor in Table 1, milk, coconut milk, and soy milk will be intact (without dilution), while for the palate cleanser fat type factor, milk and coconut milk in the palate cleanser fat type factor will be diluted to 1% fat content (to equate fat levels such as soy milk fat content is the lowest between milk and coconut milk) with water. The formulations for making standard solution milk solutions and standard solution coconut milk are listed in Table 2 based on the dilution formula.

Table 2. Formulation of milk and coconut milk standard solution.

| Sample          | Fat content (%)* | Protein content (%)** | Fat content after formulation (%)* | Weight of sample diluted with water up to 500 ml (gr)*** | Protein content after formulation (%)*** |
|-----------------|------------------|-----------------------|-------------------------------------|----------------------------------------------------------|-----------------------------------------|
| Dairy milk      | 2.83*            | 3.2**                 | 1.0**                               | 178***                                                   | 1.13***                                 |
| Coconut milk    | 25.02*           | 0.0**                 | 1.0**                               | 20***                                                    | 0.0***                                  |

*Based on fat analysis [8], **Based on product’s nutrition fact, ***Based on dilution formula

3. Results and Discussion

3.1. TDS curve

In the samples of 0.4% chili and milk (Figure 1a), there was a disappearance of the spicy (burning) sensation in the mouth at 33rd seconds. The sensation of spicy responds at 5 seconds and lasts for 29 seconds. The oral cavity then dominated by creamy attributes, changed to fatty, and again dominated by creamy until the end of sensory evaluation at the 65th second. In the samples of 0.4% chili and coconut milk (Figure 1b), the disappearance of the spicy sensation in the mouth at the 26th second. The spicy sensation is responded to at the 20th second, then the creamy attribute becomes dominant and the sensory evaluation ends at the 60th second with the fatty dominant attribute. In the soy milk sample (Figure 1c), the spicy sensation began to be dominant at the 0.4% chili powder concentration. A spicy sensation begins at the beginning of the sensory evaluation from the 4th second which lasts for 25 seconds to the 28th second. The dominant sensory attribute changes to a nutty until the end of the sensory evaluation at 95 seconds.

In the samples of chili 0.4% and milk standard solution (fat content 1%) (Figure 1d), which have the same fat content as soy milk used in the test, the spicy sensation was removed at 72nd seconds. A spicy sensation starts from the 4th second and lasts 69 seconds without dominant sensory attributes changes. In the sample of 0.4% chili and coconut milk standard solution (fat content of 1%) (Figure 1e) which has the same fat content as soy milk used in the test, the spicy sensation is removed at 73 seconds. As with standard milk, a spicy sensation is felt from the 4th second and lasts for 69 seconds to 72 seconds without changing sensory attributes. In the sample of 0.4% chili and mineral water (Figure 1f), the spicy sensation disappeared at 80 seconds. The spicy sensation is stimulated at the 4th second and lasts for 77 seconds. The use of mineral water as a palate cleanser has a dominant spicy sensation in the mouth due to the absence of other sensory attributes that are dominant in mineral water [7]. The use of mineral water is commonly used as a palate cleanser for spicy sensation even though it only contains polar water which is not efficient in dissolving nonpolar capsaicin.

Based on the expiration of the spicy dominance time on the TDS curve, coconut milk has the fastest dominance of the spicy sensation compared to other samples. According to Kim and Lee [6], the higher fat content of milk decrease more burning intensity in the mouth, because coconut milk fat content is higher than milk and soy milk so that coconut milk can decrease more burning sensation,
except for the 0.2% chilli sample where soy milk has no spicy dominance sensation. Soy milk itself has a nutty flavour as the dominant sensory attribute caused by the denaturation of soy protein when UHT sterilization products produce alkyl pyrazine compounds which then interact with the oral cavity and are more dominant than the spicy sensation due to capsaicin [9].

Figure 1. TDS Curve.
Table 3. Dominance of spicy sensation based on TDS curve.

| Type of palate cleanser | Fat content (%) | Protein content (%) | Time (second) |
|-------------------------|----------------|---------------------|---------------|
| Coconut milk            | 25.0           | 0.0*                | 26th          |
| Dairy milk              | 2.8            | 3.2*                | 33rd          |
| Soy milk                | 1.0            | 2.8*                | 28th          |
| Coconut milk standard solution | 1.0**       | 0.0**               | 72nd          |
| Dairy milk standard solution | 1.0**       | 1.13**              | 72nd          |
| Water                   | 0*             | 0*                  | 80th          |

*Based on product’s nutrition fact, **Based on dilution formula

3.2. Ending time spicy sensation dominance
The results of the Tukey test in Table 4 related to the type of palate cleanser showed that coconut milk had the greatest effectiveness in eliminating the sensation of spicy except in the concentration of 0.6% chili powder solution. At 0.2% and 0.4% chili concentrations, coconut milk removes the spicy sensation faster than milk and is followed by soymilk. At the concentration of 0.6%, chili coconut milk and milk did not have significant differences and are in the same group. This occurs because coconut milk contains more fat content compared to soymilk and milk. Thus it tends to be less polar and eases the capsaicin dissolution in the mouth. According to Lee and Kim [4], the spicy sensation palate cleanser study using milk and cream as a source of fat states that the addition of cream to milk can reduce the intensity of spicy. At high concentrations of chili, milk and coconut milk have the same position in relieving the sensation of spicy.

Table 4. Post Hoc test of ending-time spicy sensation dominance each palate cleanser.

| Type of palate cleanser | Fat content (%) | Protein content (%) | Ending time (s) for spiciness
|-------------------------|----------------|---------------------|-----------------------------|
|                         |                |                     | 0.2% | 0.4% | 0.6% |
| Soy milk1               | 1.0            | 2.8                 | 21.08a | 32.00a | 48.17a |
| Dairy milk1             | 2.8            | 3.2                 | 17.50b | 24.16b | 30.83b |
| Coconut milk1           | 25.0           | 2.8                 | 14.00c | 20.25c | 28.58c |
| Soy milk2               | 1.0            | 2.8                 | 21.08b | 32.00b | 48.17b |
| Dairy milk2             | 1.0            | 1.1                 | 30.42b | 45.58a | 53.17a |
| Coconut milk2           | 1.0            | 0.0                 | 31.58a | 50.25a | 54.25a |

1)Non diluted, 2)Diluted
Different superscript letter within the same column and group indicates significant different at 95% confidence level

This occurs because there is a casein protein that can bind capsaicin compounds [11] in the mouth and out of the mouth. In addition to the bonds with capsaicin protein compounds in milk are also hydrophobic so that the phase on the palate cleanser is more non-polar. In Table 4 above the differences in the types of palate cleanser fat show that milk and coconut milk with the same fat content does not have a real difference in each chili concentration. At concentrations of 0.2% and 0.4%, chili concentration, soymilk which has the same fat content as standard milk and standard coconut milk (Table 4) has the most effective way to eliminate the sensation of spicy. This is because the presence of protein in soybeans that are amphiphilic (soluble in water and fat) can dissolve capsaicin [12]. The addition of water to milk and coconut milk heightens the polarity of the solution phase so that capsaicin is more difficult to dissolve and get out of the mouth [13].

4. Conclusions
Coconut milk is very effective in eliminating the sensation of spicy compared to milk and soymilk except in a high concentration of chili solution (0.6%) where milk and coconut milk are in the same
group in eliminating the sensation of spicy because of high coconut fat and the presence of casein protein which is able to bind the capsaicin compounds. At the same fat content (1%), soy milk is more effective than standard milk and standard coconut milk due to the presence of protein in soy milk is higher than protein milk and coconut milk due to the standardization process except at high concentrations (0.6%) where the effectiveness of soy milk, coconut milk, and milk in the same group.

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