Journal of
Emerging Investigators

The Effectiveness of Different Palate Relievers against a Hot Chili Pepper Sauce

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Summary

Mexican food is a combination of strong flavors, and of course, spicy ingredients (hot chili peppers). However, not everybody has developed a liking or resistance to hot chili peppers, hence a method for relief from the burning feeling they provoke is necessary. The purpose of this study was to evaluate which palate reliever worked best to mitigate the aftertaste hotness induced by capsaicin, the component responsible for the hot sensation in chili peppers. The hypothesis was that a substance capable of dissolving capsaicin (a nonpolar substance) would be the best palate reliever, making olive oil a prime candidate. Sensory tests were done using 12 untrained panelists with high, medium, and low resistance to hotness, a homemade hot chili pepper sauce, and five palate relievers. Palate relievers with different solubility properties, milk and ice cream (emulsions), olive oil (nonpolar substance), and water and a soft drink (polar substances), were used to alleviate the hotness sensation after trying the hot sauce. Regardless of the panelists' tolerance towards the hot sauce (low, medium, or high), all rated milk and ice cream to be the best palate relievers and the soft drink to be the worst. The best palate reliever was an emulsion (milk or ice cream) and not olive oil, as was initially hypothesized.

Received: January 27, 2016; **Accepted:** April 11, 2016;
Published: June 11, 2016

Introduction

Food plays a very important role in Mexican culture and identity, and Mexican cuisine is characterized by strong flavors that include several spicy ingredients such as hot chili peppers. Some people enjoy and even look for this burning sensation caused by chili peppers (1), but not every person responds to spicy foods the same way. In fact, the outcome can be painful for certain people if hot chili peppers are involved. It is therefore very important to find a palate reliever capable of mitigating the hotness of chili peppers. Furthermore, people unaccustomed to Mexican cuisine would feel more comfortable trying it if they knew a way to alleviate the hotness.

To begin with, what makes hot chili peppers hot? The substance responsible for giving hot peppers their characteristic hot flavor is capsaicin, and the degree of hotness depends on its concentration. To measure how hot a chili pepper is, units of hotness called Scoville units are used, which are related to capsaicin concentration. Scoville units range from 0 to 100 units for bell peppers, 1,000 to 10,000 units for jalapeño peppers, 15,000 to 30,000 units for chile de árbol peppers (used in this study), and up to 600,000 to 2,000,000 for certain habanero and Carolina Reaper varieties (2, 3).

Capsaicin irritation depends not only on its concentration, but also on the species that ingests it: capsaicin is an irritant to mammals, but not to birds. This may be a defense mechanism used by plants: when mammals eat the hot pepper fruit, they crush and destroy the seeds, but when birds eat hot peppers, the seeds remain intact and are scattered, allowing dispersion of seeds and plant propagation (4, 5).

Capsaicin does not irritate bird taste buds, because in birds, their cell receptors are insensitive to capsaicin (6). On the other hand, when capsaicin touches the buds on the papillae of the tongue of mammals, a protein, transient receptor potential vanilloid-1 (TRPV1, also known as capsaicin receptor and located in the central nervous system), perceives it, and thanks to the structure of capsaicin, they bind together (7, 8). When acapsaicin binds to TRPV1, the lipid portion of the receptor (PIP2) separates, and then calcium ions enter the sensory neuron (7). The response is sent as a pain signal to the brain by substance P, which is a peptide that works as a neurotransmitter (7). When the bond between capsaicin and the receptor (TRPV1) is broken, the sensation of pain ends (7). Understanding how the capsaicin receptors work is necessary in order to mitigate the irritation sensed when eating spicy foods.

The TRPV1 receptor is not only activated by capsaicin, but it is also activated by temperatures higher than 43°C (5) and chemical stimuli, such as low pH (acid media), resulting in sensations of burning and pain (8). This is the reason why so many people do not tolerate spicy meals, especially if they are not used to them.

For capsaicin to activate the TRPV1 receptor, a bond between the molecule and the receptor must occur, which is possible due to the structure of capsaicin. The capsaicin molecule is a hexagonal ring of bonded carbon atoms with a long hydrocarbon chain, making

it a hydrophobic (nonpolar) substance (9). Therefore, in order to eliminate the burning sensation caused by capsaicin, we need to find a substance capable of interacting with such a structure. Commonly, the first reaction to the burning sensation in the mouth is to drink water, but it hardly relieves the irritation. The basic rule for solubility is that *like dissolves like*. Since capsaicin is a nonpolar organic substance, we hypothesized that a nonpolar palate reliever would be needed to remove capsaicin from the TRPV1 receptor, mitigating the burning sensation. This is why water should not be the preferred option when suffering from the hotness of a hot chili pepper. Water is a polar substance and is unable to dissolve the capsaicin. On the other hand, substances such as fats, oils, and dairy products are more effective, given their nonpolar properties. Milk has been found to be the best way to fight the spiciness in foods (10).

Hence, the purpose of this study was to evaluate five different palate relievers with different solubility properties for their suitability of easing the burning sensation after tasting a hot chili pepper sauce. The palate relievers chosen were olive oil, a nonpolar substance and therefore hypothesized to be the best one to alleviate the irritation that follows capsaicin; water and a soft drink, both nonpolar substances; and milk and ice cream, two dairy emulsions with both polar and nonpolar properties.

Results

The study was divided into two parts. The first part evaluated the spice tolerance of panelists, while the second part tested the effectiveness of five different palate relievers for easing the hotness sensation after tasting a homemade hot chili pepper sauce. For the first part, in order to control for the difference in hotness tolerance by different panelists, panelists were divided into three groups of four panelists each, according to their hotness tolerance: low, medium, or high. **Figure 1** shows the results of the sensory evaluations of the hotness level for the hot chili pepper sauce. There was a significant difference ($p < 0.0001$) in the intensity of hotness of the sauce graded by the panelists of the different tolerance groups, but there was no significant difference ($p = 0.722$) in the intensity of the hotness of the sauce, in all the days in which the evaluations were made. Since it was the same sauce and same panelists, no difference in the hotness tolerance score over time was expected. Low -tolerance panelists rated the hot sauce with a mean of 8.35 ± 0.38 (± standard error) for all five days; medium-tolerance panelists rated it as 6.02 ± 0.17; and high-tolerance panelists assigned a score of 1.82 ± 0.32 (on a scale from 0 to 10, 0 being not hot at all, and 10 extremely hot). Therefore, the analysis showed no difference in hotness level scores of the sauce based on the day tested, but revealed a difference in the hotness level graded by panelists with low, medium, or high tolerance.

In the second part, to mitigate the hotness sensation caused by the hot chili pepper sauce, five palate relievers were chosen with different solubility properties: olive oil (nonpolar), water and a soft drink (polar), and milk and ice cream (both polar and nonpolar properties). Evaluations were done on separate days, with panelists trying a random palate reliever after tasting the hot chili pepper sauce each day. This was done in order to avoid saturating the tongue and to randomize the tasting order for each panelist (**Table 1**). A 0-to-10 scale was used to measure hotness relief: 0 indicating no relief and 10 reflecting full relief. **Figure 2** shows the results of the sensory evaluations of hotness relief. No differences were found among panelists of different hotness tolerance (low, medium, or high) after tasting the

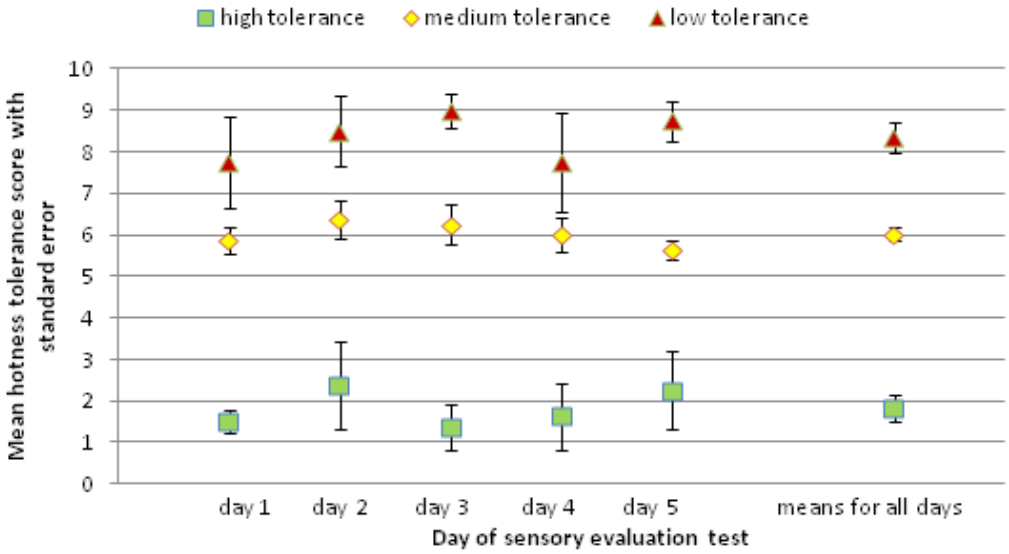

Figure 1. Hotness score for the hot chili sauce. The scores are according to the tolerance level of the three groups of panelists over all five days on a scale from 0 to 10, 0 being not hot at all and 10 being extremely hot. The mean of the hotness score was significantly different across the tolerance level groups: low and medium tolerance ($p < 0.0001$), medium and high tolerance ($p < 0.0001$), and low and high tolerance ($p < 0.0001$). The mean of the hotness score was not significantly different across the days ($p = 0.722$).

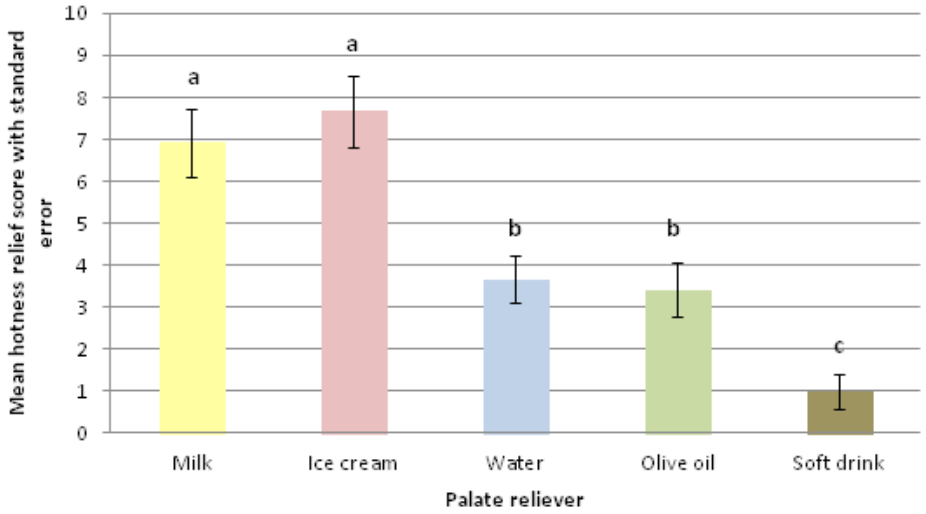

Figure 2. Hotness relief score of different palate relievers. The scores are on a scale of relief from 0 to 10, 0 being no relief at all and 10 total relief. Means with the same letters are not statistically different: milk and ice cream (p = 0.534), water and olive oil (p = 0.818). Means with different letters are statistically different: milk–ice cream group and olive oil–water group (p < 0.0001), olive oil–water group and soft drink (p = 0.0006), milk–ice cream group and soft drink (p < 0.0001).

same palate reliever (p = 0.968); that is, the panelists' tolerance to hotness (low, medium, or high) had no effect on how they rated the palate reliever. Nonetheless, there was a significant difference in relief caused by the different palate relievers (p < 0.0001). Palate relievers fell into three categories: the most effective relievers were ice cream and milk with means ± standard error of 7.67± 0.86 and 6.92 ± 0.82, respectively, followed by water and olive oil (3.67 ± 0.55 and 3.42 ± 0.66, respectively), and finally the soft drink (1.0 ± 0.42). There was no statistical difference between milk and ice cream (p = 0.534) or between water and olive oil (p = 0.818) (**Figure 2**). So even though the panelists rated the sauce with different hotness levels across tolerance groups, no differences were found for the hotness relief based on panelists´ resistance. Differences were found between the five different palate relievers used – milk and ice cream being the most effective, followed by olive oil and water, then the soft drink.

Discussion

Since capsaicin is a nonpolar substance, we expected olive oil to be the most efficient for eliminating hotness; however, this was not the case and milk and ice cream worked better. Two possible reasons can explain these findings: effect of the amount of palate reliever used and their solubility capabilities. For olive oil, a lower amount was used (15 ml, equivalent to one tablespoon), whereas for the rest of the palate relievers, including milk and ice cream, 100 ml (~1/2 cup) was used. This could have decreased the ability of olive oil to mitigate the hotness, so further experiments will be needed to properly address this variable using the same amounts of olive oil and milk or ice cream. On the other hand, panelists were not willing to take more than one tablespoon of olive oil, so it was assumed that consumers also would not be willing to ingest higher amounts of olive oil to ease the pain caused by a hot sauce.

Capsaicin is a nonpolar substance that dissolves well in olive oil, but also can be dissolved in milk or ice cream. The greater suitability of milk or ice cream as palate relievers could be because ice cream and milk are emulsions, which have both polar and nonpolar components. Therefore, emulsions not only have the capability of dissolving the capsaicin present on the palate and tongue, but also can be dissolved by saliva (contrary to olive oil), hence being more efficient in removing the remaining capsaicin. In a study where capsaicin was used to treat pain by desensitizing pain receptors (11), it was found that the more effective substances for administering capsaicin through the skin were micro-emulsions, with better results than gels or ethanol. This finding could support the theory that food emulsions are better for hotness relief than oil.

Both water and the soft drink are polar substances; therefore, they were less effective easing the hotness caused by the sauce, since they were unable to dissolve capsaicin. The effectiveness of water as a palate reliever is similar to that of olive oil, which may be due to the quantity used (100 ml of water and 15 ml of olive oil). Finally, the soft drink was the worst of all. The pH of the soft drink could be the reason why this palate reliever was the least effective. Soft drinks are high in acidity, with pH values between 3 and 4, whereas the other palate relievers have low acidity or are near neutral. For water, the pH is ~7; for milk it's 6.6–6.8; for ice cream it's 5.0–6.5. Low pH values also activate the TRPV1 receptor responsible for the burning and pain sensation associated with spicy foods (8).

The sweet flavor of the ice cream palate reliever

could also have had an effect on easing the hotness. In a study with tom yum spicy soup, 10% sucrose solutions were also effective as palate cleansers, but less effective than milk (10). Ice cream´s lower temperature could have helped diminish the hotness as well. Cold 10% sucrose solutions (5°C) were more effective in reducing mouth-burn than 10% sucrose solutions at 20°C (12). Nonetheless, temperatures below the mouth´s temperature (36°C) have been associated with only temporary relief, followed by an increase in burn intensity upon swallowing the cold food (13). In this experiment, milk and ice cream were equally effective palate relievers statistically speaking (**Figure 2**), suggesting that solubility plays a more important role in palate relief than sweetness or low temperature.

Despite the different level of tolerance towards the hot chili pepper sauce for different panelists (low, medium, or high tolerance), the palate relievers that were proven to be more suitable for relieving the burning sensation were emulsions, such as milk or ice cream, for all panelists. This is because milk and ice cream have the capability to dissolve in polar and nonpolar substances, hence they can dissolve capsaicin, separating it from the tongue and the palate and carrying it away along with saliva.

Further research to improve the understanding of hotness relief will need to consider the effects of different pH values and temperatures using the same methodology and using the same amount of palate reliever. For assessing the effect of pH, milk products at the same temperature but with different acidity levels can be used, such as milk (low acidity), sour cream (medium acidity), and yogurt (high acidity). For evaluating the effect of temperature, milk or cream at different temperatures can be used (5–10°C, 20–15°C, 30–35°C). Also, different lipid content in emulsions can be addressed using low, medium, and high fat contents. Hot chili pepper sauces with different capsaicin concentrations (amount of hot chili pepper), can also be tested to evaluate if the effectiveness in heat relief is influenced by capsaicin concentration. For better control, standard solutions of different capsaicin concentrations can be used instead. There is a high correlation between capsaicin content measured with instrumental analysis (HPLC) and sensory evaluation tests with panelists (14), so sensory evaluation tests are appropriate.

Seeking a suitable palate reliever is important for helping panelists mitigate the pain sensation caused by hot chili peppers during sensory evaluations done in the food industry. Furthermore, knowing which types of foods under normal serving conditions alleviate the hotness of chili peppers can help people select the best palate reliever if they want to eat spicy foods. Under these circumstances, dairy emulsions like milk or ice cream are the most effective relievers.

Materials and Methods

Hot sauce

Homemade chile de árbol (*Capsicum anuum*) hot sauce was prepared by first slightly frying three chile de árbol peppers (15,000–30,000 Scoville units) with one small piece of garlic, and then combining them in a blender with 2 cups of olive oil, adding the oil slowly until a homogeneous sauce was obtained. This sauce is a very hot sauce, known as “salsa macha”.

Panelists

Volunteers from ITESM-Cuernavaca high school (students between 16–18 years old) were selected and divided into three groups using a screen sensory evaluation test for identifying their tolerance to hot peppers. From this screen sensory test, three groups with 4 panelists each were formed, defined by low, medium, and high tolerance (12 students in total). Then, panelists were randomly assigned over 5 days to eat the hot sauce and a palate reliever. Each day, different panelists tried a different palate reliever, but by the end of the week, all panelists had tried all the palate relievers (**Table 1**). This was done to avoid saturation of the taste buds and desensitization, but also to randomize the tasting order. Sensory evaluations were carried out (15) using a format (**Figure 3**) where the panelists were asked on an individual basis to first try 1/4 teaspoon (5 ml) of hot sauce, wait 10 seconds, then evaluate the hotness level of the sauce on the sensory evaluation sheet (scale from 0 to 10 in increasing order). Then, panelists could spit the hot sauce or swallow it, then wait for another 30 seconds. Then the panelists tried the palate reliever: milk, strawberry ice cream (strawberry: a random flavor with no bearing on this research), water, olive oil, or the soft drink (Coca-Cola: a random flavor with no bearing on this research). The amount of each palate reliever used was 1/2 cup (100 ml), except for olive oil, where 1 tablespoon (15 ml) was used. Then the panelists selected the degree of hotness relief (on a scale of 0 to 10 in increasing order of relief) on the same sensory evaluation sheet (**Figure 3**).

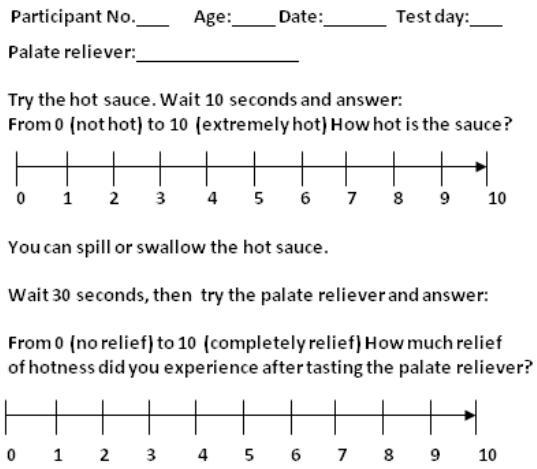

Figure 3. Sensory test format. This is an example of the form given to each panelist every day.

Day	Panelist 1	2	3	4	5	6
1	milk	soda	water	ice cream	soda	olive oil
2	olive oil	milk	ice cream	water	ice cream	water
3	soda	water	milk	soda	olive oil	soda
4	ice cream	ice cream	olive oil	milk	water	milk
5	water	olive oil	soda	olive oil	milk	ice cream

Day	Panelist 7	8	9	10	11	12
1	ice cream	water	milk	water	soda	olive oil
2	olive oil	milk	soda	milk	ice cream	ice cream
3	milk	ice cream	water	olive oil	milk	water
4	Water	soda	olive oil	ice cream	olive oil	milk
5	soda	olive oil	ice cream	soda	water	soda

Table 1. Scheduled sessions for sensory tests. Each panelist tried all five palate relievers after tasting the hot sauce, one per day, in a random order.

Statistical Analysis

The data collected was analyzed using two-way ANOVA with replication using Microsoft Office Excel (version 2010) with a significance level of $\alpha = 0.05$. Once ANOVA showed a significant difference among treatments, the Bonferroni correction (adjusting $\alpha = 0.05$ by the number of treatments – 3 for panelists´ tolerance and 5 for palate relievers) was used with Student's t-tests for each pair in order to evaluate which treatment was different from which.

Acknowledgments

The authors would like to thank Dara Lane for helping us with the spelling and grammar of this manuscript.

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