Effects of Fat on Temporal Cooling by Menthol in Lozenges


ABSTRACT: Ingredients such as fat may suppress or enhance menthol cooling in a finished product. In this study, trained descriptive sensory panelists tested oral and nasal cooling, oral burn, and other attributes in lozenges with various concentrations of fat (0 to 5%) and menthol (0 to 0.4%). Increasing fat content reduced oral and nasal cooling and burn. Linear increases in menthol resulted in linear responses to nasal cooling and oral burn and nonlinear responses to oral cooling. Residual oral and nasal cooling and burn illustrated that the effect of fat became less important after the lozenge was expectorated.

Key Words: menthol, fat, oral cool, nasal cool

Introduction

MENTHOL IS A NATURALLY OCCURRING COOLING AGENT used in confections, oral care products, frozen desserts, and beverages. Like other irritants, such as capsaicin or piperine, menthol elicits a chemesthetic response from the trigeminal and vagus nerves in the oral cavity (Green and Lawless 1991). Traditional research on the effects of basic ingredients (sucrose, citric acid, quinine, and sodium chloride) on capsaicin perception have been reported (Sizer and Harris 1983; Stevens and Lawless 1986; Cowart 1987; Nasrawi and Pangborn 1989). However, these traditional methods focused on responses to aqueous solutions and not to finished products.

A few researchers have investigated the effects of ingredients on irritant perception in finished products (Baron and Penfield 1996; Allison and others 1999; Carden and others 1999), but no research was found that focused on the effect of ingredients on menthol perception in food products. Ingredient interaction with capsaicin has been tested in finished products such as chicken broth (Cowart 1987), cheese sauce (Baron and Penfield 1996; Carden and others 1999), and salsa (Allison and others 1999). Because capsaicin is fat soluble (Huffman and others 1978), it is easily solubilized in products containing fat, such as cheese sauce. The inclusion of fat in a food product formulation may interfere with the ability of irritants, such as capsaicin, to bind to trigeminal receptors (Baron and Penfield 1996). Carden and others (1999) confirmed the suppression effect of fat on capsaicin heat and found that a fat mimetic had no effect. Menthol also is a fat-soluble food irritant and previous research clearly suggests that fat-soluble irritants are suppressed by an ingredient with lipophilic properties (Baron and Penfield 1996; Carden and others 1999).

Like all irritants, menthol has a temporal quality. Its duration, maximum intensity, and perceptual slopes depend on concentration, length of exposure, ingredient interactions, and panelists’ previous experience with menthol or other irritants. Gwartney and Heymann (1995) researched the descriptive temporal perception of menthol isomers. L-menthol, which is the primary cooling component in peppermint oil (Emberger and Hopp 1987), was reported to be considerably more irritating than d-menthol and longer in duration. Although menthol is a popular flavor in the food industry, published research on its temporal perception in food products is scarce.

Gwartney and Heymann (1995) also indicated that some of the descriptive attributes of menthol are ignored, such as oral burn. Indeed, menthol has been described as eliciting oral and nasal cooling, oral burn, bitterness, numbing, and tingling sensations. Again, publications on the descriptive profile of menthol are limited (Gwartney and Heymann 1995, 1996). Furthermore, the available published research has not tested menthol in finished products where other ingredients may modify its profile.

Given the lack of research on menthol perception in a finished product, the objectives of this research were to investigate the temporal profile of menthol in a finished product and determine the effects of fat on menthol perception.

Materials and Methods

Product

The boiled hard candy lozenges used in this study were formulated by an industry organization in a pilot plant setting. The formulation varied in concentrations of menthol (0, 0.2, 0.4%), fat (0, 1.25, 2.5, and 5%) (cottonseed oil) and a synthetic coolant WS3 (eth-p-menthane-3-carboxamide; IFF Union Beach, NJ) according to a complete factorial design. The remaining ingredients were corn syrup, sugar, and water in amounts used for a typical formulation, but were reduced slightly to account for the increased menthol and fat contents in a 100% formulation.

Reference Standards for the Descriptive Sensory Analysis

The aqueous reference standards used in this research were based on methods used by Gwartney and Heymann (1995), who researched the perception of menthol in aqueous solutions. A 10% menthol stock solution was prepared by dissolving l-menthol crystals (IFF, Union Beach, NJ) in 70% ethanol. This solution was diluted further with ethanol and H2O (treated by reverse-osmosis, deionization, and carbon filtration), resulting in the desired concentration of menthol and ethanol. Ethanol has been shown to elicit an irritative response (Withers and others 1995). Therefore, it is suggested that future studies employ nonirritative solutes, such as polysorbate-80 (Cliff and Green 1996) or mineral oil (Green 1986) to help reduce the compounding effect of ethanol on irritant ratings.
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References with higher menthol concentrations were prepared daily to prevent recrystallization. Approximately 10-ml of the aqueous reference was held in the mouth for 10 s before expectoration and scoring. Scale values for each reference (Table 1) were based on a 15-pt scale.

Descriptive Panel Orientation
The panel consisted of 6 trained individuals from The Sensory Analysis Center at Kansas State Univ. (Manhattan, Kan.). Each panelist has had at least 120 h of general training on descriptive sensory analysis and experience with evaluating irritants in food products.

The orientation for this project began with a review of references and terminology for all attributes of interest. Orientation to the reference scales and to practice with both commercial and test products took place over 3 consecutive business days. After several hours of practice, a test panel was conducted to quantify progress. After confirmation that the panel was using the references correctly and demonstrated the ability to identify product differences, the testing began. The total orientation lasted 9 h.

Testing Procedure
Each lozenge formulation was evaluated over time using semi-anchored 15-cm continuous line scales printed on ballots created by Softex® Sensorex Gold™ software (Softex 1994). Oral cool, nasal cool, oral burn, mentholic aromatic, and bitterness were evaluated at 30 timed intervals across a 24-min period. The lozenge was expectorated after 5 min of oral contact regardless of whether or not it had been completely dissolved. The remaining time (19 min) was used for residual cooling ratings. Because each panelist can salivate at a different rate when a stimulus is present in the oral cavity, all panelists expectorated the lozenge at the same time to maintain a similar duration of exposure across all panelists, albeit their response to the stimulus could vary during the 5-min exposure. Unlike oral and nasal cool, oral burn, mentholic, and bitterness, the mint aromatic was evaluated only once, after 30 s of oral contact. Because no mint flavoring was added to these formulations, the mint aromatic was expected to be low and of no consequence to the Time-Intensity (T-I) profile of the product. This attribute was added to the lexicon to demonstrate that menthol flavor, in combination with sweetness, may result in a perceived “minty” flavor, regardless of whether or not a true mint oil had been used in the formulation.

Statistical Analysis
The resulting data were analyzed using a mixed model in SAS (PROC MIXED, Statistical Analysis Systems 1994) where ingredient effects were fixed effects and panelist, rep, rep*fat*menthol*WS3, and p*fat*menthol*WS3 were designated random effects. T-I parameters of interest were slope to maximum intensity, maximum intensity, log area under the curve, and decay. To calculate slope parameters, PROC NLIN (nonlinear modeling, SAS 1994) modeled responses for 0.2 and 0.4% menthol concentrations up to the point of expectoration (5 min after initial taste); formulations containing 0% menthol had no slope. For responses after 7 min, the decay slope was modeled using predicted values calculated from the PROC NLIN procedure (SAS 1994) following expectoration at 5 min. Log area under the curve was calculated from the weighted means (“weighted” because time intervals were not equal) for data from 0.2 and 0.4% menthol formulations.

Results
Overall, increasing menthol content significantly increased ratings for oral cool, nasal cool, oral burn, mentholic and mint aromatics, and bitterness (p < 0.001). All descriptive sensory attributes were reduced significantly with increasing fat content at moderate and high menthol concentrations (p < 0.001). The effect of fat on sensory attributes was eliminated in the residual ratings approximately 8 to 10 min after the lozenge had been expectorated.

Menthol Perception
For all attributes, maximum intensity scores increased significantly with increasing menthol concentration (p <
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0.001). \( I_{\text{max}} \) scores from lozenges without menthol illustrated a low level of oral cooling (Table 2). That low level cooling effect in nonmentholated lozenges may be attributed to endothermic dissolution of sucrose on the tongue. Sugar possesses a negative heat of solution of 4.3 kcal/g (Bär 1991). Some polyols, such as xylitol, maltitol and sorbitol, also have been shown to elicit a cooling effect (Fennema 1985; Billaux and others 1991). Increasing the menthol concentration to 0.2% increased \( I_{\text{max}} \) scores, and illustrates the level of cooling found in mildly mentholated products, such as gums, mints, frozen desserts, and dairy-based beverages. The degree of oral and nasal cooling found in the high menthol concentration (0.4%), which gave statistically higher intensity scores than 0.2% menthol \((p < 0.001)\), illustrated the cooling expected from stronger mints and lozenges. Slope to maximum intensity (Table 2) increased significantly with increasing menthol concentration \((p < 0.01)\) for all attributes, except oral cool, which was only slightly enhanced. Increasing menthol concentration also significantly increased \( I_{\text{max}} \) scores \((p < 0.001)\) for all attributes, except oral cool, which was only slightly enhanced. Increasing menthol concentration also significantly increased \((p < 0.001)\) the log area under the curve (AUC) for all attributes (Table 3), indicating that total perceived intensity over time increased with increasing menthol concentration. The slope of the decay in menthol perception from maximum intensity (between 2 and 6 min after expectoration), was not significantly different between moderate and high menthol concentrations \((P > 0.05)\) for any attribute. A linear increase in menthol concentration resulted in a significant quadratic increase in maximum intensity \((I_{\text{max}})\). The effect of fat on slope to maximum intensity from lozenges with 0.4% menthol \((p < 0.001)\) was not significantly different \((p < 0.05)\) between 2 and 6 min after expectoration; the effect of fat was reduced in the late residual ratings (tails of the curve) (Figure 1).

The effect of menthol and fat varies by attribute. For oral cool, the slope to maximum intensity was only significantly reduced by 5% fat \((p < 0.05)\). However, nasal cool was immediately reduced with as little as 1.25% fat or higher \((p < 0.05)\). Oral burn was significantly reduced by 2.5% fat or higher \((p < 0.05)\).

### Table 2—Slope to maximum intensity \((I_{\text{max}})\)

<table>
<thead>
<tr>
<th>MENTHOL (%)</th>
<th>FAT (%)</th>
<th>0.00</th>
<th>1.25</th>
<th>2.50</th>
<th>5.00</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral cool(^{4,4})</td>
<td>0.2</td>
<td>1.28</td>
<td>1.27</td>
<td>0.96</td>
<td>1.15</td>
<td>1.16&lt;sup&gt;y&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>0.4</td>
<td>1.54</td>
<td>1.55</td>
<td>1.40</td>
<td>1.42</td>
<td>1.48&lt;sup&gt;x&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
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<td>1.41&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.19&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.28&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Nasal cool(^{4,4})</td>
<td>0.2</td>
<td>0.10</td>
<td>0.24</td>
<td>0.48</td>
<td>0.38</td>
<td>0.15&lt;sup&gt;y&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>0.4</td>
<td>0.68</td>
<td>0.48</td>
<td>0.32</td>
<td>0.32</td>
<td>0.45&lt;sup&gt;x&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>0.39&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.12&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.08&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Burn(^{2,4})</td>
<td>0.2</td>
<td>0.15</td>
<td>0.02</td>
<td>0.26</td>
<td>0.09</td>
<td>0.11&lt;sup&gt;y&lt;/sup&gt;</td>
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<td>0.4</td>
<td>0.60</td>
<td>0.45</td>
<td>0.35</td>
<td>0.22</td>
<td>0.4&lt;sup&gt;x&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>0.38&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.21&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.04&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.06&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
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<tr>
<td>Menthol(^{2,4})</td>
<td>0.2</td>
<td>1.01</td>
<td>0.92</td>
<td>0.72</td>
<td>0.62</td>
<td>0.82&lt;sup&gt;y&lt;/sup&gt;</td>
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<tr>
<td></td>
<td>0.4</td>
<td>1.36</td>
<td>1.25</td>
<td>1.21</td>
<td>1.16</td>
<td>1.25&lt;sup&gt;x&lt;/sup&gt;</td>
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<td>Mean</td>
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<td>1.09&lt;sup&gt;ab&lt;/sup&gt;</td>
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<td>0.89&lt;sup&gt;c&lt;/sup&gt;</td>
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<td>Bitter(^{3,4})</td>
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<td>0.77</td>
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<td>0.66</td>
<td>0.69&lt;sup&gt;y&lt;/sup&gt;</td>
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<tr>
<td></td>
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<td>0.94</td>
<td>0.91</td>
<td>0.88</td>
<td>0.92&lt;sup&gt;x&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>0.85&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.86&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.73&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.77&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

1 Means based on 15-pt line scale; Different LSD designations for equal means are subject to error from rounding off
2 Fat effect significant \((p < 0.01)\)
3 Fat effect significant \((p < 0.10)\)
4 Menthol effect significant \((p < 0.001)\)

*Means within a row with same letter are not statistically different at the 95% confidence level

\*note : statistical model available upon request

Effect Of Fat On Menthol Perception

Table 2 illustrates the significant suppression of all \( I_{\text{max}} \) attributes by increasing fat content \((p < 0.001)\), except for the control formulation (0% menthol) \((P > 0.05)\). Increasing fat content also significantly reduced slope to maximum intensity \((p < 0.05)\) and area under the curve \((p < 0.001)\) for all attributes, except bitterness which exhibited a slight fat effect \((p < 0.10)\). Increasing fat content significantly reduced the rate of decay for oral cool \((p < 0.001)\) and oral burn \((p < 0.05)\) between 2 and 6 min after expectoration; the effect of fat was reduced in the late residual ratings (tails of the curve) (Figure 1).

The effect of fat on slope to maximum intensity from lozenges containing 0.2% menthol indicated that formulations with 2.5 and 5.0% fat were not significantly different in oral cooling, although both were significantly lower than formulations containing 1.25% fat. Even 1.25% fat was enough to significantly suppress \( I_{\text{max}} \) cooling of 0.2% mentholated lozenges. It is apparent that very low levels of fat may suppress chemical cooling. Lozenges containing 0.4% menthol also showed a suppression of cooling by fat. However, increasing fat concentrations exhibited less of a depressive effect on cooling from this high menthol concentration. Only formulations with 2.5 and 5.0% fat exhibited significant suppression \((p < 0.05)\) of oral cooling (Figure 1). This illustrates menthol’s strong cooling capabilities of a formulation with 0.4% menthol. It is evident that in highly mentholated products, such as lozenges and strong mints, very low fat levels will have less effect on menthol’s oral cooling than at moderate or higher levels of fat.

The effect of fat on slope to maximum intensity from lozenges with 0.2% menthol is similar to its effect on those of lozenges containing 0.4% menthol where increasing fat decreased the slope. Interestingly, lozenges containing 0.2% and no fat had almost identical slope to maximum intensities.
for oral and nasal cooling as lozenges containing 0.4% menthol and 5% fat. In addition, maximum intensity scores indicated no significant differences between these two formulations (P > 0.05).

Lozenges containing 0% fat and 0.4% menthol had significantly higher residual oral and nasal cool and burn than lozenges containing 0% fat and 0.2% menthol. The degree of difference between the residual scores for lozenges with 0.2% and 0.4% menthol was minimized with increasing fat content. As fat content increased, the residual cooling from lozenges containing 0.4% menthol decreased to the same residual intensity level as lozenges containing 0.2% menthol (Figure 2). Despite the strong effect of fat on moderate menthol oral cooling, as illustrated by Imax scores, residual scores showed that fat had a stronger effect on high menthol concentrations than moderate concentrations in the aftermath. Lozenges with 0.4% menthol and 5% fat had a higher decay slope overall than those lozenges with 0.2% menthol and 5% fat, although this difference was not statistically significant (P > 0.05). When considering slopes from 2 to 6 min after expectoration, significant fat effects were more apparent. Oral cooling and burn exhibited significant fat effects (P < 0.01). At the 5% fat concentration, oral cool (P < 0.05) and oral burn (P = 0.05) decayed at a faster rate in lozenges containing 0.4% menthol than it did in lozenges containing 0.2% menthol.

### Discussion

**Menthol-ingredient interactions in finished products**

Current research clearly illustrates a fat-irritant interaction within a product, rather than a suppression effect found after stimulation. In this study, increasing fat content significantly reduced oral and nasal cooling and oral burn from menthol. The effect of fat in lozenges parallels research by Baron and Penfield (1996) and Carden and others (1999), who illustrated the suppressive effect of fat, but not fat mimetic, on capsaicin heat in a finished product. Those researchers suggested that fat may have solubilized capsaicin in a food product, rendering the irritant less effective at producing a chemesthetic response such as oral burn. Given these results, it may be possible that the menthol-fat interaction in lozenges is impeding the release of menthol because of the physical binding of menthol and fat within the product itself. Despite fat’s ability to carry flavors in most food systems, the mastication of this product is considerably different. Lozenges often are only lightly manipulated, without chewing, thus the effect of fat in other products may differ. Menthol is a fat-soluble compound that may bind tightly to fat in a food system. The strength of this binding may affect its release into the saliva. Furthermore, the strength of this binding may be maintained by a lack of dissociation between menthol and fat while in protein-rich aqueous solution, such as saliva.

This conclusion is supported by the effect of fat on other sensory attributes. The suppressing effect of fat on nasal cooling (Table 2) illustrates the implausibility of fat suppression of trigeminal perception by coating the receptor site, as hypothesized by Nasrawi and Pangborn (1990). Although the lozenge had no direct contact with the trigeminal receptors in the nasal cavity, increasing fat content suppressed nasal cooling. This indicates that menthol volatilites were reduced before reaching the nasal cavity. Because nasal cooling and other attributes, such as bitterness, mentholic and mint aromatics, and oral burn (Table 2), showed significant reduction with increasing fat content, the simple coating of a receptor cannot be the cause for the reduction in perception. Alternatively, the effect of fat on all sensory attributes may indicate that the stimulus or its release is being altered within the product.

The suppression effect of fat varied by attribute during the first 5 min of exposure to the lozenge. Slope to maximum intensity for oral cool was reduced with high levels of fat. Alternatively, nasal cool required very little amount of fat to obtain a significant reduction in perception. Moderate fat levels significantly reduced oral burn during the first 5 min of exposure. This variation in effects of fat on these attributes may be explained by the nature of the stimulus at each test site. Oral cool is the manifestation of menthol perception as a solute, which may differ from its perception as a volatile, such as in the case of nasal cooling. Confirmation of this hypothesis might be obtained from atmospheric pressure chemical ionization (APCI) mass spectrometry. Linforth and Taylor (1998) reported using this technique to measure the

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**Table 3-Log area under the curve**

<table>
<thead>
<tr>
<th></th>
<th>Fat (%)</th>
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<tbody>
<tr>
<td></td>
<td>0.00</td>
</tr>
<tr>
<td>Oral cool</td>
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</tr>
<tr>
<td></td>
<td>0.4</td>
</tr>
<tr>
<td>Mean</td>
<td>1.41a</td>
</tr>
<tr>
<td></td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>0.4</td>
</tr>
<tr>
<td>Nasal cool</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>0.4</td>
</tr>
<tr>
<td>Mean</td>
<td>0.38a</td>
</tr>
<tr>
<td>Burn</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>0.4</td>
</tr>
<tr>
<td>Mean</td>
<td>0.38a</td>
</tr>
<tr>
<td>Bitter</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>0.4</td>
</tr>
<tr>
<td>Mean</td>
<td>0.85x</td>
</tr>
</tbody>
</table>

1 Means based on 15-pt line scale; Different LSD designations for equal means are subject to error from rounding off
2 Fat effect significant (P < 0.01)
3 Fat effect significant (P < 0.001)
4 Menthol effect significant (P < 0.10)

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**Figure 2—Comparison of high and low fat concentration on oral cooling Imax perception of increasing menthol concentrations (based on a 15-pt intensity scale)**
amount of flavor volatiles on the breath during consumption of chewable mints, “suck-and-chew” mints, and chewing gum. The testing of volatiles in the airspace of the oral cavity should provide insight on the amount of menthol reaching the nasal cavity. Variation in volatile menthol concentration might indicate an effect of intrastimulus ingredients.

This study indicated significant reduction of oral cool and burn slope to maximum intensity caused from increasing fat content, which disagrees with Baron and Penfield (1996), although the manifestation of a slope to maximum intensity differs in both studies. Baron and Penfield (1996) rated residual heat as it was affected by fat up to 3 min after swallowing and found that the slopes of residual scores as they were nearing \( t_{\text{max}} \) were not as affected by fat as was the maximum heat intensity. Those authors also rated residual ratings after swallowing the stimulus; the residual ratings increased to a maximum intensity before decaying. On the other hand, slope to maximum intensity and decay of the perception from this study is the result of sucking on a lozenge up to 5 min and then rating residual ratings after the stimulus was removed. This study reported significant fat effects on residual oral cooling and burn, but not residual nasal cooling (measured from decay 2 to 7 min after expectoration). Because Baron and Penfield (1996) did not report on the effects of fat on perceptual decay after \( t_{\text{max}} \) was reached, direct comparisons between the decay of capsaicin heat and menthol cooling in finished products are not possible.

Menthol exhibits a strong cooling capability at high menthol concentrations. Lozenges with 0.4% menthol appeared more resistant to suppression by fat than those formulated with 0.2% menthol. It is evident that in highly mentholated products, such as lozenges and strong mints, very low fat levels will have less effect on menthol’s oral cooling than moderate or higher levels of fat. However, lozenges with higher levels of fat and menthol exhibited a higher degree of decay than did high-fat lozenges with 0.2% menthol (Figure 2). This result may indicate that formulations with high menthol and fat content will last as long as high-fat formulations with less menthol. The similarity of lozenges containing 0.2% and no fat with those containing 0.4% menthol and 5% fat clearly illustrates the degree of cooling suppression by fat in a finished product (Figure 2). Oral cooling in lozenges formulated with high menthol and high fat concentrations may be similar to those lozenges formulated with less menthol and no fat. Therefore, using more menthol with higher fat concentrations will result in a cooling perception similar to that of a product formulated with less menthol. Given the need for optimizing ingredient costs, this suppression could be detrimental to a formulation’s success.

Menthol perception in finished products

A linear increase in menthol concentration created a linear response for nasal cool and oral burn, while oral cool exhibited a quadratic response. This result suggests that confections formulated with menthol concentrations above 0.4% may not necessarily result in significant enhancement of the oral cooling perception. Consumers ingest mentholated confections for the desirable “fresh” sensation of a perceived reduction in oral cavity temperature. However, it is evident from our results that menthol concentrations above 0.4% might result in small gains in oral cooling while increasing oral burn. However, higher menthol concentrations above 0.4% may result in more nasal cooling, which is the primary purpose of many lozenges, and may provide the

sensation of nasal clearing (Eccles 1994). It is, therefore, advantageous for a lozenge formulator to use more menthol, resulting in more nasal cooling while the oral cooling effect of higher menthol concentrations tapers off. However, formulators should consider the degree of oral burn resulting from exposure to higher menthol concentrations.

The perception of increasing menthol concentration as a function of attribute type illustrates the complex responses obtained when testing menthol at different sites (oral versus nasal) and using descriptive terms (“cool” as compared to “burn”). The nature perception of oral burn differed from oral cooling in saliva. This may support the conclusions from Cliff and Green (1996), who reported that menthol stimulates nociceptors, in addition to cold fibers. Oral burn may be a manifestation of capsaicin-sensitive nociceptors, which might be sensitive to menthol (Cliff and Green 1996). The response characteristics of these receptors may vary from those of cold receptors also sensitive to menthol.

Measuring menthol perception in lozenges

Several authors have mapped the temporal perception of irritants such as menthol (Dacanay 1990; Gwartney and Heymann 1995) and capsaicin (Cliff and Heymann 1992; Baron and Penfield 1996; Carden and others 1999). However, it is difficult to compare these studies with the current study because those T-I evaluations were conducted only for the aftertaste after a relatively short period. In this study, the stimulus, a mentholated lozenge, was in contact with the oral cavity for five min before expectoration. The nature of stimulus contact in this study was similar to Duizer and others (1996), who reported the temporal perception of peppermint and sweetness in a chewing gum as affected by various flavor release mechanisms. The T-I curve for the dual attributes, sweetness and peppermint flavor, from the gum, which was chewed leisurely for 15 min, was similar to that of a lozenge in this study. The rate to maximum intensity is a result of the product interaction with saliva; decay is the residual cooling after the product is removed.

Chemosensory implications of menthol-ingredient interactions

Interestingly, the variant effect of fat on oral burn and oral and nasal cooling raises a question related to the nature of chemosensory responses. Burn is considered to be a measurement of irritation, rather than a perceptually thermal response, such as in the case of oral cool, nasal cool, or oral heat. Research by Cliff and Green (1996) concluded that menthol might stimulate capsaicin-sensitive nociceptors, although in a different manner than capsaicin. It may be speculated that this oral burn from menthol may mimic the burn from capsaicin. If menthol burn and capsaicin burn are perceived via similar neurological pathways, the effect of fat on this perception may vary from its effect on alternative pathways, such as those that elicit oral and nasal cooling. If the response variation from fat is due to physical binding of menthol with fat within the lozenge, then limiting its release may result in variable responses from capsaicin-sensitive nociceptors and menthol-sensitive cold fibers. Given these results, it may be possible that the threshold of menthol after its diffusion across the epithelium, depending on salivary menthol concentration, differs for cold fibers and nociceptors. However, the burn from menthol and capsaicin has not yet been directly compared using descriptive sensory methodology or pharmacological techniques. It is evident that this issue deserves further investigation.
Impact of synthetic coolants on menthol cooling

Synthetic coolants, such as eth-p-menthane-3-carboxamide, can be used in formulations where it is desirable to produce a pronounced cooling perception without the aromatic impact of menthol (Anonymous 1987; Eccles 1994). In this research, the concentration of WS3 was not as high as originally recommended by Wilkinson’s for confections (Anonymous 1987). However, a distinct trend \( (P = 0.05) \) was observed when adding 70-ppm WS3 to lozenges with high concentrations of menthol (0.4%) and fat (5%). Figure 3 demonstrates the potential of WS3 to help overcome the attenuating effect of fat at higher menthol concentrations. This result demonstrates that as the fat content in formulations increases, a synthetic coolant such as WS3 may help achieve the desired cooling intensity without increasing the amount of menthol.

Conclusions

MENTHOL IS USED FOR ITS COOLING PROPERTIES IN CONFECTIONS, which, for functional purposes, typically contain small amounts of vegetable oil (<5%). This study investigated the sensory effect of increasing fat on chemesthetic responses and found that oral and nasal coolness, in addition to oral burn, may be significantly suppressed by increasing fat concentration. As product formulators increase fat in lozenges, alternative menthol concentrations should be considered.

Lozenges made with higher levels of fat (up to 5%) may require higher concentrations of menthol to achieve the same coolness response intensity as lozenges containing less oil.

References


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