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Effects of Hydrocolloid Thickeners on the Perception of Savory Flavors

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The perceived intensities of savory flavors in hydrocolloid-thickened solutions were investigated using sensory paired comparison tests between two distinct thickener concentrations (high and low viscosities). The perceived saltiness of 3.5 g/L NaCl was found to be significantly reduced ($P < 0.01$) at the higher thickener concentration of both hydroxypropylmethyl cellulose (HPMC) and λ-carrageenan, relative to the lower concentration. Mushroom flavor (8 ppm of 1-octen-3-ol with 3 g/L NaCl) was perceived as significantly more intense ($P < 0.05$) in 1.7 g/L λ-carrageenan as compared with the same concentration of flavoring in 10.2 g/L λ-carrageenan. Garlic flavor (2.5 ppm of diallyl disulfide with 2 g/L NaCl) was perceived to be significantly more intense in 2 g/L HPMC ($P < 0.01$) than in 10 g/L HPMC. However, when the NaCl concentration in the more viscous sample was increased to 3 g/L, the garlic flavor intensities of the two systems were not significantly different, suggesting a perceptual interaction (enhancement) between salt taste and garlic flavor. In vivo aroma release measurements from the same samples, using API-MS, showed that hydrocolloid concentration did not significantly alter the amount of mushroom or garlic aromas released when solutions were consumed. It was concluded that changes in perceived saltiness were driving the reduction in savory flavor perception even though the aroma stimulus was unchanged (a taste−aroma interaction). These findings parallel previous results in sweet hydrocolloid-thickened solutions.

KEYWORDS: Savory; hydrocolloid; flavor perception; aroma release; HPMC; carrageenan; mushroom; garlic; taste−aroma interaction

INTRODUCTION

The influence of hydrocolloid thickeners on the perception of taste and aroma is an area of research that has received much attention, predominantly in viscous liquid systems. Most foodstuffs are complex in terms of both their structure and chemical composition. Many factors influence the partition, release, and perception of flavor active molecules from a food matrix, making it difficult to control and measure the effects of each of these independently. Because of this, fundamental research into the principal factors influencing flavor perception in viscous liquid systems has employed model solutions containing a limited number of ingredients.

Results of these fundamental studies (*1*−*4*) have identified two distinct phases, with regard to flavor perception, as hydrocolloid concentration is increased in a model system. In the dilute hydrocolloid concentration range (where zero-shear viscosity, η_0, is <10 mPas), a set amount of flavoring is perceived at approximately the same intensity as in water. Above this viscosity, both taste and aroma perception are suppressed with increasing hydrocolloid concentration (*1*−*4*). All of these experiments investigated systems that were sweetened with sucrose and flavored with a sweet-associated aroma, that is, one which is normally experienced in (and becomes perceptually associated with) sweet foods (*5*, *6*), for example, benzaldehyde (almond/cherry), isoamyl acetate (banana), or commercial strawberry aromas (*1*, *2*). To investigate the mechanisms behind these perceptual changes, Hollowood et al. (*2*) analyzed the release of aroma in-nose from hydroxypropylmethyl cellulose (HPMC)-thickened solutions using atmospheric pressure ionization mass spectrometry [API-MS (*7*, *8*)]. In two separate experiments they found that the nose-space release of either benzaldehyde or strawberry aromas was not affected by hydrocolloid concentration, even though sensory perception of almond and strawberry flavors decreased significantly over the same range. Because flavor perception was shown to decrease in the presence of a constant aroma stimulus, it was hypothesized that a taste−aroma interaction (*9*) between sweetness and a sweet-associated aroma caused the decrease in perceived flavor.

To test this taste−aroma interaction hypothesis, we wished to study systems flavored with a congruent taste−aroma pairing based on a different taste modality, for example, salt−savory-flavored systems. A limiting factor in designing such an experiment (and presumably the reason systems to date have been based upon sucrose) is the unpalatable nature of viscous salty solutions in the absence of other taste components. This

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Table 1. Sample Composition Details for the Sensory Paired Comparison Tests

test	judged attribute	solution 1 (less viscous)	solution 2 (more viscous)
1	saltiness	2 g/L HPMC and 3.5 g/L NaCl	10 g/L HPMC and 3.5 g/L NaCl
2	saltiness	1.7 g/L λ-carrageenan and 3.5 g/L NaCl	10.2 g/L λ-carrageenan and 3.5 g/L NaCl
3	mushroom flavor	2 g/L HPMC, 3 g/L NaCl, and 8 ppm of 1-octen-3-ol	10 g/L HPMC, 3 g/L NaCl, and 8 ppm of 1-octen-3-ol
4	mushroom flavor	1.7 g/L λ-carrageenan, 3 g/L NaCl, and 8 ppm of 1-octen-3-ol	10.2 g/L λ-carrageenan, 3 g/L NaCl, and 8 ppm of 1-octen-3-ol
5	garlic flavor	2 g/L HPMC, 2 g/L NaCl, and 2.5 ppm of diallyl disulfide	10 g/L HPMC, 2 g/L NaCl, and 2.5 ppm of diallyl disulfide
6	garlic flavor	2 g/L HPMC, 2 g/L NaCl, and 2.5 ppm of diallyl disulfide	10 g/L HPMC, 3 g/L NaCl, and 2.5 ppm of diallyl disulfide

limits the number of samples that can realistically be presented to a sensory panel and therefore the size of experimental design employed. There have consequently been very few papers describing the effects of hydrocolloid thickeners on the perception of savory flavors.

Yven et al. (*10*) investigated aroma release and perception of mushroom (1-octen-3-ol), garlic (diallyl disulfide), and butter (diacetyl) aromas from hydrocolloid solutions (1 g/L xanthan and 3 g/L guar gum) and water. However, their systems contained no tastants [e.g., salt or monosodium glutamate (MSG)] and so were not designed to evaluate taste−aroma interactions as a mechanism for flavor suppression in viscous solutions.

Rosett et al. (*11*) investigated the effects of added hydrocolloids on flavor perception in low-sodium soups. Although their findings were clearly of relevance to this specific product type, the complexity of soup systems makes comparison with more fundamental research difficult. For instance, the flavor system was a chicken broth (Campbell Soup Co.), of undefined aroma or tastant composition. Chicken flavor was rated as an overall attribute, but there was no analysis of the compounds responsible for the attribute scored and no investigation of the effects of hydrocolloids on aroma release. Without a detailed knowledge of the flavor system, it is impossible to place a clear interpretation upon sensory scores.

In a preliminary study (*12*), we demonstrated a decrease in perceived salt intensity in viscous solutions thickened with HPMC. The present study expands on this finding by investigating the perception of savory flavors in salty viscous solutions thickened with either HPMC or λ-carrageenan. To limit problems caused by the unpalatability of such systems, we adopted a sensory strategy of using paired comparison tests to make specific comparisons between different viscosity levels, as opposed to attempting to model perception over a large design space. Although there are undoubtedly more powerful sensory techniques, the paired comparison design enabled sample numbers to be minimized while probing some specific questions regarding the mechanisms involved in flavor perception from viscous savory systems.

The ideal aroma for this kind of experiment would be a single character impact compound that can be analyzed with adequate sensitivity in the exhaled breath by API-MS. This ensures a clearly defined flavor for sensory evaluation purposes and simplifies aroma release measurements and their interpretation. However, savory aromas are often complex in composition, relying upon a blend of compounds to produce a specific character. Consequently, there are fewer clear-cut character impact compounds to choose from. Additionally, many savory aromas have low sensory thresholds and can be present in foods at parts per billion levels and below while still influencing perception. This may present problems with analytical sensitivity in detecting nose-space release concentrations. Taking these factors into account, we selected 1-octen-3-ol for its mushroom character (*13*−*15*), compatibility with salt taste, and ease of ionization during API-MS analysis; similarly, diallyl disulfide was chosen to flavor garlic (*16*, *17*) "sauces".

MATERIALS AND METHODS

Samples. *Preparation of Hydrocolloid Solutions.* Hydrocolloids were dispersed in water using an overhead paddle stirrer at between 200 and 600 rpm. HPMC (Methocel, The Dow Chemical Co.) was dispersed in water at 95 °C and λ-carrageenan (Red Carnation Gums Ltd., Laindon, U.K.) in water at 60 °C. Hydrocolloid dispersions were subsequently cooled to 5 °C and stirred for a further 6 h to ensure adequate hydration of the polymer chains.

Preparation of Taste Panel Samples. Samples for sensory analysis were prepared by pipetting an appropriate volume of 150 g/L NaCl (aq) (Fisher Scientific, Loughborough, U.K.) into the hydrocolloid solution and mixing thoroughly for 2 h on a roller bed (SRT2; Stuart Scientific, Redhill, U.K.). A final concentration of 3.5 g/L NaCl was used for paired comparison tests of salt taste in the absence of aroma. This gave a medium to strong intensity of saltiness, which could be perceived and judged in the presence of thickener. When the savory systems incorporating mushroom and garlic flavors were developed, it was necessary to lower the salt concentration to 3 and 2 g/L, respectively, to maintain a balanced flavor system at realistic aroma concentrations. In systems incorporating aroma, this was added in the form of a concentrate, prepared by diluting the neat volatile in propylene glycol/water (4:1). The addition rate was calculated to give final concentrations of 8 ppm of 1-octen-3-ol (Firmenich SA, Geneva, Switzerland) or 2.5 ppm of diallyl disulfide (Firmenich SA). The solutions were mixed on a roller bed for a further 2 h to fully disperse the aroma prior to sensory evaluation.

Sensory Evaluation. *Sensory Panel.* Untrained panelists were recruited from colleagues and students in the Food Sciences Department [aged 22−42; the gender balance was approximately 2:1 (male/female)]. Panelists were screened for sensitivity to the sensory modality under consideration; that is, each session started with a ranking exercise in which the panelist had to place a series of three solutions of differing flavor intensities in order of magnitude. Provided that panelists are able to discriminate between different concentrations of a specified sensory attribute, paired comparison tests are straightforward and do not require further training.

Paired Comparison Tests. Each session consisted of no more than four paired comparison tests. Samples were presented in pairs in plastic cups labeled with a random three-digit code. Panelists tasted the same volume of each sample from a spoon (8 mL) and were asked to select the code of the solution that tasted more intense in a specified taste attribute (e.g., saltiness or mushroom flavor). The test was used in forced-choice mode; that is, the panelist was required to give an answer even if the perceived difference was negligible. Assessment of each pair was replicated within the session with reversed presentation order to avoid bias. Evaluations were conducted in isolated booths under controlled lighting conditions. Plain crackers and water were supplied to assist in cleansing the palate between tastings.

The compositions of samples used in the six paired comparison tests are listed in **Table 1**. Tests 1 and 2 compared the saltiness of 3.5 g/L NaCl in two different concentrations of HPMC (1) and λ-carrageenan (2). Tests 3 and 4 looked at the perception of a mushroom flavor incorporated at the same level in each of the thickener concentrations used in tests 1 and 2. Test 5 compared the intensity of a garlic flavor between the 2 and 10 g/L concentrations of HPMC. Test 6 repeated test 5, but with a higher salt concentration in the viscous (10 g/L HPMC) sample.

Table 2. Results of the Paired Comparison Tests for Salt Taste[a]

taste rated	thickener	NaCl concn	more intense at lower viscosity	more intense at higher viscosity	outcome/significance
saltiness	HPMC	3.5 g/L in each	28	11	perceived as more salty in 2 g/L HPMC than 10 g/L HPMC ($P < 0.01$)
saltiness	λ-carrageenan	3.5 g/L in each	19	5	perceived as more salty in 1.7 g/L λ-carrageenan than 10.2 g/L ($P < 0.01$)

[a] Test statistic = two-sided paired comparison test for difference (*18*).

Table 3. Results of the Paired Comparison Tests for Mushroom Flavor Intensity[a]

flavor rated	thickener	NaCl concn	more intense at lower viscosity	more intense at higher viscosity	outcome/significance
mushroom	HPMC	3 g/L in each	17	7	no significant difference, but borderline
mushroom	λ-carrageenan	3 g/L in each	18	6	perceived as stronger mushroom flavor in 1.7 g/L λ-carrageenan ($P < 0.05$)

[a] Test statistic = two-sided paired comparison test for difference (*18*).

Table 4. Results of the Paired Comparison Tests for Garlic Flavor Intensity

flavor rated	NaCl concn	more intense in 2 g/L HPMC	more intense in 10 g/L HPMC	outcome/significance
garlic	2 g/L in each	14	2	perceived as stronger garlic flavor in 2 g/L HPMC than in 10 g/L HPMC ($P < 0.01$)
garlic	2 g/L in 2 g/L HPMC; 3 g/L in 10 g/L HPMC	7	9	no significant difference

[a] Test statistic = two-sided paired comparison test for difference (*18*).

Statistical Analysis. Panel responses for each test pair were tallied (**Tables 2−4**), and significant differences between samples were judged against tabulated critical numbers of correct answers [two-sided paired comparison test for difference (*18*)]. In forced-choice mode, an even spread of responses between the two samples would be predicted if there was no difference in taste intensity between samples.

Aroma Release Measurements. Aroma release from each of the savory-flavored samples was analyzed by API-MS using the MS-Nose [Micromass, Manchester, U.K. (*8*)]. In positive ion mode API-MS, 1-octen-3-ol protonates and dehydrates to yield the principal ion *m*/*z* 111 (cone voltage = 20 V). Diallyl disulfide predominantly protonates to the M + 1 ion (*m*/*z* 147; cone voltage = 12 V).

Headspace Analysis. Five replicate aliquots (40 g) of each thickened savory solution were weighed into individual 100 mL Schott bottles (Fisher Scientific) fitted with stoppered lids. The samples were allowed to equilibrate at room temperature (24 °C) for 1 h. The resultant headspaces were sampled in turn into the MS-Nose by removing the headspace stopper and inserting the heated transfer line (sampling rate = 4 mL/min) directly into each headspace. The mass spectrometer was operating in selected ion mode, monitoring either *m*/*z* 111 (1-octen-3-ol) or *m*/*z* 147 (diallyl disulfide). Garlic and mushroom samples were analyzed on separate days, but using the same procedure. Static headspace measurements were taken for all sensory samples. Additionally, the partition behavior of the garlic flavor system (2 g/L NaCl, 2.5 ppm of diallyl disulfide) was measured in water.

Nose-Space Release Measurements. Real-time release of savory aromas was measured in-nose using the MS-Nose. Three panelists drank four replicates of each of the experimental solutions, using a fixed protocol. They were asked to breathe in, sip 8 mL of solution from a spoon, close their mouths, swallow the sample, then exhale and continue to breathe normally while resting their nose on the MS-Nose nasal sampling tube. Air from the nose was sampled directly to the source of an API-MS at 85 mL/min. Exhaled aroma was monitored for either *m*/*z* 111 (1-octen-3-ol) or *m*/*z* 147 (diallyl disulfide) as appropriate. Gas phase aroma concentrations were calibrated by comparison against known standards, which were injected into the API-MS at the beginning and end of each analysis (*8*).

RESULTS AND DISCUSSION

Salt Taste Perception in Hydrocolloid Solutions. The perceived saltiness of 3.5 g/L NaCl was found to be significantly reduced ($P < 0.01$) at the higher thickener concentration of both HPMC and λ-carrageenan, relative to the lower concentration (**Table 2**). In the subsequent experiments in which savory garlic or mushroom aromas were added, we can assume that the aroma was tasted in a less salty context at higher thickener concentrations. Previous investigations into the effects of hydrocolloids on the perception of salt taste (*19*−*22*) showed different effects depending on the nature of the hydrocolloid (ionic or nonionic) and the particular concentrations of both thickener and NaCl. With ionic hydrocolloids, specific effects depend on the nature of the counterions intrinsic to the hydrocolloid. For instance, sodium carboxymethylcellulose had an enhancing effect on salt taste with increasing concentration (*19*), presumably because of the Na^+ ions being added with the thickener. Alternatively, when sodium is not present as a counterion, the sodium ions from NaCl may compete with other cations for binding sites on the hydrocolloid, making them unavailable for salt perception (*21*). The latter effect may explain the observed reduction in perceived saltiness at the higher concentration of λ-carrageenan, which is a polyelectrolyte. HPMC, however, is a nonionic hydrocolloid, and direct ion-binding cannot be responsible for the reduction in salt intensity that occurred at the higher concentration (10 g/L). It is possible that viscous HPMC solutions interact with salt taste at a perceptual level rather than through a physical reduction in stimulus due to ion binding.

Mushroom-Flavored Systems. The mushroom flavor of 8 ppm of 1-octen-3-ol and 3 g/L NaCl was perceived as significantly less intense in 10.2 g/L λ-carrageenan as compared with 1.7 g/L λ-carrageenan ($P < 0.05$, **Table 3**). In HPMC solutions, the difference in mushroom flavor perception between

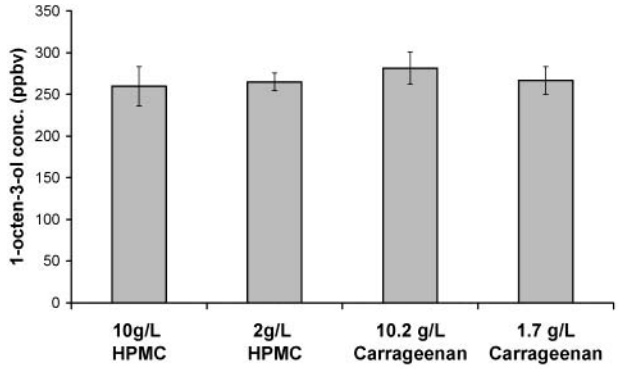

Figure 1. Equilibrium static headspace concentrations of 1-octen-3-ol above four thickened solutions. Data are the mean of five replicates ± standard deviation. Original liquid phase concentration was 8 ppm of 1-octen-3-ol.

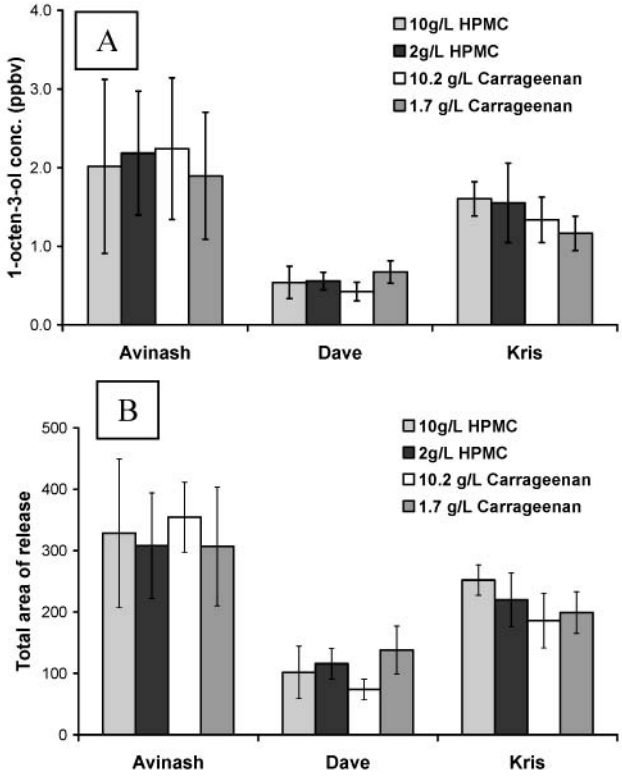

Figure 2. Nose-space release of 1-octen-3-ol during consumption of thickened solutions (8 mL): (A) maximum in-nose concentration; (B) pooled area for first three exhalations (measure of total release). Data are the mean of four replicates ± standard deviation. Liquid phase concentration of 1-octen-3-ol was 20 ppm.

the two thickener concentrations was not quite statistically significant ($P < 0.05$), although there was a clear trend for panelists to judge the less viscous sample as having the greater mushroom flavor intensity (17 of 24 times).

Aroma release measurements from the same samples showed no significant effects of thickener type or concentration on either static equilibrium headspace measurements (**Figure 1**) or in-nose release as the samples were consumed (**Figure 2**). Static equilibrium headspace analysis is a convenient method of measuring physicochemical interactions of aroma compounds with solutes. It can be concluded from **Figure 1** that there was no binding between 1-octen-3-ol and either HPMC or λ-carrageenan, because the amount of hydrocolloid present did not significantly change the equilibrium headspace aroma concentration. Yven et al. (*10*) reported weak binding between 1-octen-3-ol and xanthan and guar gums, leading to a 30% reduction in equilibrium static headspace concentrations (when comparing these results, one should remember that there was no added salt in the systems used by Yven et al.). However, this did not result in either case in significant changes in perceived mushroom intensity when the solutions were tasted. This is not altogether surprising; static headspace measurements indicate the nature of orthonasal (sniffed) odors but do not take into account the dynamic processes of release leading to retronasal odor perception during the consumption of foods (*23*, *24*). Yven et al. characterized the binding between xanthan and 1-octen-3-ol as weak and reversible; in a dynamic release situation, this reversibility probably meant that the binding was not rate-limiting.

For dynamic release measurements, two parameters are presented (**Figure 2**) because both intensity and temporal elements of aroma release affect perception (*25*). Maximum in-nose volatile concentration (I_{max}) is the peak stimulus reaching the olfactory receptors; for liquid foods, this normally occurs on the first exhalation after swallowing. The pooled area of release is the total area underneath the aroma release trace for the first three exhalations after swallowing and thus reflects the total amount of aroma release from liquid samples. Successive exhalations decay exponentially in aroma concentration, so, for solutions, the bulk of the aroma is released in the first three breaths unless the volatile is particularly persistent (*26*). Neither measure of aroma release showed significant effects of sample matrix. Nor were there consistent trends in release with matrix type when data for each panelist were compared. This suggests that differences in individual mean values were arbitrary and within the range of variation associated with nose-space release measurements.

Garlic-Flavored Systems. Diallyl disulfide (2.5 ppm) and NaCl (2 g/L) were perceived as tasting more intensely of garlic when presented in 2 g/L HPMC than in 10 g/L HPMC ($P < 0.01$; **Table 4**). When the NaCl concentration in the more viscous sample was increased to 3 g/L, panel responses were split evenly between the two samples, suggesting that they now had garlic intensities similar to one another (test 6, **Table 1**). This result was important in two respects. First, it showed that there were circumstances in which the panelists would select a more viscous sample as tasting more intense and, thus, that they were not simply responding to differences in viscosity as opposed to flavor intensity when making their choices. Second, it provided evidence of a perceptual interaction between garlic flavor and salt taste, because garlic intensity was enhanced by an increase in NaCl concentration.

Static equilibrium headspace measurements showed evidence of binding effects between HPMC and diallyl disulfide (**Figure 3**). Increasing the HPMC concentration from 0 to 2 to 10 g/L resulted in a progressive decrease in headspace diallyl disulfide concentration (salting-in or binding effect), which dropped by ~40% over this range. This parallels the findings of Yven et al. (*10*), who concluded that xanthan and guar gums had the most effect on the static headspace concentrations of aroma compounds with a high air−water partition coefficient. This observation might explain why HPMC concentration affected the static partitioning behavior of diallyl disulfide [$K_{aw} = 1.6 \times 10^{-2}$ (*10*)], but not 1-octen-3-ol [$K_{aw} = 3.1 \times 10^{-3}$ (*10*)]. Alternatively, the difference might be due to specific molecular interactions between HPMC and diallyl disulfide. At 10 g/L HPMC, increasing the NaCl concentration from 2 to 3 g/L did not affect aroma partitioning behavior.

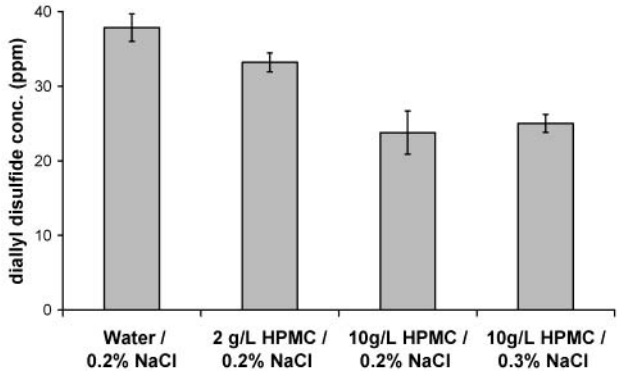

Figure 3. Equilibrium static headspace concentrations of diallyl disulfide above four solutions. Data are the mean of five replicates ± standard deviation. Original liquid phase concentration was 2.5 ppm of diallyl disulfide.

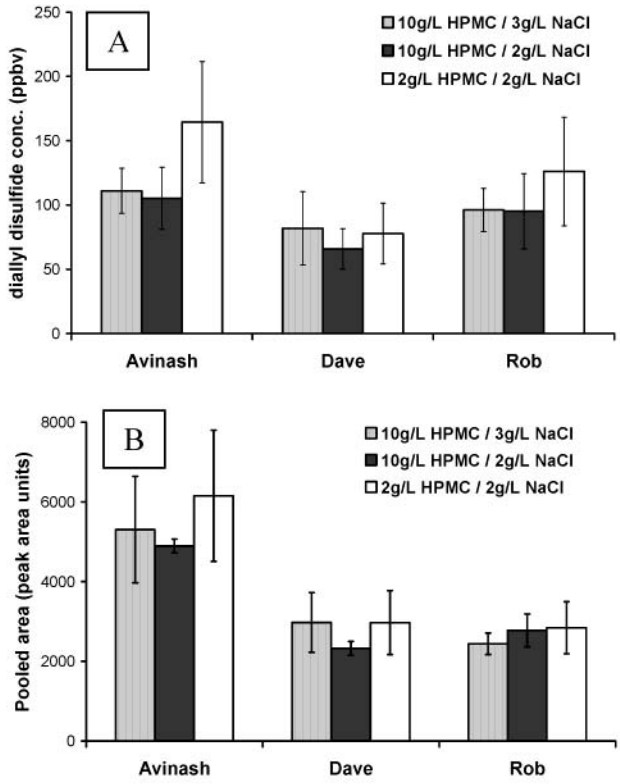

Figure 4. Nose-space release of diallyl disulfide during consumption of thickened solutions (8 mL): (A) maximum in-nose concentration; (B) pooled area for first three exhalations (measure of total release). Data are the mean of four replicates ± standard deviation. Liquid phase concentration of diallyl disulfide was 2.5 ppm.

The interaction between dially disulfide and HPMC in static systems did not, however, affect the dynamic release of aroma in-nose when panelists consumed the garlic solutions (**Figure 4**). There were no significant differences in mean in-nose release between the three samples for any of the panelists using either the I_{max} or total area measures of release. Two of the panelists had higher mean values of maximum in-nose concentration for the less viscous HPMC system. However, this difference was not significant and did not affect the total aroma release (e.g., compare panels A and B of **Figure 4** for panelist Rob). The nature of the static interaction between diallyl disulfide and HPMC did not affect the "pool" of aroma available for dynamic release, either because the binding was reversible or because the amount of aroma binding was not rate-limiting on release under experimental conditions. A similar finding was reported by Kant et al. (*27*) when studying aroma release from potato starch solutions. Volatiles that bound to starch (as measured by a reduction in static equilibrium headspace concentration) did not show a proportionate reduction in aroma release measured in vivo.

Savory Flavor Perception in Hydrocolloid Solutions. Garlic and mushroom flavors were both perceived as less intense at higher concentrations of hydrocolloid, although in each case there was no significant effect of hydrocolloid concentration on aroma release measured in-nose. This effect is probably attributable to a reduction in perceived saltiness against which the aroma was tasted at higher thickener concentrations (**Table 2**). The perception of salt taste was thus driving perception of savory-associated aromas at a constant aroma stimulus. Such cognitive interactions between taste and aroma are thought to be learned through association from frequent pairing in food products (*5*, *9*, *28*). Tastes and aromas that are normally experienced together are effectively perceived as a joint construct. Both mushroom and garlic aromas are frequently encountered in salty food systems (soups, sauces, etc.), so their pairing in a cognitive sense seems to be logical. The co-integration of taste and aroma is complex, and enhancement probably depends on each stimulus being presented within a certain concentration range, determined by experience. In this way, there will be a perceptual response surface for intensity resulting from combinations of taste and aroma stimuli; our experiments form a few points on such response surfaces. In the sensory tests, untrained panelists were asked to rate perception of a whole flavor, without the option to score individual sensory attributes such as saltiness. Such conditions encourage a panelist to adopt a synthetic approach to flavor judgments, a process that is probably closer to the way in which consumers perceive flavor than the analytical approach of trained panels, who learn to break flavor down into distinct experiences of taste, aroma, mouthfeel, color, and so on.

Looking generically at flavor perception in hydrocolloid solutions, we believe the results published here are consistent with parallel studies on sweet systems combining sucrose with a sweet-associated aroma (*1*−*4*). There have now been a range of such systems studied, and, in each case, thickener concentration (hence solution viscosity) did not affect aroma release in vivo. The principal effects of thickener in the systems studied appear to be upon taste perception, with flavor perception following such changes due to taste−aroma interactions. We may conclude that, when the addition of hydrocolloid modifies the perception of salt taste, there are implications for savory flavor perception. In the kitchen, this may be something that chefs cope with intuitively, learning to add more flavoring to a sauce or soup as they thicken it. With palatable food products such as soups, it should be practical to employ a more rigorous experimental design and thus model perceptual changes over a range of thickener concentrations. It might then be possible to predict the amount of added salt necessary to redress the flavor balance at a particular thickener level. However, many other factors, for example, fat content and MSG content, would also need to be taken into account.

ABBREVIATIONS USED

HPMC, hydroxypropylmethyl cellulose; MSG, monosodium glutamate.

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