Decrease of Vanillin Flavor Perception in the Presence of Casein and Whey Proteins

A. P. HANSEN and J. J. HEINIS
Department of Food Science
North Carolina State University
Raleigh

ABSTRACT

The effect of sodium caseinate and whey protein concentrate on vanillin flavor intensity was determined by quantitative descriptive analysis deviation from reference. A 12-member trained panel marked a horizontal line to rate vanillin, sodium caseinate, and whey protein concentrate flavor intensities in vanillin-sodium caseinate or vanillin-whey protein concentrate solutions using vanillin (78.5 ppm), sodium caseinate (.25%), or whey protein concentrate (.25%) references. The vanillin-sodium caseinate and vanillin-whey protein concentrate solutions contained 78.5 ppm vanillin, 2.5% sucrose, and .125, .25, and .5% sodium caseinate or whey protein concentrate, which were held 17 h at 6°C. The panel evaluated samples at room temperature and found that vanillin flavor intensity was moderately less than the reference for all sodium caseinate levels. As whey protein concentrate concentration increased from .125 to .5%, vanillin flavor decreased from moderately less than vanillin reference to much less than vanillin reference. This decrease in vanillin flavor intensity in the presence of sodium caseinate or whey protein concentrate may be due to cysteine-aldehyde condensation or Schiff base formation.

(Key words: vanillin, casein, whey protein, quantitative descriptive analysis)

Abbreviation key: CAS = sodium caseinate, WPC = whey protein concentrate.

INTRODUCTION

Interaction of aldehydes with proteins has been extensively studied because protein additions to aldehyde solutions can lead to decreased aldehyde concentration (3, 6, 8, 12, 22, 29). Decrease in aldehyde concentration can lead to a decrease in flavor perception by altered flavor release (18, 27) or small changes in flavor compound concentration (4). The concentration of citral, a major component of lemon flavor (7, 20), was reduced by almost 100% when 5% casein or soy protein isolate was also present in aqueous solution (6, 8). Sixty-eight percent of the initial vanillin concentration measured by HPLC is lost after 26 h in cola drinks containing cinnamaldehyde and aspartame (29). Vanillin concentrations decreased 72.8% after 25 h at 26°C with aspartame to form a Schiff base (13). The reaction between vanillin and aspartame followed second-order kinetics with an activation energy of 11.67 kcal/mol (5, 12). Similar Schiff bases were formed between L-tyrosine ethyl ester and heptanal (26).

Reduced vanillin flavor with reduced vanillin concentrations (25, 26) have been found after faba bean (Vicia faba) proteins were added to vanillin solutions (25, 26). The concentration of vanillin bound to protein increased when protein concentration increased or proteins were subjected to thermal treatment. This increase in bound vanillin was accompanied by reduced vanillin flavor intensity (26).

In low fat dairy desserts, sodium caseinate (CAS) or whey protein concentrate (WPC) often serve as fat replacements (2). Sodium caseinate is a good emulsifier and surfactant...
that provides body in beverages, whipped toppings, ice cream, and coffee whiteners (16, 24). Whey protein concentrate is a good emulsifier and provides aeration stability in beverages and ice cream (17, 23) but is reactive toward aliphatic aldehydes and methyl ketones (14, 21). Vanilla is a widely used food flavorant (7, 20). Because vanillin, an aromatic aldehyde, is the primary flavor component of vanilla (30), vanillin-protein interactions that give decreased vanillin perception may also reduce consumer acceptability in a variety of food products. The purpose of this research was to determine the effect of CAS and WPC, two commercially available dairy proteins, which are used in ice cream, ice milk, and beverages, upon vanillin perception in an aqueous system.

MATERIALS AND METHODS

Reagents

Deionized, double glass-distilled water was used for all tests. Panelists did not detect any flavor defects in the water. The CAS and WPC were obtained from New Zealand Milk Products (Petaluma, CA). Proximate analyses furnished by the manufacturer indicated that CAS (Alanate 180) contained 91.1% protein, 3.5% ash, 4.0% moisture, 1.1% fat, and .1% lactose and gave a pH of 6.6 in 5% aqueous solution at 21°C. The WPC (Alacen 855) contained 76.5% protein, 3.5% ash, 4% moisture, and 12.5% lactose and gave a pH of 6.7 in 5% aqueous solution at 20°C.

Food grade vanillin (Rhone Poulenc, Princeton, NJ) was recrystallized twice from water before use. Before the test, stock solutions were made of vanillin (10.04%), CAS (1.68%), and WPC (1.68%).

Vanillin, Sucrose, and Dairy Protein Levels

Preliminary trials by a 4-member laboratory panel evaluated vanillin flavor in water at concentrations that began at .316 ppm and doubled stepwise in vanillin concentration to a maximum of 333 ppm. The panel found that vanillin below 5 ppm produced pronounced bitter notes, but concentrations above 156 ppm produced a burning sensation on the tongue. A vanillin level of 78.5 ppm gave a definite vanillin aroma, flavor, and a smooth mouthfeel. The panel also found that the slightly sweet sensation of 2.5% sucrose reduced the unpleasant bitter note of vanillin. The CAS and WPC concentrations were kept below 1% because higher protein levels overpowered the flavor of vanillin and fatigued panelists.

Sensory Analysis

Nine females (aged 21 to 36) and three males (aged 21 to 50) were trained to evaluate vanillin and protein flavor intensities by quantitative descriptive analysis deviation from reference (5). These panelists were selected from 45 members of the Food Science Department, based on their success in duo-trio plus reference tests using vanillin (78.5 ppm) as an external reference. The samples consisted of vanillin (78.5 ppm) and vanillin plus CAS (0, .25, or .5% CAS) or vanillin plus WPC (0, .25, or .5% WPC). Candidates who had been more than 80% successful in these trials were selected for the trained panel.

Candidates were trained to detect and identify vanillin, CAS, and WPC flavors during four sessions (15). During the first session, panelists identified the four basic tastes (sweet, salt, sour, bitter) and rated three sucrose and vanillin solutions on the basis of flavor intensity. Concentrations for the four basic tastes were sweet (1% sucrose), salt (.1% NaCl), sour (.01% citric acid), and bitter (.01% caffeine). Three additional trials were used to train the panelists to rate the flavor intensities of CAS, WPC, and vanillin. For rating, three levels were used for vanillin (58.6, 78.5, and 114.2 ppm), CAS (.25, .5, and 1%), WPC (.25, .5, and 1%) and sucrose (.5, 1, and 1.5%). After rating the samples, the individual flavor and aroma notes were noted, and the samples were retasted for discussions by the entire panel.

Sample Preparation, Presentation, and Panelist Evaluation

Samples were prepared by mixing vanillin stock solution, sucrose, CAS, and WPC to give concentrations of .125, .25, and .5% CAS or WPC in 2.5% sucrose. After mixing, CAS and WPC solutions were held overnight (17 h) at 6°C to simulate aging of ice cream mix (1) during which initial vanillin-protein interaction would occur.
VANILLIN FLAVOR IN THE PRESENCE OF CASEIN

1. Please taste Sample A and identify which aromas and flavors are present.

<table>
<thead>
<tr>
<th>Aroma</th>
<th>Flavor</th>
</tr>
</thead>
</table>

2. Please taste Sample B and identify which aromas and flavors are present.

<table>
<thead>
<tr>
<th>Aroma</th>
<th>Flavor</th>
</tr>
</thead>
</table>

The next samples (C, D, E) contain vanillin in the presence of casein. Ignore the opacity of the solution.

3. For Sample C, please give the amount of casein flavor compared with Sample A by placing a mark on the line that indicates the extent of casein flavor.

None  Same  Overpowering

4. For Sample C, please give the amount of vanillin flavor compared with Sample B by placing a mark on the line that indicates the extent of vanillin flavor.

None  Same  Overpowering

5. For Sample D, please give the amount of casein flavor compared with Sample A by placing a mark on the line that indicates the extent of casein flavor.

None  Same  Overpowering

6. For Sample D, please give the amount of vanillin flavor compared with Sample B by placing a mark on the line that indicates the extent of vanillin flavor.

None  Same  Overpowering

7. For Sample E, please give the amount of casein flavor compared with Sample A by placing a mark on the line that indicates the extent of casein flavor.

None  Same  Overpowering

8. For Sample E, please give the amount of vanillin flavor compared with Sample B by placing a mark on the line that indicates the extent of vanillin flavor.

None  Same  Overpowering

Figure 1. Ballot used for quantitative difference analysis deviation from reference.
Figure 2. Vanillin flavor intensity relative to reference in the presence of sodium caseinate (CAS) and whey protein concentrate (WPC). Reference vanillin concentration was 78.5 ppm in a 2.5% sucrose solution. A sample with lower vanillin flavor intensity than the 78.5 ppm reference had a flavor intensity below .5. Letters indicate significant differences between means (P < .05).

Samples were allowed to warm to room temperature and then were presented to the trained panel, which rated flavor intensity for vanillin, CAS, and WPC relative to the reference according to the ballot (Figure 1). The ratio of panelist response to total line length is the flavor intensity relative to reference for the appropriate flavor. Two references were given (.25% CAS or .25% WPC and 78.5 ppm vanillin) but not identified as such. The rating of protein intensity (CAS or WPC) was used to check panelist performance. The WPC score sheet was identical to Figure 1 but substituted the word whey for casein. Because sample order was randomized, there were four ballots for CAS and WPC.

Samples were presented to the panelists in individual booths maintained at 25°C and illuminated with red light. Panelists were instructed to rinse their palates with water between each sample. Samples (50 ml) were poured into 148-ml (5-oz) juice glasses that had been placed in plywood trays.

RESULTS AND DISCUSSION

Figure 2 indicates vanillin flavor intensity relative to the 78.5 ppm vanillin reference standard for both CAS and WPC. The trained panel agreed with laboratory panel assessments for vanillin, CAS, WPC, and sucrose levels. As expected, the panel found greater flavor intensity for casein and whey protein at higher CAS and WPC concentrations. However, vanillin flavor intensity was reduced when CAS and WPC were present. Although there was no significant difference in vanillin flavor intensity (P = .05) with increasing CAS concentration, vanillin flavor declined from .32 (moderately less than reference) to .15 (much less than reference) as WPC concentration increased from .125 to .5%.

Differences in flavor loss between CAS and WPC may be due to differences in the extent of protein denaturation due to processing and amino acid composition. There is minimal casein degradation during CAS isolation from skim milk (17, 23, 24) and subsequent heat treatment (24). In contrast, WPC production results in substantially more protein denaturation than CAS (19). Denaturation can cleave disulfide linkages and permit amino acids that are normally buried within the protein to interact with the flavor compound. The CAS and WPC also differ in amino acid composition. Casein has less cystine and lysine but more aromatic amino acids, methionine, arginine, and histidine than WPC (9).

The reduced vanillin flavor intensity in the presence of WPC compared with CAS may be attributed to Schiff base formation or interaction between the thiol group of cysteine and vanillin. The thiol groups of β-lactoglobulin were exposed at pH 8 and become more active at alkaline pH and elevated temperatures (19). Cysteine is highly reactive toward aldehydes and condenses with them (28). Similar vanillin reactivity in aqueous ethanolic solutions with urea, egg albumin, casein, peptone, fibrin, and pepsin to form Schiff base imine compounds has been observed (10, 11).

This study has shown that vanillin flavor decreased in the presence of both WPC and CAS. If these proteins are used in low fat dairy deserts to replace fat, they may interact with the flavoring and reduce flavor intensity to a level that may be unacceptable to the consumer. Further research is necessary to understand and control these flavor-protein interactions and enable producers to provide products with improved flavor and consumer acceptability.

REFERENCES

1 Arbuckle, W. S. 1977. Ice cream. AVI Publ. Co., Westport, CT.


