Effect of Low Levels of Pregelatinized Starch on the Sweetness of Sucrose†

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A sensory investigation of the effect of solution viscosity on sweetness is reported in this paper. A trained taste panel compared the sweetness of 5% sucrose in water to a solution of 5% sucrose containing 2% pregelatinized starch. When the starch was tapioca or waxy corn there was no significant difference between the samples with and without starch although there was a tendency to rank the starch containing solution as less sweet. When the starch was potato there was a statistically significant reduction in sweetness of the starch containing solution. These results are discussed and a possible mechanism for sweetness reduction is postulated.

Pregelatinized starches are used widely in today's food industry as thickeners, stabilizers, binders and bulking agents. They are particularly useful for foods in which precooked thickeners are essential, such as instant puddings.

The production of pregelatinized starches involves precooking to gelatinize the starch followed by a drying process.1 Tapioca, potato and corn starch are the prevailing sources of pregelatinized starch. Each have the common property of cold-water dispersability yet the dispersions reflect the attributes of the raw starch. They may be modified to comply with certain desired viscosity, stability, texture and taste characteristics.

The swelling power of raw potato starch is greater than that of both waxy maize and tapioca starches. Factors which influence the strength of the micellar network and, hence, the swelling power of a starch are numerous and include such factors as: the ratio of amylose to amyllopectin, the molecular weight of these components, conformation, degree of branching and the length of the outer branches in the amyllopectin.

It has been demonstrated that changes in viscosity affect the taste intensity of various types of aqueous solutions.2–7 Stone and Oliver8 reported that sucrose solutions containing gums were ranked higher on a 100 point sweetness scale than sucrose solutions without gums. However, there was no significant difference in a paired comparison of the sweetness of the solutions with gums and those without. In general, it is thought that the addition of hydrocolloids depresses taste intensity.

In magnitude estimation experiments, the sweetness of wide concentration ranges of both sodium saccharin and sucrose were masked by carboxymethylcellulose.9 This masking occurred at all concentrations of sucrose. Vaisey et al.7 reported maximum sensitivity to sucrose sweetness in gums with the greatest shear thinning as measured on a Brookfield viscometer.

Depression of sweetness intensity of sucrose by xanthan gum is dependent on viscosity.6 High viscosity solutions of carboxymethylcellulose depress sweetness only in lower concentrations of sucrose. A viscosity of about 16 cps is reported as necessary to significantly reduce the sweetness of sucrose.5

There are several possible mechanisms to explain alterations in taste intensity by alteration of viscosity. It is possible that the thickener and taste

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stimulus physically or chemically interact to change the accessibility of the taste substance to the taste receptor site. Or, the thickener may interact with the taste receptor.

Although the effects of a wide variety of thickeners on taste intensity have been examined, the effects of pregelatinized starches have not been investigated. It is the purpose of this study to determine the effect of low levels of pregelatinized starch from three sources on the perceived sweetness of sucrose.

EXPERIMENTAL

Panel selection and training. The panel consisted of 11 nonsmoking students and employees of Purdue University, West Lafayette, Indiana. Ages ranged from 21 to 63 with a median age of 27. All potential panelists were screened for an ability to distinguish four basic tastes: sweet, sour, salty and bitter and to rank 5 sucrose solutions in order of sweetness intensity. Selection was based on each panelist's results in a sequential analysis test as well as demonstrated dependability and interest in the study. Panelists were trained to determine differences in sucrose concentrations of 1 % wt/vol (0.029 M) in forced-choice triangle and paired comparison tests.

Taste sessions were conducted in an air conditioned tasting room containing individually lighted, partitioned booths.

Materials. The pregelatinized starches were provided by A.E. Staley Manufacturing Company, Decatur, Illinois. Starches which gave maximum viscosity at lowest concentration were chosen. They are listed in Table 1. Sucrose was commercial grade. Solutions were prepared wt/vol with distilled, deionized water 24 hr prior to each taste session to allow for maximum hydration of the starch.

Pregelatinized starch solutions were prepared by placing approximately 750 ml of distilled, deionized water in a blender, adding the weighed and mixed sucrose and starch while blending and mixing for 2 min at a medium speed. The solution was quantitatively transferred to a 1,000 ml volumetric flask and brought to volume.

The Brookfield Viscometer Synchrolectric model RV was used to measure apparent viscosity just prior to presentation. Measurements were taken with spindle number 1 at 2, 4, 10 and 20 rpm.

Sample presentation. Samples of 15 ml were served at 25° in 3/4 ounce paper portion cups (Sweetheart, No. 075) and coded with 3 digit random numbers. Panelists were instructed to sip the samples, turn them over in their mouths and retain them until they perceived maximum sweetness intensity and the intensity had begun to decrease. At that point they were to expectorate the sample, rinse with distilled, deionized water and proceed to the next sample.

Sensory evaluation. Panelists compared the sweetness intensity of 2 % pregelatinized starch/5 % sucrose solutions to 5 % sucrose solutions in forced-choice paired comparison tests. Panelists judged 5 pair of samples per session and were instructed to wait at least 1 min between pairs. Data were analyzed through binomial probability distribution.

RESULTS

The viscosities of the pregelatinized starches are given in Fig. 1 for different spindle speeds of the Brookfield viscometer. The 2 % potato starch/5 % sucrose solution was most viscous followed by the 2 % waxy maize/5 % sucrose solution, then the 2 % tapioca/5 % sucrose solution. The rheological properties of the potato starch appear to be pseudoplastic while the waxy maize and tapioca starches are nearly Newtonian.

Table 2 lists the results of the paired comparison test between 5 % sucrose and 2 % pregelatinized starch/5 % sucrose.

<table>
<thead>
<tr>
<th>Type</th>
<th>Concentration (%)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potato</td>
<td>2.0</td>
<td>5.8</td>
</tr>
<tr>
<td>Tapioca</td>
<td>2.0</td>
<td>6.35</td>
</tr>
<tr>
<td>Waxy maize</td>
<td>2.0</td>
<td>6.15</td>
</tr>
</tbody>
</table>

The differences in sweetness were not significant for the 5 % sucrose, 2 % pregelatinized tapioca starch/5 % sucrose solutions nor were they significant for the waxy maize solution. There was a significant difference between the 5 % sucrose and the 2 % pregelatinized potato starch/5 % sucrose solution; the potato starch solution was significantly less sweet (p value = 0.104).
DISCUSSION

Reference to Table 2 clearly demonstrates a general reduction of sweetness at viscosity levels slightly elevated relative to sucrose solutions. The tapioca and waxy corn samples show a tendency to lower sweetness but this trend is not statistically significant. However, the potato starch/sucrose is less sweet than the sucrose control (statistically significant $p \leq 0.05$). As shown in Fig. 1 tapioca and waxy corn starches have the lowest viscosities with solution rheologies approximating Newtonian fluids. Pangborn\(^5\) has suggested that a viscosity at least 16 cps is necessary to reduce the sweetness of sucrose. Thus, one would not expect a difference between 5% sucrose with and without 2% tapioca starch (12 cps at lowest spindle speed). An effect might be expected in 2% waxy corn starch dispersion showing 25 cps at lowest spindle speed. A trend in the direction of reduced sweetness due to the presence of waxy corn starch is noted but this is not statistically significant. The high potato starch viscosity of 75 cps at lowest spindle speed suggests a reduction of sweetness if this taste is mediated by diffusion of the tastant molecule onto the proteinaceous receptors of the circumvallate papillae. Indeed in this case a statistically significant reduction in sweetness is observed.

Individual panel member observations included the detection of delayed sweetness onset and increased persistence time for the potato starch/sucrose combination. This is consistent with a mechanism of sweet taste wherein initial steps are diffusion controlled processes. Other panelists noted an unpleasant slimy mouthfeel in potato starch and a tendency for waxy corn starch to "mask" the sweetness of sucrose. Little unpleasantness was noted with tapioca which is generally regarded as the most bland starch of the three tested.

Individual panelist observations as well as the statistically significant reduction in sweetness at higher viscosity levels are thus, important factors in formulation of food products containing both sucrose and pregelatinized starch, such as instant puddings.

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