CONTRIBUTIONS OF SELECTED FLAVOR COMPOUNDS TO THE SENSORY PROPERTIES OF MAPLE SYRUP[1]

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ABSTRACT

A base syrup formulation containing nonvolatile flavor compounds was used to systematically evaluate the sensory contributions of selected volatile compounds (Furaneol, 2,5-dimethyl-4-hydroxy-3(2H)-furanone; sugar furanone, 4,5-dimethyl-3-hydroxy-2(5H)-furanone; guaiacol, 2-methoxy phenol; vanillin, 4-hydroxy-3-methoxy-benzaldehyde) to maple syrup flavor. Descriptive sensory panels showed that all compounds contributed to maple flavor intensity, but sugar furanone was an exceptionally important determinant. Medium and dark amber syrups contained generally higher concentrations of the selected flavor compounds than the light amber syrup. 5'-Inosine monophosphate was tentatively identified in maple syrup by HPLC analysis, and was found to contribute important taste characteristics to maple syrup. Consumer studies showed that more flavorful, darker grade A syrups were preferred over light amber grade A syrup.

INTRODUCTION

The principal species of maple used for the production of authentic maple syrup is *Acer saccharum* or the sugar maple. Because of limited distribution for this species, maple syrup is manufactured only in North America (Sendak 1982). About 80% of the annual crop of maple syrup is produced in Canada, primarily in Quebec (Flaherty 1990), and the remainder originates in the northeastern and northern sections of the United States. Maple syrup from Canada is sold to both food manufacturers and the retail market, whereas most of the maple syrup

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produced in the United States is sold directly to consumers (Sendak and Jenkins 1982).

Maple syrup is graded on the basis of color, although there is an implied association between grades and flavor (USDA 1979). Color grades used in the United States include three grade A categories: light, medium, and dark ambers, grade B for processing, and substandard (USDA 1979). It is generally accepted that the darker colored and lower grades of syrup possess stronger flavors than the lighter syrups. However, the desirability and specific type of flavors found in the various grades may vary widely depending on the initial sap and subsequent processing and holding conditions.

Among the grade A categories, light amber syrup has been priced higher than darker syrups (Sendak 1982). Only limited research has been carried out on consumer preferences for maple syrups, but Sendak (1978,1982) has collected data which suggested that the darker grade A amber syrups were preferred over light grade A amber syrup. Such observations indicate that pricing practices may not be in concert with consumer preferences for maple syrup.

The relationship between flavor compounds and the sensory quality of maple syrups has received limited attention, although progress has been made recently on the identification and quantification of influential flavor compounds (Kallio 1988). Kallio *et al.* (1987) studied the effect of heating birch syrup, which is a similar product recently developed in Finland, and compared the sensory qualities of birch syrups with a maple syrup sample. The maple syrup sample was found to exhibit a stronger vanillin aroma, but was distinctly weaker in Furaneol, caramel and burnt aromas.

There is commercial interest in developing methods to improve and assure the production of consistent maple syrup flavors, and further information about the sensory properties of compounds contributing to maple syrup flavors is needed. Therefore, the purpose of this study was to develop a formulated syrup base, and to add selected flavor compounds to the formulated syrup base to determine their influence on the sensory properties of maple flavors. It was also a purpose of the study to document consumer preferences for selected authentic maple syrups.

MATERIALS AND METHODS

Flavor Compounds and Syrup Ingredients

Flavor compounds included in the study were Furaneol (2,5-dimethyl-4-hydroxy-3(2H)-furanone; Aldrich Chemical Co., Milwaukee, WI), sugar furanone (4,5-dimethyl-3-hydroxy-2(5H)-furanone; Aldrich Chemical Co., Milwaukee, WI), guaiacol (2-methoxyphenol; Eastman, Rochester, NY), vanillin (4-hydroxy-3-methoxy-benzaldehyde; Sterwin Chemicals, New York, NY), and maple lactone (methylcyclopentenolone; California Aromatics and Flavor, Belleville, NJ).

Ingredients used for the base syrup were granulated beet sugar (Crystal Sugar, Moorehead, MN), malic acid (Sigma, St. Louis, MO), fumaric acid (Pfizer, New York, NY), a commercial mixture of disodium 5′-inosinate and disodium 5′-guanlyate (IMP, GMP, 1:1, Ribotide, Takeda USA, Orangeburg, NY) and retail red, yellow, and green food colors (McCormick, Baltimore, Md.). Also used in the base syrup were reagent grade fructose, glucose (Aldrich Chemical Co., Milwaukee, WI), sodium chloride, potassium chloride, and citric acid (Columbus Chemical Industries, Columbus, WI). Authentic maple syrups were obtained from regional producers in northern Wisconsin.

Laboratory Sensory Analysis

Individuals from a pool of over 50 panelists experienced in the practices of sensory analysis of foods participated in each laboratory panel evaluation. Each panel was composed of 25–35 panelists who were available for participation. Panelists initially participated in group sessions to select a lexicon of terms for use in descriptive analysis. Panelists were also employed initially to establish consensus flavor-active concentration ranges for the flavor compounds selected for study.

Panel sessions were carried out in the UW Sensory Analysis Laboratory under conditions prescribed for sensory analyses (IFT 1981; ASTM 1968). Each panelist, situated in an isolated, fully lighted (daylite-type fluorescent; 335 lux) booth equipped with running water, was presented with samples, a ballot, an unsalted rice cake, and a cup of water for rinsing. Where appropriate for comparison, reference samples containing prescribed concentration of flavor compounds or authentic maple syrup samples were presented either before or along with the test samples. Samples (ca ½ oz each) were contained in 1-oz odorless plastic cups coded with random 3-digit numbers.

When combinations of flavor compounds were initially evaluated in the base syrup, degree of difference procedures (Mahoney *et al.* 1957) were used to limit the number of optional formulas for further consideration. Flavor compounds were added at suprathreshold concentration for initial degree of difference panels, and successive panels were carried out using lesser concentrations until the no effect level was found for each. For characterization of flavors in syrup samples, descriptive sensory analysis (Stone *et al.* 1974; Stone and Sidel 1985; Meilgaard *et al.* 1987) was employed. These ballots contained descriptors selected to focus on the flavor characteristics of maple syrup (Kallio *et al.* 1987) and included scales for overall color (light amber to very dark amber), viscosity (very thin, not viscous to very thick, viscous), maple flavor intensity (very weak maple flavor to very strong maple flavor), sweetness intensity (modestly sweet to intensely sweet), richness of flavor (not rich, not full-flavored to rich, full flavored), and off-flavor intensity (none to very pronounced).

Additionally, other intensity scales (absent to pronounced) were included on ballots where appropriate for the particular flavor compound under study. These included vanilla flavor intensity, cotton candy flavor intensity, burnt-sugar flavor intensity, caramel flavor intensity, smokey flavor intensity, and medicinal flavor intensity. Ballots were constructed with semi-structured, horizontal lines (18 cm long), and each was constructed with a descriptor-labelled anchor point at each end. Panelists were also encouraged to provide voluntary comments about flavors in samples.

Ballot scales were coded on a 7-point basis, and coded values were analyzed using analysis of variance for a randomized block design. Individual analysis were performed for each quality attribute of samples tested in each session, and mean scores, F-values, and least significant difference (LSD) were computed for each sample pair in a session (Steel and Torrie 1960).

Consumer Sensory Analysis

Three different groups were employed in consumer preference evaluations. Two panels were conducted in Wisconsin which was considered a geographic region where residents were familiar with authentic maple syrup, although they may not have been regular users.

Consumer preference panels were conducted at the 1987 Wisconsin Farm Progress Days held at Barron, WI. Two samples were presented to each panelist in each of two sessions which allowed comparison of syrups. In the first session panelists evaluated grade A light amber and grade A medium amber and grade A dark amber syrups. Panelists were served about ¾ oz of each maple syrup sample in 1 oz plastic cups coded with a random 3-digit numbers and two toasted waffle (Aunt Jemima Toaster Waffles) sections. A total of 454 panelists participated in the first session, and 474 panelists participated in the second session.

Panelists utilized 7-point structured hedonic preference scales to evaluate the samples (Amerine et al. 1965). Coded values were analyzed using one-way analysis of variance for a completely random design. Mean scores, F-values, and least significant differences (LSD) were computed for each sample pair in a session (Steel and Torrie 1960).

An evaluation was also conducted at the Wisconsin State Fair (Milwaukee, WI) in 1987. In this test, monadic presentation of a Grade A medium amber maple syrup was used. Panelists received about ¾ oz. of maple syrup in a 1-oz plastic cup coded with a random 3-digit number. For one session, a traditional structured 7-point hedonic preference scale ranging from dislike to like very much (Amerine *et al.* 1965) was used. For a second session, a structured product rating scale (fair to excellent) was used. Panelists were also asked to complete a demographic questionnaire which included questions about place of residence, maple syrup usage pattern, and age. Data were tabulated for evaluation.

A third consumer panel was conducted at Utah State University (Logan, UT) in 1988 using a consumer population that was geographically removed from an active maple syrup producing region. In this test panelists were also specifically asked whether they had ever tasted authentic maple syrup. This was done to emphasize the difference between real maple syrup and maple-flavored syrups. This panel consisted of 116 consumers who evaluated grade A light, medium, and dark amber maple syrups that were each served with a toasted waffle (Aunt Jemima) as described earlier. Panelists recorded their responses on structured 7-point hedonic preference scales, and data were tabulated and analyzed by analysis of variance as stated earlier.

Syrup Base Formulation

A base formulation of syrup was developed using compositional data for nonvolatile constituents found in maple syrup (Porter *et al.* 1951; Mollica and Morselli 1984; Morselli and Feldheim 1988). Since published compositional data varied, systematic degree of difference panel evaluations of syrup formulations for taste, viscosity and color qualities were used to select formulas that best matched selected maple syrup samples. The base formula, which was selected for evaluation of volatile flavor compounds, simulated the color and basic taste qualities of a grade A medium amber maple syrup, and the recipe for its preparation is shown in Table 1.

Gas Chromatographic Analysis of Maple Syrup

Authentic maple syrup samples (60 g each) were analyzed by the procedure reported by Kallio (1989). Each sample was mixed with 60 g of saturated NaCl, and extracted consecutively 5 times with 30 mL batches of 2:1 diethyl ether/pentane. Each combined extract was dried with excess anhydrous sodium sulfate and concentrated under a slow stream of nitrogen in a Concentratetube (Laboratory Research Co., Los Angeles, CA).

The concentrated samples were then analyzed with a Varian 3400 (Palo Alto, CA) gas chromatograph equipped with a fused silica column coated with SPB-1 (60 m × .32 mm i.d., 1.0 μm coating thickness, Supleco, Bellefonte, PA). The oven temperature was set initially at 50°C with a 1 min hold, then was programmed to 250°C at a rate of 2°C/min. Helium carrier gas flow in the column was at 2 mL/min, and the compounds were detected by a flame ionization detector (temperature, 270°C; hydrogen, 30 mL/min; air, 300 mL/min). Chromatographic data were recorded with a Varian DS Data System (Varian, Palo Alto, CA), and peaks for compounds were located in chromatograms by coincidence with re-

TABLE 1.
RECIPE FOR BASE MAPLE SYRUP FORMULATION USED TO EVALUATE VOLATILE FLAVOR COMPOUNDS

Ingredient	Percent of Formula	Weight per batch(g)[a]	Instructions
water	31	88.0	A) Mix and weigh the ingredients. Heat with stirring to dissolve completely. Cool, weigh and add back water lost by boiling. Then add B, C, and D
granulated sucrose	67	196.1	
fructose	0.04	0.1188	
glucose	0.04	0.1188	
citric acid	0.003	0.0099	B) Weigh into a 10 ml volumetric flask. Add water to the mark and mix until dissolved. Stir into syrup mix.
malic acid	0.03	0.0901	
fumaric acid	0.002	0.0040	
potassium chloride	0.07	0.20	C) Same as step B.
sodium chloride	0.003	0.01	
IMP-GMP	0.05	0.15	
color system:			
red	0.16	0.4680	D) Add to syrup and stir well.
green	0.08	0.2340	
yellow	0.32	0.9360	

[a]Formula to prepare 285 g batch.

tention indices (Van den Dool and Kratz 1963) for authentic compounds. Retention indices on the SPB-1 capillary column for methylcyclopentenolone, Furaneol, sugar furanone, guaiacol, and vanillin were 6.21, 6.46, 6.88, 6.90, and 9.93, respectively.

HPLC Analysis of 5′-Inosine Monophosphate (IMP) in Maple Sap and Syrup

The ribonucleotide analysis procedure outlined by Woyewoda et al. (1986) was used for the determination of IMP in maple sap and syrup. The mobile phase was altered to a mixture of 0.04 M sodium phosphate monobasic/ 0.06

M sodium phosphate dibasic (1:1). Samples (20 ul) were separated with a Zorbax C18 reverse phase HPLC column (DuPont, Wilmington, DE) supplied with mobile phase (1 ml/min) by an ISCO model 2300 pump (ISCO, Lincoln, NE) and detected with an Isco V^4 UV absorbance detector (ISCO, Lincoln, NE) operated at 254 nm.

RESULTS AND DISCUSSION

Characteristics of the Base Syrup Formulation

Initial simulated maple syrup formulations were prepared with various combinations of colorings and 66% sucrose, which is the minimum standard of identity concentration of sugars in maple syrup (Willits and Hills 1976). Although amber colors were readily matched, these formulations lacked the sweetness intensity compared to maple syrups. Using simulated medium amber coloring, addition of glucose and fructose in concentrations found in maple syrup (0–1.7%; Morselli and Feldheim, 1988), and increasing the concentration of sucrose to 67% resulted in sensory scores showing a match for color and sweetness intensity scores between the formulation and a medium amber maple syrup. However, the base formulation containing only sugars possessed an inherently different in taste character compared to maple syrup samples.

Through a series of intensity-of-difference tests employing typical concentrations of organic acids and salts in the base syrup that are found in maple syrups (Morselli and Feldheim 1988; Mollica and Morselli 1984), maple flavor and richness flavor intensity-of-difference scores were improved to a point of relatively limited significant difference. The concentration of malic acid, fumaric acid, and potassium (added as potassium chloride) were within the reported ranges for maple syrup (Morselli and Feldheim 1988). However, the final concentrations selected for sodium (added as sodium chloride) and citric acid were below the reported concentrations in maple syrup (ca 5 ppm and ca 150 ppm, respectively; Morselli and Feldheim 1988).

Some panelists suggested that the taste qualities provided by 5′-ribonucleotide flavor enhancers were missing from the base formulation containing sugars, organic acids and salts, and preliminary testing showed additions provided needed taste qualities. However, the literature did not contain reference to the occurrence of flavor enhancers in maple syrup. In order to verify the presence of 5′-ribonucleotides in maple syrup, samples were analyzed by an HPLC method (Woyewoda *et al.* 1986). Based on coincidence of retention time, inosine monophosphate was tentatively identified as the only 5′-ribonucleotide found in maple syrup (Table 2). Thus, it was verified that the richness taste component of maple syrup could be provided by 5′-ribonucleotides.

TABLE 2.
CONCENTRATIONS OF INOSINE MONOPHOSPHATE (IMP) IN MAPLE SYRUPS

Sample	Concentration (ppm)
Experimental Early Season	513
Experimental Mid Season	347
Commercial	243

A commercial mixture of IMP and GMP was employed in the base syrup formula, and the level of this mixture selected by the panel to match the flavor of a medium amber sample of maple syrup was similar to that found in early season maple syrup (Tables 1 and 2). The relative flavor enhancing properties vary among the 5′-ribonucleotides, and IMP has been reported to be 0.43 times as potent as GMP (Kuninaka 1981).

With the inclusion of 5′-ribonucleotides, the syrup base provided taste qualities similar to those encountered in samples which were judged to represent desirable medium amber maple syrup. The taste and overall flavor properties of maple syrup may vary quite substantially among samples within grades as well as between grades, and the variables chosen for the study would not account for all the differences found in maple syrup flavors. However, the flavors addressed in the study are believed to encompass the primary flavors and aromas encountered in typical maple syrup.

Flavor Properties of Individual Selected Volatile Flavor Compounds in the Formulated Maple Syrup Base

For these evaluations, trials were conducted to determine the lowest concentrations of individual flavor compound which could be either detected or recognized when added to base syrups. Detection thresholds were assigned to the lowest concentration of a compound tested, which gave a significant difference from the base syrup when evaluated by overall intensity of difference testing. Recognition thresholds were assigned to the lowest concentration, which gave a significant difference on the appropriate descriptive analysis scale when the sample was tested against the unflavored base formulation.

The data summarized in Table 3 gives the approximate detection and recognition thresholds for the selected compounds in the syrup base. Vanillin could be recognized at 2.5 ppm in the base syrup, and this concentration was near the lower end of the range reported by Kallio (1988) for maple syrup (1–10 ppm). Nevertheless, as reported by Kallio *et al.* (1987), vanillin notes were important to desirable maple syrup flavor. Vanillin provided a smoothing or flavor-blending

TABLE 3.
FLAVOR PROPERTIES OF SELECTED VOLATILE COMPOUNDS IN A BASE SYRUP FORMULATION SIMULATING MEDIUM AMBER MAPLE SYRUP

Compound	Descriptive Flavor Attribute Intensity Scales	Approximate Thresholds (ppm)	
		Detection[a]	Recognition[b]
Vanillin	Vanilla	1.5	2.5
Maple Lactone	Maple; Richness	5.0	5.0;10.0[c]
Guaiacol	Smokey; Medicinal	0.005	0.01;0.01
Furaneol	Caramel; Cotton Candy	0.1	0.2;0.5
Sugar Furanone	Maple;Burnt Sugar Cotton Candy; Richness	0.5	1.0;>5.0; >5.0;>5.0

[a]Determined by intensity of difference testing.
[b]Determined by descriptive sensory analysis with appropriate sensory scale.
[c]The respective concentrations for each of the descriptive flavor attributes evaluated for a flavor compound.

property, and none of the other compounds studied appeared to contribute directly to recognizable vanillin flavor in maple syrup.

Maple lactone (methylcyclopentenolone, Cyclotene) has long been used to artificially flavor maple syrups (Danehy 1986), and has been reported by Kallio *et al.* (1987) to be present in maple syrups at concentrations from 1–10 ppm. The impact of maple lactone compound on the flavor of the syrup base was less than originally anticipated, and concentrations below 5 ppm were not detected in difference-intensity testing. However, in our testing of the syrup base the detection and recognition threshold for the maple flavor descriptor coincided. At concentrations near 10 ppm, maple lactone additionally provided an enhancement of the richness of flavor property for maple syrup, and like vanillin, appeared to effect a blending of notes from other flavor compounds when they were present.

Although guaiacol could be detected at a very low concentration (0.005 ppm) in the base syrup formulation, and concentrations of 0.01 could be recognized, the flavor notes were not extraordinarily pronounced at concentrations up to 0.05 ppm. Guaiacol has been reported at concentrations around 0.1 ppm in maple syrup (Kallio 1988). This compound is likely derived from sap, and is likely responsible for some of the smokey flavors found in maple syrups, although many believe this flavor note is added entirely from absorbed smoke encountered during direct-fired syrup manufacture. Pronounced smokey-medicinal (cough drop like) flavors are often considered undesirable in maple syrup, and additional research on guaiacol and its occurrence and relationship to lignin biosynthesis in the maple tree appears warranted.

Furaneol has been reported in maple syrup at concentrations of 0.1–1.0 ppm (Kallio 1988). This compound, also known as strawberry furanone, possesses a rich, ripe strawberry-like aroma at higher concentrations, but attempts to use this descriptor for characterizing its flavor in the syrup base were unsuccessful. However, the panel could utilize separate scales for caramel and cotton candy to describe the flavor notes provided by Furaneol. The minimum detection threshold for Furaneol in the syrup base was 0.1 ppm (Table 3). Significant differences were obtained between the base syrup sample and samples containing 0.2 ppm of Furaneol using the cotton candy scale, indicating that this descriptor is effective for low concentrations of this compound. However, the caramel scale was not effective for describing the flavor of Furaneol until the concentrations equalled or exceeded 0.5 ppm. Thus, as the concentration of Furaneol increased in the maple syrup, panelists utilized caramel flavor intensity scale to a greater extent while reacting correspondingly less to the cotton candy scale.

Sugar furanone (sotolon) has been recognized as an extremely high flavor-impact compound with a threshold of 0.01 ppb in raw sugar (Kobayashi 1989). Although this compound has not been completely characterized in earlier studies on maple syrup because of lack of reference samples, it likely has been noted and partially characterized (Underwood 1971). In this study, sugar furanone was found in maple syrup samples between 0.03–0.56 ppm. Importantly, when tested alone, sugar furanone in the syrup base did not provide recognizable flavor effects at lower concentrations (< 0.5 ppm). However, at 1.0 ppm in the base syrup sugar furanone elicited a significantly stronger flavor intensity score on the maple flavor intensity scale compared to the syrup base. When tested alone, concentrations of sugar furanone greater than 5 ppm in the base syrup were required to obtain panelist recognition of burnt sugar, cotton candy and richness of flavor attributes.

The ranges of concentrations for the selected compounds in maple syrup reported by Kallio (1988) generally bracket the concentrations of the compounds that evoke either detection or recognition responses. Commercial syrup samples were analyzed for the selected volatile compounds in this study, and the data are presented in Table 4. These data show that many concentrations in the samples were below the expected levels for contributing flavors based on assessment of individual compounds, but flavor interactions could readily affect contributions. The data also show that concentrations of compounds, especially the three produced through heat induced reactions involving sugars (maple lactone, sugar furanone, and Furaneol; Shaw *et al.* 1968; Belitz and Grosch, 1986; Takahashi, 1976), generally increased in parallel with intensity of color. These data support

TABLE 4.
CONCENTRATIONS OF SELECTED VOLATILE FLAVOR COMPOUNDS FOUND IN AUTHENTIC GRADE A MAPLE SYRUP SAMPLES

Grade A Amber Samples	Concentrations (ppm)				
	Maple Lactone	Sugar Furanone	Furaneol	Guaiacol	Vanillin
Group 1-Used in Farm Progress Days Consumer Preference Test					
Light	0.30	0.03	0.05	0.05	0.24
Medium	0.62	0.12	0.40	0.05	2.5
Dark	1.3	0.28	0.14	0.23	1.7
Group 2-Commercial Northern Wisconsin Syrups					
Light	0.42	0.03	0.07	0.04	0.90
Medium	1.3	0.37	0.32	0.10	2.3
Dark	3.0	0.56	0.38	0.15	2.0

the views that syrups with darker colors possess stronger maple syrup flavors than those with light color, and that light amber syrup possesses very mild flavor intensity.

Flavor Interactions Between Selected Flavor Compounds in the Formulated Maple Syrup Base

Concentrations of individual selected flavor compounds for addition in combinations to the base syrup were chosen for further testing considering factors that included detection thresholds, natural occurrence concentrations, and perceived importance of the compound to flavors encountered in maple syrup. The concentrations chosen for each compound for evaluation in mixtures are shown in Table 5, and samples with combinations of 2, 3, 4, and 5 flavor compounds were systematically evaluated using descriptive sensory analysis scales for the attributes that were found associated with the flavor compounds when they were added individually to the base syrup. Samples provided to each panelist in a session consisted of two samples containing flavor mixtures and a control sample of base without added volatile flavor compounds.

Combinations including sugar furanone at 0.5 ppm possessed significantly enhanced maple flavor intensities when compared to any of the samples not containing sugar furanone. Additionally, the presence of sugar furanone significantly enhanced richness intensity. For example, data for a sample containing

TABLE 5.
FIXED CONCENTRATIONS OF SELECTED MAPLE SYRUP FLAVOR COMPOUNDS USED IN PREPARATION OF FLAVOR MIXTURES FOR DESCRIPTIVE SENSORY ANALYSIS

Compounds	Concentrations used in mixture (ppm)
Vanillin	2.5
Maple Lactone	5.0
Furaneol	0.5
Sugar Furanone	0.5
Guaiacol	0.5

maple lactone and sugar furanone scored significantly higher for richness than a sample containing maple lactone and Furaneol. When tested alone, sugar furanone did not score significantly higher for richness compared to the base control unless concentrations were above 5.0 ppm. Results from testing mixtures of volatile flavor compounds showed that sugar furanone was a major impact compound in maple flavor. The importance of sugar furanone as a characterizing maple flavor compound is supported by the recent commercial introduction of fenugreek seed (*Trigonella foenum graecum* L.) extracts as a source of natural maple-type flavor (Anon. 1990). Girardon *et al.* (1986) have reported that the dominant and characteristic aroma of fenugreek seed extracts is provided by sugar furanone.

Vanillin intensity in samples was scored higher when vanillin was combined with sugar furanone or guaiacol when compared to the similar mixtures that did not contain either of these two compounds. Thus, the vanillin notes observed by Kallio *et al.* (1987) in maple syrup may have been influenced by these compounds. Combining guaiacol with maple lactone resulted in significantly lowered scores for smokey flavor intensity, whereas the other compounds evaluated did not evoke a similar effect. Thus, high concentrations of maple lactone in syrup appear to decrease the smokey notes in syrup when guaiacol is present above recognition threshold levels.

When the complete mixture of flavor compounds (Table 5) was added to the base formulation, it exhibited color and flavor characteristics that were very similar to samples of commercial grade A medium amber maple syrup. However, it differed in viscosity or tactile properties that perhaps reflected a thinner viscosity due to the absence of certain plant gums in the formulated syrup (Storz *et al.* 1986). The complete mixture of flavors also gave a more pronounced smokiness because of the concentration of guaiacol (0.5 ppm) was higher than usually present in grade A authentic maple samples. In comparison with grade A light amber maple syrup, the complete mixture exhibited a more intense maple syrup flavor and lacked some light green notes that were reminiscent of 2-hexenal and/or 2-methoxy-3-isopropylpyrazine. When compared to a grade A dark amber syrup, the complete mixture gave a more balanced maple syrup flavor and lacked the pronounced burnt sugar flavors often present in authentic grade A dark amber maple syrups, as well as grade B and substandard syrups.

Consumer Preference Evaluations of Maple Syrups

Sendak (1978) has reported that consumers preferred darker amber maple syrups over light amber syrups. Data for grade A maple syrup samples from a population accessed at the Wisconsin Farm Progress Days (1987) showed that light amber syrup was significantly less preferred than medium amber syrup (Table 6). However, medium amber and dark amber syrups were equally preferred. Since medium amber syrup was included in each session, it seems reasonable to infer that the dark amber sample would also be preferred over the light amber sample.

Data from the analysis of the selected volatile flavor compounds in these three samples evaluated at Farm Progress Days (Table 4) revealed that the less preferred light amber syrup sample contained notably lower concentrations of flavor compounds than the two darker grades, which were equally preferred. The influence of color was not segregated in the testing, and thus it was not possible to assign

TABLE 6.
CONSUMER PREFERENCE EVALUATION OF MAPLE SYRUP SAMPLES WITH TOASTED WAFFLES

Grade A Maple Syrup Samples	Mean Scores[a]
1987 Wisconsin Farm Progress Days	
Session A (454 panelists)	
Light Amber	5.71[b]
Medium Amber	6.00[c]
Session B (474 panelists)	
Medium Amber	5.91[b]
Dark Amber	5.96[b]
1988 Utah State University (116 panelists)	
Light Amber	5.21[b]
Medium Amber	5.49[c]
Dark Amber	5.60[d]

[a]Scale: dislike extremely (1) to like extremely (7).
[b,c,d]Mean scores with the same superscript in a panel session are not significantly different at the 5% level of significance.

the lowered preference for the light amber syrup to flavor alone. Nevertheless, it is significant that the usually higher-priced light amber syrup was the least preferred among the three A-grades, and these results agree with those of Sendak (1978).

The population participating in the Farm Progress Days panels was largely rural (68%) and small town (28%) residents with a good representation of panelists over 51 years of age (37%). This group was geographically situated in a maple syrup producing region, and they claimed 22 and 48% usage patterns for the regularly and occasionally categories, respectively. However, based on industry sales data and subsequent discussions, it was concluded that the consumers were including syrups flavored (<5%) with real maple syrup in their usage pattern responses.

In a later study conducted at Utah State University using a group geographically apart from maple syrup producing regions, light amber syrup was significantly less preferred than either medium of dark amber syrups (Table 6). For this set of samples, the panelists also expressed a significant preference for the dark amber sample over the medium amber sample which again indicates that consumers prefer maple syrups possessing more robust flavors and colors. This group of panelists was heavily in the age groups of 21–30 (49%) and 31–49 (19%), and were less rural (22%; small town, 42%; large city, 36%) than the Farm Progress Days group.

In the Utah State study, panelists were carefully questioned about maple syrup experiences, and it was revealed that only 42% were certain they had consumed authentic maple syrup previous to the panel. In responses to a query about usage of real maple syrup, only 5% responded regularly, and 15% responded occasionally. Those indicating that they never used maple syrup formed a substantial subgroup (45%). Thus, when specifically researched, it was found that usage of authentic maple syrup is quite limited, perhaps because of factors such as visibility in the market and high prices.

Consumer testing was also carried out at the 1987 Wisconsin State Fair (Milwaukee), which accessed greater numbers of urban dwellers (large city, 52%; small town, 35%). In this test panelists were distributed quite evenly across the age groups. The data again indicated that consumers do not distinguish between syrups flavored with maple syrup and authentic maple syrups because 70% claimed to be regular or occasional users of maple syrup. In these tests medium amber syrup was presented monadically to determine consumer reactions to overall properties of maple syrup when served alone. Data in Table 7 show that the panelists rated medium amber syrup at 6.3 on the 7-point preference scale with an overwhelming response in the two top categories.

When consumers at the State Fair were asked to rate medium amber maple syrup on a 4-point product rating scale (Table 7), the average score was very

TABLE 7.
CONSUMER PREFERENCE EVALUATION OF GRADE A MEDIUM AMBER MAPLE SYRUP AT THE 1987 WISCONSIN STATE FAIR

Preference or Product Rating	Number of Responses
Panel Session 1 (302 panelists)	
Like extremely	151
Like moderately	117
Like slightly	20
Neither like nor dislike	6
Dislike slightly	4
Dislike moderately	4
Dislike extremely	0
Mean score = 6.30 (7-point Scale)	
Panel Session 2 (324 panelists)	
Excellent	129
Very Good	126
Good	53
Fair	16
Mean score = 3.14 (4-point scale)	

good. Interestingly, 69 of the 324 panelists rated maple syrup in the fair to good categories which indicated a subdued response to the product. Voluntary consumer comments indicated that many felt that the syrup was either too sweet, too thin, or lacked flavor. Overall, however, the consumer testing with the three populations showed a high degree of liking for grade A maple syrups, and samples exhibiting darker colors and stronger flavors were preferred over those with light colors and mild flavors.

In summary, 5′-IMP was tentatively identified in maple syrup, and it was required to provide taste qualities to syrup bases that simulated authentic maple syrup. Using a syrup base containing only nonvolatile flavor ingredients found in maple syrup, it was shown that five selected volatile flavor compounds contributed specific flavor notes to maple syrup. However, sugar furanone was found to be a major impact compound in maple flavor. Quantitative analysis showed that darker syrup colors provided higher concentrations of sugar-derived reaction flavors compounds that contribute to maple flavors. Preference testing showed that consumers preferred grade A medium and dark amber maple syrups over light amber maple syrup. The results indicated that the maple syrup industry should consider developing controlled production means to provide consumers with maple syrup possessing the flavor characteristics of the darker grade A categories of syrups.

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