AN ABSTRACT OF THE THESIS OF

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Title: Process Development and Sensory Evaluation of a Sweetened Flavored Carbonated Milk Beverage

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The processing parameters of and processing procedures for sweetened blueberry flavored carbonated milk beverages were developed in this study. Foam formation of the milk after carbonation was controlled by a precharging of the vessel headspace. A combination of heat treatment (85°C, 30 minutes) and CMC addition was conducted to minimize the acid coagulation of casein with added fruit concentrate.

Both carbonated and noncarbonated, sweetened blueberry flavored milk were evaluated by a trained panel. The effect of carbonation and sweetener source on taste properties in a blueberry flavored milk beverage system were discussed. Carbonation enhanced the sensory rating of overall

intensity, sweetness and blueberry flavor. There was no significant carbonation effect on perceived viscosity. The sweetener source (sucrose, HFCS, pear concentrate and aspartame) caused a significant effect on the sensory rating of viscosity, but a nonsignificant effect on that of overall intensity, sweetness and blueberry flavor.

Two consumer panels evaluated the carbonated, sweetened blueberry flavored milk beverages. The percentage of panelists who liked the products was approximately 50%. The results from the distributions of responses on a "just right" scale indicated that the carbonation and sweetness level probably were optimum formulations, and the level of blueberry flavor was too low. The results also implied that sucrose and HFCS were more appropriate sweeteners in flavored carbonated milk beverages than aspartame and pear concentrate. Two obstacles for consumer potential were the rapid separation phenomenon and the unattractive color of the products.

Process Development and Sensory Evaluation of a Sweetened Flavored Carbonated Milk Beverage

By

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PROCESS DEVELOPMENT AND SENSORY EVALUATION OF A SWEETENED FLAVORED CARBONATED MILK BEVERAGE

INTRODUCTION

Carbonated Milk

A survey of the market share for carbonated beverages (soft drinks) in the U.S. showed that the consumption of carbonated beverages has increased dramatically since 1960 (Shanken, 1979). The "refreshing" aftertaste may be responsible for the popularity of carbonated beverages. The "refreshing" aftertaste, or so-called "sparkle", of a carbonated beverage is due to the carbon dioxide it contains.

On the contrary, the consumption and market share for fluid milk in the U.S. has decreased in the past twenty years (Shanken, 1979) Fluid milk tends to exhibit certain consumer acceptance limitations, such as a too subtle flavor profile, a mouth-coating characteristic that is viewed as an objectionable aftertaste, and a distinct lack of flavor variety and "refreshing" aftertaste.

Currently, U.S. milk producers urgently seek expanded market opportunities for Grade A milk, especially for beverage utilization. The concept of improving the sensory properties of fluid milk by the simple process of carbonation and simultaneous incorporation of high quality fruit flavorings has arisen.

This study developed a method for incorporating CO_2 into a flavored milk beverage without incurring a foaming problem, as well as a formulation and procedures for producing a sweetened fruit-flavored carbonated milk beverage. Subsequently, flavor acceptance panels were conducted to obtain information on the potential consumer acceptance for a carbonated flavored milk beverage.

Carbonation and Sweetener Source Effect

Carbonation level could affect the perception of the other taste properties in a beverage system. Because limited research has been conducted previously on the effect of carbonation on the perception of other taste properties in a milk based beverage, its study was one of the objectives of this research.

Different natural and synthetic sweetener sources provide similar sweetness, but they simultaneously impart different "flavor" characteristics to the beverage system in which they are used. One of the objectives of this research was to quantify the effect of sweetener source on the flavor properties of a sweetened fruit flavored milk beverage.

Magnitude Estimation

Magnitude estimation is a ratio scaling method which results in sensory intensity ratings that have ratio properties. The modulus normalization procedure for normalizing the data from magnitude estimation scaling was developed by Lane et al. in 1961. This normalization procedure has been applied in several magnitude estimation studies (Moskowitz, 1970a, 1970b, and Moskowitz and Arabie, 1970 and McDaniel, 1974). One alternative normalization procedure was applied in this research and compared versus modulus normalization.

Objectives

The specific objectives of this thesis are listed below:

1) To develop a method for injecting carbon dioxide into formulated (sweetened and flavored) milk beverages, which can reduce excessive foaming.
2) To develop a method for reducing or eliminating casein acid coagulation.
3) To develop a general processing procedure for sweetened flavored carbonated milk beverages.
4) To train a panel for the measurement of the effect of carbonation and sweetener source on taste properties of a sweetened flavored milk beverage.
5) To compare the effectiveness of the geometric mean normalization (modulus normalization) versus the normal logarithm normalization in data analysis.
6) To evaluate the general consumer acceptability of flavored carbonated milk beverages sweetened with different sweetener sources.

REVIEW OF LITERATURE

Carbonated Dairy Products

Carbon dioxide has been used extensively in the preparation of many beverages, especially the popular soft drinks. Jacobs (1959) stated that the "sparkle" of a carbonated soft drink is due to the CO_2 it contains. Furthermore, CO_2 is one of the components of the flavor system in the drink and it adds to the life of the beverage.

Prucha et al. (1922, 1925 and 1931) reported the effect of carbon dioxide on inhibition of bacterial growth in dairy products. They found that carbonation tends to inhibit the multiplication of some bacterial species, thus prolonging the keeping period of products. Daniels et al. (1985) stated in their review of effects of CO_2 on microbial growth that the overall effect of CO_2 is to increase both the lag phase and the generation time of spoilage microorganisms. They also discussed that the possible mechanisms for bacteriostatic effect are displacement of oxygen, intracellular acidification, cellular penetration and metabolic interference by CO_2.

Carbonated dairy products have not become a commercial reality, though there have been a number of efforts to develop such products. Van Slyke and Bosworth (1907) experimented with carbonation of milk at the turn of the century. They concluded that carbonation of milk results in a "pleasant beverage and a healthful drink". Prucha et al (1931) worked on the carbonation of dairy products. They found that carbonation did not prevent the deterioration of dairy products, but it may cause a delay or a complete inhibition in the development of certain off-flavors. Also there are several patents for carbonated dairy beverages. Guterman et al (1968) submitted a U.S. patent application for a, " Frozen carbonated confection yielding ice cream soda on addition of water", which patents a process which provides a frozen confection that can be mixed with a suitable quantity of water to produce an ice cream soda without the separate addition of syrup or carbonated water. Campbell and Ford (1977) submitted a British patent application for a, "Carbonated milk-based beverage", which patents a carbonated milk-based beverage consisting of a blend of an edible acid, CMC, sweetener, flavoring and coloring with milk solid and/or liquid milk. The standardized pH of the product is in the range of 2.5-4.0.

Choi and Kosikowski (1985) developed and tested a carbonated yogurt beverage. Sweetened plain and strawberry-flavored carbonated yogurt beverages without any visible free whey were developed. Yogurts, after blending with a 12% sucrose solution and additionally with flavor extract, were carbonated under 0.5 Kg/cm^2 at 4^oC. The sweetened flavored yogurt beverage contained 15.5% total solids, 2.7% protein, 1.5% fat, 0.5% ash, and 10.7%

carbohydrates. The pH value of the sucrose-sweetened, carbonated yogurt beverage was 4.0 while that of the sweetened, plain noncarbonated product was 4.1. Chemical, microbial and sensory evaluations were conducted on both the carbonated and noncarbonated beverages. The consumer acceptance test indicated that 89.8% of the respondents liked the strawberry-flavored carbonated yogurt beverage and 5.1% disliked it. They reported that the sweetened, strawberry-flavored carbonated yogurt beverage displayed clean, high quality yogurt flavor, delicately balanced between acidity, sweetness, and fruit flavor. The tingling effect of carbon dioxide was described by many panelists as thirst-quenching and refreshing. The authors concluded that carbonation apparently enhances the sensory qualities through its effect on mouthfeel. These researchers also demonstrated that the introduction of carbon dioxide under pressure could help extend the shelf-life of the product. Their carbonated yogurt beverage was stored for up to 4 months at 4.4^{o}C without serious loss of sensory quality while noncarbonated controls were unacceptable within 30 days.

Foam From Protein

A foam can be considered as a type of emulsion in which the inner phase is gas. The principle of foam formation has been discussed (Becher, 1965; Adamson, 1967; and Kinsella, 1981). Bikerman (1973) proposed that there are two distinct types of foam, namely those formed by a dispersion method and a condensation method. Each type occurs under different physical conditions. Clarke and Wilson (1983) and Powrie and Tung (1980) discussed the relationship between foam formation/destruction and foaming/antifoaming agents. Salant (1975) proposed that a bodying agent like CMC could act as a foaming agent.

Food scientists have long recognized that proteins and other food components serve as efficient foaming agents. Kinsella (1976) reviewed the role of protein in foam formation. Further, he discussed the nature of food foams, the relationships between the molecular structure and the foaming capacity of different proteins, and factors affecting the foaming capacity of a system (Kinsella, 1981). He found that when the pH of the food system approximated the pI of the protein, the foam volume and foam stability were maximum.

Walstra and Jenness (1984) discussed the foaming properties of casein and whey proteins and the associated foaming problem in dairy products. In food systems, most of the research has concentrated on increasing the foaming ability or foam stability of a given food system since foaming is often desirable. Though some anti-foaming agents are used in brewing industries and in carbonated beverage production, there has been limited research concerning ways to eliminate protein foam in food systems.

Protein Coagulation

Physical-chemical properties of milk proteins have been studied for many years. Since casein is the major protein in milk, numerous researchers have focused on the stability it lends to food systems. Walstra and Jenness (1984) reviewed the structure and stability of the casein micelle. The stability of the colloidal casein structure depends on Van Der Waals force, electrostatic force and adsorption of macromolecules. Colloidal calcium phosphates attach to the phosphoserine residue on casein by electrostatic attraction, hence the Ca/P ratio and pH are relatively important to casein stability. When the pH is near the pI of casein, casein looses its net electrical charge and protein conformation is changed. Subsequently, internal salt bridges and hydrophobic interactions occur and a lower solubility complex is formed.

Brunner (1980) discussed the effect of heat treatment on casein stability. Partially denatured whey proteins can bind to the reactive site of casein and stabilize the casein. Parry (1974) reported that a given heat treatment (85^{o}C, 30 min) can stabilize the casein in milk bases used to produce yogurt and buttermilk. There appears to be limited specific research related to how to stabilize casein under changing pH conditions. Batdorf (1964) studied the function of cellulose gums, which can provide negative charged groups to the system. Asano (1966) reported that the interaction between milk protein and CMC was due to electrostatic force. At low pH, the protein molecule is more positively charged while CMC is a negatively charged electrolyte. He also reported that a heat treatment ($80^{o}C$, 30 minutes) increased the extent of protein-CMC interaction.

Sweeteners and Sweetness Perception

Sweetness plays a major role in the sensory acceptance of many foods, especially beverages. Some researchers have studied the chemical theory of sweetness (Shallenberger, 1979), and the mechanisms of sweetness perception (Birch et al., 1980). There have also been considerable efforts to find new sweeteners and compare them with traditional sweeteners (Larson-Powers and Pangborn, 1978a, 1978b and Harrison and Bernhard, 1984). Usually, the measurement of perceived sweetness among sweeteners is based on the concept of relative sweetness. Horn (1981) defined relative sweetness as the ratio of concentration of sweetener solutions that are observed to possess equal intensity of sweetness. He also stated that sucrose is the nearly universal reference standard to other sweeteners.

Though different sweeteners have the general characteristic of sweetness, they tend to differ in the "flavor" that they contribute to food or beverage systems. Moskowitz (1972) stated that sucrose provides a uniquely acceptable sweet taste, free from the considerable side-tastes that pervade other sweeteners. He also stated that subjects appear capable of changing their "focus" in sensory evaluation, so that the flavor differences between like-tasting substances are enhanced by attention to other salient dimensions (ex: viscosity-fluidity). Redlinger and Setser (1987) found that no sweetener is perceived exactly like sucrose and that sweetness profiles vary among sweeteners. However, Larson-Powers and Pangborn (1978a) found that the time-intensity curves for the sweetness of aspartame closely resembles those for sucrose in all media tested.

Corn syrup is produced by conversion of corn starch, and dextrose results from the complete conversion of starch. High fructose corn syrup (HFCS) is produced by inversion of dextrose in corn syrup to fructose. The relative sweetness of fructose is 1.1-1.8 times (molecular basis) that of sucrose and is much higher than that of dextrose (Shallenberger and Acree, 1971). So with conversion the amount of sweetener needed is reduced. The other effects of using high conversion corn syrup are : an increase in the browning reaction, osmotic pressure and sweetness, and a decrease in viscosity (Hobbs, 1986). HFCS is used widely in the food industries nowadays. It is an important ingredient in ice cream, canned and frozen fruits, jams, jellies, soft drinks, and numerous other food products.

Aspartame was discovered in 1965 by a researcher at G.D Searle and Company (Skokie, IL). Aspartame is a methyl ester of two amino acids, phenylalanine and aspartic acid. At a normal use level for sucrose, it would take only 1/200 of the amount of aspartame to achieve equisweetness, therefore only a small amount is needed to sweeten a product. Newsome (1986) summarized the application of aspartame and stated that aspartame enhances some flavors and can be used in high acid carbonated beverages, but it will degrade and lose flavor in more neutral solutions such as dairy-based products. McCormick (1975) reported that the time required for a 20% loss in sweetness of aspartame at pH 4.0 at 10^{o}C is 387 days while at 80^{o}C it is only 1 day. It can not be used in baked products or other products which undergo heat processing. The applications for aspartame include numerous products, such as beverage powders, concentrates, milk shakes, toppings and many other foods. Dever et al. (1986) studied the stability of aspartame in a fruit spread and concluded that aspartame storage losses are modeled as a first order reaction with an average half life of 168 days.

Salant (1975) summarized the benefits of nonnutritive sweeteners in carbonated beverages as: 1) imparting sweetness 2) providing a more rounded and blended flavor 3) "gushing the gas out", which serves to enhance bervage mouthfeel.

Fruit concentrate recently has been used as a natural fruit sweetener. Duxbury (1986) stated it can satisfy the consumer's desire for "natural" foods because it has natural sweetness, nutrients and vitamins, and it "looks and tastes like food". Duxbury also stated the advantages of using fruit concentrate as a sweetener include: 1) it is heat stable and 2) it improves the overall taste.

Moskowitz and Arabie (1970, 1971) found that increased viscosity could cause a decrease in taste intensity, which was reconfirmed by Moskowitz (1972) in another study. Redlinger and Setser (1987) studied sensory quality of selected sweeteners in aqueous and lipid model systems and found that the perception of sweetness intensity for individual sweetener varies in the two different systems. They concluded that the character of the food system influences perception of sweetness and aftertaste.

The type of sweetener used in a beverage may influence the perception of other tastes. Baldwin and Korschgen (1979) reported that aspartame could intensify certain fruit flavors in a beverage system. They compared orange, cherry and strawberry flavored noncarbonated beverages containing 0.065% aspartame with those containing 9.52% sucrose and found that both orange and cherry flavored beverages sweetened by aspartame have a significantly higher intensity of fruit flavor than their counterparts sweetened by sucrose.

Magnitude Estimation

Magnitude estimation is a type of ratio scaling method which yields a direct quantitative measure of subjective intensity of an attribute. Stevens (1961) compared the magnitude estimation (ME), category scale (CS) and discriminability scale methods. He found that ME is most directly related to the physical measurements of the samples. Stone and Oliver (1969) used ME to measure relative sweetness and stated that it is a rapid, reliable, and effort saving method.

Lane et al. (1961) developed a normalization procedure for the data from ME scaling, which they called modulus normalization. The magnitude estimates for the entire set of stimuli for each descriptor were multiplied by the same constant for a given observer, where the constant was a factor required to make the geometric mean of the estimates of each observer equal to 1.0.

Moskowitz (1970a, 1970b) and Moskowitz and Arabie (1970) conducted several studies using the ME method. They stated that the geometric mean normalization procedure is employed as the measure of central tendency for ME, which reduces the effect of extreme values, because the logarithms of the judgements tend to be distributed symmetrically. At the same time, by this normalization, the modulus of each observer is brought into congruence with the group modulus (the size of the numbers is equalized for all observers), but no changes are made in the ratios of magnitude estimates of a single observer.

Moskowitz and Sidel (1971) compared the ME scale with the hedonic category scale. The hedonic scale is a simple and effective measuring method, however it has limitations. For example, one cannot conclude anything about the ratio of two items for it lacks a true zero and cannot avoid the bias of central tendency. A ME scale can produce reliable and meaningful ratio scales of sensory magnitude that may be correlated with measures of physical intensity. They concluded that both scales appear to be equally sensitive to differences of food acceptability, but each procedure provides additional information as well. Results from use of the ME scale provide estimates of the ratios of food acceptability among different items, while results from use of the hedonic scale provide numerical and verbal categories of acceptance. ME may be able to supplement category scaling in determining the degree of food acceptability.

McDaniel and Sawyer (1981) also compared ME with the 9-point CS for rating intensities of sensory characteristics. They found no differences between the two methods regarding scaling sample differences, but large differences were found in other variables tested (panelist, replication and panelist-mix interaction). The ME method resulted in more panelist-mix interaction than CS, while CS resulted in more variability due to panelist and replication. The normalization procedure inherent with ME method was responsible for diminishing the panel variability. Further, McDaniel (1985) stated that magnitude estimation results tend to show more differences when the differences are very small than do other methods.

Shand et al. (1985) conducted comparative studies using CS, ME and line scaling (LS) in sensory assessment of beef steak. They found that CS was most sensitive and LS was least sensitive in detecting differences in steak quality attributes. ME was as sensitive as CS to most treatment differences. Also they found CS was most preferred and ME was least preferred by panelists because panelists felt CS and LS were easier to learn and required less effort for sample evaluation than ME. Panelists stated that the principle of ME was easy to understand, but that its application to meat was difficult. The descriptive sensory assessment of beef involves the simultaneous evaluation of several characteristics. This type of evaluation may be more difficult for ME than for either CS or LS.

METHODS AND MATERIALS

Determination of Processing Parameters

Foam Control

Fifteen liters (4 gallons) of skim milk (0.2% fat), purchased at a retail store (Fred Meyer, Corvallis, OR), were placed into a 19-liter (5-gallon) pilot scale carbonation tank and filler device (Zahm and Nagel Co. INC., Buffalo, NY). The tank was 4/5 full to allow adequate headspace for carbonation. Carbonation was conducted under 1.4-1.75 Kg/cm^2 (20-25 PSI) at 4.4^{o}C to a final pressure of 1.4 Kg/cm^2 (20 PSI). All carbonation procedures followed the steps recommended in the guide manual of the Zahm carbonation equipment (Anonymous, 1964). Shaking of the carbonation tank was required to reach equilibrium of the final pressure.

This carbonation procedure resulted in the production of excessive foam. To reduce or eliminate the foaming problem three efforts were taken: 1) Low fat milk (2% fat, Fred Meyer, Corvallis, OR) was carbonated instead of skim milk described above to determine the effect of fat content on foam formation. 2) Two percent (wt/wt) liquid lecithin (Fred Meyer Nutrition Centers, Portland, OR) was added as an emulsifier before the carbonation procedures.

3) Precharging of the vessel headspace, an engineering

modification step of the carbonation procedure, was conducted to inhibit the foam formation. CO_2 gas was pumped directly into the headspace to 1.05 Kg/cm^2 (15 PSI) and then the milk was carbonated as described above.

Reduction of the Acid Coagulation of Protein

Acid coagulation occurred when milk was flavored with fruit concentrate. Two steps, heat treatment of milk and sodium carboxylmethyl cellulose (CMC) addition to the milk, were taken in an effort to reduce the protein acid coagulation problem.

One gallon (3.8 L) of 2% fat milk in a 3.8-liter (one gallon) stainless steel milk-can was heated in a water bath to 38^{o}C. Carboxylmethyl cellulose (7H3SXF, Hercules INC., Wilmington, DL) at 0.2% (wt/wt) was mixed with 5% (wt/wt) sucrose homogeneously. The mixture was added to the milk during the time the milk was being heated from 38^{o} to 72^{o}C, and then the milk was held at 85^{o}- 87^{o}C for 30 minutes. After cooling to ambient temperature in a cold water bath, marion berry concentrate (68^{o}Brix, pH 3.0, IFF Kerr Concentrate, INC. Salem, OR) at 1% (wt/wt), 2% and 3% levels were added to the heat treated milk. Heat treated milks with/without CMC addition were compared to determine the effect of CMC addition on protein acid coagulation. CMC levels 0.15%, 0.2% and 0.4% (wt/wt) were added in repeating experiments and tasted by five co-workers to determine the proper level of CMC.

Equisweetness Point Determination

Because of the intrinsic differences between sweetener strength, equisweetness levels for each sweetener source compared to sucrose needed to be determined. Also relative sweetness is not consistent in different food systems for the same sweetener. So equisweetness levels needed to be determined in the flavored milk beverage system. Four different sweeteners were chosen:

1). Sucrose - commercial source.

2). High Fructose Corn Syrup (HFCS) - DE55. Liquid Sugar INC. Salem, OR.

3). L-aspartyl-L-Phenylalanine methyl ester (Aspartame) - A00120, Nutrasweet Co. Skokie, IL.

4). Pear concentrate - type II (decolorized low flavor concentrate), TDS 120, 70.5^{o}Brix, PH 4.2, Tree Top INC. Selah, WA.

Blueberry concentrate (68^{o}Brix, pH 2.9, IFF Kerr Concentrate INC. Salem, OR.) and blueberry WONF (135-8880, IFF Kerr Concentrate INC. Salem, OR) were chosen as the flavoring system.

Low fat (2% fat) milk, CMC (0.15% wt/wt), blueberry concentrate (1.5% wt/wt) and blueberry WONF (0.06% wt/wt) served as the material base of the final product. Samples with varying sucrose levels, 4.5%, 5% and 8% (wt/wt), were prepared and tasted by five co-workers to determine the proper level of sucrose. A sucrose level of 4.5% wt/wt was chosen for the standard reference.

Preparation of Equisweetness Samples

One liter of milk was placed in a one liter erlenmeyer flask and heated with magnetic-bar-stirring heater (Corning, PC353) to 38°C. Carboxylmethyl cellulose (0.75% wt/wt) was added into the vortex of the milk slowly while the milk was kept stirring and heated from 38° to 72°C. It typically required 90 minutes to dissolve CMC completely.

After cooling to ambient temperature, 165 ml (1/6 of one liter) of the milk-CMC solution was poured into each of six flasks (flask weight was taken), and then fresh milk was added into each flask to 1000 ml (CMC was diluted to 0.15%). Sucrose (4.5% wt/wt) was added to one of the six flasks before the heat treatment. All samples were subjected to the heat treatment (maintained at 85°C for 30 minutes in water bath). After cooling to ambient temperature using a cold water bath, blueberry concentrate (1.5% wt/wt) and blueberry WONF (0.06% wt/wt) were mixed with each sample, then HFCS was added based on the levels shown in Table 1 and stirred without heat to mix the product homogeneously. The aspartame and pear concentrate sweetened samples were prepared by the same procedure described above.

Sensory Evaluation of Samples

--Panel Selection:

Fifteen subjects (graduate students and staff members

TABLE 1. The Levels of Sweeteners Used in Equisweetness Point Determination

sweeteners	%levels (wt/wt)				
HFCS	2	4	5	6	8
pear concentrate	4	6	7	8	10
aspartame	0.01	0.02	0.03	0.04	0.05

in the Food Science and Technology Department of Oregon State University) volunteered to evaluate the samples. Three sessions for HFCS, aspartame and pear concentrate were conducted on different days to determine the equisweetness points of each sweetener.

--Testing Facility

Evaluation took place in individual testing booths (Sensory Science Laboratory in the Food Science and Technology Department of Oregon State University) under white light. Drinking water and unsalted crackers were available for panelists. Magnitude estimation was the scaling method used for evaluation. The subjects were given the following written instruction, "This is a magnitude estimation test. The score (degree) of sweetness for the reference is 50. Please score the sweetness of each of the five samples by comparing them with the reference. For example, if the sample is 1.5 times as sweet, assign it a value of 75. If it is 1/5 as sweet, assign it a value of 10. You are free to use any number, but do not use zero." The ballot is shown in Figure 1.

--Serving Procedures :

Each panelist was served the five treatments (one sweetener at five levels) and a reference sample, all in 60 ml plastic cups at about 4°C. The treatments were coded with 3-digit random numbers and were presented in a random

EQUISWEETNESS OF HFCS

NAME____________

DATE____________

Thank you for volunteering for this evaluation of equisweetness. This is a magnitude estimation test. The score (degree) of sweetness for the reference is 50. Please score the sweetness of each of the 6 samples by comparing with the reference sample. For example, if the sample is 1.5 times as sweet, assign it a value of 75. If it is 1/5 as sweet, assign it a value of 10. You are free to use any numbers, but do not use zero.

Code	M.E	Code	M.E	Code	M.E
Ref.	50	______	______	______	______
		______	______	______	______
		______	______	______	______

Thank you for your cooperation and volunteering.

NY #1.

FIGURE 1. The Ballot of Evaluation for Equisweetness Determination

order to the panelists. The reference in all cases was the sucrose (4.5% wt/wt) sweetened sample.

Data Analysis

The responses for each judge were normalized by a geometric mean normalization procedure (McDaniel, 1974). The geometric mean was calculated for each set of response magnitudes of each panelist. The reference value (50) was included in the geometric mean. Then each set of response magnitudes was divided by the given geometric mean of that set. Group means for each sample were computed from the normalized data. A Statistical Analysis System (SAS) program (SAS, copyright(c) 1985, SAS Institute INC, Cary, NC 27511, USA) was used to regress the logarithm value of the response data on the logarithm value of the levels of the sweetener addition. From the regression equation, equisweetness levels of each sweetener were calculated by interpolation. These equisweetness levels represent relative sweetness equal to the reference (sucrose 4.5%) in the milk beverage system.

Conformation of Equisweetness Across All Sweeteners

Since equisweetness levels of HFCS, aspartame and pear concentrate were determined separately, the procedures above were repeated for the four sweeteners together. All procedures were the same except the samples were the four different sweetener sources (including sucrose 4.5%)

against the 4.5% sucrose reference. The normalized response data were analyzed by ANOVA with multiple comparisons tested by use of Tukey's test (Larmond, 1977). If significant differences among the four sweeteners still existed, levels were revised and testing was repeated until no significant differences were found.

Production Process of Sweetened Fruit-Flavored Milk Beverages

There were eight different treatments in the test design, four different sweeteners (sucrose, 4.5% wt/wt, HFCS, 6.5% wt/wt, pear concentrate, 10% wt/wt and aspartame, 0.015% wt/wt), each prepared with and without carbonation.

Production of Sucrose Sweetened Product

Five ppm iodophor sanitizer (iodine based detergent-sanitizer, Mikroklene-DF, Klenzade INC, MN) was used for sanitizing (holding 2 minutes) the 15-liter (4-gallon) stainless-steel-milk-can and manual agitator device. Fifteen liters(4 gallons) of milk, in a sanitized milk can, were heated in a water bath to 38°C. The mixture of sucrose (4.5% wt/wt) and CMC (0.15% wt/wt) was added into the milk with vigorous agitation while being heated from 38° to 72°C. Then the milk base was subjected to the heat treatment (maintained at 85^{o}- $87^{o}C$ for 30 minutes), followed by cooling to ambient temperature with flowing cold water in a water bath. Bottles were autoclaved at $125^{o}C$ for 15 minutes while the carbonation equipment (the tubes, valves, gauges, carbonation stone and carbonation tank) and crowns were sanitized (holding 2 minutes) using a five ppm iodophor sanitizer. After cooling to ambient temperature, heated milk was mixed with blueberry concentrate (1.5% wt/wt) and blueberry WONF (0.06% wt/wt) with agitation. The sample was then poured into the sanitized carbonation tank, and moved to a temperature controlled room (about $0^{o}C$). Once the product cooled to approximately $0^{o}C$, the carbonation procedure was begun. Carbonation and bottling procedures were conducted in the $0^{o}C$ cold room.

The extra air in the carbonation tank was exhausted at 0.35 Kg/cm^2 (5 PSI) and the vessel headspace was precharged with CO_2 at 1.05 Kg/cm^2 (15 PSI) , then :

a) for the carbonated product - The flavored milk was carbonated at 1.4-1.75 Kg/cm^2 (20-25 PSI) at 0^{o}-$4^{o}C$. The final pressure was 1.4-1.5 Kg/cm^2 (20-22 PSI).

b) for the noncarbonated product - The flavored milk was injected with a low volume of CO_2 (at 0.2-0.35 Kg/cm^2 [3-5 PSI]) for a period of 10 minutes to facilitate blending of ingredients. The CO_2 pressure was then released on the carbonation tank; CO_2 bubbles were not noticeable in the flavored milk at this time.

The carbonated and noncarbonated milk product was bottled, under 1.05 Kg/cm^2 (15 PSI), into 1.2 liter carbonated beverage bottles. Immediately after filling product aliquot, the bottle was capped with a crown using a manual capper. Each 15-liter (4-gallon) of product could fill sixteen bottles. All bottled products were labeled and then stored in the $0^{o}C$ cold room. Two bottles of each treatment were used for the trained panel, and six bottles of carbonated product were used for the consumer panel. Three bottles of each beverage treatment were used for the measurement of the physical-chemical properties.

Production of HFCS, Pear Concentrate and Aspartame Sweetened Products

HFCS and pear concentrate were difficult to mix with CMC (as described above) because of their physical properties. Aspartame could not be subjected to the selected heat treatment because of its heat sensitivity. Therefore, the mixing and heating procedures for producing these three sweetened products were different from those for the sucrose sweetened product.

Three liters of the fifteen liters (4 gallons) of milk were reserved for dissolving CMC. Carboxylmethyl cellulose (0.15% wt/wt) was divided into three parts. The reserved milk was heated with stirring on a heat-magnetic-stirrer to $38^{o}C$. Each part of CMC was added slowly into each liter of heated milk during the time the milk was heated from 38^{o} to $72^{o}C$ with stirring. The milk-CMC solution (3 liter) was mixed with the rest of the fifteen liters (4 gallon) of milk and poured into a sanitized 15-liter (4-gallon) stainless steel milk can. The fifteen liters (4 gallons) of CMC-treated milk sample were subjected to heat treatment (maintained at 85^{o} -$87^{o}C$ for 30 minutes) in a water bath. After cooled to ambient temperature by flowing cold water, the milk sample was mixed with 1.5% (wt/wt) blueberry concentrate , 0.06% (wt/wt)blueberry WONF and 6.5% (wt/wt) HFCS (or 10% (wt/wt) pear concentrate or 0.015% (wt/wt) aspartame) with agitation. The rest of the steps were the same as for sucrose for both the carbonated and noncarbonated products.

Each beverage treatment was replicated twice. The order of treatment production was randomized. The production schedule is shown in Table 2.

Measurement of CO2 Level and pH

Physical measurement of the CO_2 level was conducted on the carbonated products and the pH value was taken for both carbonated and noncarbonated products. The measurement of CO_2 level was undertaken with a Zahm Model-D-T Piercing Device (Zahm and Nagel CO. INC., Buffalo, NY). Bottles were inverted back and forth 50 times before piercing. After piercing, the pressure in the bottle and the temperature of the product were read from the device.

TABLE 2. The Schedule of Production Order

first batch replication		second batch replication	
days	treatments	days	treatments
1	carbonated sucrose	17	carbonated sucrose
2	carbonated pear concentrate	18	carbonated aspartame
3	noncarbonated sucrose	19	carbonated HFCS
4	carbonated aspartame	20	noncarbonated aspartame
5	noncarbonated HFCS	21	noncarbonated HFCS
6	carbonated HFCS	22	noncarbonated sucrose
7	noncarbonated pear concentrate	23	carbonated pear concentrate
8	noncarbonated aspartame	24	carbonated sucrose
9	carbonated sucrose	25	noncarbonated pear concentrate

The interval between first batch and second batch was one week.

Each pair of data from the pressure and temperature measurement was transformed to CO_2 volume according to the transformation table in the Zahm carbonation equipment manual (Anonymous, 1964).

The pH values were measured with a Corning 125 pH meter at 4-5^{o}C.

Sensory Evaluation of Sweetened Fruit-Flavored Milk Beverage

Trained Panel

Panel Training

Twelve panelists who were students and staff members in the Food Science and Technology department of Oregon State University (six male and six female) volunteered to be part of the trained panel. The training, which lasted two weeks (six sessions), gave panelists the opportunity to become familiar with the attributes of the product in order to develop descriptive terms, and to become familiar with the scaling technique. Panelists were given carbonated and noncarbonated sucrose sweetened samples and asked to generate terms by concentrating on aroma first and then flavor-by-mouth. Panelists were seated around a common table, working independent of each other initially and then sharing individual results or comments in group discussion.

After two sessions, the group decided to eliminate aroma descriptors since there was no particular aroma detected, and to simply emphasize flavor-by-mouth descriptors. After four sessions, panelists could not agree on the presence or absence of "cooked" flavor. Panelists were also confused by an apparent "fruity flavor" from pear concentrate for the pear concentrate sweetened sample. The group decided to eliminate "cooked" flavor as a descriptor and use "blueberry flavor" instead of "fruity flavor". A final ballot was developed, which used the five attributes agreed upon by the group; overall (flavor) intensity, sweetness, blueberry (characterizing) flavor, viscosity and CO_2 level (applicable only to the carbonated products).

Sensory Evaluation

--Experimental Design

The evaluation lasted two weeks, one week for each production batch. There were three sessions per week, one for each panel replication within the same batch. Each session contained two sets of four samples, one for carbonated beverage samples and one for noncarbonated ones.

--Serving Procedures

Samples (in bottles) were taken randomly from the stored batch. Before the bottles were opened, they were gently turned until the bottle contents appeared homogeneous. This was done very slowly to minimize the loss of carbonation in the bottles. After opening, the bottles were capped with a rubber stopper. Fifty ml samples were served in 60 ml plastic cup, coded with three-digit random numbers; the reference was labeled as such. The samples were served at 5-8^{o}C. There were two trays served for each panelist. Each tray contained four samples (carbonated or noncarbonated) and a reference (sucrose sweetened carbonated samples). The same reference was used to compare the carbonation effect. The presentation order of the two trays was randomized, as well as that of the four samples on each tray.

--Testing Facility

Panelists were seated in individual testing booths with white light. Drinking water and unsalted crackers were available for panelists. The magnitude estimation scaling method was used for attribute intensity ratings. The ballot is shown in Figure 2. Panelists were given the following written instruction, "You have received a reference and four samples. For each attribute, evaluate the reference first, and assign it an intensity value of 20. Then taste each coded sample and record the perceived intensity value by comparing it with the reference. For example, if the sweetness of sample X is 1.5 times the reference, assign it a value of 30. If the viscosity of the sample is 1/5 as much as the reference, assign it a value of 4. You are free to use any number except zero. For noncarbonated samples, just mark x for CO_2 level attribute." Panelists were asked to taste the sample, expectorate, and then rinse before going to the next attribute.

SENSORY PROPERTY OF CARB./NONCARB. FLAVORED MILK BEVERAGE

NAME___________
DATE___________

You have recieved a reference and 4 samples. For each attribute, evaluate the reference first, and assign it an intensity value of 20. Then taste each coded sample and record the percieved intensity value by comparing it with the reference. For example, if the sweetness of sample X is 1.5 times the reference, assign it a value of 30. If the viscosity of sample is 1/5 as much as the reference, assign it a value of 4. You are free to use any number except Zero. Be sure to Rinse your mouth with water between samples. If you have any questions, please contact me before/after tasting. Thank you for your cooperation and help. For noncarbonated samples, just mark X for CO2 level attribute

	Ref	Code	Value
Overall Intensity	20	______ ______ ______ ______	______ ______ ______ ______
Sweetness	20	______ ______ ______ ______	______ ______ ______ ______
Blue Berry (Flavor)	20	______ ______ ______ ______	______ ______ ______ ______
CO2 level	20	______ ______ ______ ______	______ ______ ______ ______
Viscosity	20	______ ______ ______ ______	______ ______ ______ ______

COMMENTS

NY#2

FIGURE 2. The Ballot of Evaluation for Trained Panel

Data Analysis

A split-plot design (O'Mahony, 1986 and Snedecor and Cochran, 1980) was established. The model of Analysis of Variance (ANOVA) was as follows: two batches as a block, two carbonation levels as a whole plot and four sweeteners as a split plot. The model is shown in Appendix 1.

The original magnitude estimation data was normalized by both a geometric mean (GM) method (Stone and Oliver, 1969 and McDaniel, 1974) and a normal logarithm (LOG) method. For the GM method, the reference value of "20" was included in the panelist's geometric mean calculation. There were two steps. First, the geometric mean of treatment ratings for each attribute for a given panelist was calculated. Second, each original rating was divided by the geometric mean of that set. This normalization procedure made the geometric mean of the new value equal to 1.0. The values were then converted to logarithm values. For the LOG method, all data were transformed to logarithm values after division by 20 - the value assigned for the intensity of the reference. After normalizing, the average of the three replications of the panel was computed, and the normalized data of four attributes (except CO_2 level) were analyzed by using a computer SAS program for the designed ANOVA model. Means and standard deviations were computed. Main effects and interactions were tested using F-values based on the specific defined equations (Anderson and Bancroft, 1952) which are shown in Tables 5 and 6. Batch and panelist, two of the main effects, were designed as random effect components and were not tested by F-value. All interactions were random effect components except carbonation level by sweetener source interaction. The carbonation level by sweetener source interaction and other interactions involving panelists were tested for significant differences. The Least Significant Difference (LSD) test was applied for multiple comparsions when the F-value test showed there was a significant difference for the main effect.

The ANOVA model for sensory perception of the CO_2 level for the carbonated samples was as follows: two batches as a whole plot and four sweeteners as a split plot. The model is shown in Appendix 2. The data were normalized by both the GM method and the LOG methods described above. The average of three replications was computed, and the normalized data were analyzed by using a computer SAS program. The F values were obtained based on the specific defined equations (Table 9 and 10) and tested on the established model. Again, batch and panelist, which are random components, were not tested by F values. The panelist by batch and panelist by sweetener source interaction were tested by F values.

<u>Consumer Panel</u>

Sensory Evaluation

In order to measure the consumer acceptability of the sweetened flavored carbonated milk beverages, the four carbonated products were tested by a consumer panel.

Two sessions were held in the Sensory Science Laboratory in the Food Science and Technology Department of Oregon State University. Forty-seven panelists and fifty panelists volunteered to evaluate the samples for panel I and panel II, respectively.

The serving conditions and procedures were the same as those described for the trained panel. Four carbonated samples were presented at one time. The ranges of serving temperatures for samples for the two sessions were different. For the first panel, the temperature of serving was not well controlled and ranged from 4° to 11°C. For the second panel, the serving temperature (ranged from 4° to 7°C) was controlled by keeping the bottles of beverage in an ice bath.

The following written instructions were given to panelists, "You have been presented four samples of blueberry flavored carbonated milk. Please taste all four, and place the number of each sample next to the scale point which describes best how much you like it. Then rate how appropriate you believe the carbonation, sweetness and flavor levels are. Again, place all four numbers on the scale rating each characteristic". Panelists were asked to evaluate the samples and rate them using a 9-point hedonic scale (9=like extremely, 5=neither like nor dislike, 1=dislike extremely), then evaluate the carbonation, sweetness and flavor intensity by rating on a "just right" scale (7=way too high, 4=just right, 1=way too low). The ballot is shown in Figure 3.

Data Analysis

Data from each session were analyzed separately. Data were analyzed using a computer SAS program. The sweetener source, as main effect in ANOVA model, was tested by the F-value test. The LSD test was applied for multiple comparisons. The means and standard deviations of each sweetener source were computed. The percentage of responses for each attribute were calculated.

NAME________________________
AGE GROUP: Less than 21 _____
21-30 _____
31-40 _____
41 & above _____

Thank you for volunteering to taste blueberry flavored carbonated milk!

Have you ever consumed a root beer float or a coke float (mixing soda pop and ice cream)? This is the style of product you are testing today, however, milk is used instead of ice cream.

You have been presented four samples of blueberry flavored carbonated milk. Please taste all four, and place the number of each sample next to the scale point which describes best how much you like it.

__________ like extremely
__________ like very much
__________ like moderately
__________ like slightly
__________ neither like nor dislike
__________ dislike slightly
__________ dislike moderately
__________ dislike very much
__________ dislike extremely

Now, please taste them again, and rate how appropriate you believe the carbonation, sweetness and flavor levels are. Again, place all four numbers on the scale rating each characteristic.

Amount of Carbonation	Degree of Sweetness	Flavor Level
________way too high	________way too high	________way too high
______moderately too high	________moderately too high	________moderately too high
________slightly too high	________slightly too high	________slightly too high
________just right	________just right	________just right
________slightly too low	________slightly too low	________slightly too low
________moderately too low	________moderately too low	________moderately too low
________way too low	________way too low	________way too low

Finally, what did you particularly like about the flavored carbonated milk.
____
____
____

If anything, what did you dislike about the flavored carbonated milk.
____
____
____

Thank you for helping us with this project!

FIGURE 3. The Ballot of Evaluation for Consumer Panel

RESULTS AND DISCUSSIONS

Efforts at Foam Reduction

Foam formed during carbonation was markedly inhibited by a headspace-precharging modification. Carbonation without headspace-precharging produced carbonated milk with 60-80% (v/v) foam on the top; by contrast there was only 10% (v/v) foam within the carbonated milk when headspace-precharging was implemented. There was little favorable effect from the addition of lecithin on reduction of foaming since lecithin is not readily soluble in milk beverage systems.

In foam formation, the general accessibility of the hydrophobic portion of caseinates permits casein particles to be strongly absorbed at the air-water interface, which is indicative of the foaming properties of caseinates (Walstra and Jenness, 1984). Although there are numerous antifoaming agents which could suffice as surfactants and subsequently serve to displace the foam producing surfactant from the interface, they are not generally used in milk based systems because the casein would easily bind with many surfactants. Walstra and Jenness (1984) stated that this binding phenomenon helps explain the limited activity of various surfactants in milk; sometimes this binding effect can change the properties of casein.

Bikerman (1973) proposed an interesting theory of foam formation in various liquid/gas systems. When gas diffuses from within a given system to an interface (liquid-to-gas), the liquid film can form numerous bubbles at the liquid surface if the system has adequate surface tension. The function of antifoaming agents in food system is to reduce or more favorably modify surface tension.

In this research, a procedure for precharging the vessel headspace with CO_2 was applied. This approach was suggested by the theory of bubble formation. If the pressure of the air portion (headspace) is high enough (greater than the gas pressure from the system) to inhibit bubble formation at the liquid surface, it was believed that the foaming problem in carbonated milk could be reduced. The headspace of the carbonation chamber was precharged initially with CO_2. Then the carbonation procedure was conducted under a controlled headspace pressure of 1.05 Kg/cm^2, which served to inhibit the formation of bubbles at the surface.

Furthermore, the lower the temperature for a beverage system, the higher the developed surface tension and the lower the protein solubility a given beverage system possesses. This leads to a lower foam stability (Kinsella, 1976). For this reason and because low temperature substantially enhances the solubility of CO_2, the carbonation procedures in this study were conducted at a low temperature (0^o-1^oC).

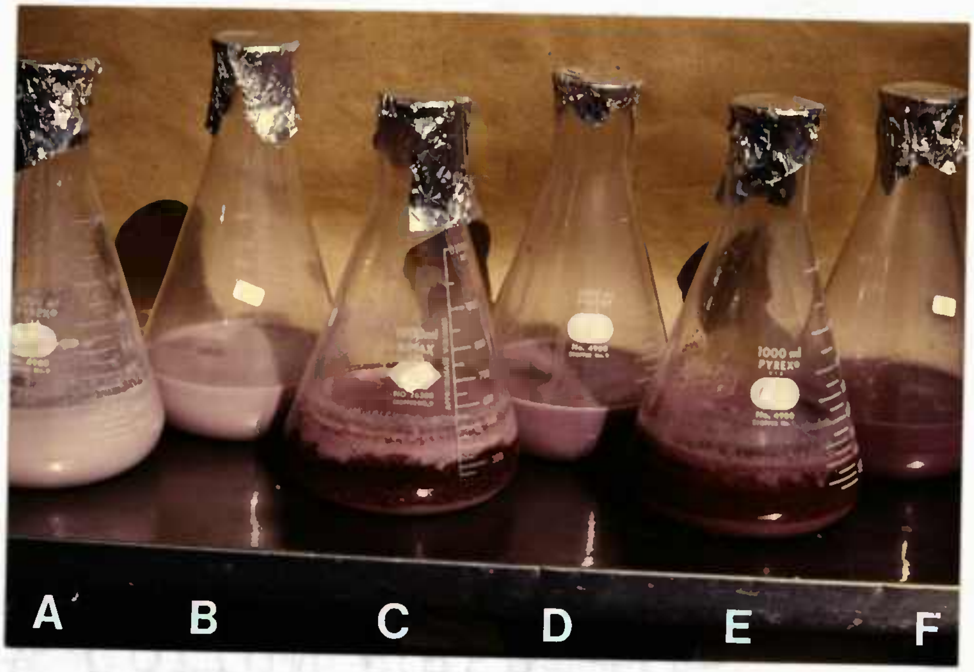
<u>Control of Protein Coagulation</u>

The results showed that a combination of heat treatment of the milk base and CMC addition improved markedly the stability of the casein.

A comparison of heated milk (with and without CMC added) demonstrated that the beverage formulation with added CMC resulted in substantial reduction of casein coagulation, which was caused by the formation of carbonic acid from CO_2 and the added fruit concentrate. After mixing with 1%, 2% and 3% (wt/wt) Marion berry concentrate (pH 3.0), the amounts of precipitate volume in the samples without added CMC were approximately 15%, 40% and 50% (v/v), respectively. For the samples with added CMC, there was no severe coagulation for any of the three levels of added fruit concentrate. The comparison is shown in Figure 4.

The heat treatment of milk (maintained at $85^{\circ}C$ for 30 minutes) serves to partially denature whey proteins, while there is little effect on casein (Walstra and Jenness, 1984). The partially-denatured whey proteins can bind to reactive sites on the casein, which partially enhances the stability of casein (Parry, 1974).

The acid coagulation of casein is due to the loss of a net electrical charge on casein, the formation of a "salt bridge" between different casein micelles and the formation of low solubility complexes as the pH is reduced below the pI of casein (Walstra and Jenness, 1984). The contribution



A = milk samples without CMC at 1%
B = milk samples with CMC at 1%
C = milk samples without CMC at 2%
D = milk samples with CMC at 2%
E = milk samples without CMC at 3%
F = milk samples with CMC at 3%

FIGURE 4. The Comparisons Between Heated Milk With and Without Added CMC at Different Marion Berry Concentrate Levels (wt/wt)

of CMC in reducing the acid coagulation of casein is not well understood. It is possibly related to a primary functional group (carboxyl) of CMC, which can provide additional negatively charged sites to the system. This excess of negatively charged sites may affect the net electrical charge of the casein and the electrostatic interaction between the casein micelles, when the pH of a milk system is decreased below the pI of the casein (pH 4.6). Asano (1966) reported that electrostatic attraction appears to be the mechanism for the interaction between CMC and milk proteins under acidic condition. He also reported that heat treatments could extend the magnitude of protein-CMC interaction. This may be a valid explanation for the positive result in this research from the incorporation of CMC into the beverage system prior to heat treatment. Also, the excess carboxyl groups may tend to bind hydrogen ions and hence help reduce the effect of acid on "stressing" the casein toward the precipitation point. Casein precipitation results in a definite degree of graininess, which is generally unacceptable from both a visual and mouthfeel standpoint in flavored milk beverages.

Determination of Equisweetness Point

The equisweetness-point determination was conducted on the sweetened blueberry flavored milk beverage, which was identical to the final product except it was not carbonated. The intensity of sensory perceptions of

TABLE 3. Magnitude Estimates of Sweetness for Each Level of Each Sweetener in Equisweetness Determination

	HFCS					Reference (sucrose)
physical levels (%)	2	4	5	6	8	4.5
sweetness rating	0.41	0.67	0.98	1.49	2.33	1.47

	Pear Concentrate					Reference (sucrose)
physical levels (%)	4	6	7	8	10	4.5
sweetness rating	0.49	0.82	1.00	1.23	1.71	1.44

	Aspartame					Reference (sucrose)
physical levels (%)	0.01	0.02	0.03	0.04	0.05	4.5
sweetness rating	0.36	0.90	1.15	1.82	2.51	0.85

sweetness for each sweetener are shown in Table 3. From the regression equation and the interpolation, the estimate of equisweet level for each sweetener were 4.5% (wt/wt) sucrose, 6.2% (wt/wt) HFCS, 9% (wt/wt) pear concentrate and 0.02% (wt/wt) aspartame. The confirmation of equisweetness for the four sweeteners was conducted three times, and the magnitude estimates of sweetness for them are shown in Table 4. The perceived sweetness of the HFCS (6.2%) and pear concentrate (9%) sweetened samples were significantly lower than those of the sucrose (4.5%) and aspartame (0.02%) sweetened samples in the first confirmation. For the second confirmation, the perceived sweetness of the aspartame (0.02%) was significantly higher than those of the others when the HFCS level was increased to 6.5% and the pear concentrate level was raised to 10%. After reducing the aspartame level to 0.015%, there was no significant difference in sweetness perception for the four sweeteners. The final selected equisweet levels for the four sweeteners were 4.5% (wt/wt) sucrose, 6.5% (wt/wt) HFCS, 10% (wt/wt) pear concentrate and 0.015% (wt/wt) aspartame.

During evaluation of the four equisweet sweeteners, there were some panelists who used the terms "bitter", "acidic" and "oxidized" off-flavor as descriptors to describe pear concentrate sweetened product.

TABLE 4. Magnitude Estimates of Sweetness for Four Sweeteners in Equisweetness Confirmation

sweeteners	sucrose	HFCS	pear concentrate	aspartame	ref(sucrose)
Four Sweeteners (I)					
physical levels(%)	4.5	6.2	9	0.02	4.5
sweetness rating	1.17[a]	0.90[bc]	0.74[c]	1.27[a]	1.11[ab]
Four Sweeteners (II)					
physical levels(%)	4.5	6.5	10	0.02	4.5
sweetness rating	1.02[a]	0.99[a]	0.89[a]	1.37[b]	1.04[a]
Four Sweeteners (III)					
physical levels(%)	4.5	6.5	10	0.015	4.5
sweetness rating	1.07[a]	1.08[a]	0.98[a]	0.93[a]	1.08[a]

a-c means with common superscripts within each row are not significantly different ($P < 0.05$).

Physical-Chemical Properties of Sweetened Fruit-Flavored Milk Beverages

Two-layers of separation occurred when beverages were stored under refrigeration (0^{o}-$1^{o}C$) for two days. Settling or "streaking" occurred in different patterns among the four different sweetened product trials. Up to 7-8 cm of gelation (curd) formed on the bottom of the bottles for both the HFCS and sucrose sweetened products, while 3-4 cm gel formation occurred on the bottom for the aspartame sweetened products. Approximately a 4-6 cm zone of gel formed on the top of the bottles for the pear concentrate sweetened products. The products would convert immediately to a homogeneous state after the bottles had been shaken gently. The same phenomenon was observed in Choi's and Kosikowski's (1985) study of the carbonated yogurt. They reported that the rapid separation of curd and serum occurs in about equal parts in their carbonated yogurt beverage, and that shaking the bottles is required before consumption. The reason for this phenomenon is not well understood. Walstra and Jenness (1984) reported that casein may interact with certain hydrocolloids by electrostatic attraction, which can suspend the particles in the system. The separation phenomenon may be related to the interaction between casein and CMC and the colloidal dispersion properties of CMC.

The pH values of eight treatments for each batch are summarized in Table 5. The pH values for carbonated

TABLE 5. The pH Value and Physical CO_2 Level* of Each Treatment

treatment	CS	NS	CH	NH	CP	NP	CA	CS
				pH value				
Batch								
1	5.94	6.23	5.93	6.35	5.78	6.02	5.99	6.37
2	5.95	6.17	5.95	6.36	5.79	6.03	6.02	6.37
$\bar{X}$	5.945	6.200	5.940	6.355	5.785	6.025	6.005	6.370

Batch	Sucrose	HFCS	Pear Conc.	Aspartame
		CO2 level		
1	1.76^{ax}	1.75^{ax}	1.74^{ax}	1.76^{ax}
2	1.73^{ax}	1.72^{ax}	1.76^{ax}	1.78^{ax}
$\bar{X}$	1.745^{a}	1.735^{a}	1.75^{a}	1.77^{a}

C - Carbonated product N - Noncarbonated product
S - Sucrose
H - HFCS
P - Pear Concentrate
A - Aspartame

* - CO_2 volumes of carbonated product transformed from the Zahm Model-D-T piercing device readings. They were means of nine bottles for each treatment.

a - means with common superscripts within each row are not significantly different ($p<0.05$).

x - means with common superscripts within each column are not significantly different ($p<0.05$)

products were always lower than those of the counterpart noncarbonated products for each sweetener. These pH differences were due to the carbonic acid formed after carbonation. The products sweetened by pear concentrate had lower pH than those sweetened by the other three sweeteners. This was obviously due to the greater acidity (pH 4.3) of the pear concentrate.

The physical measurement of CO_2 levels (volume) of four carbonated products are shown in Table 5. There was no significant variation between the batches and among the sweeteners.

Sensory Evaluation of Sweetened Fruit-Flavored Milk Beverages

Trained Panel

The ANOVA design used to analyze the data from the trained panel for four attributes , overall intensity, sweetness, blueberry flavor and viscosity, is summarized in Tables 6 and 7. The results from the normal logarithm (LOG) normalization (Table 6) were compared with those from the geometric mean (GM) normalization (Table 7). Both normalizations indicated that there were significant differences from carbonation on overall intensity, sweetness and blueberry flavor. The mean scores and standard deviations of the two carbonation levels and the other main effects are shown in Tables 8 (from the LOG normalization). Examination of the standard deviations

TABLE 6. The ANOVA of the Trained Panel Data (Normal Logarithm method)

descriptor		overall intensity		sweetness		blueberry flavor		viscosity	
source	DF	MS	F	MS	F	MS	F	MS	F
Batch(B)	1	0.0275		0.0352		0.0131		0.0062	
Panel(P)	11	0.0074		0.0387		0.0116		0.0066	
BXP	11	0.0154	1.10	0.0190	0.64	0.0080	0.79	0.0080	1.14
Carbonation level(C)	1	0.3456	30.16**	0.0541	10.36**	0.2781	38.37**	0.0011	0.16
PXC	11	0.0070	0.74	0.0087	0.40	0.0074	0.74	0.0070	0.51
BXC	1	0.0053		0.0000		0.0002		0.0623	
BXPXC	11	0.0220		0.0360		0.0136		0.0101	
Sweetener source(S)	3	0.0013	0.66	0.0166	1.45	0.0062	0.90	0.0086	2.06*
PXS	33	0.0115	1.36	0.0155	1.12	0.0080	1.06	0.0077	0.98
BXS	3	0.0031		0.0045		0.0086		0.0019	
CXS	3	0.0016	1.08	0.0024	1.04	0.0048	1.73	0.0076	1.28
BXPXS	33	0.0086		0.0121		0.0092		0.0117	
PXCXS	33	0.0129	0.70	0.0118	1.02	0.0078	0.78	0.0138	0.82
BXCXS	3	0.0056		0.0016		0.0008		0.0052	
BXPXCXS	33	0.0185		0.0115		0.0100		0.0169	

DF - Degree of freedom   MS - Mean square   F - F-test value

* - P <0.05   ** - P <0.01

TEST C F = MS(C)+MS(PXBXC)/MS(BXC)+MS(PXC)
TEST S F = MS(S)+MS(PXBXS)/MS(BXS)+MS(PXS)
TEST CXS F = MS(CXS)+MS(PXBXCXS)/MS(BXCXS)+MS(PXCXS)
TEST PXB F = MS(PXB)+MS(PXBXCXS)/MS(PXBXC)+MS(PXBXS)
TEST PXC F = MS(PXC)+MS(PXBXCXS)+MS(PXBXC)+MS(PXBXS)
TEST PXS F = MS(PXS)+MS(PXBXCXS)/MS(PXBXS)+MS(PXCXS)

TABLE 7. The ANOVA of the Trained Panel Data (Geometric Mean method)

descriptor		overall intensity		sweetness		blueberry flavor		viscosity	
source	DF	MS	F	MS	F	MS	F	MS	F
Batch(B)	1	0.0058		0.0074		0.0028		0.0013	
Panel(P)	11	0.0016		0.0082		0.0025		0.0014	
BXP	11	0.0033	2.02*	0.0040	0.90	0.0017	1.06	0.0017	1.42
Carbonation level(C)	1	0.0073	29.93**	0.0115	10.33**	0.0590	38.77**	0.0002	0.16
PXC	11	0.0015	1.36	0.0018	0.90	0.0016	1.23	0.0015	1.21
BXC	1	0.0011		0.0000		0.0000		0.0132	
BXPXC	11	0.0047		0.0076		0.0029		0.0021	
Sweetener source(S)	3	0.0068	0.68	0.0879	1.43	0.0330	0.93	0.0455	2.16*
PXS	33	0.0610	1.39	0.0823	1.13	0.0424	1.06	0.0409	0.96
BXS	3	0.0166		0.0237		0.0456		0.0103	
CXS	3	0.0085	1.09	0.0127	1.06	0.0256	1.71	0.0401	1.29
PXBXS	33	0.0458		0.0640		0.0487		0.0618	
PXCXS	33	0.0690	0.70	0.0624	1.02	0.0414	0.78	0.0733	0.82
BXCXS	3	0.0297		0.0085		0.0044		0.0276	
BXPXCXS	33	0.0983		0.0611		0.0532		0.0894	

DF - Degree of freedom MS - Mean square F - F-test value

* - P <0.05 ** - P <0.01

TEST C F = MS(C)+MS(PXBXC)/MS(BXC)+MS(PXC)
TEST S F = MS(S)+MS(PXBXS)/MS(BXS)+MS(PXS)
TEST CXS F = MS(CXS)+MS(PXBXCXS)/MS(BXCXS)+MS(PXCXS)
TEST PXB F = MS(PXB)+MS(PXBXCXS)/MS(PXBXC)+MS(PXBXS)
TEST PXC F = MS(PXC)+MS(PXBXCXS)/MS(PXBXC)+MS(PXCXS)
TEST PXS F = MS(PXS)+MS(PXBXCXS)/MS(PXBXS)+MS(PXCXS)

TABLE 8. Means and Standard Deviations of Main Effects of Trained Panel (Normal logarithm method)

descriptor	overall intensity			sweetness			blueberry flavor			viscosity		
main effect	mean*	t-mean**	SD	mean*	t-mean**	SD	mean*	t-mean**	SD	mean*	t-mean**	SD
Batch 1	0.852	-0.070	0.123	0.804	-0.095	0.140	0.905	-0.043	0.106	0.940	-0.027	0.113
Batch 2	0.900	-0.046	0.114	0.856	-0.068	0.107	0.871	-0.060	0.096	0.964	-0.016	0.098
Carbonated	0.966^{a}	-0.015	0.103	0.862^{a}	-0.064	0.134	0.969^{a}	-0.014	0.091	0.947	-0.024	0.102
Non-carbonated	0.794^{b}	-0.100	0.119	0.798^{b}	-0.098	0.113	0.813^{b}	-0.090	0.096	0.957	-0.019	0.110
Sucrose	0.867	-0.062	0.135	0.854	-0.068	0.134	0.875	-0.058	0.110	0.912	-0.040	0.109
HFCS	0.878	-0.056	0.109	0.857	-0.067	0.104	0.913	-0.039	0.086	0.959	-0.018	0.104
Pear concentrate	0.869	-0.061	0.111	0.827	-0.083	0.119	0.902	-0.045	0.104	0.982	-0.008	0.104
Aspartame	0.890	-0.051	0.121	0.782	-0.110	0.139	0.863	-0.064	0.104	0.956	-0.020	0.107

a-b - means with common superscripts within each colume are not significantly different ($P < 0.05$).

* - means
** - means transformed to logarithm value
SD - standard deviations transformed to logarithm value

showed that panel reproducibility was quite consistent between batches, carbonation levels and among sweeteners.

The perception of overall (flavor) intensity, sweetness and blueberry (characterizing) flavor were higher for the carbonated products than those for the noncarbonated products. Overall intensity for the carbonated products was 1.22 times that for the noncarbonated products. The perceived intensities of sweetness and blueberry flavor for the carbonated products were 1.08 and 1.19 times those for the noncarbonated product, respectively. Carbonation appears to enhance the sensory perception of overall intensity, sweetness and blueberry flavor in this flavored milk beverage system. A similar effect was observed in Choi's and Kosikowski's research (1985) on a carbonated yogurt beverage.

AS far as the effect of carbonation on viscosity, the perceived viscosity of the carbonated product tended to be less (but not to a significant degree) from that of the noncarbonated beverage.

There was also a significant difference among sweetener sources for perception of viscosity by both data normalization methods. The LSD test was not applicable for the perceived viscosity of four sweeteners, because of the negative value obtained from the calculated mean square of error term from the defined F-value test (Tables 6 & 7). Perceived viscosity for the pear concentrate sweetened product was highest, while viscosity of the sucrose sweetened product was lowest. This might be due to the relatively large amount of pear concentrate (10% wt/wt) added to achieve equisweetness as compared to the other three sweeteners.

There were no significant differences among sweetener sources for the other three sensory attributes. The intensity of perceived sweetness was lowest for the aspartame sweetened product. There may have been a loss of sweetness for the aspartame sweetened product during processing and storage. Dever et al. (1986) stated that aspartame is subject to hydrolysis in aqueous system (moisture level above 8%) to end products which do not exhibit sweetness. For blueberry flavor of the beverages, the sensory results did not agree with that obtained by Baldwin and Korschgen (1979), who reported that aspartame enhances certain fruit flavors in flavored noncarbonated beverages. However, the milk beverage system in this study was probably more viscous and different in mouthfeel properties than their beverages system.

The mean scores of each treatment (Table 9) reconfirmed the carbonation effect on overall intensity, sweetness and blueberry flavor. The mean scores of the carbonated beverages were higher than those of the counterpart noncarbonated products for each sweetener on overall intensity, sweetness and blueberry flavor. In comparing the mean scores of carbonated and noncarbonated beverages across the four sweeteners, there was no apparent sweetener

TABLE 9. Means and Standard Deviations of Each Treatment of Trained Panel (Normal logarithm method)

descriptor	overall intensity			sweetness			blueberry flavor			viscosity		
treatments	mean*	t-mean**	SD	mean*	t-mean**	SD	mean*	t-mean**	SD	mean*	t-mean**	SD
carbonated sucrose	0.964	-0.016	0.137	0.893	-0.049	0.134	0.965	-0.016	0.101	0.945	-0.025	0.091
carbonated HFCS	0.949	-0.023	0.086	0.905	-0.043	0.105	1.019	0.008	0.086	0.953	-0.021	0.107
carbonated pear conc.	0.966	-0.015	0.086	0.840	-0.076	0.128	0.953	-0.021	0.101	0.952	-0.021	0.110
carbonated aspartame	0.984	-0.007	0.101	0.815	-0.089	0.164	0.942	-0.026	0.093	0.936	-0.029	0.106
noncarbonated sucrose	0.780	-0.108	0.118	0.818	-0.087	0.134	0.793	-0.101	0.104	0.881	-0.055	0.124
noncarbonated HFCS	0.812	-0.090	0.121	0.813	-0.090	0.100	0.819	-0.087	0.076	0.964	-0.016	0.103
noncarbonated pear concen.	0.782	-0.107	0.112	0.814	-0.089	0.111	0.853	-0.069	0.103	1.012	0.005	0.098
noncarbonated aspartame	0.804	-0.094	0.126	0.750	-0.125	0.109	0.791	-0.102	0.102	0.976	-0.010	0.110

* - means
** - means transformed to logarithm value
SD - standard deviation transformed to logarithm value

source effect on the four attributes. However, the perceived sweetness of both carbonated and noncarbonated products sweetened by aspartame were lowest in the sets of carbonated and noncarbonated products, respectively. This also was observed in the means of the main effects in the ANOVA model for the trained panel.

Extra information on the comparison of the four sweeteners can be obtained from the written comments from the trained panelists (Appendix 3). A "corn flavor" was used to described the HFCS sweetened product; "bitter" and "bland" taste were used to described the aspartame sweetened product; "wheaties", "grainy", "stale", "strong pear", "honey-like", "cooked" flavor and "offensive" taste were terms used to describe the pear concentrate sweetened product. The bitter taste for the aspartame sweetened product was the same as that obtained by Redlinger and Setser (1987). They reported that bitterness was perceived frequently in both aqueous and lipid systems for the aspartame sweetened products.

The GM normalization method was compared with the LOG normalization method to ascertain the sensitivity of each method to detect the differences among treatments. The discriminating power of the two methods for the main effects were described earlier. Similar results were obtained except for the batch by panelist interaction on overall intensity. This effect was significant for results from the GM normalization method while it was not significant for those from the LOG normalization method. The mean squares of main or interaction effects that tend to cause more extreme valued observations will be larger with the GM normalization method. This is due to dividing all observations by the GM which is influenced by extreme observations. Those mean squares of other main or interaction effects were decreased by the normalizing process and the subsequent averaging out of extreme valued observations. The data with the LOG normalization method were not influenced as much by extreme observations as the GM method since all observations were divided by a constant. In this case all sources of variation (including the "sweetener source" as a main or interaction effect) were larger for the GM normalization method. All other sources of variation in GM method were smaller than the LOG normalization method (Tables 6 and 7). This variation phenomenon is most evident with the four way interaction mean square. The ANOVA result showed an increased significance level for the GM normalization method since the four way interaction mean square is in the numerator of the F value. Mean squares used in the numerator and denominator for the other F values were all affected in the same way by the adjusting nature of the GM normalization procedure. Therefore, all other F-tests were found to be in close agreement between these two methods. In summary, there was little difference between the results from the LOG and GM normalization methods.

The CO_2 bubbles released in the mouth from the carbonated product developed a unique mouth-feel, commonly described as "sparkle", "effervescence" or "biting". This special mouth-feel may affect the perception of other tastes, thus the perceived intensity of carbonation is important. The ANOVA analysis for perceived carbonation level for the carbonated products is summerized in Tables 10 and 11. Again, the results from the LOG normalization method were compared with those from the GM normalization method. Both methods indicated that there were no significant difference for sweetener source effect. However, there were significant differences for panel by batch interaction in the LOG normalization method and this interaction was nonsignificant in the GM normalization method. The panel by batch interaction indicated that the directions of panelist scaling between batches were not consistent. Some panelists rated the perception of carbonation higher for batch 1 while the other panelists rated the carbonation higher for batch 2.

A comparison between the physical measurement (CO_2 volume) and the sensory perception of carbonation level is shown in Table 12. Though there was no significant difference between batches and among sweeteners for either physical measurement or sensory perception, the directions of differences between batches and among sweeteners for physical measurement seemed to be consistent with those for sensory perception. The products in batch 1 were higher

TABLE 10. The ANOVA of Perception of Carbonation by the Trained Panel (Normal logarithm method)

source	Degree of Freedom	Mean Square	F value
Batch(B)	1	0.0235	
Panel(P)	11	0.0160	
BXP	11	0.0240	4.41**
Sweetener source(S)	3	0.0167	0.41
BXS	3	0.0089	
PXS	33	0.0444	1.63
BXPXS	33	0.0054	

* - P <0.05
** - P <0.01

TEST B F = MS(B)+MS(BXPXS)/MS(BXP)+MS(BXS)
TEST P F = MS(P)+MS(BXPXS)/MS(BXP)+MS(PXS)
TEST S F = MS(S)+MS(BXPXS)/MS(BXS)+MS(PXS)

TABLE 11. The ANOVA of Perception of Carbonation by the Trained Panel (Geometric mean method)

source	Degree of Freedom	Mean Square	F value
Batch(B)	1	0.0049	
Panel(P)	11	0.0034	
BXP	11	0.0051	0.18
Sweetener source(S)	3	0.0886	0.42
BXS	3	0.2353	
PXS	33	0.0471	1.63
BXPXS	33	0.0289	

* - P <0.05
** - P <0.01

TEST B F = MS(B)+MS(BXPXS)/MS(BXP)+MS(BXS)
TEST P F = MS(P)+MS(BXPXS)/MS(BXP)+MS(PXS)
TEST S F = MS(S)+MS(BXPXS)/MS(BXS)+MS(PXS)

TABLE 12. The Comparison Between the Physical Measurement and the Sensory Perception of Carbonation

	physical measurement *		sensory perception **	
effect	mean	SD	mean	SD
Batch 1	1.753[a]	0.0096	1.026[a]	0.1167
Batch 2	1.748[a]	0.0275	0.955[a]	0.0984
Sucrose	1.745[a]	0.0212	1.007[a]	0.1126
HFCS	1.735[a]	0.0141	0.914[a]	0.0855
Pear concentrate	1.750[a]	0.0212	0.988[a]	0.0949
Aspartame	1.770[a]	0.0141	1.057[a]	0.1322

* - CO2 volume transformed from Model-D-T piercing device
** - means normalized from normal logarithm method

SD - Standard Deviation

a - means with common superscripts within each column are not significantly different ($P < 0.05$)

than those in batch 2 for both physical measurement and sensory perception. The aspartame sweetened product was highest while the HFCS sweetened product was lowest for both physical measurement and sensory perception.

Consumer Panel

Four carbonated samples were presented to each of the two separate consumer panels (panel I and II) on different days. Panelists rated the overall acceptability on a 9-point hedonic scale and the carbonation level, sweetness and flavor levels on a "just right" scale. Mean scores and F values from the ANOVA to determine sweetener-source effects on hedonic rating, carbonation level, sweetness and blueberry flavor are shown in Table 13. The results in panel I were quite different from those in panel II. There were significant differences among sweeteners for carbonation level and blueberry flavor in panel I and nonsignificant difference for hedonic rating and sweetness. For panel II, there were significant sweetener sources effects on hedonic rating, sweetness and blueberry flavor and a nonsignificant difference for carbonation level. This could be due to the fact that the panelists were not the same each day. Also the different serving temperature range of samples for the two panels (4^{o}-11^{o}C and 4^{o}-7^{o}C, respectively) might have been a factor.

For the hedonic score results from panel I, there was no significant difference among sweeteners, but the product

TABLE 13. Means, Standard Deviations, F Values and LSD Values of Sweetener Source Effect from the Consumer Panel

Panel I (N=47)

descriptor	hedonic scale^{x}		carbonation level^{y}		sweetness^{y}		blueberry flavor^{y}	
sweetener source	mean	SD	mean	SD	mean	SD	mean	SD
sucrose	4.98^{a}	1.83	3.66^{bc}	1.29	3.94^{a}	1.05	3.43^{b}	1.12
aspartame	4.83^{a}	1.77	3.43^{c}	1.14	4.09^{a}	1.08	3.23^{b}	1.00
HFCS	4.79^{a}	1.94	3.91^{b}	1.12	4.06^{a}	1.15	3.23^{b}	1.27
pear concentrate	4.36^{a}	2.22	4.79^{a}	1.43	3.98^{a}	1.38	4.51^{a}	1.38
F value	1.88		15.76^{***}		0.27		19.01^{***}	
LSD value	0.540		0.419		0.381		0.393	

Panel II(N=50)

descriptor	hedonic scale^{x}		carbonation level^{y}		sweetness^{y}		blueberry flavor^{y}	
sweetener source	mean	SD	mean	SD	mean	SD	mean	SD
sucrose	5.40^{a}	1.71	4.28^{a}	1.19	3.90^{b}	1.04	3.46^{b}	1.13
aspartame	4.78^{b}	1.83	3.84^{a}	1.52	3.18^{c}	1.21	2.98^{c}	1.19
HFCS	5.66^{a}	1.73	3.92^{a}	1.22	4.06^{b}	1.00	3.56^{ab}	0.88
pear concentrate	5.16^{ab}	1.73	3.96^{a}	1.28	4.48^{a}	0.97	3.80^{a}	1.01
F value	3.18^{*}		2.53		19.48^{***}		9.25^{***}	
LSD value	0.586		0.329		0.343		0.316	

x - 9-point Hedonic scale(9=like extremely, 5=neither like nor dislike, 1=dislike extremely)

y - Just-right scale(7=way too high, 4=just right, 1=way too low)

a-c - means with common superscripts within each column are not significantly different ($P < 0.05$)

* - $P < 0.05$

** - $P < 0.01$

*** - $P < 0.001$

sweetened by sucrose had the highest mean score, while the product sweetened by pear concentrate had the lowest score. The sucrose sample, although rated the highest, received a score of only 4.98, on the dislike side of the hedonic scale. For the hedonic scale results in panel II, the aspartame sweetened product was rated significantly lower than the sucrose and HFCS sweetened products. Comparing the two panels, overall hedonic scores were much higher in panel II.

Mean scores of hedonic ratings are important, however, more detailed information can be gained by inspection of the distributions of the ratings. The percentages of "like" and "dislike" ratings on the hedonic scale for each sweetener are shown in Table 14. The percentage of respondents liking the product in panel II was higher than that in panel I. This was also indicated from the mean scores comparisons. Different serving temperatures of the samples may have caused an effect on the acceptability of the products. Since the serving temperature of panel II was lower, panelists seemed to prefer colder beverage products. For the average of the two panels, the percentages of the "like" ratings for the sucrose and HFCS sweetened products were higher. Again, this was in agreement with the comparisons from the mean scores.

The distribution of hedonic ratings for the four sweeteners by panels I and II are shown in Figures 5-8. For sucrose (Figure 5), the results from both panel I and II

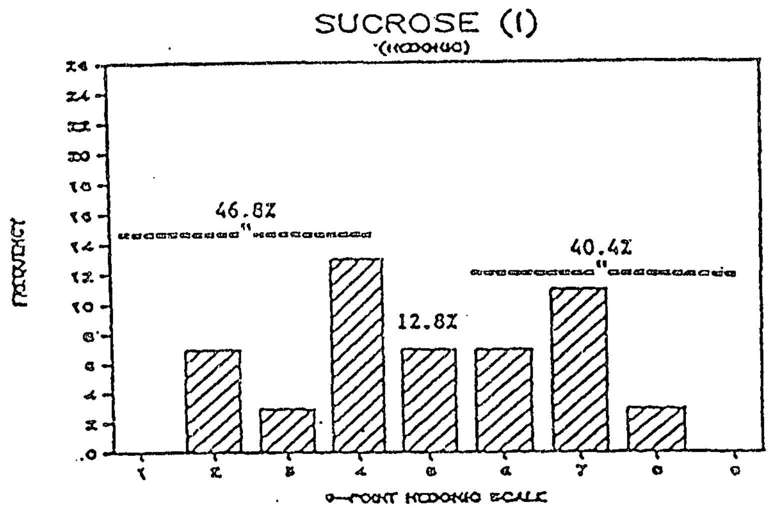
TABLE 14. The Percentage of Like and Dislike Ratings on the Hedonic Scale by the Consumer Panel

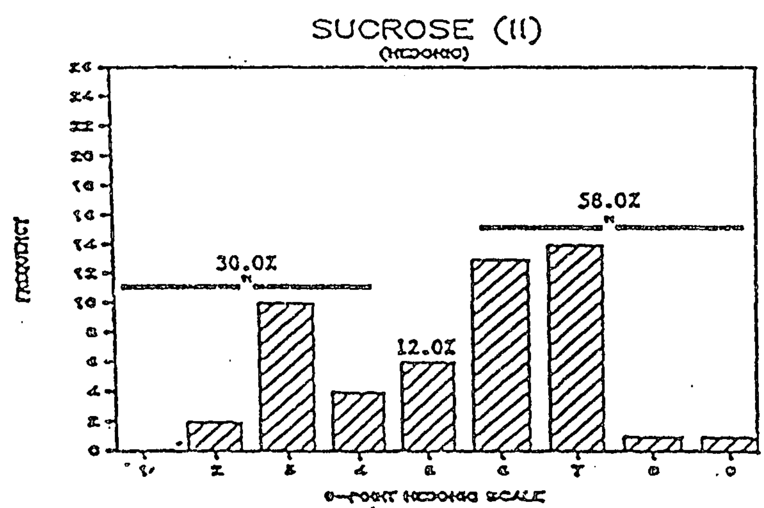
panel	attribute/ sweetener	sucrose	aspartame	HFCS	pear concentrate
	like (%)*	40.4	40.4	38.3	36.2
I	dislike(%)*	46.8	46.8	51.1	57.4
	neither(%)*	12.8	12.8	10.6	6.4
	like (%)*	58.0	40.0	60.0	52.0
II	dislike(%)*	30.0	48.0	28.0	34.0
	neither(%)*	12.0	12.0	12.0	14.0
	like (%)*	49.2	40.2	49.2	44.1
average	dislike(%)*	38.4	47.4	39.6	45.7
	neither(%)*	12.4	12.4	11.3	10.2

* - like is sum of scale 6,7,8,9(9=like extremely, 8=like very much, 7=like moderately, 6=like slightly)

- dislike is sum of scale 4,3,2,1(1=dislike extremely, 2=dislike very much, 3=dislike moderately, 4=dislike slightly)

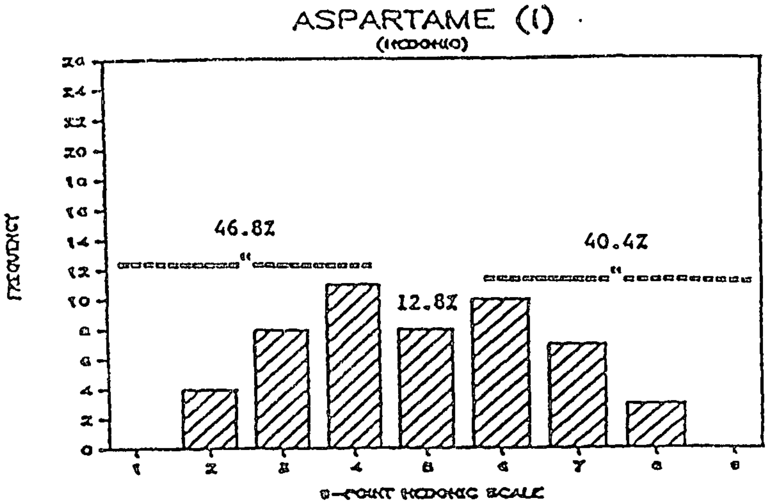
- neither for scale 5(5=neither like nor dislike)

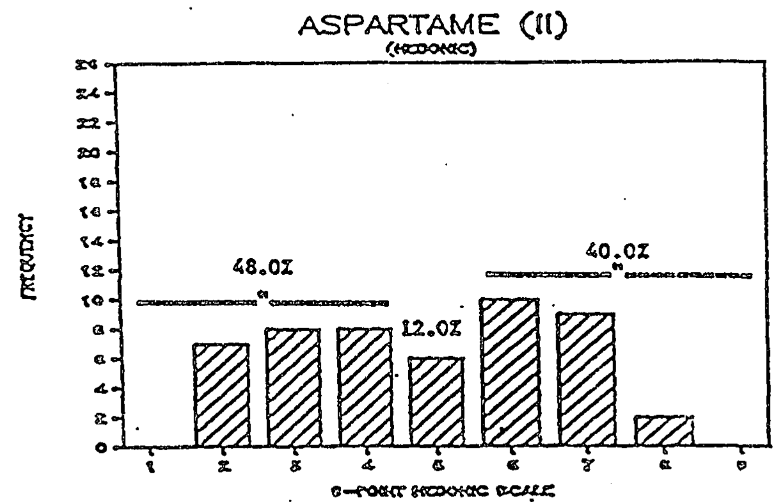




9-like extremely
8-like very much
7-like moderately
6-like slightly
5-neither like nor dislike
4-dislike slightly
3-dislike moderately
2-dislike very much
1-dislike extremely

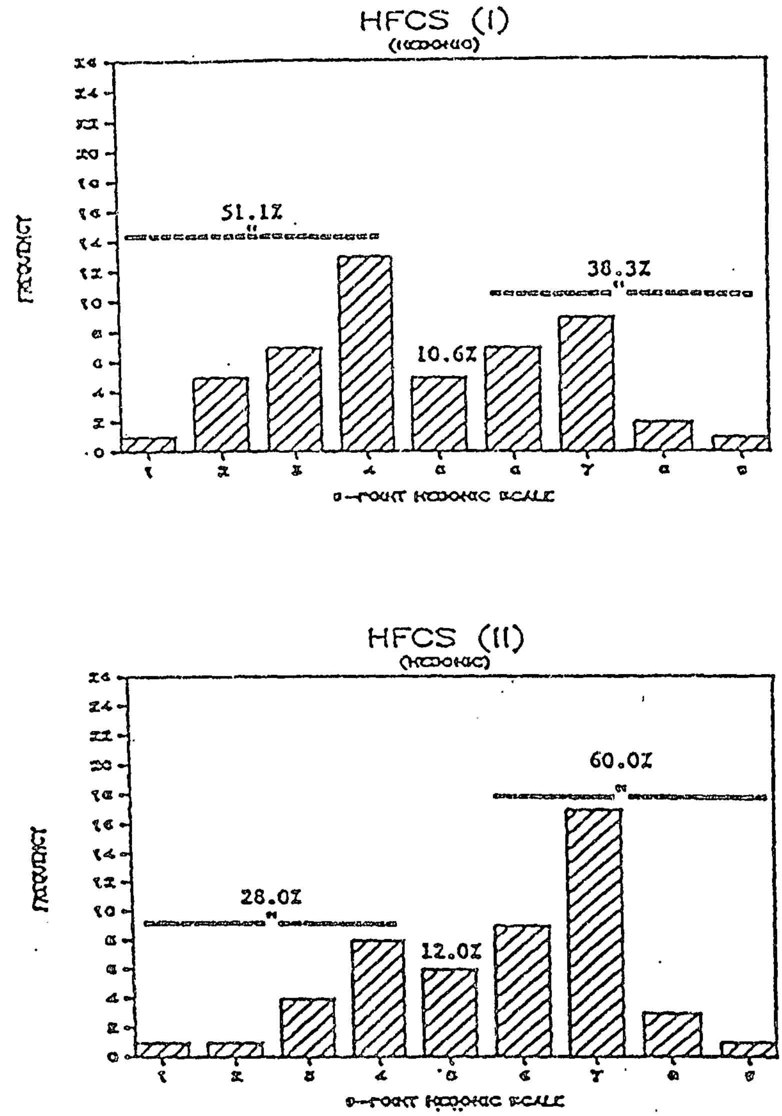
FIGURE 5. The Distribution of Hedonic Ratings for the Sucrose Sweetened Product by Consumer Panels I and II.





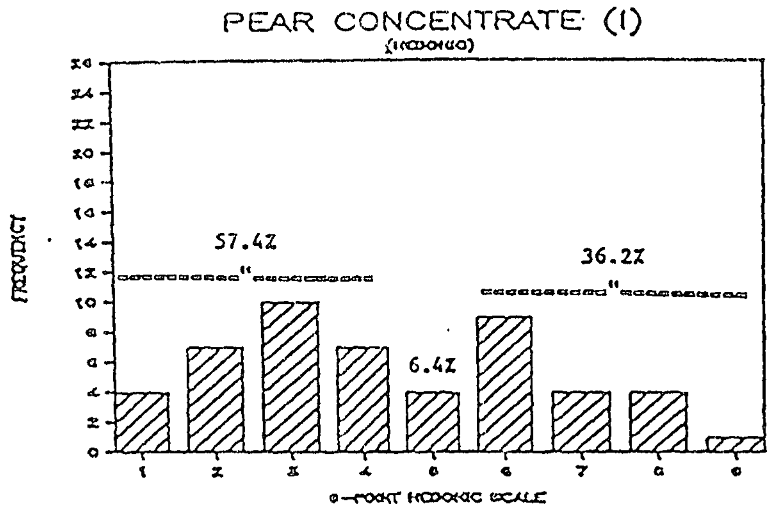
9-like extremely
8-like very much
7-like moderately
6-like slightly
5-neither like nor dislike
4-dislike slightly
3-dislike moderately
2-dislike very much
1-dislike extremely

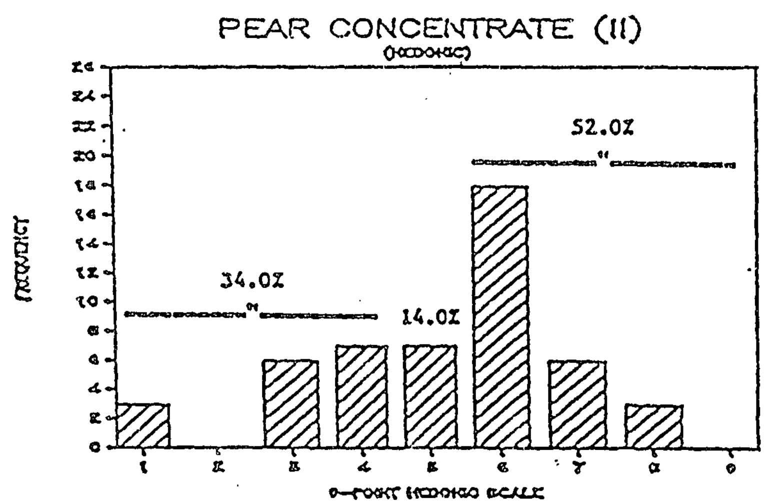
FIGURE 6. The Distribution of Hedonic Ratings for the Aspartame Sweetened Product by Consumer Panels I and II.



9-like extremely
8-like very much
7-like moderately
6-like slightly
5-neither like nor dislike
4-dislike slightly
3-dislike moderately
2-dislike very much
1-dislike extremely

FIGURE 7. The Distribution of Hedonic Ratings for the HFCS Sweetened Product by Consumer Panels I and II.





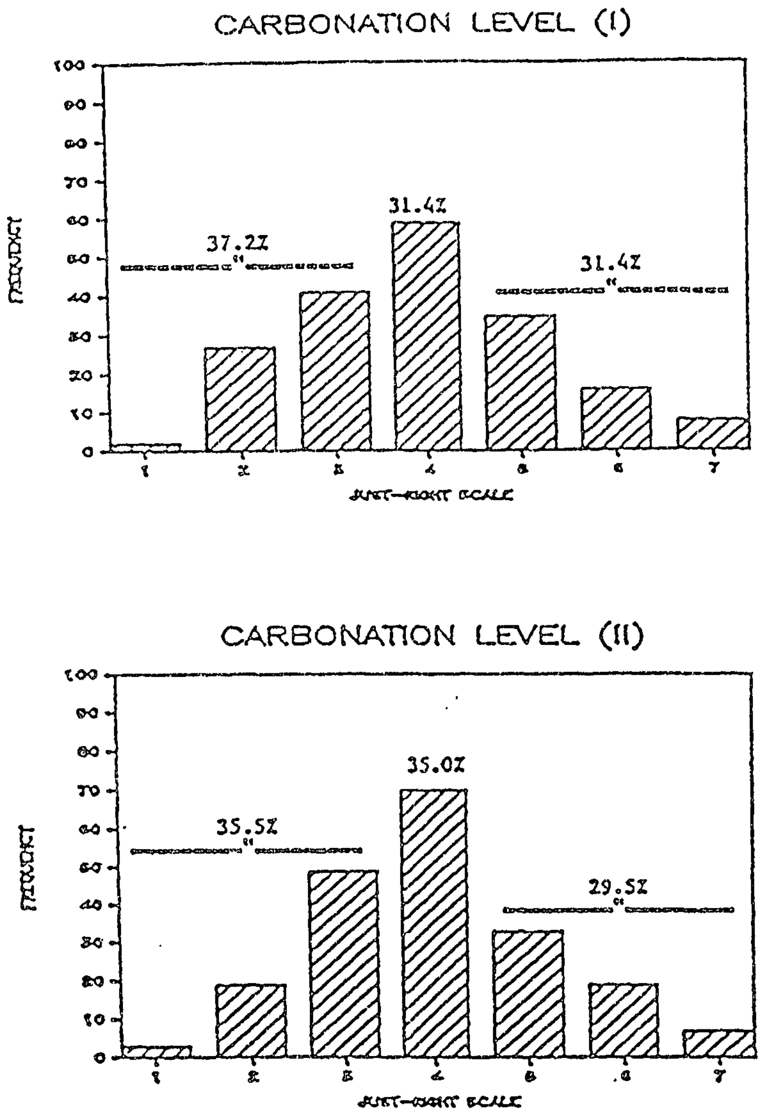
9-like extremely
8-like very much
7-like moderately
6-like slightly
5-neither like nor dislike
4-dislike slightly
3-dislike moderately
2-dislike very much
1-dislike extremely

FIGURE 8. The Distribution of Hedonic Ratings for the Pear Concentrate Sweetened Product by Consumer Panels I and II.

did not appear normally distributed. The midpoint category, "neither like nor dislike" was not used often by the panelists, while both "like" and "dislike" categories were heavily used, thus creating an apparent bimodal distribution. There was an almost even weighting for the "like" and "dislike" sides in panel I. Again, there were higher overall ratings in panel II. With the aspartame sweetened product (Figure 6), there was an almost even weighting for the "like" and "dislike" sides in both panels I and II. For HFCS (Figure 7), the two distributions appear to be skewed in opposite directions. Hedonic ratings tended to be low in panel I, but were much higher for panel II. Again, the hedonic ratings were skewed in different directions by panel I and panel II for pear concentrate sweetened product (Figure 8). Fifty-seven percent of the panelists disliked the product in panel I, and 52% of the panelists liked the product in panel II.

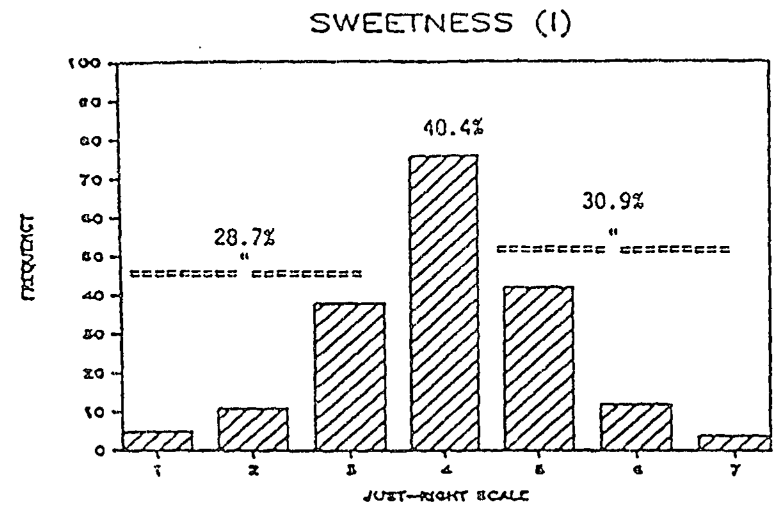
In general, the acceptability by panelists of sweetened blueberry-flavored carbonated milk beverage was not high. Some of the reasons for the limited acceptance may become evident after examination of the results from the ratings on the "just right" scale.

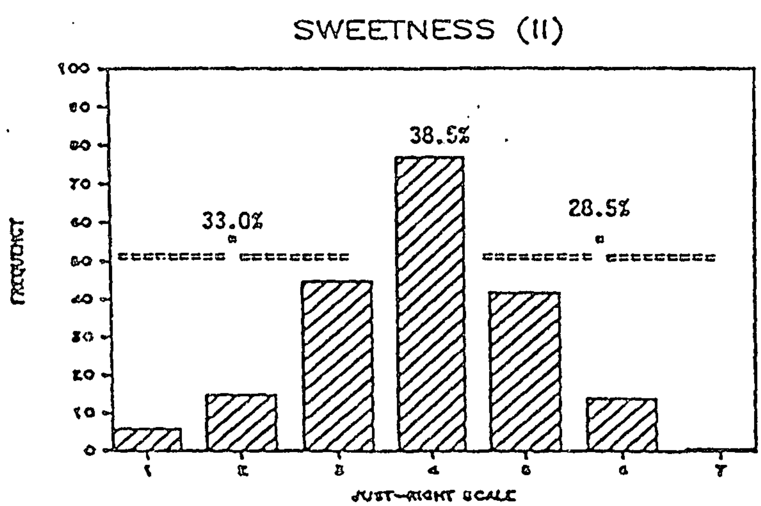
An important goal of this work was to evaluate the levels of carbonation, sweetness and blueberry flavor in the formulated drink, irrespective of sweetener sources. The distributions and percentages of responses of carbonation level, sweetness and blueberry flavor averaged



1 – way too low — II
2 – moderately too low — II – too low
3 – slightly too low — II
4 – just right
5 – moderately too high — II
6 – slightly too high — II – too high
7 – way too high — II

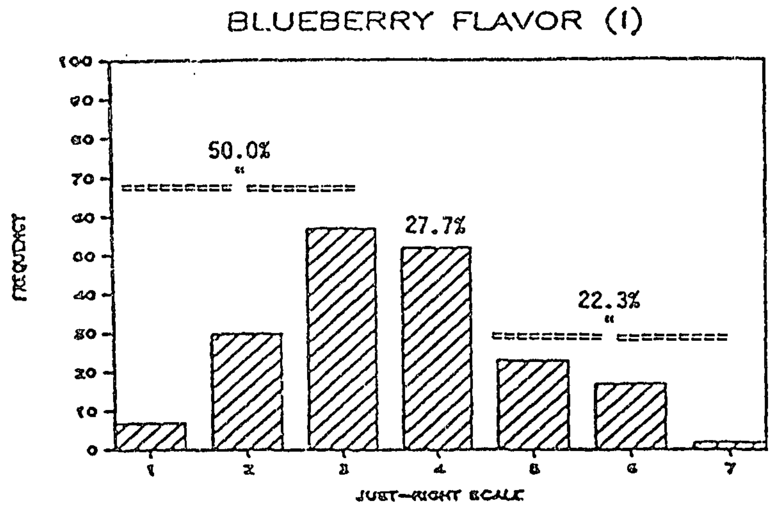
FIGURE 9. The Distribution of the Carbonation Level Responses for the Sweetened Blueberry Flavored Carbonated Milk Beverages by the Consumer Panels I and II (regardless of sweetener source)

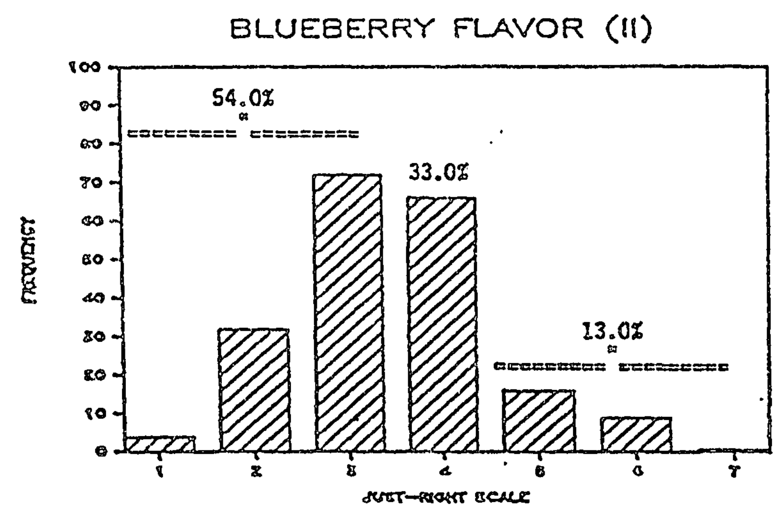




1 - way too low	II
2 - moderately too low	II - too low
3 - slightly too low	II
4 - just right	
5 - moderately too high	II
6 - slightly too high	II - too high
7 - way too high	II

FIGURE 10. The Distribution of the Sweetness Responses for the Sweetened Blueberry Flavored Carbonated Milk Beverages by the Consumer Panels I and II (regardless of sweetener source)





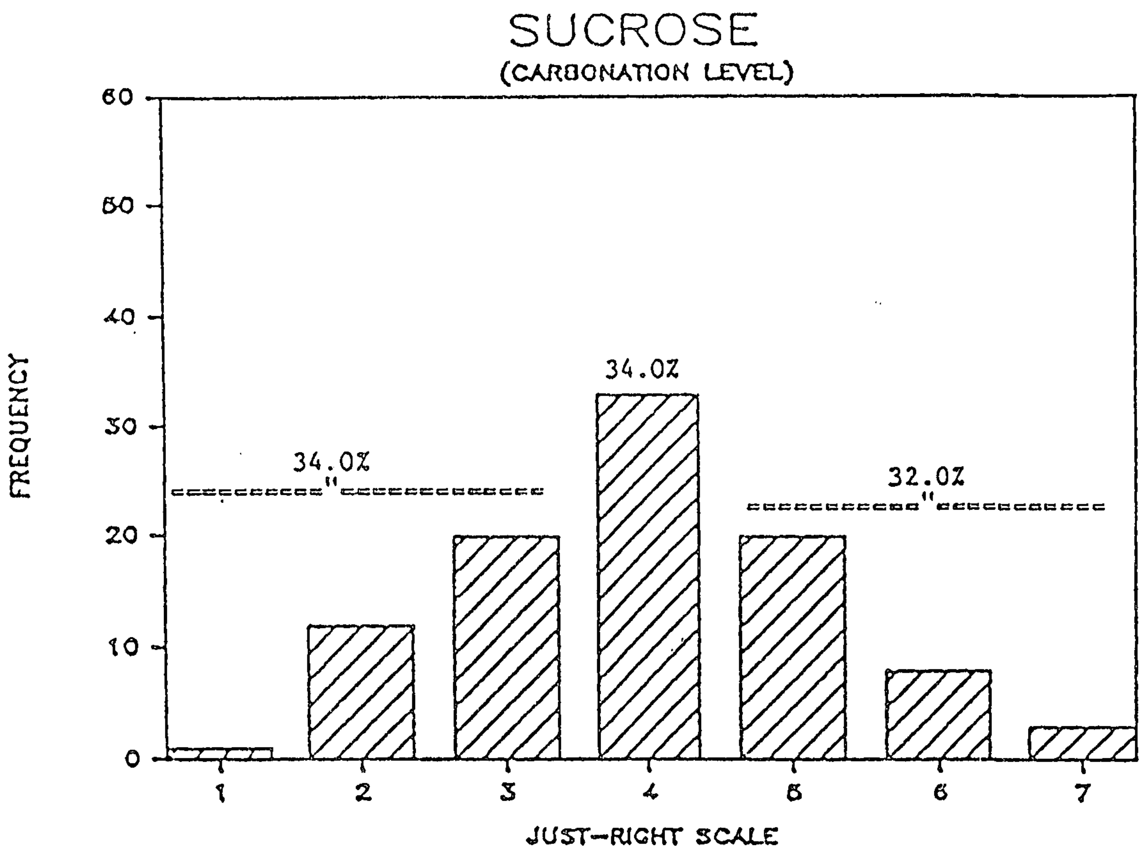
1 = way too low — II
2 = moderately too low — II = too low
3 = slightly too low — II
4 = just right
5 = moderately too high — II
6 = slightly too high — II = too high
7 = way too high — II

FIGURE 11. The Distribution of the Blueberry Flavor Responses for the Sweetened Blueberry Flavored Carbonated Milk Beverages by the Consumer Panels I and II (regardless of sweetener source)

over sweetener source for products in consumer panel I and II are summerized in Figures 9, 10 and 11, respectively. For carbonation level (Figure 9), sensory responses for both panel I and II appear as a normal distribution, but observation values were widely dispersed. These results suggest that the carbonation level employed in this study may be optimum. For sweetness (Figure 10), both panel results appear normally distributed with higher percentages at the "just right" rating. It could be inferred that the level of sweetness was close to the optimum level. For the blueberry flavor rating (Figure 11), however, both distributions were skewed to the "too low" side. Half of the panelists felt that the flavor level was too low; thus an increase in the level of blueberry flavor appears advisable. Although results from use of the "just right" scale for sensory assessment of the carbonation and sweetness level appear to be distributed normally around the "just right" category, a high number of judges felt the carbonation level was either too high or too low. This pattern of responses obviously contributed to the relatively low hedonic rating for the carbonated flavored beverages.

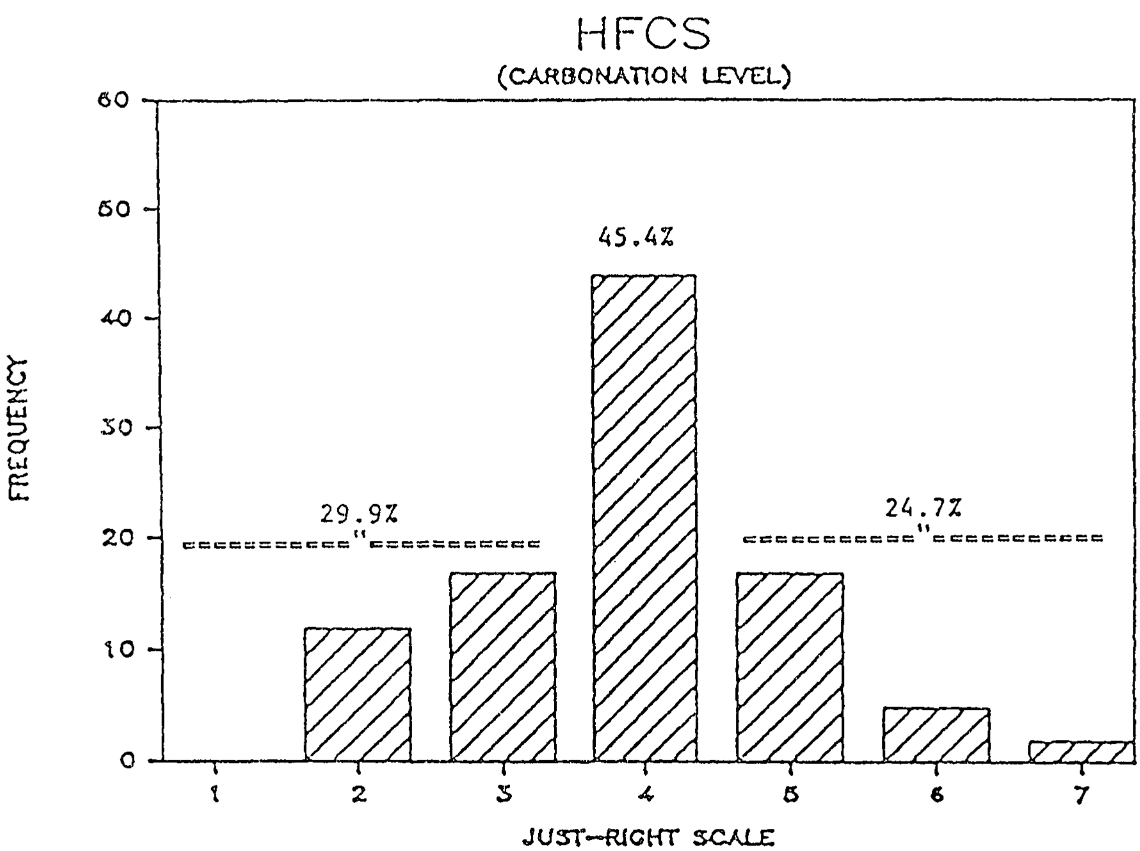
Additional detailed information was obtained from the panelists' comments (Appendix 4). Many panelists commented about the mouthfeel of the beverages. "Mouth coating", "over/under carbonation", "not refreshing", 'thin", "watery", "unusual texture", "chalky" and "high viscosity" were used for describing the products. These observations were in contrast to the results from Choi's and Kosikowski's research (1985). They reported that the panelists described the effect of carbon dioxide in sweetened flavored carbonated yogurt beverages as "thirst-quenching" and "refreshing". However, their products were less sweet and more acidic by the nature of yogurt. Panelists were also critical of the unacceptable color (purple-gray) of the product. The color of the beverages, not one of the attributes tested, could have caused a psychological effect when panelists evaluated the products. A most unattractive color of samples could quite possibly cause panelists to assign a lower rating for other sensory attributes, and hence be reflected in the hedonic rating of the product.

The distributions of responses of the three attributes averaged over two panels for each sweetener are shown in Figures 12 to 23. For carbonation level, the distributions appear normal for the sucrose (Figure 12) and HFCS (Figure 13) sweetened products, with the HFCS having a very high "just right" response (45.4%). It seems that the carbonation level was appropriate in these two products. For the aspartame sweetened product (Figure 14), the carbonation level was judged too low by over 50% of the panelists, perhaps due to the low viscosity (Table 9) of the product which caused the "too low" rating of carbonation level for the consumer panel. For the pear



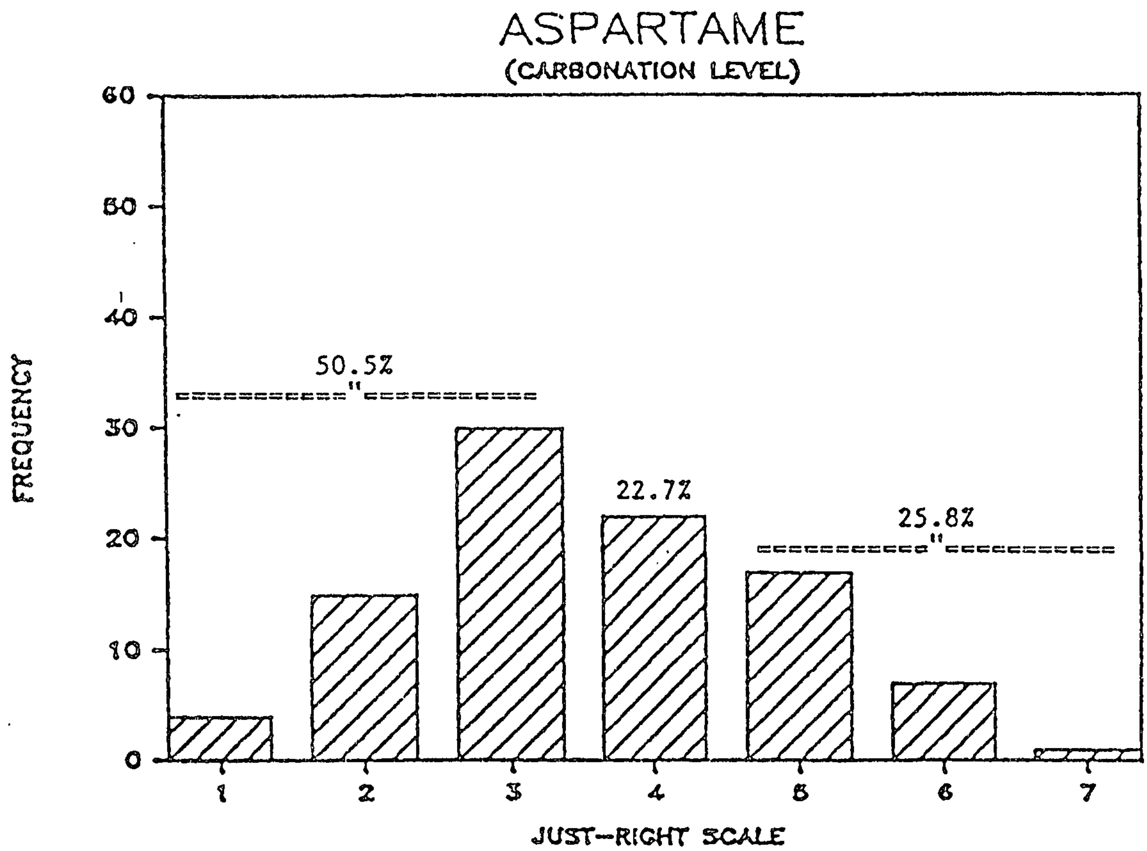
1 - way too low II
2 - moderately too low II - too low
3 - slightly too low II
4 - just right
5 - moderately too high II
6 - slightly too high II - too high
7 - way too high II

FIGURE 12. The Distribution of the Carbonation Level Responses for the Sucrose Sweetened Product by the Consumer Panels (combination of panels I and II)



1 - way too low II
2 - moderately too low II - too low
3 - slightly too low II
4 - just right
5 - sightly too high II
6 - moderately too high II - too high
7 - way too high II

FIGURE 13. The Distribution of the Carbonation Level Responses for the HFCS Sweetened Product by the Consumer Panels (combination of panels I and II)

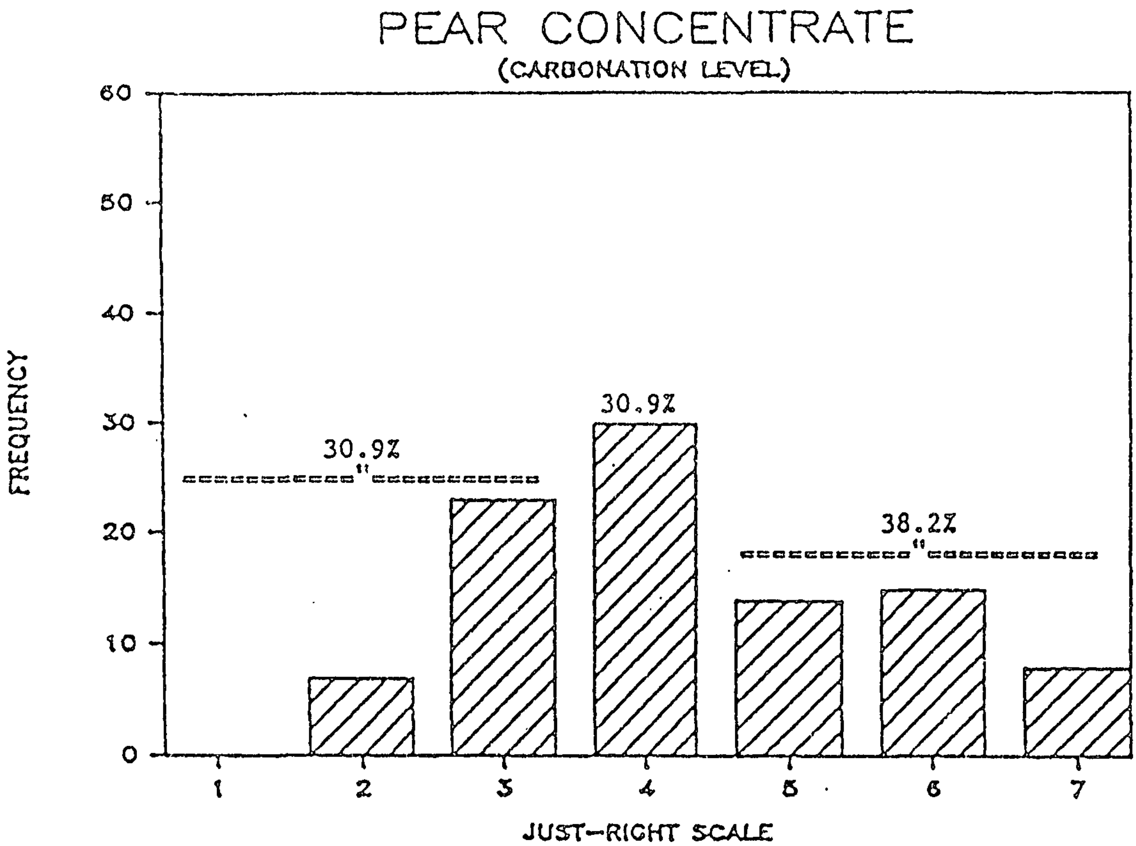


1 = way too low II
2 = moderately too low II = too low
3 = slightly too low II
4 = just right
5 = moderately too high II
6 = slightly too high II = too high
7 = way too high II

FIGURE 14. The Distribution of the Carbonation Level Responses for the Aspartame Sweetened Product by the consumer Panels (combination of panels I and II)

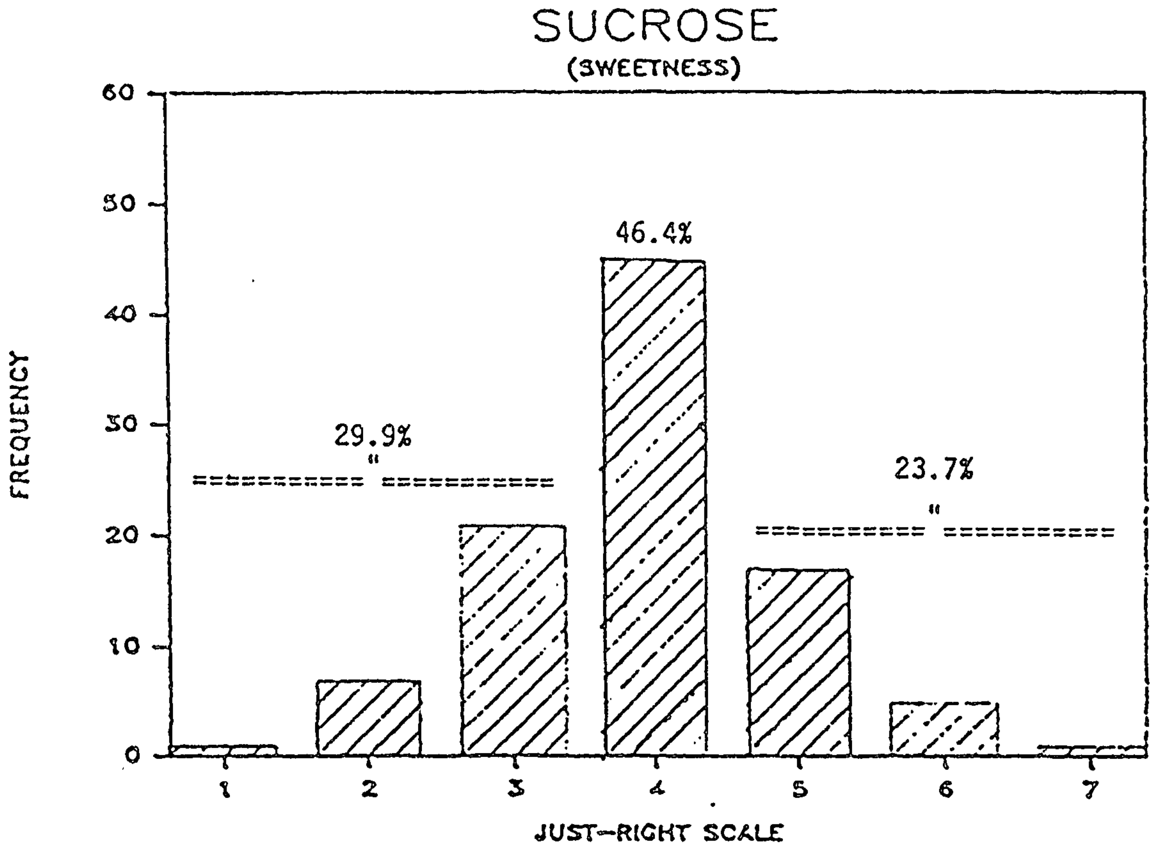
concentrate sweetened product (Figure 15), 38.2% of the panelists felt the carbonation level was too high. The higher viscosity and fruity flavor in the product may have enhanced carbonation perception.

For sweetness, the sucrose (Figure 16) and the HFCS (Figure 17) sweetened products both had high percentages of responses at the "just-right" rating and an apparently normal distribution. The use of sucrose and HFCS at the levels tested provided appropriate sweetness in the flavored carbonated milk beverage system. From the panelist responses of carbonation level and sweetness on the "just right" scale, sucrose and HFCS seemed to performe as the more appropriate sweeteners for a flavored carbonated milk beverage than either aspartame or pear concentrate. Though there was no significant difference among sweeteners for the attributes rated as judged by the trained panel, the descriptive terms used in their comments (Appendix 3) indicated that the aspartame and pear concentrate sweetened products manifested such undesirable characteristics as "wheaties", "grainy", "stale" and "cooked" off-flavors, and "bitter" and "offensive" taste. The results from both the trained and consumer panels indicated that there were some problems in the use of pear concentrate and aspartame in these flavored carbonated milk beverages. The aspartame sweetened product (Figure 18) was judged to be not sweet enough by 42.3% of the panelists. This was congruous with the sweetness perceived by the trained panel. Again the



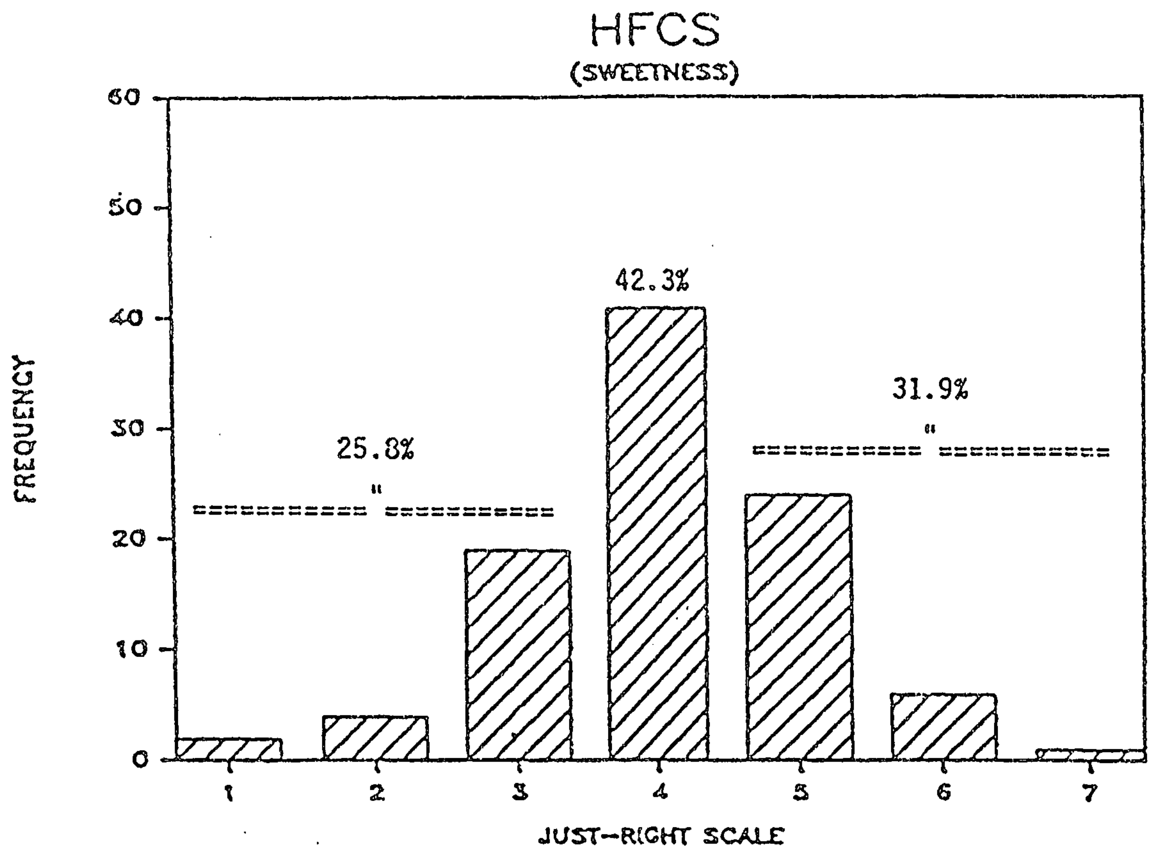
1 - way too low II
2 - moderately too low II - too low
3 - slightly too low II
4 - just right
5 - slightly too high II
6 - moderately too high II - too high
7 - way too high II

FIGURE 15. The Distribution of the Carbonation Level Responses for the Pear Concentrate Sweetened Product by the Consumer Panels (combination of panels I and II)



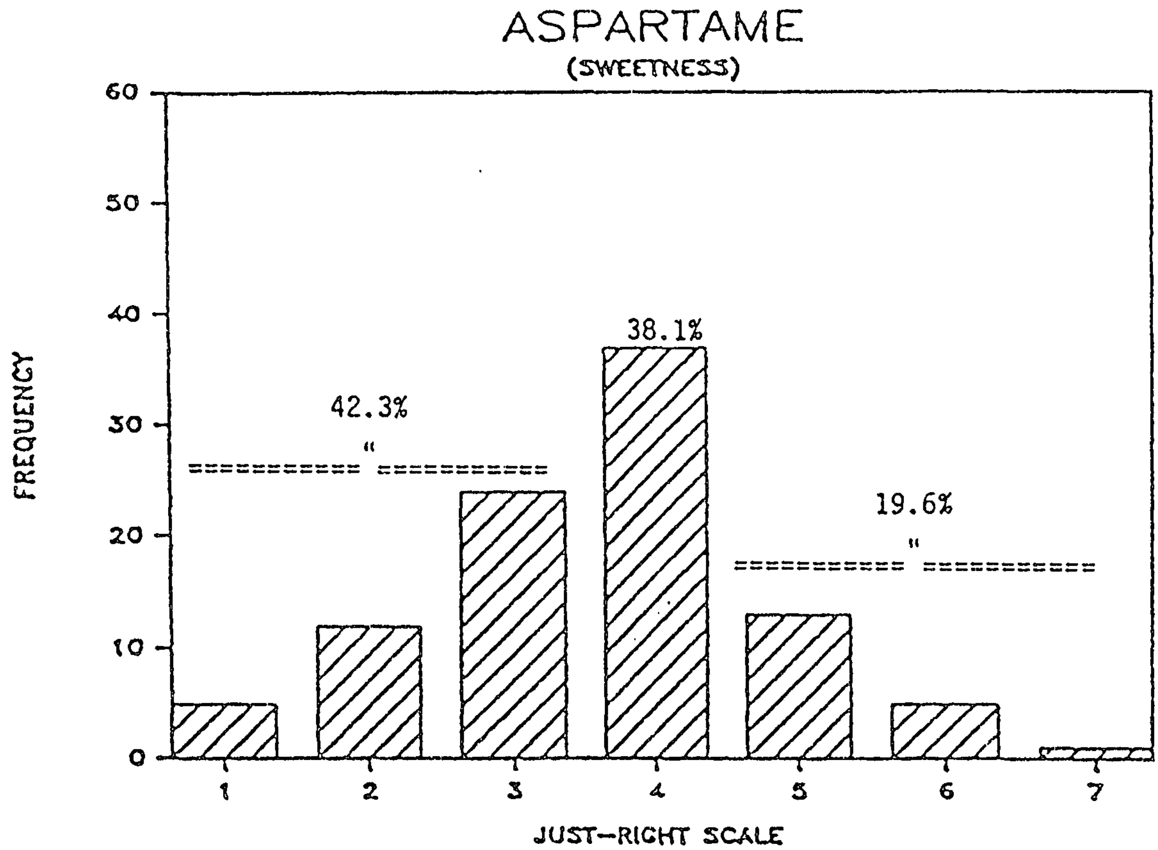
1 = way too low	II
2 = moderately too low	II = too low
3 = slightly too low	II
4 = just right	
5 = sightly too high	II
6 = moderately too high	II = too high
7 = way too high	II

FIGURE 16. The Distribution of the Sweetness Responses for the Sucrose Sweetened Product by the Consumer Panels (combination of panels I and II)



1 = way too low	II
2 = moderately too low	II = too low
3 = slightly too low	II
4 = just right	
5 = moderately too high	II
6 = slightly too high	II = too high
7 = way too high	II

FIGURE 17. The Distribution of the Sweetness Responses for the HFCS Sweetened Product by the Consumer Panels (combination of panels I and II)



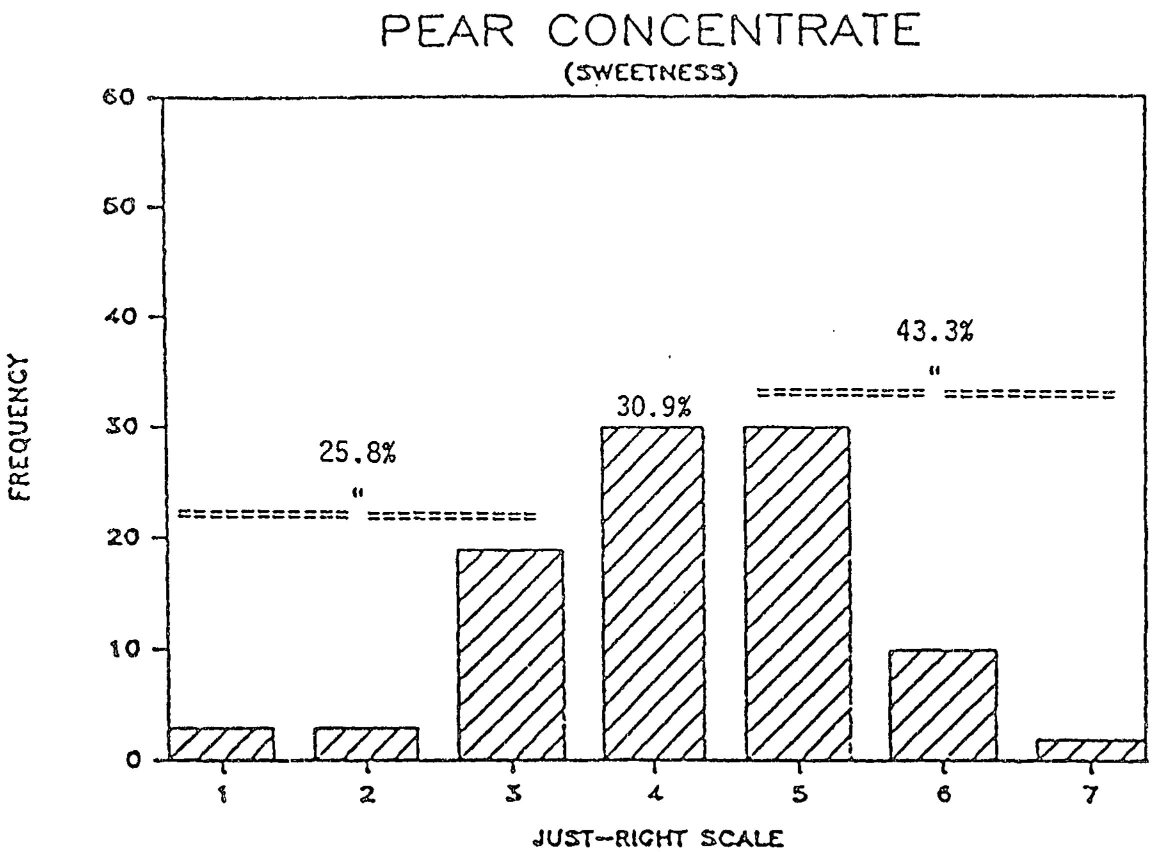
1 = way too low II
2 = moderately too low II = too low
3 = slightly too low II
4 = just right
5 = slightly too high II
6 = moderately too high II = too high
7 = way too high II

FIGURE 18. The Distribution of the Sweetness Responses for the Aspartame Sweetened Product by the Consumer Panels (combination of panels I and II)

reduction of sweetness for the aspartame sweetened product was quite possible due to processing affects. However, chemical analysis of final aspartame levels were not undertaken in this project. Aspartame breakdown should be monitored in subsequent studies. The pear concentrate sweetened product (Figure 19) was rated "too sweet" by 43.3% of the panelists. The characteristic fruit-like flavor in pear concentrate may enhance the sweetness perception for the consumer panel.

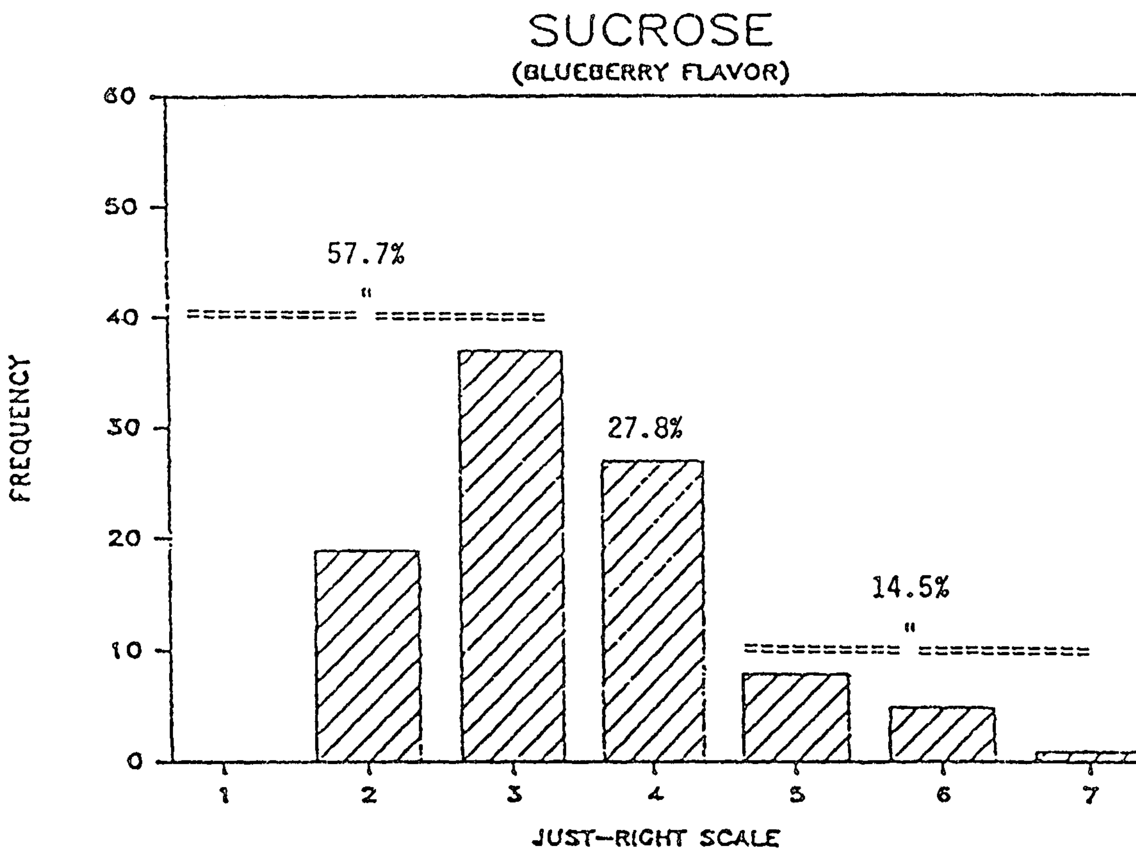
The blueberry flavor was apparently too low for the sucrose (Figure 20), HFCS (Figure 21) and aspartame (Figure 22) sweetened products by 57.7%, 48.5% and 60.0% of the panelists, respectively. The responses for blueberry flavor in the pear concentrate sweetened product (Figure 23) had a more normal distribution than the other three sweetened products. A high proprotion of the panelists felt that the flavor level was "too high" in the pear concentrate sweetened product. This was quite possibly due to the fruit-like flavors possessed by the pear concentrate.

Consumer panels are usually made up of "users" of the product. In this research which involved a new product concept, product users as such were not available. Because nearly all the participating consumer panelists had never evaluated a carbonated milk beverage before, some negative reaction was expected. In subsequent research efforts that may use consumer panels for the evaluation of flavored carbonated milk beverages, the screening of panelists with



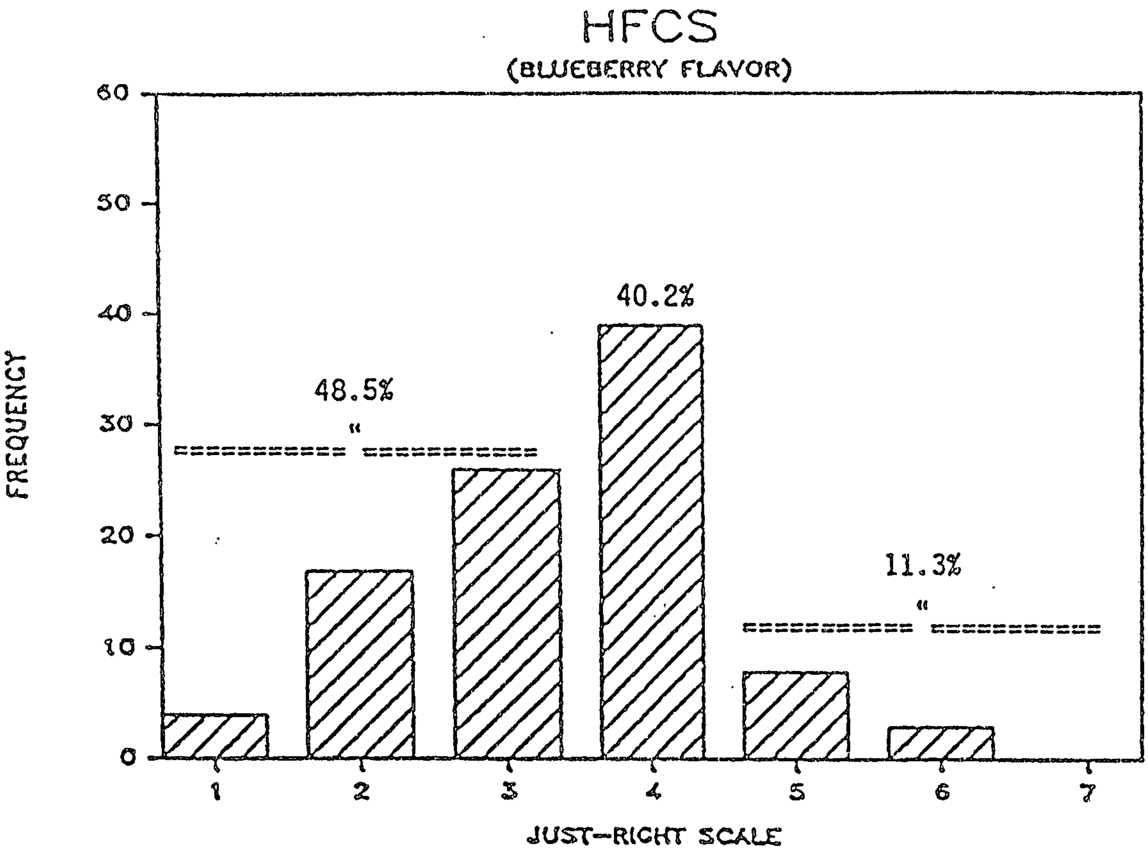
1 = way too low II
2 = moderately too low II = too low
3 = slightly too low II
4 = just right
5 = slightly too high II
6 = moderately too high II = too high
7 = way too high II

FIGURE 19. The Distribution of the Sweetness Responses for the Pear Concentrate Sweetened Product by the Consumer Panels (combination of panels I and II)



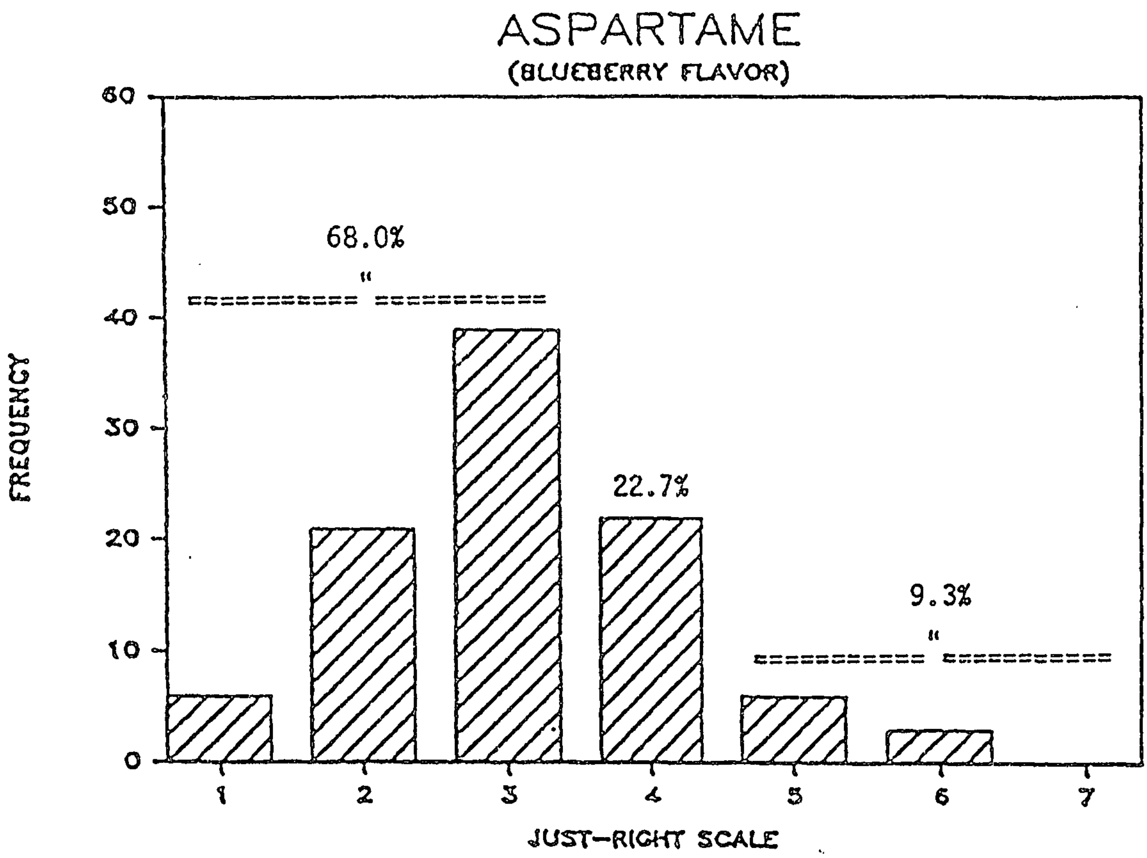
1 = way too low — II
2 = moderately too low — II = too low
3 = slightly too low — II
4 = just right
5 = moderately too high — II
6 = slightly too high — II = too high
7 = way too high — II

FIGURE 20. The Distribution of the Blueberry Flavor Responses for the Sucrose Sweetened Product by the Consumer Panels (combination of panels I and II)



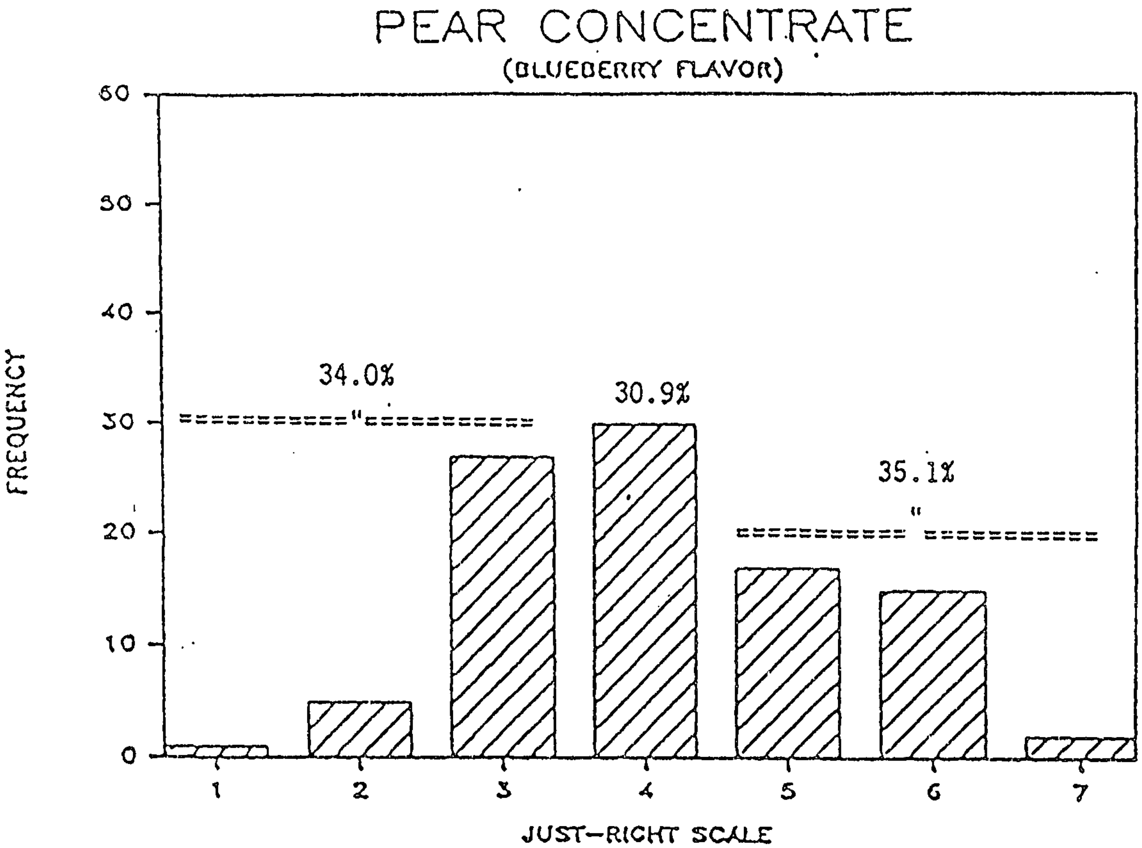
1 - way too low II
2 - moderately too low II - too low
3 - slightly too low II
4 - just right
5 - slightly too high II
6 - moderately too high II - too high
7 - way too high II

FIGURE 21. The Distribution of the Blueberry Flavor Responses for the HFCS Sweetened Product by the Consumer Panels (combination of panels I and II)



1 = way too low II
2 = moderately too low II = too low
3 = slightly too low II
4 = just right
5 = slightly too high II
6 = moderately too high II = too high
7 = way too high II

FIGURE 22. The Distribution of the Blueberry Flavor Responses for the Aspartame Sweetened Product by the Consumer Panels (combination of panels I and II)



1 - way too low — II
2 - moderately too low — II - too low
3 - slightly too low — II
4 - just right
5 - sightly too high — II
6 - moderately too high — II - too high
7 - way too high — II

FIGURE 23. The Distribution of the Blueberry Flavor Responses for the Pear Concentrate Sweetened Product by the Consumer Panels (combination of panels I and II)

regard to their milk consumption habits and their acceptance of a "carbonated milk" concept would be advisable. Potential panelists might be classified into two distinct groups: 1)those individuals who drink fluid milk beverages and 2) those persons who do not consume milk. This could help discern if milk consumption patterns influence the sensory acceptability of carbonated milk beverage.

CONCLUSIONS

Determination of Process Parameters

The following conclusions were drawn from the results of experiments and product trials in this study:

1) A carbonation procedure which employed precharging of the vessel headspace with CO_2, served to markedly inhibit foam formation (protein) during carbonation. The pressure for precharging was 1.05 Kg/cm^2 (15 PSI) and the pressure for carbonation was 1.4-1.75 Kg/cm^2 (20-25 PSI).

2) A combination of heat treatment(85^{o}C, 30 minutes) and addition of carboxylmethyl cellulose (CMC) decreased markedly the initial casein coagulation caused by the low pH of the fruit concentrate. The appropriate level of CMC for a sweetened blueberry flavored milk beverages was 0.15%. (wt/wt).

3) The equisweetness levels for the flavored milk beverage system for four different sweetener sources were 4.5% (wt/wt) sucrose, 6.5% (wt/wt) high fructose corn syrup (HFCS), 10.0% (wt/wt) pear concentrate and 0.015% (wt/wt) aspartame.

Sensory Evaluation

The results indicated that the carbonation level significantly enhanced the sensory ratings of overall (flavor) intensity, sweetness and blueberry (characterizing) flavor while there was no effect on perceived viscosity ratings. There was a significant sweetener source effect for perceived viscosity while there was no significance for the other three attributes. The perceived viscosity was highest for the pear concentrate sweetened product while it was lowest for the sucrose sweetened product.

Normalization Procedure

The comparison between the LOG normalization method and the GM normalization method demonstrated that the results from both normalization methods were identical for this given ANOVA model.

Consumer Acceptability

The consumer panel rating of the products which employed a 9-point hedonic scale indicated that there was not a significant difference among sweeteners for panel I. For panel II, there were significant differences among sweeteners on hedonic ratings. The sucrose and HFCS sweetened product had significantly higher hedonic ratings than the aspartame sweetened product. Sensory results reflected that the consumer panel acceptability of the current formulation of a carbonated blueberry flavored milk beverage was not very high. The percentage of the respondents who liked the product was approximately 50%. Beverage formulas obviously require adjustments to increase potential product acceptability. The results on the "just right" scale indicated that sucrose and HFCS were more appropriate beverage sweeteners than were aspartame and pear concentrate. Panel results indicated that the level of flavorings (blueberry concentrate and blueberry WONF) need to be increased.

The objectionable separation of beverage components (protein) and the unattractive color of the beverage system at its current state of development certainly appear to be severe obstacles for consumer acceptability. Further research work on reduction of the separation phenomenon may require the use of a more complex stabilizer and/or buffering system(s) (ie. appropriate type of carrageenan in conjunction with various forms of CMC [Anonymous, 1984]). In an effort to overcome the unattractive beverage color, further research on the use of either decolorized fruit concentrate or the incorporation of appropriate colorants may be required.

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APPENDICES

APPENDIX 1. The ANOVA Model of Overall Intensity, Sweetness Blueberry Flavor and Viscosity for the Trained Panel Data

Source	Effect	Expected value of mean square
Batch(B)	R	$\delta_{pbcs}+S\delta_{pbc}+C\delta_{bps}+P\delta_{bcs}$ $+SP\delta_{bc}+CP\delta_{bs}+CS\delta_{bp}+CSP\delta_{p}$
Panelist(P)	R	$\delta_{pbcs}+S\delta_{pbc}+C\delta_{bps}+B\delta_{pcs}$ $+CB\delta_{ps}+BS\delta_{pc}+CS\delta_{bp}+BCS\delta_{p}$
BXP	R	$\delta_{pbcs}+S\delta_{pbc}+C\delta_{bps}+CS\delta_{bp}$
Carbonation level(C)	F	$\delta_{pbcs}+S\delta_{pbc}+P\delta_{bcs}+B\delta_{pcs}$ $+SP\delta_{bc}+BS\delta_{pc}+BSP\phi_{c}$
BXC	R	$\delta_{pbcs}+S\delta_{pbc}+P\delta_{bcs}+SP\delta_{bc}$
PXC	R	$\delta_{pbcs}+S\delta_{pbc}+B\delta_{pcs}+BS\delta_{pc}$
PXBXC	R	$\delta_{pbcs}+S\delta_{pbc}$
Sweetener source(S)	F	$\delta_{pbcs}+B\delta_{pcs}+P\delta_{bcs}+C\delta_{bps}$ $+CP\delta_{bs}+CB\delta_{ps}+BCP\phi_{s}$
BXS	R	$\delta_{pbcs}+C\delta_{bps}+P\delta_{bcs}+CP\delta_{bs}$
PXS	R	$\delta_{pbcs}+C\delta_{bps}+B\delta_{pcs}+CB\delta_{ps}$
BXPXS	R	$\delta_{pbcs}+C\delta_{bps}$
CXS	F	$\delta_{pbcs}+P\delta_{bcs}+B\delta_{pcs}+BP\phi_{cs}$
BXCXS	R	$\delta_{pbcs}+P\delta_{bcs}$
PXCXS	R	$\delta_{pbcs}+B\delta_{pcs}$
PXBXCXS	R	δ_{pbcs}

R - Random effect   F - Fixed effect

δ- Random effect component
ϕ- Fixed effect component

APPENDIX 2. The ANOVA Model of Carbonation Perception for the Trained Panel Data

Source	Effect	Expected value of mean square
Batch(B)	R	$\delta_{bps}+S\delta_{bp}+P\delta_{bs}+PS\delta_{b}$
Panelist(P)	R	$\delta_{bps}+S\delta_{bp}+B\delta_{ps}+BS\delta_{p}$
BXP	R	$\delta_{bps}+S\delta_{bp}$
Sweetener source(S)	F	$\delta_{bps}+P\delta_{bs}+B\delta_{ps}+BP\phi_{s}$
BXS	R	$\delta_{bps}+P\delta_{bs}$
PXS	R	$\delta_{bps}+B\delta_{ps}$
BXPXS	R	δ_{bps}

δ- Random effect component
ϕ- Fixed effect component

APPENDIX 3. Comments From the Trained Panel

Sweeteners	Carbonated Beverages	Noncarbonated Beverages
Sucrose	none	none
HFCS	none	old milk flavor, clean sweetness, cooked taste, corn flavor
Aspartame	bitter taste, cooked taste	bland flavor, cooked flavor, not refreshing, un-mouth coating
Pear concentrate	sour berry flavor, wheaties flavor, stale taste, grainy, honey-like taste, burnt sweetness, offensive taste	wheaties flavor, off taste stale taste, cooked flavor grainy flavor, extremely sour flavor

APPENDIX 4. Comments From the Consumer Panel
(for general description of product regardless sweetener)

Panelists who	description terms
LIKED :	
	smooth mouth-feel, refreshing taste, carbonation pleasant, pleasant effervesce, milkshake-like, satisfying balance.
DISLIKED :	
	unnatural bitter, over carbonation, mouth coating, not refreshing, carbonation does not fit with overall taste, lack of effervesce, high viscosity, thin, watery, unusual texture, cooked milk, color is too grey.