SENSORY CHARACTERISTICS OF ICE CREAM PRODUCED IN THE UNITED STATES AND ITALY

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ABSTRACT

This study was conducted to define and compare sensory characteristics of high quality Italian gelati to ice creams produced in the United States. Trained descriptive sensory panelists evaluated gelato samples in Italy, purchased direct from local gelaterias, and ice cream samples in the U.S., purchased from grocery stores and local shops. In general, gelati obtained higher overall fruity and fruit ID scores, chocolate gelati higher chocolate and cocoa notes, and vanilla gelati higher vanilla and lower vanillin intensities than most U.S. ice creams. Gelati were consistently associated with higher density, lower firmness, and slower meltdown. When compared to U.S. ice creams, Italian gelati are characterized by specific sensory properties: “true to type” flavors: high intensity flavors considered to be typical to that flavor category or specific fruit and are combined with a dense, smooth texture that allows for the development of flavor, body and bloom, enhancing the perception of flavors.

PRACTICAL APPLICATIONS

The research conducted in this study may be useful for ice cream manufacturers and sensory scientists. These results are the first to define sensory characteristics of high quality Italian gelati and may be used to produce ice cream with increased consumer liking. The descriptive attributes developed can be used for the development of new flavors or for the improvement of ice cream products already on the market.

Key words: Ice cream, Gelato, Sensory, Descriptive Analysis

INTRODUCTION

Over the past 10 years ice cream consumption in the U.S. has remained stable, averaging approximately 15 pounds of ice cream per capita (USDA 2006). However, higher priced, higher milk fat premium and superpremium ice creams sales have risen (Putnam and Allhouse 2003). A main competitor of superpremium ice cream is gelato, which has been popular in Italy and is increasing in popularity in the United States (Ryan 2005; Bray 1993). Approximately 92% of Italians consume gelato (Magretti 1997), which is most notable for its natural flavors and denseness that produces heightened flavor (Berry 2004; International Dairy Foods Association 2005).

Although ice cream and gelato appear similar, there are differences. Italian gelato has little or no overrun, the air added to frozen dessert products to increase volume (Marshall et al. 2003), whereas ice cream overrun varies from 30% or less for superpremium ice cream to 95-100% for other types (U.S. Dairy Export Council 2001). Italian gelato has no stabilizers or emulsifiers that typically are used in ice creams to increase viscosity (Marshall et al. 2003; Clark, 2004). Gelato is made using 4-8% butterfat (Bray 1993; Marshall and Goff 2003) and ice creams are made with at least 10% butterfat and premium and superpremium ice creams contain 12-18% fat (Marshall et al. 2003; IDFA 2005; Pszczola 2002; U.S. Dairy Export Council 2001).

In addition to compositional differences, gelato and ice cream quality differ based on differences in production and storage. Gelato typically is produced fresh using a batch freezer and is extruded immediately. Gelato is held and served at a consistent temperature, around -11˚C (12-15˚F), allowing it to be served in a highly viscous semi-frozen state (Marshall et al. 2003). U.S. style ice cream on the other hand, typically is produced using an industrial ice cream freezer that simultaneously aerates and freezes the mix. The ice cream then is stored at a

temperature of about -18˚C (-0.4˚F), with an ideal serving temperature of -14 to -12˚C (6-10˚F) (Clarke 2004; IDFA 2007).

Many studies have measured sensory properties of ice cream to examine the relationship among various ingredients and sensory characteristics such as flavor and texture. Hyvönen et al. (2003) found that the nature of strawberry flavoring affects flavor perception and that modifying fat distribution influences flavor release in ice cream; dairy fat retards flavor release at the highest level (~18 %). Replacement of milk fat with tapioca dextrin or potato maltodextrin also significantly affects textural properties; increasing coarseness and wateriness and decreasing creaminess of ice cream (Specter and Sester 1994). Stampanoni-Koeferli et al. (1996) showed that the addition of fat increased the buttery and creamy notes in ice cream as well as its mouthcoating, while increases in sugar levels increased sweetness, caramel and vanillin attributes, and decreased milkiness. Guinard et al. (1996) demonstrated that sugar and, to a lesser extent, fat were key determinants of ice cream acceptability and that too little or too much sugar or fat was detrimental to ice cream quality. Other studies also determined that higher fat content positively affected overall sensory quality of ice cream (Zheng et al. 1997; Roland et al. 1999; Ohmes et al. 1998).

No studies were found related to factors affecting the sensory properties of Italian gelato. The objectives of this study are to define typical sensory characteristics of high quality Italian gelati and to compare that to ice creams produced in the U.S.

MATERIALS AND METHODS

Samples

Sensory characteristics of 14 U.S. ice creams, 3 U.S. gelati, and 18 Italian gelati, all commercially available, were evaluated (Table 1). Fruit, chocolate and vanilla flavored ice creams were chosen for this study based on their availability and popularity.

Ice cream samples were purchased from a local grocery store and an ice cream specialty shop (Dillon's and Cold Stone Creamery, respectively) in Manhattan, KS and were stored in a Frigidaire Commercial Freezer (Model # FFC05K2CW) at approximately -19°C (-2˚F) until testing. Cold Stone Creamery samples were purchased and evaluated within the same day; other commercial ice cream samples were tested within 1 week of purchase. To eliminate bias, no information was given to the panelists about the samples. All samples were served in a Styrofoam cup with random 3-digit numbers. Apples and water were provided between samples for rinsing between samples.

Italian gelati were made fresh, daily, and were maintained at approximately -13°C (8˚F). The Italian samples were purchased in Styrofoam containers from local gelaterias (gelato shops); Vivoli, Perseo, Conti, and Badiani (all in Florence, Italy). Samples were purchased one or two at a time and were evaluated within 45 minutes of purchase. Specific gelaterias were selected based on referrals from travel guides, local recommendations, and availability of specific flavor variations. Although the Italian gelati were made fresh daily, production was considered proprietary and no information was available concerning the specific production procedures. Gelato samples from the U.S. were produced in a local specialty shop (Love Bites Café, Riverside, Missouri). These samples were purchased in individual 3 oz. cups and were evaluated immediately after purchase. The U.S. gelato samples were made fresh daily, using an imported

batch freezer (Carpigiani brand, model 3LB502G, Anzola dell'Emilia, Italy) made specifically for the production of gelato.

Panelists

Five professional panelists from the Sensory Analysis Center, at Kansas State University, Manhattan, Kansas, U.S.A. participated in this study. The highly trained and experienced panelists had completed 120 hours of general training and had an average of more than 2,000 hours of testing experience. All panelists had more than 200 hours of prior testing experience with a variety of diary products including milk, cheese, and ice cream and had previously used flavor profile procedures adapted from Caul (1957) and Keane (1992). Trained panels have typically been used in recent studies of dairy products for development of attributes and comparison of products (Drake et al, 2007; Yates and Drake, 2007; Karagul-Yuceer, Isleten, and Uysal-Pala, 2007; Talavera-Bianchi, Chambers, and Chambers, 2008);

Lexicon Development

During 15 hours of orientation, prior to testing, lexicons for ice cream, fruit, vanilla, and chocolate previously developed in the Sensory Analysis Center were used by the panel. Because orientation was held in the U.S., without the availability of Italian gelato samples, samples for orientation included a number of samples not included in the final study, such as sorbets and homemade gelati. Panelists also understood that they could add new terms if needed during the evaluation phase. The combined generalized lexicon consisted of 42 descriptors and definitions (Tables 2 and 3).

Evaluation Procedures

Panelists evaluated 35 ice cream and gelato samples using the developed lexicon for intensities of flavor, texture and amplitude attributes. A modified texture and flavor profile method adapted from Caul (1957) and Keane (1992) was used. The flavor profile method is based on consensus data obtained from highly trained panelists. A 15-point intensity scale with a range of 0 (none) to 15 (extremely high) was used by the panelists. Each panelist individually assigned a score for each attribute perceived in the sample. Once all panelists finished assigning intensity scores for a sample, a discussion was held among the panelists to reach a consensus list of attributes and attribute scores for that product. This procedure has been used for a wide variety of product types including but not limited to: soymilk (Chambers et al. 2005), beany aroma (Vara-Ubol et al. 2004), cheese (Retiveau et al. 2005) and apple juice (Cliff et al. 2000).

Eighteen gelato samples were evaluated over a 5 day period in Florence, Italy. Samples were purchased fresh, one or two at a time, from local gelaterias and evaluated within 30 minutes of purchase. Blind samples were served in 3.25 oz plastic cups. No references were given.

In order to test the U.S. gelato in a similar manner to testing in Italy, panelists traveled to the site of production; Love Bites Café, Riverside, MO. Three gelato samples were evaluated. Samples were purchased in 3 ounce servings and evaluated in twenty minute timeframes, similar to previous testing. The gelati were evaluated using consensus data and were scored on the same worksheet designed in Italy based on texture, flavor, tastes and amplitude (Appendix E).

Fourteen U.S. ice cream samples were was evaluated over a five day period. Each day the panelists saw three ice cream samples. Each sample was evaluated in approximately thirty minutes. Each panelist was given three scoops of ice cream per Styrofoam bowl (8S-J20), using a Pampered Chef Large Scoop #1790. Samples were served at ~15°C (-5°F). All samples were

coded with three-digit random numbers and all orders of serving were completely randomized. No references were provided to the panelists so that the evaluation would be similar to the testing in Italy.

Data Analysis

Ice creams and gelatos were organized into categories: fruits, vanillas and chocolates. Unscrambler 9.6 was used to provide a principal component analysis (PCA) for each flavor category. The analysis was conducted using the covariance matrix because all attributes were scored on the same 15 pt. scale. PCA maps were created individually for flavor, texture and amplitude for each flavor category.

RESULTS AND DISCUSSION

For most flavors, Italian gelati scored higher in characteristic notes (i.e. fruity, chocolate/cocoa, vanilla), flavor bloom, and fullness of flavor than the U.S. ice creams (Figures 1-9). Overall, fruit flavored gelati from Italy were less bitter, less sweet, more sour, and more astringent than fruit flavored ice creams (Figure 1). On the contrary, vanilla and chocolate gelati from Italy were sweeter than their U.S. counterparts (Figure 4 and Figure 7). Gelati consistently were associated with higher density, lower firmness, and slower meltdown (Figure 3, Figure 6, and Figure 9). Otherwise, gelati and ice cream samples had similar intensity for textural characteristics.

Flavor Characteristics of Fruit Samples

All Italian samples of fruit flavored gelati, with the exception of coconut, were associated with fresh and fruity characteristics (Principal Component (PC)1, Fig. 1), while all U.S. samples, with the exception of superpremium raspberry, mango, and lemon, were more associated with diary, cooked, and filler characteristics (PC2, Fig. 1). In Figure 1 fresh, fruit ID, fruity, floral,

sour, astringent, and bitter align on the same side of the map. Those notes typically are found in ripe, fresh fruits (Baron and Hanger 1998; Heath 1978). Dairy, dairy fat, dairy-cooked, fruity-cooked, and filler flavor properties all appear on the opposite side of the map. Those characteristics appear more typical of dairy products (Ohmes et al. 1998; Drake 2004). Thus, the Italian gelati samples have sensory properties that are more like fresh fruit with some dairy notes, whereas the U.S. samples were more similar to dairy products with some added fruit flavor characteristics.

Interestingly, the Italian lemon gelato created somewhat of an outlier, compared to the other fruit samples because it was more fresh and fruity flavored than other products. The Italian lemon also was more sour and less sweet. These characteristics previously have been associated with fresh lemon flavors (May 1980; Baron and Hanger 1998).

Amplitude Characteristics of Fruit Samples

Amplitude reflects the degree to which characteristics fit together and last while the product is in the mouth and immediately after swallowing. The variation in amplitude of the fruit flavored samples is driven by overall amplitude, longevity, bloom (PC1, Fig. 2) and impact (PC 2, Fig. 2). Approximately, two-thirds of the Italian samples and the more expensive U.S. ice cream products had amplitude scores that are in the upper half of the range (PC1 and PC2). Products with substantial fruit identity and fewer off-flavors appear to provide flavor experiences that are more full and long-lasting, which may be associated with higher quality.

Texture Characteristics of Fruit Samples

Particle awareness drove variation in texture of the fruit samples (PC 1, Fig. 3). The Italian strawberry and raspberry gelato samples were high in seed awareness, which indicates the use of fresh fruit. The majority of the Italian samples and the U.S. raspberry, lemon and coconut

samples also are associated with fruit awareness, which is the perception of fruit within the ice cream. The Italian strawberry sample as well as the U.S raspberry and lemon samples are driving the iciness attribute as seen on the right side of the map, this can be attributed to the fact that the U.S samples are sorbet-type of products which are water based. Fat feel/mouth coating-type attributes, as seen in PC 2, Fig. 3, are more commonly associated with dairy products such as milk and cream (Ohmes 1998). Most of the Italian samples with the exception of mango, coconut and banana, align on the opposite map from the mouth coating/fat feel attributes. This probably is because the majority of Italian gelato is made with fresh fruits and little cream (Bray 1993). The Italian samples mango, coconut and banana found on the same side of the map as the dairy attributes are types of fruit that are naturally rich, thick and creamy, giving the impression of fat feel and mouth coating.

Flavor Characteristics of Vanilla Samples

The Italian samples were characterized as eggy and caramelized (PC1, Fig. 4), typical descriptors of European ice creams (Piccinali 1996). The less expensive U.S. ice creams were associated with vanillin and dairy cooked flavors (PC2, Fig. 4), while the more expensive U.S. ice creams were more associated with the attributes of vanilla, dairy fat and floral. Chung (2003) and Zheng (1997) determined that the increase of fat level in ice creams enhances overall vanilla intensity, and decreases vanillin perception, which explains the high vanilla scores in the higher-fat premium ice creams and high vanillin scores in regular, lower-fat ice creams similarly. Homer (1994) indicates that 'harsher' vanilla flavor notes, which normally are masked by fat, might be more intense in lower-fat products. Low scores for vanilla and higher scores for vanillin, as exemplified in some U.S. ice cream samples, may also be the result of the use of imitation vanilla or vanilla flavorings.

Amplitude Characteristics of Vanilla Samples

For vanilla, most of the Italian samples, as well as the super premium U.S. ice cream and U.S. gelato, exhibited high scores for amplitude. The inexpensive U.S. ice creams align on the opposite side of the map indicating low scores in all amplitude measures. Inexpensive U.S. ice creams typically are lower in fat and use imitation vanilla or vanilla flavorings resulting in a product that it one dimensional and does not bloom nor last while in the mouth. The variation in amplitude is driven by base/fullness, overall amplitude and impact (PC1, Fig. 5), and blendedness and longevity (PC2, Fig. 5).

Texture Characteristics of Vanilla Samples

U.S.Van1 and 3 ice creams were more firm (PC1, Fig. 6) and less dense (PC2, Fig. 6) than the Italian and U.S. gelati. This is most likely attributed to the higher amount of overrun that is incorporated into U.S. ice creams (USDEC 2001; Bray and Milano 1993), but also may be related to differences in serving temperatures of the ice cream and gelati samples; ~15°C and -13°C, respectively. The superpremium U.S.Van4 was both firm and dense; it is most likely dense due to the decrease in overrun that is typical of superpremium ice creams, it is firm as a result of its frozen storage conditions.

Flavor Characteristics of Chocolate Samples

The Italian samples were associated with chocolate complex, cocoa, and dark roast characteristics (PC1, right side of Fig. 7), flavor attributes typically associated with quality chocolate (Hoskin 1994; Minifie 1999). The U.S. samples were more associated with dairy, cooked and filler characteristics (PC2, Fig. 7); characteristics more typical of artificial chocolate products. This is largely due to great differences, both in grade or quality, in the cocoa and chocolate used for the flavor in chocolate ice creams produced in the U.S. (Welty et al. 2001).

Amplitude Characteristics of Chocolate Samples

All of the Italian samples were associated with overall amplitude yet exhibit different aspects of amplitude (PC1, Fig. 8). ItChoc2 is more blended and has more base/fullness indicating the use of milk chocolate flavorings. ItChoc3 exhibits more impact properties which is the immediate reaction to the dominant flavor notes and their intensities demonstrating that this sample may have been flavored with a stronger, dark roast type of chocolate that has a greater impact than a more blended milk chocolate. The U.S. samples were less blended, had less base/fullness and, generally, were lower in overall amplitude. Amplitude scores were probably lower for the U.S. samples as a result of the use of imitation flavorings or rework typical in U.S. ice creams (Clark 2004). The Italian samples on the other hand had high amplitude scores as their flavors were more complex, most likely due to the use of quality ingredients and little or no rework.

Texture Characteristics of Chocolate Samples

The U.S. chocolate ice creams were more firm, (PC 1, Fig. 9), and less viscous probably because of increased overrun (U.S.D.E.C 2001; Bray and Milano 1993) compared to the Italian samples. The Italian products were more dense with rapid-meltdown (PC2, Fig. 9) and less icy.

CONCLUSIONS

A total of 35 Italian and United States produced ice creams were evaluated for their flavor and texture attributes. These results show that sensory characteristics of the Italian gelato samples clearly were different from many U.S. samples. The Italian gelati were most similar to higher-end U.S. ice cream samples, but differences existed even in those comparisons. When compared to U.S. ice creams, Italian gelati were characterized by “true to type” flavors; flavors that generally are intense and considered to be typical of ripe fruit in that flavor category. The

fruit gelati can be described as fresh, fruity and more sour than sweet; an eating experience that is similar to eating a piece of fruit. The U.S fruit ice creams, on the other hand, had more dairy notes and some off-flavors. The chocolate and vanilla gelati, and the more expensive U.S ice creams, can also be characterized as having flavors that are associated with higher quality ingredients including natural flavorings and extracts (e.g. cocoa powder and pure vanilla). Some U.S. samples had flavors associated with imitation flavorings.

Texturally, the Italian samples can be characterized as having a dense, smooth texture that may have allowed for the development of body and bloom in the flavor, resulting in enhanced perception. The U.S ice cream samples are firmer, which has been related to the increased amount of overrun typical in ice cream production, but also may be related to differences in serving temperature.

When comparing the U.S. gelati to the Italian gelati, the U.S. produced fruit gelati are more similar to U.S. ice cream than to Italian gelati samples. The flavor of the U.S. fruit gelati is more typical of dairy products with some added fruit flavor characteristics. U.S. gelati fruit samples have amplitude scores in the low end of the range whereas Italian gelati score in the upper half of the range. Additionally the texture of the U.S. gelati can also be associated with dairy-like attributes fat feel and mouthcoating. The U.S. vanilla gelato on the other hand is more similar to the Italian gelati in amplitude and texture. The flavor of the U.S. vanilla gelato is more closely related to the U.S. superpremium ice creams; exhibiting vanilla, floral and dairy fat characteristics.

The research conducted in this study may be useful for ice cream manufacturers and sensory scientists. The descriptive terms developed, defined, and referenced can be used for the development of new flavors or for the improvement of ice cream products already on the market.

Ice cream can be described using this set of objectively determined sensory attributes instead of being judged subjectively by defects alone.

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TABLE 1.
ICE CREAM FLAVORS AND BRANDS

Flavor	ID	Brand	Production
Fruit			
Pineapple Sherbet	US Pineap	Kroger Deluxe	Hutchinson, KS
Pineapple Gelato	It. Pineap	Vivoli	Florence, Italy
Pineapple Gelato	USG Pineap	Love Bites Café	Riverside, MO
Strawberry Ice Cream	US Straw	Country Club	Cincinnati, OH
Strawberry Gelato	It. Straw1	Conti	Florence, Italy
Strawberry Gelato	It. Straw2	Vivoli	Florence, Italy
Lemon Sorbet	US Lemon	Cold Stone Creamery	Manhattan, KS
Lemon Gelato	It. Lemon	Vivoli	Florence, Italy
Coconut Ice Cream	US Coconut	Edy's	Oakland, CA
Coconut Gelato	It. Coconut	Perseo	Florence, Italy
Coconut Gelato	USG Coconut	Love Bites Café	Riverside, MO
Raspberry Sorbet	US Rasp	Cold Stone Creamery	Manhattan, KS
Raspberry Gelato	It. Raspb	Conti	Florence, Italy
Mango Ice Cream	US Mango	Edy's	Oakland, CA
Mango Gelato	It. Mango1	Vivoli	Florence, Italy
Mango Gelato	It. Mango2	Perseo	Florence, Italy
Orange Gelato	It. Orange	Vivoli	Florence, Italy
Tangerine Gelato	It. Tang	Badiani	Florence, Italy
Banana Gelato	It. Banana	Vivoli	Florence, Italy
Apple Gelato	It. Apple	Vivoli	Florence, Italy
Vanilla			
Vanilla Ice Cream	US Van1	Kroger Deluxe	Hutchinson, KS
Vanilla Ice Cream	US Van2	Edy's	Oakland, CA
Vanilla Ice Cream	US Van3	Blue Bunny	LeMars, IA
Vanilla Ice Cream	US Van4	Haagen Dazs	Oakland, CA
Vanilla Gelato (crema)	It.Crema1	Badiani	Florence, Italy
Vanilla Gelato (crema)	It. Crema2	Vivoli	Florence, Italy
Vanilla Gelato (crema)	It.Crema3	Conti	Florence, Italy
Vanilla Gelato	USG Van	Love Bites Café	Riverside, MO
Chocolate			
Chocolate Ice Cream	US Choc1	Blue Bunny	LeMars, IA
Chocolate Ice Cream	US Choc2	Kroger Deluxe	Hutchinson, KS
Chocolate Ice Cream	US Choc3	Edy's	Oakland, CA
Chocolate Gelato	It. Choc1	Vivoli	Florence, Italy
Chocolate Hazelnut	It. Choc 2	Vivoli	Florence, Italy
Chocolate w/Red Pepper	It.Choc3	Vivoli	Florence, Italy

TABLE 2.
SENSORY DESCRIPTORS FOR THE FLAVOR EVALUATION OF ICE CREAM AND GELATO

Flavor Attributes	***Definition***
Overall Dairy	A general term for the aromatics associated with products made from cow's milk.
Dairy Fat	The oily aromatics reminiscent of milk or dairy fat.
Dairy-Cooked	Aromatics reminiscent of heated or processed dairy products, similar to evaporated or sweetened condensed milk.
Eggy	Aromatics associated with a cooked whole egg.
Fruity-Ripe	Aromatics, which are sweet and reminiscent of a variety of ripe fruits.
Floral	Sweet, light, slightly perfumey impression associated with flowers.
Green-Unripe	An aromatic found in green/under-ripe fruit.
Vanilla	A woody, slightly chemical aromatic associated with vanilla bean.
Vanillin	The sweet aromatics and character identified with marshmallow.
Alcohol-like	The sharp, chemical medicinal impression associated with some flavoring extracts.
Chocolate Complex	A blend of cocoa and dark roast aromatics at varying intensities. This impression may also be accompanied by the following flavor notes: dairy, fruity, nutty, and sweet.
Cocoa	The aromatics associated with cocoa bean, powdered cocoa and chocolate bars. A dark brown, sweet, often musty aromatic.
Nutty	A non-specific, slightly sweet brown, nutty impression.
Caramelized	The aromatics that are sweet, brown, and may create a rounded, full-bodied impression.
Toasted	A moderately brown, baked impression.
Dark Roast	A burnt, somewhat bitter character present in a product that has been cooked at a high temperature, typical of very strong dark coffee.
Fruit ID (Typical)	An overall intensity of the specific fresh fruit which can include juice, pulp, or peel.
Fresh	An aromatic impression associated with fresh fruit.
Fruity-Cooked	An aromatic associated with heat-processed fruit, characterized as brown
Non-Natural	A sweet, somewhat fruity, non-natural aromatic commonly associated with candy products (e.g. lemon drops).
Overripe	Aromatics associated with fruits that are too ripe; marked by decay or decline.
Citrus-overall	Aromatics associated with commonly known citrus fruits such as fresh lemons and fresh limes.
Filler	Impression of a thickening substance added to the base product (e.g. starch).
Peely	The sour, slightly pungent, oil-like, citrus aromatics associated with the outer skin of a citrus fruit.
Sweet	Fundamental taste sensation of which sucrose is typical.
Bitter	Fundamental taste sensation of which caffeine or quinine are typical.
Sour	Fundamental taste sensation of which citric acid is typical.
Salt	Fundamental taste sensation of which sodium chloride is typical.
Astringent	Drying, puckering, or tingling sensation on the surface and/or edges of the tongue and mouth.

TABLE 3.
SENSORY DESCRIPTORS FOR THE TEXTURE AND AMPLITUDE EVALUATION OF ICE CREAM AND GELATO

Texture Attributes	***Definition***
Firmness	The force required to compress the sample between the tongue and palate (use the ice cream base only, without obvious inclusions, if present).
Density	The degree of compactness of the sample when pressed between the tongue and palate(use the ice cream base only, without obvious inclusions, if present).
Meltdown	The time required for the product to melt in the mouth when continuously pressed by the tongue against the palate. The number of seconds counted equals the numerical score (1/1000 count). Sample size is 1/3 tsp.
Viscosity	The measure of flow as the product melts on the tongue when pressed between the tongue and the palate; the more viscous the product the higher the number is on the scale.
Fat Feel	Refers to the intensity of the 'oily' feeling in the mouth when the product is manipulated between the tongue and the palate; perceived fat content.
Chalkiness	Measure of dry, powdery sensation in the mouth.
Iciness	The immediate perception of crystal-like particles within the sample. This measurement is taken immediately after sample has been placed in the mouth. The crystals often dissolve quickly at first manipulation.
Seed Awareness	The perception of berry seeds while the product is in the mouth.
Fruit Awareness	The perception of fruit within the ice cream, felt while the product is in the mouth.
Mouth Coating	A sensation of having a slick/fatty coating on the tongue and other mouth surfaces.
Amplitude Attributes	***Definition***
Impact	The immediate reaction to the intensity of the dominant flavor notes.
Blendedness	The combination of flavor notes that interact to create an equally balanced character in the product.
Base/Fullness	The foundation and interplay of flavor notes that gives substance to the product.
Longevity	The duration or continuation of attribute intensities after swallowing.
Bloom	The evaluation of the flavors ability to grow or “fill” the mouth, from first bite through swallowing.
Overall Amplitude	The overall impression of a product judged on three aspects: the base (body, fullness); impact and longevity; balance and blendedness. Amplitude reflects the degree to which characteristics have a base and blend, bloom, and last.

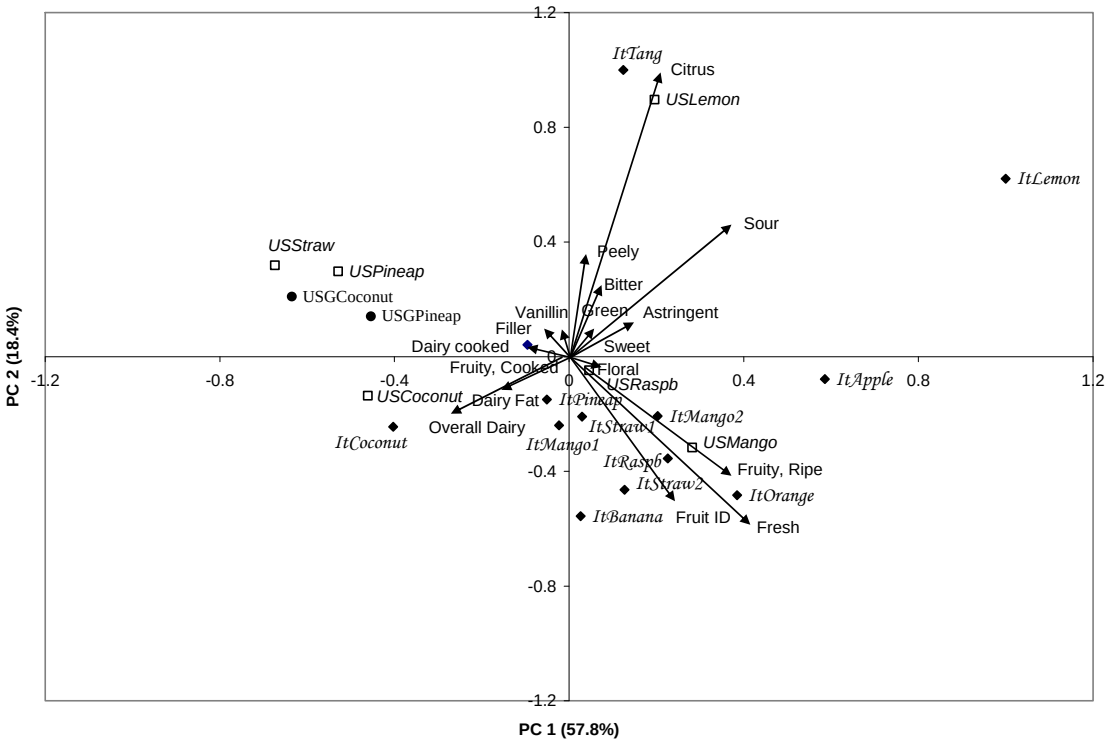

FIG. 1. THE FIRST TWO PRINCIPAL COMPONENTS ANALYZING FLAVOR OF FRUIT ICE CREAM AND GELATO SAMPLES

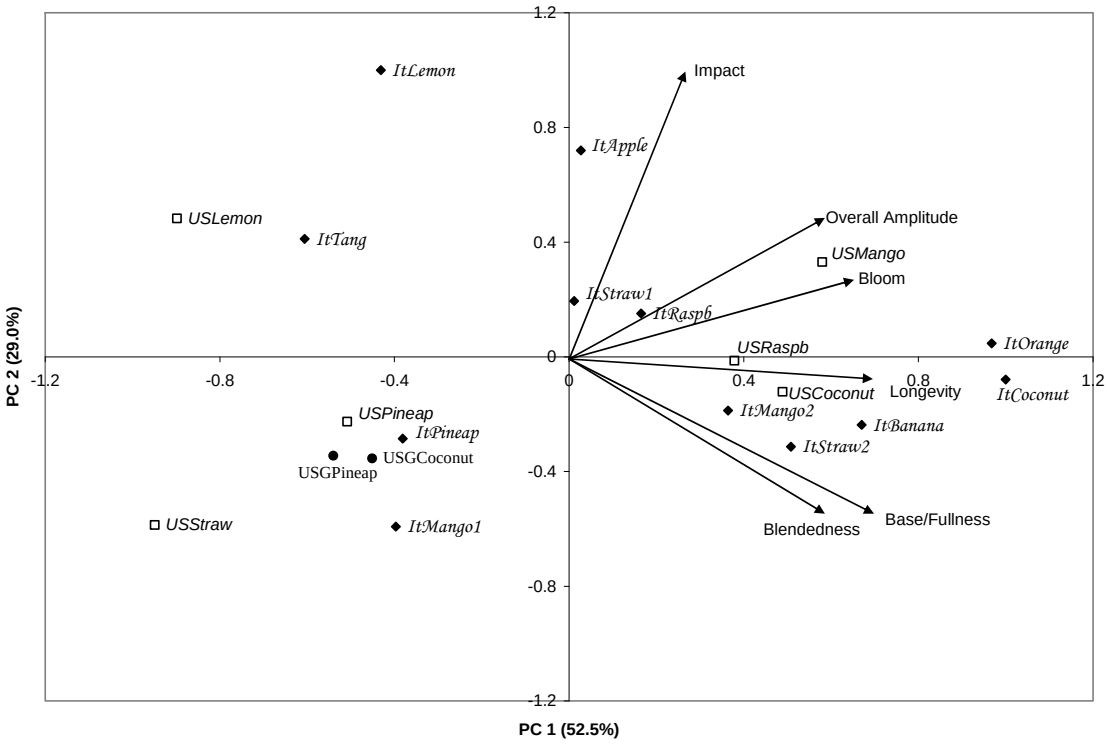

FIG. 2. THE FIRST TWO PRINCIPAL COMPONENTS ANALYZING AMPLITUDE OF FRUIT ICE CREAM AND GELATO SAMPLES

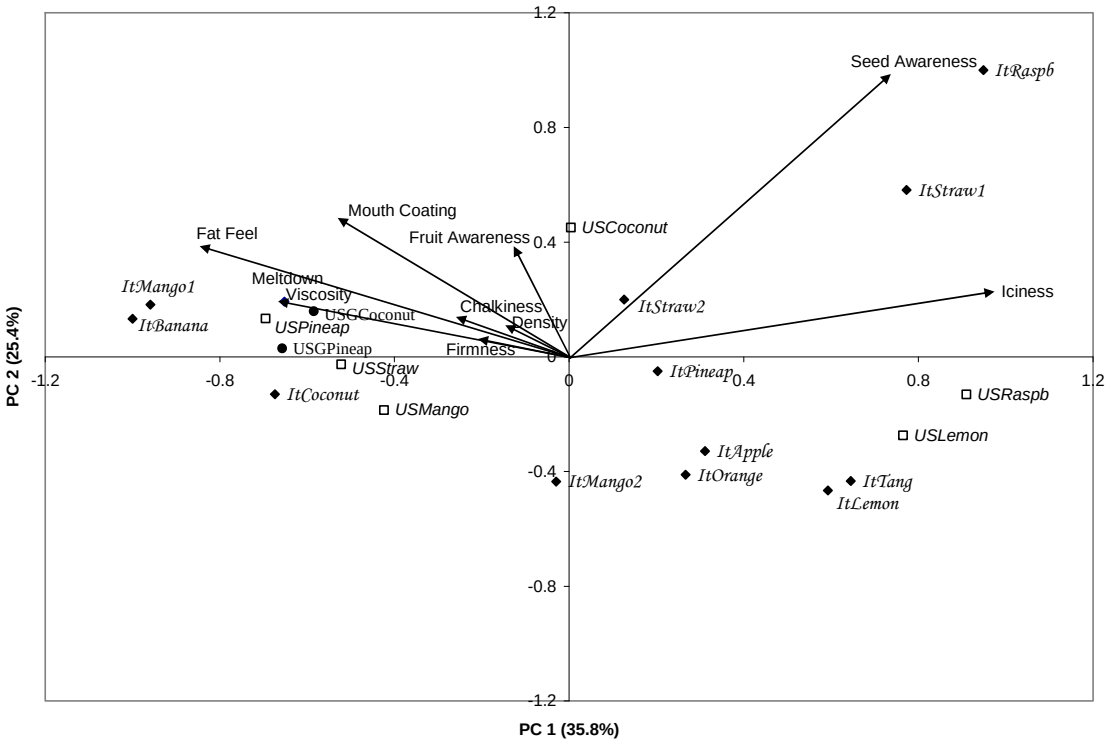

FIG. 3. THE FIRST TWO PRINCIPAL COMPONENTS ANALYZING TEXTURE OF FRUIT ICE CREAM AND GELATO SAMPLES

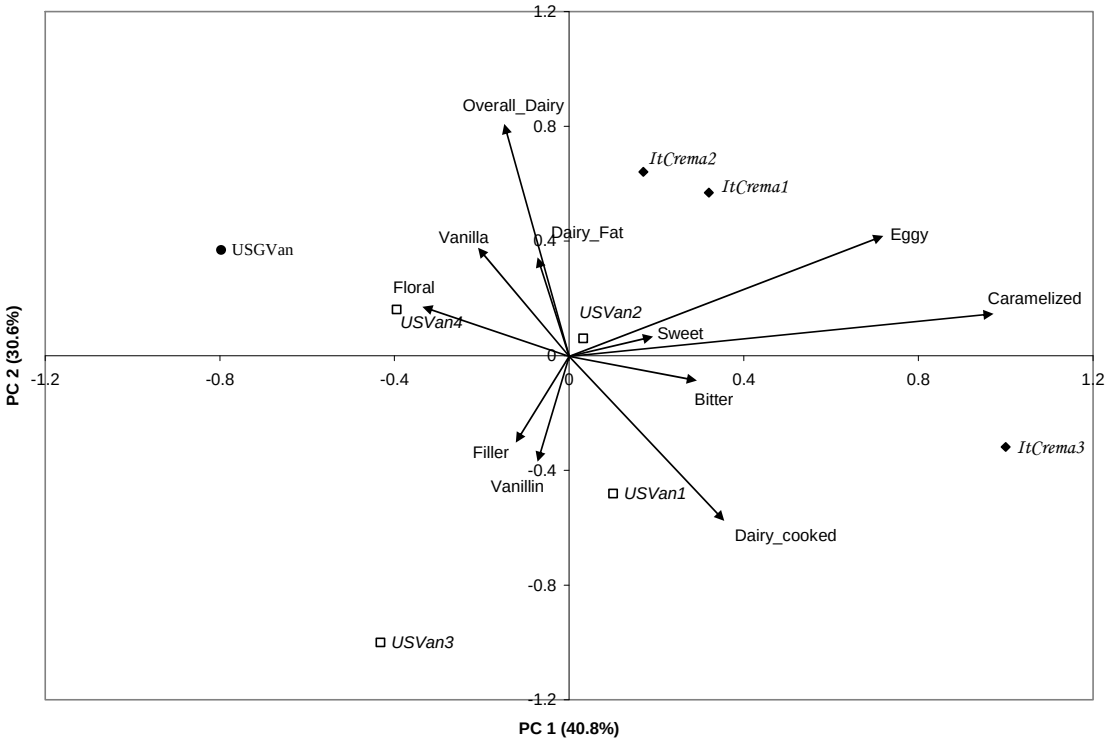

FIG. 4. THE FIRST TWO PRINCIPAL COMPONENTS ANALYZING FLAVOR OF VANILLA ICE CREAM AND GELATO SAMPLES

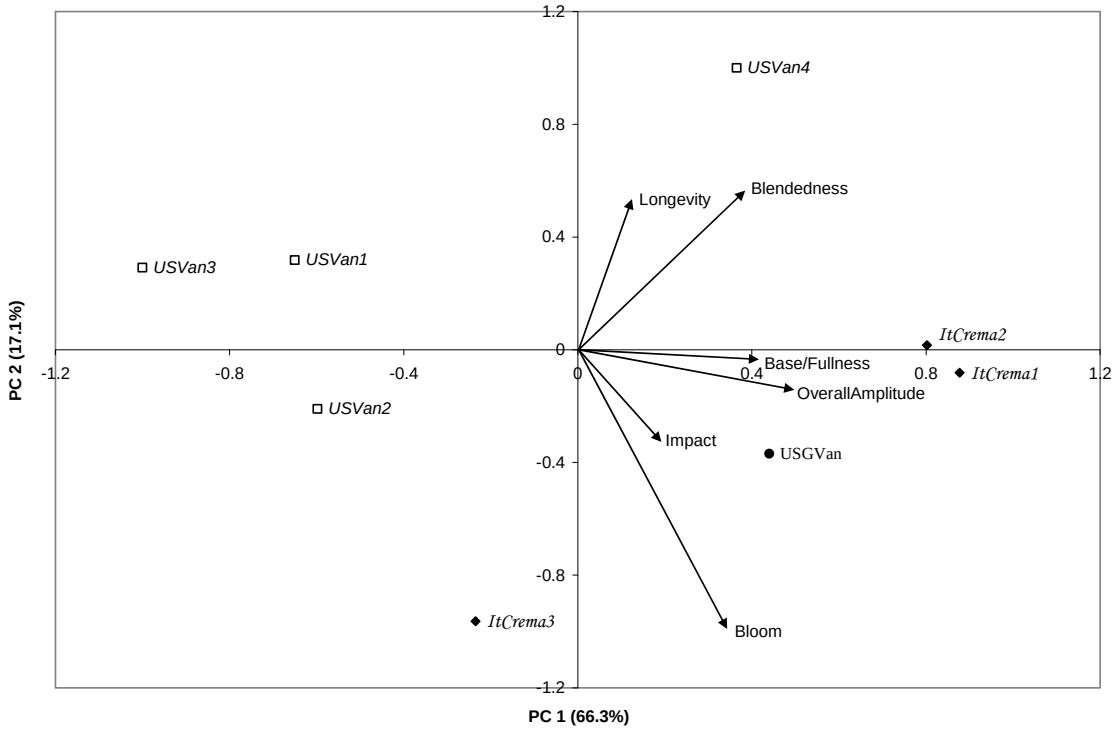

FIG. 5. THE FIRST TWO PRINCIPAL COMPONENTS ANALYZING AMPLITUDE OF VANILLA ICE CREAM AND GELATO SAMPLES

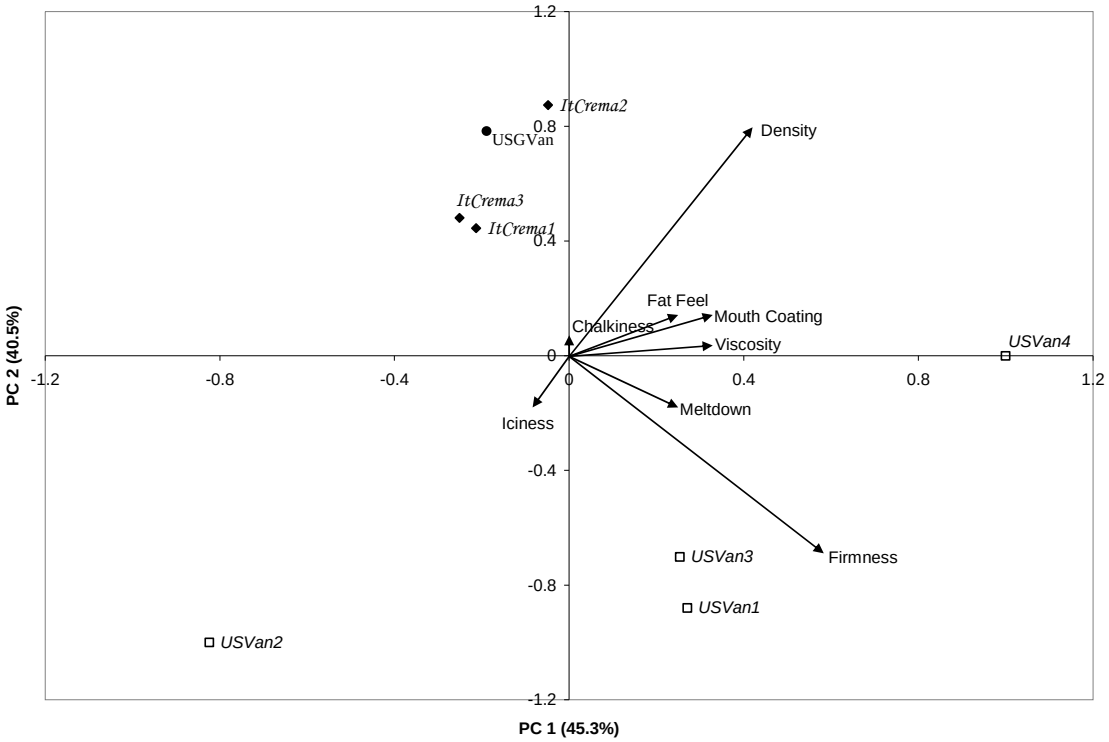

FIG. 6. THE FIRST TWO PRINCIPAL COMPONENTS ANALYZING TEXTURE OF VANILLA ICE CREAM AND GELATO SAMPLES

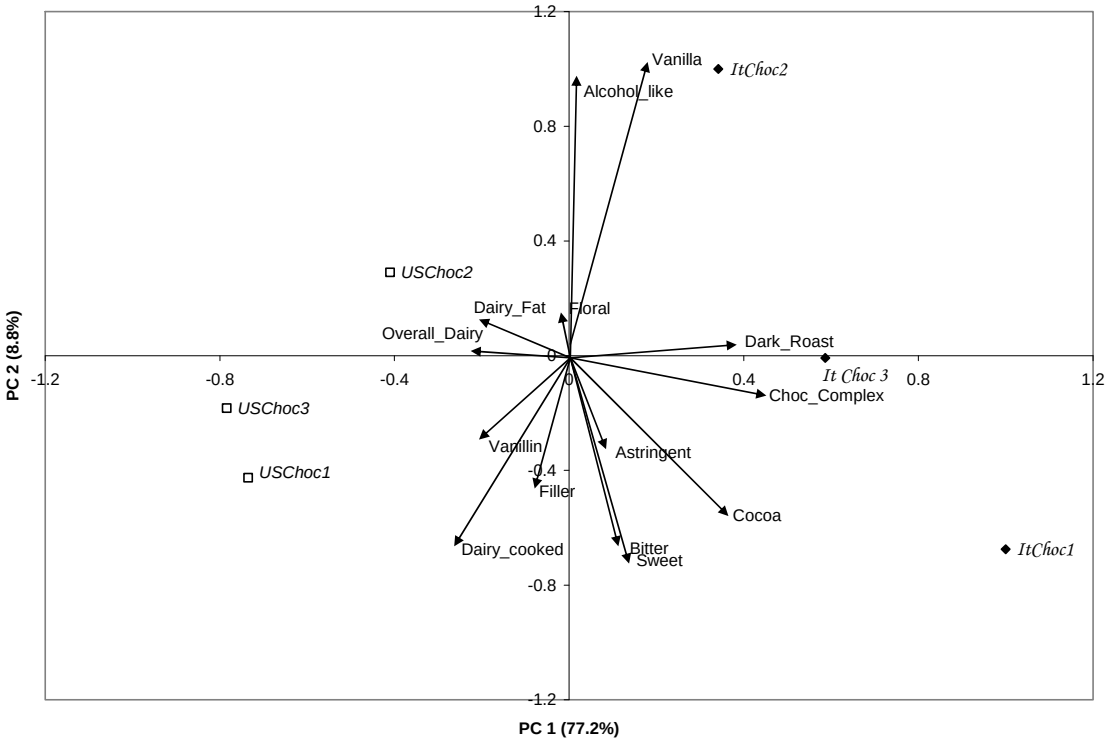

FIG. 7. THE FIRST TWO PRINCIPAL COMPONENTS ANALYZING FLAVOR OF CHOCOLATE ICE CREAM AND GELATO SAMPLES

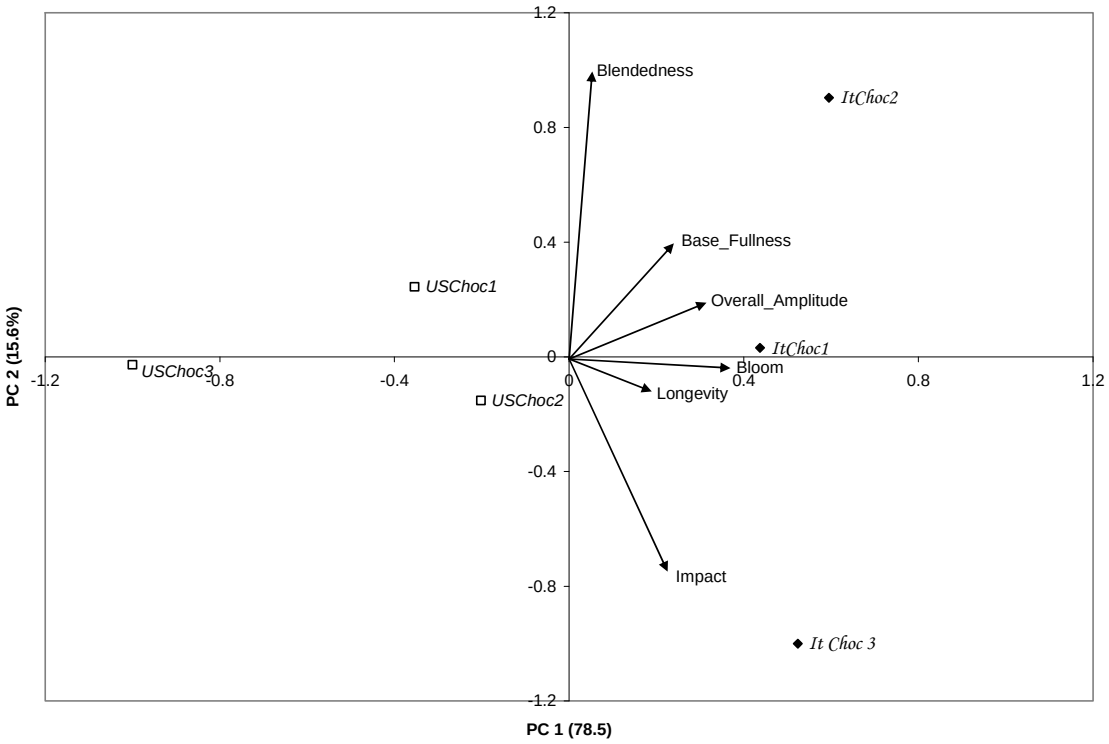

FIG. 8. THE FIRST TWO PRINCIPAL COMPONENTS ANALYZING AMPLITUDE OF CHOCOLATE ICE CREAMS AND GELATO SAMPLES

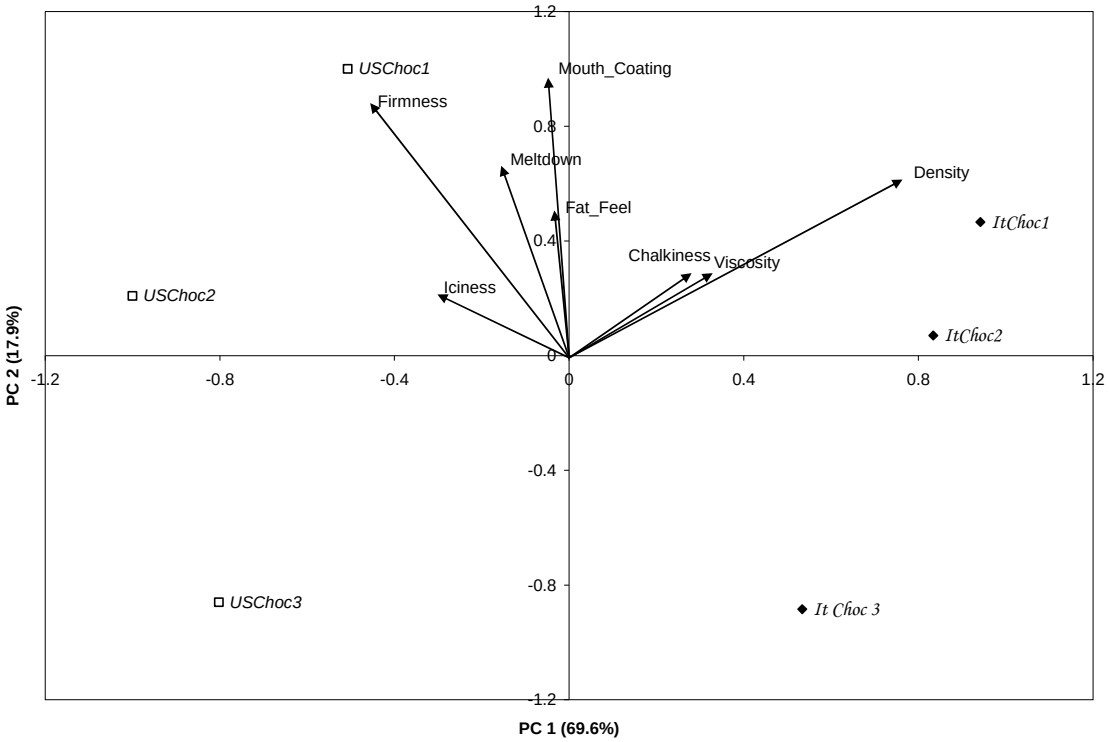

FIG. 9. THE FIRST TWO PRINCIPAL COMPONENTS ANALYZING TEXTURE OF CHOCOLATE ICE CREAM AND GELATO SAMPLES