# COMPARISON OF THE SENSORY PROPERTIES OF UHT MILK FROM DIFFERENT COUNTRIES

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## ABSTRACT

Shelf-stable milk, also known as ultra-high temperature (UHT) milk is the most common form of milk in many parts of the world. This study compared the differences in flavor and texture of 37 commercially available UHT and sterilized milk samples including whole, 2% reduced-fat, and low-fat milk obtained from markets in seven countries: France (n = 2), Italy (n = 11), Japan (n = 1), Korea (n = 2), Peru (n = 3), Thailand (n = 13), and the U.S. (n = 5). Five highly trained panelists used flavor and texture profiling to describe the sensory properties of each milk sample. Data were analyzed by principal component analysis and hierarchical cluster analysis. Higher levels of processed, chalky, brown, and cooked flavor notes generally corresponded to lower levels of fresh dairy flavor characteristics. In general, samples did not vary consistently within a country. Fat content did not correlate with dairy fat flavor or with viscosity. This research suggests that companies' manufacturing processes for UHT milk may have more impact than country or fat content in determining sensory properties of UHT milk.


## PRACTICAL APPLICATIONS

Sensory properties of UHT milk from different countries developed in this study could be used by the dairy industry to understand the similarities and differences of UHT milk characteristics from different regions and to modify UHT milk characteristics to meet consumers' criteria or expectation. The study suggests that manufacturers who want to improve quality of UHT milk by modify flavor and texture properties should focus on improvements to the manufacturing processes.


Key words: UHT Milk, Sensory Properties, Flavor, Texture, Milk, Comparison

# INTRODUCTION

The growth of UHT milk has been remarkable, increasing worldwide in the past 20 years especially in Europe, Asia, and South America. Surprisingly, shelf-stable milk consumption in the U.S. is very low compared to other regions in the world (Burton 1988; Kissell 2004). UHT-processed fluid milk is very popular in other parts of the world; however, the U.S. population has been slow to accept it because of the "cooked" flavor in the UHT milk, their familiarity with fresh milk (Dairy Biz Archive 2000), and the higher cost of UHT milk (Kissell 2004).

A number of studies have determined sensory properties of various milk samples including plain milk (Claassen and Lawless 1992; Frost *et al.* 2001; Francis *et al.* 2005), chocolate milk (Thompson *et al.* 2004), powdered milk (Kamath *et al.* 1999; Drake *et al.* 2003) and processed milks that are not specific to UHT milk (Chapman *et al.* 2001; Fromm and Boor 2004; Clare *et al.* 2005). In addition, lexicons for milk alternatives, such as soymilk, have been published (Torres-Penaranda and Reitmeier 2001; Day N' Kouka *et al.* 2004; Chambers *et al.* 2006; Keast and Lau 2006).

Descriptive sensory terms for ultra-pasteurized milk were developed by Chapman *et al. (* 2001) and were primarily described as "cooked aroma" and "cooked flavor". Clare *et al.* (2005) used cooked/ caramelized, sweet aromatic/cake mix, fatty/ stale, sweet taste, bitter taste, astringent, and color intensity to differentiate UHT from microwave-treated milks. Fromm and Boor (2004) characterized sensory shelf-life attributes for pasteurized fluid milk. Attributes related to milk flavor defects describing as hay/grain, sour/fermented, baby formula, nutty, rancid, and metallic were key sensory attributes associated with pasteurized fluid milk throughout shelf-life. These results showed that excluding bacterial contaminants from milk is essential to extend shelf-life of milk products.

Processing variables have been shown to affect sensory properties of preserved milk. Clare *et al.* (2005) found that UHT milk had more caramelized and fatty/stale flavor, more brown color, and more astringency than microwave processed milk probably because of the higher heat treatment. Keast and Lau (2006) found regional differences in

sensory quality of soymilk with those from Asia (Hong Kong, Malaysia and Singapore) being sweeter, less salty, darker in color, and stronger in beany flavor than soymilks from Australia.

Although previous researchers have investigated the sensory properties of processed milks, none have shown complete information for explaining the sensory characteristics of UHT milk or have considered the differences of UHT milk properties based on country of origin. Although there are many potential reasons that UHT milk is more accepted in countries other than the U.S., it is possible that differences in regional milk source or processing requirements from country to country could result in sensory differences that would have an impact on acceptance. If the sensory properties of UHT milk from different countries can be grouped and differentiated from those in the U.S., it may be possible to determine sensory properties of UHT milk that can be modified to improve U.S. UHT milk.

The objectives of this study were to 1) determine the sensory properties of a wide range of commercial UHT milk samples from various countries representing different regions of the world, to 2) compare flavor and texture differences among samples from various countries to determine if regional differences are a major influence on sensory properties of UHT milk, and to 3) compare UHT to control pasteurized and sterilized milk samples.

## MATERIALS AND METHODS

### *Milk Samples*

Thirty-seven low-fat, 2% reduced-fat, and whole UHT and sterilized milk samples were used in this study. The samples were purchased from seven countries on four continents to represent a variety of shelf-stable milks. Samples were based on origin, fat content, and availability. Table 1 shows the product description, origin, type of milk, heat processing, and product abbreviation that were used for the study. Samples were obtained from France (n = 2), Italy (n = 11), Japan (n = 1), Korea (n = 2), Peru (n = 3), Thailand (n = 13), and the U.S. (n = 5). Fresh pasteurized whole and 2% reduced-fat milk samples were purchased from a local retail grocery store in Manhattan, Kansas (Dillons, A Kroger

subsidiary) and used as a control. Samples had similar expiration date to avoid extraneous factors, such as sample age, that might affect the flavor and texture of each sample.

UHT and sterilized samples were purchased in tetra-packed cartons, plastic bottles, or tin cans depending on each country and were held at room temperature after purchasing until the day prior to testing. At that time they were moved to a refrigerator (TS-49 commercial refrigerator, True Manufacturing Co, St Louis, MO, USA) for storage at 1ºC.

***Sample Preparation***

Seventy-five mL portions of milk were poured into six 8 oz Styrofoam cups (H8S, James River Corp, Easton, PA, USA), labeled with 3-digit random numbers for the first serving. An additional 25 mL of milk was served to each of the panelists as a second serving to maintain temperature during testing. Samples were tempered at room temperature for thirteen minutes until the serving temperature of 6-7ºC was reached. During tempering, sample cups were covered with clean dark paper to avoid light oxidation. Sample cups were covered with plastic lids before serving to the panelists.

***Panelists***

Five highly trained panelists from the Sensory Analysis Center, Kansas State University (Manhattan, KS) participated in the study. Each panelist had completed 120 h of training in sensory evaluation of foods; had a minimum of 2000 h of testing experience on a variety of food products including fresh milk, UHT milk, soy milk, yogurt, ice cream, and cheese. Other researchers have used trained panelists to describe the flavor (Talavera-Bianchi, Chambers, and Chambers, 2008) and texture characteristics of dairy products (Yates and Drake, 2007; Karagul-Yuceer, Isleten, and Uysal-Pala, 2007).

***Descriptive Orientation Sessions***

The panelists used attributes, definitions and references from previous studies of milk (Bassette *et al.* 1986; Tuorila 1986; Claassen and Lawless 1992; Chapman *et al.* 2001; Frost *et al.* 2001; Frandsen *et al.* 2003; Francis *et al.* 2005) as initial guidelines for this study. Three 1 ½ h orientation sessions were conducted to help the panel reacquaint themselves with the flavor and texture of milk, to develop the attributes and references

for UHT milk, and to rate the intensities of the control milk samples. Because of the limited amount of international samples, panelists were initially given six locally purchased UHT and ultra-pasteurized milk samples to begin the lexicon development.

During orientation sessions, the procedures for attribute determination and vocabulary description were adapted from flavor profile analysis (Caul 1957; Keane 1992) and other studies for developing flavor and texture lexicons (Drake *et al.*, 2007; Lee and Chambers 2007; Talavera-Bianchi, Chambers, and Chambers, 2008; Hongsoongnern and Chambers, 2008a,b). A discussion of milk samples was held until the panel came to agreement on attribute description of UHT milk.

The panel changed some attribute definitions and references after orientation sessions. They deleted attributes that they did not find in UHT, pasteurized or sterilized milk samples and added new attribute terms they found in samples they had not previously tasted. The final attributes, definitions, and references used to describe sensory properties of UHT, pasteurized, and sterilized milk samples are given in Table 2.

## *Determining Sensory Properties*

Thirty-seven UHT and sterilized milk samples were evaluated using profile techniques during thirteen 1 ½ h sessions to determine sensory properties of the milk samples for texture and flavor characteristics. Attribute intensities were scored on a 15-point numerical scale with 0.5 increments, where 0 represents “not detectable” and 15 represents “extremely strong”. The panel evaluated texture attributes for each sample followed by the flavor evaluation. After all panelists individually provided intensity scores for all the attributes found in the milk sample, the panel leader then led a discussion to arrive at an agreement of consensus scores for each product. Panelists were provided new samples to maintain temperature as they discussed the samples to reach consensus on the attributes and intensities. Panelists ate a bite of carrot, an unsalted top saltine crackers (Nabisco, East Hanover, NJ, USA), and purified water between each sample to cleanse the palate.

### *Experimental Design and Statistical Analysis*

A completely randomized design was used for the sample presentation. A maximum of three samples were tested in each 1½ h session. Multivariate statistical analyses were used to explain the relationships among the sensory terms of UHT, pasteurized, and sterilized milk samples. Principal components analysis (PCA) was conducted using SYSTAT® program (Version 10.2, 2005, SYSTAT Software, Inc, San Jose, CA). The covariance matrix was used for extraction and the varimax procedure was used for rotation. Attributes where all scores were the same for all samples and attributes present in 5 or fewer samples were removed before the analysis. PCA plots of the major principal components were made to show differences and similarities among UHT, pasteurized, and sterilized milks.

Hierarchical cluster trees based on sensory properties were obtained from hierarchical cluster analysis (Ward's method) using the SYSTAT® program version 10.2 (2005, SYSTAT Software, Inc, San Jose, CA).

## RESULTS AND DISCUSSION

Attributes added to previous lexicons to better describe the texture and flavor of the range of the milks in this study were: lip and mouthfeel, fermented, grainy, malty, medicinal, oily, plastic, vanilla/vanillin, and nutty. Many of those terms were added during testing, along with appropriate definitions and references (Table 2) to describe particular characteristics found in samples that were not available during orientation.

Figure 1 illustrates the PCA map for 15 flavor and texture characteristics of low-fat, 2% reduced-fat, and whole UHT, pasteurized, and sterilized milk samples from the seven different countries. The first two principal components explained 65.78% of the variance. Principal component 1 (55.87% total variance explained) essentially differentiates samples with high in chalky texture and/or processed flavor and those high in fat feel and overall dairy, dairy fat, and dairy sweet flavors. Principal component 2 (9.91% total variance explained) emphasizes the cooked, brown, and malty notes found in some samples.

Dairy notes (overall dairy, dairy fat and dairy sweet) and fat feel were negatively correlated with chalky texture and processed flavor. Overall dairy showed little linear or curvilinear relationship to cooked and brown flavors when examined either by correlation or plots. That indicates that brown and cooked notes may be modified independently of dairy impact. Malty flavor appeared in only a few samples, but when it did it seemed to have some positive relationships to brown, cooked, fat feel, and dairy fat.

Three major clusters of UHT, pasteurized, and sterilized milk samples were found, but they did not group on the basis of either country or fat content (Figure 2). There were more similarities of milks from the same manufacturer than milks from the same country or milks with the same fat content. This suggests that manufacturing process may have affected the sensory properties of UHT milks much more than did country of origin or fat content, disproving our theory that the base milk may be a major factor in U.S. consumers dislike of UHT milk, while consumers in other countries find it acceptable.

Cluster 1 consisted of milk samples from most countries included in this study, except for Peru and the U.S., with the different manufacturers. The milks in this cluster were highest in dairy fat, dairy sweet, overall dairy flavor, and fat feel and had little or no chalky or processed flavor. The two pasteurized control milk samples also appeared in this cluster. Although other clusters contained whole milk samples, this cluster consisted only of whole milk, which may indicate that in order to have the highest dairy notes and fat feel with little or no processing effect, the UHT milk should be made from whole milk.

Cluster 2 consisted of samples from six of the seven countries included in this study, all the various fat levels, and various manufacturers. These samples typically were moderate to high in dairy notes (dairy fat, dairy sweet, and overall dairy) and fat feel, and had low levels of chalky and processed notes. This cluster included most of the samples from Parmalat and most of the U.S. samples. A subcluster in that group contained samples that generally were highest in cooked, but without the processed note found in some other samples. All the products in that subcluster were malty; something unique to that group. Products in that subcluster came from Italy, Thailand, and Peru, including 2 samples (a whole and a low-fat) from the same manufacturer in Thailand. One of the sub-

clusters included most of the U.S. milk samples (four out of seven) and half of the Parmalat samples, including Parmalat samples from both Italy and the U.S. This group of milk had higher processed notes and scored in the middle of all samples for cooked and brown. Those products had moderate to higher levels of dairy notes and no maltiness was found in them. The third subcluster in that group was comprised of samples from Italy, France, Korea, and Peru. Sensory properties in that subcluster fell in the midrange of most products.

Cluster 3 consisted of about one-third of the Thai samples (including 2 pairs of products from the same brands in Thailand), two Italian samples, and 1 U.S. sample from the same manufacturer as one of the Italian samples. These products had the highest levels of processed, cooked, brown and some of the highest chalky scores of all products tested. This groups contained samples with the lowest levels of dairy sweet and dairy fat. The two sterilized milk samples from Thailand were in this cluster which should not be surprising given their high level of processing. The attributes in this cluster and the fact that the sterilized milks are in this cluster suggest processing, rather than country or fat content, related issues associated with the milks in this group.

## CONCLUSIONS

UHT milk samples varied widely in flavor and texture characters. Some samples had more cooked and processed notes than others. Some exhibited more dairy notes and fat feel texture than others. In general, samples did not vary consistently within a country. Several Thai samples were among the highest for sweet and dairy flavor. Similarly, one U.S. sample had processed, chalky, and sour notes, but most of the U.S. samples had sweet dairy character. Additionally, many samples from Peru were among the least viscous, although one Peruvian sample was perceived as among the most viscous. Interestingly, fat content of samples did not correlate with dairy fat flavor, or with viscosity. This research suggests that companies' manufacturing processes for UHT milk may have more impact than country (i.e. regional milk type or source) or fat content in determining quality of UHT milk.

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## TABLE 1. LIST OF MILK SAMPLES USED FOR DESCRIPTIVE ANALYSIS

| Origin | Product | Type | Heat Processing | Product Abbreviation |
|---|---|---|---|---|
| France | Monoprix Lait | Low-Fat Milk | UHT | LFFrance1 |
| France | Monoprix Lait | Whole Milk | UHT | WFrance2 |
| Italy | Fattoria Scaldasole | 2% Reduced-Fat Milk | UHT | RFItaly1 |
| Italy | Latte | 2% Reduced-Fat Milk | UHT | RFItaly2 |
| Italy | Latte Maremma | 2% Reduced-Fat Milk | UHT | RFItaly3 |
| Italy | Mukki Scorta | 2% Reduced-Fat Milk | UHT | RFItaly4 |
| Italy | Parmalat Fibresse | 2% Reduced-Fat Milk | UHT | RFItaly5 |
| Italy | Parmalat Natura Premium | 2% Reduced-Fat Milk | UHT | RFItaly6 |
| Italy | Parmalat Omega 3 | 2% Reduced-Fat Milk | UHT | RFItaly7 |
| Italy | Polenghi | 2% Reduced-Fat Milk | UHT | RFItaly8 |
| Italy | Mukki Scorta | Whole Milk | UHT | WItaly9 |
| Italy | Parmalat Natura Premium | Whole Milk | UHT | WItaly10 |
| Italy | Polenghi | Whole Milk | UHT | WItaly11 |
| Japan | Morinaga Milk | Whole Milk | UHT | WJapan1 |
| Korea | Maeil Milk | Whole Milk | UHT | WKorea1 |
| Korea | Seoul Milk | Whole Milk | UHT | WKorea2 |
| Peru | Bella Holandesa | Whole Milk | UHT | WPeru1 |
| Peru | Gloria | Whole Milk | UHT | WPeru2 |
| Peru | Laive | Whole Milk | UHT | WPeru3 |
| Thailand | Bear Brand | Low-Fat Milk | Sterilized | LFThai1S |
| Thailand | Country Fresh | Low-Fat Milk | UHT | LFThai2 |
| Thailand | Foremost | Low-Fat Milk | UHT | LFThai3 |
| Thailand | Foremost Calcimex | Low-Fat Milk | UHT | LFThai4 |
| Thailand | Mali | Low-Fat Milk | UHT | LFThai5 |
| Thailand | Meiji | Low-Fat Milk | UHT | LFThai6 |
| Thailand | Bear Brand | Whole Milk | Sterilized | WThai7S |
| Thailand | Country Fresh | Whole Milk | UHT | WThai8 |
| Thailand | Foremost | Whole Milk | UHT | WThai9 |
| Thailand | Meiji | Whole Milk | UHT | WThai10 |
| Thailand | Nongpho | Whole Milk | UHT | WThai11 |
| Thailand | Chitralada | Whole Milk | UHT | WThai12 |
| Thailand | Thai-Danish | Whole Milk | UHT | WThai13 |
| U.S. | Horizon Organic | 2% Reduced-Fat Milk | UHT | RFUS1 |
| U.S. | Parmalat | 2% Reduced-Fat Milk | UHT | RFUS2 |
| U.S. | Parmalat Lil Milk | 2% Reduced-Fat Milk | UHT | RFUS3 |
| U.S. | Parmalat | Whole Milk | UHT | WUS4 |
| U.S. | Parmalat Lil Milk | Whole Milk | UHT | WUS5 |
| U.S. | Dillons (control) | 2% Reduced-Fat Milk | Pasteurized | RFcontrol |
| U.S. | Dillons (control) | Whole Milk | Pasteurized | Wcontrol |

**TABLE 2. SENSORY ATTRIBUTES, DEFINITIONS, REFERENCES FOR UHT, PASTEURIZED, AND STERIZELED MILKS**

| Sensory Attributes | Definition | Reference[a] with their Intensities[b] |
|---|---|---|
| **Texture** | | |
| Chalky | A measure of dry, powdery sensation in the mouth. | Carnation Non-Fat Dry Milk = 4.5<br>Kroger Non-Dairy Coffee Cream = 7.5<br>Eagle Brand Sweetened Condensed Milk = 13.0 |
| Fat Feel | Related to the perceived fat content. Refers to the intensity of the oily feeling in the mouth when the product is manipulated between the tongue and the palate. | Land O'Lakes Fat Free Half and Half = 8.0 |
| Viscosity | The measure of the flow as the product moves across the tongue.<br>Technique: place 1 teaspoon of sample on tongue and judge rate of flow across. | Water = 0.0<br>Dillon's 2% Reduced-Fat Milk = 1.0<br>Dillon's Half and Half = 2.0<br>Dillon's Whipping Cream = 4.0 |
| Lip and Mouthfeel** | The impression of slick powdery or oily sensations on the surface of the lips and/or the interior of the mouth. | N/A |
| **Flavor** | | |
| Brown | The aromatics that are brown and create a rounded full-bodied impression. This is brown not attributed to the cooked attribute. | Carnation Evaporated Milk = 6.0 |
| Butyric Acid | An aromatic that is sour and cheesy and slightly buttery reminiscence of baby vomit. | Kraft 100% Grated Romano Cheese = 6.0 (aroma)<br>Butyric Acid (in propylene glycol) = 13.0 (aroma) |
| Cardboard | The aromatics associated with cardboard or paper packaging. The intensity rating is only for the 'cardboard' character within the sample. | 2 by 2 inches Cardboard in Water = 6.0 (aroma) |

| | | |
|---|---|---|
| Cooked | The combination of brown flavor notes and aromatics associated with heated milk. | Dillon's 2 Minutes Heated Whole Milk = 4.5 |
| Overall Dairy | A general term for the aromatics associated with products made from cow's milk. | Carnation Evaporated Milk = 12.0<br>Carnation Non Fat Dry Milk = 4.5 |
| Dairy Fat | Aromatics associated with dairy fat. | Dillon's Half and Half = 10.0<br>Carnation Non Fat Dry Milk = 0.0<br>Land O'Lakes Fat Free Half and Half = 5.0 |
| Dairy Sweet | The sweet aromatics associated with fresh dairy products. | Dillon's Half and Half = 6.0 |
| Feed | Slightly nutty, grainy aromatics associated with silage, dry alfalfa, and/or various grains which may include brewers' grains. | N/A |
| Fermented* | Combination of sour aromatics associated with somewhat fermented dairy/cheesy notes that may include green vegetation, such as sauerkraut, soured hay, or decomposed grass. | Reese Vintage Cooking Wine (Chablis) = 7.0 (aroma) |
| Flat | Aromatic characterized by lack of flavor, richness. Watery, associated with lack of flavor. | Carnation Non Fat Dry Milk = 12.0 |
| Floral | Sweet, light, slightly perfuming aromatics associated with flowers. | Welch's White Grape Pear Juice = 7.0 |
| Grainy* | Brown aromatics that are musty dusty and malty. May include sweet, sour and slightly fermented. | Post Grape nuts = 11.0 |
| Green | Aromatics associated with green vegetable vegetation that may include green, bitter notes. | Parsley = 8.0 (aroma) |
| Lack of Freshness | The overall rounded dairy notes, commonly associated with fresh ilk are altered. A combination of changes in amount or interactions of such attributes as sweet, bitter, sour, dairy fat, butyric acid and/or brown. | N/A |
| Light-Oxidized | Flavor caused by light catalyzed oxidation. Characterized by aromatics that may be described as burnt feathers, slightly sour burnt protein, tallowy and/or medicinal: may include increased astringency or metallic mouthfeels. | Light Oxidized Skimmed Milk = 2.0 |
| Malty* | An aromatic described as brown sweet, musty and somewhat grainy. | Carnation Malted Milk = 12.0 |

| | | |
|---|---|---|
| Medicinal* | Aromatic characteristic of antiseptic-like products. | Band-Aid = 6.0 (aroma) |
| Metallic | The chemical feeling factor on the tougue described as flat. Associated with iron, copper, and/or silver spoons. | N/A |
| Musty/Dusty | Dry, dirt-like aromatic associated with dry, brown soil. | Bush's Best Pinto Beans (canned) = 3.0 |
| | | Post Grape Nuts = 5.0 |
| Musty/Earthy | Humus-like aromatics that may or may not include known damp soil, decaying vegetation or cellar like characteristics. | Kroger Butter Beans (canned) = 5.5 |
| Oily* | The light aromatics associated with vegetable oil. | Wesson Vegetable Oil (Heated) = 10.0 (aroma) |
| Plastic* | An aromatic associated with plastic polyethylene containers or food stored in plastic. | Ziploc Bag in Medium Covered Snifter = 3.0 (aroma) |
| Processed | Non-natural characteristic that maybe slightly powdery resulting from the change or adulteration of the product. (e.g. drying, caning, irradiation) | Carnation Non fat Dry Milk (reconstituted) = 7.5 |
| Refrigerator | A lack of freshness/Flat. Impression of the product absorbing a combination of odors while stored in the refrigerator. | N/A |
| Sweet | The basic taste sensation of which sucrose in water is typical. | 1% Sucrose Solution = 1.0 |
| Vanilla/Vanillin* | The brown, sweet aromatics and character identity commonly associated with vanilla. | ICN Scientific Vanillin in Water = 6.0 (aroma) |
| Vitamins | The aromatics associated with a just opened bottle of vitamin pills. (Generally thought to be oxidized thiamin) (aroma) | Total Corn Flakes = 4.0 (aroma) |
| Sour Aromatics | Slightly pungent aromatic similar to those found in slightly fermented products such as sour creams, buttermilk and yogurt. | Kraft Philadelphia Cream Cheese = 8.0 |
| Sour | Fundamental taste factor of which citric acid in water is typical. | 0.015% Citric Acid = 1.5 |
| | | 0.025% Citric Acid = 2.5 |
| Nutty** | A non-specific, slightly sweet, brown, nut-like impression. | Kretschmer Wheat Germ = 7.5 |
| Bitter | The fundamental taste factor of which caffeine in water is typical. | 0.01% Caffeine Solution = 2.0 |
| Astringent | Dry and puckering mouth feel associates with an alum solution in the mouth. | 0.3% Alum Solution = 1.5 |

[a] References were prepared approximately 24 hours before a testing session, refrigerated overnight and removed from the refrigerator 30 minutes before a testing session.

[b] Intensity based on a 15-point numerical scale with 0.5 increments, where 0 represents not detectable and 15 represents extremely strong.

* described additional attributes that were added from previous milk lexicons.
** described additional attributes that were added during testing sessions.

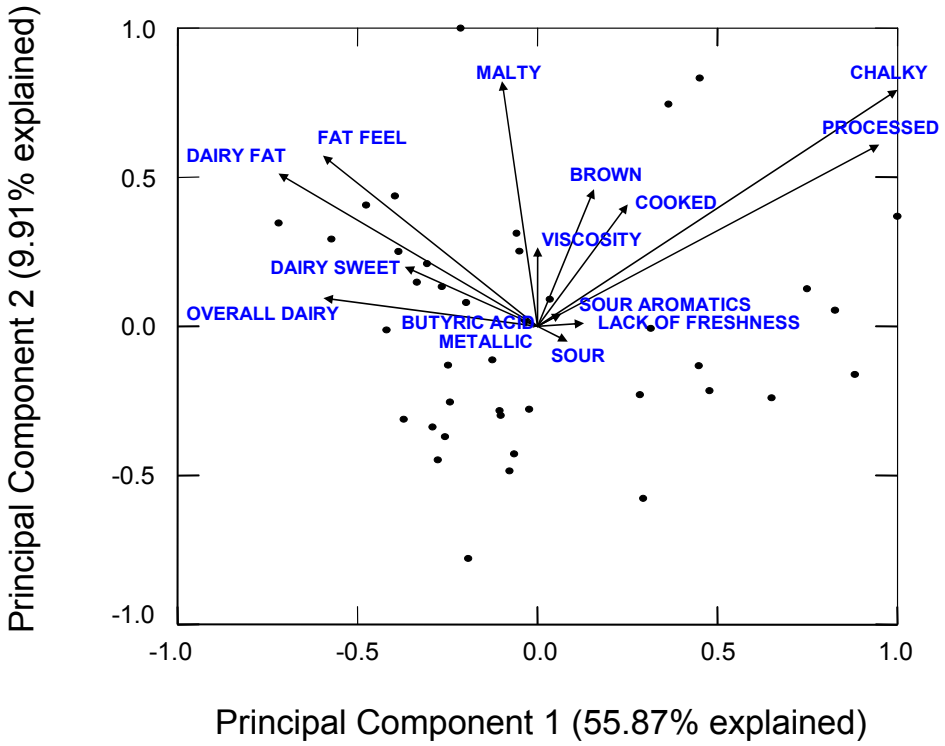


**FIGURE 1. PRINCIPAL COMPONENT ANALYSIS (PCA) RESULTS FOR DESCRIBING FLAVOR AND TEXTURE CHARACTERISTICS OF UHT, PASTEURIZED, AND STERILIZED MILK FROM VARIOUS COUNTRIES**

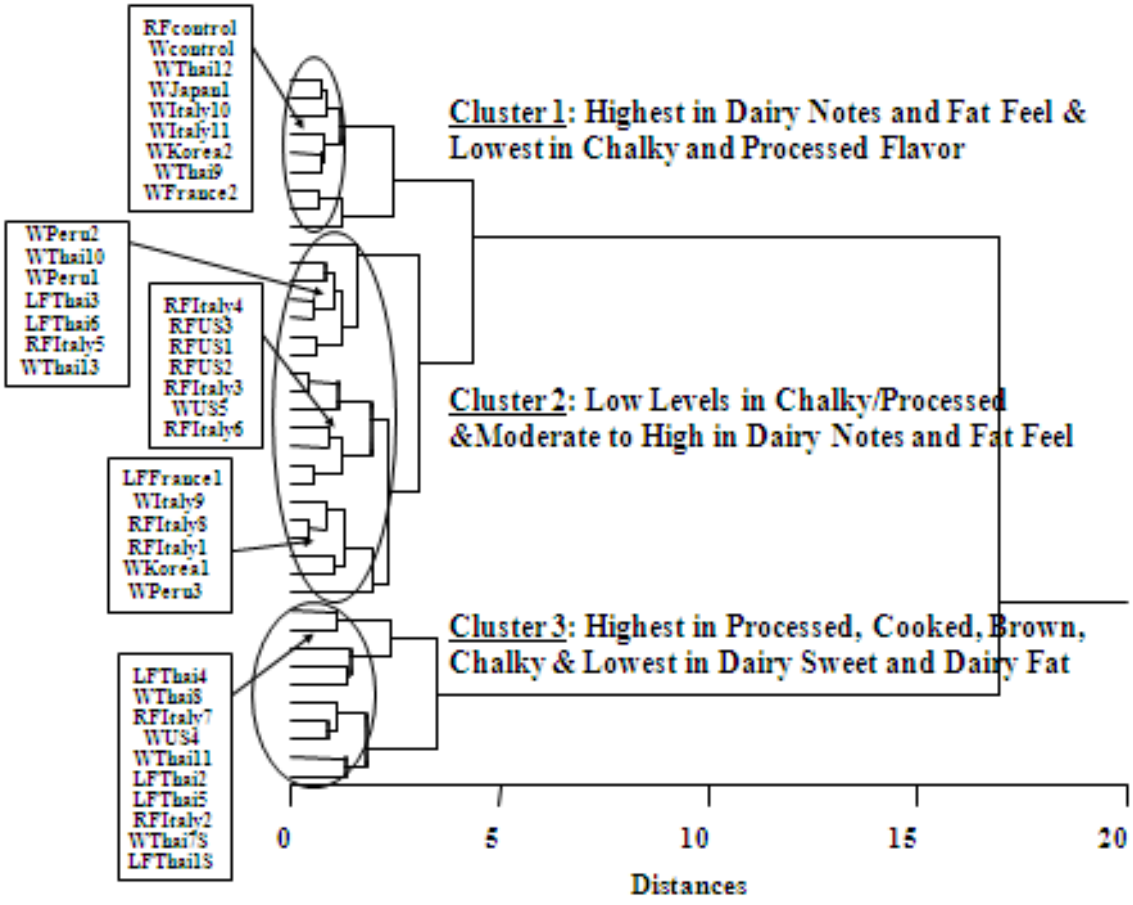


**FIGURE 2. HIERARCHICAL CLUSTER TREE DIAGRAM FOR DESCRIBING FLAVOR AND TEXTURE CHARACTERISTICS OF UHT MILK, PASTEURIZED AND STERILIZED MILK FROM VARIOUS COUNTRIES**