

COMPARISON OF THE SENSORY PROPERTIES OF  
ULTRA-HIGH TEMPERATURE (UHT) MILK FROM DIFFERENT  
COUNTRIES AND PREFERENCE MAPPING OF UHT MILK  
BETWEEN U.S. AND THAI CONSUMERS

by

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## **Abstract**

Ultra-high temperature (UHT) milk is marketed as a convenience product in the United States (U.S.) and as the most common form of milk in many other parts of the world. Two studies were conducted to get a better understanding of sensory properties and consumer acceptability in UHT milk.

First study compared the differences in flavor and texture of commercial UHT milk from different countries (France, Italy, Japan, Korea, Peru, Thailand, and the U.S.). A total of 37 UHT and sterilized milk samples including whole, 2% reduced-fat, and low-fat milk were evaluated. Five highly trained panelists used flavor and texture profiling to describe the sensory properties of each milk sample. 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. Interestingly, fat content did not correlate with dairy fat flavor or with viscosity. This research suggests that companies' manufacturing processes may have more impact than country or fat content in determining quality of UHT milk.

Second study compared UHT milk acceptability by U.S. milk consumers unused to UHT milk and Thai consumers who typically drank UHT milk. Preference mapping technique was used to study sensory characteristics of UHT milk that drive overall liking from each of those consumer groups. Consumer studies were conducted in Bangkok, Thailand and in Manhattan, Kansas with one hundred consumers participating in each location. Both groups of consumers evaluated five commercial UHT whole milks that represented a range of UHT milk properties. U.S. consumers thought that the UHT milks had more off-flavor and liked them overall less than did Thai consumers. Results from the external preference map showed that both groups of consumers liked UHT milk with more dairy characteristics and higher fat feel. However, there was a separate group of Thai consumers who liked UHT milk with processed, cooked, and brown flavors. Lack of freshness, butyric acid, and sour aromatics were undesirable sensory attributes in UHT milk, regardless of consumer population. Off-flavors in the UHT milks in this study may be described with those attributes.

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## **Dedication**

I would like to dedicate the work of my thesis to my family. Thank you so much mom and dad for supporting and helping me to move on to the next educational path. I love both of you so much.

# **CHAPTER 1 - Review of Literature**

## INTRODUCTION

The growth of UHT milk has been remarkable, increasing worldwide in the past 20 years especially in Europe, Asia, and South America. However, shelf-stable milk consumption in the United States (U.S.) is very low compared to other regions in the world (Burton 1988; Kissell 2004). The cooked flavor in the UHT milk, the familiarity with fresh milk (Dairy Biz Archive 2000), and the higher cost of UHT milk (Pearson *et al.* 1990; Kissell 2004) may be the reasons why the U.S. population has been slow to accept it.

One of the benefits in consuming UHT milk is convenience. The high thermal treatment and aseptic package yield the product to last for several months without refrigeration (Chapman and Boor 2001; Kissell 2004). The reason of not drinking UHT milk might be from the cooked aroma and flavor of UHT milk and the warm temperature as it does not require a refrigerated condition (Solomon *et al.* 2005).

The objectives of study 1, the descriptive analysis phase were to determine the sensory properties of UHT milk from various countries representing different regions of the world and to compare flavor and texture differences among samples from various countries to determine if regional milk source or milk type is a major influence on sensory properties of UHT milk. The objective of study 2, the consumer test phase was to understand what key sensory characteristics might drive differences in liking of UHT milk acceptability in a U.S. population unused to drinking UHT milk and a Thai population that typically consumes that product. The results from this study could be useful to the U.S. dairy industry to better understand the sensory properties needed for optimizing UHT milk acceptance by U.S. consumers.

## **DEFINITION OF MILK**

From the Code of Federal Regulations by the United State Food and Drug Administration (Title 21 Food and Drugs: CFR131.110), milk is defined as “the lacteal secretion, practically free from colostrum, obtained by the complete milking of one or more healthy cows. Milk should not contain less than 8.25% milk solids not fat and not less than 3.25% milk fat. Pasteurization and ultra-pasteurization could be used for beverage in final package form”.

## **TYPES OF MILK**

### ***Categorizing by fat content***

Milk can be categorized into three major types based on fat content regarding the dairy grading from U.S. Food and Drug Administration: whole milk, low-fat milk, and skimmed milk or non-fat milk. The percentages of milk fat are different for each type of milk: at least 3.25% in whole milk, 0.5-2% in low-fat milk, and not more than 0.5% in skimmed milk (Dairy Aisle 2007).

### ***Categorizing by processing***

Milk can also be separated by the type of processing which mainly based on the temperature and time of heating process (U.S. FDA 2004). The purpose of the heat treatment is to minimize possible health hazards caused by pathogenic and spoilage microorganisms that might occur during storage time with minimal loss in nutritional value and sensory quality (U.S. FDA 2004; Dumalisile *et al.* 2005).

#### ***Pasteurized Milk***

Two pasteurization methods generally used in the dairy industry are the low temperature long time (LTLT) and the high temperature short time (HTST) (Dumalisile *et al.* 2005). LTLT milk is heated to 63°C (145°F) and held at this temperature continuously for at least 30 minutes or the equivalent (Shew 1977; FDA 1999). HTST milk is heated to 72°C (161°F) for a minimum of 15 seconds or the equivalent (FDA

1999). Both LTLT and HTST milks have to be stored at a relatively low temperature below 5°C (41°F) for keeping the quality. The product usually lasts 10 to 14 days at refrigerated storage temperature after the date of processing (Shew 1977).

### ***UP Milk***

“Ultra-pasteurized milk or UP milk has been thermally processed at or above 138°C (280°F) for at least 2 seconds, either before or after aseptic packaging. The high temperature will extend shelf-life of the milk under refrigerated conditions” [Title 21 Food and Drugs: CFR131.3 Milk and Cream] (U.S. FDA 2004). Generally, the ultra-pasteurized milk has a shelf-life of several weeks under refrigerated conditions (Shew 1977).

### ***UHT Milk***

Ultra-high temperature milk (UHT) or shelf-stable milk has been heated to a very high temperature 135-150°C (275-302°F) for 1 to 5 seconds to destroy any spoilage microorganisms, and then cooled quickly. It is packed in sterile packaging under sterile conditions after the cooling process, and will keep for many months without refrigeration. Refrigerate the milk before opening, and once opened, it can be used it like normal or pasteurized fresh milk. UHT milk has the same nutritional value as normal milk. It does not lose nutrients during processing (FDA 1999). Due to the short processing time of the high temperature treatment, there are less chemical changes in UHT milk compared to in-container sterilization (Browning *et al.* 2001). The difference between the UP milk and UHT milk is that there is no aseptic packaging in UP milk (Shew 1977). Browning *et al.* (2001) reported that the combination of heat and homogenization causes the color of UHT milk after processing to be whiter than raw milk.

### ***Sterilized Milk***

Sterilized milk is heated to higher temperature than pasteurized milk. It is heated to 121°C (250°F) for 15-20 minutes to kill all the contaminating bacteria using a retort or pressure cooker. The higher temperature and longer time cause the deterioration of nutritional value and change the sensory quality of sterilized milk. It can be kept up to several months at room temperature (FAO Corporate Document Repository 2007).

## MILK COMPOSITION

Milk is composed of water (87.3%) which is the principal constituent of milk, milk fat (3.7%), milk-solids-not-fat (8.9%), lactose (4.6%), protein (3.25%), mineral substances (0.65%), organic acids (0.18%), and miscellaneous substances (0.14%) (Lampert 1970; Walstra and Jenness 1984).

Milk fat is composed of approximately 70% of saturated fatty acids, 2% polyunsaturated fatty acids (Welch *et al.*, 1997), and 12.5% of glycerol. Milk fat gives unique appearance, flavor, and texture of milk. Milk with high fat content has larger fat globules than average size. Oxidized and cardboard flavor in milk are associated with oxidized phospholipids of milk which may turn the milk brown and give it an unpleasant odor (Lampert 1970).

Lactose is a reducing disaccharide composed of glucose and galactose molecules and is the distinctive carbohydrate found in milk (Rosenthal 1991). Lactose gives the milk a slightly sweet taste (Walstra and Jenness 1984).

The main milk proteins are caseins which represent about 80% of the total milk proteins. The principal milk caseins are alpha (s1) and alpha (s2)-caseins,  $\beta$ -casein, and kappa-casein. The remaining 20% are whey or serum proteins. The main whey proteins are  $\beta$ -lactoglobulin and  $\alpha$ -lactalbumin (Walstra and Jenness 1984; Varnam and Sutherland 2001). Homogenization may cause the casein proteins to combine with fat globules and reduce the size of the fat globules which create a uniform suspension of the fat. However, heating process does not change the dispersion of the casein. Bacterial contamination can cause the casein to precipitate in milk (Lampert 1970).

The minor components of milk are enzymes (lipase, alkaline phosphatase, lactoperoxidase and catalase), non-protein nitrogenous substances, vitamin (both fat and water-soluble vitamins), citric acid, inorganic elements, and gases (Rosenthal 1991).



## NUTRITIONAL VALUE OF MILK

Milk is considered to be one of the most nearly perfect foods (Lampert 1970). It provides significant amounts of protein and most micronutrients including calcium, vitamin Bs, vitamin A, iodine, magnesium, phosphorus, potassium, and zinc. It helps to improve the bone by preventing osteoporosis, dental health by preventing dental caries, and also assists in preventing hypertension by reducing blood pressure. The calcium in milk products aid in reducing the risk of colon cancer (Wells 2001).

Milk is also a great source of 8 essential amino acids: Tryptophan, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Threonine, and Valine which are required in the human diet (Lampert 1970). Some vitamins in milk can be partly destroyed during heating process (Walstra and Jenness 1984; Ford and Thompson 1988) as shown in table 1.1.

**Table 1.1 Vitamin content of milk and typical percent losses caused by heat treatment <sup>1</sup>**

Vitamin	Raw milk, content/100 mL	Loss (%)		
		Pasteurized	Sterilized	UHT
Thiamin	45 µg	<10	30	10
Riboflavin	180 µg	ns	ns	ns
Nicotinic acid	80 µg	ns	ns	ns
Vitamin B <sub>6</sub>	40 µg	<10	20	10
Vitamin B <sub>12</sub>	0.3 µg	<10	<90	10
Pantothenic acid	350 µg	ns	ns	ns
Biotin	2.0 µg	ns	ns	ns
Folic acid	5.0 µg	<10	50	15
Ascorbic acid	2.0 µg	20	90	25
Vitamin A	30 µg	ns	ns	ns
Vitamin D	22 ng	ns	ns	ns
Vitamin E	86 µg	ns	ns	ns
B-carotene	17 µg	ns	ns	ns

<sup>1</sup>From Ford and Thompson, 1988. New Monograph on UHT milk.

ns = not significant

Pasteurized = 72°C for 15 seconds; Sterilized = 115°C for 30 minutes

## **MILK CONSUMPTION AROUND THE WORLD**

The total milk consumption and production vary widely from highest in Europe and North America to lowest in Asia and South America. Table 1.2 shows the world-wide milk consumption and production of various countries (FAO 2004). However, Asia Pacific had the highest acceleration of new milk product innovation in 2006 and the first 8 months of 2007 as shown in table 1.3 (Dairy Foods 2007).

**Table 1.2 Milk consumption and production of selected countries in the world in 2001-2003 (1000 tons) <sup>1</sup>**

<b>Country</b>	<b>Milk Consumption</b>	<b>Milk Production</b>
France	16,505	25,695
Italy	14,618	12,305
Thailand	1,386	607
Korea	1,386	2,419
Japan	8,441	8,362
Peru	1,317	1,198
U.S.	76,212	76,487

<sup>1</sup>From FAO Statistical Yearbook: Country Profiles 2004

**Table 1.3 White milk introduction by region <sup>1</sup>**

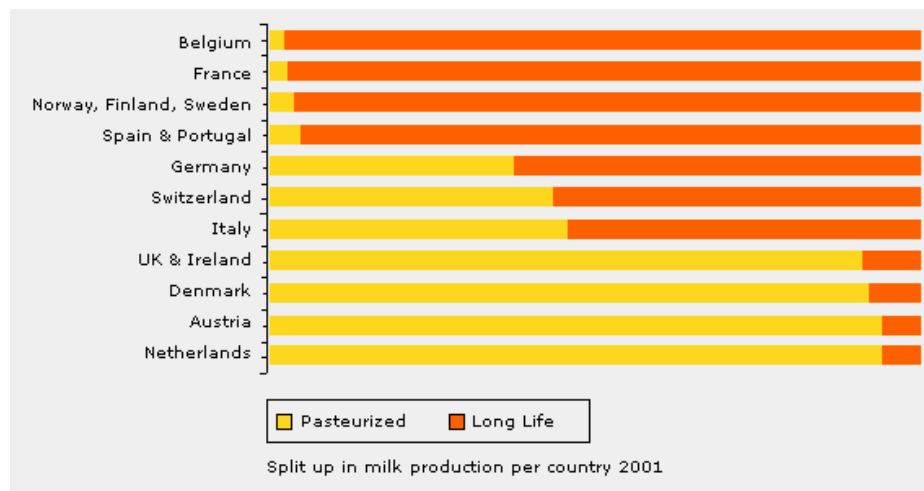
<b>Region</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>01/07-08/07</b>
Asia Pacific	130	148	187	217
Europe	165	174	172	168
Latin America	82	85	134	103
North America	25	37	44	59
Middle East & Africa	17	30	29	21
Total Sample	419	474	566	568

<sup>1</sup>From the Mintel Custom Solution's Global New Product Database 2007

## Europe

UHT milk had the largest market share in Europe in 2001. The consumption of UHT milk accounts for 54% compared with 42% of pasteurized fresh milk and 4% of sterilized milk (SABIC 2001). The proportion of milk production in Europe varies by country as shown in figure 1.1. The UHT milk accounts for 95% and sterilized milk accounts for 5% in the long life milk category. Belgium, Spain, and France are the primary users of sterilized milk. However, the consumption of sterilized milk has been declining continually because of better taste in UHT milk (SABIC 2001). Solomon *et al.* 2005 reported the large success of UHT milk in Europe with \$6 billion of sales in 1999 for Parmalat, the largest UHT milk manufacturer in the world. Low-fat milks were consumed more than full-fat milks by European (Raats and Shepherd 1993).

**Figure 1.1 Production comparison of pasteurized fresh milk and long-life milk per European country (SABIC 2001)**



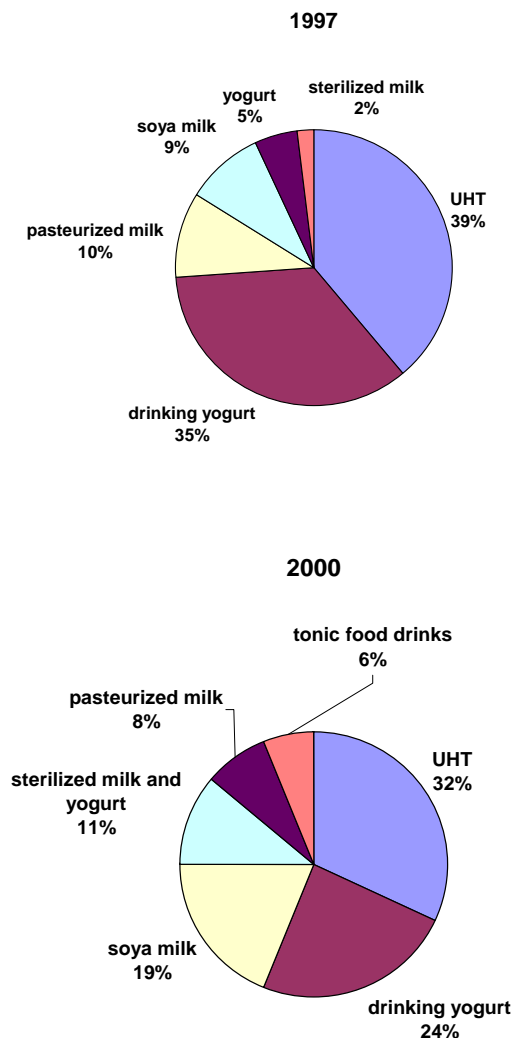
## Asia

Liquid milk consumption dramatically increased from 6.6 grams/person/day in 1986 to 39.3 grams/person/day in 1995 (Smitasiri and Chotiboriboon 2003). Asian females had lower calcium intake as compared with Hispanic and White females (Auld *et al.* 2002). In an attempt to increase calcium intake among Thais, the Royal Thai government initiated a campaign to increase milk consumption with the slogan 'Have you

*had your milk today?'* (Leekpai 1999; Smitasiri and Chotiboriboon 2003). In 2000, UHT milk was the primary milk consumed by Thais which accounted for 32% of the total milk consumption as shown in figure 1.2 (Itsaranuwat and Robinson 2003).

The consumption of liquid milk in Japan is considerably lower than in European countries (Barrager 1992). This may be attributed by lactose intolerance among Japanese and the misunderstanding of fat content effect in milk which might affect on obesity, high cholesterol, and high blood pressure (Mitsui *et al.* 2007). In Korea, the health benefits of milk may play an important role in increasing milk consumption (Lee *et al.* 2003).

**Figure 1.2 Thailand total milk consumption profile in 1997 and 2000**

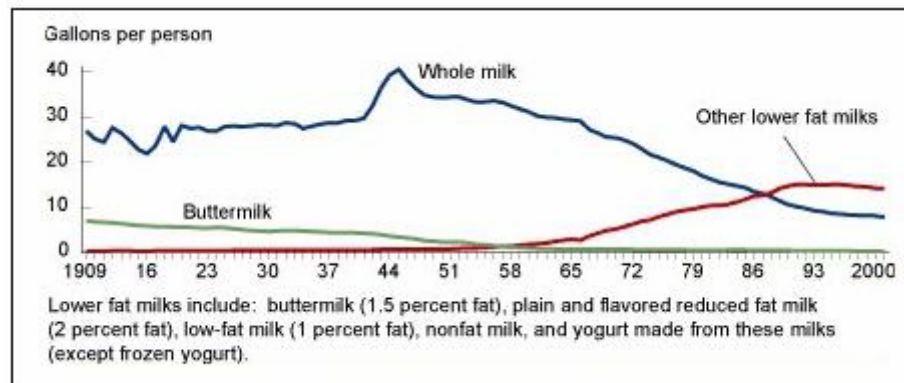


## *North America*

Americans have a high risk for osteoporosis which may be prevented by consuming calcium-rich foods such as milk (Auld *et al.* 2002). Milk is one of the most ideal sources of calcium in American diets because it contains vitamin D, which assists in calcium absorption (Kim and Douthitt 2004).

Fluid milk consumption of Americans has been changing from whole milk to lower fat milks since 1987 (Amber Waves 2003; Robb *et al.* 2006) as shown in figure 1.3 due to the concern over cholesterol, saturated fat, and calories.

**Figure 1.3 Fluid milk consumptions of Americans (Amber Waves 2003)**



The low consumption of UHT milk in North America may be because consumers feel uncomfortable about drinking milk that has been stored with no refrigeration and therefore are unwilling to purchase it (Solomon *et al.* 2005).

## *Australia*

Milk consumption in Australia has been steadily changing from whole milk to reduced and low-fat milks (Dairy Australia 2006). The sales of UHT milk increased from 40 million liters in 1990 to 153 million liters in 2006. UHT milk has shown a slight growth over low-fat milk since 2000 (Dairy Australia 2006). However, UHT milk consumption in Australia is lower than the countries such as France, Spain, Germany, and Italy (Perkins and Deeth 2001). Reasons given for lower market share of UHT milk in Australia are the higher price of UHT milk, differences in flavor of UHT milk from

pasteurized fresh milk, packaging type, and current purchasing habits of pasteurized fresh milk (Perkins and Deeth 2001).

## **MILK QUALITY**

The cooked flavor that arises from processing is one of the main reasons why US consumers have lower acceptability of UHT milk. It is mainly caused by the formation of hydrogen sulfide during heat treatment. Flavor deterioration and age gelation also affect the shelf-life of UHT milk. The flavor quality of UHT milk is influenced by the severity of the heat treatment, storage temperature, and storage time (Hill 1988).

Browning *et al.* (2001) used chemical change, thiamin loss, lactulose formation, Maillard browning, and hydroxymethylfurfural to predict quality parameters in UHT-processed milk. Elliott *et al.* (2005) used changes in lactulose, furosine, and acid-soluble whey proteins ( $\alpha$ -Lactalbumin,  $\beta$ -Lactoglobulin, bovine serum albumin) to examine heat-induced changes in commercial UHT milks during 24-week of storage. The results showed that the indirectly heated UHT milks had more heat damage than the directly heated UHT milks.

## **MILK EVALUATION TECHNIQUES**

Dairy quality judging methods or traditional dairy terminology systems using score cards are widespread used by the dairy industry to determine sensory quality of dairy products (Bodyfelt 1981; Claassen and Lawless 1992). Claassen and Lawless (1992) compared the “traditional defect-oriented sensory terminology system” to the “panel-generated consumer-oriented terminology system” representing a descriptive analysis procedure for evaluating fluid control and defective treated milks. The results showed that the consumer-oriented descriptive terms were more sensitive than the defect-oriented terms. Some of the attributes (sweet, plastic, cardboard, and metallic) from

Claasen and Lawless (1992) were used in the descriptive analysis part of these studies to describe the sensory characteristics of UHT milk.

## **FLAVOR IN MILK**

### ***Effect of Feed***

Feeding practices can affect the flavor of dairy products including milk, cheese and butter (Urbach 1990; Forss 1992; Visser 1992; Martin *et al.* 2005). Milk from cows fed on dry feed is more vulnerable to oxidation than milk from cows fed on the pasture. Dry feeding increased the oxidized flavor in milk more than forage crops (Urbach 1990). Most milk from cows fed on fresh feeds and silages gave more desirable milk with less off-flavor notes and more pleasant flavor (Forss 1992). Feed of poor quality may be responsible for off-flavors associated in milk (Urbach 1990).

Milk with feed flavor will produced a product that is less acceptable to consumers. The more of the feed flavor (haylage and corn silage), the greater the potential for the milk to be creamier, had more body, had less fresh taste, and possibly had a slight sour taste. Appropriate processing procedures may reduce or eliminate feed flavor in milk (Modler *et al.* 1977).

The major feeds for cattle, pigs and poultry in the US were maize and soybean meal. In European, cattle, pigs and poultry were fed mostly with cereals (Pressenda and Lapierre 2000).

### ***Effect of Serving Temperature***

Francis *et al.* (2005) reported that the fat content and milk composition had the impact on milk flavor, texture, and aftertaste. Whole milk was perceived with sweeter taste, less cooked flavor, less sour aromatics, and less bitter taste than non-fat milk. The texture of non-fat milk was considered to be chalkier and less viscous than whole milk. Different serving temperature of 4°C and 15°C did not affect the flavor, texture, or aftertaste of milk therefore the UHT milk samples in these studies were served at 6-7°C.

## **OFF-FLAVORS IN MILK**

Light induced off-flavors which are the most important off-flavors found in milk can be separated into two reasons: burnt sunlight off-flavor and metallic or cardboardy off-flavor (lack of freshness) (Zygoura *et al.* 2004). The descriptive panel defined milk inducing with light-oxidized, metallic-oxidized, and rancid flavors as sweet, cream, plastic, cardboard, metallic, old oil, butter, cheese, mouthcoating, mouthdrying, and irritation (Claassen and Lawless 1992).

Heat treatment during processing can affect the flavor of sterilized and UHT milks. The heat may increase browning reactions which causes cooked flavor (Walstra and Jenness 1984; Bodyfelt *et al.* 1988). Stale flavors may develop during storage from an increased concentration of volatile compounds such as 2-alkanones, benzaldehyde, acetophenone (Walstra and Jenness 1984). At the final stage, bitterness and lipolyzed flavors may develop due to the activities of heat-stable enzymes (Hill 1988). Lipolyzed flavors in milk may be described as rancid, butyric, bitter, and goaty off-flavors (Bodyfelt *et al.* 1988).

Microbial contamination in milk is one of the major reasons in creating off-flavor in milk. The off-flavor may be described as acid, bitter, fruity, malty, putrid, and unclean. Cowy and barny are related to the unclean off-flavor which is detected by unpleasant, lingering aftertaste (Bodyfelt *et al.* 1988).

## **DESCRIPTIVE SENSORY ANALYSIS OF MILK**

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 specifically related to UHT milk (Chapman *et al.* 2001; Lee *et al.* 2003; 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). The



descriptive terms used by trained panelists to describe the sensory characteristics of milk from previous research are shown in table 1.4.

Clare *et al.* (2005) used cooked/ caramelized, sweet aromatic/cake mix, fatty/ stale, sweet taste, bitter, astringent, and color intensity to differentiate UHT from microwave-treated milks. Microwave milk had lower caramelized flavor, less astringency, less fatty/ stale flavors, and less brownish color compared with UHT milk. 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 the key sensory attributes associated with pasteurized fluid milk throughout shelf-life. These results showed that excluding bacterial contaminants from milk is very essential to extend shelf-life of milk products.

Processing variables have been shown to affect sensory properties of preserved milk. Clare *et al.* (2005) compared sensory characteristic of milk processing with indirect UHT and microwave methods. UHT milk had more caramelized and fatty/ stale flavor, more brown color, and more astringency because of the higher heat treatment. Keast and Lau (2006) found the flavor differences of soymilk processed from different countries. Soymilks from Asia (Hong Kong, Malaysia and Singapore) were sweeter, less salty, darker in color, and stronger in beany flavor than soymilks from Australia.

**Table 1.4 Sensory descriptive terms for milk used by various authors**

<b>Author</b>	<b>Country</b>	<b>Type of Milk</b>	<b>Descriptors/Attributes</b>
Claassen and Lawless 1992	U.S.	Pasteurized milk (contain light-oxidized, metallic-oxidized, and rancid flavor defects)	"Panel-Generated Terms Panel" <u>Aroma</u> Cardboard <u>Flavor</u> Sweet taste Cream flavor Plastic flavor Old oil flavor Butter flavor Cheese flavor

<b>Author</b>	<b>Country</b>	<b>Type of Milk</b>	<b>Descriptors/Attributes</b>
Clasassen and Lawless 1992	U.S.	Pasteurized milk (contain light-oxidized, metallic-oxidized, and rancid flavor defects)	<u>Aftertaste</u> Metallic <u>Texture/Mouthfeel</u> Mouthcoating Mouthdrying Irritation "Traditional Terms Panel" <u>Flavor</u> Light-oxidized flavor Metallic-oxidized flavor Rancid flavor
Chapman <i>et al.</i> 2001	U.S.	UP Milk	<u>Aroma</u> Cooked aroma Caramelized aroma Grainy/Malty aroma <u>Flavor</u> Cooked flavor Sweet flavor Caramelized flavor Bitter flavor Metallic flavor <u>Texture</u> Viscosity Drying Chalky <u>Aftertaste</u> Drying aftertaste Metallic aftertaste Bitter aftertaste Lingering aftertaste

<b>Author</b>	<b>Country</b>	<b>Type of Milk</b>	<b>Descriptors/Attributes</b>
Lee <i>et al.</i> 2003	Korea	Commercial milk	<u>Odor</u> Raw milk aroma Milky aroma <u>Flavor</u> Sweet taste Raw milk taste Metallic Cooked taste Creaminess <u>Texture</u> Thickness <u>Aftertaste</u> Clear aftertaste
Fromm and Boor 2004	U.S.	HTST pasteurized milk	<u>Aroma</u> Cheese aroma Cooked aroma Cream aroma Hay/grain aroma Sulfur aroma Sour/fermented aroma Putrid aroma <u>Taste</u> Baby formula taste Butter taste Cooked taste Flat taste Nutty taste Rancid taste Sweet taste <u>Aftertaste</u> Cardboard aftertaste

<b>Author</b>	<b>Country</b>	<b>Type of Milk</b>	<b>Descriptors/Attributes</b>
Fromm and Boor 2004	U.S.	HTST pasteurized milk	<u>Aftertaste</u> Sweet aftertaste Sour aftertaste Metallic aftertaste <u>Aftertaste</u> Drying aftertaste Lingering aftertaste
Clare <i>et al.</i> 2005	U.S.	UHT and microwave milks	<u>Flavor</u> Cooked/caramelized flavor Sweet aromatic/cake mix flavor Chocolate flavor (chocolate milks only) Fatty/stale flavor Sweet flavor Bitter flavor <u>Mouthfeel</u> Astringent <u>Color</u> Color intensity
Francis <i>et al.</i> 2005	U.S.	Pasteurized milk	<u>Texture</u> Chalky Fat feel Viscosity <u>Flavor</u> Bitter taste Cooked flavor Fat flavor Flat flavor Sour taste Sour aromatics Sweet taste

<b>Author</b>	<b>Country</b>	<b>Type of Milk</b>	<b>Descriptors/Attributes</b>
Francis <i>et al.</i> 2005	U.S.	Pasteurized milk	<u>Flavor</u> Sweet aromatics <u>Aftertaste</u> Astringent aftertaste Bitter aftertaste Chalky aftertaste Cooked aftertaste Fat aftertaste Fatty mouthfilm aftertaste Overall sour aftertaste Overall sweet aftertaste

## **CONSUMER TESTS ON MILK**

There have been a limited number of published researches on acceptability and consumption of pasteurized fresh milk and UHT milk (Horner *et al.* 1980; Pearson *et al.* 1990; Raats and Shepherd 1993; Chen *et al.* 1996; Chapman *et al.* 2001; Lee *et al.* 2003).

Horner *et al.* (1980) observed that people in the U.S. could differentiate whole pasteurized fresh milk (WPM) from UHT milk and that they significantly preferred WPM to UHT milk. Differences and preferences were possibly related to how milk was normally consumed.

The supermarket survey conducted by Pearson *et al.* in 1990 revealed that UHT milk was most frequently described as “easy to store” and “convenient”. Female and young adults aged 25-44 years were most familiar with UHT milk.

Raats and Shepherd (1993) conducted short structured interviews to study the use of milk, the type of milk consumed, the appropriateness of milk perception, and people’s beliefs concerning different types of milk: UHT versus pasteurized fresh milk and different fat levels in Finland, France, the Netherlands, and the United Kingdom (UK). UHT milk was almost only consumed by French subjects. The sensory attributes, preferences, attitudes, and beliefs toward the different milk types have influence on milk

purchasing. Low-fat milks which described as “watery”, “healthy”, and “digestible” were consumed more than full-fat milks which described as “creamy”, “fat content”, “full”, and “rich”.

The study from Chen *et al.* (1996) showed that 2% pasteurized fresh milk was preferred over 2% UHT milk by children aged 36-71 months because of its taste and mouthfeel. Chapman and Boor (2001) conducted a study with 6 to 11 year-old children and found that HTST milks were preferred over UHT and UP milks. The UP milks were preferred the least by the children.

Milk with more cooked taste, creaminess, and sweetness were perceived with more overall quality acceptance and were liked more by consumers compared to milk with raw milk taste, raw milk aroma, metal taste, and clear aftertaste. Thickness in milk did not show significant effect on overall acceptance (Lee *et al.* 2003)

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## **CHAPTER 2 - Detailed Materials and Methods**

## **PHASE 1: DESCRIPTIVE ANALYSIS**

### **(Sensory Properties Determination of UHT Milk)**

#### ***Milk Samples***

Thirty-seven low-fat, 2% reduced-fat, and whole ultra-high temperature (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. Sample selection was based on origin, fat content, and availability (Table 2.1). Samples were procured 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). There were seven low-fat, eleven 2% reduced-fat, and nineteen whole UHT milk samples. 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 were purchased with the same code date when available otherwise samples were purchased with the same expiration date to avoid extraneous factors, such as sample age, that might affect the flavor and texture of each sample.

Samples were purchased in either tetra-packed cartons or plastic bottles depending on each country and were held at room temperature after purchasing until the day prior to testing. The control samples were purchased in 1-gallon translucent white plastic jugs every three days and were stored in a 1°C refrigerator (TS-49 commercial refrigerator, True Manufacturing Co, St Louis, MO, USA). UHT milk samples were placed in the refrigerator the day before testing and were held at 1°C.

**Table 2.1 List of milk samples used for descriptive analysis**

<b>Origin</b>	<b>Product</b>	<b>Type</b>	<b>Heat Processing</b>	<b>Package</b>
France	Monoprix Lait	Low-Fat Milk	UHT	1000 mL carton
France	Monoprix Lait	Whole Milk	UHT	1000 mL carton
Italy	Fattoria Scaldasole	2% Reduced-Fat Milk	UHT	1000 mL carton
Italy	Latte	2% Reduced-Fat Milk	UHT	500 mL carton
Italy	Latte Maremma	2% Reduced-Fat Milk	UHT	1000 mL carton
Italy	Mukki Scorta	2% Reduced-Fat Milk	UHT	1000 mL carton
Italy	Parmalat Fibresse	2% Reduced-Fat Milk	UHT	1000 mL bottle
Italy	Parmalat Natura Premium	2% Reduced-Fat Milk	UHT	1000 mL bottle
Italy	Parmalat Omega 3	2% Reduced-Fat Milk	UHT	1000 mL carton
Italy	Polenghi	2% Reduced-Fat Milk	UHT	1000 mL carton
Italy	Mukki Scorta	Whole Milk	UHT	1000 mL carton
Italy	Parmalat Natura Premium	Whole Milk	UHT	1000 mL bottle
Italy	Polenghi	Whole Milk	UHT	1000 mL carton
Japan	Morinaga Milk	Whole Milk	UHT	250 mL carton
Korea	Maeil Milk	Whole Milk	UHT	1000 mL carton
Korea	Seoul Milk	Whole Milk	UHT	1000 mL carton
Peru	Bella Holandesa	Whole Milk	UHT	1000 mL carton
Peru	Gloria	Whole Milk	UHT	1000 mL carton
Peru	Laive	Whole Milk	UHT	1000 mL carton
Thailand	Bear Brand	Low-Fat Milk	Sterilized	140 mL can
Thailand	Country Fresh	Low-Fat Milk	UHT	250 mL carton
Thailand	Foremost	Low-Fat Milk	UHT	250 mL carton
Thailand	Foremost Calcimex	Low-Fat Milk	UHT	250 mL carton
Thailand	Mali	Low-Fat Milk	UHT	250 mL carton
Thailand	Meiji	Low-Fat Milk	UHT	250 mL carton
Thailand	Bear Brand	Whole Milk	Sterilized	140 mL can
Thailand	Country Fresh	Whole Milk	UHT	250 mL carton
Thailand	Foremost	Whole Milk	UHT	250 mL carton

<b>Origin</b>	<b>Product</b>	<b>Type</b>	<b>Heat Processing</b>	<b>Package</b>
Thailand	Meiji	Whole Milk	UHT	250 mL carton
Thailand	Nongpho	Whole Milk	UHT	250 mL carton
Thailand	Chitralada	Whole Milk	UHT	200 mL carton
Thailand	Thai-Danish	Whole Milk	UHT	250 mL carton
U.S.	Horizon Organic	2% Reduced-Fat Milk	UHT	236 mL carton
U.S.	Parmalat	2% Reduced-Fat Milk	UHT	946 mL carton
U.S.	Parmalat Lil Milk	2% Reduced-Fat Milk	UHT	236 mL carton
U.S.	Parmalat	Whole Milk	UHT	946 mL carton
U.S.	Parmalat Lil Milk	Whole Milk	UHT	236 mL carton
U.S.	Dillons (control)	2% Reduced-Fat Milk	Pasteurized	1 gallon jug
U.S.	Dillons (control)	Whole Milk	Pasteurized	1 gallon jug

### ***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 6-7°C 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 professional 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, yogurt, ice cream, and cheese.

### ***Descriptive Orientation Sessions***

The panelists were given a set of attributes, definitions and references previously developed to describe the flavor of fresh 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. They were asked to make modifications to the attributes and adapt it to the flavor and texture of UHT milks. Panelists were asked to be as specific as possible in identifying the attributes. General 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 (Chambers *et al.* 2006; Vara-Ubol *et al.* 2006; Lee and Chambers 2007).

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 (Table 2.2) to begin the lexicon development. Panelists independently evaluated the milk samples and wrote down any new descriptors found. The panel leader then led a discussion to arrive at an agreement of any new descriptors, definitions, and references that needed to be added to the lexicon. The control, 2% reduced-fat, and whole milks were given scores for each attribute during the orientation sessions.

During orientation, 100 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 after holding overnight in the refrigerator at 1°C. Sample cups were covered with clean dark paper to avoid light oxidation that might happen during tempering. After the temperature of milk samples reached 6-7°C, the sample cups were covered with plastic lids and served to the panelists.



**Table 2.2 Local milk samples used for orientation**

<b>Product</b>	<b>Type</b>	<b>Heat Processing</b>	<b>Package</b>
Horizon Organic	Organic Low Fat Milk (1% Milk Fat)	UP	500 mL carton
Horizon Organic	Organic Low Fat Milk	UHT	500 mL carton
Horizon Organic	Organic Reduced Fat Milk (2% Milk Fat)	UP	236 mL carton
Organic Valley	Organic Reduced Fat Milk (2% Milk Fat)	UP	330 mL bottle
Parmalat	2% Reduced Fat Milk	UHT	946 mL carton
Parmalat	Whole Milk	UHT	946 mL carton

The panel changed some attribute definitions and references after orientation sessions. They deleted attributes: thickness, drying, creaminess, raw milk, cream, butter, cheese, barny, chemical, old oil, rancid, and caramelized flavors that they did not find in UHT, ultra-pasteurized, or sterilized milk samples and added new attributes: lip and mouthfeel, fermented, grainy, malty, medicinal, oily, plastic, vanilla/vanillin, and nutty flavors that they found in samples they had not previously tested. Every panelist had to agree with all attributes that were deleted and added to the profile ballot. The final attributes, definitions, and references used to describe sensory properties of UHT milk samples are given in Table 2.3.

**Table 2.3 UHT, pasteurized, and sterilized milk sensory attributes, definitions, references and intensities on a 15-point scale**

<b>Sensory Attributes</b>	<b>Definition</b>	<b>Reference<sup>a</sup> and Intensity<sup>b</sup></b>
<b><u>Texture</u></b>		
Chalky	A measure of dry, powdery sensation in the mouth.	Carnation Non-Fat Dry Milk = 4.5 Kroger Non-Dairy Coffee Cream = 7.5 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.	Carnation Non Fat Dry Milk (reconstituted) = 0.0 Land O'Lakes Fat Free Half and Half = 8.0
Viscosity	The measure of the flow as the product moves across the tongue. Technique: place 1 teaspoon of sample on tongue and judge rate of flow across.	Water = 0.0 Dillons 2% Reduced-Fat Milk = 1.0 Dillons Half and Half = 2.0 Dillons 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
<b><u>Flavor</u></b>		
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) 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)

<b>Sensory Attributes</b>	<b>Definition</b>	<b>Reference<sup>a</sup> and Intensity<sup>b</sup></b>
Cooked	The combination of brown flavor notes and aromatics associated with heated milk.	Dillons 2 Minutes Heated Whole Milk = 4.5 Carnation Evaporated Milk = 12.0
Overall Dairy	A general term for the aromatics associated with products made from cow's milk.	Carnation Non Fat Dry Milk = 4.5 Dillons Half and Half = 10.0
Dairy Fat	Aromatics associated with dairy fat.	Carnation Non Fat Dry Milk = 0.0 Land O'Lakes Fat Free Half and Half = 5.0
Dairy Sweet	The sweet aromatics associated with fresh dairy products.	Dillons 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 (Chalbis) = 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)

<b>Sensory Attributes</b>	<b>Definition</b>	<b>Reference<sup>a</sup> and Intensity<sup>b</sup></b>
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 some what 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)

<b>Sensory Attributes</b>	<b>Definition</b>	<b>Reference<sup>a</sup> and Intensity<sup>b</sup></b>
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

<sup>a</sup> References were prepared approximately 24 hours before a testing session, refrigerated overnight and removed from the refrigerator 30 minutes before a testing session.

<sup>b</sup> 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.

Each milk sample was evaluated for texture: chalky, fat feel, viscosity, and other attributes that may come up after each sample evaluation and flavor characteristics: brown, butyric acid, cardboard, cooked, overall dairy, dairy fat, dairy sweet, feed, fermented, flat, floral, grainy, green, lack of freshness, light-oxidized, malty, medicinal, metallic, musty/dusty, musty/earthy, oily, plastic, processed, refrigerator, sweet, vanilla/vanillin, vitamins, sour aromatics, sour, astringent, bitter, and other attributes that may come up after each sample evaluation.

The panelists had 25 min in total to evaluate each milk sample and 5 min break between each sample to minimize the carry-over effect. Each milk sample was served two times to the panel. For the first serving, 75 mL of each sample was served and they were allowed 15 min to evaluate each sample. After 15 min of evaluation, additional 25 mL of each sample was served. 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 milk samples. Principal components analysis (PCA) was conducted using SYSTAT<sup>®</sup> program (Version 10.2, 2005, SYSTAT Software, Inc, San Jose, CA). Principal components analysis was used to group attributes of each sample into principal component of texture and flavor characteristics. The covariance matrix for extraction and varimax rotated loading parameter were used for the analysis. 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 milks.

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

## **PHASE 2: CONSUMER TEST**

### **(Acceptability and Preference Mapping of UHT Milk)**

#### ***Samples***

Five commercial UHT whole milks from Thailand: WThai8 (Country Fresh), WThai9 (Foremost), WThai10 (Meiji), WThai11 (Nong Pho), and WThai12 (Chitralada) were used for consumer tests. The reason for choosing those samples was that prior research conducted in our laboratory suggested they represented a range of different sensory characteristics present in UHT milk. Thus, this set could be used to compare liking patterns between Thai and U.S. consumers on UHT milk. All samples were from Thailand because it was easier to import the Thai milks to the U.S. than to import U.S. milks to Thailand.

Samples were purchased in tetra-packed cartons at a local grocery store in Bangkok, Thailand and were shipped to the U.S. for the testing in Manhattan, Kansas. Samples were purchased with the same code date when available otherwise samples were purchased with the same expiration date to avoid extraneous factors, such as sample age, that might affect the flavor and texture of each sample. Appendix 8 shows samples used for consumer testing in both locations.

Samples with 3-digit random numbers labeled on each package were stored at room temperature until the day prior to testing and were moved to a refrigerator (True Model TS-49 commercial refrigerator (Model TS-49, True Manufacturing Co, St Louis, MO, USA) for overnight storage at 1°C.

#### ***Subjects***

One hundred consumers participated in the consumer testing in both Bangkok, Thailand and Manhattan, KS, USA. In Thailand, the consumer panelists were recruited in person, through paper fliers, and broadcast advertisements during a festival time at Kasetsart University. In the U.S., the consumers were recruited by telephone or e-mail using consumer databases provided by the Sensory Analysis Center, Kansas State University.

All consumers were screened using the same criteria: age (18-70) with age category restriction to ensure an even distribution; no immediate family employed in a food manufacturing, a market research, or an advertising firm; no food allergies; and must consume milk at least once per week. For the U.S. study, consumers must have lived in the U.S. for at least ten years prior to the study (Appendices 5, 6, and 14).

For the testing in Thailand, consumers came to the sensory facilities at the Sensory and Consumer Research Center at Kasetsart University and in the US, consumers came to the Sensory Analysis Center facilities at Kansas State University. Both facilities have appropriate temperature and lighting for conducting consumer tests. Participants in both locations were paid for their time.

### ***Consumer Testing Procedures***

The procedures of testing were similar for both locations. The consumers were asked to come to the testing location on a specific date and time. They were checked in and assigned consumer numbers at a counter before going to the testing room. The project was approved by the Kansas State University (KSU) committee on Human Subjects and all consumers signed consent forms (Appendices 7 and 16) provided in their local language.

Each consumer was provided a set of ballots with questionnaire (Appendices 12 and 19) and demographic questions (Appendices 13 and 20), a testing instructions sheet (Appendices 11 and 18), a pencil, a placemat, a napkin, and either a bottled water (Nestlé® Pure Life®, Nestlé SA, Vevey, Switzerland) for the testing in Thailand or purified water in a 12 oz Styrofoam cup (C12A, James River Corp, Easton, PA, USA) for the testing in the US, and three unsalted top saltine crackers (Nabisco, East Hanover, NJ, USA) for cleansing the palate before testing and between each sample.

At the beginning of each session, the testing procedure (Appendix 10) was explained by a moderator. Each session lasted approximately 30 min and each consumer tested each of the five milk samples. Samples, 50 mL each, were served one at a time in 8 oz Styrofoam cups (H8S, James River Corp, Easton, PA, USA) labeled with 3-digit random codes. Samples were served at 6-7°C following the test designs (See appendices 9 and 17) after 8 minutes of tempering. The consumer participants were given 5 minutes



to evaluate each UHT milk sample. They were asked to take at least 3 sips of the milk samples before answering any of the questions and to drink the entire sample before completing the last question. The consumers answered 4 liking questions (overall, sweetness, fresh taste, and thickness) and 1 intensity (amount of off-flavor) question for each sample. Liking was scored on a 9-point hedonic scale (1 = “dislike extremely” to 9 = “like extremely”) and off flavor was scored on a 9 point intensity scale (1 = “none”, 5 = “moderate”, 9 = “extremely strong”). After they finished testing all five milk samples, they were asked to fill out a consumer demographic questionnaire including regular and UHT milk consumption.

All questionnaires were originally created in English and were translated into Thai by a native Thai speaker. The Thai questionnaires were translated back into English by a different native Thai speaker to assure the consistency of the information in the questionnaires used in the testing at both locations

### ***Experimental Design***

A Williams design constructed from 5x5 Latin square was used for consumer testing in both locations to ensure that each sample was tested in each position. The sequences of sample servings were the same for a set of five consumers which accommodated for serving efficiency.

### ***Statistical Analysis***

Analysis of variance (ANOVA) was conducted using PROC GLIMMIX in SAS<sup>®</sup> version 9.1 (2003, Cary, NC, USA) on the consumer testing data to compare the differences and similarities in UHT milk acceptability between U.S. and Thai consumers. Country (Thailand or U.S.) was considered as one factor. Least square means were analyzed for each sample, country, and interaction between sample and country. The consumers within each country and serving block were considered as random effects. Correlation analysis was conducted on the individual consumer data using PROC CORR on SAS<sup>®</sup> version 9.1 (2003, Cary, NC, USA) to determine the linear relationships among overall liking, liking of sweetness, liking of fresh taste, liking of thickness, and amount of off-flavor. The correlation was measured by Pearson correlation coefficients. All significant differences were determined at the 95% confidence level ( $P < 0.05$ ).

An external preference map was created for the consumer data by regressing the consumer overall liking data on the descriptive panel data using Partial Least Squares Regression (PLSR2) to identify sensory aspects of acceptance for the UHT milks. Unscrambler® (2004, version 9.0, Camo, Norway) was used for the external preference mapping techniques. An external preference map is a multivariate technique using the consumers' liking scores and the descriptive analysis data to determine the position of the products and the descriptive sensory attributes, and show consumer preference patterns toward those products (Schlich 1995; McEwan 1996). This technique is similar to a principal component analysis, where the consumers are the dependent or response variables, and the resultant map shows the liking information of each individual consumer.

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**CHAPTER 3 - Comparison of the Sensory Properties of UHT  
Milk from Different Countries**

## **ABSTRACT**

Shelf-stable milk, also known as ultra-high temperature (UHT) milk because of the pasteurization method (135-150°C or 300°F for 1 to 5 sec) with the aseptic package, is marketed as a convenience product in the United States (U.S.) and as the most common form of milk in many other parts of the world. This study compared the differences in flavor and texture of commercially available UHT milks from different countries. A total of 37 UHT and sterilized milk samples including whole, 2% reduced-fat, and low-fat milk were evaluated. Samples were 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 previously trained in evaluating dairy products, including milk, 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. 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.

## **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 flavor and texture of UHT milk should focus on improvements to manufacturing processes.

## 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 for Quantitative Descriptive Analysis methodology (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, 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. It seems reasonable that differences in regional milk source or processing requirements from country to country could result in differences that may explain why UHT milk is more accepted in countries other than the U.S. If the 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. Sample was based on origin, fat content, and availability. Table 3.1 shows product description, origin, type of milk, heat processing, and product abbreviation that 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). 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.



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 1°C.

### ***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 6-7°C 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, yogurt, ice cream, and cheese. Panelists were reoriented to milk testing for this project.

**Table 3.1 List of milk samples used for descriptive analysis with product abbreviation**

<b>Origin</b>	<b>Product</b>	<b>Type</b>	<b>Heat Processing</b>	<b>Product Abbreviation</b>
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

<b>Origin</b>	<b>Product</b>	<b>Type</b>	<b>Heat Processing</b>	<b>Product Abbreviation</b>
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

<b>Origin</b>	<b>Product</b>	<b>Type</b>	<b>Heat Processing</b>	<b>Product Abbreviation</b>
U.S.	Dillons (control)	2% Reduced-Fat Milk	Pasteurized	RFcontrol
U.S.	Dillons (control)	Whole Milk	Pasteurized	Wcontrol

### ***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 (Chambers *et al.* 2006; Vara-Ubol *et al.* 2006; Lee and Chambers 2007). 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 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 3.2.

**Table 3.2 UHT, pasteurized, and sterilized milk sensory attributes, definitions, references and intensities on a 15-point scale**

Sensory Attributes	Definition	Reference <sup>a</sup> and Intensity <sup>b</sup>
<b><u>Texture</u></b>		
Chalky	A measure of dry, powdery sensation in the mouth.	Carnation Non-Fat Dry Milk = 4.5 Kroger Non-Dairy Coffee Cream = 7.5 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.	Carnation Non Fat Dry Milk (reconstituted) = 0.0 Land O'Lakes Fat Free Half and Half = 8.0
Viscosity	The measure of the flow as the product moves across the tongue. Technique: place 1 teaspoon of sample on tongue and judge rate of flow across.	Water = 0.0 Dillons 2% Reduced-Fat Milk = 1.0 Dillons Half and Half = 2.0 Dillons 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
<b><u>Flavor</u></b>		
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) 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)

<b>Sensory Attributes</b>	<b>Definition</b>	<b>Reference<sup>a</sup> and Intensity<sup>b</sup></b>
Cooked	The combination of brown flavor notes and aromatics associated with heated milk.	Dillons 2 Minutes Heated Whole Milk = 4.5 Carnation Evaporated Milk = 12.0
Overall Dairy	A general term for the aromatics associated with products made from cow's milk.	Carnation Non Fat Dry Milk = 4.5 Dillons Half and Half = 10.0
Dairy Fat	Aromatics associated with dairy fat.	Carnation Non Fat Dry Milk = 0.0 Land O'Lakes Fat Free Half and Half = 5.0
Dairy Sweet	The sweet aromatics associated with fresh dairy products.	Dillons 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 (Chalbis) = 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)

<b>Sensory Attributes</b>	<b>Definition</b>	<b>Reference<sup>a</sup> and Intensity<sup>b</sup></b>
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 some what 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)

<b>Sensory Attributes</b>	<b>Definition</b>	<b>Reference<sup>a</sup> and Intensity<sup>b</sup></b>
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

<sup>a</sup> References were prepared approximately 24 hours before a testing session, refrigerated overnight and removed from the refrigerator 30 minutes before a testing session.

<sup>b</sup> 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.

### ***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<sup>®</sup> 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<sup>®</sup> program version 10.2 (2005, SYSTAT Software, Inc, San Jose, CA).



## RESULTS AND DISCUSSION

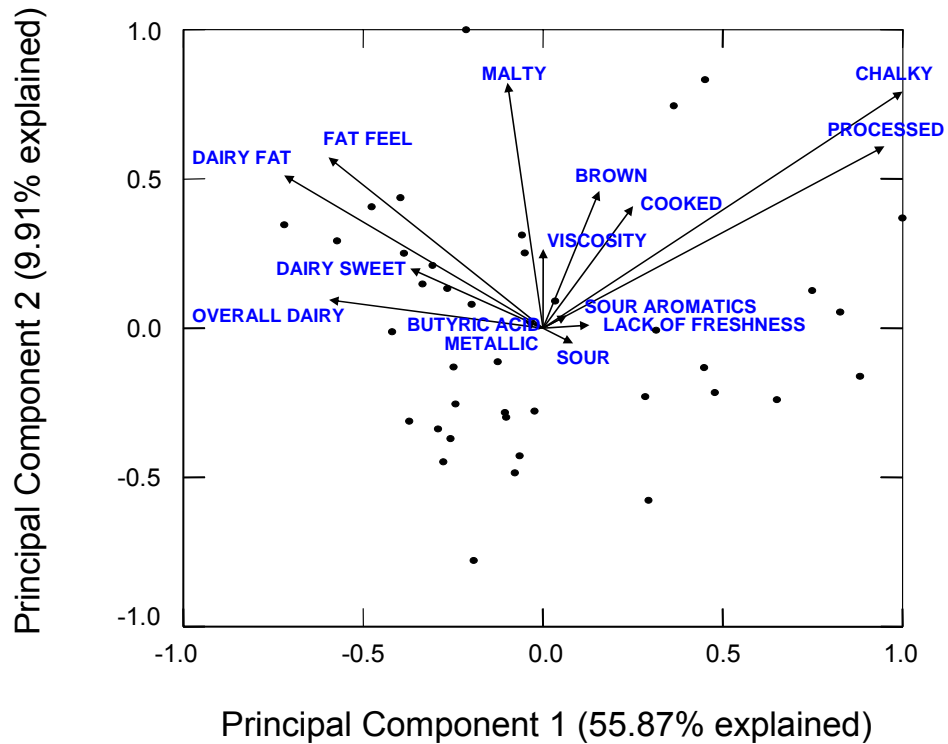
Attributes added to previous lexicons to better describe the texture and flavor of the range of the milks in this study were: lip and mouthfeel, fermented, grainy, malty, medicinal, oily, plastic, vanilla/vanillin, and nutty. Many of those terms were added during testing, along with appropriate definitions and references (table 3.2) to describe particular characteristics found in samples that were not available during orientation.

Figure 3.1 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 with 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 relationship to cooked and brown flavors indicating that brown and cooked notes can 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.

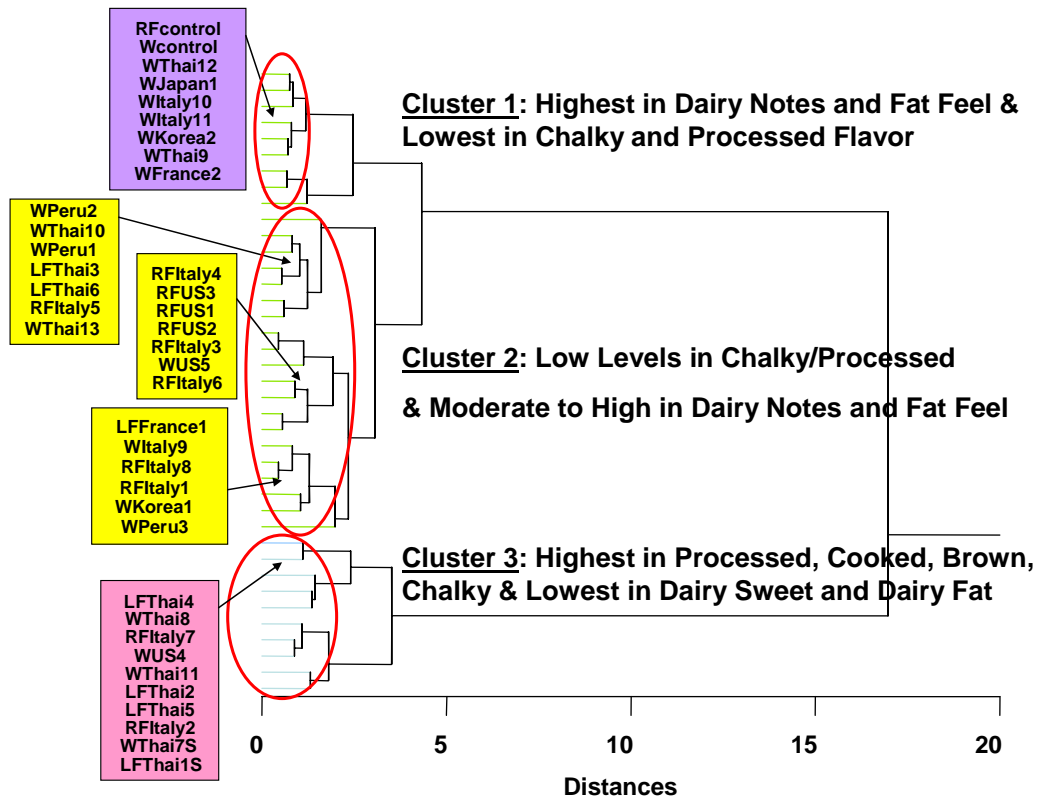
Three major clusters of UHT, pasteurized, and sterilized milk samples were found, but they did not group on the basis of either country or fat content (figure 3.2). There were more similarities of milks from the same manufacturer than milks from the same country or milks with the same fat content. This 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.

**Figure 3.1 Principal component analysis (PCA) results for describing flavor and texture characteristics of UHT, pasteurized, and sterilized milk from various countries**



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. The milks in this cluster 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.

**Figure 3.2 Hierarchical cluster tree diagram for describing flavor and texture characteristics of UHT milk, pasteurized and sterilized milk from various countries**



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 subclusters 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, 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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**CHAPTER 4 - Acceptability and Preference Mapping of UHT  
Milk: A Case Study between U.S. and Thai Consumers**

## **ABSTRACT**

Ultra-high temperature (UHT) milk is consumed widely in Europe, South America, Australia, and Asia. Surprisingly, UHT milk consumption in the United States (U.S.) is very low compared to other regions in the world. The U.S. population has been slow to accept it because of the cooked flavor in UHT milk, their familiarity with fresh milk, and the higher cost of UHT milk. This study compared UHT milk acceptability by U.S. milk consumers unused to UHT milk and Thai consumers who typically drank UHT milk. Preference mapping technique was used to study sensory characteristics of UHT milk that drive overall liking from each of those consumer groups. Two consumer studies were conducted, one in Bangkok, Thailand, and one in Manhattan, Kansas with one hundred consumers participating in each location. Both groups of consumers evaluated five commercially available UHT whole milks (from Thailand) that represented a range of UHT milk flavor properties.

Liking of sweetness, fresh taste, and thickness were positively correlated with overall liking for both U.S. and Thai consumers. Off-flavor intensity was negatively correlated with the overall liking. U.S. consumers thought that the UHT milks had more off-flavor and generally liked them less than did Thai consumers. Results from external preference maps showed that both groups of consumers liked UHT milk with more dairy characteristics and higher fat feel. However, there was a separate group of Thai consumers who liked UHT milk with processed, cooked, and brown flavors. Lack of freshness, butyric acid, and sour aromatics were undesirable sensory attributes in UHT milk, regardless of consumer population. Off-flavors in the UHT milks in this study may be described with those attributes.

Keywords: UHT milk, acceptability, preference mapping, Thai, U.S.

### ***Introduction***

UHT milk consumption in the U.S. is low compared to other regions in the world (Burton 1988; Kissell 2004). The cooked flavor in UHT milk, the familiarity with fresh milk (Dairy Biz Archive 2000), and the higher cost of UHT milk (Pearson and others 1990; Kissell 2004) might be the reasons why the U.S. population has been slow to



accept it. In 2000, UHT milk was the primary milk consumed by Thais which accounted for 32% of the total milk consumption (Itsaranuwat and Robinson 2003). One of the benefits in consuming UHT milk is convenience. The high thermal treatment and aseptic package help the product last for several months without refrigeration (Chapman and Boor 2001; Kissell 2004).

A number of studies on acceptability and consumption of pasteurized fresh milk and UHT milk were found (Horner and others 1980; Pearson and others 1990; Raats and Shepherd 1993; Chen and others 1996; Chapman and Boor 2001). Horner and others (1980) observed that people in the U.S. had an ability to differentiate whole pasteurized fresh milk (WPM) from UHT milk and that they significantly preferred WPM to UHT milk. Differences and preferences possibly were related to how milk was normally consumed. A supermarket survey conducted by Pearson et al. in 1990 showed that UHT milk was most frequently described as “easy to store” and “convenient”. Female and young adults aged 25-44 years were most familiar with UHT milk.

Raats and Shepherd (1993) conducted short structured interviews to study the use of milk, the type of milk consumed, the appropriateness of milk perception, and people's beliefs concerning different types of milk: UHT versus pasteurized fresh milk and different fat levels in Finland, France, the Netherlands, and the United Kingdom (UK). UHT milk was consumed the most by French subjects. The sensory attributes, preferences, attitudes, and beliefs toward the different milk types had an influence on milk purchasing. Low-fat milks which were described as “watery”, “healthy”, and “digestible” were consumed more than full-fat milks which were described as “creamy”, “fat content”, “full”, and “rich”. The descriptions of UHT milk were “keeps well”, “dirty/off aroma or flavor”, and “manipulated or contains preservatives”.

Chen and others (1996) showed that 2% pasteurized fresh milk was preferred over 2% UHT milk by children aged 36-71 months because of its taste and mouthfeel. Chapman et al. (2001) studied various 2% milks with 6-11 years olds and found that samples treated by high temperature short time (HTST) pasteurization were liked more than ultra-pasteurized (UP) or UHT milks. The degree of liking of unflavored milk prior to testing affected how much they liked or disliked the tested milks.

Preference mapping is a widely used method to understand the descriptive sensory attributes that drive consumer preferences in products (Schlich 1995; McEwan 1996). Previous studies have shown the implementation of preference mapping in a variety of dairy products; plain pasteurized fresh milk (Frandsen and others 2003), chocolate milk (Hough and Sanchez 1998; Thompson and others 2004), cheese (Pagliarini and others 1997; Young and others 2004), and ice cream (Bower and Baxter 2003). We did not find a preference mapping study of UHT milk to help understand the sensory driver of liking or disliking for this type of milk in various populations. Thus, the purpose of this study was to understand what key sensory characteristics might drive differences in liking of UHT milk acceptability in a U.S. population unused to drinking UHT milk and a Thai population that typically consumed that product. The results of this study could be used by the U.S. dairy industry to better understand the sensory properties needed for optimizing UHT milk acceptance by U.S. consumers.

## **MATERIALS AND METHODS**

### ***Samples***

Five commercial UHT whole milks from Thailand: WThai8, WThai9, WThai10, WThai11, and WThai12 were used for descriptive sensory analysis and consumer tests (See appendix K for the samples used for descriptive analysis and consumer tests). The reason for choosing these samples was that prior research conducted in our laboratory suggested they represented a range of different sensory characteristics present in UHT milk. Thus, this set could be used to compare liking patterns between Thai and U.S. consumers on UHT milk. All samples were from Thailand because it was easier to import the Thai milks to the U.S. than to import U.S. milks to Thailand.

Samples were purchased in tetra-packed cartons at a local grocery store in Bangkok, Thailand and were shipped to the U.S. for the testing in Manhattan, Kansas. Samples were purchased with the same code or expiration date to avoid extraneous factors, such as sample age, that might affect the flavor and texture of each sample.

Samples were stored at room temperature until the day prior to testing and were moved to a refrigerator (Model TS-49, True Manufacturing Co, St Louis, MO, USA) for overnight storage at 1°C.

### ***Descriptive Panelists***

A descriptive panel composed of five highly trained professional panelists from the Sensory Analysis Center at Kansas State University (Manhattan, KS, USA) participated in the study. Each panelist had completed 120 h of training in all aspects of basic sensory evaluation techniques and had a minimum of 2000 h of testing experience on a variety of food products including plain fresh milk, UHT milk, yogurt, ice cream, and cheese. Panelists were reoriented to milk testing for this project.

### ***Descriptive Procedures***

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 (Chambers and others 2006; Vara-Ubol and others 2006; Lee and Chambers 2007). A discussion of milk samples was held until the panel came to agreement on attribute description of UHT milk. Attribute intensities were scored on 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. The final attributes and definitions used to describe sensory properties of UHT milk samples were given in Chapter 3 (Pages 49-52).

For the first serving, 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 codes. An additional 25 ml of milk was served for a second serving to maintain temperature during testing. Samples were tempered at room temperature for thirteen minutes until the serving temperature of 6-7°C 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.

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 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.

### ***Consumer Subjects***

One hundred consumers participated in the consumer testing in both Bangkok, Thailand and Manhattan, KS, USA. In Thailand, the consumer panelists were recruited in person, through paper fliers, and broadcast advertisements during a festival time at Kasetsart University. In the U.S., the consumers were recruited by telephone or e-mail using consumer databases provided by the Sensory Analysis Center, Kansas State University.

All consumers were screened using the same criteria: age (18-70) with age category restriction to ensure an even distribution; no immediate family employed in a food manufacturing, a market research, or an advertising firm; no food allergies; and must consume milk at least once per week. For the U.S. study, consumers must have lived in the U.S. for at least ten years prior to the study.

For the testing in Thailand, consumers came to the sensory facilities at the Sensory and Consumer Research Center at Kasetsart University and in the U.S., consumers came to the Sensory Analysis Center facilities at Kansas State University. Both facilities have appropriate temperature and lighting for conducting consumer tests. Participants in both locations were paid for their time.

### ***Consumer Testing Procedures***

The procedures for testing were similar for both locations. The consumers were asked to come to the testing location on a specific date and time. They were checked in and assigned consumer numbers at a counter before going to the testing room. The project was approved by the Kansas State University (KSU) committee on Human Subjects and all consumers signed consent forms provided in their local language.

Each consumer was provided a set of ballots with questionnaire and demographic questions, a testing instructions sheet, a pencil, a placemat, a napkin, and either a bottled water (Nestlé® Pure Life®, Nestlé S.A., Vevey, Switzerland) for the testing in Thailand or purified water in a 12 oz Styrofoam cup (C12A, James River Corp, Easton, PA, USA) for

the testing in the US, and three unsalted top saltine crackers (Nabisco, East Hanover, NJ, USA) for cleansing the palate before testing and between each sample.

At the beginning of each session, the testing procedure was explained by a moderator. Each session lasted approximately 30 min and each consumer tested each of the five milk samples. Samples, 50 ml each, were served one at a time in Styrofoam cups labeled with 3-digit random codes. Samples were served at 6-7°C following the test design after 8 minutes of tempering. Consumers were asked to take at least 3 sips of the milk before answering any of the questions and to drink the entire sample before completing the last question. The consumers answered 4 liking questions (overall, sweetness, fresh taste, and thickness) and 1 intensity (amount of off-flavor) question for each sample. Liking was scored on a 9-point hedonic scale (1 = “dislike extremely” to 9 = “like extremely”) and off flavor was scored on a 9 point intensity scale (1 = “none”, 5 = “moderate”, 9 = “extremely strong”). After they finished testing all five milk samples, they were asked to fill out a consumer demographic questionnaire including regular and UHT milk consumption.

All questionnaires were originally created in English and were translated into Thai by a native Thai speaker. The Thai questionnaires were translated back into English by a different native Thai speaker to assure the consistency of the information in the questionnaires used in the testing at both locations.

### ***Experimental Design***

A Williams design constructed from 5x5 Latin square was used for consumer testing in both locations to ensure that each sample was tested in each position. The sequences of sample servings were the same for a set of five consumers which accommodated for serving efficiency.

### ***Statistical Analysis***

Analysis of variance (ANOVA) was conducted using PROC GLIMMIX in SAS<sup>®</sup> version 9.1 (2003, Cary, NC, USA) on the consumer testing data to compare the differences and similarities in UHT milk acceptability between US and Thai consumers. Country (Thailand or US) was considered as one factor. Least square means were analyzed for each sample, country, and interaction between sample and country. The

consumers within each country and serving block were considered as random effects. Correlation analysis was conducted on the individual consumer data using PROC CORR on SAS<sup>®</sup> version 9.1 (2003, Cary, NC, USA) to determine the linear relationships among overall liking, liking of sweetness, liking of fresh taste, liking of thickness, and amount of off-flavor. Correlations were measured by Pearson correlation coefficients. All significant differences were determined at the 95% confidence level ( $P<0.05$ ).

An external preference map was created for the consumer data by regressing the consumer overall liking data on the descriptive panel data using Partial Least Squares Regression (PLSR2) to identify sensory aspects of acceptance for the UHT milks. Unscrambler<sup>®</sup> (2004, version 9.0, Camo, Norway) was used for the external preference mapping techniques. An external preference map is a multivariate technique using the consumers' liking scores and the descriptive analysis data to determine the position of the products and the descriptive sensory attributes, and show consumer preference patterns toward those products (Schlich 1995; McEwan 1996). This technique is similar to a principal component analysis, where the consumers are the dependent or response variables, and the resultant map shows the liking information of each individual consumer.

## **RESULTS AND DISCUSSION**

Generally, Thai consumers showed higher overall liking for UHT milks compared to U.S. consumers (Table 4.1). The U.S. consumers perceived significantly higher off-flavor in the UHT milk samples than did Thai consumers. WThai11 was scored lowest in liking by both groups of consumers. It also scored highest in off-flavor intensity by both U.S. and Thai consumers. WThai8 scored significantly higher in liking than other samples for the Thai consumers, but WThai8, WThai9, WThai10, and WThai12 were not significantly different in liking as scored by the U.S. consumers. U.S. consumers considered WThai8 and WThai11 to have the least fresh taste, but Thai consumers scored WThai8 as highest.

Correlations among the consumer attributes evaluated were observed (Table 4.2). As expected, overall liking was positively correlated with sweetness liking, fresh taste

liking, and thickness liking in both consumer groups. It was negatively correlated with off-flavor intensity perceived by consumers.

**Table 4.1 Comparison of consumer attribute means between U.S. and Thai consumers for selected UHT milks<sup>a</sup>**

UHT Milk Samples	Overall Liking <sup>b</sup>		Sweetness Liking <sup>b</sup>		Fresh Taste Liking <sup>b</sup>		Thickness Liking <sup>b</sup>		Off-flavor Intensity <sup>c</sup>	
	U.S.	Thai	U.S.	Thai	U.S.	Thai	U.S.	Thai	U.S.	Thai
<b>WThai8</b>	5.67e	7.34a	5.68b	6.29a	5.76e	7.20a	6.08bc	7.08a	4.45b	2.26d
<b>WThai9</b>	5.90cde	6.45bc	5.77ab	6.03ab	6.23cd	6.70bc	6.41b	6.39b	4.52b	2.61cd
<b>WThai10</b>	5.62e	6.55b	5.48bc	5.72b	5.89de	6.84ab	6.08bc	6.54b	4.47b	2.40cd
<b>WThai11</b>	5.05f	6.06cde	5.15c	5.72b	5.30f	6.38cd	5.79c	6.16bc	5.23a	2.73c
<b>WThai12</b>	5.88de	6.39bcd	5.70b	5.96ab	6.19cd	6.61bc	6.36b	6.26bc	4.12b	2.43cd

<sup>a</sup> Mean scores followed by different letters within a sensory quality (e.g. overall liking) represent significant differences ( $P < 0.05$ ).

<sup>b</sup> 1 = dislike extremely and 9 = like extremely.

<sup>c</sup> 1 = none and 9 = extremely strong.



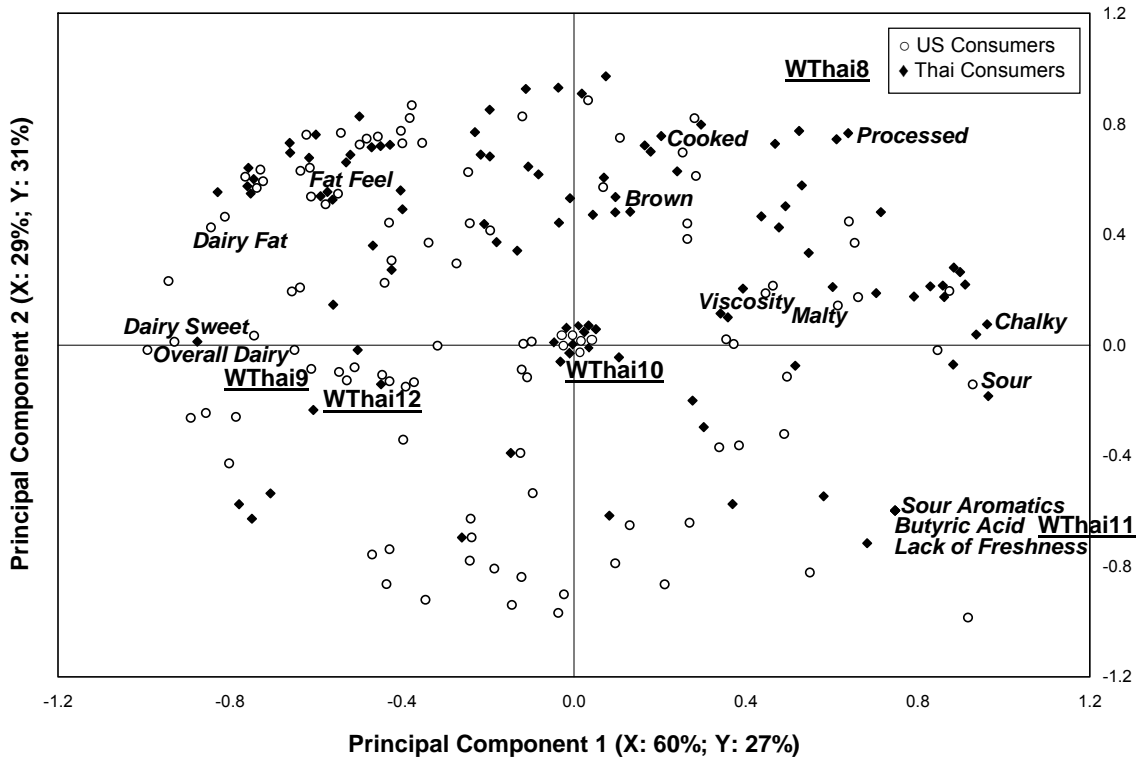
**Table 4.2 Correlation among consumer responses relating to UHT milk acceptability from US and Thai consumer data sets<sup>a</sup>**

	U.S. Consumers					Thai Consumers				
	Overall Liking	Sweetness Liking	Fresh Taste Liking	Thickness Liking	Off-Flavor Liking	Overall Liking	Sweetness Liking	Fresh Taste Liking	Thickness Liking	Off-Flavor Liking
<b>Overall Liking</b>	1.00	0.80	0.82	0.58	-0.65	1.00	0.63	0.64	0.56	-0.28
<b>Sweetness Liking</b>	0.80	1.00	0.75	0.58	-0.58	0.63	1.00	0.46	0.46	-0.13
<b>Fresh Taste Liking</b>	0.82	0.75	1.00	0.62	-0.57	0.64	0.46	1.00	0.63	-0.23
<b>Thickness Liking</b>	0.58	0.58	0.62	1.00	-0.37	0.56	0.46	0.63	1.00	-0.07
<b>Off-Flavor Liking</b>	-0.65	-0.58	-0.57	-0.37	1.00	-0.28	-0.13	-0.23	-0.07	1.00

<sup>a</sup>Numbers in grey areas represent significant correlation (P<0.001).

14 descriptive sensory attributes: 3 texture attributes: chalky, fat feel, viscosity, and 11 flavor attributes: brown, butyric acid, cooked, overall dairy, dairy fat, dairy sweet, lack of freshness, malty, processed, sour aromatics, and sour were the main sensory attributes used for characterizing UHT milk samples in the descriptive sensory analysis. The external preference map (Figure 4.1) shows a mapping of the five products based on their sensory scores and shows which parts of the map individual consumer tend to rate liking highest for the UHT samples. These results suggest that dairy notes (overall dairy, dairy sweet, and dairy fat) and fat feel were important characteristics for increased liking by many U.S. and Thai consumers. However, Thai consumers appeared more tolerant of processed, cooked, and brown flavors than U.S. consumers. In fact, a group of consumers (mostly Thai) are found in the quadrant with the WThai8 product that had mostly cooked and processed notes.

**Figure 4.1 External preference mapping of U.S. ( $n = 100$ ) and Thai ( $n = 100$ ) consumers indicating the position of 5 UHT milk samples and the sensory attributes**



Of special note, however, is that consumer preferences ranged across the map indicating wide variability in consumer liking. Only in the area of the map (near WThai11) where the attributes sour aromatics, butyric acid, and lack of freshness group together, are there few consumers, which indicates general disliking of products with those characteristics. Although all the samples in this study were whole milk, WThai11, has characteristics that Francis and others (2005) associated with non-fat milk samples: higher scores for chalky and lower scores for fatty and sweet. Bodyfelt and others (1988) suggest those characteristics are potential defects and we found WThai11 was the least liked milk by both U.S. and Thai consumers. Off-flavors, which were found by consumers in this study to be higher in WThai11, were described as slightly stale or lack of freshness (Zygoura and others 2004), and light oxidized (Claassen and Lawless 1992; Zygoura and others 2004) in previous studies of pasteurized fresh milk.

## **CONCLUSIONS**

Thai consumers showed higher overall liking in all tested UHT milks compared with U.S. consumers, perhaps because U.S. consumers perceived more off-flavor in UHT milk. Overall liking appears to be related to sweet and fatty dairy flavors regardless of whether consumers were from the U.S. or Thailand. However, Thai consumers, who are more used to drinking UHT milk, generally were more tolerant of slight cooked, processed flavor notes. In fact, one group of consumers, primarily Thai, appeared to prefer a product with more processed, cooked, and brown flavors. Lack of freshness, butyric acid, and sour aromatics were undesirable sensory attributes in UHT milk for both Thai and U.S. consumers.

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**Appendix A - Attributes, definitions and references for UHT  
milk descriptive analysis**

## **TEXTURE**

- Chalky:** A measure of dry, powdery sensation in the mouth.  
Reference: Carnation Non-Fat Dry Milk = 4.5  
Kroger Non-Dairy Coffee Cream = 7.5  
Eagle Brand Sweetened Condensed Milk = 13.0  
Preparation: Mix 1 part of milk with 3 part of water
- 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.  
Reference: Carnation Non Fat Dry Milk(reconstituted) = 0.0  
Land O'Lakes Fat Free Half and Half = 8.0  
Preparation: Mix 1 part of milk with 3 part of water
- Viscosity:** The measure of the flow as the product moves across the tongue.  
Technique: Place 1 teaspoon of sample on tongue and judge rate of flow across.  
Reference: Water = 0.0  
Dillons 2% milk = 1.0  
Dillons Half and Half = 2.0  
Dillons 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.

## **FLAVOR**

- Brown:** The aromatics that are brown and create a rounded full-bodied impression. This is brown not attributed to the cooked attribute.  
Reference: Carnation Evaporated Milk = 6.0 (flavor)
- Butyric Acid:** An aromatic that is sour and cheesy and slightly buttery reminiscence of baby vomit.  
Reference: Kraft 100% Grated Romano Cheese = 6.0 (aroma)  
Butyric Acid (in propylene glycol) = 13.0 (aroma)  
Preparation: Dip a perfumer strip in full strength Butyric Acid. Place in large test tube and cap
- Cardboard:** The aromatics associated with cardboard or paper packaging. The intensity rating is only for the 'cardboard' character within the sample.  
Reference: 2 by 2 inches cardboard in water = 6.0(aroma)  
Preparation: Cut 2 by 2 inches piece of cardboard, place in a medium covered snifter, soaked in 30ml of water for 1 hour.

- Cooked:** The combination of brown flavor notes and aromatics associated with heated milk.  
 Reference: Dillons 2 Minutes Heated Whole Milk =4.5 (flavor)  
 Carnation Evaporated Milk = 12.0 (flavor)  
 Preparation: 1 cup of Dillons Whole Milk microwave on high for 2 minutes.
- Overall Dairy:** A general term for the aromatics associated with products made from cow's milk.  
 Reference: Carnation Non Fat Dry Milk = 4.5 (flavor)  
 Dillons Half and Half = 10.0 (flavor)
- Dairy Fat:** Aromatics associated with dairy fat.  
 Reference: Carnation Non Fat Dry Milk = 0.0 (flavor)  
 Land O'Lakes Fat Free Half and Half = 5.0 (flavor)  
 Preparation: Mix 1 part of milk with 3 parts of water
- Dairy Sweet:** The sweet aromatics associated with fresh dairy products  
 Reference: Dillons Half and Half = 6.0 (flavor)
- Feed:** Slightly nutty, grainy aromatics associated with silage, dry alfalfa, and/or various grains which may include brewers' grains.
- 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.  
 Reference: Reese Vintage Cooking Wine (Chalbis) = 7.0 (aroma)  
 Preparation: 1 part wine to 1 part water.
- Flat:** Aromatic characterized by lack of flavor, richness. Watery, associated with lack of flavor.  
 Reference: Carnation Non Fat Dry Milk = 12.0 (flavor)  
 Preparation: Mix 1 part of milk with 6 part of water
- Floral:** Sweet, light, slightly perfuming aromatics associated with flowers  
 Reference: Welch's White Grape Pear Juice = 7.0 (flavor)  
 Preparation: Dilute Welch's White Grape Pear Juice 1 to 1 with water.
- Grainy:** Brown aromatics that are musty dusty and malty. May include sweet, sour and slightly fermented.  
 Reference: Post Grape nuts = 11.0 (flavor)



- Green: Aromatics associated with green vegetable vegetation that may include green, bitter notes.  
Reference: Parsley = 8.0 (aroma)  
Preparation: Place 1 teaspoon of McCormick Dried Parsley in covered snifter
- 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.
- 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.  
Reference: Light Oxidized Skim Milk = 2.0 (flavor)  
Preparation: Leave homogenized milk uncovered in sunlight for 2-3 hours (fluorescent lighting also works)
- Malty: An aromatic described as brown sweet, musty and some what grainy.  
Reference: Carnation malted milk = 12.0 (flavor)
- Medicinal: Aromatic characteristic of antiseptic-like products  
Reference: Band-Aid = 6.0 (Aroma)  
Preparation: Place Band-aid in medium snifter with cover.
- Musty/Dusty: Dry, dirt-like aromatic associated with dry, brown soil.  
Reference: 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.  
Reference: Kroger Butter Beans (canned) = 5.5
- Nutty: A non-specific, slightly sweet, brown, nut-like impression.  
Reference: Kretschmer Wheat Germ = 7.5
- Oily: The light aromatics associated with vegetable oil.  
Reference: Wesson Vegetable Oil (Heated) = 10.0 (aroma)
- Plastic: An aromatic associated with plastic polyethylene containers or food stored in plastic.  
Reference: 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). Reference: Carnation non fat Dry Milk (reconstituted) = 7.5 (flavor) Preparation: Mix 1 part of milk with 3 part of water
Refrigerator:	A lack of freshness/Flat. Impression of the product absorbing a combination of odors while stored in the refrigerator.
Sweet Aromatics:	Aromatics associated with the impression of all sweet substances. Reference: Dillons Whipping Cream = 7.5 (flavor)
Vanilla/ Vanillin:	The brown, sweet aromatics and character identity commonly associated with vanilla. Reference: ICN scientific vanillin in water = 6.0 (aroma) Preparation: Mix 2 grams of Vanillin in 250ml water in large covered snifter.
Vitamins:	The aromatics associated with a just opened bottle of vitamin pills. (Generally thought to be oxidized thiamin) (aroma) Reference: Total Corn Flakes = 4.0 (aroma)
Astringent:	Dry and puckering mouth feel associates with an alum solution in the mouth. Reference: 0.3% Alum Solution = 1.5 (flavor)
Bitter:	The fundamental taste factor of which caffeine in water is typical Reference: 0.01% Caffeine solution = 2.0
Sweet:	The basic taste sensation of which sucrose in water is typical. Reference: 1% Sucrose Solution = 1.0 2% Sucrose Solution = 2.0
Sour:	Fundamental taste factor of which citric acid in water is typical. Reference: 0.015% Citric Acid = 1.5 0.025% Citric Acid = 2.5
Sour Aromatics:	Slightly pungent aromatic similar to those found in slightly fermented products such as sour creams, buttermilk and yogurt. Reference: Kraft Philadelphia Cream Cheese = 8.0 (flavor)

## **Appendix B - Detailed samples for descriptive analysis**

<b>Origin</b>	<b>Product</b>	<b>Type</b>	<b>Heat Processing</b>	<b>Package</b>	<b>Product Abbreviation</b>	<b>Manufacturer or Distributor</b>	<b>Website</b>
France	Monoprix Lait	Low-Fat Milk	UHT	1000 mL carton	LFFrance1	L.R.M.D. “Tour Vendome”	www.monoprix.fr
France	Monoprix Lait	Whole Milk	UHT	1000 mL carton	WFrance2	L.R.M.D. “Tour Vendome”	www.monoprix.fr
Italy	Fattoria Scaldasole	2% Reduced-Fat Milk	UHT	1000 mL carton	RFItaly1	Fattoria Scaldasole	N/A
Italy	Latte	2% Reduced-Fat Milk	UHT	500 mL carton	RFItaly2	Gruppo Rinascente	N/A
Italy	Latte Maremma	2% Reduced-Fat Milk	UHT	1000 mL carton	RFItaly3	Consorzio Produttori Latte Maremma	www.lattemaremma.it
Italy	Mukki Scorta	2% Reduced-Fat Milk	UHT	1000 mL carton	RFItaly4	Centrale del Latte di Firenze Pistoia Livorna Spa	N/A
Italy	Parmalat Fibresse	2% Reduced-Fat Milk	UHT	1000 mL bottle	RFItaly5	Parmatlat S.p.A. Sede e stabilimento Collecchio Parma - Italia	www.parmalat.it

<b>Origin</b>	<b>Product</b>	<b>Type</b>	<b>Heat Processing</b>	<b>Package</b>	<b>Product Abbreviation</b>	<b>Manufacturer or Distributor</b>	<b>Website</b>
Italy	Parmalat Natura Premium	2% Reduced-Fat Milk	UHT	1000 mL bottle	RFItaly6	Parmalat S.p.A. Collecchio Parma - Italia	www.parmalat.com
Italy	Parmalat Omega 3	2% Reduced-Fat Milk	UHT	1000 mL carton	RFItaly7	Parmatlat S.p.A. Sede e stabilimento Collecchio Parma - Italia	www.parmalat.it
Italy	Polenghi	2% Reduced-Fat Milk	UHT	1000 mL carton	RFItaly8	Polenghi	N/A
Italy	Mukki Scorta	Whole Milk	UHT	1000 mL carton	WItaly9	Centrale del Latte di Firenze Pistoia Livorna Spa Parmalat S.p.A.	N/A
Italy	Parmalat Natura Premium	Whole Milk	UHT	1000 mL bottle	WItaly10	Collecchio Parma - Italia	www.parmalat.com
Italy	Polenghi	Whole Milk	UHT	1000 mL carton	WItaly11	Polenghi	N/A
Japan	Morinaga Milk	Whole Milk	UHT	250 mL carton	WJapan1	Morinaga Milk Industry Co., Ltd.	www.morinagamilk.co.jp

<b>Origin</b>	<b>Product</b>	<b>Type</b>	<b>Heat Processing</b>	<b>Package</b>	<b>Product Abbreviation</b>	<b>Manufacturer or Distributor</b>	<b>Website</b>
Korea	Maeil Milk	Whole Milk	UHT	1000 mL carton	WKorea1	Maeil Dairy Business	www.maeil.com
Korea	Seoul Milk	Whole Milk	UHT	1000 mL carton	WKorea2	Seoul Milk	www.seoulmilk.com
Peru	Bella Holandesa	Whole Milk	UHT	1000 mL carton	WPeru1	Gloria S.A.	www.grupogloria.com.pe
Peru	Gloria	Whole Milk	UHT	1000 mL carton	WPeru2	Gloria S.A.	www.grupogloria.com.pe
Peru	Laive	Whole Milk	UHT	1000 mL carton	WPeru3	Laive S.A.	www.laive.com.pe
Thailand	Bear Brand	Low-Fat Milk	Sterilized	140 mL can	LFThai1S	Nestlé Foods (Thailand) Ltd.	www.nestlethai.com
Thailand	Country Fresh	Low-Fat Milk	UHT	250 mL carton	LFThai2	Country Fresh Dairies Co., Ltd.	N/A
Thailand	Foremost	Low-Fat Milk	UHT	250 mL carton	LFThai3	Foremost Freelance (Thailand) Co., Ltd.	www.foremostforlife.com
Thailand	Foremost Calcimex	Low-Fat Milk	UHT	250 mL carton	LFThai4	Foremost Freelance (Thailand) Co., Ltd.	www.foremostforlife.com
Thailand	Mali	Low-Fat Milk	UHT	250 mL carton	LFThai5	The Thai Dairy Industry Co., Ltd.	www.thaidairy.co.th

<b>Origin</b>	<b>Product</b>	<b>Type</b>	<b>Heat Processing</b>	<b>Package</b>	<b>Product Abbreviation</b>	<b>Manufacturer or Distributor</b>	<b>Website</b>
Thailand	Meiji	Low-Fat Milk	UHT	250 mL carton	LFThai6	CP-Meiji Co., Ltd.	N/A
Thailand	Bear Brand	Whole Milk	Sterilized	140 mL can	WThai7S	Nestlé Foods (Thailand) Ltd.	www.nestlethai.com
Thailand	Country Fresh	Whole Milk	UHT	250 mL carton	WThai8	Country Fresh Dairies Co., Ltd.	N/A
Thailand	Foremost	Whole Milk	UHT	250 mL carton	WThai9	Foremost Freelance (Thailand) Co., Ltd.	www.foremostforlife.com
Thailand	Meiji	Whole Milk	UHT	250 mL carton	WThai10	CP-Meiji Co., Ltd. Ratchaburi	N/A
Thailand	Nongpho	Whole Milk	UHT	250 mL carton	WThai11	Nongpho Dairy Cow Cooperative, Ltd.	www.nongpho.com
Thailand	Chitralada	Whole Milk	UHT	200 mL carton	WThai12	Royal Chitralada Projects	N/A
Thailand	Thai-Danish	Whole Milk	UHT	250 mL carton	WThai13	Thai-Danish Dairy Farm	www.thaidanskmilk.com

<b>Origin</b>	<b>Product</b>	<b>Type</b>	<b>Heat Processing</b>	<b>Package</b>	<b>Product Abbreviation</b>	<b>Manufacturer or Distributor</b>	<b>Website</b>
U.S.	Horizon Organic	2% Reduced-Fat Milk	UHT	236 mL carton	RFUS1	Horizon Organic	www.horizonorganic.com
U.S.	Parmalat	2% Reduced-Fat Milk	UHT	946 mL carton	RFUS2	Parmalat USA	www.parmalatusa.com
U.S.	Parmalat Lil Milk	2% Reduced-Fat Milk	UHT	236 mL carton	RFUS3	Parmalat USA	www.parmalatusa.com
U.S.	Parmalat	Whole Milk	UHT	946 mL carton	WUS4	Parmalat USA	www.parmalatusa.com
U.S.	Parmalat Lil Milk	Whole Milk	UHT	236 mL carton	WUS5	Parmalat USA	www.parmalatusa.com
U.S.	Dillons (control)	2% Reduced-Fat Milk	Pasteurized	1 gallon jug	RFcontrol	Dillons	www.dillons.com
U.S.	Dillons (control)	Whole Milk	Pasteurized	1 gallon jug	Wcontrol	Dillons	www.dillons.com



## **Appendix C - Test design for the orientation sessions of the descriptive analysis phase**

<b>Date</b>	<b>Code</b>	<b>Product</b>	<b>Type</b>	<b>Processing</b>	<b>Country</b>	<b>Pouring Time</b>	<b>Serving Time</b>
10/5/2004	983	Horizon Organic	Organic Low-Fat Milk (1% Milk Fat)	UP	U.S.	10:20	10:35
10/5/2004	153	Horizon Organic	Organic Low-Fat Milk	UHT	U.S.	10:45	11:00
10/5/2004	455	Organic Valley	Organic Reduced-Fat (2% Milk Fat)	UP	U.S.	11:05	11:20
10/5/2004	347	Horizon Organic	Organic Reduced-Fat (2% Milk Fat)	UP	U.S.	11:25	11:40
10/6/2004	379	Parmalat	2% Reduced-Fat Milk	UHT	U.S.	10:20	10:35
10/6/2004	713	Parmalat	Whole Milk	UHT	U.S.	11:05	11:20
10/7/2004	983	Horizon Organic	Organic Low-Fat Milk (1% Milk Fat)	UP	U.S.	10:20	10:35
	983	Horizon Organic	Organic Low-Fat Milk (1% Milk Fat)	UP	U.S.	10:30	10:45
10/7/2004	713	Parmalat	Whole Milk	UHT	U.S.	10:40	10:55
	713	Parmalat	Whole Milk	UHT	U.S.	10:50	11:05
10/7/2004	347	Horizon Organic	Organic Reduced-Fat (2% Milk Fat)	UP	U.S.	11:00	11:15
	347	Horizon Organic	Organic Reduced-Fat (2% Milk Fat)	UP	U.S.	11:10	11:25
10/7/2004	379	Parmalat	2% Reduced-Fat Milk	UHT	U.S.	11:20	11:35
	379	Parmalat	2% Reduced-Fat Milk	UHT	U.S.	11:30	11:45

## **Appendix D - Test design for the testing sessions of the descriptive analysis phase**

<b>Date</b>	<b>Code</b>	<b>Product</b>	<b>Type</b>	<b>Processing</b>	<b>Country</b>	<b>Pouring Time</b>	<b>Serving Time</b>
10/8/2004	329	Country Fresh	Low-Fat Milk	UHT	Thailand	10:22	10:35
	329	Country Fresh	Low-Fat Milk	UHT	Thailand	10:37	10:50
			Break 11:05-11:10AM				
10/8/2004	967	Thai-Danish	Whole Milk	UHT	Thailand	10:57	11:10
	967	Thai-Danish	Whole Milk	UHT	Thailand	11:12	11:25
			Break 11:25-11:30AM				
10/8/2004	707	Chitralada	Whole Milk	UHT	Thailand	11:17	11:30
	707	Chitralada	Whole Milk	UHT	Thailand	11:32	11:45
<hr/>							
10/11/2004	926	Latte	2% Reduced-Fat Milk	UHT	Italy	10:22	10:35
	926	Latte	2% Reduced-Fat Milk	UHT	Italy	10:37	10:50
			Break 11:05-11:10AM				
10/11/2004	691	Mali	Low-Fat Milk	UHT	Thailand	10:57	11:10
	691	Mali	Low-Fat Milk	UHT	Thailand	11:12	11:25
			Break 11:25-11:30AM				
10/11/2004	554	Parmalat Natura	Whole Milk	UHT	Italy	11:17	11:30
	554	Premium Parmalat Natura Premium	Whole Milk	UHT	Italy	11:32	11:45
<hr/>							
10/12/2004	480	Parmalat	Whole Milk	UHT	U.S.	10:22	10:35
	480	Parmalat	Whole Milk	UHT	U.S.	10:37	10:50

Date	Code	Product	Type	Processing	Country	Pouring Time	Serving Time
Break 11:05-11:10AM							
10/12/2004	612	Polenghi	Whole Milk	UHT	Italy	10:57	11:10
	612	Polenghi	Whole Milk	UHT	Italy	11:12	11:25
Break 11:25-11:30AM							
10/12/2004	831	Nong Pho	Whole Milk	UHT	Thailand	11:17	11:30
	831	Nong Pho	Whole Milk	UHT	Thailand	11:32	11:45
10/13/2004	980	Parmalat Omega 3	2% Reduced-Fat Milk	UHT	Italy	10:22	10:35
	980	Parmalat Omega 3	2% Reduced-Fat Milk	UHT	Italy	10:37	10:50
Break 11:05-11:10AM							
10/13/2004	833	Parmalat Fibresse	2% Reduced-Fat Milk	UHT	Italy	10:57	11:10
	833	Parmalat Fibresse	2% Reduced-Fat Milk	UHT	Italy	11:12	11:25
Break 11:25-11:30AM							
10/13/2004	490	Parmalat Natura Premium	2% Reduced-Fat Milk	UHT	Italy	11:17	11:30
	490	Parmalat Latte Natura Premium	2% Reduced-Fat Milk	UHT	Italy	11:32	11:45
10/14/2004	378	Country Fresh	Whole Milk	UHT	Thailand	10:22	10:35
	378	Country Fresh	Whole Milk	UHT	Thailand	10:37	10:50
Break 11:05-11:10AM							

<b>Date</b>	<b>Code</b>	<b>Product</b>	<b>Type</b>	<b>Processing</b>	<b>Country</b>	<b>Pouring Time</b>	<b>Serving Time</b>
10/14/2004	525	Latte Maremma	2% Reduced-Fat Milk	UHT	Italy	10:57	11:10
	525	Latte Maremma	2% Reduced-Fat Milk	UHT	Italy	11:12	11:25
Break 11:25-11:30AM							
10/14/2004	609	Polenghi	2% Reduced-Fat Milk	UHT	Italy	11:17	11:30
	609	Polenghi	2% Reduced-Fat Milk	UHT	Italy	11:32	11:45
Break 11:05-11:10AM							
10/15/2004	460	Mukki Scorta	Whole Milk	UHT	Italy	10:22	10:35
	460	Mukki Scorta	Whole Milk	UHT	Italy	10:37	10:50
Break 11:05-11:10AM							
10/15/2004	478	Fattoria Scaldasole	2% Reduced-Fat Milk	UHT	Italy	10:57	11:10
10/15/2004	478	Fattoria Scaldasole	2% Reduced-Fat Milk	UHT	Italy	11:12	11:25
Break 11:25-11:30AM							
10/15/2004	173	Mukki Scorta	2% Reduced-Fat Milk	UHT	Italy	11:17	11:30
	173	Mukki Scorta	2% Reduced-Fat Milk	UHT	Italy	11:32	11:45
Break 11:05-11:10AM							
10/18/2004	799	Foremost	Whole Milk	UHT	Thailand	10:22	10:35
	799	Foremost	Whole Milk	UHT	Thailand	10:37	10:50
Break 11:05-11:10AM							
10/18/2004	900	Parmalat LiLMilk	2% Reduced-Fat Milk	UHT	U.S.	10:52	11:05
	900	Parmalat LiLMilk	2% Reduced-Fat Milk	UHT	U.S.	11:07	11:20
Break 11:30-11:35AM							

<b>Date</b>	<b>Code</b>	<b>Product</b>	<b>Type</b>	<b>Processing</b>	<b>Country</b>	<b>Pouring Time</b>	<b>Serving Time</b>
10/18/2004	157	Bella Holandesa	Whole Milk	UP	Peru	11:22	11:35
	157	Bella Holandesa	Whole Milk	UP	Peru	11:37	11:50
10/20/2004	314	Foremost	Low-Fat Milk	UHT	Thailand	10:22	10:35
	314	Foremost	Low-Fat Milk	UHT	Thailand	10:37	10:50
Break 11:00-11:05AM							
10/20/2004	635	Horizon Organic	2% Reduced-Fat Milk	UHT	U.S.	10:52	11:05
	635	Horizon Organic	2% Reduced-Fat Milk	UHT	U.S.	11:07	11:20
Break 11:30-11:35AM							
10/20/2004	160	Meiji	Low-Fat Milk	UHT	Thailand	11:22	11:35
	160	Meiji	Low-Fat Milk	UHT	Thailand	11:37	11:50
10/21/2004	775	Gloria	Whole Milk	UHT	Peru	10:22	10:35
	775	Gloria	Whole Milk	UHT	Peru	10:37	10:50
Break 11:00-11:05AM							
10/21/2004	706	Foremost Calcimex	Low-Fat Milk	UHT	Thailand	10:52	11:05
	706	Foremost Calcimex	Low-Fat Milk	UHT	Thailand	11:07	11:20
Break 11:30-11:35AM							
10/21/2004	652	Parmalat LiL Milk	Whole Milk	UHT	U.S.	11:22	11:35
	652	Parmalat LiL Milk	Whole Milk	UHT	U.S.	11:37	11:50

<b>Date</b>	<b>Code</b>	<b>Product</b>	<b>Type</b>	<b>Processing</b>	<b>Country</b>	<b>Pouring Time</b>	<b>Serving Time</b>
10/22/2004	567	Meiji	Whole Milk	UHT	Thailand	10:22	10:35
	567	Meiji	Whole Milk	UHT	Thailand	10:37	10:50
Break 11:00-11:05AM							
10/22/2004	125	Parmalat	2% Reduced-Fat Milk	UHT	U.S.	10:52	11:05
	125	Parmalat	2% Reduced-Fat Milk	UHT	U.S.	11:07	11:20
Break 11:30-11:35AM							
10/22/2004	814	Laive	Whole Milk	UHT	Peru	11:22	11:35
	814	Laive	Whole Milk	UHT	Peru	11:37	11:50
12/13/2004	368	Seoul Milk	Whole Milk	UHT	Korea	8:52	9:05
	368	Seoul Milk	Whole Milk	UHT	Korea	9:07	9:20
Break 9:30-9:35AM							
12/13/2004	941	Morinaga Milk	Whole Milk	UHT	Japan	9:22	9:35
	941	Morinaga Milk	Whole Milk	UHT	Japan	9:37	9:50
Break 10:00-10:05AM							
12/13/2004	891	Maeil Milk	Whole Milk	UHT	Korea	9:52	10:05
	891	Maeil Milk	Whole Milk	UHT	Korea	10:07	10:20
12/14/2004	859	Monoprix Lait	Low-Fat Milk	UHT	France	10:22	10:35
	859	Monoprix Lait	Low-Fat Milk	UHT	France	10:37	10:50
Break 11:00-11:05AM							



Date	Code	Product	Type	Processing	Country	Pouring Time	Serving Time
12/14/2004	125	Monoprix Lait	Whole Milk	UHT	France	10:52	11:05
	125	Monoprix Lait	Whole Milk	UHT	France	11:07	11:20
Break 11:30-11:35AM							
12/14/2004	634	Monoprix Lait	Skimmed Milk	UHT	France	11:22	11:35
	634	Monoprix Lait	Skimmed Milk	UHT	France	11:37	11:50
3/18/2005	594	Bear Brand	Low-Fat Milk	Sterilized	Thailand	8:52	9:05
	594	Bear Brand	Low-Fat Milk	Sterilized	Thailand	9:07	9:20
Break 9:30-9:35AM							
3/18/2005	318	Bear Brand	Whole Milk	Sterilized	Thailand	9:22	9:35
	318	Bear Brand	Whole Milk	Sterilized	Thailand	9:37	9:50
Break 10:00-10:05AM							
3/18/2005	750	Nestlé	Pure Dairy Sterilized	Sterilized	Thailand	9:52	10:05
			Cream				
	750	Nestlé	Pure Dairy Sterilized	Sterilized	Thailand	10:07	10:20
			Cream				

**Serving direction:**

Pour 75 ml of milk sample into the 8-oz Styrofoam cup (James River Corp. C12A) and lid (PL 5) at the first serving and 25 ml of milk for second serving. When tempering, please cover with dark paper. Serving Temperature needs to be over 43°F, but lower than 45°F

## **Appendix E - UHT milk descriptive analysis data worksheet**

Date:

Sample:	
<i>Attribute</i>	<i>Intensity</i>
<b><u>TEXTURE</u></b>	
Chalky	
Fat Feel	
Viscosity	
<b><u>FLAVOR</u></b>	
Brown	
Butyric Acid	
Cardboard	
Cooked	
Overall Dairy	
Dairy Fat	
Dairy Sweet	
Feed	
Fermented	
Flat	
Floral	
Grainy	
Green	
Lack of freshness	
Light-Oxidized	
Malty	
Medicinal	
Metallic	
Musty/Dusty	
Musty/Earthy	
Oily	
Plastic	

Date:

Sample:	
<i>Attribute</i>	<i>Intensity</i>
<b><u>TEXTURE</u></b>	
Chalky	
Fat Feel	
Viscosity	
<b><u>FLAVOR</u></b>	
Brown	
Butyric Acid	
Cardboard	
Cooked	
Overall Dairy	
Dairy Fat	
Dairy Sweet	
Feed	
Fermented	
Flat	
Floral	
Grainy	
Green	
Lack of freshness	
Light-Oxidized	
Malty	
Medicinal	
Metallic	
Musty/Dusty	
Musty/Earthy	
Oily	
Plastic	

<b>Sample:</b>	
<i>Attribute</i>	<i>Intensity</i>
<b><u>FLAVOR</u></b>	
Processed	
Refrigerator	
Sweet	
Vanilla/Vanillin	
Vitamins	
Sour Aromatics	
Sour	
Bitter	
Astringent	

<b>Sample:</b>	
<i>Attribute</i>	<i>Intensity</i>
<b><u>FLAVOR</u></b>	
Processed	
Refrigerator	
Sweet	
Vanilla/Vanillin	
Vitamins	
Sour Aromatics	
Sour	
Bitter	
Astringent	

## **Appendix F - Complete UHT milk descriptive analysis data set**

Country	Milk Product	Product Abbreviation	Type	Chalky	Fat Feel	Viscosity	Lip and Mouthfeel	Brown	Butyric Acid	Cardboard	Cooked	Overall Dairy	Dairy Fat	Dairy Sweet	Feed
France	Monoprix Lait	LFFrance1	Low-Fat Milk	1.5	7.0	1.5	0.0	1.0	2.0	0.0	3.5	8.5	7.5	4.5	0.0
France	Monoprix Lait	WFFrance2	Whole Milk	0.0	8.0	2.0	0.0	1.5	0.0	0.0	2.0	9.5	8.5	6.0	0.0
Italy	Fattoria Scaldasole	RFItaly1	2% Reduced-Fat Milk	3.5	6.0	1.5	0.0	0.0	2.0	0.0	2.0	7.5	6.0	4.5	0.0
Italy	Latte	RFItaly2	2% Reduced-Fat Milk	8.0	2.0	1.5	0.0	2.0	0.0	0.0	3.5	5.5	2.5	2.5	0.0
Italy	Latte Maremma	RFItaly3	2% Reduced-Fat Milk	2.0	6.0	1.5	0.0	2.0	1.0	0.0	2.5	7.5	5.0	4.0	0.0
Italy	Mukki Scorta	RFItaly4	2% Reduced-Fat Milk	2.0	4.5	1.0	0.0	2.0	1.5	0.0	2.5	6.5	5.5	3.5	0.0
Italy	Parmalat Fibresse	RFItaly5	2% Reduced-Fat Milk	1.0	5.0	1.0	0.0	1.0	0.0	0.0	1.5	7.5	6.0	4.0	0.0
Italy	Parmalat Latte Natura Premium	RFItaly6	2% Reduced-Fat Milk	1.0	6.5	1.5	0.0	0.0	0.0	0.0	2.5	8.0	7.0	5.0	0.0
Italy	Parmalat Omega 3	RFItaly7	2% Reduced-Fat Milk	3.5	3.0	1.0	0.0	0.0	2.5	0.0	3.0	6.0	5.0	3.5	0.0
Italy	Polenghi	RFItaly8	2% Reduced-Fat Milk	2.0	6.5	1.5	0.0	0.0	1.5	2.0	2.0	8.0	6.0	4.0	0.0
Italy	Mukki Scorta	WItaly9	Whole Milk	2.0	7.0	1.5	3.5	0.0	1.5	0.0	1.5	8.5	7.0	5.0	0.0
Italy	Parmalat Natura Premium	WItaly10	Whole Milk	1.0	6.0	1.5	0.0	0.0	0.0	0.0	2.0	8.0	6.5	5.0	0.0
Italy	Polenghi	WItaly11	Whole Milk	1.0	4.0	2.0	0.0	0.0	0.0	0.0	3.0	8.0	7.5	5.0	0.0
Japan	Morinaga Milk	WJapan1	Whole Milk	1.0	6.0	2.0	0.0	0.0	1.0	0.0	2.0	9.0	7.5	5.5	0.0
Korea	Maeil Milk	WKorea1	Whole Milk	2.5	6.0	1.5	0.0	1.0	2.0	0.0	4.0	8.0	7.5	5.0	1.5
Korea	Seoul Milk	WKorea2	Whole Milk	2.0	7.0	2.0	0.0	1.5	0.0	0.0	2.0	10.0	8.5	6.0	0.0
Peru	Bella Holandesa	WPeru1	Whole Milk	1.5	6.0	2.0	0.0	2.5	0.0	0.0	4.0	8.0	7.0	5.0	0.0
Peru	Gloria	WPeru2	Whole Milk	5.0	6.5	2.0	0.0	3.0	1.5	0.0	4.0	8.0	8.0	5.0	0.0
Peru	Laive	WPeru3	Whole Milk	2.0	6.5	2.0	0.0	2.0	3.0	0.0	3.0	5.0	7.0	2.5	3.5

Country	Milk Product	Product Abbreviation	Type	Chalky	Fat Feel	Viscosity	Lip and Mouthfeel	Brown	Butyric Acid	Cardboard	Cooked	Overall Dairy	Dairy Fat	Dairy Sweet	Feed
Thailand	Bear Brand	LFTThai1S	Low-Fat Milk	6.0	3.0	1.5	0.0	4.0	0.0	0.0	5.5	5.0	2.5	3.0	0.0
Thailand	Country Fresh	LFTThai2	Low-Fat Milk	8.5	2.5	2.0	0.0	2.0	0.0	0.0	4.0	4.0	2.5	4.0	0.0
Thailand	Foremost	LFTThai3	Low-Fat Milk	1.0	6.0	1.5	0.0	2.0	1.5	0.0	3.0	8.0	8.0	5.0	0.0
Thailand	Foremost Calcimex	LFTThai4	Low-Fat Milk	6.5	6.0	3.0	0.0	2.0	0.0	0.0	3.0	6.0	7.0	3.5	0.0
Thailand	Mali	LFTThai5	Low-Fat Milk	8.0	2.5	2.0	0.0	3.0	0.0	0.0	5.0	4.5	3.0	2.5	0.0
Thailand	Meiji	LFTThai6	Low-Fat Milk	1.0	6.0	2.0	0.0	1.0	0.0	0.0	2.5	7.5	7.5	5.0	0.0
Thailand	Bear Brand	WThai7S	Whole Milk	5.0	2.0	2.0	0.0	4.5	1.5	0.0	6.0	5.0	2.5	2.0	0.0
Thailand	Country Fresh	WThai8	Whole Milk	4.0	6.5	2.0	0.0	2.5	0.0	0.0	4.0	6.0	6.5	3.5	0.0
Thailand	Foremost	WThai9	Whole Milk	1.0	7.5	2.0	0.0	2.5	0.0	0.0	3.0	9.0	8.0	5.5	0.0
Thailand	Meiji	WThai10	Whole Milk	3.0	5.0	1.0	0.0	2.0	0.0	0.0	2.5	8.0	6.0	4.5	0.0
Thailand	Nong Pho	WThai11	Whole Milk	5.0	4.0	2.0	0.0	2.0	2.0	0.0	2.0	5.0	3.5	2.5	2.0
Thailand	Chitralada	WThai12	Whole Milk	0.0	5.5	1.5	0.0	1.5	0.0	0.0	1.0	8.0	7.5	5.0	0.0
Thailand	Thai-Danish	WThai13	Whole Milk	2.5	6.0	1.5	0.0	0.0	0.0	0.0	1.5	7.0	6.0	4.0	0.0
U.S.	Horizon Organic	RFUS1	2% Reduced-Fat Milk	3.0	2.5	1.0	0.0	0.0	0.0	0.0	3.0	6.5	5.0	4.0	0.0
U.S.	Parmalat	RFUS2	2% Reduced-Fat Milk	4.0	5.0	1.0	0.0	1.0	0.0	0.0	2.0	6.5	5.0	4.0	0.0
U.S.	Parmalat LiL Milk	RFUS3	2% Reduced-Fat Milk	1.5	4.5	1.5	0.0	1.0	1.5	0.0	3.0	6.5	5.5	4.0	2.0
U.S.	Parmalat	WUS4	Whole Milk	7.0	4.5	1.5	0.0	0.0	0.0	0.0	1.5	6.0	4.0	3.0	0.0
U.S.	Parmalat LiL Milk	WUS5	Whole Milk	1.5	6.0	1.5	0.0	0.0	0.0	0.0	2.0	7.5	6.5	4.0	0.0
U.S.	Dillons (Control)	RFcontrol	2% Reduced-Fat Milk	0.0	5.0	1.0	0.0	0.0	0.0	0.0	0.0	8.0	5.5	4.0	0.0
U.S.	Dillons (Control)	Wcontrol	Whole Milk	0.0	7.0	1.5	0.0	0.0	0.0	0.0	0.0	9.0	7.0	5.0	0.0

Country	Milk Product	Product Abbreviation	Type	Fermented	Flat	Floral	Grainy	Green	Lack of Freshness	Light-Oxidized	Malty	Medicinal	Metallic	Musty/Dusty	Musty/Earthy
France	Monoprix Lait	LFFrance1	Low-Fat Milk	0.0	0.0	1.5	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
France	Monoprix Lait	WFrance2	Whole Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	3.0	0.0	0.0
Italy	Fattoria Scaldasole	RFItaly1	2% Reduced-Fat Milk	0.0	0.0	0.0	0.0	0.0	1.5	0.0	2.0	0.0	0.0	0.0	0.0
Italy	Latte	RFItaly2	2% Reduced-Fat Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Italy	Latte Maremma	RFItaly3	2% Reduced-Fat Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0
Italy	Mukki Scorta	RFItaly4	2% Reduced-Fat Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0
Italy	Parmalat Fibresse	RFItaly5	2% Reduced-Fat Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0
Italy	Parmalat Latte Natura Premium	RFItaly6	2% Reduced-Fat Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
Italy	Parmalat Omega 3	RFItaly7	2% Reduced-Fat Milk	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Italy	Polenghi	RFItaly8	2% Reduced-Fat Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Italy	Mukki Scorta	WItaly9	Whole Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Italy	Parmalat Natura Premium	WItaly10	Whole Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Italy	Polenghi	WItaly11	Whole Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Japan	Morinaga Milk	WJapan1	Whole Milk	0.0	0.0	0.0	0.0	2.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
Korea	Maeil Milk	WKorea1	Whole Milk	0.0	0.0	0.0	0.0	0.0	1.5	0.0	1.0	0.0	2.5	0.0	0.0
Korea	Seoul Milk	WKorea2	Whole Milk	0.0	0.0	1.5	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0
Peru	Bella Holandesa	WPeru1	Whole Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0
Peru	Gloria	WPeru2	Whole Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0
Peru	Laive	WPeru3	Whole Milk	0.0	0.0	0.0	2.0	0.0	3.0	0.0	0.0	0.0	3.0	1.5	0.0



Country	Milk Product	Product Abbreviation	Type	Fermented	Flat	Floral	Grainy	Green	Lack of Freshness	Light-Oxidized	Malty	Medicinal	Metallic	Musty/Dusty	Musty/Earthy
Thailand	Bear Brand	LFThai1S	Low-Fat Milk	0.0	3.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	3.5	0.0	0.0
Thailand	Country Fresh	LFThai2	Low-Fat Milk	0.0	0.0	0.0	0.0	0.0	1.5	0.0	2.0	0.0	0.0	0.0	0.0
Thailand	Foremost	LFThai3	Low-Fat Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0
Thailand	Foremost Calcimex	LFThai4	Low-Fat Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	2.5	0.0	0.0
Thailand	Mali	LFThai5	Low-Fat Milk	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0
Thailand	Meiji	LFThai6	Low-Fat Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	1.0	0.0	0.0	0.0
Thailand	Bear Brand	WThai7S	Whole Milk	0.0	0.0	0.0	0.0	0.0	1.5	0.0	2.0	1.0	0.0	0.0	0.0
Thailand	Country Fresh	WThai8	Whole Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0
Thailand	Foremost	WThai9	Whole Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0
Thailand	Meiji	WThai10	Whole Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0
Thailand	Nong Pho	WThai11	Whole Milk	0.0	0.0	0.0	0.0	0.0	2.0	0.0	2.0	1.5	0.0	0.0	0.0
Thailand	Chitralada	WThai12	Whole Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thailand	Thai-Danish	WThai13	Whole Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0
U.S.	Horizon Organic	RFUS1	2% Reduced-Fat Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U.S.	Parmalat	RFUS2	2% Reduced-Fat Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
U.S.	Parmalat LiL Milk	RFUS3	2% Reduced-Fat Milk	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U.S.	Parmalat	WUS4	Whole Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U.S.	Parmalat LiL Milk	WUS5	Whole Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0
U.S.	Dillons (Control)	RFcontrol	2% Reduced-Fat Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
U.S.	Dillons (Control)	Wcontrol	Whole Milk	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Country	Milk Product	Product Abbreviation	Type	Oily	Plastic	Processed	Refrigerator	Sweet	Vanilla/Vanillin	Vitamins	Sour Aromatics	Sour	Nutty	Bitter	Astringent
France	Monoprix Lait	LFFrance1	Low-Fat Milk	0.0	0.0	2.0	0.0	1.5	0.0	0.0	2.0	1.0	0.0	0.0	0.0
France	Monoprix Lait	WFFrance2	Whole Milk	0.0	0.0	0.0	0.0	1.5	0.0	0.0	1.5	1.0	0.0	0.0	0.0
Italy	Fattoria Scaldasole	RFItaly1	2% Reduced-Fat Milk	0.0	0.0	2.0	0.0	1.5	0.0	0.0	2.5	1.5	0.0	0.0	0.0
Italy	Latte	RFItaly2	2% Reduced-Fat Milk	0.0	0.0	5.0	0.0	1.5	0.0	0.0	1.0	1.0	0.0	0.0	0.0
Italy	Latte Maremma	RFItaly3	2% Reduced-Fat Milk	0.0	0.0	2.0	0.0	1.5	0.0	0.0	2.0	1.0	0.0	0.0	0.0
Italy	Mukki Scorta	RFItaly4	2% Reduced-Fat Milk	0.0	0.0	1.5	0.0	1.5	0.0	0.0	2.0	1.5	2.0	2.0	0.0
Italy	Parmalat Fibresse	RFItaly5	2% Reduced-Fat Milk	0.0	0.0	2.0	0.0	1.5	0.0	0.0	1.0	1.0	0.0	0.0	0.0
Italy	Parmalat Latte Natura Premium	RFItaly6	2% Reduced-Fat Milk	1.5	0.0	1.5	0.0	1.5	0.0	0.0	1.0	1.0	0.0	0.0	0.0
Italy	Parmalat Omega 3	RFItaly7	2% Reduced-Fat Milk	0.0	0.0	6.5	0.0	1.5	0.0	0.0	2.0	1.5	0.0	0.0	0.0
Italy	Polenghi	RFItaly8	2% Reduced-Fat Milk	0.0	0.0	1.5	0.0	1.5	0.0	0.0	2.0	1.5	0.0	0.0	0.0
Italy	Mukki Scorta	WItaly9	Whole Milk	0.0	0.0	1.5	0.0	1.5	0.0	0.0	1.5	1.5	0.0	0.0	0.0
Italy	Parmalat Natura Premium	WItaly10	Whole Milk	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	1.0	0.0	0.0	0.0
Italy	Polenghi	WItaly11	Whole Milk	0.0	0.0	0.0	0.0	1.5	0.0	0.0	1.0	1.5	0.0	0.0	0.0
Japan	Morinaga Milk	WJapan1	Whole Milk	0.0	0.0	0.0	2.0	1.5	0.0	0.0	2.0	1.0	0.0	0.0	0.0
Korea	Maeil Milk	WKorea1	Whole Milk	0.0	0.0	2.0	0.0	1.0	0.0	0.0	3.0	1.5	0.0	0.0	0.0
Korea	Seoul Milk	WKorea2	Whole Milk	0.0	0.0	0.0	0.0	1.5	1.5	0.0	0.0	0.0	0.0	0.0	0.0
Peru	Bella Holandesa	WPeru1	Whole Milk	0.0	0.0	1.5	0.0	1.5	0.0	0.0	1.0	1.0	0.0	0.0	0.0
Peru	Gloria	WPeru2	Whole Milk	0.0	0.0	2.0	0.0	1.5	0.0	0.0	1.5	1.0	0.0	0.0	0.0
Peru	Laive	WPeru3	Whole Milk	0.0	0.0	2.0	0.0	1.5	0.0	0.0	3.0	2.0	0.0	0.0	0.0

Country	Milk Product	Product Abbreviation	Type	Oily	Plastic	Processed	Refrigerator	Sweet	Vanilla/Vanillin	Vitamins	Sour Aromatics	Sour	Nutty	Bitter	Astringent
Thailand	Bear Brand	LFThai1S	Low-Fat Milk	0.0	0.0	7.0	1.5	1.0	0.0	0.0	2.0	1.5	0.0	2.0	1.5
Thailand	Country Fresh	LFThai2	Low-Fat Milk	0.0	0.0	7.5	0.0	1.5	0.0	0.0	1.0	1.5	0.0	0.0	0.0
Thailand	Foremost	LFThai3	Low-Fat Milk	0.0	0.0	2.0	0.0	1.5	0.0	0.0	1.0	1.0	0.0	0.0	0.0
Thailand	Foremost Calcimex	LFThai4	Low-Fat Milk	0.0	0.0	6.5	0.0	1.5	0.0	0.0	1.5	1.0	0.0	0.0	0.0
Thailand	Mali	LFThai5	Low-Fat Milk	0.0	0.0	6.0	0.0	1.5	0.0	0.0	2.5	2.0	0.0	0.0	0.0
Thailand	Meiji	LFThai6	Low-Fat Milk	0.0	0.0	2.0	0.0	1.5	0.0	0.0	1.0	1.0	0.0	0.0	0.0
Thailand	Bear Brand	WThai7S	Whole Milk	0.0	0.0	5.5	0.0	1.0	0.0	0.0	2.0	1.0	0.0	2.5	0.0
Thailand	Country Fresh	WThai8	Whole Milk	0.0	0.0	8.0	0.0	1.5	0.0	0.0	1.0	1.5	0.0	0.0	0.0
Thailand	Foremost	WThai9	Whole Milk	0.0	0.0	0.0	0.0	1.5	0.0	0.0	1.0	1.0	0.0	0.0	0.0
Thailand	Meiji	WThai10	Whole Milk	0.0	0.0	2.5	0.0	1.5	0.0	0.0	1.0	1.0	0.0	0.0	0.0
Thailand	Nong Pho	WThai11	Whole Milk	0.0	0.0	3.0	0.0	1.5	0.0	0.0	3.0	2.0	0.0	0.0	0.0
Thailand	Chitralada	WThai12	Whole Milk	0.0	0.0	1.5	0.0	1.5	0.0	1.0	1.0	1.0	0.0	0.0	0.0
Thailand	Thai-Danish	WThai13	Whole Milk	0.0	0.0	2.5	0.0	1.5	0.0	0.0	1.0	1.0	0.0	0.0	0.0
U.S.	Horizon Organic	RFUS1	2% Reduced-Fat Milk	0.0	0.0	3.0	0.0	1.5	0.0	0.0	1.0	1.5	0.0	0.0	0.0
U.S.	Parmalat	RFUS2	2% Reduced-Fat Milk	0.0	0.0	3.5	0.0	1.5	0.0	0.0	1.0	1.0	0.0	0.0	0.0
U.S.	Parmalat LiL Milk	RFUS3	2% Reduced-Fat Milk	0.0	0.0	1.5	0.0	0.0	0.0	0.0	1.0	1.5	0.0	0.0	0.0
U.S.	Parmalat	WUS4	Whole Milk	0.0	0.0	5.0	0.0	1.5	0.0	0.0	2.0	2.0	0.0	0.0	0.0
U.S.	Parmalat LiL Milk	WUS5	Whole Milk	0.0	0.0	3.0	0.0	1.5	0.0	0.0	1.0	1.0	0.0	0.0	0.0
U.S.	Dillons (Control)	RFcontrol	2% Reduced-Fat Milk	0.0	0.0	0.0	0.0	1.5	0.0	0.0	1.0	1.0	0.0	0.0	0.0
U.S.	Dillons (Control)	Wcontrol	Whole Milk	0.0	0.0	0.0	0.0	1.5	0.0	0.0	1.0	1.0	0.0	0.0	0.0

## **Appendix G - UHT milk descriptive analysis raw data for PCA and Cluster Analysis**

Country	Milk Product	Product Abbreviation	Type	Chalky	Fat Feel	Viscosity	Brown	Butyric Acid	Cooked	Overall Dairy	Dairy Fat
France	Monoprix Lait	LFFrance1	Low-Fat Milk	1.5	7.0	1.5	1.0	2.0	3.5	8.5	7.5
France	Monoprix Lait	WFrance2	Whole Milk	0.0	8.0	2.0	1.5	0.0	2.0	9.5	8.5
Italy	Fattoria Scaldasole	RFItaly1	2% Reduced-Fat Milk	3.5	6.0	1.5	0.0	2.0	2.0	7.5	6.0
Italy	Latte	RFItaly2	2% Reduced-Fat Milk	8.0	2.0	1.5	2.0	0.0	3.5	5.5	2.5
Italy	Latte Maremma	RFItaly3	2% Reduced-Fat Milk	2.0	6.0	1.5	2.0	1.0	2.5	7.5	5.0
Italy	Mukki Scorta	RFItaly4	2% Reduced-Fat Milk	2.0	4.5	1.0	2.0	1.5	2.5	6.5	5.5
Italy	Parmalat Fibresse	RFItaly5	2% Reduced-Fat Milk	1.0	5.0	1.0	1.0	0.0	1.5	7.5	6.0
Italy	Parmalat Latte Natura Premium	RFItaly6	2% Reduced-Fat Milk	1.0	6.5	1.5	0.0	0.0	2.5	8.0	7.0
Italy	Parmalat Omega 3	RFItaly7	2% Reduced-Fat Milk	3.5	3.0	1.0	0.0	2.5	3.0	6.0	5.0
Italy	Polenghi	RFItaly8	2% Reduced-Fat Milk	2.0	6.5	1.5	0.0	1.5	2.0	8.0	6.0
Italy	Mukki Scorta	WItaly9	Whole Milk	2.0	7.0	1.5	0.0	1.5	1.5	8.5	7.0
Italy	Parmalat Natura Premium	WItaly10	Whole Milk	1.0	6.0	1.5	0.0	0.0	2.0	8.0	6.5
Italy	Polenghi	WItaly11	Whole Milk	1.0	4.0	2.0	0.0	0.0	3.0	8.0	7.5
Japan	Morinaga Milk	WJapan1	Whole Milk	1.0	6.0	2.0	0.0	1.0	2.0	9.0	7.5
Korea	Maeil Milk	WKorea1	Whole Milk	2.5	6.0	1.5	1.0	2.0	4.0	8.0	7.5
Korea	Seoul Milk	WKorea2	Whole Milk	2.0	7.0	2.0	1.5	0.0	2.0	10.0	8.5
Peru	Bella Holandesa	WPeru1	Whole Milk	1.5	6.0	2.0	2.5	0.0	4.0	8.0	7.0
Peru	Gloria	WPeru2	Whole Milk	5.0	6.5	2.0	3.0	1.5	4.0	8.0	8.0
Peru	Laive	WPeru3	Whole Milk	2.0	6.5	2.0	2.0	3.0	3.0	5.0	7.0

Country	Milk Product	Product Abbreviation	Type	Chalky	Fat Feel	Viscosity	Brown	Butyric Acid	Cooked	Overall Dairy	Dairy Fat
Thailand	Bear Brand	LFThai1S	Low-Fat Milk	6.0	3.0	1.5	4.0	0.0	5.5	5.0	2.5
Thailand	Country Fresh	LFThai2	Low-Fat Milk	8.5	2.5	2.0	2.0	0.0	4.0	4.0	2.5
Thailand	Foremost	LFThai3	Low-Fat Milk	1.0	6.0	1.5	2.0	1.5	3.0	8.0	8.0
Thailand	Foremost Calcimex	LFThai4	Low-Fat Milk	6.5	6.0	3.0	2.0	0.0	3.0	6.0	7.0
Thailand	Mali	LFThai5	Low-Fat Milk	8.0	2.5	2.0	3.0	0.0	5.0	4.5	3.0
Thailand	Meiji	LFThai6	Low-Fat Milk	1.0	6.0	2.0	1.0	0.0	2.5	7.5	7.5
Thailand	Bear Brand	WThai7S	Whole Milk	5.0	2.0	2.0	4.5	1.5	6.0	5.0	2.5
Thailand	Country Fresh	WThai8	Whole Milk	4.0	6.5	2.0	2.5	0.0	4.0	6.0	6.5
Thailand	Foremost	WThai9	Whole Milk	1.0	7.5	2.0	2.5	0.0	3.0	9.0	8.0
Thailand	Meiji	WThai10	Whole Milk	3.0	5.0	1.0	2.0	0.0	2.5	8.0	6.0
Thailand	Nong Pho	WThai11	Whole Milk	5.0	4.0	2.0	2.0	2.0	2.0	5.0	3.5
Thailand	Chitralada	WThai12	Whole Milk	0.0	5.5	1.5	1.5	0.0	1.0	8.0	7.5
Thailand	Thai-Danish	WThai13	Whole Milk	2.5	6.0	1.5	0.0	0.0	1.5	7.0	6.0
U.S.	Horizon Organic	RFUS1	2% Reduced-Fat Milk	3.0	2.5	1.0	0.0	0.0	3.0	6.5	5.0
U.S.	Parmalat	RFUS2	2% Reduced-Fat Milk	4.0	5.0	1.0	1.0	0.0	2.0	6.5	5.0
U.S.	Parmalat LiL Milk	RFUS3	2% Reduced-Fat Milk	1.5	4.5	1.5	1.0	1.5	3.0	6.5	5.5
U.S.	Parmalat	WUS4	Whole Milk	7.0	4.5	1.5	0.0	0.0	1.5	6.0	4.0
U.S.	Parmalat LiL Milk	WUS5	Whole Milk	1.5	6.0	1.5	0.0	0.0	2.0	7.5	6.5
U.S.	Dillons (Control)	RFcontrol	2% Reduced-Fat Milk	0.0	5.0	1.0	0.0	0.0	0.0	8.0	5.5
U.S.	Dillons (Control)	Wcontrol	Whole Milk	0.0	7.0	1.5	0.0	0.0	0.0	9.0	7.0

Country	Milk Product	Product Abbreviation	Type	Dairy Sweet	Lack of Freshness	Malty	Metallic	Processed	Sour Aromatics	Sour
France	Monoprix Lait	LFFrance1	Low-Fat Milk	4.5	1.0	0.0	0.0	2.0	2.0	1.0
France	Monoprix Lait	WFrance2	Whole Milk	6.0	0.0	3.0	3.0	0.0	1.5	1.0
Italy	Fattoria Scaldasole	RFItaly1	2% Reduced-Fat Milk	4.5	1.5	2.0	0.0	2.0	2.5	1.5
Italy	Latte	RFItaly2	2% Reduced-Fat Milk	2.5	0.0	0.0	0.0	5.0	1.0	1.0
Italy	Latte Maremma	RFItaly3	2% Reduced-Fat Milk	4.0	0.0	0.0	2.0	2.0	2.0	1.0
Italy	Mukki Scorta	RFItaly4	2% Reduced-Fat Milk	3.5	0.0	0.0	0.0	1.5	2.0	1.5
Italy	Parmalat Fibresse	RFItaly5	2% Reduced-Fat Milk	4.0	0.0	1.5	0.0	2.0	1.0	1.0
Italy	Parmalat Latte Natura Premium	RFItaly6	2% Reduced-Fat Milk	5.0	0.0	0.0	2.5	1.5	1.0	1.0
Italy	Parmalat Omega 3	RFItaly7	2% Reduced-Fat Milk	3.5	1.0	0.0	0.0	6.5	2.0	1.5
Italy	Polenghi	RFItaly8	2% Reduced-Fat Milk	4.0	0.0	0.0	0.0	1.5	2.0	1.5
Italy	Mukki Scorta	WItaly9	Whole Milk	5.0	0.0	0.0	0.0	1.5	1.5	1.5
Italy	Parmalat Natura Premium	WItaly10	Whole Milk	5.0	0.0	0.0	0.0	0.0	0.0	1.0
Italy	Polenghi	WItaly11	Whole Milk	5.0	0.0	0.0	0.0	0.0	1.0	1.5
Japan	Morinaga Milk	WJapan1	Whole Milk	5.5	0.0	1.0	0.0	0.0	2.0	1.0
Korea	Maeil Milk	WKorea1	Whole Milk	5.0	1.5	1.0	2.5	2.0	3.0	1.5
Korea	Seoul Milk	WKorea2	Whole Milk	6.0	0.0	1.5	0.0	0.0	0.0	0.0
Peru	Bella Holandesa	WPeru1	Whole Milk	5.0	0.0	4.0	0.0	1.5	1.0	1.0
Peru	Gloria	WPeru2	Whole Milk	5.0	0.0	3.0	0.0	2.0	1.5	1.0
Peru	Laive	WPeru3	Whole Milk	2.5	3.0	0.0	3.0	2.0	3.0	2.0

Country	Milk Product	Product Abbreviation	Type	Dairy Sweet	Lack of Freshness	Malty	Metallic	Processed	Sour Aromatics	Sour
Thailand	Bear Brand	LFThai1S	Low-Fat Milk	3.0	2.5	0.0	3.5	7.0	2.0	1.5
Thailand	Country Fresh	LFThai2	Low-Fat Milk	4.0	1.5	2.0	0.0	7.5	1.0	1.5
Thailand	Foremost	LFThai3	Low-Fat Milk	5.0	0.0	2.0	0.0	2.0	1.0	1.0
Thailand	Foremost Calcimex	LFThai4	Low-Fat Milk	3.5	0.0	1.5	2.5	6.5	1.5	1.0
Thailand	Mali	LFThai5	Low-Fat Milk	2.5	1.5	0.0	0.0	6.0	2.5	2.0
Thailand	Meiji	LFThai6	Low-Fat Milk	5.0	0.0	2.0	0.0	2.0	1.0	1.0
Thailand	Bear Brand	WThai7S	Whole Milk	2.0	1.5	2.0	0.0	5.5	2.0	1.0
Thailand	Country Fresh	WThai8	Whole Milk	3.5	0.0	2.0	0.0	8.0	1.0	1.5
Thailand	Foremost	WThai9	Whole Milk	5.5	0.0	1.5	0.0	0.0	1.0	1.0
Thailand	Meiji	WThai10	Whole Milk	4.5	0.0	3.0	0.0	2.5	1.0	1.0
Thailand	Nong Pho	WThai11	Whole Milk	2.5	2.0	2.0	0.0	3.0	3.0	2.0
Thailand	Chitralada	WThai12	Whole Milk	5.0	0.0	0.0	0.0	1.5	1.0	1.0
Thailand	Thai-Danish	WThai13	Whole Milk	4.0	0.0	2.0	0.0	2.5	1.0	1.0
U.S.	Horizon Organic	RFUS1	2% Reduced-Fat Milk	4.0	0.0	0.0	0.0	3.0	1.0	1.5
U.S.	Parmalat	RFUS2	2% Reduced-Fat Milk	4.0	0.0	0.0	2.5	3.5	1.0	1.0
U.S.	Parmalat LiL Milk	RFUS3	2% Reduced-Fat Milk	4.0	0.0	0.0	0.0	1.5	1.0	1.5
U.S.	Parmalat	WUS4	Whole Milk	3.0	0.0	0.0	0.0	5.0	2.0	2.0
U.S.	Parmalat LiL Milk	WUS5	Whole Milk	4.0	0.0	0.0	2.5	3.0	1.0	1.0
U.S.	Dillons (Control)	RFcontrol	2% Reduced-Fat Milk	4.0	0.0	0.0	0.0	0.0	1.0	1.0
U.S.	Dillons (Control)	Wcontrol	Whole Milk	5.0	0.0	0.0	0.0	0.0	1.0	1.0



**Appendix H - Consumer screener for testing in Manhattan,  
Kansas**

**Hello, I am \_\_\_\_\_ from the Sensory Analysis Center.** We are conducting a test on food products, and I would like to ask you a few questions to see if you qualify. If you qualify and want to participate, you would receive \$10 upon completion of the test. The test will last approximately 30 minutes.

*(Please ask the following 6 questions before letting them know whether they qualify or not, and do not tell them why they do not qualify.)*

1.  **Female** **Male**

2. Which of the following best describes your age? (If *Under 18 or 71 and older*, **Discontinue**)

Under 18                      **18 to 25**                      **26 to 70**                      71 and older

3. Do you or any of your immediate family work for a food manufacturing, a market research or advertising firm? (If *Yes*, **Discontinue**)

**Yes**                      **No**

4. How long have you been living in the US? (If *Less than 10 years*, **Discontinue**)

Less than 3 years              3 to 5 years                      6 to 9 years                      **10 years or more**

5.  **Yes**              **No**

6.

• **Chips**

Once a month or less      2-4 times a month      1 to 5 times a week      More than 5 times a week

- **Milk** (*Has to drink milk either 1 to 5 times a week or more than 5 times a week to qualify for this test*)

Once a month or less    2-4 times a month    **1 to 5 times a week**    **More than 5 times a week**

- **Soft Drink**

Once a month or less    2-4 times a month    1 to 5 times a week    More than 5 times a week

We are conducting a taste test on food products. The sessions will be held in Justin Hall Room 146. The test will last approximately 30 minutes. If you decide to participate you will receive \$10 upon completion of the test.

Would you be willing to participate (Circle)

**Yes**    No

What time would be best for you to participate?

(They have to choose one time.)

**Wednesday, March 16** in Justin Hall Room 146.

**11:15-11:45 AM**

**12:00-12:30 PM**

**12:45-1:15 PM**

**5:00-5:30 PM**

**5:45-6:15 PM**

Name: \_\_\_\_\_

Address: \_\_\_\_\_

Manhattan or \_\_\_\_\_ 6650\_\_ or \_\_\_\_\_

SS# \_\_\_\_\_

Telephone Number: Day \_\_\_\_\_

Night \_\_\_\_\_

Cell \_\_\_\_\_

Email address: \_\_\_\_\_

**Appendix I - Consumer self screener for testing in Manhattan,  
Kansas**

We are conducting a test on food products, and we would like to ask you a few questions to see if you qualify. If you qualify and want to participate, you would receive \$10 upon completion of the test. The test will last approximately 30 minutes.

**Call The Sensory Analysis Center, 532-7924 or stop by Justin Hall Room 147 with your answers to see if you qualify.**

1.  Are you : **Female** **Male**

2.  Which of the following best describes your age?

**Under 18** **18 to 25** **26 to 70** **71 and older**

3.  Do you or any of your immediate family work for a food manufacturing, a market research or advertising firm?

**Yes** **No**

4.  How long have you been living in the US?

**Less than 3 years** **3 to 5 years** **6 to 9 years** **10 years or more**

5.  Do you have any food allergies? **Yes** **No**

6.  How often on average do you eat or drink...

• **Chips**

Once a month or less    2-4 times a month    1 to 5 times a week    More than 5  
times a week

• **Milk**

Once a month or less    2-4 times a month    1 to 5 times a week    More than 5  
times a week

-OVER-

- **Soft Drink**

Once a month or less    2-4 times a month    1 to 5 times a week    More than 5  
times a week

We are conducting a test on food products. The sessions will be held in Justin Hall Room 146. The test will last approximately 30 minutes. If you decide to participate you will receive \$10 upon completion of the test.

Times to participate: (Please circle only one of the following times.)

**Wednesday, March 16** in Justin Hall Room 146.

**11:15-11:45 AM**

**12:00-12:30 PM**

**12:45-1:15 PM**

**5:00-5:30 PM**

**5:45-6:15 PM**

CLEARLY PRINT NAME, ADDRESS, AND  
TELEPHONE NUMBER.

Name: \_\_\_\_\_

Address: \_\_\_\_\_

Manhattan or \_\_\_\_\_ 6650\_\_ or \_\_\_\_\_

SS# \_\_\_\_\_

Telephone Number: Day \_\_\_\_\_ Night \_\_\_\_\_

Cell \_\_\_\_\_

Email address: \_\_\_\_\_

**YOU MUST BE CONFIRMED BY THE  
SENSORY ANALYSIS CENTER STAFF  
PRIOR TO FINAL COMMITMENT.**



**Appendix J - Informed consent statement for consumer testing  
in Manhattan, Kansas**

**INFORMED CONSENT STATEMENT  
THE SENSORY ANALYSIS CENTER**

**Kansas State University**

1. I (print) \_\_\_\_\_, agree to participate as a panelist in research conducted by The Sensory Analysis Center of Kansas State University.
2. I understand that the purpose of this project is to evaluate samples in taste tests. I will be asked to give my opinions through completion of a self-administered questionnaire.
3. I will receive \$10 at the end of this 30 minute session.
4. I understand my performance as an individual will be treated as research data and will in no way be associated with me for other than identification purposes, thereby assuring confidentiality of performance and responses.
5. I understand that I do not have to participate in this research, and may choose not to participate without penalty.
6. I understand that I may withdraw from the research at any time.
7. If I have any questions concerning this study, I understand that I can contact Dr. Edgar Chambers IV, 143D Justin Hall, Kansas State University, Manhattan, KS, U.S.A. (785-532-0156).

8. If I have any questions about my rights as a panelist or about the manner in which this research was conducted, I may contact Rick Scheidt, Chair, Committee on Research Involving Human Subjects, 103 Fairchild Hall, Kansas State University, Manhattan, KS, U.S.A. (785-532-6195).

---

(Signature)

---

(Date)

**Appendix K - Detailed samples for consumer testing at both  
locations**

<b>Product</b>	<b>PCA Code</b>	<b>Serve Code</b>	<b>Type</b>	<b>Process</b>	<b>Manufacturer</b>	<b>Net Content (ml.)</b>	<b>Best Before Date</b>	<b>Fat Content</b>
Country Fresh	WThai8	629	Whole Milk	UHT	Country Fresh Dairies Co., Ltd. Nakornrachasima	250	10/13/2005	8g/250ml
Foremost	WThai9	236	Whole Milk	UHT	Foremost Freelance Thailand Co., Ltd. Samutprakran	250	9/3/2005	7g/250ml
Meiji	WThai10	814	Whole Milk	UHT	CP-Meiji Co., Ltd. Saraburi	250	9/7/2005	10g/250ml
Nongpho	WThai11	542	Whole Milk	UHT	Ratchaburi Nongpho Dairy Cow Cooperative, Ltd. Rachaburi	250	9/3/2005	10g/250ml
Chitralada	WThai12	758	Whole Milk	UHT	Royal Chitralada Projects	200	8/28/2005	N/A

**Appendix L - Test design for consumer testing in Manhattan,  
Kansas**

## 11:15 session

Sample	Sample Code	Consumer ID	Pouring Time	Serving Time
1st	629	# 1 - 5	11:12 a.m.	11:20 a.m.
	758	# 6-10		
	814	# 11-15		
	236	# 16-20		
	542	# 21-25		
2nd	814	# 1 - 5	11:17 a.m.	11:25 a.m.
	542	# 6-10		
	758	# 11-15		
	629	# 16-20		
	236	# 21-25		
3rd	542	# 1 - 5	11:22 a.m.	11:30 a.m.
	629	# 6-10		
	236	# 11-15		
	758	# 16-20		
	814	# 21-25		
4st	236	# 1 - 5	11:27 a.m.	11:35 a.m.
	814	# 6-10		
	629	# 11-15		
	542	# 16-20		
	758	# 21-25		
5st	758	# 1 - 5	11:32 a.m.	11:40 a.m.
	236	# 6-10		
	542	# 11-15		
	814	# 16-20		
	629	# 21-25		

Pour 50 ml of milk sample in the 8 oz styrofoam cup. When you tempering, please cover with dark paper. Serving temperature needs to be over 43°F, but lower than 45°F.

Each sample needs to temper about 8 minutes before serving.

## 12:00 session

Sample	Sample Code	Consumer ID	Pouring Time	Serving Time
1 <sup>st</sup>	629	# 26-30	11:57 a.m.	12:05 p.m.
	814	# 31-35		
	542	# 36-40		
	758	# 41-45		
	236	# 46-50		
2 <sup>nd</sup>	236	# 26-30	12:02 p.m.	12:10 p.m.
	629	# 31-35		
	758	# 36-40		
	814	# 41-45		
	542	# 46-50		
3 <sup>rd</sup>	758	# 26-30	12:07 p.m.	12:15 p.m.
	542	# 31-35		
	629	# 36-40		
	236	# 41-45		
	814	# 46-50		
4 <sup>st</sup>	814	# 26-30	12:12 p.m.	12:20 p.m.
	758	# 31-35		
	236	# 36-40		
	542	# 41-45		
	629	# 46-50		
5 <sup>st</sup>	542	# 26-30	12:17 p.m.	12:25 p.m.
	236	# 31-35		
	814	# 36-40		
	629	# 41-45		
	758	# 46-50		

Pour 50 ml of milk sample in the 8 oz styrofoam cup. When you tempering, please cover with dark paper. Serving temperature needs to be over 43°F, but lower than 45°F.

Each sample needs to temper about 8 minutes before serving.



## 12:45 session

Sample	Sample Code	Consumer ID	Pouring Time	Serving Time
1 <sup>st</sup>	629	# 51-55	12:42 p.m.	12:50 p.m.
	814	# 56-60		
	629	# 61-65		
	236	# 66-70		
	814	# 71-75		
2 <sup>nd</sup>	814	# 51-55	12:47 p.m.	12:55 p.m.
	758	# 56-60		
	814	# 61-65		
	629	# 66-70		
	758	# 71-75		
3 <sup>rd</sup>	542	# 51-55	12:52 p.m.	1:00 p.m.
	236	# 56-60		
	542	# 61-65		
	758	# 66-70		
	236	# 71-75		
4 <sup>st</sup>	236	# 51-55	12:57 p.m.	1:05 p.m.
	629	# 56-60		
	236	# 61-65		
	542	# 66-70		
	629	# 71-75		
5 <sup>st</sup>	758	# 51-55	1:02 p.m.	1:10 p.m.
	542	# 56-60		
	758	# 61-65		
	814	# 66-70		
	542	# 71-75		

Pour 50 ml of milk sample in the 8 oz styrofoam cup. When you tempering, please cover with dark paper. Serving temperature needs to be over 43°F, but lower than 45°F.

Each sample needs to temper about 8 minutes before serving.

## 5:00 session

Sample	Sample Code	Consumer ID	Pouring Time	Serving Time
1 <sup>st</sup>	758	# 76-80	4:57 p.m.	5:05 p.m.
	542	# 81-85		
	629	# 86-90		
	814	# 91-95		
	542	# 96-100		
2 <sup>nd</sup>	542	# 76-80	5:02 p.m.	5:10 p.m.
	236	# 81-85		
	236	# 86-90		
	629	# 91-95		
	758	# 96-100		
3 <sup>rd</sup>	629	# 76-80	5:07 p.m.	5:15 p.m.
	814	# 81-85		
	758	# 86-90		
	542	# 91-95		
	629	# 96-100		
4 <sup>st</sup>	814	# 76-80	5:12 p.m.	5:20 p.m.
	758	# 81-85		
	814	# 86-90		
	758	# 91-95		
	236	# 96-100		
5 <sup>st</sup>	236	# 76-80	5:17 p.m.	5:25 p.m.
	629	# 81-85		
	542	# 86-90		
	236	# 91-95		
	814	# 96-100		

Pour 50 ml of milk sample in the 8 oz styrofoam cup. When you tempering, please cover with dark paper. Serving temperature needs to be over 43°F, but lower than 45°F.

Each sample needs to temper about 8 minutes before serving.

## 5:45 session

Sample	Sample Code	Consumer ID	Pouring Time	Serving Time
1 <sup>st</sup>	758 542 629 236	# 101-105 # 106-110 # 111-115 # 116-120	5:42 p.m.	5:50 p.m.
2 <sup>nd</sup>	542 758 814 629	# 101-105 # 106-110 # 111-115 # 116-120	5:47 p.m.	5:55 p.m.
3 <sup>rd</sup>	629 629 758 814	# 101-105 # 106-110 # 111-115 # 116-120	5:52 p.m.	6:00 p.m.
4 <sup>st</sup>	814 236 236 542	# 101-105 # 106-110 # 111-115 # 116-120	5:57 p.m.	6:05 p.m.
5 <sup>st</sup>	236 814 542 758	# 101-105 # 106-110 # 111-115 # 116-120	6:02 p.m.	6:10 p.m.

Pour 50 ml of milk sample in the 8 oz styrofoam cup. When you tempering, please cover with dark paper. Serving temperature needs to be over 43°F, but lower than 45°F.

Each sample needs to temper about 8 minutes before serving.

**Appendix M - Moderator's guide for consumer testing in  
Manhattan, Kansas**

### **Moderator's guide**

Hello. My name is \_\_\_\_\_. On behalf of the Sensory Analysis Center, I would like to thank you for your participation in this test. The test will last approximately 30 minutes. For your time and opinions, you will receive \$10. If you have questions after participation in the test, please feel free to call us at 532-7924.

You will be evaluating five samples of **UHT or shelf stable milk** while you are here. They will be presented to you one at a time. **You must drink the entire sample to complete the study.**

There are several things you need to remember as you evaluate the samples today.

- Be honest in answering the questions. There are no right or wrong answers to any of the questions you will be asked.
- Please do not discuss your answers with your neighbors. We want to know what **you** think.

On the table is a consent form. If you have not read through and signed it yet, please do so right now. There is also a milk demographics form. Please answer the questions about yourself. There will be UHT milk questionnaire on the last page.

The questionnaire that you will use is also on the table. Each one has 5 pages stapled together. Your consumer number is on the upper left hand corner. The sample number you are evaluating is at the top of each page. As you receive your samples, please be sure that the sample on your questionnaire matches the sample number of the product you have received. If does not, please let us know immediately.

- You will answer questions today about **shelf stable milk**.
  - The questions ask how much you like or dislike something about the **shelf stable milk**. The scale is Dislike extremely in the left hand box to Like extremely in the right hand box. The closer you mark to the left hand side the less you like it, the closer you mark to the right hand side the more you like it.
  - Last question ask your opinion about off-flavor in the **shelf stable milk**. These scales range from None in the left hand box to Extreme in the right hand box. The closer you mark to the left hand side the less the **milk** has amount of off-flavor, the closer you mark the right hand side the more the **milk** has of amount of off-flavor.
  - You will make one **x** per question.
- 
- Again, there should be no talking about the products during the evaluation. If you have questions, please raise your hand.
  - There are no incorrect answers. We want your unbiased opinions.
  - The results of this study are confidential. Please do not discuss what you have tested with anyone outside this room.
  - Make sure that you answer all of the questions. Please double check all responses when you are through to make sure all questions have been answered.
  - There is water provided for you to drink and crackers to eat between samples or as needed. Go ahead right now and take a drink of water and a bite of cracker to clear your mouth of any lingering tastes.

Are there any questions? If you have a question during the study, please feel free to ask.

When you have finished with the last sample, please wait to be dismissed to receive your payment. Please review the information on the signature sheet to make sure it is correct before signing.

**Appendix N - UHT milk consumer testing instructions  
(Manhattan, Kansas)**

## **Instruction**

**You will be evaluating 5 samples of UHT milk today.**

**UHT milk is shelf stable milk.  
It can keep outside the fridge at  
room temperature for a year.**

- **Each one will be served separately. There is a 3 digit code number on each cup for sample identification purposes.**
- **When you receive each sample, please make sure that the number you see on the cup is the same as the number at the top of the questionnaire.**
- **Be sure to use both sides of the paper as you answer the questions. Each side of the paper will have one sample.**
- **Read the instructions on the questionnaire carefully before answering any of the questions.**
- **Make sure that you have answered all of the questions about each of the 5 samples before returning to staff.**



**Appendix O - Consumer questionnaire for testing in Manhattan,  
Kansas**

Consumer # \_\_\_\_\_

Sample # \_\_\_\_\_

*Instruction*  
**A.**  
*Instruction*  
**B.**  
*Instruction*  
**C.**

**You are evaluating UHT MILK.**  
**Please rinse your mouth with water and take a bite of the cracker between samples or as needed.**  
**Take at least 3 sips of the milk before answering any of the questions. Make sure that you drink the entire sample before completing the last question.**

*Instruction*  
**D.**

**Check one box for each question to rate your opinion of the MILK from Dislike extremely to Like extremely.**

	Dislike extremely				Neither like nor dislike				Like extremely
1. How much do you like the Milk <u>OVERALL</u> ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. How much do you like the <u>Sweetness</u> ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. How much do you like the <u>Fresh Taste</u> ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. How much do you like the <u>Thickness</u> ?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

*Instruction*  
**E.**

**Check one box to rate the amount you get from the MILK from None to Extremely Strong.**

	None				Moderate				Extremely Strong
5. How much <u>Off-Flavor</u> is in this milk?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**Please comment specifically on what you LIKE or DISLIKE about this MILK:**

**Appendix P - Consumer demographic questionnaire and milk  
consumption behavior for testing in Manhattan, Kansas**

Consumer # \_\_\_\_\_

1. What is your gender?

Male \_\_\_\_\_

Female \_\_\_\_\_

2. Which age group are you in?

Under 18 \_\_\_\_\_

18-25 \_\_\_\_\_

26-70 \_\_\_\_\_

71 and older \_\_\_\_\_

3. How often do you usually drink milk?

Daily \_\_\_\_\_

Once or twice a week \_\_\_\_\_

Once every two weeks \_\_\_\_\_

Once every three weeks \_\_\_\_\_

Once a month \_\_\_\_\_

Less often than once a month \_\_\_\_\_

4. Have you ever drank UHT milk? (If no, skip question 5)      Yes \_\_\_\_\_      No \_\_\_\_\_

5. How often do you usually drink UHT MILK?

Daily \_\_\_\_\_

Once or twice a week \_\_\_\_\_

Once every two weeks \_\_\_\_\_

Once every three weeks \_\_\_\_\_

Once a month \_\_\_\_\_

Less often than once a month \_\_\_\_\_

6. What are/would be your reasons of not drinking UHT MILK? (select all that apply)

Bad Flavor \_\_\_\_\_

Difficult to purchase \_\_\_\_\_

Expensive \_\_\_\_\_

Health issue Health issue \_\_\_\_\_

Not familiar with the product \_\_\_\_\_

Others (please specify) \_\_\_\_\_

**Appendix Q - Consumer screener testing in Bangkok,  
Thailand**

พวกเราดำเนินการทดสอบผลิตภัณฑ์ที่เกี่ยวข้องกับอาหารและต้องการถามคำถาม  
 เพื่อที่จะตรวจสอบว่าคุณมีคุณสมบัติตรงตามที่เราต้องการหรือไม่  
 ถ้าคุณมีคุณสมบัติเหมาะสมและต้องการเข้าร่วมใน การทดสอบ คุณจะได้รับค่าตอบแทน  
 100 บาทหลังจากเสร็จสิ้นการทดสอบแต่ละอย่าง

คุณเป็น  เพศชาย  หรือ  เพศหญิง

1. ช่วงอายุใดข้างล่างนี้บ่งบอกถึงอายุของคุณ
- ต่ำกว่า 17 ปี
- 18-25 ปี
- 26-60 ปี
- 61-70 ปี
- 70 ปีขึ้นไป

2. คุณหรือบุคคลใกล้ชิดในครอบครัวมากกว่าจ้างหรือมีความสัมพันธ์กับบริษัท  
 ผู้ผลิตอาหาร, บริษัทวิจัยตลาด หรือบริษัทโฆษณาหรือไม่
- ใช่
- ไม่ใช่

3. คุณแพ้อาหารหรือไม่
- ใช่
- ไม่ใช่

4. รายการใดข้างล่างนี้ที่คุณชอบบริโภคหรือดื่ม

มะขามหวาน

กล้วย

มะม่วง

นมยูเอชที

น้ำอัดลม

น้ำผลไม้

กรุณาเขียนชื่อสกุลและหมายเลขโทรศัพท์ด้วยตัวบรรจง

ชื่อ-สกุล: \_\_\_\_\_

หมายเลขโทรศัพท์: (โปรดระบุโทรศัพท์เคลื่อนที่หรือ PCT)

\_\_\_\_\_

กรุณาให้เจ้าหน้าที่คนใดคนหนึ่งตรวจสอบหน้านี้ก่อนเข้าร่วมการทดสอบ

สำหรับเจ้าหน้าที่เท่านั้น:

มีคุณสมบัติเหมาะสมกับ

การทดสอบที่ 1

การทดสอบที่ 2

การทดสอบที่ 3

การทดสอบที่ 1 และ 2 เป็นการทดสอบที่เกิดขึ้นทันที

การทดสอบที่ 3 ผู้ทดสอบต้องกลับมาร่วมทดสอบอีกครั้งในวันพุธนี้

### **Uเวลาทดสอบ**

### **Uพุธ ที่ 2 กุมภาพันธ์ 2548**

11:00 น.

12:30 น.

14:00 น.

15:30 น.

17:30 น.

ที่ห้อง 254 ชั้น 2 อาคาร 1 คณะอุตสาหกรรมเกษตร

มหาวิทยาลัยเกษตรศาสตร์ บางเขน

### **Uกรณาวงกลมรอบการทดสอบที่ผู้ทดสอบมีคุณสมบัติเหมาะสมบนแบบฟอร์ม มเลือกผู้เข้าร่วมการทดสอบ**

(วงกลมรอบเวลาทดสอบสำหรับการทดสอบที่ 3 ด้วย)

**Appendix R - Protocol for consumer testing in Bangkok,  
Thailand**



## Protocol for UHT Milk

**Objective:** To determine consumer liking by Thai consumers of 5 brands of UHT shelf stable milk, whole milk

**Products:** 5 brands of UHT shelf stable milk, whole milk (250 ml). Brands are:

- Country Fresh
- Meiji
- Foremost
- Chitralada (200ml) – have to buy 30 boxes
- Nongpho

For testing in Thailand, need 25 boxes of each sample. For testing in US, need 25 boxes of each sample. Each individual sample in the same brand will be purchased from the same production manufacturing lot code or expiration date. And samples of different brands will be chosen to have as similar expiration date as possible.

Milks will be refrigerated and will be served at ~43-45 degrees Fahrenheit (6-7 degrees C), this will require milk to be refrigerated at ~34 degrees Fahrenheit (1 degree C) for at least one day prior to serving.

~50 ml of milk will be served to each consumer (8 oz. Styrofoam cups to be used to serve each consumer)(Pre-labeled cups will be provided by Sensory Analysis Center (SAC))

Cups will be labeled with 3 digit code numbers

- | <u>Code number</u> | <u>Product</u> |
|--------------------|----------------|
| • 629              | Country Fresh  |
| • 814              | Meiji          |
| • 236              | Foremost       |
| • 758              | Chitralada     |
| • 542              | Nongpho        |

**Consumers:** General Population Thai, who like fresh cow milk, no allergy, 18-70 years old. No other recruiting requirements

A minimum of 100 consumers who participate in PROP intercept test will be recruited to come back at specific times to participate in milk study. (I DOUBT THAT THEY WILL COME BACK. WE MAY HAVE TO FIND ANOTHER CONSUMER TARGET) There would be 5 sessions scheduled with up to 25 people coming at each time.

**Serving:**

1. Testing location is at sensory testing laboratory of the Department of Product Development, Faculty of Agro-Industry, Kasetsart University (17 booths)

(If you need it to be table we can still set up the table in the hallway)

2. Sample presentation is sequential monadic (one at a time). Panel time is ~30 minutes.

3. Each of the 5 panels will be given oral instructions.

4. Sample will be served at the designated temperature.

Note: One moderator for each group and 1 person to pour and 1 person to serve and 1 person to pay (may be some overlap – the person paying will help pour and serve as needed). (Please consider helpers. These many in a group will help for all tests including PROP. (Would we pay the helper, 2,500 Bahts each for 5 days = \$65. If we need the evening we will consider to add 200 Bahts more. But to see the number here we can finish in each day)

Number of helpers needed depends upon how each of the studies are set up, can the PROP and other tests be run at the same time? In different locations? Or do we stop PROP while we are running the milk and sweet tamarind?

**Appendix S - Informed consent statement for consumer testing  
in Bangkok, Thailand**

แบบฟอร์มแสดงการยินยอมเข้าร่วมการทดสอบ  
ศูนย์วิเคราะห์ทางด้านประสาทสัมผัส

มหาวิทยาลัยแคนซัสสเตท  
(Kansas State University)

1. ข้าพเจ้า (เขียนตัวบรรจง) \_\_\_\_\_, ยินยอมเข้าร่วมเป็นผู้ทดสอบในการวิจัยที่ดำเนินการโดยศูนย์วิเคราะห์ทางด้านประสาทสัมผัสของมหาวิทยาลัยแคนซัสสเตท ที่ มหาวิทยาลัยเกษตรศาสตร์, กรุงเทพมหานคร ประเทศไทย
2. ข้าพเจ้าตระหนักว่าวัตถุประสงค์ของโครงการวิจัยนี้เพื่อประเมินตัวอย่างในการทดสอบรส ข้าพเจ้าจะถูกถามความคิดเห็นโดยการตอบแบบสอบถามด้วยตนเองให้เสร็จสมบูรณ์
3. ข้าพเจ้าจะได้รับค่าตอบแทน 100 บาท เมื่อเสร็จสิ้นการทดสอบ
4. ข้าพเจ้าตระหนักว่าผลการปฏิบัติงานของข้าพเจ้าจะถูกเก็บเป็นข้อมูลในการวิจัยและจะ  
ไม่มีความสัมพันธ์กับข้าพเจ้ามากไปกว่าการชั่งชั่งชั่งนั้นจึงเป็นการประกันว่าผลการปฏิบัติงาน  
และการตอบสนองต่างๆ จะถือเป็นความลับ
5. ข้าพเจ้าตระหนักว่าข้าพเจ้าไม่จำเป็นต้องเข้าร่วมการวิจัยนี้และสามารถเลือกที่จะไม่เข้าร่วมการทดสอบโดยไม่มีภาระโทษ
6. ข้าพเจ้าตระหนักว่าข้าพเจ้าสามารถที่จะถอนตัวจากการวิจัยเมื่อไรก็ได้
7. ถ้าข้าพเจ้ามีข้อสงสัยเกี่ยวกับการวิจัยนี้ ข้าพเจ้าตระหนักว่าข้าพเจ้าสามารถติดต่อ  
ดร.เอ็ดการ์ แชมเบอร์ที่สี่ (Dr.Edgar Chambers IV) ที่อยู่ 143ดี อาคารจัสติน  
มหาวิทยาลัยแคนซัสสเตท, แมนแฮทตัน, แคนซัส ประเทศสหรัฐอเมริกา  
หมายเลขโทรศัพท์ (001)(1)(785)(532-0156).

8. ถ้าข้าพเจ้ามีข้อสงสัยเกี่ยวกับสิทธิ์ของข้าพเจ้าในฐานะของผู้ทดสอบหรือเกี่ยวกับวิธีดำเนินการงานวิจัยนี้ ข้าพเจ้าสามารถติดต่อกับริก สคีด์ท (Rick Scheidt) หัวหน้าคณะกรรมการงานวิจัยที่เกี่ยวข้องกับการใช้ มนุษย์เป็นผู้ทดสอบ ที่อยู่ 103 อาคารแฟร์ชาลส์ มหาวิทยาลัยเคนซัสสเตท, แมนแฮทตัน, แคนซัส ประเทศสหรัฐอเมริกา หมายเลขโทรศัพท์ (011)(1)(785)(532-6195).

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(ลายเซ็น)

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(วันที่)

**Appendix T - Test Design for Consumer Testing in Bangkok,  
Thailand**

<b>Consumer</b>	<b>1st</b>	<b>2nd</b>	<b>3rd</b>	<b>4th</b>	<b>5th</b>
1	629	814	542	236	758
2	629	814	542	236	758
3	629	814	542	236	758
4	629	814	542	236	758
5	629	814	542	236	758
6	758	542	629	814	236
7	758	542	629	814	236
8	758	542	629	814	236
9	758	542	629	814	236
10	758	542	629	814	236
11	814	758	236	629	542
12	814	758	236	629	542
13	814	758	236	629	542
14	814	758	236	629	542
15	814	758	236	629	542
16	236	629	758	542	814
17	236	629	758	542	814
18	236	629	758	542	814
19	236	629	758	542	814
20	236	629	758	542	814
21	542	236	814	758	629
22	542	236	814	758	629
23	542	236	814	758	629
24	542	236	814	758	629
25	542	236	814	758	629
26	629	236	758	814	542
27	629	236	758	814	542
28	629	236	758	814	542
29	629	236	758	814	542
30	629	236	758	814	542
31	814	629	542	758	236
32	814	629	542	758	236
33	814	629	542	758	236
34	814	629	542	758	236
35	814	629	542	758	236

<b>Consumer</b>	<b>1st</b>	<b>2nd</b>	<b>3rd</b>	<b>4th</b>	<b>5th</b>
36	542	758	629	236	814
37	542	758	629	236	814
38	542	758	629	236	814
39	542	758	629	236	814
40	542	758	629	236	814
41	758	814	236	542	629
42	758	814	236	542	629
43	758	814	236	542	629
44	758	814	236	542	629
45	758	814	236	542	629
46	236	542	814	629	758
47	236	542	814	629	758
48	236	542	814	629	758
49	236	542	814	629	758
50	236	542	814	629	758
51	629	814	542	236	758
52	629	814	542	236	758
53	629	814	542	236	758
54	629	814	542	236	758
55	629	814	542	236	758
56	814	758	236	629	542
57	814	758	236	629	542
58	814	758	236	629	542
59	814	758	236	629	542
60	814	758	236	629	542
61	629	814	542	236	758
62	629	814	542	236	758
63	629	814	542	236	758
64	629	814	542	236	758
65	629	814	542	236	758
66	236	629	758	542	814
67	236	629	758	542	814
68	236	629	758	542	814
69	236	629	758	542	814
70	236	629	758	542	814



<b>Consumer</b>	<b>1st</b>	<b>2nd</b>	<b>3rd</b>	<b>4th</b>	<b>5th</b>
71	814	758	236	629	542
72	814	758	236	629	542
73	814	758	236	629	542
74	814	758	236	629	542
75	814	758	236	629	542
76	758	542	629	814	236
77	758	542	629	814	236
78	758	542	629	814	236
79	758	542	629	814	236
80	758	542	629	814	236
81	542	236	814	758	629
82	542	236	814	758	629
83	542	236	814	758	629
84	542	236	814	758	629
85	542	236	814	758	629
86	629	236	758	814	542
87	629	236	758	814	542
88	629	236	758	814	542
89	629	236	758	814	542
90	629	236	758	814	542
91	814	629	542	758	236
92	814	629	542	758	236
93	814	629	542	758	236
94	814	629	542	758	236
95	814	629	542	758	236
96	542	758	629	236	814
97	542	758	629	236	814
98	542	758	629	236	814
99	542	758	629	236	814
100	542	758	629	236	814
101	758	542	629	814	236
102	758	542	629	814	236
103	758	542	629	814	236
104	758	542	629	814	236
105	758	542	629	814	236

<b>Consumer</b>	<b>1st</b>	<b>2nd</b>	<b>3rd</b>	<b>4th</b>	<b>5th</b>
106	542	758	629	236	814
107	542	758	629	236	814
108	542	758	629	236	814
109	542	758	629	236	814
110	542	758	629	236	814

**Appendix U - UHT milk consumer testing instructions  
(Bangkok, Thailand)**

- ในวันนี้คุณจะประเมินตัวอย่างนมยูเอชที 5 ตัวอย่าง
- ตัวอย่างแต่ละตัวอย่างจะแยกเสิร์ฟจากกัน โดยจะมีรหัสตัวเลข 3 หน่วยอยู่บนถ้วยของแต่ละตัวอย่างเพื่อบ่งชี้ถึงชื่อตัวอย่าง
- เมื่อคุณได้รับตัวอย่างแต่ละตัวอย่าง ให้ใส่หมายเลขตัวอย่างที่คุณเห็นบนถ้วยลงตรงกลางหัวแบบสอบถาม
- แบบสอบถามแต่ละชุดจะมี 3 แผ่นเย็บติดกัน ในการตอบคำถามกรุณาตรวจสอบว่าคุณได้ใช้กระดาษทั้งสองด้าน ซึ่งแต่ละด้านจะมีคำถามของ 1 ตัวอย่าง (หน้าสุดท้ายจะเป็นข้อมูลผู้ทดสอบ)
- อ่านคำสั่งบนแบบสอบถามอย่างรอบคอบก่อนที่จะตอบคำถามใดๆ ก็ตาม
- หลีกเลี่ยงการสนทนาระหว่างการทดสอบ ถ้าคุณมีคำถามให้ยกมือถามเจ้าหน้าที่
- กรุณาตรวจสอบว่าคุณได้ตอบคำถามทั้งหมดในแบบสอบถามของทั้งห้าตัวอย่างก่อนส่งคืนให้กับเจ้าหน้าที่

**Appendix V - Consumer questionnaire for testing in Bangkok,  
Thailand**

ผู้ทดสอบเลขที่ \_\_\_\_\_

ตัวอย่างเลขที่ \_\_\_\_\_

- คำสั่ง A.** คุณกำลังประเมิน นมยูเอชที  
กรุณาล้างปากด้วยน้ำเปล่าและกัดแครกเกอร์ระหว่างแต่ละตัวอย่างหรือเท่าที่  
**คำสั่ง B.** จำเป็น
- คำสั่ง C.** จิบนมอย่างน้อย 3 จิบก่อนตอบคำถามใดก็ตาม และให้แน่ใจว่าคุณเต็มตัวอย่างทั้งหมดก่อนที่จะตอบคำถามสุดท้ายเสร็จ
- คำสั่ง D.** ทำเครื่องหมายในช่องว่าง 1 ช่องสำหรับแต่ละคำถาม เพื่อให้คะแนน ความคิดเห็นของคุณ ที่มีต่อตัวอย่าง นมยูเอชที จาก ไม่ชอบอย่างยิ่ง ถึง ชอบอย่างยิ่ง

	ไม่ชอบ อย่างยิ่ง					เฉย เฉย				ชอบ อย่างยิ่ง
1) คุณชอบตัวอย่างนี้ <u>โดยรวม</u> เท่าไร	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2) คุณชอบ <u>ความหวาน</u> ของตัวอย่างนี้เท่าไร	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3) คุณชอบ <u>รสชาติความสด</u> ของตัวอย่างนี้เท่าไร	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4) คุณชอบ <u>ความข้น</u> ของตัวอย่างนี้เท่าไร	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

- คำสั่ง E.** ทำเครื่องหมายในช่องว่าง 1 ช่อง เพื่อให้คะแนน ปริมาณ ที่คุณได้รับจากตัวอย่าง นมยูเอชที จาก ไม่มีเลย ถึง มีมากอย่างยิ่ง

	ไม่มีเลย					ปาน กลาง				มีมาก อย่างยิ่ง
5) ตัวอย่างนี้มี <u>รสแปลกปลอมหรือผิดปกติ</u> มากเท่าไร	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

กรุณาให้ข้อคิดเห็นเกี่ยวกับสิ่งที่คุณชอบหรือไม่ชอบในตัวอย่างนมยูเอชทีนี้

**Appendix W - Consumer demographic questionnaire and milk  
consumption behavior for testing in Bangkok, Thailand**

ผู้ทดสอบเลขที่ \_\_\_\_\_

วันที่ \_\_\_\_\_

ข้อมูลผู้ทดสอบ

**กรุณาตอบคำถามเกี่ยวกับตัวคุณ ข้อมูลเหล่านี้จะถือเป็นความลับ**

1) กรุณาวางกลมเพศของคุณ

เพศชาย

เพศหญิง

2) กรุณาวางกลมช่วงอายุของคุณ

ต่ำกว่า 18 ปี

18-25 ปี

26-70 ปี

70 ปีขึ้นไป

3) คุณดื่มนมยูเอชทีบ่อยแค่ไหน

ทุกวัน

1-2 ครั้งต่อสัปดาห์

1 ครั้งทุก 2 สัปดาห์

1 ครั้งทุก 3 สัปดาห์

1 ครั้งต่อเดือน

น้อยกว่า 1 ครั้งต่อเดือน



**Appendix X - Consumer demographic comparison between  
two groups of consumers**

<b>Consumer Origin</b>	<b>Gender</b>		<b>Age Range</b>	
	<b>Male</b>	<b>Female</b>	<b>18-25</b>	<b>26-70</b>
<b>U.S. consumers</b>	37	65	46	57
<b>Thai consumers</b>	34	69	54	49

## **Appendix Y - SAS code for consumer testing data analysis**

```

options nodate pageno=1;
data UHTmilkconsumer;
title1 'UHT Milk Consumer Study-US vs. Thai';
Input country$ consumer block sample OverallLiking Sweetness
FreshTaste Thickness OffFlavor;
  IF sample=629 THEN prod='CountryFresh';
  IF sample=814 THEN prod='Meiji';
  IF sample=236 THEN prod='Foremost';
  IF sample=758 THEN prod='RoyalChitralada';
  IF sample=542 THEN prod='Nongpho';
cards;
(data has been deleted)
;
proc glimmix;
title2 'Anova and LSD Mean Comparison by Product and Country for
Overall Liking';
class country consumer block prod;
model OverallLiking = country|prod/ddfm=satterth;
random consumer(country) block;
lsmeans country|prod /pdiff lines;
run;
proc glimmix;
title2 'Anova and LSD Mean Comparison by Product and Country for
Sweetness Liking';
class country consumer block prod;
model Sweetness = country|prod/ddfm=satterth;
random consumer(country) block;
lsmeans country|prod /pdiff lines;
run;
proc glimmix;
title2 'Anova and LSD Mean Comparison by Product and Country for
Fresh Taste Liking';
class country consumer block prod;
model FreshTaste = country|prod/ddfm=satterth;
random consumer(country) block;
lsmeans country|prod /pdiff lines;
run;
proc glimmix;
title2 'Anova and LSD Mean Comparison by Product and Country for
Thickness Liking';
class country consumer block prod;
model Thickness = country|prod/ddfm=satterth;
random consumer(country) block;
lsmeans country|prod /pdiff lines;
run;
proc glimmix;
title2 'Anova and LSD Mean Comparison by Product and Country for
OffFlavor Liking';
class country consumer block prod;
model OffFlavor = country|prod/ddfm=satterth;
random consumer(country) block;
lsmeans country|prod /pdiff lines;
run;
**check means and standard deviations**;
proc sort; by country prod;
proc means;
var OverallLiking--OffFlavor;

```

```
by country prod;
output out=means;
run;
proc sort; by prod;
proc means;
var OverallLiking--OffFlavor;
by prod;
output out=means;
run;
data means; set means;
if _stat_='MEAN';
run;
proc print; run;
data step2; set UHTmilkconsumer;
proc corr;
var OverallLiking--OffFlavor;
by country;
run
```