

# Consumer Preferences for Mild Cheddar Cheese Flavors

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**ABSTRACT:** Flavor is an important factor in consumer selection of cheeses. Mild Cheddar cheese is the classification used to describe Cheddar cheese that is not aged extensively and has a “mild” flavor. However, there is no legal definition or age limit for Cheddar cheese to be labeled mild, medium, or sharp, nor are the flavor profiles or flavor expectations of these cheeses specifically defined. The objectives of this study were to document the distinct flavor profiles among commercially labeled mild Cheddar cheeses, and to characterize if consumer preferences existed for specific mild Cheddar cheese flavors or flavor profiles. Flavor descriptive sensory profiles of a representative array of commercial Cheddar cheeses labeled as mild ( $n = 22$ ) were determined using a trained sensory panel and an established cheese flavor sensory language. Nine representative Cheddar cheeses were selected for consumer testing. Consumers ( $n = 215$ ) assessed the cheeses for overall liking and other consumer liking attributes. Internal preference mapping, cluster analysis, and discriminant analysis were conducted. Mild Cheddar cheeses were diverse in flavor with many displaying flavors typically associated with more age. Four distinct consumer clusters were identified. The key drivers of liking for mild Cheddar cheese were: color, cooked/milky, whey and brothy flavors, and sour taste. Consumers have distinct flavor and color preferences for mild Cheddar cheese. These results can help manufacturers understand consumer preferences for mild Cheddar cheese.

**Keywords:** consumer acceptance, lexicon, mild Cheddar cheese, preference mapping

## Introduction

The United States is the world's largest cheese producer with 4.3 metric tons of Cheddar cheese produced in 2005 (Anonymous 2008). In general, cheese consumption has tripled since the 1970s. In 2005, cheese consumption totaled 14.24 kg per capita, Cheddar cheese accounts for 4.60 kg per capita (Dairy Facts 2006). Between 2001 and 2005, there was a 10% increase in the U.S. production of Cheddar cheese (Anonymous 2008). In the United States in 2005, the most popular varieties of cheese were processed American (primarily Cheddar cheese), Cheddar cheese, and Mozzarella with total volume sales in the supermarket of 243.3, 239.0, and 119.7 million kg, respectively (Anonymous 2005).

A little over half of Cheddar sales nationally fall in the mild Cheddar cheese category (Berry 2006). There is no legal definition, age limit, or flavor profile for Cheddar cheese to be labeled as mild, medium, or sharp. Drake and others (2001) developed a sensory lexicon for describing Cheddar cheese flavor attributes. Mild or young Cheddar cheese (<6 mo) flavor was generally characterized by “young/undeveloped” flavors such as cooked/milky, whey, diacetyl, and milkfat flavors and as cheeses aged, intensities of “aged flavors” such as sulfur and brothy, developed (Drake and others 2001, 2005, 2008; Carunchia Whetstine and others 2006; Rehman and others 2008).

Internal preference mapping is a principal component analysis (PCA) of the matrix of hedonic scores across the products

(the observations) and the consumer (the variables) which is carried out on a covariance matrix to allow for differences in the strength of consumer preferences to be expressed (Guinard 1998). External preference mapping is a technique that identifies relationships between consumer acceptability and descriptive sensory attributes or other analytical data (Schlich 1995). When applied with descriptive flavor data, specific trained panel sensory flavors that are associated with consumer like or dislike can be identified. External preference mapping regresses individual consumer preferences onto the first 2 principal components of the covariance matrix of descriptive or other analytical ratings across products. Young and others (2004) conducted external preference mapping using 6 Cheddar cheeses with very diverse flavor profiles and ages. They found that consumers were able to differentiate “young” and “aged” Cheddar cheeses in agreement with trained panel profiles of “young/undeveloped” and “aged/developed” flavors. However, consumers thought both types of cheeses (young and aged flavored) had intense cheese flavor. Six consumer segments, each with specific likes and dislikes for Cheddar cheese flavors were identified from this study. Three of these segments liked Cheddar cheeses characterized by young flavors (cooked, whey, diacetyl, and milkfat) in conjunction with low intensities of aged Cheddar cheese flavors such as sulfur and brothy. In a similar more recent study, Caspia and others (2006) also reported 6 consumer segments when Cheddar cheeses of varying ages were evaluated. Four of the segments preferred cheeses characterized by “young” flavors.

Mild Cheddar cheese is generally aged for 2 to 6 mo (Anonymous 2008). However, mild Cheddar cheeses are expected to be sold within 6 mo from manufacture (Jed Davis, Cabot Cheese, personal communication). Previous preference mapping studies with Cheddar cheese have not exclusively focused on mild Cheddar cheeses, but published results suggest that a diverse array of flavors and flavor intensities may be preferred by consumers. The objectives of this study was to determine if distinct flavor profiles existed among

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commercially labeled mild Cheddar cheeses, and to characterize if consumer preferences existed for specific mild Cheddar cheese flavors or flavor profiles.

### Materials and Methods

#### Cheeses

Commercially labeled mild Cheddar cheeses ( $n = 22$ ) were collected from the west coast, midwest, and northeast. Cheeses were selected based on label (mild), availability, and to represent mild Cheddar cheeses manufactured across the U.S. Cheeses were received by overnight carrier on ice from the manufacturer or ordered from a local distributor. Ten kilograms of each cheese were obtained. Cheeses were examined for shipping damage and stored at 5 °C in the dark until analysis. All cheeses were full fat commercial U.S. Cheddar cheeses manufactured from pasteurized (21) or thermalized (1) milk.

#### Descriptive sensory analysis

Sensory testing was conducted in compliance with NCSU Institutional Review Board for Human Subjects approval. Cheddar cheeses were cut into 3.5 cm cubes for descriptive sensory analysis. The cheeses were placed into lidded 58 mL soufflé cups with 3-digit codes. The cheeses were tempered at 12 °C for 1 h and were served at this temperature with room temperature deionized water and unsalted crackers for palate cleansing. Descriptive analysis was conducted using a 0 to 15 universal intensity scale with the Spectrum™ method (Meilgaard and others 1999; Drake and Civille 2003) and an established cheese flavor sensory language (Drake and others 2001). A trained descriptive sensory panel ( $n = 10$ ) with over 150 h of experience each with descriptive analysis of cheese flavor evaluated the cheeses. Consistent with Spectrum descriptive analysis training, the panelists were presented with reference solutions of sweet, sour, salty, and bitter tastes to learn to use the universal intensity scale (Meilgaard and others 1999; Drake and Civille 2003). Discussion and evaluation of a wide array of cheeses (Cheddar cheeses labeled as mild and sharp) was also conducted during training to enable panelists to consistently differentiate and repli-

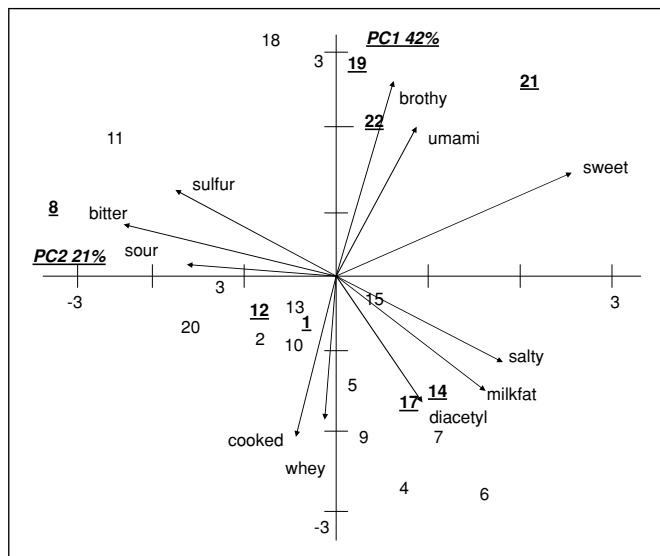
cate samples. Analysis of data collected from training sessions confirmed that the panel and panelists could consistently use the attributes to differentiate cheeses (Drake and others 2001).

Cheeses were evaluated monadically in triplicate in a randomized balanced block design. Each panelist evaluated no more than 4 cheeses in a given session with an enforced 3 min rest between samples. Each cheese was evaluated one time per replication in a randomized order for each panelist prior to proceeding to the subsequent replication. Evaluations were conducted individually in an enclosed room with positive air pressure dedicated to sensory analysis and free from external aromas, noise, and distractions. The panelists were instructed to expectorate samples after evaluation and paper ballots were used.

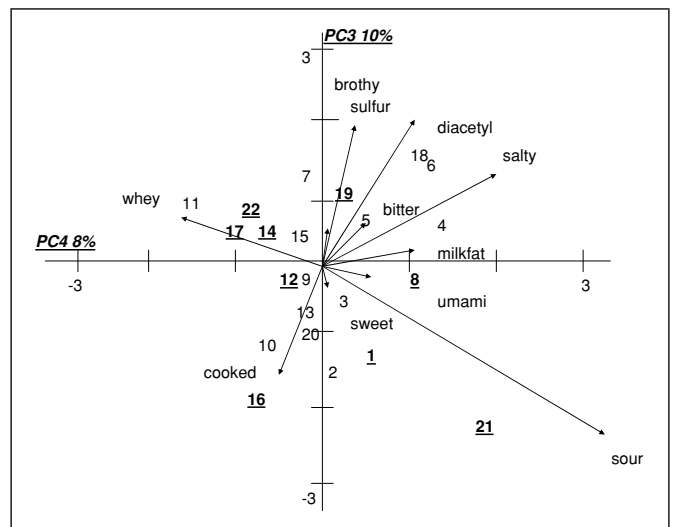
#### Consumer evaluation

Nine representative cheeses were selected for consumer testing based on examination of descriptive panel mean flavor intensities and principal component biplots and color. Consumer testing was conducted within 2 wk of the descriptive analysis of the cheeses. Cheeses were cut into 3.5 cm cubes and dispensed into lidded 58 mL soufflé cups numbered with 3-digit codes. The cheeses were served at 12 °C. Self-reported consumers of mild Cheddar cheese were recruited from the university students, staff, and faculty through emails and fliers. The Cheddar cheeses ( $n = 9$ ) were tested in a single session with a 3-min rest between each sample. Consumers ( $n = 215$ ) were provided with consent forms consistent with NCSU Human Subjects approval, a demographic screener, and a scoring ballot. Cheeses were presented individually in a randomized balanced order. A screener form was designed for collecting demographic information and evaluating consumer opinions for cheese and/or cheese products. The scoring ballot was used to evaluate consumer evaluations of cheese for: overall acceptance, color liking, mild cheese flavor liking, mild cheese flavor intensity, salty taste liking, and texture liking using a 9-point hedonic scale where 1 = dislike extremely or low intensity and 9 = like extremely or high intensity. Consumers also rated purchase intent using a 5-point scale where 1 = definitely would not buy and 5 = definitely would buy. Consumers were provided with deionized water

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**Figure 1 – Principal component (1 and 2) biplot of descriptive analysis of mild Cheddar cheeses. Cheeses are represented by numbers. Attributes only present in 1 cheese were not included in the PCA analysis. Underlines denote cheeses selected for consumer testing.**



**Figure 2 – Principal component (3 and 4) biplot of descriptive analysis of mild Cheddar cheeses. Cheeses are represented by numbers. Attributes only present in 1 cheese were not included in the PCA analysis. Underlines denote cheeses selected for consumer testing.**

and unsalted crackers for palate cleansing. Responses were collected using Compusense Five v4.6 (Compusense, Guelph, Ontario, Canada). Consumers were provided with gift certificates for their participation.

### Proximate analysis and color analysis

Proximate analysis and color measurements were conducted on cheeses selected for consumer testing. Cheeses were analyzed for moisture and fat using the SMART Trac system (CEM Microwave Technology, Matthews, N.C., U.S.A.), which uses nuclear magnetic resonance. Cheese pH was measured using a Xerolyt combination electrode (Model HA405; Mettler Toledo, Columbus, Ohio, U.S.A.) and an Accumet pH meter (Model AR 25, Fisher Scientific, Pittsburgh, Pa., U.S.A.) after tempering to 23 °C (Carunchia Whetstine and others 2006). Samples were shipped to a commercial testing laboratory for salt analysis by the Volhard method (Carunchia Whetstine and others 2006). All proximate analyses were conducted in duplicate. For color analysis, an approximately 300 g block of cheese was trimmed 1 cm on all sides to eliminate any color inconsistencies due to packaging.

Three measurements of Hunter color ( $L^*$ ,  $a^*$ ,  $b^*$ ) were taken at random places on each cheese under incandescent lighting with a Minolta Colorimeter, which measured color of a 2.5-cm radius on the product surface (Konica Minolta, Tokyo, Japan).

### Statistical analysis

Univariate and multivariate statistical methods were used in analyzing the results using SAS (SAS, version 9.1, Cary, N.C., U.S.A.). Descriptive and consumer data were analyzed individually and then together. Analysis of variance including effects for treatment repetition and panelist with means separation was used to analyze the descriptive data. PCA was also applied to evaluate how treatments were differentiated by descriptive analysis. Attributes that were only present in 1 cheese were not included in the PCA analysis. Correlation analysis was conducted on descriptive and consumer data individually and together to determine linear relationships. Possible nonlinear relationships between consumer attributes and cheese attribute intensities were visually assessed using scatterplots.

Internal preference mapping was conducted on consumers' means and treatment mean scores were plotted on the resulting principal component eigenvectors. External preference mapping was conducted on the descriptive data and the consumer

acceptance scores using partial least squares regression analysis (PLS). A good fit model was not obtained so alternative methods were explored. Consumer acceptability scores were segmented using PCA followed by cluster analysis with Ward's criterion. Clusters were confirmed using stepwise discriminant analysis with cross-validation. Characteristics of each cluster were determined by analysis of variance of acceptance scores between clusters, examination of descriptive flavor profiles, and discriminant analysis classification. Chi-square tests were conducted to determine if there were differences in demographic attributes among consumer in different clusters.

## Results

### Descriptive analysis

Descriptive analysis results showed distinguishing flavor differences between the Cheddar cheeses (Figure 1 and 2). Four principal components (PCs) explained 81% of the variability. Based on the eigenvector loadings (not shown) cheeses were primarily differentiated by brothy and umami attributes loading positively, and cooked, whey, and milkfat flavors negatively loading (PC1 42%). PC2 (21%) differentiated cheeses by sweet taste (loading positively) and bitter taste (loading negatively). PC3 (10%) comprised diacetyl and sulfur flavors (loading positively) and PC4 (8%) comprised sour and salty taste (loading positively). All of the mild cheeses contained high intensities of cooked/milky and milkfat flavors, and

**Table 2—Proximate analysis of mild Cheddar cheeses selected for consumer testing.**

Treatment	pH	Fat (%)	Moisture (%)	Salt content (%)	Color		
					L	a	b
1	5.4	22.3	34.3	1.7	77.2	5.9	30.8
8	5.2	23.3	38.2	1.2	69.2	16.2	55.5
12	5.1	24.6	38.4	1.4	83.5	-3.0	23.5
14	5.2	23.8	37.8	1.8	76.7	10.3	49.9
16	5.1	24.5	38.2	1.4	83.6	2.8	20.0
17	5.5	23.0	39.2	2.2	73.2	10.6	16.3
19	5.5	21.4	33.1	1.6	80.4	-4.0	27.9
21	5.0	23.5	38.4	1.8	86.2	-2.7	21.4
22	5.2	21.8	34.5	1.9	83.2	-2.4	21.3
LSD	0.5	0.4	0.5	0.2	0.3	0.5	0.8

LSD = least significant difference.  
Means in a column that differ by the LSD are different ( $P < 0.05$ ).

**Table 1—Descriptive attribute means for the mild Cheddar cheeses selected for consumer testing.**

Cheese	Trt 1	Trt 8	Trt 12	Trt 14	Trt 16	Trt 17	Trt 19	Trt 21	Trt 22	LSD
Cooked	3.3	3.0	3.0	3.4	2.8	3.4	2.5	3	2.9	0.4
Whey	2.3	3.1	3.4	3.7	2.8	3.6	1.8	ND	2.3	0.4
Diacetyl	ND	ND	ND	0.8	ND	ND	ND	ND	ND	0.3
Milkfat	3.1	2.9	3.0	3.4	3.0	3.3	2.7	3.2	3.0	0.3
Fruity	ND	ND	ND	ND	1.1	ND	ND	ND	ND	NA
Sulfur	ND	1.4	ND	ND	ND	ND	1.7	ND	1.4	0.2
Brothy	0.9	ND	ND	ND	2.1	ND	2.2	2.4	2.2	0.3
Nutty	ND	ND	ND	ND	1.6	ND	ND	ND	ND	NA
Mothball/grassy	ND	ND	ND	ND	ND	ND	1.9	ND	ND	NA
Sour	3.5	3.8	3.2	2.7	2.5	2.6	3.1	3.7	2.8	0.3
Bitter	ND	1.0	0.5	ND	ND	ND	ND	ND	ND	0.2
Salty	3.7	3.5	3.8	3.8	3.7	4.2	3.8	4.0	3.7	0.3
Sweet	1.8	1.5	1.7	1.7	2.3	1.6	2.3	2.2	2.0	0.3
Umami	1.8	1.5	1.2	1.6	2.0	1.6	2.1	2.1	1.8	0.5
Age <sup>a</sup>	55 d	60 d	45 d	30 d	70 d	30 d	90 d	105 d	120 d	NA
Color	Orange	Orange	White	Orange	White	Orange	Orange	White	White	NA

Intensities were scored using a 15-point universal Spectrum™ intensity scale where 15 = very high intensity of attribute and 0 = absence of attribute (Meilgaard and others 1999; Drake and Civille 2003). Most Cheddar cheese flavor intensities fall between 0 and 5 on this scale (Drake and others 2001, 2005, 2008). NA = not applicable; ND = not detected; LSD = least significant differences. Means in a row that differ by the LSD are different ( $P < 0.05$ ).

<sup>a</sup>Age at the time of commercial store packaging.

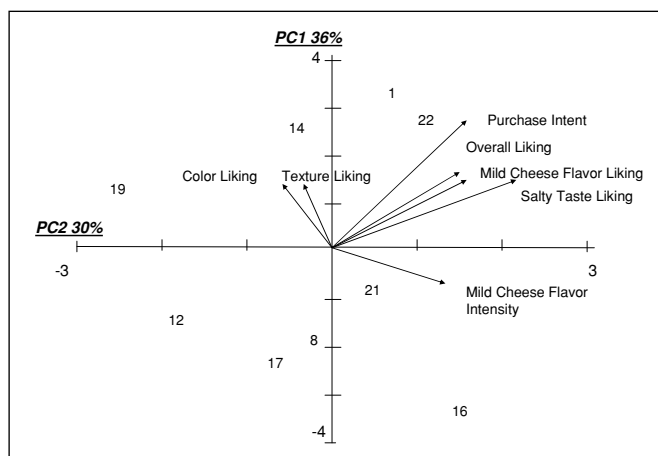
**Table 3—Demographic information and consumption characteristics of mild Cheddar cheese consumers (n = 215).**

	Percent of consumers (%)
Gender (male/female)	42/58
Age group	
19 to 24 y	19
25 to 30 y	21
31 to 35 y	11
36 to 45 y	19
46 to 55 y	19
> 55 y	12
Cheddar cheese consumption	
Never consume	0
< 1 mo	13
2 to 4 times a mo	33
More than once a week	47
Everyday	8
Types of Cheddar cheese consumed <sup>a</sup>	
Lowfat	26
Reduced fat	33
Mild Cheddar	100
Sharp Cheddar	83
Extra sharp Cheddar	50
NY style sharp cheddar	31
Non-U.S. based sharp Cheddar	15
Usage of mild Cheddar cheese <sup>a</sup>	
As a snack	51
On a salad	68
On a sandwich	73
Baking	88
Soups/sauces	69
Other	54
Factors influencing purchase <sup>a</sup>	
Price	69
Availability	80
Brand	50
Health	35
Flavor	63
Packaging	38
Other	8
Brands of Cheddar cheese purchased <sup>a</sup>	
Kraft	70
Sargento	72
Lighthouse	22
Tillamook	4
Cabot	21
Land O'Lakes	23
Store brands	53
Other	31
Mild Cheddar cheese products purchased <sup>a</sup>	
Already sliced in the package	73
Already sliced from the Deli	37
Shreds	57
Block, chunk, or wheel	62
Cubes	45
Sticks	27

<sup>a</sup>Consumers were allowed to choose more than 1 category so category percentages do not add up to 100.

sour and salty basic tastes. Furthermore, most of the cheeses were also characterized by whey flavor, but this attribute was absent in 2 cheeses (treatments 18 and 21). A few cheeses displayed diacetyl flavor (treatments 4, 5, 6, 7, and 9). All of these flavor attributes have been classified as “young/undeveloped” flavors (Drake and others 2001; 2005, 2008; Young and others 2004) due to their prevalence in Cheddar cheeses less than 6 mo old. Diacetyl flavor has been shown to decrease with ripening (Carunchia-Whetstine and others 2007; Rehman and others 2008).

Some of the mild cheeses were characterized by low intensities of brothy and sulfur flavors and bitter taste. In particular, treatments 8, 11, and 12 contained all of these attributes that have been associated with more aged cheeses. Drake and others (2001) classified these flavors as “aged/developed” flavors due to their prevalence in Cheddar cheeses aged over 1 y. Some flavors such as fruity and nutty were only present in 1 or 2 cheeses. Cheddar cheeses classified as “mild” are generally cut and packaged commercially between 60 and 120 d of ripening. Once packaged commercially, cheeses are stored at 3 to 5 °C and ripening or flavor development slows to an extremely low rate and very little flavor changes would be expected across storage time at this temperature (Singh and others 2003). Cheeses may take another 3 to 5 wk to reach the store and are packaged with a commercial shelf life of 9 to 12 mo. Flavor variability observed among commercial mild Cheddar cheeses is likely due to a combination of facts including age at commercial packaging and specific facility practices (Carunchia-Whetstine and others 2007; Drake and others 2008; Rehman and others 2008). There was variability in the sensory characteristics of commercially labeled mild Cheddar cheeses and the products chosen for consumer testing were representative of this variability (Table 1). Similarly, proximate analysis of the selected cheeses also revealed variability in pH, fat, moisture, and salt content (Table 2).



**Figure 3—Internal preference map of mild Cheddar cheese liking attributes from consumers. Numbers represent cheeses (Table 1).**

**Table 4—Consumer liking means for mild Cheddar cheeses.**

Treatments	Trt 1	Trt 8	Trt 12	Trt 14	Trt 16	Trt 17	Trt 19	Trt 21	Trt 22	Trt LSD
Overall liking	6.5	5.6	5.5	6.3	5.4	5.3	5.8	6.0	6.6	0.4
Color liking	6.7	6.6	6.2	6.7	5.9	5.8	6.7	6.0	6.4	0.3
Salty taste liking	6.3	5.7	5.6	6.0	5.8	5.7	5.7	5.7	6.2	0.3
Mild cheese flavor liking	6.5	5.6	5.3	6.3	5.4	5.3	5.8	5.9	6.5	0.4
Mild cheese flavor intensity	5.8	6.0	5.7	5.4	5.7	6.0	5.2	5.8	6.3	0.3
Texture liking	6.4	6.0	6.1	6.4	5.1	6.1	5.8	6.2	6.3	0.3
Purchase Intent	3.5	2.8	2.7	3.3	2.8	2.8	3.1	3.1	3.5	0.2

Attributes were scored on a 9-point hedonic scale where 1 = dislike extremely and 9 = like extremely. Purchase intent was scored on a 5-point scale where 1 = definitely would not purchase and 5 = definitely would purchase. LSD = least significant difference. Means in a row that differ by more than the LSD are different  $P < 0.05$ .

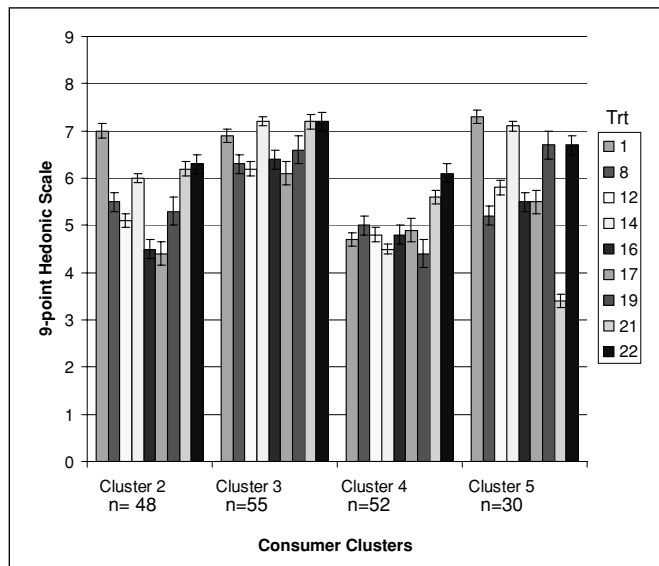
### Consumer acceptance

Mild Cheddar cheese consumers differed in gender, age, cheese consumption, types of cheeses consumed, usage of cheese, and factors influencing choice/purchase of Cheddar cheese (Table 3). Differences in liking and liking attributes were documented for the cheeses (Table 4, Figure 3). Internal preference mapping was conducted to visualize differences in consumer acceptance among the cheeses (Figure 3). Cheeses 1, 14, 21, and 22 scored the highest in overall liking and mild Cheddar cheese flavor liking. Two of these cheeses were orange and two were white suggesting that both orange and white mild Cheddar cheeses are appealing to consumers.

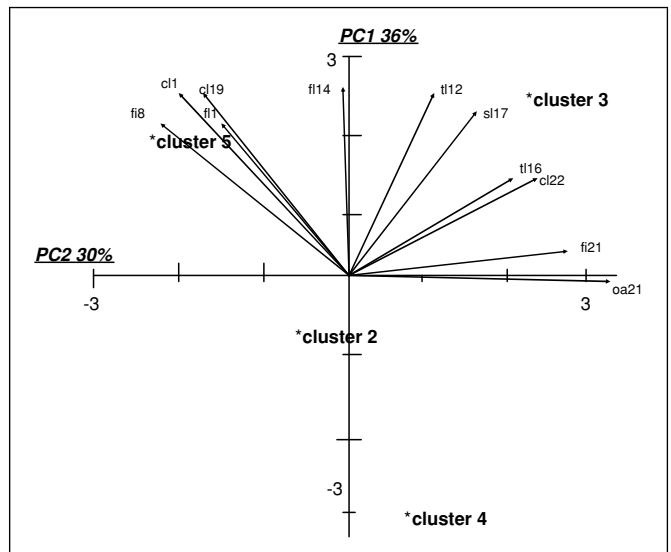
Several linear relationships among consumer results were determined (Table 5). Young and others (2004) also reported relationships between “overall acceptance,” “overall flavor liking,” and “overall texture liking,” and “overall Cheddar cheese intensity” among Cheddar cheese consumers. In the current study, there was not a correlation between “overall liking” and “overall texture liking” which suggests that texture was not a critical attribute for overall liking or that all cheeses presented met expectations for texture. Previous studies have also documented that while flavor was a driving force in overall liking, more so than texture, cheese

textures that were outside of consumer expectations negatively influenced overall liking and/or purchase intent (Carunchia Whets-tine and others 2006; Yates and Drake 2007). Treatments 16 and 17 were not well liked, scoring 5.3 and 5.4, respectively (Table 4). Treatment 16 was characterized by aged Cheddar flavors such as fruity, nutty, and brothy (Table 1). It could be that these aged flavors, especially fruity which is not frequently observed with Cheddar cheeses (Drake and others 2001, 2008), is not what most consumers expected in Cheddar cheeses labeled as mild. Cheese 17 was characterized by the absence of any aged flavors and exemplified flavors typically expected in very young Cheddar cheeses (cooked/milky, whey, and milkfat flavors with high salty taste). This bland profile may also fall outside the consumer expectation of mild Cheddar cheese.

Linear relationships were also investigated between consumer scores, descriptive flavor profiles, and proximate analysis. The only significant correlation found between trained panel profiles and consumer scores was between overall mild cheese flavor intensity and bitter taste ( $r = 0.75, P = 0.02$ ). The association of higher cheese flavor intensity with increased bitterness might explain why there was not a relationship between overall liking and mild cheese



**Figure 4**—Mean overall liking scores for each consumer cluster. Treatment numbers refer to cheeses. Cluster 1 ( $n = 7$ ) was discarded and is not shown. Error bars represent the standard error of each mean. Products were scored on a 9-point hedonic scale where 1 = dislike extremely and 9 = like extremely.



**Figure 5**—Discriminant biplot of consumer clusters across treatment liking attributes. Numbers by vectors refer to cheeses (Table 1). PC = principal component, ol = overall liking, cfl = mild Cheddar cheese flavor liking, cl = color liking, tl = texture liking, ci = mild Cheddar cheese flavor intensity, sl = salty taste liking. Numbers refer to cheeses. Cluster 1 ( $n = 7$ ) was discarded and is not shown.

**Table 5**—Correlations between consumer perceptions of cheese attributes.

	Overall liking	Color liking	Mild Cheddar cheese flavor liking	Mild Cheddar cheese flavor intensity	Salty taste liking	Texture liking	Purchase intent
Overall liking	1.00	0.56	<b>0.98</b>	-0.05	0.86	0.63	<b>0.98</b>
Color liking	0.56	1.00	0.59	-0.03	0.40	0.44	0.52
Mild Cheddar cheese liking	<b>0.98</b>	0.60	1.00	-0.07	<b>0.90</b>	0.58	<b>0.99</b>
Mild Cheddar cheese flavor intensity	-0.05	-0.03	-0.07	1.00	-0.07	0.03	-0.14
Salty taste liking	0.86	0.40	<b>0.90</b>	-0.07	1.00	0.36	<b>0.90</b>
Texture liking	0.64	0.44	0.59	0.03	0.36	1.00	0.60
Purchase intent	<b>0.98</b>	0.52	<b>0.99</b>	-0.14	<b>0.90</b>	0.60	1.00

Numbers in bold represent significant correlations ( $P < 0.0001$ ). Numbers underlined represent significant correlations ( $P < 0.05$ ).

flavor intensity. Young and others (2004) found cheeses that exhibited aged, mature cheese flavor by descriptive analysis were cheeses that had the highest consumer scores for overall aged cheese flavor intensity. These cheeses also had distinct bitter taste intensities by descriptive analysis. Caspia and others (2006) also reported that a 12-mo-old cheese with the lowest overall liking score had a distinct bitter taste by descriptive analysis. Bitter taste is not a desirable attribute in Cheddar cheese although it may be a sensory attribute associated by consumers with cheese age or cheese flavor intensity.

Hunter lab  $b^*$  values were correlated with color liking ( $r = 0.71$ ,  $P < 0.05$ ). Relationships were not documented between Hunter  $L^*$  or  $a^*$  values and color liking ( $P > 0.05$ ). The  $b^*$  value is an indicator of blue (–) and yellow (+). Higher  $b^*$  values indicate more intense yellow color. Cheeses 1, 8, 14, and 19 received the highest color liking scores and  $b^*$  values, and these were all orange-colored cheeses (Table 2). Although color liking did not influence overall liking of cheeses, these scores suggested that most consumers preferred mild Cheddar cheeses that were orange in color. Overall liking, flavor liking, and purchase intent were negatively correlated with cheese moisture content ( $r = -0.66$ ,  $P < 0.05$ ). A higher moisture content can influence Cheddar cheese texture (Carunchia-Whetstine and others 2007; Rehman and others 2008), but since texture liking was not correlated to overall liking, this did not suggest that this might be the reason. Similarly, a higher moisture content can influence specific cheese flavors but there were no specific trained panel attributes correlated with overall liking.

Five mild Cheddar cheese consumer clusters were identified. Close examination of cluster 1 revealed that this cluster contained only 7 consumers and results suggested that these were also nondiscriminators. This cluster was discarded from further analy-

sis. The remaining 4 clusters were large and diverse in liking profiles (Figure 4, Table 6). Cluster membership influenced consumer usage and perception for certain things. Fewer consumers in cluster 5 indicated that price was a key influence for cheese purchase compared to other clusters, and fewer consumers in clusters 2 and 5 consumed reduced fat cheeses on a regular basis compared to other clusters ( $P < 0.05$ ). Other relationships between demographic data and liking were not observed.

Liking profiles of each cluster were closely examined and compared with descriptive profiles to clarify cheese attributes that were appealing to specific clusters. In addition, discriminant analysis was applied to confirm clusters and to determine which consumer treatment liking attributes were critical in cluster differentiation (Figure 5). Cluster 2 consumers ( $n = 48$ ) liked cheeses with moderate whey flavor, sour taste, and preferred orange colored cheeses. Treatment 1 was the best-liked cheese (mean = 7.0), while treatments 16 and 17 were not liked (mean = 4.5). Both treatments 16 and 17 were perceived as having too little mild cheese flavor. The salty taste liking of cheese 17 was not liked. By descriptive analysis, cheese 17 was the highest in salty taste intensity and cheese 16 was the only treatment to have fruity and nutty flavor attributes (Table 1). These attributes may not equate to mild Cheddar cheese flavor to these consumers. Consumers ( $n = 55$ ) in cluster 3 liked all mild Cheddar cheeses (mean > 6.0), but also documented differences among the cheeses. Treatments 1, 14, 21, and 22 were best-liked (mean = 6.9 to 7.2). These consumers enjoyed the characteristic flavors of mild Cheddar cheese: cooked/milky, whey, and milkfat flavors. Low levels of brothy or sulfur flavors and sour taste were also liked. Discriminant analysis indicated that cluster 3 consumers were distinguished from other clusters by their high color liking score for cheese 22 (mean = 7.4). However, these consumers also assigned high color liking scores (scores > 7.0) to other

**Table 6 – Consumer attribute means within each consumer cluster.**

	Trt 1	Trt 8	Trt 12	Trt 14	Trt 16	Trt 17	Trt 19	Trt 21	Trt 22
Cluster 2 ( $n = 48$ )									
Overall liking	7.0aA	5.5aCD	5.1bD	5.9bBC	4.5cE	4.4bE	5.3bD	6.2bB	6.3bB
Color liking	6.8bA	6.5aA	5.5bC	6.5bA	5.0bD	4.8cD	6.4cB	5.0cD	5.4cC
Mild Cheddar cheese flavor	7.1aA	5.6aC	5.0bD	5.9bBC	4.5bE	4.4bE	5.2bD	6.0bB	6.0bB
Mild Cheddar cheese intensity	6.0aA	6.9bA	5.4bC	5.6aBC	5.2bCD	5.2bD	4.9bD	6.0aA	5.7bAB
Salty liking	6.2bA	5.1bD	5.0bD	5.5bBC	5.0cD	4.9cCD	5.2bCD	5.6bB	5.6bB
Texture liking	6.6aA	5.3bC	5.9bB	5.9bB	3.7cD	5.3cC	5.3bC	6.0bB	5.8bB
Cluster 3 ( $n = 55$ )									
Overall liking	6.9aAB	6.3aCDE	6.2aDE	7.2aA	6.4aCDE	6.1aE	6.6a	7.2aBC	7.2aA
Color liking	7.1bB	6.9aB	7.1aB	7.2aAB	7.0aB	6.8aB	7.1b	7.1aB	7.4aA
Mild Cheddar cheese flavor	6.9aB	6.0aD	5.9aD	7.3aA	6.4aC	5.9aD	6.6a	7.1aC	7.3aA
Mild Cheddar cheese intensity	6.4aBC	6.9bA	6.2aC	6.2aC	6.6aB	6.9aA	6.0a	6.6aC	6.9aA
Salty liking	6.9aA	6.3aB	6.3aB	6.9aA	6.7aAB	6.7aAB	6.5a	6.8aB	6.8aA
Texture liking	6.9aBC	6.9aBC	7.0aB	7.4aA	6.1aD	7.0aB	6.7a	7.3aC	7.0aB
Cluster 4 ( $n = 52$ )									
Overall liking	4.7bCD	5.0bC	4.8bC	4.5cD	4.8bcC	4.9bC	4.4cD	5.6bB	6.1bA
Color liking	5.0cD	5.4bC	6.0bA	5.3cC	5.6bB	5.6bB	5.6dB	5.9bA	6.0bA
Mild Cheddar cheese flavor	4.7bDE	5.1bC	4.6bE	4.6cE	4.9bCD	5.0bC	4.6cE	5.4bB	6.1bA
Mild Cheddar cheese intensity	4.2bD	6.2cA	5.1bC	3.8bE	5.3bC	5.3bC	4.1cD	5.2bC	5.8bB
Salty liking	4.8cC	4.9bC	5.1bBC	4.8cC	5.3b,cB	5.0cBC	4.8bC	5.2bB	5.7bA
Texture liking	5.0bD	5.4bC	5.0cD	4.8cD	5.0bD	5.4cC	4.6bBC	5.7bAB	5.9bA
Cluster 5 ( $n = 30$ )									
Overall liking	7.3aA	5.2bD	5.8aC	7.1aA	5.5abCD	5.5aCD	6.7aB	3.4cE	6.7aB
Color liking	7.7aA	7.2aB	6.0bC	7.7aA	5.5bD	5.6bD	7.7aA	5.2bcE	6.0bC
Mild Cheddar cheese flavor	7.4aA	5.3aE	5.2aE	7.1aAB	5.5abDE	5.8aD	7.0aB	3.9cF	6.5bC
Mild Cheddar cheese intensity	6.4aC	7.8aA	5.7abE	5.9aDE	5.4bF	6.3aC	6.0aD	4.5bG	6.7aB
Salty liking	6.9aA	5.7aD	5.1bE	6.8aA	6.0bC	5.8bCD	6.3aBC	4.2cF	6.5aB
Texture liking	7.0aA	5.7bC	6.1bB	7.2aA	5.0bD	6.2bB	6.4aB	4.5cE	6.2bB

Means within a column for each attribute and treatment followed by different lowercase letters are different ( $P < 0.05$ ). Cluster 1 ( $n = 7$ ) was discarded and is not shown.

Means within a row for each attribute followed by different capital letters are different ( $P < 0.05$ ).

Products were scored on a 9-point hedonic scale where 1 = dislike extremely and 9 = like extremely.

cheeses as well which suggested that color preferences did not define this cluster of consumers. Additionally, the salty taste intensity of cheese 17, which was not liked by other consumer clusters, was liked by cluster 3 consumers.

Consumers ( $n = 52$ ) in cluster 4 were more discerning of mild Cheddar flavor. Treatment 22 was the best-liked cheese with a mean overall liking score of 6.0 followed by cheese 21. Treatment 22 was distinguished by a mellow balanced flavor of moderate cooked and whey flavors with low intensities of sulfur and brothy. These consumers preferred white colored cheeses based on color liking scores. Consumers ( $n = 30$ ) in cluster 5 were similar to consumers in cluster 2 in that 3 of the top 4 cheeses were the same (cheeses 1, 14, and 22). Cheese 19 was also well liked by cluster 5, but was not preferred by cluster 2. Cheese 19 had a distinct mothball/grassy flavor and this flavor, as well as low intensities of sulfur and brothy flavors (cheeses 19 and 22), were not objectionable to cluster 5 consumers. Color liking scores of the top 4 cheeses from cluster 5 suggested that orange color was preferred over white (Table 6, Figure 4).

### Conclusions

Previous research has addressed cheese flavor and consumer preference for Cheddar cheeses of all ages (Murray and Delahunty 2000; Young and others 2004; Caspia and others 2006). One would expect to observe wide consumer preferences among different types and ages of Cheddar cheeses. The current study demonstrated that there was wide variability in the flavor of a single category of Cheddar cheese, mild Cheddar cheese, as well as variability in consumer preferences. Both flavor and color influenced preferences and specific consumer clusters were identified. Previously published studies have not evaluated the impact of color on consumer Cheddar cheese segments (Young and others 2004; Caspia and others 2006). Texture did not appear to influence overall liking scores (no correlation between overall liking and texture liking), but consumers did document differences in texture liking suggesting that there were expectations for mild Cheddar cheese texture. Future studies with mild

Cheddar should examine the role of price and packaging on liking and purchase.

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