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Effects of Processing Conditions on the Sensory Properties of Cheddar Cheese

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Abstract

The perceived intensities of Cheddar cheese flavor were investigated in terms of cheese processing conditions and types of panels participated. The mean intensities of sensory properties for Cheddar cheese were higher in untrained panels compared to those in trained panels. There are significant differences in Cheddar cheese flavor between six-month and eight-month ripening. Cheddar cheese ripening at 13℃ resulted in positive effects on sensory attributes compared to ripening at 8℃. The addition of lactobacilli as starter culture caused an increase of sharpness and a decrease of bitterness. Sharpness and bitterness were not related to other cheese sensory properties, and revealed a positive relationship each other. Cheese acidity was negatively related to rancidity and fruitiness.

Key words : Cheddar cheese, sensory property

Introduction

Cheddar cheese has been one of the most popular variety consumed in the world. Cheese ripening was known to be crucial for development of desirable Cheddar cheese flavor through the enzymatic activity to milk ingredients and metabolic pathways of milk ingredients in living microbes.

The flavor of a nine-month-old Cheddar cheese was preferred over that of a six-month-old Cheddar cheese in consumer preference test.[1] Recently, non-starter lactobacilli was adopted to develop a desirable Cheddar cheese flavor, whereas the streptococci nowadays decreased in frequency as starter culture of cheese manufacture.[2,3] Previous studies suggest that certain *Lactobabillus* are typically associated with either good or poor quality cheese.[4-6] Fedrick *et al.*[7] were able to produce the equivalent of a six-month old Cheddar cheese in 1.4 months without any major flavor defects using an elevated ripening temperature(15℃) along with the incorporation of both a neutral bacterial proteinase and whole cells of lac$^-$ prt$^-$ *Streptococcus cremoris* C2. Even though ripened at 8℃, the identical cheese was reported to develop a similar flavor intensity at just 2.6 months. Aston *et al.*[8] investigated the combination effects of elevated temperature(20℃ vs. 8℃) and addition of modified starter. They observed the most flavor enhancement in cheeses subjected to both treatments, although the differences between experimental and control cheeses were not nearly as substantial as for those made with neutral proteinase as well.

The objective of the present work was to determine the effects of processing conditions on sensory properties of Cheddar cheese, to compare the difference of perceived intensities among the untrained and trained panel, and to define the relationships among the sensory attributes of Cheddar cheese.

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Materials and Methods

Cheddar cheeses

Control cheeses A was manufactured with a mixture of *Lactococcus lactis subsp. cremoris* such as *Lactococcus cremoris* ML8, *Lactococcus cremoris* IT4 and *Lactococcus cremoris* SLM1, while experimental cheeses B was made by adding non-starter *Lactobacilus* sp. 7A(lac$^-$prt$^-$) found in commercial Cheddar cheese[4] with lactococci following standardized cheese making process. Both cheese varieties were made in three replications using same starter cultures, and ripened at 8, 13 and 18℃. The ripening time of cheeses A and B was six and eight months at 8, 13 and 18℃. The number of sample cheeses was thirty-six with combination of two cheese varieties, three replications, two ripening times, and three ripe-

ning temperatures.

Sensory analysis

Sensory evaluation of sample Cheddar cheeses were carried out by six well-trained panelists in the Department of Food Science and Nutrition, University of Missouri-Columbia who were thought to be semi-experts for grading daity products such as cheese, milk and yoghurt. The sensory properties investigated were sharpness, bitterness, acidity, rancidity and fruitiness related to Cheddar cheese flavor. All cheese samples were evaluated in two replications. A 9-point scale on a scoresheet was used where 1=none and 9=high. All 1.5 pound cheese blocks were cut one hour prior to serving. One centimeter was cut from all sides of the cheese block to prevent the interference of the vacuum bags. The specification of cheese sample served was 1 cm^3 cube for sensory evaluation. The cheese samples were set out one-half hour prior to serving to reach room temperature(22℃). White light was used, because color was not implicated and did not influence cheese flavor.

Sensory evaluation of Cheddar cheese samples A and B was also conducted by fifteen untrained panelists who were changed frequently. The panelists were asked to evaluate only the perceived intensities of sharpness and bitterness in cheese samples because they were not familiar with other sensory properties of Cheddar cheese. Two sets of samples evaluated were presented in different serving orders. One set was served for sharpness evaluation and the other for bitterness evaluation. The serving order of two sets was dependent upon preference by panelist for evaluating sharpness or bitterness first. A 9-point scale on the scoresheet was utilized to represent the intensity of the specific sensory property where the scaling was 1=none and 9=high.

Statistical analysis

The sensory data obtained from the experiments were subjected to appropriate statistical analyses using the SAS package.[9] The statistical packages used were PROC ANOVA, PROC FACTOR in SAS programs.

Results and Discussion

Five descriptive terms were used to evaluate analytically the sensory properties of Cheddar cheese. They were sharpness, bitterness, acidity, rancidity and fruitiness. For untrained panel testing, cheese samples were investigated on the basis of two terms "sharp" and "bitter". Table 1 is a tabulation of resu-

Table 1. Comparison of analysis of variance and mean intensity[a] for sensory properties of cheese samples A and B by untrained sensory and analytical sensory tests

Source of variation	Sharpness		Bitterness	
	Untrained	Analytical	Untrained	Analytical
Time	***		*	
6-month	5.26[b]	5.06[a]	4.66[b]	4.02[a]
8-month	5.85[a]	5.08[a]	5.04[a]	4.13[a]
LSD	0.271		0.318	
Replication	*			***
1	5.26[b]	4.98[a]	4.69[a]	4.74[a]
2	5.66[a]	5.11[a]	4.82[a]	4.01[b]
3	5.74[a]	5.12[a]	5.04[a]	3.47[c]
LSD	0.332			0.447
Temperature	***	***	***	**
8℃	4.73[b]	4.56[b]	4.30[b]	3.70[b]
13℃	5.81[a]	5.32[a]	5.04[a]	4.53[a]
18℃	6.13[a]	5.34[a]	5.21[a]	4.00[b]
LSD	0.332	0.365	0.389	0.447
Cheese	*			**
A	5.40[b]	5.01[a]	4.90[a]	4.35[a]
B	5.71[b]	5.13[a]	4.80[a]	3.80[b]
LSD	0.271			0.365

[a]Numbers sharing the same letters in columns within variables are not signifiantly different at the $p<0.05$ level
*, **, ***: Significant at $p<0.05$, $p<0.01$, and $p<0.001$, respectively

Table 2. Analysis of variance and mean intensity[a] for sensory properties of cheese samples A and B by analytical sensory tests

Source of variation	Sensory property				
	Sharpness	Bitterness	Acidity	Rancidity	Fruitiness
Time			**	***	***
6-month	5.06[a]	4.02[a]	5.02[a]	1.40[b]	1.49[b]
6-month	5.08[a]	4.13[a]	4.45[b]	2.46[a]	1.97[a]
LSD					
Repliation		***		*	***
1	4.98[a]	4.74[a]	4.56[a]	1.88[ab]	1.65[a]
2	5.11[a]	4.01[b]	4.82[a]	2.17[a]	2.12[a]
3	5.12[a]	3.47[c]	4.83[a]	1.75[b]	1.42[b]
LSD		0.447		0.328	0.311
Temperature	***	**	*	***	***
8℃	4.56[b]	3.70[b]	5.05[a]	1.39[b]	1.40[c]
13℃	5.32[a]	4.53[a]	4.59[b]	2.16[a]	1.73[b]
18℃	5.34[a]	4.00[b]	4.58[b]	2.24[a]	2.04[a]
LSD	0.365	0.447	0.425	0.328	0.311
Cheese		**			
A	5.01[a]	4.35[a]	4.79[a]	1.87[a]	1.67[a]
B	5.13[a]	3.80[b]	4.69[a]	2.01[a]	1.79[a]
LSD		0.365			

[a] Numbers sharing the same letters in columns within variables are not significantly different at the $p<0.05$ level
*, **, ***: Significantly different at $p<0.05$, $p<0.01$, and $p<0.001$, respectively

lts of analysis of variance(ANOVA) and mean intensities of sharpness and bitterness for cheese samples A and B as evaluated by the untrained and analytical sensory panels. The mean scores for "sharp" and "bitter" were all higher in the untrained panel test than those in the analytical test for all categories compared. The general trends of mean intensities within a specific variable exhibited similar patterns among untrained panel and analytical sensory tests. The only exception came from repliation variable on bitterness. Replication variable was related to different processing time of Cheddar cheese samples using the same starter cultures. Consumer panelists failed to find significant differences in bitterness among replicates, but trained panelists found the same samples to vary significantly among replications. Reipening time, repening temperature and cheese sample appeared to have significant effects on sharpness by consumer panels, whereas cheese bitterness, as determined by analytical panels, was affected with repening temperature and cheese sample. The important thing was that regardless of type of panel, untrained or analytical, the perceived intensities for sharpness and bitterness had similar trends relative to experimental variables. As the sensory responses of untrained and analytical panelists for Cheddar cheese samples are relatively different, the effects of experimental variables may be significant for cheese sensory properties according to the type of panelists used. The perceived intensities of sensory properties for Cheddar cheese can be concluded to be higher in untrained panelists than in trained panelists.

Sharpness was related to ripeness of cheese. As the ripening time increased from six to eight months, mean intensities of sharpness increased from 5.26 to 5.85 in the untrained panel test and from 5.06 to 5.08 in the analytical sensory tests. For replication study, the trained panels responded with similar intensities to sharpness of cheeses among replicated samples as expected because of application of the same starter cultures. However, the results of untrained panel tests suggest significant differences($p<0.05$) between replication 1 and the others.

The effect of temperature was highly significant ($p<0.001$) in sharpness of cheeses. Mean intensities of sharpness in cheese ripened at 13℃ and at 18℃ were increased relative to that of cheese ripened at 8℃. However, there was no statistical difference between cheeses at 13℃ and those at 18℃. Therefore, cheese ripening at 18℃ should be considered carefully with respect to more energy saving. There were some differences among control cheese A and treatment cheese B. Cheese B had higher mean intensi-

Table 3. Correlation and probability levels of sensory properties for cheese samples A and B[a]

	Untrained panel		Trained panel				
	Sharp	Bitter	Sharp	Bitter	Acid	Rancid	Fruit
Untrained Panel							
Sharpness	1.000	0.664	0.574	0.188	−0.221	0.547	0.395
		<.001	<.001	0.272	0.195	<.001	0.017
Biitterness		1.000	0.479	0.138	−0.018	0.342	0.262
			0.003	0.422	0.918	0.041	0.123
Trained Panel							
Sharpness			1.000	0.434	0.120	0.029	−0.175
				0.008	0.485	0.867	0.307
Bitterness				1.000	−0.224	0.146	−0.144
					0.189	0.395	0.401
Acidity					1.000	−0.611	−0.380
						<.001	0.022
Rancidity						1.000	0.539
							<.001
Fruitiness							1.000

[a]Top value is the correlation coefficient and bottom value is the probability level. N=36

ties of sharpness than cheese A. As *Lactobacillus* sp. 7A was inoculated in treatment cheese B with several *Lactococcus* sp. as basic starter cultures, these organisms appear to be important for cheese sharpness.

The mean intensity of cheese bitterness decreased for cheese B compared to that in cheese A. Results from trained panel were significantly different ($p<0.01$) for cheese bitterness among both cheeses. Eight-month ripened cheese had a much more bitter taste compared to six-month aged cheeses in untrained panel test. Ripening temperature appeared to be statistically significant relative to cheese bitterness. As the aging temperature increased, the mean intensity of cheese bitterness increased concurrently. There were large difference on bitter taste of cheeses ripened at 8℃ compared to that at 13℃ or 18℃, but there were no significant difference in bitterness of cheeses ripened at 13℃ and 18℃.

There are positive relationships between sharpness and bitterness relative to ripening time and temperature, and negative relationships between sharpness and bitterness relative to cheese samples.

Table 2 is a summary of the results of ANOVA and mean intensities of sharpness, bitterness, acidity, rancidity and fruitiness of Cheddar cheese samples A and B. There were significant differences ($p<0.05$) in mean intensities of acidity, rancidity and fruitiness due to aging time and temperature. Cheese acidity decreased with increase in ripening time, whereas rancidity and fruitiness increased significantly ($p<0.001$) during aging. Mean scores for acidity, rancidity and fruitiness were changed significantly as the ripening temperature increased from 8℃ to 13℃.

Cheese B had a low mean score for acidity compared to cheese A while the mean scores for rancidity and fruitiness increased, but not significantly.

There were negative relationships between acidity compared to rancidity and fruitiness, and a positive relationship between rancidity and fruitiness.

The relationships between descriptive terms were analyzed using Pearson correlation coefficients (Table 3) and by two dimensional plots of descriptor terms by the FACTOR procedure(Fig. 1).[9] Regardless of untrained and analytical sensory tests, there were positive relationships between sharpness and bitterness. As reported in Table 1 it is obvious that acidity is negatively related to rancidity and fruitiness of cheese samples analyzed. In addition, cheese rancidity had a positive correlation with cheese fruitiness(0.539).

Data from the plot of the rotated factor patterns of sensory properties using analytical sensory results [9] indicate that the first two principal components accounted for 71.4% of total variation of sensory properties. On the plot of the first two principal components, sharpness and bitterness of cheese were placed simultaneously in positive direction of principal component 2(PC 2) that accounted for 30.3% of the total variance of sensory properties.

Contrary to this, principal component 1(PC 1) accounted for the relationships among acidity, rancidity and fruitiness of Cheddar cheese. Cheese acidity was

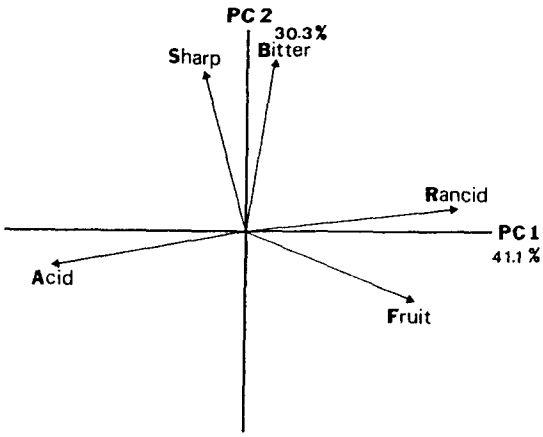

Fig. 1. Interrelationships of sensory properties in Cheddar cheese samples

in the negative position of PC 1 while cheese rancidity and fruitiness were in the positive direction of PC 1 which accounts for 41.4% of total variation.

The following relationship were found concerning the sensory properties of Cheddar cheese samples: 1) sharpness and bitterness were not related to other cheese sensory properties; 2) there was a positive relationship among sharpness and bitterness; 3) cheese acidity was related negatively to rancidity and fruitiness; and 4) when cheese rancidity increased the fruitiness of cheese also increased.

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체다치즈의 제조조건이 관능특성에 미치는 영향

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체다치즈 풍미의 인지 강도를 치즈 제조공정 조건과 관능검사요원 형태별로 조사하였다. 훈련 되지 않은 관능검사원의 치즈관능치가 훈련받은 관능검사원들에 비해 높은 수치를 나타내었으며, 6개월과 8개월 숙성한 치즈의 관능치는 서로 상이하였다. 13℃에서의 치즈숙성이 8℃에서의 숙성보다 더 효과적이었으며, starter culture로서 lactobacilli를 첨가해 주는 것이 체다치즈의 숙성취를 증가시키고, 쓴맛을 감소시켜 주었다. 치즈의 숙성취와 쓴맛은 높은 상관관계를 나타냈으며, 치즈의 산도는 산패취와 과일향에 대해 부의 상관관계를 보여주었다.