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L.L. Francis

S.H. Kong

Delores H. Chambers

See next page for additional authors

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Abstract

Many people seem to prefer to drink milk when it is cold. Research describing flavor and aftertaste of milk, and then correlating these traits with their chemical composition, has not previously been done. The objectives of this study were to describe milk flavor and aftertaste by using a descriptive sensory panel and to quantify the headspace volatiles of nonfat and whole milk as a function of serving temperature. Headspace volatile compounds of milk samples served at 40°F and 60°F were quantified by using solid-phase microextraction (SPME) analysis, with a 75-Î¼m Carboxen- PDMS fiber, sampling milk at 140oF for 30 minutes, and then analyzing by gas chromatography, flame ion detection (GCFID) for quantification. Descriptive-panel results indicated that serving temperature did not affect the milk flavor. Nonfat milk flavor and texture were rated to have greater sour aromatics, and to be slightly chalky, flat, and bitter, but less sweet, than whole milk. Characterization of milk aftertaste at 15 seconds after swallowing indicated that nonfat milk had very slight sour and cooked attributes. Characterization of milk aftertaste at 90 seconds after swallowing indicated that nonfat milk had very slight cooked attributes and was less sweet than whole milk. Serving temperature did not affect concentrations of volatile compounds, but nonfat milk had a greater concentration of hexanal and lesser ($P < 0.05$) concentrations of benzaldehyde, ethyl caproate, heptanal, 2-heptanone, and nonanal than whole milk did. These data provide evidence that fat contributes to the "flavor"? and aftertaste attributes of milk more than serving temperature does.; Dairy Day, 2004, Kansas State University, Manhattan, KS, 2004;

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Authors

L.L. Francis, S.H. Kong, Delores H. Chambers, and I.J. Jeon

SERVING TEMPERATURE EFFECTS ON MILK FLAVOR, MILK AFTERTASTE, AND VOLATILE-COMPOUND QUANTIFICATION IN NONFAT AND WHOLE MILK

L. L. Francis, S. H. Kong, D. H. Chambers,
I. J. Jeon, S. R. Simmons, and K. A. Schmidt

Summary

Many people seem to prefer to drink milk when it is cold. Research describing flavor and aftertaste of milk, and then correlating these traits with their chemical composition, has not previously been done. The objectives of this study were to describe milk flavor and aftertaste by using a descriptive sensory panel and to quantify the headspace volatiles of nonfat and whole milk as a function of serving temperature. Headspace volatile compounds of milk samples served at 40°F and 60°F were quantified by using solid-phase microextraction (SPME) analysis, with a 75-µm Carboxen-PDMS fiber, sampling milk at 140°F for 30 minutes, and then analyzing by gas chromatography, flame ion detection (GC-FID) for quantification. Descriptive-panel results indicated that serving temperature did not affect the milk flavor. Nonfat milk flavor and texture were rated to have greater sour aromatics, and to be slightly chalky, flat, and bitter, but less sweet, than whole milk. Characterization of milk aftertaste at 15 seconds after swallowing indicated that nonfat milk had very slight sour and cooked attributes. Characterization of milk aftertaste at 90 seconds after swallowing indicated that nonfat milk had very slight cooked attributes and was less sweet than whole milk. Serving temperature did not affect concentrations of volatile compounds, but nonfat milk had a greater concentration of hexanal and lesser ($P < 0.05$) concentrations of benzaldehyde, ethyl caproate, heptanal, 2-heptanone, and nonanal than whole milk did. These data provide evidence that fat contributes to the "flavor" and aftertaste attributes of milk more than serving temperature does.

(Key Words: Milk Aftertaste, Milk Flavor, GC Analysis.)

Introduction

Milk is an excellent nutrient source for humans. But milk components are also excellent substrates for certain microorganisms and are susceptible to undesirable chemical reactions that cause the quality of fresh milk to deteriorate and cause off flavors. The taste of high-quality milk should be clean and sweet, with no odor or aftertaste. The mouthfeel of milk should be smooth and have a sensation of richness. Milk fat contributes to milk mouthfeel and flavor as a consequence of naturally present flavor compounds and by its ability to change flavor "onset and diminishment" intensities and rates. Research has shown that alcohols, carbonyl compounds, free fatty acids, and sulfur compounds all contribute to the flavor of fresh milk. Volatile compounds previously reported in raw milk include 2-butanone, ethyl caproate, heptanal, 2-heptanone, hexanal, nonanal, octanal, and pentanal.

Flavor and nutrition are the main reasons people consume milk. People who do not drink milk think that milk does not taste good, is too sour or not sweet enough, or has an unpleasant aftertaste. Sensory and chemical analyses have been conducted on milk flavor as it undergoes microbial or chemical-induced changes, but very little research has focused on aftertaste. It has been determined that "dairy sour," "sour," "fatty mouth coating," "lingering dry mouth coating," and the time for flavors and textures to clear the mouth are attributes associated with aftertaste. One study found that high-fat milk samples had greater intensities of "fatty mouth coating," "sour," and increased time for flavor and texture to clear the mouth. These descriptors were not correlated with the chemical composition of the milk. The objectives of this study were to: 1) describe the aftertaste of nonfat and whole milk; 2) analyze chemical compositions and physical properties of nonfat and whole milks; and 3) correlate the results of descriptive analyses with those obtained from gas chromatography headspace analyses.

Experimental Procedures

Nonfat and whole milk (1.965 L) were obtained within 2 days of production from the Kansas State University dairy plant, Manhattan, Kansas, during November 2003, and were maintained in the dark at $\leq 40^{o}$F.

Five highly trained and experienced panelists from the Sensory Analysis Center at Kansas State University, Manhattan, Kansas, participated in the study. Panelists had completed 2000 hr of general sensory testing and 120 hr of training in sensory techniques and analysis. Panelists scored intensities (on a 15-point numerical scale divided into half-point increments, with 0 representing "none" and 15 representing "extremely strong") of milk texture, milk flavor, and milk aftertaste at 15 and 90 seconds after swallowing. A lexicon was developed to identify and score 3 texture, 23 flavor, and 11 aftertaste attributes of milk.

Milk samples were tempered to 40 and 60^{o}F and served to a descriptive sensory panel. Analytical testing for headspace, total solids content, fat content, total plate counts, and apparent viscosity started within 30 minutes of serving the milk samples to the panel. For headspace analysis, the milk samples were analyzed by solid phase microextraction-gas chromatography (SPME-GC) for volatile compound identification. For total solids, an atmospheric oven method was used. Fat content was measured by the Babcock method, and total aerobic counts were done by using petrifilm. Apparent viscosity was determined at a frequency of 2 Hz within a shear-rate range of 1 to 40 seconds^{-1}, with a rheometer set at 40 and 60^{o}F, and compared at 10 seconds^{-1}.

The experimental structure was a two-way factorial design with the main effects of milk type (nonfat vs. whole) and serving temperature (40 vs. 60^{o}F), with milk type by temperature as the interaction. Three replications were done. Differences among means were determined by Tukey's pair-wise comparison.

Results and Discussion

Seven major volatile compounds were present in both nonfat and whole milk: benzaldehyde, ethyl caproate, heptanal, 2-heptanone, hexanal, nonanal, and pentanal (Table 1). Whole milk had greater ($P<0.05$) concentrations of benzaldehyde, ethyl caproate, heptanal, 2-heptanone, and nonanal, and had smaller concentrations of hexanal than nonfat milk did. The pentanal concentration did not differ for the two milk types. Headspace concentrations were unaffected by serving temperature, probably because the extraction method used a heat treatment (140^{o}F for 30 minutes) to force the volatile compounds into the headspace. All concentrations of volatile compounds were greater than reported threshold values, with the exception of heptanal in nonfat milk and pentanal in whole milk (Table 1). Greater mean concentrations for heptanal, 2-heptanone, hexanal, nonanal, and pentanal were observed in our study than in previous reports.

Whole milk had greater fat and total solids contents than nonfat milk did, but had similar total plate counts (Table 2). Serving temperature did not affect the chemical contents or microbial counts.

Serving temperature and milk fat affected the apparent viscosity of the milk types. Milk served at 40^{o}F was more viscous (3.55 mPa·s) than milk served at 60^{o}F (2.18 mPa·s). Nonfat milk was less viscous (2.76 mPa·s) than whole milk was (2.98 mPa·s).

Results from the descriptive panel indicated that no differences were detected for the sensory attributes of milk served at either 40 or 60^{o}F, but some texture, flavor, and after-taste attributes were affected by milk-fat content (Figures 1 and 2). Nonfat milk texture was rated as being more chalky, less viscous, and having less "fatfeel" than whole milk. Nonfat milk was described as having less "fat," "sweet," and "sweet aromatics," but more "flat" and "sour aromatics" than whole milk. Differences in after-taste descriptors (at 15 and 90 seconds after swallowing) and their reported intensities are shown in Figure 2. At 15 seconds after swallowing, nonfat milk aftertaste was described as being less overall sweet, fat, and having a less fatty mouthfilm, but having more overall sour and cooked traits, than whole milk did. At 90 seconds after swallowing, nonfat milk aftertaste was described as being less overall sweet, fat, and having less fatty mouthfilm, but having more cooked traits than were present with whole milk. When after-taste attributes and intensities of whole and nonfat milks at 15 and 90 seconds after swallowing were compared, intensities decreased for all attributes. Our study confirms previous research in which high-fat milk samples rated higher for fatty mouthfilm aftertaste, and the nonfat milk aftertaste was rated as being more overall sour. Previous research also indicated that high-fat milk samples had greater intensities of sour taste. In contrast, the nonfat milk in our study was rated as more sour than whole milk. Others have reported that heptanal, 2-heptanone, and nonanal are compounds formed by milk fat and are often described as blue cheese, oily, and fatty flavors in milk samples. These three compounds were observed to have greater concentrations in the whole-milk sample, and the whole-milk sample was described as having a greater fat flavor and greater fat feel than the nonfat milk sample. Perhaps the best milk flavor is related to a favorable quantity of volatile flavor compounds at an optimal ratio.

Our study provides evidence that fat contributes to the flavor and aftertaste attributes of milk. Milk composition, especially fat content, affected milk aftertaste, whereas serving temperature had no effect. Whole milk had greater concentrations of benzaldehyde, ethyl caporate, heptanal, 2-heptanone, and nonanal, but had lesser concentrations of hexanal than nonfat milk did. Further work is needed to describe flavor and aftertaste differences on the basis of known off flavors present in milk.

Table 1. Mean Headspace Concentrations (mg/kg) of Volatile Flavor Compounds in Whole and Nonfat Milk

Volatile compound	Threshold value in milk (mg/kg)	Nonfat milk n = 3	Whole milk n = 3
Benzaldehyde[1]	0.0004	0.8741 ± 0.007[b]	1.0750 ± 0.007[a]
Ethyl caproate	0.075	0.3957 ± 0.002 [b]	0.6450 ± 0.001[a]
Heptanal	0.12	0.0959 ± 0.002[b]	0.9868 ± 0.002[a]
2-Heptanone	0.70	0.9076 ± 0.002[b]	1.0117 ± 0.002[a]
Hexanal	0.05	0.6433 ± 0.002[a]	0.5927 ± 0.002[b]
Nonanal	0.22	0.9444 ± 0.03[b]	1.1419 ± 0.03[a]
Pentanal	0.13	0.2151 ± 0.09[a]	0.0730 ± 0.08[a]

[a,b]Means within row having different superscript letters differ (*P*<0.05).
[1]Value in water.

Table 2. Mean Values of Fat Total Solids, and Total Plate Counts in Nonfat and Whole Milks

Item	Nonfat milk, n = 3	Whole milk, n = 3
Fat, %	0.07 ± 0.04[b]	3.40 ± 0.04[a]
Total solids, %	9.97 ± 0.06[b]	12.20 ± 0.06[a]
TPC (log CFU/mL)	2.52 ± 2.27[a]	1.28 ± 2.27[a]

[a,b]Means within row having different superscript letters differ (*P*<0.05).

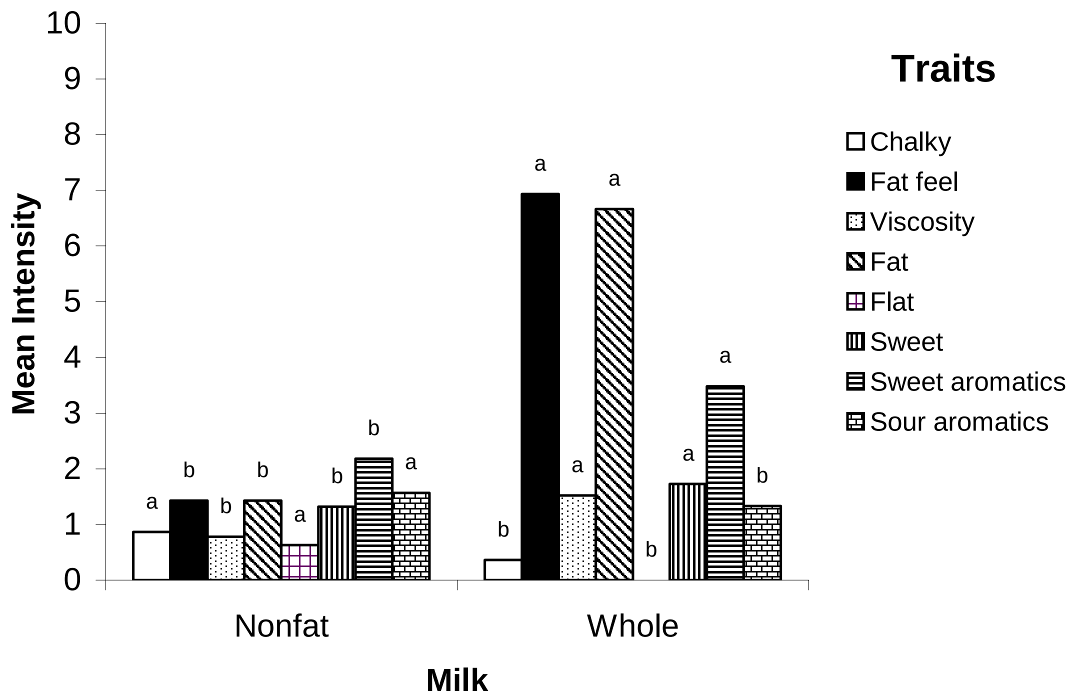

Figure 1. Mean Intensities of the Texture and Flavor Traits of Nonfat and Whole Milks.
[a,b]Bars within milk type having different superscript letters differ (P<0.05).

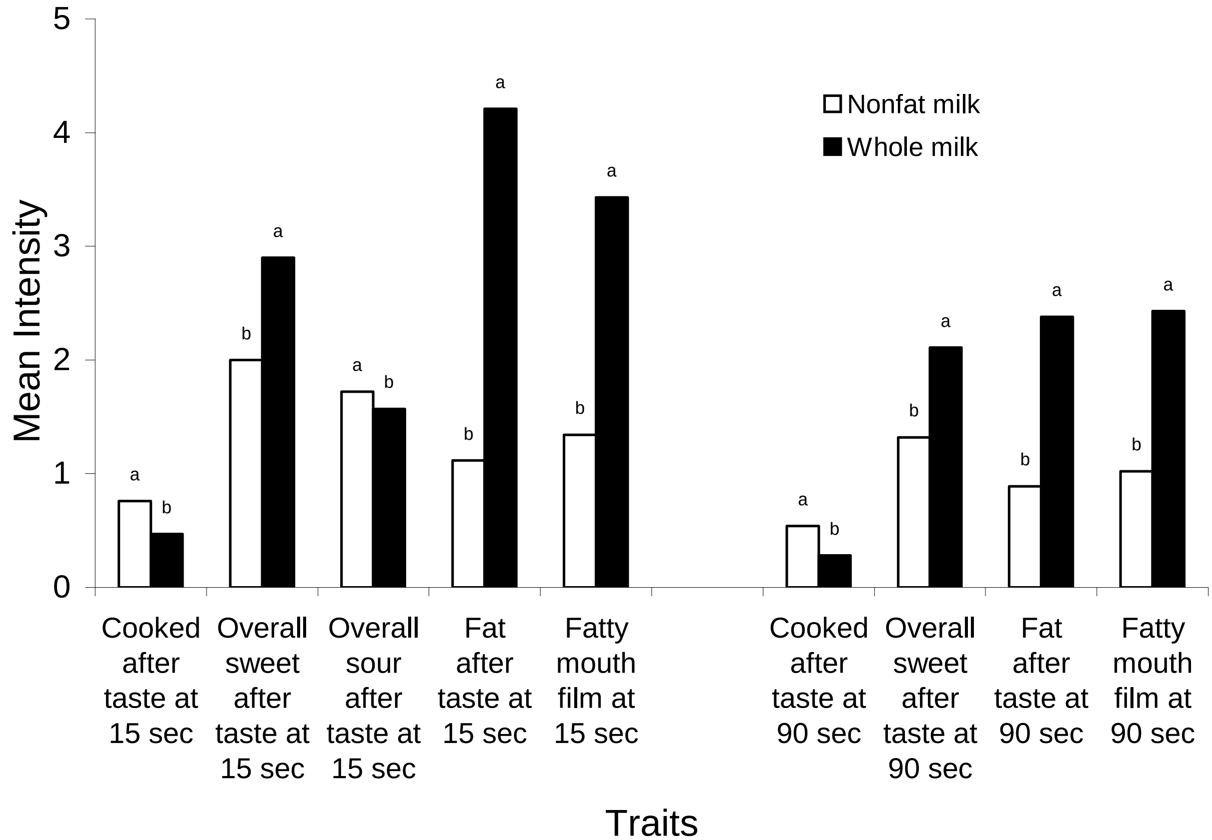

Figure 2. Mean Intensities of the Aftertaste (15 and 90 seconds After Swallowing) Traits of Nonfat and Whole Milks. [a,b]Bars between milk types having different superscript letters differ (P<0.05).