

Characterization of Nutty Flavor in Cheddar Cheese

Y. K. Avsar,¹ Y. Karagul-Yuceer,² M. A. Drake,³
T. K. Singh,⁴ Y. Yoon,³ and K. R. Cadwallader⁴

¹Department of Dairy Technology, Mustafa Kemal University, Antakya, Turkey

²Department of Food Engineering, Onsekiz Mart University, Canakkale, Turkey

³Department of Food Science, Southeast Dairy Foods Research Center, North Carolina State University, Raleigh

⁴Department of Food Science and Human Nutrition, University of Illinois, Urbana

ABSTRACT

The objectives of this study were to determine the volatile components responsible for the sensory perception of nutty flavor in Cheddar cheese. Cheddar cheeses with and without nutty flavors were selected by descriptive sensory analysis. Volatile aroma components from Cheddar cheeses with and without nutty flavors were isolated and characterized using solvent extraction with high vacuum distillation, dynamic headspace analysis, gas chromatography-olfactometry, and gas chromatography-mass spectrometry. More than 50 aroma-active compounds were detected in Cheddar cheeses. Consistent differences were observed between nutty and not nutty Cheddar cheeses. Strecker aldehydes were detected in higher amounts in Cheddar cheeses with nutty flavors compared with Cheddar cheeses without nutty flavors. Strecker aldehydes, dimethyl sulfide, and propionic acid were evaluated in young and aged Cheddar cheese models for nutty flavor by descriptive sensory analysis. Dimethyl sulfide and propionic acid did not contribute to nutty flavor in Cheddar cheese. The addition of Strecker aldehydes to young (<4 mo old) Cheddar cheese models resulted in nutty/malty flavor perceived by sensory analysis. When Strecker aldehydes were incorporated into aged (>9 mo old) Cheddar cheese models, nutty flavor perception increased. Strecker aldehydes contribute to nutty flavor in aged Cheddar cheese.

(Key words: Cheddar cheese, cheese flavor, nutty flavor, Strecker aldehyde)

Abbreviation key: DHS-GC-MS = dynamic headspace analysis-gas chromatography-mass spectrometry, DSE = direct solvent extraction, FID = flame ionization detector, GC-MS = gas chromatography-mass spectrometry, GCO = gas chromatography-olfactometry,

GCO-DHS = gas chromatography-olfactometry dynamic headspace analysis, HVD = high vacuum distillation, N = nutty, NN = not nutty.

INTRODUCTION

Cheese flavor is one of the most important criteria determining consumer choice and acceptance. Cheddar cheese flavor varies widely with source, age, and fat content. However, aged Cheddar cheese flavor is characterized by sulfur, brothy, and nutty flavors (Urbach, 1997; Drake et al., 2001). The role of sulfur compounds in Cheddar cheese flavor (Milo and Reineccius, 1997) and their formation from sulfur containing amino acids by bacterial activity (Urbach, 1995; Weimer et al., 1999) or Strecker degradation (Griffith and Hammond, 1989) have been investigated extensively and reviewed (Weimer et al., 1999). Unlike sulfur flavor, knowledge on the nutty flavor of Cheddar cheese is scarce. First of all, defining the sensory term “nutty” appeared to be a difficult task, as the aroma quality in all nuts are not exactly the same (Clark and Nursten, 1977). Drake et al. (2001) developed a defined sensory language for Cheddar cheese flavor. Nutty flavor was defined as the “(nonspecific) nut-like aromatic associated with different nuts.” Lightly toasted unsalted nuts, unsalted wheat thins, or roasted peanut oil extract were used as references for nutty flavor. It is not clear whether nutty flavor is a product of a single compound or a combined effect of several compounds. Also, nutty character and the volatile source of nutty flavor may vary with different types of cheese (Clark and Nursten, 1977).

The majority of studies on nutty flavor in cheese have been carried out on Swiss type cheese due to its distinct sweet and nutty notes. A range of compounds, such as ketones, lactones, esters, alcohols, aldehydes, pyrazines, sulfurous compounds, carbonyl compounds, free fatty acids, free amino acids, and salts have been reported to contribute to nutty flavor (Biede and Hammond, 1979a, 1979b; Liardon et al., 1982; Vangtal and Hammon, 1986; Warmke et al., 1996; Preininger et al., 1996; Rychlik and Bosset, 2001a). Specifically, acetic and propionic acids, the major products of propionic

Received October 29, 2003.

Accepted December 12, 2003.

Corresponding author: M. A. Drake; e-mail: mdrake@unity.ncsu.edu.

acid bacteria, were claimed to play an important role in nutty flavors of this particular cheese type. It is important to note that descriptive sensory analysis using a defined sensory language was not conducted in these studies nor were model studies conducted to confirm or pinpoint the exact cause of nutty flavors.

Numerous studies have likewise been conducted to reveal the overall chemical profile of Cheddar cheese flavor and identify the most potent compounds (Milo and Reineccius, 1997; Suriyaphan et al., 2001; O'Riordan and Delahunty, 2001; Zehentbauer and Reineccius, 2002). The presence of pyrazines in Cheddar cheese has been reported in a few studies (Suriyaphan et al., 2001). In addition, 2-acetylthiazoline (Milo and Reineccius, 1997), 2-acetyl-1-pyrroline, and 2-acetyl-2-thiazoline (Zehentbauer and Reineccius, 2002) were identified as compounds in Cheddar cheese that exhibited nutty aromas. However, no sensory analysis revealing the relationship between those compounds and the nutty flavor of Cheddar cheese were reported. In their research, Fernandez-Espla and Fox (1998) produced Cheddar cheese with nutty flavor using propionic acid bacteria as an adjunct culture. The researchers stated that this flavor was associated with increased levels of free amino acids and that the cheese flavor resembled that of Swiss cheese. Descriptive sensory analyses were not conducted.

Identifying specific chemical compounds associated with particular flavors requires extensive and specific instrumental and sensory analysis. First, the sensory perceived flavor of a food should be identified by descriptive sensory analysis. Descriptive sensory analysis qualitatively and quantitatively identifies all of the sensory-perceived flavor and tastes present in the food and provides definitions and references for the perceived flavors and tastes (Drake and Civille, 2003). Instrumental analysis can then be conducted to identify volatile compounds that contribute to flavor. The presence of a particular compound, identified by gas chromatography-mass spectrometry, does not necessarily mean the compound plays a role in flavor because many volatile compounds can be present in a food, but concentrations may be below actual sensory thresholds (McGorin, 2002). Gas chromatography-olfactometry (GCO) can assist in identification of compounds that are actually present in the sensory threshold range, and it is often used as a way of further screening volatile compounds that play key roles in flavor (Friedrich and Acree, 1998). However, the aroma of an individual compound identified by instrumental analysis is not necessarily indicative of its role on flavor in a food due to interactions with the matrix and other compounds (Drake and Civille, 2003). Model systems, similar to the actual food, should then be constructed to evaluate the role of spe-

cific compound(s) on sensory-perceived flavor. To our knowledge, compounds responsible for nutty flavor in Cheddar cheese have not been reported and specifically linked to sensory perception of nutty flavor in Cheddar cheese. The purpose of this study was, therefore, to identify and quantify volatile compound(s) responsible for nutty flavor in Cheddar cheese.

MATERIALS AND METHODS

Experimental Overview

Cheddar cheeses were screened and selected for initial sensory and instrumental experiments. Due to sample size limitations, additional cheeses were selected for further experiments to confirm observations.

Cheese Selection

Forty 5-kg blocks of Cheddar cheese were purchased on the retail market and screened for nutty flavor by 3 sensory experts, each with more than 150 h of experience in the sensory evaluation of cheese flavor. Cheeses selected (15 total) were 1 to 3 yr old. Cheeses with intense nutty (**N**) flavors (designated as N1, N2, N3, ..., N8) and without nutty (**NN**) flavor (designated as NN1, NN2, NN3, ..., N7) were selected for volatile aroma analyses and descriptive sensory analysis.

Chemicals

Diethyl ether (anhydrous, 99.8%), sodium chloride (99%), sodium sulfate (99%), and 2-methyl-3-heptanone (internal standard for neutral/basic fractions) were purchased from Aldrich Chemical Company (St. Louis, MO) and 2-methylpentanoic acid (internal standard for acidic fractions) was obtained from Lancaster (Windham, NH). Aroma compounds listed in Tables 2, 3, 4, and 7 below were provided from the following commercial sources: numbers 1 to 4, 6, 8, 9, 10 to 12, 14 to 20, 22 to 26, 28, 29, 30, 33, 35, 37 to 39, 42 to 46, 50, 52 to 54, 56, 59, 61 to 66 (Aldrich Chemical Co.); numbers 47 and 48 (Sigma, St. Louis, MO), number 13 (Lancaster), and number 59 (Firmenich Inc., Plainsboro, NJ). Sodium bicarbonate (99.7%), hydrochloric acid (36.5%), and acetic acid (number 42) were obtained from Fisher Scientific (Pittsburgh, PA).

Sensory Evaluation of Cheeses

A trained sensory panel ($n = 8$) evaluated the selected cheeses using a lexicon developed for Cheddar cheese flavor (Drake et al., 2001). Definitions and references for the terms used are given in Table 1. Panelists each received 75 h training on descriptive analysis of cheese

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