Evaluation of Off-Flavor Development in Alpine Cheese Using Selected Ion Flow Tube Mass Spectrometry

Elana Berusch[a], Kaitlyn Taylor[a] and W. James Harper[a]

[a]The Ohio State University, Columbus, OH

Abstract

A manufacturer of Alpine cheese has found that within three weeks of removing their product from vacuum packaging, off-flavors start to develop in the cheese. It was speculated that the development of these off-flavors was caused by lipid oxidation. The objective of this study was twofold: determine if the flavor change is, in fact, caused by lipid oxidation, and if it is not, find the agent causing the flavor profile to change. Both goals were met by using selected ion flow tube-mass spectrometry (SIFT-MS) to evaluate two different lots of Alpine cheese, #153 and #160. SIFT-MS is a direct mass spectrometric technique used to quantify volatile compounds in the headspace of a sample in real time. To prepare the samples, both cheeses were divided in half and grated – one part vacuum sealed and the other part exposed to oxygen. Over the course of 56 days, both the samples exposed to oxygen and the vacuum-packed samples were examined for development of off-flavors using SIFT-MS for cheeses #153 and #160. Concentrations of thirty-two compounds in the cheeses, including alcohols, aldehydes, ketones, esters, sulfur compounds, and pyrazines, were analyzed. The results showed that 6-7 compounds, which changed in concentration over the testing period in samples exposed to oxygen, were derived from degradation of amino acids and lipids. This suggests that the off-flavors produced in the Alpine cheeses are due to amino acid degradation as well as lipid oxidation. The compounds that underwent significant concentration changes, however, varied between cheese #153 and #160. In addition, the impact of time and oxygen on cheese #160 appears to be far greater than that on cheese #153. Further studies will be done to narrow down the causes of the changes in the Alpine cheese flavor profile and to determine ways to prevent the development of these off-flavors.

Introduction

Alpine cheese is made from the milk of grass-fed cows, and the nature of the cows' diet causes the cheese to have especially high concentrations of ω-3 fatty acids, especially alpha-linolenic acid, when compared to other cheeses. These ω-3 fatty acids are especially susceptible to lipid oxidation, and such oxidation can contribute an off-flavor to the Alpine cheese (Hausworth and others 2003).

In order to identify the off-flavor, Selected Ion Flow Tube Mass Spectrometry (SIFT-MS) in combination with odor activity values (OAVs) was used to identify important volatile compounds found in the headspace of Alpine Cheese. SIFT-MS is a direct mass spectrometric technique based on chemical ionization of a gas sample using selected precursor reagent positive ions (Spanel and Smith 1999). SIFT-MS makes it possible to measure volatile organic compound headspace concentrations in parts-per-trillion in real time.

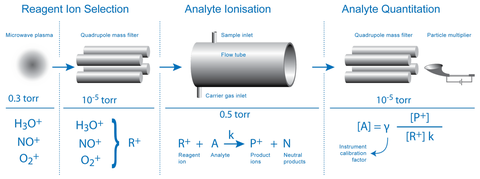


Figure 1. Schematic Diagram of the Analytical Process used in a SIFT-MS Instrument.

Odor Activity Value (OAV)

Odor activity value (OAV) is the compound concentration divided by its odor recognition threshold in air.

Compound concentrations alone can indicate physical changes within a sample but do not indicate the impact of a given compound on the overall flavor profile.

The OAV is an indicator of how much impact the compound in question actually has on the overall flavor profile. Compounds with an OAV ≥1 are above the recognition threshold and therefore considered to have "high impact" on flavor (Preininger and Grosch 1994).

Methods

Grate cheese sample. Divide sample into two. Half vacuum-packed, half sealed with air. Samples stored at 4°C.

Weigh 5 grams of sample into bottles.

Equilibrate at 40°C for 1 hour.

Determine volatile compound concentrations (in ppb) using SIFT-MS.

Calculate odor activity values (OAVs) from concentrations and odor thresholds.

OAV data evaluated using one-way analysis of variance (ANOVA) with Tukey's honestly significant difference (T-HSD).

Acknowledgements

We'd like to thank Cowslip Creamery for providing the Alpine Cheese samples.

Results

Table 1. Changes in Odor Activity Values (OAVs) in Alpine cheese #160 over 56 days while exposed to oxygen.

Compound	Odor Threshold (ppb)	Average Odor Activity Value				
		Day 0	Day 7	Day 14	Day 21	Day 56
1-octen-3-ol	9.15	3.14[a]	4.33[a]	3.93[a]	2.22[a]	0.99[a]
1-octen-3-one	0.12	80.64[a]	118.22[a]	95.45[a]	82.12[a]	46.80[a]
(E)-2-heptenal	610.33	0.007[a]	0.015[a]	0.014[a]	0.016[a]	0.008[a]
(E)-2-hexenal	448.43	0.008[a]	0.016[a]	0.016[a]	0.018[a]	0.007[a]
(E)-2-nonenal	0.19	11.32[a]	20.71[a]	21.36[a]	24.24[a]	10.88[a]
Dimethyl sulfide	6.26	4.89[ab]	7.37[a]	4.39[ab]	2.11[ab]	0.51[b]
Ethyl methyl sulfide	39.81	1.42[b]	3.83[ab]	5.00[a]	4.52[ab]	4.57[ab]
Methional	0.01	1736.82[b]	5178.17[ab]	6451.73[a]	5745.10[ab]	4504.41[ab]
Methyl mercaptan	1.27	105.74[ab]	202.73[a]	179.86[ab]	128.08[ab]	49.33[b]

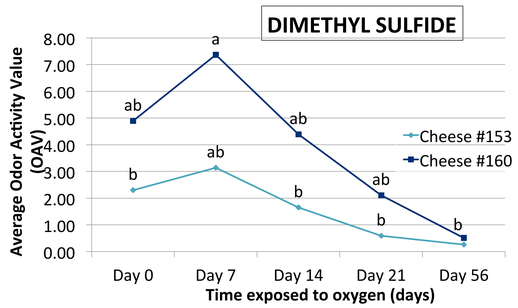
[a,b] Different letters indicated significant differences over time.
Purple indicates lipid oxidation compounds. Blue indicates amino acid degradation compounds

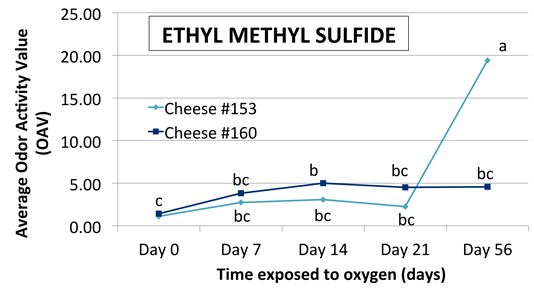
Table 2. Changes in Odor Activity Values (OAVs) in Alpine cheese #153 over 56 days while exposed to oxygen.

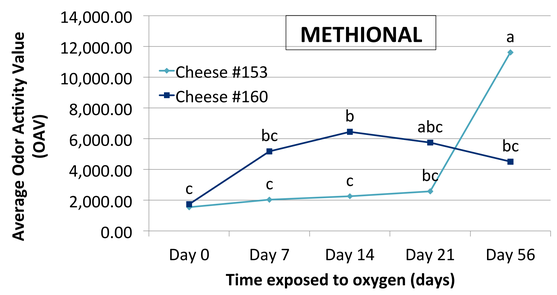
Compound	Odor Threshold (ppb)	Average Odor Activity Value				
		Day 0	Day 7	Day 14	Day 21	Day 56
1-octen-3-ol	9.15	1.77[a]	2.02[a]	2.73[a]	1.41[a]	0.89[a]
1-octen-3-one	0.12	65.99[a]	94.96[a]	126.29[a]	73.35[a]	54.26[a]
(E)-2-heptenal	610.33	0.007[a]	0.010[a]	0.014[a]	0.014[a]	0.010[a]
(E)-2-hexenal	448.43	0.006[a]	0.009[a]	0.015[a]	0.015[a]	0.008[a]
(E)-2-nonenal	0.19	9.31[a]	12.80[a]	19.18[a]	14.82[a]	13.42[a]
Dimethyl sulfide	6.26	2.30[ab]	3.14[a]	1.65[ab]	0.59[ab]	0.26[b]
Ethyl methyl sulfide	39.81	1.12[b]	2.74[b]	3.07[b]	2.24[b]	19.39[a]
Methional	0.01	1544.34[b]	2038.48[b]	2253.64[b]	2580.18[b]	11610.35[a]
Methyl mercaptan	1.27	100.66[ab]	116.80[a]	94.59[ab]	51.51[ab]	14.84[b]

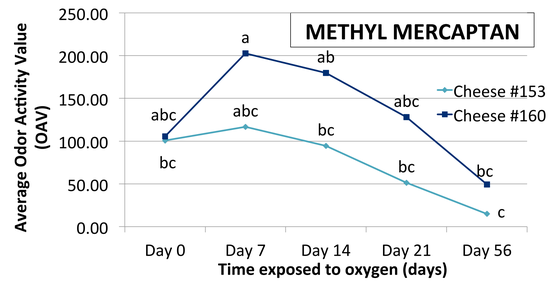
[a,b] Different letters indicated significant differences over time.
Purple indicates lipid oxidation compounds. Blue indicates amino acid degradation compounds

Compounds with significant changes in Odor Activity Values (OAVs) in both Cheese #153 and #160 over 56 days while exposed to oxygen.









Conclusion and Ongoing Study

Through OAV analysis of compounds commonly associated with lipid oxidation, it was determined that lipid oxidation is not responsible for the changing flavor profiles of Cheeses #153 and #160. Since consumer complaints reported that Cheeses #153 and #160 developed the same off-flavor over time, compounds that underwent the same OAV changes in both cheeses over time were examined. It was found that four compounds had significant changes in OAV over time in both Cheese #153 and Cheese #160. These compounds were methional, methyl mercaptan, ethyl methyl sulfide, and dimethyl sulfide, all of which are derived from the degradation of the amino acid methionine.

Alpine cheese samples containing tocopherol, an antioxidant, are currently being studied to determine whether or not the presence of tocopherol in the cheese prevents the development of off-flavors. In the future, the cheese manufacturer may benefit from studying the causes of methionine degradation and relating those causes to factors of Alpine cheese production. Sensory studies may also help narrow down the particular off-flavor that is forming over time.

References

1. Hauswirth CB, Scheeder MRL, Beer JH. 2003 High ω-3 Fatty Acid Content in Alpine Cheese: The Basis for an Alpine Paradox. American Heart Association. 109 : 103-07.
2. Preininger, M. and W. Grosch. 1994. Evaluation of Key Odorants of the Neutral Volatiles of Emmentaler Cheese by the Calculation of Odor Activity Values. Lebensm.-Wiss. Und Technol. 27: 237-244
3. Spanel P, Smith D. 1999. Selected Ion Flow Tube- Mass Spectrometry: Detection and Real-time Monitoring of Flavors Released by Food Products. Rapid Comm. Mass Spectrom 13: 585-596.