

Guidelines for MAFMA Final Report

Final Reports due 3 months after completion of project
(4-5 pages)

Project Title Predicting the Quality of Cheddar Cheese by Infrared Spectroscopy

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Please complete all questions below and attached form

1. Objective Summary (1-2 sentence summary)

Develop a rapid and simple instrumental method based on infrared spectroscopy to analyze flavor quality and composition of Cheddar cheese.

2. Objective Accomplishments

(If objectives were not met, what extenuating circumstances contributed to that factor?)

Convey all of your progress on this project including that obtained with the industry and other matching funds.

The objective of our research was to develop a technique to monitor biochemical changes in cheddar cheese ripening by using Fourier transform infrared spectroscopy. IR spectra will be matched with sensory data at various stages of maturation to build classification models that will help in predicting cheese flavor quality during early stages of ripening. Additionally, this will also enable optimization of production process parameters to achieve uniformity and desired cheddar cheese quality.

An efficient sample preparation method was required to extract unique spectral profiles that relate to cheddar flavor quality, without extracting compounds that may interfere with the signal. This sample preparation method allowed obtaining reproducible FT-IR spectra of samples. A sample preparation protocol for extraction of flavor compounds from cheese was developed, standardized, and tested with cheddar cheese samples of known flavor quality. The developed extraction method yielded extracts, whose IR spectra were highly consistent within each sample and distinct from other cheese samples. This enabled development of multivariate classification models that could classify various cheddar cheese samples (Fig 1) based on their flavor quality (good, creamy, sour, whey, sulfide, unclean, fermented, etc.) (Table 1). A simple extraction of the water-soluble compounds from the cheese powder, without interfering compounds such as fat and protein, allowed clustering of data points according to their flavor quality (Table 1). The orientation of the clusters in 3D space correlated well with the cheese flavor quality descriptors. Sample 4 (fermented flavor) and sample 5 (unclean flavor), which

are considered low quality clustered separately from samples 1, 2 and 3 (good samples). This extraction method apart from improving clustering reduced the analysis time significantly; with total time required for analysis of around 20 minutes. Furthermore, absorption bands from the aliphatic chains (presumably from lipids) in the range 1500-1200 cm^{-1} played a major role in discriminating the cheese samples. Compounds such as carbohydrates or acids with signal associated to C–O and C–C stretching modes (900–1200 cm^{-1} region), also influenced the discrimination of the cheese samples.

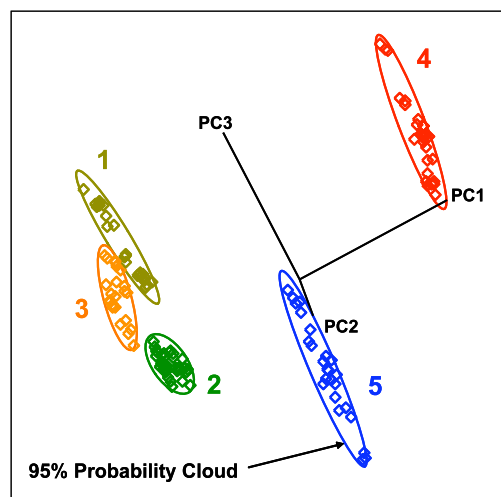


Table 1. Flavor quality descriptor for Cheddar cheese samples.

Sample	Flavor Quality
1	<i>Slight sulfur burn</i>
2	<i>Sour</i>
3	<i>Creamy</i>
4	<i>Fermented</i>
5	<i>Unclean</i>

Figure 1. SIMCA classification model for cheddar cheese samples

The new extraction method shows great potential for rapid cheese quality and composition analysis, significantly reducing the time and effort compared to existing method. The method described in detail in “Subramanian et al. Manuscript 1” explains the potential of the novel Water-Chloroform-Ethanol extraction method combined with Fourier transform-Infrared Spectroscopy as to classify Cheddar cheese based on flavor quality. Cheese samples were classified based on their flavor quality descriptors (fermented, unclean, low flavor, sour, good cheddar, etc.). This technique can be a rapid, inexpensive, high-throughput and simple tool to the cheese industry for predicting the flavor quality of cheese. The developed technique can save time and money for the cheese industry. It will enable better quality control and rapid monitoring of ripening process to achieve cheese of desired flavor quality.

“Subramanian et al. Manuscript 2” further verifies the potential of this method to classify Cheddar cheese based on flavor and extends its application to prediction of age, pH, moisture, salt and fat contents and monitoring the biochemical changes in cheese during the ripening process. The age, fat, salt, moisture, pH and flavor quality of the cheese could be predicted in less than 20 min. Furthermore, the method could also identify some of the biochemical changes that take place in cheese during ripening. This can greatly benefit with the industry as well as cheese research for the currently multiple methods, extensive labor, excessive use of organic solvents, and complicated methodologies to determine flavor quality and composition. The data obtained in this research has prompted further research on cheese ripening. We care currently

working on correlating the data obtained in this research with organic acid profiles determined using high performance liquid chromatography and amino acid profiles obtained using gas chromatography to identify infrared marker bands that could signal the formation of specific flavors. The findings from this part of the research will be a part of our third manuscript for publication in International Dairy Journal.

3. Unexpected findings, if any

Interestingly, multivariate analysis based on direct spectral measurements obtained from cheddar samples or cheese powder did not provided good reproducibility among samples. There was a strong effect of extraction variability which reduced the robustness of the classification models. Based on analysis of the discriminating factor, the source of variability might be related to the level of fat extracted (confounding factor) in each sample.

4. Practical impacts of research efforts. Include: implementation of accomplishments by industry partners (if any), identification of economic impacts, and any further pursuit by PI of research in area of this project whether MAFMA or not.

a. Short Term Impacts

Cheese flavor is currently determined using trained human tasting panels. This process is time consuming and very expensive. Predicting the flavor quality of cheese using instrumental methods during early stages of maturation can save time and money for the industry. However, complexity of cheese maturation and composition make it difficult to develop rapid and reliable instrumental methods for flavor quality analysis.

Results show that all the cheese samples could be classified based on their flavor quality descriptors (fermented, unclean, low flavor, sour, good cheddar, etc.). Additionally, the composition could also be predicted, early in the ripening process. This technique can be a rapid, inexpensive, high-throughput and simple tool to the cheese industry for rapidly predicting the flavor quality of cheese and provide an accept/reject status for the cheese. Time and money can be saved through intensive analysis of a few variables in the cheese whereby quality control of the product could be established early in the manufacturing process.

b. Long Term Impacts

About 9.13 billion pounds of cheese is produced in the US every year, of which 34% is cheddar cheese. Flavor quality of cheddar cheese significantly influences its consumer acceptance, price and food processing application. Cheese flavor is directly affected by the physical, chemical and microbiological changes that occur during maturation. Hence, it is imperative to understand the biochemical changes occurring during cheese maturation to achieve desired cheese quality. Currently, the cheese industry relies on empirical parameters to determine ripening time and predict cheese quality during the manufacturing process. The findings of this study has both applied and scientific significance. Rapid prediction of flavor quality and composition of cheese would 1) enable manufacturers to identify cheese that might develop undesirable flavor and modify the ripening process parameters to aid desirable flavor formation 2) save money by

eliminating ripening costs for cheese that have developed undesirable flavor and 3) help in making decisions on the possible applications of the cheese based on its flavor.

5. If you are also making reports to other funding agencies in the course of this research work, please include a copy of that report.

Not Applicable.

6. a. If any publications resulted from the research, a copy must be included. Please note we were notified by the USDA/CSREES National Program Leader for the Midwest Advance Food Manufacturing Alliance (MAFMA) that all publications resulting from research that was funded by MAFMA must include the following wording **“The project was supported by the USDA Cooperative State Research, Education and Extension Service, special research grant number 200X-34328-xxxxx.”**

Two manuscripts were written based on the findings of this research. One titled *“Classification of Cheddar Cheese Based on Flavor Quality using Infrared Spectroscopy”* has been submitted for publication in Journal of Dairy Science. The second attached manuscript titled *“Rapid Prediction of Composition and Flavor Quality of Cheddar Cheese during Using Infrared Spectroscopy”* was presented as proceedings at the Edward F. Hayes Graduate Research Forum (The Ohio State University) and a manuscript is currently under preparation for publication in Journal of Food Science. Both the manuscripts are attached with this report. Upon completion of the study on understanding cheese ripening using chromatography, a third manuscript will be submitted for publication in International Dairy Journal.

Noteworthy Awards:

Anand Subramanian, 2nd Place, FAES and Human Ecology Oral Competition, 21st Hayes Graduate Forum. The Ohio State University Council of Graduate Students. April, 2007.

Anand Subramanian, 2nd Place Dairy Foods Division Graduate Paper Competition, ADSA Annual Meeting, San Antonio, TX, July, 2007.

Anand Subramanian, 1st Place, IFT Dairy Foods Division Manfred Kroger Oral Competition, Annual Meeting, Chicago, IL. July 2007.

Anand Subramanian, Finalist. Dairy Foods Division Graduate Paper Competition, ADSA Annual Meeting, Indianapolis, IN, July, 2008.

b. If any patents (pending or granted) resulted from the research, please include the patent information.

Title: Rapid Extraction Method for Analysis of Cheese Flavor Using Infrared Spectroscopy

Provisional Appln Ser. No. 61/059,890 filed June 9, 2008