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SENSORY, RHEOLOGICAL AND MICROSTRUCTURAL CHARACTERISTICS OF MODEL EMULSIFIED DAIRY SYSTEMS

A thesis presented in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Food Technology at Massey University, Palmerston North New Zealand

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2000
Texture is an important sensory property of foods. It is sensed mostly in the mouth during the process of mastication and is an indicator of food quality. To enable faster and cheaper prediction of textural characteristics, extensive research has been done to establish instrumental techniques to produce data that correlates well with the sensory appraisal of texture. In this study, model emulsified dairy systems, represented by processed cheese analogues, were characterised using sensory, microstructural and rheological techniques. Correlation between instrumental and sensory textural data was investigated.

A range of experimental cheeses with differing textural attributes was produced by modifications to the moisture content of the products and the mixing speed during manufacture. Twelve experimental cheeses were used in a partial response surface design in four experimental blocks. These cheeses were subjected to compositional analysis. Two weeks after manufacture, the cheeses were texturally evaluated using a trained sensory panel and quantitative descriptive analysis (sensory), confocal laser scanning microscopy and image analysis (microstructure) and fundamental physical tests including frequency sweep, creep compliance and compression to 70% (rheology). Sensory-instrumental correlations included the chemical data and were performed using pairwise correlation, stepwise regression, principal component analysis and canonical correlation analysis.

Significant differences in moisture, total protein, fat content and pH were found between the experimental cheeses, as expected by the formulation changes. The confocal micrographs showed that fat globule size decreased with decreasing moisture content, but little effect was found for mixing speed. Reduction of the globule size resulted in cheeses that were firmer, better emulsified and stickier.

Sensory evaluation of the cheeses in the mouth was not used in this study because of oral fatigue. Instead, seven hand evaluated attributes were selected from a sensory profiling session. Fracturability, rubberiness and
greasiness proved not to be good sensory attributes to discriminate between these cheeses. Significant differences between the cheeses were found for firmness, curdiness and stickiness. Cheeses with lower moisture content were, in general, firmer, more curdy and less sticky than cheeses with higher moisture content.

Frequency sweep, creep compliance and compression to fracture were all useful tests for providing rheological discrimination between the experimental cheeses. Cheeses with lower moisture content showed higher values of storage and loss moduli, Young's modulus, peak stress and work in compression as well as lower values for compliance. These results provide an indication that these cheeses are firmer, better emulsified and more stable products than those with higher moisture content.

Pairwise correlation was used to correlate the microstructural results to the sensory, chemical and rheological data. It was shown that the area occupied by the protein matrix in the micrographs correlates significantly with most chemical and rheological parameters as well as those sensory attributes that adequately discriminated between the experimental cheeses. Microstructural information was insufficient for use in regression analysis.

Stepwise regression analysis was a useful technique for generating simple models to fit the sensory scores with rheological and chemical data. The regression equations for firmness, stickiness and curdiness produced R-square values above 85%, indicating good predictive ability. Principal component analysis was used to tackle the problem of multicollinearity of the predictive parameters. However, combining those instrumental parameters that were not independent from each other did not improve the quality of the correlation coefficients obtained. Firmness in compression and curdiness were the only two sensory attributes satisfactorily modelled using the first rheological principal component, with R-squares of 88.4% and 90.0%, respectively.

Canonical correlation analysis proved to be a useful statistical tool for maximising the correlation between individual sensory textural attributes and instrumental data. Similarly to the stepwise regression analysis,
fracturability, rubberiness and greasiness could not be satisfactorily modelled. In general, firmness (compression and cutting), stickiness and curdiness were very satisfactorily modelled using only the results from the frequency sweep and creep compliance tests. Compression test data appeared not to lead to any improvement in the correlation coefficients.

Overall, the present study showed that sensory, microstructural and rheological characteristics of the processed cheese analogues investigated do correlate. It is possible to generate predictive models for some individual hand evaluated sensory attributes using chemical and instrumental (rheological) parameters. Prediction using microstructural information has yet to be verified.
"The public sees only the accomplished trick; they have no conception of the tortuous, demanding preliminary self-training that was necessary to conquer that fear."

"The secrets of Houdini" (J.C.Cannell)
To J.

For the love and support, 
for the beauty and joy brought into my life, 
for the infinite patience 
and for making a better me. 

Thank you.
ACKNOWLEDGEMENTS

I would like to express my gratitude and appreciation to Mr Rod J. Bennett, my chief supervisor, for the invaluable guidance and constant encouragement throughout my research work. Thank you so much for sharing your knowledge, for understanding the difficulties of being far from the family and the loved ones, and, above all, for caring.

I also wish to extend my gratitude to my co-supervisors, Dr Osvaldo H. Campanella and Prof Ken J. Kirkpatrick, and special advisor, Mrs Kay McMath, for their assistance and contribution in their areas of expertise. My special thanks to Dr Osvaldo H. Campanella for the support, friendship and for believing in my potential from the very beginning.

I am extremely thankful to the New Zealand Dairy Board for the research funding granted and the New Zealand Dairy Research Institute (NZDRI), in the person of Mr Robbie Buwalda, for providing the equipment, the materials and technical support for the research work.

For their invaluable contribution at different stages of the research work, I would like to thank

- Mrs Maree Luckman, for her support with the statistical analysis, suggestions and helpful discussions, the friendship and the constant words of encouragement.
- Dr Yacine Hemar, for his very helpful contribution in the discussion of the rheological data, for his friendship and constant support.
- Mr Guy Hessell and Mrs Elisabeth M. Nickless, for their help with the sample preparation for microstructural analysis and with the confocal microscopy and image analysis sessions.
- Mr Garry C. Radford, Mr Byron D. McKillop, Mr Mark Dorsey, Mr John F. Dawber, Mr Steven Glasgow, Mrs Geedha Sivalingam-Reid and Mrs
Wibha Desai, for their help and guidance in specific analyses during the experimental work.

The staff of the Auckland Product Evaluation Centre (NZDB), for all the help with the sensory evaluation of my samples, and the members of the cheese panel, for putting up with an organoleptic unpleasant product and yet doing their best to generate good, accurate sensory results.

Mrs Miria Busby, for her invaluable assistance, for the friendship and for always cheering me up

Mrs Karen Pickering, for the assistance with the set up of the final version of the thesis

Mrs Marlene T. Turei, Mrs Helen T. Tong, Mrs Loren S. Winter and Mrs Christine R. Ramsay from the Finance Section of the IFNHH-Massey University, for their assistance with travel arrangements and research expenses.

Ms Lisa M. Duizer, who, in spite of the sad events in the course of our friendship, always believed in me and my potential to achieve my Ph.D. degree.

The staff of the International Students’ Office, for the efficient management of my scholarship and for helping me during my establishment in New Zealand. Special thanks to Mrs Margaret Smillie, who always went beyond her duties to make my life in New Zealand a most enjoyable experience and who understood, every step of the way, the sacrifices of being far from family and friends. Thank you so much for caring.

I would like to thank the Ministry of Foreign Affairs and Trade and the Government of New Zealand for the NZODA scholarship awarded and Mr Brian Sinclair, ex-Honorary Consul of New Zealand in Sao Paulo/Brazil, for supporting me in my application to come to New Zealand.

To all my friends at Massey University, for sharing the good and bad times and for their support, my sincere appreciation.
To old friends back in Sao Paulo, in special to Maria Spinola Miranda and Orlando Vian Junior, for putting up with my being so far away all these years and for never giving up the faith in my success, thank you very much. Special thanks to Peter G. Holmes and Catherine M. Bentley for their invaluable support, encouragement and friendship. I love you all.

Last but not least, I want to thank, with all my heart, everyone in my family (my mother, brother and sister) as well as D. Cida and the girls (Maga and Simone). I can not express strongly enough my gratitude for your support and constant words of encouragement, for your love and caring for me, and for helping me realise, every day over the past four years, how blessed I am to have you all in my life. I could not have accomplished this without you.
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Linear regression between the storage ($G'$) and Young’s (E) moduli from the frequency sweep and compression tests, respectively ($n = 36$)

Sensory firmness in compression as a function of moisture content of the experimental cheeses (• raw data), with prediction interval

Sensory curdiness as a function of moisture content of the experimental cheeses (• raw data), with prediction interval

Sensory stickiness as a function of fat content of the experimental cheeses (• raw data), with prediction interval

Sensory firmness in cutting as a function of moisture and fat content of the experimental cheeses (• raw data)

Sensory firmness in compression as a function of Young’s modulus of the experimental cheeses (• raw data), with prediction interval

Sensory curdiness as a function of the area (of the compression curve) for the experimental cheeses (• raw data), with prediction interval

Sensory stickiness as a function of P2 in deformation and P4 in compliance for the experimental cheeses (• raw data)

Sensory firmness (compression) as a function of the main chemical and rheological principal components (PCChem and PCRheo, respectively) for the experimental cheeses (• raw data), with prediction intervals

Sensory firmness (cutting) as a function of the main chemical and rheological principal components (PCChem and PCRheo, respectively) for the experimental cheeses (• raw data), with prediction intervals
Sensory rubberiness as a function of the main chemical and rheological principal components (PCChem and PCRheo, respectively) for the experimental cheeses (raw data), with prediction intervals

Sensory stickiness as a function of the main chemical and rheological principal components (PCChem and PCRheo, respectively) for the experimental cheeses (raw data), with prediction intervals

Sensory curdiness as a function of the main chemical and rheological principal components (PCChem and PCRheo, respectively) for the experimental cheeses (raw data), with prediction intervals

Sensory PC1 as a function of the main rheological principal component (PC1 Rheo) for the experimental (raw data), with prediction intervals

Canonical correlation between firmness in compression and the reduced set of rheological parameters (raw data and regression line)

Canonical correlation between firmness in cutting and the reduced set of rheological parameters (raw data and regression line)

Canonical correlation between stickiness and the reduced set of rheological parameters (raw data and regression line)

Canonical correlation between curdiness and the reduced set of rheological parameters (raw data and regression line)

Canonical correlation between a reduced set of sensory attributes (sensory canonical variable) and the reduced set of rheological parameters (rheological canonical variable) (raw data and regression line)

Canonical correlation between fracturability and the reduced set of rheological + chemical parameters (raw data and regression line)

Canonical correlation between firmness in compression and the reduced set of rheological + chemical parameters (raw data and regression line)
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Canonical correlation between rubberiness and the reduced set of rheological + chemical parameters (raw data and regression line) 258

Canonical correlation between stickiness and the reduced set of rheological + chemical parameters (raw data and regression line) 258

Canonical correlation between curdiness and the reduced set of rheological + chemical parameters (raw data and regression line) 259

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