

Microbiological quality of shredded Cheddar cheese packaged in modified atmospheres

DECLARATION

I declare that the dissertation herewith submitted for the degree MSc (Agric) Food Science and Technology at the University of Pretoria, has not previously been submitted for a degree at any other university or institution of higher education.

By

Evonne Laura Adhiambo Oyugi

Submitted in partial fulfilment of the requirements for the degree

MSc (Agric) Food Science and Technology

in the

Faculty of Natural and Agricultural Sciences

University of Pretoria

Pretoria

November 2004

17/11/04
11/11/2004
11/11/2004

DECLARATION

I declare that the dissertation herewith submitted for the degree MSc (Agric) Food Science and Technology at the University of Pretoria, has not previously been submitted by me for a degree at any other university or institution of higher education.

Secretly I would like to dedicate this dissertation to my mother who supported me for the duration of my studies.

DEDICATION

This dissertation is firstly dedicated to my Lord and God who kept me going through the tough times.

Dr. E. M. M. M. for her guidance, advice, patience and encouragement during the study.

Secondly I would like to dedicate this dissertation to my mother who supported me for the duration of my studies.

Marratle Tsoete at the department of Microbiology and Plant pathology for her assistance and guidance with the identification of moulds.

The post-graduate students of the department of Food Sciences, for their cooperation, encouragement and help during the course of the study.

The International Foundation for Science for funding this project.

Franklin SA Pty. for providing the chives used during the project and Liquid N₂ Cryosol for donating the oxygen scavenging and control film.

ACKNOWLEDGEMENTS

I would sincerely like to thank:

Dr. E. M. Buys for her guidance, advice, patience and encouragement during the course of the study.

Marriette Trutter at the department of Microbiology and Plant pathology for her assistance and guidance with the identification of moulds.

The postgraduate students of the department of Food Science, for their constant encouragement and help during the course of the study.

The International Foundation for Science for funding this project.

Parmalat SA Pty. for providing the cheese used during the project and Liquid Air Cryovac for donating the oxygen scavenging and control film.

ABSTRACT

MICROBIOLOGICAL QUALITY OF SHREDDED CHEDDAR CHEESE PACKAGED IN MODIFIED ATMOSPHERES

By Evonne Laura Adhiambo Oyugi

Supervisor: Dr. E. M. Buys

Department: Food Science

Degree: MSc (Agric) Food Science and Technology

Modified atmosphere packaging (MAP) is a technology commonly used to extend the shelf life of cheese. However, MAP on its own is not always successful in the prevention of mould growth on cheese because of residual levels of oxygen that may occur in the package. As a result, oxygen scavengers in a laminate packaging film were combined with MAP in this study to lower the residual oxygen conditions in shredded Cheddar cheese packages. The study investigated the microbiological quality, shelf life extension and mycoflora of shredded Cheddar cheese packaged in different modified atmospheres with and without oxygen scavengers included in the packaging material.

Shredded Cheddar cheese samples were packaged with each of 3 atmospheres (air, 80% CO₂ / 17% N₂ / 3% O₂, 73% CO₂ / 27% N₂) combined either with an oxygen scavenging or control film. The samples were stored for 16 weeks at 5 ± 1°C and analysed for lactic acid bacteria (LAB), yeast and moulds counts. In addition, the time taken for the first visible signs of mould growth on the cheese was noted. Mould isolates from the cheese were identified initially (0 weeks) and at 16 weeks.

The LAB counts in the cheese were unaffected by the gaseous atmosphere or packaging film. The cheese packaged in the 73% CO₂ / 27% N₂ atmosphere combined with the oxygen scavenging film had the lowest mould counts and the cheese in this packaging

combination took 12 weeks to develop visible mould growth along with the cheese packaged in the 73% CO₂ / 27% N₂ atmosphere in the control and 80% CO₂ / 17% N₂ / 3% O₂ atmosphere in the oxygen scavenging film. The cheese packaged in the air atmosphere combined with the control film had the highest yeast and mould counts and took 4 weeks to develop visible mould growth.

The genus *Penicillium* predominated initially (week 0) at 41% of all mould isolates on the shredded Cheddar cheese. At 16 weeks, the mycoflora differed according to the treatment in which the cheese was stored and the species isolated were fewer in the different treatments indicating that selection took place. In addition, the number of species isolated from the shredded Cheddar cheese packaged in the film with oxygen scavengers were fewer than the isolates from the cheese packaged in the control film which indicated that the lower oxygen conditions further restricted the mould growth.

The results of the study indicate that the 73% CO₂ / 27% N₂ atmosphere in combination with the oxygen scavenging film, resulted in the cheese with the best microbiological quality. In addition, it had the fewest mould species causing spoilage indicating that the atmosphere was restrictive to the range of species causing spoilage. While in general, the use of the oxygen scavenging film in combination with MAP was more effective than the control film in combination with MAP against mould growth.

TABLE OF CONTENTS

DECLARATION	i
DEDICATION	ii
ACKNOWLEDGEMENTS	iii
ABSTRACT	iv
LIST OF TABLES	ix
LIST OF FIGURES	x
1 INTRODUCTION AND LITERATURE REVIEW	1
1.1 Introduction	1
1.2 Literature review	2
1.2.1 Cheddar cheese	2
1.2.2 Modified atmosphere packaging	3
1.2.2.1 Mechanism of action of carbon dioxide	4
1.2.2.2 Factors affecting the anti-microbial activity of carbon dioxide	5
1.2.2.2.1 Temperature	5
1.2.2.2.2 Micro organisms	5
1.2.2.2.3 Initial CO ₂ concentration in the gas state	6
1.2.2.2.4 CO ₂ headspace to volume ratio	6
1.2.2.2.5 pH of the food	7
1.2.2.2.6 Packaging film permeability	7
1.2.2.2.7 Water activity of the food	7
1.2.3 Active packaging	7
1.2.3.1 Oxygen scavengers	8
1.2.4 Packaging of cheese under modified atmosphere conditions	9
1.2.5 Moulds	13
1.2.5.1 Moulds in cheese spoilage	13
1.2.5.1.2 Mould species isolated from various cheeses	15
1.3 Objectives	20
1.4 Hypotheses	21

2 RESEARCH.....	22
2.1 MICROBIOLOGICAL QUALITY OF SHREDDED CHEDDAR CHEESE PACKAGED IN MODIFIED ATMOSPHERES WITH OXYGEN SCAVENGERS.	24
2.1.1 Introduction.....	25
2.1.2 Materials and methods	25
2.1.2.1 Packaging materials	25
2.1.2.2 Packaging treatments of shredded Cheddar cheese	25
2.1.2.3 Storage period of shredded Cheddar cheese	25
2.1.2.4 Microbiological analysis of shredded Cheddar cheese	26
2.1.2.5 Water activity of the shredded Cheddar cheese samples	26
2.1.2.6 Visual inspection of the shredded Cheddar cheese for mould growth	26
2.1.2.7 Statistical analysis.....	26
2.1.3 Results.....	27
2.1.3.1 Oxygen scavenging activity of the laminate film	27
2.1.3.2 Shredded Cheddar cheese packaged in air + control film (treatment 1) and air + oxygen scavenging film (treatment 4) for 16 weeks at 5 ± 1 °C ..	28
2.1.3.3 Shredded Cheddar cheese samples packaged in 80% CO ₂ / 17% N ₂ 3% O ₂ + control film (treatment 2) and 80% CO ₂ / 17% N ₂ / 3% O ₂ + oxygen scavenging film (treatment 5) stored for 16 weeks at 5 ± 1 °C.....	32
2.1.3.4 Shredded Cheddar cheese samples packaged in 73% CO ₂ / 27% N ₂ + control film (treatment 3) and 73% CO ₂ / 27% N ₂ + oxygen scavenging film (treatment 6) and stored at 5 ± 1 °C for 16 weeks	34
2.1.4 Discussion	36
2.1.5 Conclusion	40
2.2 CHARACTERISATION OF MOULDS ON SOUTH AFRICAN CHEDDAR CHEESE PACKAGED IN MODIFIED ATMOSPHERES WITH AND WITHOUT OXYGEN SCAVENGERS	41
2.2.1 Introduction.....	42

2.2.2 Materials and methods	44
2.2.2.1 Packaging materials	44
2.2.2.2 Packaging treatments of shredded Cheddar cheese	44
2.2.2.3 Storage period of shredded Cheddar cheese	44
2.2.2.4 Mould isolation	44
2.2.2.5 Mould identification.....	44
2.2.3 Results.....	45
2.2.3.1 Mould species isolated from shredded Cheddar cheese at 0 weeks and after 16 weeks of storage at 5 ± 1 °C packaged in treatments 1 – 6.	45
2.2.4 Discussion	48
2.2.4.1 Mould species isolated from shredded Cheddar cheese packaged in treatments 1 – 6 at week 0.....	48
2.2.4.2 Mould species isolated from shredded Cheddar cheese packaged in air + control film (treatment 1) and air + oxygen scavenging film (treatment 4) and stored at 5 ± 1 °C for 16 weeks	50
2.2.4.3 Mould species isolated from shredded Cheddar cheese packaged in 80 % CO ₂ / 17% N ₂ / 3% O ₂ + control film (treatment 2) and 80% CO ₂ / 17% N ₂ / 3% O ₂ + oxygen scavenging film (treatment 5) and stored at 5 ± 1 °C for 16 weeks.....	51
2.2.4.4 Mould species isolated from shredded Cheddar cheese packaged in 73% CO ₂ / 27% N ₂ + control film (treatment 3) and 73% CO ₂ / 27% N ₂ + oxygen scavenging film (treatment 6) stored at 5 ± 1 °C for 16 weeks.....	54
2.2.5 Conclusions.....	57
3 GENERAL DISCUSSION	58
4 CONCLUSIONS AND RECOMMENDATIONS	66
5 REFERENCES	67

LIST OF TABLES

Table 1.1	Incidence of mould genera isolated from various cheeses.....	16
Table 2.1.1	Water activity values of shredded Cheddar cheese packaged in treatments 1 - 6 and stored at 5 ± 1 °C (n = 36).....	27
Table 2.1.2	Statistical analysis of lactic acid bacteria counts in shredded Cheddar cheese packaged in treatments 1 – 6 and stored for 16 weeks at 5 ± 1 °C	27
Table 2.1.3	Statistical analysis of yeast and mould counts in shredded Cheddar cheese packaged in treatment 1 - 6 stored for 16 weeks at 5 ± 1 °C	28
Table 2.1.4	Mould growth (log cfu/g) in shredded Cheddar cheese packaged in air + control film (treatment 1) and air + oxygen scavenging film (treatment 4) and stored at 5 ± 1 °C for 16 weeks (n=36).....	30
Table 2.1.5	Mould populations (log cfu/g) in shredded Cheddar cheese packaged in 80% CO ₂ / 17% N ₂ / 3% O ₂ + control film (treatment 2) and 80% CO ₂ / 17% N ₂ / 3% O ₂ + oxygen scavenging film (treatment 5) stored for 16 weeks at 5 ± 1 °C (n=36).....	33
Table 2.1.6	Mould growth (log cfu/g) in shredded Cheddar cheese packaged in treatment 73% CO ₂ / 27% N ₂ + control film (treatment 3) and 73% CO ₂ / 27% N ₂ + oxygen scavenging film (treatment 6) and stored at 5 ± 1 °C for 16 weeks (n=36).....	36
Table 2.2.1	Mould species isolated from shredded Cheddar cheese at 0 weeks and after 16 weeks of storage at 5 ± 1 °C packaged in modified atmospheres combined with an oxygen scavenging and control film (treatments 1 - 6)	46

LIST OF FIGURES

Figure 2.1.1	Lactic acid bacteria and yeast populations in shredded Cheddar cheese packaged in air + control film (treatment 1) and air + oxygen scavenging film (treatment 4) for 16 weeks at 5 ± 1 °C (n=36)...	29
Figure 2.1.2	Shelf life of shredded Cheddar cheese packaged in an oxygen scavenging and control film in 3 atmospheres (air, 80% CO ₂ / 17% N ₂ / 3% O ₂ , 73% CO ₂ / 27% N ₂) and stored at 5 ± 1 °C (n=108) based on visible mould growth. Control film Oxygen scavenging film 	31
Figure 2.1.3	Lactic acid bacteria and yeast populations in shredded Cheddar cheese packaged in 80% CO ₂ / 17% N ₂ / 3% O ₂ + control film (treatment 2) and 80% CO ₂ / 17% N ₂ / 3% O ₂ + oxygen scavenging film (treatment 5) for 16 weeks at 5 ± 1 °C (n=36).....	32
Figure 2.1.4	Lactic acid bacteria and yeast populations in shredded Cheddar cheese packed in 73% CO ₂ / 27% N ₂ + control film (treatment 3) and 73% CO ₂ / 27% N ₂ + oxygen scavenging film (treatment 6) and stored at 5 ± 1 °C for 16 weeks (n=36).....	35
Figure 3	Proposed model for the microbiological quality, shelf life and mould species isolated from shredded Cheddar cheese packaged in modified atmospheres with and without oxygen scavengers and stored at 5 ± 1 °C for 16 weeks	62