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THE LOSS OF GRAIN FRESHNESS

**Indicators of storage induced quality loss in dry
barley and canola grain.**

Volume I: Parts one to three

Thesis submitted to the Faculty of Applied Science of the
University of Canberra to meet the requirements for the award
of Doctor of Philosophy.

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Summary

The work presented here explores the effect of storage on chemical and other characteristics of dry, free of added chemicals and pest-free barley and canola grain. This was achieved by measuring the changes in a number of variables of grain stored at different temperatures under laboratory conditions and in commercial storage. The following measurements were carried out: Viability, moisture contents (mc), oil contents (oc), whole grain colour, spectrophotometry of grain extracts, hydroxy methyl furfuraldehyde (HMF), changes in storage atmospheres, organic sulphide levels, tocol concentrations (vitamin E), Iodine Value (IV), Thiocyanogen Value (TV), Peroxide Value (PV), p-Anisidine Value (p-AV) and Acid Value (AV).

The mc of canola and barley were within the range considered safe for storage. Oil content of canola did not change significantly with storage. Viability of canola stored at 4 and 25°C did not change noticeably, but higher storage temperatures resulted in seed death. Barley maintained high viabilities at low temperatures, but was more susceptible to high temperatures than canola. Colour changes of whole barley grain in storage were pronounced and temperature dependent. Colorimetry of whole barley grain showed potential as a tool for monitoring quality changes in storage. Absorption spectra of grain extracts reflected chemical and physiological changes in storage. HMF, an indicator of Maillard browning, accumulated in short to medium term storage at 45°C and in long term storage at 25 and 35°C. Measurement of HMF was considered useful for monitoring quality changes of stored cereal grain.

In a study of storage atmospheres, changes in the concentrations of carbon dioxide, carbon monoxide, oxygen, carbon disulphide and carbonyl sulphide were shown to be useful indicators of quality loss of grain in storage. Gas concentrations usually depended on storage temperature and time and reflected the storage history of the commodity. They indicated loss of carbohydrates and lipids by respiration, oxidative damage and deterioration of sulphur containing amino acids and other compounds.

Oil quality indicators were consistent with oxidative damage to canola lipids in storage. IV, TV, and p-AV of canola oil did not correlate with quality of commercial samples. However, a relationship between increases in PV and high storage temperatures in canola was shown and AV increased in storage dependent on storage temperature and time. In barley and canola, the concentration of anti-oxidant tocol species (vitamin E) decreased at 35 and 45°C storage dependent on storage time. The overall tocol content as well as vitamin E activity decreased with storage decreasing the nutritional value of the commodities and indicating oxidative damage to lipids.

It was concluded that the storage of dry, pest-free whole barley and canola grain at moderate temperatures (25-45°C) resulted in chemical and other changes. The consequence of these changes was a measurable reduction in the freshness of grain relevant to the nutritional, food technological and commercial quality of grain.

Table of Content

Volume I

Certificate of authorship of thesis-----c

Retention and use of thesis-----d

Revisions-----e

Acknowledgments-----f

Preface-----g

Summary-----h

Conventions-----i

Glossary-----j

Abbreviations-----k

Part one: Background

Chapter 1 Introduction-----2

Chapter 2 Barley and canola in the marketplace & particulars of experimental grain--12

Part two: Moisture content, oil content and viability

Chapter 3 Moisture content of grain-----22

Chapter 4 Oil content of grain-----43

Chapter 5 Viability-----70

Part three: Colour

Chapter 6 Reflectance- Colorimetry of whole grain-----95

Chapter 7 Absorbance- Spectrophotometry of grain extracts-----123

Chapter 8 Maillard browning in barley grain-----166

Volume II

Part four: Headspace composition

<i>Chapter 9 The gases of respiration</i> -----	197
<i>Chapter 10 The organic sulphides</i> -----	227
<i>Chapter 11 Accumulation of carbon monoxide</i> -----	246

Part five: Lipids

<i>Chapter 12 Quality of oil extracted from stored canola</i> -----	260
<i>Chapter 13 Tocols(vitamin E) in stored grain</i> -----	304

Part six: Conclusions

<i>Chapter 14 Grain freshness- Its loss in storage</i> -----	358
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Appendices

<i>Appendix I Mathematical models describing isotherms</i> -----	ii
<i>Appendix II Models of viability loss</i> -----	vii
<i>Appendix III The CIE ideal observer and the CIELAB colour space</i> -----	x
<i>Appendix IV Plant pigments</i> -----	xv
<i>Appendix V Toxicity of carbon monoxide</i> -----	xxxiii
<i>Appendix IV ANOVA tables</i> -----	xxvi

Glossary

Börner divider: apparatus for randomising grain samples to ensure representative sampling

fresh, freshness: retaining its original quality, unimpaired, not deteriorated.

headspace: the gaseous atmosphere above an enclosed quantity of grain or grain-product or, more generally, above some other solid or liquid phase.

kernel: whole seed

miscella: mixture of oil and solvent

on farm storage: Commodities are often stored centrally by bulk handlers who specialise in the handling and storage of grain. In contrast, 'on farm' storage refers to storage in small silos that are managed independently by farmers.

paddy rice: whole, unhulled kernels of rice

rachis: primary axis of an inflorescence

reival: point at which grain is accepted into storage

seed coat: testa

seed death: A seed is considered to be 'dead' when it becomes incapable of germination.

Soxhlet: apparatus for the continuous extraction of a solid by a hot solvent.

swathing: windrowing

viability: capability to germinate, usually expressed as a percentage.

Abbreviations

AACC	American Association of Cereal Chemists
ABARE	Australian Bureau for Agricultural Research Economics
ACGIH	American Conference of Governmental Industrial Hygienists
ANOVA	Analysis of variance
AOAC	Association of Official Analytical Chemists
AOCS	American Oil Chemist Society
AOF	Australian Oilseed Federation
ASAE	American Society of Agricultural Engineers
AV	acid value
A_w	water activity
AWB	Australian Wheat Board
bp	boiling point
CAA	Canola Association of Australia
CIE	Commission Internationale de l'Eclairage
CIELAB	CIE L*a*b* uniform colour space
cv	Cultivar (= Variety)
CZE	Capillary Zone Electrophoresis
DAD	Diode Array Detection
DML	Dry Matter Loss
emc	equilibrium moisture content
erh	equilibrium relative humidity
EU	European Union
FA	fatty acids
FAO	Food and Agricultural Organisation
FFA	Free Fatty Acids
FOSFA	Federation of Oil Seeds and Fats Associations
FPD	Flame Photo-ionisation Detector
GC	Gas Chromatography
GC-MS	gas chromatography-mass spectrophotometry

Abbreviations (continued)

GSL	Glucosinolates
ha	hectares
HEAR	High Erucic Acid Rapeseed
HMF	hydroxy methyl furaldehyde
HPLC	High Performance Liquid Chromatography
id	identification denomination
ID	internal diameter
IEF	Iso-Electric Focusing
ISO	International Organisation for Standardisation
ISTA	International Seed Testing Association
ITC	isothiocyanates
IV	iodine value
JFWCAC	Joint FAO/WHO Codex Alimentarius Commission
kt	kilo tonnes
LEAR	Low erucic Acid Rapeseed
mc (db)	moisture content (dry basis) %

mc (wb)	moisture content (wet basis) %
mE	milli Equivalents
MRP	Maillard reaction products
MRP	Maillard Reaction Products
NACMA	National Agricultural Commodities Marketing Association Inc.
NIR	Near Infrared Reflectance
NMR	Nuclear Magnetic Resonance
np	normal phase
oc	oil content %
pAV	p-anisidine value
PMCAM	programmable microprocessor control and monitoring system
PUFA	polyunsaturated fatty acids
PV	peroxide value
rh	relative humidity %
rp	reversed phase
RQ	Respiratory Quotient
sd	standard deviation
sem	standard error of the mean
SFE	Supercritical Fluid Extraction
SMCO	s-methyl cysteine sulphoxide
STEL	Short Term Exposure Limit
TCD	Thermal Conductivity Detector
TE	Tocopherol Equivalents
TLC	Thin Layer Chromatography
TLV	Threshold Limit Value
TTC	Total Tocol Content
TV	thiocyanogen value
UCS	Uniform Colour Scale
UFA	Unsaturated Fatty Acids
USDA	United States Department of Agriculture
UV-Vis	Ultraviolet-Visible light