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Phytochemical variation during blueberry juice processing

A thesis presented in partial fulfilment of the requirements for the
degree of Doctor of Philosophy in Biotechnology at
Massey University, New Zealand.

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2015

ABSTRACT

Blueberry is regarded as a ‘super fruit’ by many consumers and believed to offer health benefits for humans. It is well known for its high antioxidant levels and for the diversity of its anthocyanins. Blueberries can be eaten fresh but are very perishable, so are commonly kept frozen and available all year round. Frozen blueberries are suitable for a range of products including juice. During juicing, there are likely to be changes in phytochemical constituents arising from the various processing steps. These changes lead to variable composition of the finished juice and uncertain impacts on the ‘health value’ of the product. Therefore, this study focused on evaluating three major phytochemicals (anthocyanins, chlorogenic acid (CGA), and procyanidin B2) throughout juice processing in order to model compositional change.

Blueberry juice processing involves a series of unit operations: thawing, blanching, mincing, enzyme treatment, separation of juice from pomace, pasteurisation, and bottling. Enzymatic degradation occurs during thawing of blueberries as they still contain ‘live’ oxidases. Prolonged thawing at warm temperatures would therefore be particularly bad for phytochemical degradation. If these oxidases are destroyed by blanching, thermal degradation also occurs but was found to be less aggressive than polyphenoloxidase (PPO) activity. Blanching at high temperature ($\geq$ 70 °C) for 3 min eliminated PPO and significantly increased the phytochemical concentration in the juice but it induced pectin gel formation which reduced juice recovery. Depectinisation is essential after berry blanching to dissolve pectin gel and to avoid juice volume penalty. Significant losses of phytochemicals were also observed during pressing of the berries into juice, due to physical associations between the phytochemicals and the berry matrix, and entrapment. Blanching at 90 °C for 3 min followed by pectinase enzyme treatment at 50 °C for 2 h was the best way to deliver high phytochemical concentration in the juice with high juice volume recovery and acceptable viscosity. There is a risk that juices with high phytochemical concentration will seem bitter or astringent. This was found not to be the case in sensory trials, with consumers consistently preferring the high-phytochemical juices; it seems sugars in the juice masked any adverse perceptions.

Because of the complexity of blueberry juice processing, the processing model developed in this study was simplified into three components: a defrost model, a recovery model and a thermal model. In short, the defrost model was used for the whole berry phase during thawing when PPO was still active; the recovery model accounted for losses into the pomace; and the thermal model covered the subsequent liquid phase. These processing models were able to predict anthocyanin and CGA changes throughout processing (particularly in blanched products) but procyanidin B2 behaviour was not predictable.

This modelling approach provides the ability to predict variations in composition arising from changes in the juicing process and offers manufacturers the opportunity to produce consistent blueberry juice with a high phytochemical concentration.

ACKNOWLEDGEMENTS

I am grateful to the Lord God Almighty for giving me the opportunity to complete my research and making all things possible.

I would like to express sincere gratitude to my supervisor, Professor Julian Heyes, for the valuable guidance, continuous support and encouragement, immense patience and generous assistance throughout the ‘ups and downs’ of this journey. Special appreciation is extended to my co-supervisor, Dr Alistair Carr for his excellent support, guidance, and assistance especially on the modelling part. Last but not least to my co-supervisor, Dr Roger Hurst from Plant and Food Research Institute (PFR) for the generous support and encouragement throughout my study especially for the opportunity to work with ‘blueberry industry people’.

I would like to thank Dr Andrew East and Professor John Bronlund for modelling advice; Dr Geoff Jones for statistical assistance and Dr David Stevenson from PFR for HPLC technical advice and analysis.

Thanks to all School of Food and Nutrition (SFN) staff and lab managers especially Sue Nicholson, Peter Jeffery, Michelle McGrath, Steve Glasgow, Michelle Tamehana, Garry Radford, Warwick Johnson, Julia Good, and John Sykes for their technical support during my research work. Thanks also to my ‘sensory team’ from PFR: Virginia Corrigan, Claire Redman, and Duncan Hedderley for technical support and analysis of sensory work.

I would like to acknowledge Blueberry New Zealand Inc. and Mamaku Blue for donating a continuous supply of blueberries for the study.

Special thanks to my sponsor, Universiti Malaysia Perlis (UniMAP) and Ministry of Education Malaysia (MOE) for the scholarship and research funding and the opportunity to pursue my PhD at Massey University, New Zealand.

I would like to thank my colleagues in the Centre for Postharvest and Refrigeration Research: Pilirani, Jantana, Natasha, Gayani, Pang, Abdul, Srikanth, Palash, Majid, Justin, Janelle, Matthew, Munazza, and Himani for continuous support and encouragement during the study. Thanks to my friends; Kak Sha, Kak Maz, Soffa, Yen, and Ina, who have been there for me even at hard times of my life and for encouragement during this tough journey.

Special gratitude to my beloved parents and siblings for encouragement and patiently waiting for me to finish the study. I am deeply grateful and indebted for their unconditional love, wisdom, and their inspiration in every aspect of my life.

Last but not least, thanks to all who have helped me in completing this thesis.

In loving memory of my mother

You are so loved and missed....

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ABBREVIATIONS

AOAC	Association of Official Analytical Chemists
BI	browning index
C	concentration
C_o	initial phytochemical concentration
CGA	chlorogenic acid
DW	dry weight
E_a	activation energy
FCP	free choice profiling
FW	fresh weight
GRG	generalized reduced gradient algorithm
h	hour
H_2O_2	hydrogen peroxide
HPLC	high performance liquid chromatography
IDF	insoluble dietary fiber
k	rate constant
k_o	frequency factor
MAF	Ministry of Agriculture and Fisheries (up till 1995) / Ministry of Agriculture and Forestry
min	minute
NTU	Nephelometric Turbidity Units
ORAC	Oxygen radical absorbance capacity
PCA	principal component analysis
PET	polyethylene terephthalate
PFR	NZ Institute for Plant and Food Research Ltd
POD	peroxidase
PPO	polyphenoloxidase
PVPP	polyvinylpolypyrrolidone
R	universal gas constant
R^2	regression coefficient
s	second
SDF	soluble dietary fiber
SSE	sum of squares error
t	time
T	temperature
$t_{1/2}$	half-life
TA	titratable acidity
TDF	total dietary fiber
T_{ref}	arbitrary reference temperature
TSS	total soluble solids
T_t	temperature at time
β	thermal history