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Yours sincerely,

Natalie d'Avila

**Stability of ultra-high temperature (UHT)  
processed beverages infused with white tea  
(*Camellia sinensis*) and grape seed  
(*Vitis vinifera*) extracts**

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# Abstract

*Camellia sinensis* and grape seed extracts have been associated with health benefits due to their high phenolic content. White tea, derived from young buds and leaves of *Camellia sinensis*, is high in catechins. Grape seeds are also high in catechins, as well as gallic acid and proanthocyanidins. In addition, it has been suggested that grape phenolics may interact synergistically with *Camellia sinensis* extracts, increasing their biological activities.

Although white tea and grape seed extracts can be easily incorporated into beverages, the impact of processing conditions on the stability of bioactive compounds ought to be considered when developing functional beverages. The stability of white tea and grape seed phenolics can be affected by processing and storage conditions, such as temperature, pH and beverage ingredients. Catechins may undergo changes through epimerisation, oxidation and polymerisation, altering the chemical profile of the finished product. The impact of heat treatment on the stability of catechins may be reduced by applying heat for a shorter period of time. Hence, ultra-high temperature (UHT) processing might be a suitable technique to commercially sterilise functional beverages without significantly affecting grape seed and white tea phenolic compounds. There is, however, a lack of information available on the impact of UHT treatment on white tea and grape seed polyphenols. The aim of this project was to evaluate the stability of phenolics, methylxanthines and antioxidant activity in UHT-treated beverages infused with white tea and grape seed (*Vitis vinifera* var. Sauvignon Blanc) extracts during storage.

This study comprised two integrated phases. The first phase aimed at determining the optimum UHT processing temperature based on chemical, microbiological and sensory characteristics of the beverages infused with white tea and grape seed extracts. In this experiment, one commercial formulation (mango-flavoured beverage) was UHT-treated at four temperature levels (110, 120, 130 and 140 °C) for 5 s. The UHT-treated beverages in this study contained catechins, gallic acid, caffeine, and theobromine. The beverages were also expected to contain other phenolics and methylxanthines, which were not investigated. The levels of theobromine and caffeine in the beverages were stable following UHT processing. Even though the impact of UHT-treatment (at 110, 120, 130 and 140 °C for 5 s) on the stability of phenolics in the RTD mango-flavoured beverages was not significant ( $P > 0.05$ ), the levels of GCG increased slightly following UHT processing, and EGCG decreased following treatment at 140 °C, suggesting that epimerisation of catechins may have occurred. Therefore, the optimum UHT treatment conditions chosen for further work were 130 °C for 5 s.

In the second phase of the study, the previously determined UHT processing temperature (130 °C) was used to process pomegranate, mango and nectarine beverages. Microbiological, chemical, and sensory analyses were conducted to investigate the stability of the three UHT-treated beverages stored for 90 days at 20 °C and 40 °C.

Yeasts and moulds were not present in the three UHT-treated beverages stored for up to 42 days. Moulds initially present in the packaging may have contributed to the mould growth in the beverages observed after 63 days of storage, since moulds that have been injured during processing are able to recover during storage. The beverages stored for 90 days at both 20 °C and 40 °C showed acceptable flavour. However, the beverages stored at 40 °C were less well liked ( $P < 0.05$ ), possibly due to the presence of sediment in the beverages stored at 40 °C. The darkening of the beverages stored at 40 °C, possibly caused by oxidation of phenolics, may also have contributed to the lower appearance acceptance scores of the beverages.

Antioxidant capacity of the beverages decreased ( $P < 0.05$ ) after 90 days of storage, while total phenolics ( $P < 0.05$ ) increased slightly. The compositional differences in the formulation of the beverages affected ( $P < 0.05$ ) the phenolic compounds and antioxidant capacity of the products during the 90-day period of storage, suggesting that the different levels of citric acid and ascorbic acid in the beverages could have affected the stability of the phenolics. Epimerisation of catechins may have occurred in the beverages during storage, increasing (+)-catechin levels. Gallic acid also increased ( $P < 0.05$ ) in the beverages during storage, possibly as a product of hydrolysis. Decreases ( $P < 0.05$ ) in the levels of ECG, EGCG, GCG, and EC in the beverages were also observed during storage. Oxidation appeared to be the main reaction responsible for degradation of the catechins in the beverages. In addition, the higher storage temperature (40 °C) increased degradation of catechins and formation of gallic acid. Since catechins are effective radical scavengers, degradation of catechins may partially explain the decrease in antioxidant capacity of the UHT-treated beverages during storage.

In conclusion, the UHT-treated beverages used in this study contained a unique mixture of chemical compounds that may prove beneficial to human health. However, the storage-induced changes in the phenolic profile of the beverages could exert an impact on the efficacy of any potential biological effects of the beverages. These findings contribute to understanding the composition and stability of phenolics and methylxanthines in UHT-treated beverage systems, and this information can be used to improve both the formulation and storage strategies for high-quality beverages infused with white tea and grape seed extracts.

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# Table of Contents

<b>Abstract</b>	<b>i</b>
<b>Acknowledgments</b>	<b>iii</b>
<b>Table of Contents</b>	<b>iv</b>
<b>List of Figures</b>	<b>ix</b>
<b>List of Tables</b>	<b>xi</b>
<b>List of Abbreviations</b>	<b>xii</b>
 <b>Chapter 1 Introduction</b>	 <b>1</b>
 <b>Chapter 2 Literature Review</b>	 <b>4</b>
2.1 Plant phenolics	4
2.1.1 Classification of plant phenolics	4
2.1.1.1 Flavonoids	5
2.1.1.2 Phenolic acids	7
2.1.1.3 Tannins	7
2.1.2 Bioavailability and metabolism of flavan-3-ols and proanthocyanidins	9
2.1.3 Intercellular mechanisms of action of phenolic compounds	11
2.2 Tea ( <i>Camellia sinensis</i> )	12
2.3 Tea ( <i>Camellia sinensis</i> ) processing	13
2.3.1 White tea ( <i>Camellia sinensis</i> )	14
2.3.2 Chemical composition of white tea	14
2.3.3 Tea catechins	16
2.3.4 Biological activities of white and green tea ( <i>Camellia sinensis</i> )	17
2.4 Grape seed extract ( <i>Vitis vinifera</i> )	18
2.4.1 Chemical composition of grape seed	18
2.4.2 Biological activity of grape seed	19
2.5 Grape seed and tea extracts in foods	20
2.6 Ready-to-drink (RTD) tea-based beverage market	20
2.7 Stability of phenolics and methylxanthines in processed beverages	22
2.7.1 Effect of brewing conditions on phenolics and methylxanthines	23

2.7.2 Effect of pH on phenolics in RTD beverages	23
2.7.3 Effect of ingredients on phenolics in RTD beverages	24
2.7.4 Effect of heat treatment on phenolics and methylxanthines in RTD beverages	24
2.7.5 Storage conditions and stability of phenolics and methylxanthines	25
2.8 Antioxidant capacity of food systems	26
2.8.1 Autoxidation mechanisms	26
<i>Oxygen radical absorbance capacity (ORAC) assay</i>	27
<i>Ferric reducing antioxidant power (FRAP) and Trolox equivalent antioxidant capacity (TEAC) assay</i>	28
<i>Radical scavenging activity using 2,2-diphenyl-1-picrylhydrazyl (DPPH<sup>•</sup>)</i>	28
<i>Correlation of antioxidant assays</i>	29
2.9 Chemical analysis of phenolics and methylxanthines	29
2.9.1 Extraction of phenolics and methylxanthines	29
2.9.2 Analysis of total phenolic content using Folin-Ciocalteu's reagent	32
2.9.3 Analysis of phenolics and methylxanthines by High-Performance Liquid Chromatography (HPLC)	32
2.10 Microbiological stability of beverages	34
2.11 Preservation techniques used in the beverage industry	36
2.11.1 Chemical preservatives	37
2.11.2 Aseptic processing and packaging (APP)	37
<i>Pre-sterilisation of plant and packaging</i>	38
<i>Aseptic filling of beverages using bottles</i>	38
<i>Packaging materials</i>	39
2.11.3 Heat treatment	40
<i>Continuous flow systems</i>	40
<i>Heating methods</i>	41
<i>Ultra-high temperature (UHT) processing</i>	41
<i>Heat treatment of beverages</i>	42
2.11.4 Non-thermal preservation technologies	43
2.11.4.1 Membrane technology	43
2.11.4.2 High pressure processing (HPP)	44
2.11.4.3 Ultraviolet (UV) technology	46



2.11.4.4 Hurdle technology	47
2.12 Stability and shelf life of beverages	48
2.13 Accelerated shelf life and predictive modelling	49
2.14 Sensory evaluation	50
2.15 Project overview	52
<i>Aims and Objectives</i>	52
<b>Chapter 3 Materials and Methods</b>	<b>54</b>
3.1 Experimental design	54
3.2 Materials	55
3.3 Phase I: Optimisation of ultra-high temperature (UHT) processing	56
3.3.1 Description of the ultra-high temperature (UHT) equipment	56
3.3.2 Packaging, raw materials and formulation of beverages	57
3.3.3 Processing	57
<i>Mixing ingredients and brewing</i>	57
<i>Ultra-high temperature (UHT) treatment</i>	58
<i>Cold-filling and storage of beverages</i>	58
3.3.4 Total soluble solids	59
3.3.5 pH measurement	59
3.3.6 Microbiological analysis	59
<i>Preparation of media</i>	59
<i>Preparation of 0.1% peptone water</i>	60
<i>Enumeration of yeasts and moulds</i>	60
<i>Detection of heat-resistant moulds</i>	60
3.3.7 Chemical analyses	61
3.3.7.1 Estimation of total phenolic content	61
3.3.7.2 Determination of radical scavenging activity using $\alpha,\alpha$ -diphenyl- $\beta$ -picrylhydrazyl (DPPH $\bullet$ )	62
3.3.7.3 Determination of oxygen radical absorbance capacity (ORAC)	63
<i>Solutions</i>	63
<i>Procedure</i>	63

3.3.7.4 Analysis of phenolic and methylxanthine compounds by High-Performance Liquid Chromatography (HPLC)	65
<i>Preparation of standard solutions</i>	66
<i>Preparation of grape seed and white tea extracts</i>	67
<i>Preparation of samples</i>	67
3.3.8 Sensory evaluation	67
<i>Consumer recruitment</i>	68
<i>Sensory methodology</i>	68
3.3.9 Statistical data analysis	69
<b>3.4 Phase II: Stability of ultra-high temperature (UHT) processed beverages during storage</b>	<b>70</b>
3.4.1 Packaging, raw materials and formulations	70
3.4.2 Description of the ultra-high temperature (UHT) equipment	70
3.4.3 Processing	71
<i>Mixing ingredients and brewing</i>	71
<i>Ultra-high temperature (UHT) treatment</i>	71
<i>Sterilisation of packaging</i>	72
<i>Cold-filling of beverages</i>	73
<i>Transportation and storage conditions</i>	74
3.4.4 Analyses of UHT-treated beverages during storage	74
3.4.4.1 Total soluble solids and pH measurement	74
3.4.4.2 Microbiological analysis	74
<i>Preparation of media</i>	75
<i>Microbiological analysis of packaging</i>	75
3.4.4.3 Chemical analyses	76
3.4.4.4 Sensory evaluation	76
<b>Chapter 4 Optimisation of ultra-high temperature (UHT) processing conditions of beverages infused with white tea and grape seed extracts (Phase I)</b>	<b>77</b>
4.1 Introduction	77
4.2 Results and Discussion	78
4.2.1 Total soluble solids and pH	78
4.2.2 Microbiological analysis of yeasts and moulds	78
4.2.3 Total phenolic content and antioxidant capacity	81

4.2.4 Analysis of phenolic and methylxanthine compounds by HPLC	88
4.2.5 Sensory evaluation	92
4.3 General Discussion	94
4.4 Conclusion	95
<b>Chapter 5 Stability of UHT-treated beverages infused with white tea and grape seed extracts during storage (Phase II)</b>	<b>96</b>
5.1 Introduction	96
5.2 Results and Discussion	98
5.2.1 Total soluble solids and pH	98
5.2.2 Microbiological analysis	100
5.2.3 Total phenolic content and antioxidant capacity	107
5.2.4 Analysis of phenolic and methylxanthine compounds by HPLC	112
5.2.5 Sensory evaluation	120
5.3 Conclusion	124
<b>Chapter 6 General Discussion &amp; Recommendations</b>	<b>125</b>
<b>Chapter 7 Conclusions</b>	<b>130</b>
<b>8. References</b>	<b>131</b>
<b>Appendices</b>	<b>154</b>

# List of Figures

Figure	Title	Page
2.1	General chemical structure of flavonoids	5
2.2	Basic chemical structure of flavanols and tannins	6
2.3	Basic structure of proanthocyanidins	8
2.4	Tea ( <i>Camellia sinensis</i> ) manufacturing processes	12
2.5	Green tea and white tea ( <i>Camellia sinensis</i> )	14
2.6	Chemical structures of major tea catechins	16
2.7	Trends of soft drinks production in Japan (1986-2009)	22
3.1	Layout of microplates used for ORAC assay	64
3.2	Schematic flow diagram of the UHT plant (Alfa Laval NZ Ltd)	72
3.3	Laminar flow cabinet (Laftech, Australia) and filler	73
4.1	General chemical structures of catechins	87
5.1	Growth of yeasts and moulds from internal surfaces of PET bottles and lids after plating on YGC agar	102
5.2	Growth of mould on YGC agar after plating nectarine beverage stored at 20 °C for 90 days	104
5.3	Growth of mould on YGC agar after plating nectarine beverage stored at 20 °C for 90 days	104
5.4	Growth of mould on YGC agar after plating mango beverage stored at 20 °C for 63 days	105
5.5	Growth of mould on YGC agar after plating nectarine beverage stored at 20 °C for 90 days	105
5.6	Growth of mould on YGC agar after plating heat-shocked mango beverages	106

5.7	Total phenolics in non-UHT-treated and UHT-treated beverages during storage	108
5.8	Oxygen radical absorbance capacity (ORAC) in non-UHT-treated and UHT-treated beverages during storage	109
5.9	Free radical scavenging activity (DPPH• EC <sub>50</sub> ) in non-UHT-treated and UHT-treated beverages during storage	109
5.10	Concentrations of phenolics and methylxanthines (µg/mL) in non-UHT-treated and UHT-treated mango beverages stored for 90 days at 20 °C.	113
5.11	Concentrations of phenolics and methylxanthines (µg/mL) in non-UHT-treated and UHT-treated mango beverages stored for 90 days at 40 °C.	113
5.12	Concentrations of phenolics and methylxanthines (µg/mL) in non-UHT-treated and UHT-treated nectarine beverages stored for 90 days at 20 °C.	114
5.13	Concentrations of phenolics and methylxanthines (µg/mL) in non-UHT-treated and UHT-treated nectarine beverages stored for 90 days at 40 °C.	114
5.14	Concentrations of phenolics and methylxanthines (µg/mL) in non-UHT-treated and UHT-treated pomegranate beverages stored for 90 days at 20 °C.	115
5.15	Concentrations of phenolics and methylxanthines (µg/mL) in non-UHT-treated and UHT-treated pomegranate beverages stored for 90 days at 40 °C.	115
5.16	Formation of gallyl and galloyl radicals from EGCG	119
5.17	UHT-treated beverages stored for 90 days at 20 and 40 °C	123

# List of Tables

Table	Title	Page
2.1	Estimated wholesale value (USD \$billion) of the tea industry in the United States	21
2.2	Procedures for extraction of phenolic and methylxanthine compounds	31
2.3	Parameters of HPLC-DAD systems used for analysis of phenolic and methylxanthine compounds	33
3.1	Gradient program used to separate phenolics and methylxanthines	66
4.1	Heat-resistant moulds (cfu/50 mL) in mango-flavoured beverages	79
4.2	Total phenolic content and antioxidant capacity in non-UHT-treated and UHT-treated mango-flavoured beverages	82
4.3	Concentration of phenolics and methylxanthines (mg/L) in white tea and grape seed aqueous extracts	89
4.4	Concentration of phenolics and methylxanthines (mg/L) in non-UHT-treated and UHT-treated mango-flavoured beverages	89
5.1	Total soluble solids (°Brix) and pH of UHT-treated pomegranate-, mango-, and nectarine-flavoured beverages stored for 90 days at 20 and 40 °C.	99
5.2	Heat-resistant moulds (cfu/50 mL) in non-UHT treated and UHT-treated pomegranate-, mango-, and nectarine-flavoured beverages (cfu/50 mL) stored for 90 days at 20 and 40 °C.	101
5.3	Hedonic rating scores for flavour and appearance of UHT-treated beverages stored for 90 days at 20 and 40 °C	121

# List of Abbreviations

AAPH	2,2'-Azobis (2-amidino-propane) dihydrochloride
ANOVA	Analysis of variance
cfu	Colony forming units
CG	(-)-Catechin gallate
CIP	Cleaning-in-place
CV	Coefficient of variance
DPPH	2,2-Diphenyl-1-picrylhydrazyl
DAD	Diode array
EC	(-)-Epicatechin
ECG	(-)-Epicatechin gallate
EGC	(-)-Epigallocatechin
EGCG	(-)-Epigallocatechin gallate
FDA	Food and Drug Administration
FL	Fluorescein
GC	(-)-Gallocatechin
GCG	(-)-Gallocatechin gallate
GLM	General Linear Model
h	Hour
HAT	Radical quenching via hydrogen atom transfer
HPLC	High-performance liquid chromatography
HTST	High-temperature short-time
LDL	Low-density lipoproteins
MF	Microfiltration
ORAC	Oxygen radical absorbance capacity
PDA	Potato dextrose agar
Re	Reynolds number
RTD	Ready-to-drink
s	Seconds

SD	Standard deviation
SET	Single electron transfer
TEAC	Trolox equivalent antioxidant capacity
TFA	Trifluoroacetic acid
UF	Ultrafiltration
UHT	Ultra-high temperature
YGC	Yeast glucose agar with chloramphenicol