To whom it may concern

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Natalie d'Avila

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

A thesis submitted in partial fulfilment of the requirements for the degree of Master of Food Technology

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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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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