Cyprus University of Technology

Faculty of Geotechnical Sciences and Environmental Management

DOCTORAL THESIS

"The effect of canning process on textural properties, sensorial attributes and bioactive content of non-melting peach cultivars"

Author:

Marina Christofi

A thesis submitted in fulfilment of the requirements

for the degree of Doctor of Philosophy

in the

Department of Agricultural Sciences,

Biotechnology and Food Science

September, 2021

CYPRUS UNIVERSITY OF TECHNOLOGY

FACULTY OF GEOTECHNICAL SCIENCES AND ENVIRONMENTAL MANAGEMENT

DEPARTMENT OF AGRICULTURAL SCIENCES, BIOTECHNOLOGY AND FOOD SCIENCE

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Approval Form

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Presented by

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Cyprus University of Technology
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DECLARATION

This is to certify that the data presented in this doctoral thesis are the results of an original research work conducted by the author at the Cyprus University of Technology (CUT), unless otherwise indicated. The work contained herein has not been submitted, in whole or in part, to obtain any other degree or professional qualification in this or any other academic institution. Data of this study have been published or submitted in three peer-reviewed journals. In addition, part of the data of the current dissertation have been defended as an oral presentation in a conference, held under the auspices of the European Cooperation in Science and Technology – COST action (CA15136).

Signature: Marina Christofi

PUBLICATIONS

During the course of this PhD degree, data have been published or submitted in peer-reviewed journals which are based on the work presented in this thesis. They are listed here for reference:

1. Christofi, M., Mourtzinos, I., Lazaridou, A., Drogoudi, P., Tsitlakidou, P., Biliaderis, C.G. and Manganaris, G.A., 2021. Elaboration of novel and comprehensive protocols toward determination of textural properties and other sensorial attributes of canning peach fruit. *Journal of Texture Studies*, 52, 228-239.

2. Christofi, M., Mauromoustakos, A., Mourtzinos, I., Lazaridou, A., Drogoudi, P., Theodoulidis, S., Biliaderis, C.G. and Manganaris, G.A., 2021. The effect of genotype and storage on compositional, sensorial and textural attributes of canned fruit from commercially important non-melting peach cultivars. *Journal of Food Composition & Analysis*, 103, 104080.

3. Christofi, M., Pavlou, A., Lantzouraki, D.Z., Tsiaka, T., Myrtsi, E., Zoumpoulakis, P., Haroutounian, S.A., Mauromoustakos, A., Biliaderis, C.G. and Manganaris, G.A., 2021. Profiling phytochemicals in fresh and canned fruit of non-melting peach cultivars: impact of genotype and canning process on their content. *Manuscript under evaluation*

Oral Presentation

1. The impact of genotype and canning process on phenolic and carotenoid composition of eight non-melting peach cultivars reveals varietal differences among fresh and processed products. International Conference on Carotenoid research and applications in agro-food and health, 26-28 November 2019, Lemesos, Cyprus

ACKNOWLEDGEMENTS

The completion of this PhD dissertation could not have been accomplished without the continued support and nurturing of my husband Stavros Panayiotou. Nobody has been more important to me in the pursuit of this PhD than him. His endless patience, generous guidance and encouragement kept me going even in most difficult moments faced throughout all these years.

I would like to thank my esteemed supervisor, Dr. George Manganaris for his invaluable supervision, support and tutelage during the course of my PhD degree. I offer to him my sincere appreciation for the learning opportunities provided me and his continuous motivation on all aspects of this research. Besides my academic advisor, I would like to express my deepest gratitude to Prof. Costas Biliaderis, as a member of my advisory committee, for his treasured support and extensive guidance which was really influential in shaping my experimental procedures and critiquing my results throughout this PhD. My gratitude extends to his research group in Aristotle University of Thessaloniki, particularly to Dr. Athina Lazaridou for her vast and insightful knowledge she conveyed to me especially regarding the elaboration of mechanical and textural protocols, as well as to Dr. Ioannis Mourtzinos for his knowledge and guidance provided me during the development of a comprehensive protocol in sensory analysis of canned peach products.

I am grateful to all of those with whom I have had the opportunity to interact during my mobility grant to Aristotle University of Thessaloniki under the scheme of a 3-

month scientific mission, funded by the COST action (CA15136). I am deeply indebted to Dr. Pavlina Drogoudi for her precious assistance and scientific contribution kindly providing especially in the beginning and during this PhD. I additionally thank Mr. Evangelos Karaindros, an agronomist, for provision of the raw fruit material of the examined cultivars and Mr. Stelios Theodoulidis, CEO of Venus Growers, for providing his technical assistance and support during fruit processing.

I would also like to express my sincere thanks to Dr. Andrea Pavlou for her precious contribution, constructive suggestions and decisive role in the analysis of phytochemicals. My sincere thanks also goes to Dr. Andy Mauromoustakos who kindly assisted me to become acquainted with sophisticated statistical analysis in this dissertation. I very much appreciate the support and the practical advices of Mr. Panagiotis Mousikos.

I must also thank Dr. Panagiotis Zoumpoulakis and his research group members, Dr. Dimitra Lantzouraki and Dr. Thalia Tsiaka as well as Dr. Serkos Haroutounian and his research group members, particularly Mrs. Elena Mirtsi, for providing their knowledge in analytical chemistry and performing the phytochemical analyses using state-of-the-art infrastructure.

Most importantly, I would like to thank and express my forever grateful to my family, for always being there for me when I needed. This dissertation stands as a testament to their unconditional love and patience.

My heartfelt thanks to all!

ABSTRACT

Peach (*Prunus persica* (L.) Batsch) belongs to the Rosaceae family and Amygdyloideae subfamily, grouped under the *Prunus* genus with origin from the Asian continent. It is one of the most important temperate fruit crops worldwide in terms of production volumes. A significant portion of peach fruits are being processed and are being offered as canning product throughout the year. Canned peach fruit is an added-value product, attractive to a different target market than the fresh fruit and facilitate year-round availability. Peach canning industry largely expands its finished products in the global market, having important economic implications for the main peach producing countries. Despite the great economic importance, a limited number of studies have dealt with the assessment of textural properties, compositional and sensorial perception as well as the nutritional profile of peaches destined for canning process.

Fruit of eight clingstone non-melting peach cultivars (cvs. 'Romea', 'Catherina', 'Mirel®', 'Fercluse®', 'Andross', 'Everts', 'Ferlate®', 'VLG') with scalar on-tree ripening, spanning from beginning of July to mid of September, was used as study material for the needs of the current dissertation. Fruits were harvested at commercially maturity stage based on destructive and non-destructive indicators and qualitative attributes, including flesh colour, flesh firmness, soluble solids content and titratable acidity of fresh produce, were determined. Subsequently, lots of fruit with similar maturity indices per cultivar were processed at two filling mediums; the standard (LS, light syrup) and a low-calorie filling medium (GJ, grape juice syrup) to fit with current consumer-market trends. Canned peaches were assessed for their qualitative and textural attributes.

The latter were assessed with the employment of a multipurpose texture analyzer through application of three large deformation assays (Puncture, Texture Profile Analysis, Kramer shearing). Individual organic acids and sugars in the fresh and canned fruit were quantified using liquid chromatography. Sensory quality attributes of canned products were evaluated through the establishment of a customized quantitative descriptive analysis. Total phenolics, total carotenoids and individual bioactive compounds (both in fresh and canned forms) were determined with the employment of UV-vis spectrophotometer and LC-MS/MS, respectively.

The abovementioned protocols were employed in three interrelated, yet complementary, research works. Initially, the aim of the first technical study was dual and included the setting up of a list of sensorial descriptors and the elaboration of an analytical toolkit to evaluate the textural properties of canned peaches using large deformation mechanical analysis. Thereafter, the effect of canning process on compositional, sensorial and textural attributes of fruit of an array of non-melting peach cultivars, packed in LS and GJ syrup was assessed. Such analyses were conducted after 6 and 24 months post-canning. Subsequently, the phytochemical content (carotenoids and phenolic compounds) of the examined cultivars was determined in order to assess the effect of both the genotype and the canning process on the bioactive content of peach fruit.

The objective of the initial study dealt with the setting up of a list of sensorial descriptors and the elaboration of a toolkit to evaluate the textural properties of canned peaches using large deformation mechanical testing. To this aim, a standardized vocabulary ("consensus language") was initially developed towards the determination and

quantification of 15 sensorial attributes through a quantitative descriptive analysis (QDA) approach. Textural properties were additionally evaluated with a TA-XT Plus texture analyzer by applying three discrete large deformation tests [(a) puncture test with a flat cylindrical probe; (b) texture profile analysis (TPA) with a flat compression plunger; and (c) Kramer shear test (KST) cell with a bladed fixture]; that is a total of nine textural properties, namely, "puncture firmness" (individual halves), "Kramer" hardness (applied in a complex mixture of peach slices), "TPA" hardness (central section of halves), fracturability, consistency, cohesiveness, springiness, chewiness, and total hardness. The established protocols, providing complementary information, are readily applicable to the canning industry in setting up qualitative tests to determine product shelf life as well as to assist on going breeding programs for the evaluation of new candidate clingstone cultivars.

Subsequently, the above-mentioned protocols were employed in an array of non-melting peach cultivars. Descriptive quantitative analysis indicated discrete varietal differences, providing useful insights for the industry regarding the quality and marketing potential for canned products of each cultivar. Fruit packed in diluted clarified grape juice concentrate, aiming towards a less caloric content product, demonstrated an inferior consumer perception regarding bitterness, astringency and off-taste. Storage of the canned fruit (6 versus 24 months) led to texture depletion modifications on a cultivar-dependent manner. 'Ferlate®' registered desirable textural properties, while 'Mirel®', besides the appealing orange-coloured fruit pieces, aligned with satisfactory sensorial properties, provide further marketing options for the peach canning industry. Both early ('Romea')

and late season ripening ('VLG') cultivars were proven amenable to canning with acceptable quality attributes, offering a sustainable solution towards extension of the non-melting peach harvesting season. However, their qualitative attributes were inferior of the rest examined cultivars and new genotypes with early or late ripening can be exploited towards the extension of the peach canning campaign.

Lastly, the effect of genotype and canning process on bioactive content was determined. Data showed that the individually quantified phytochemicals as identified in fresh fruit, differ significantly among the examined cultivars. Notably, the widely grown 'Andross' cultivar demonstrated the highest contents. In terms of phytochemical profile upon canning, the use of grape juice as filling medium, a liquid matrix higher in bioactive content compared to sugar syrup, resulted in reduction of the degradation of bioactive compounds, possibly by balancing out diffusion processes between fruit tissue and packing medium. In addition, grape juice also supplies a good source of polyphenols while this is not the case for the sugar-based standard syrup. Overall, the canning process differentially affected individual carotenoids and phenolic compounds. Peach carotenoids and α-tocopherol with the exemption of β-carotene were more stable than phenolic compounds upon thermal treatment and subsequent storage. The sum of zeaxanthin and lutein remained unaffected by the caning process compared to β-carotene. All soluble phenolic compounds, including neochlorogenic acid, chlorogenic acid, procyanidin B1 and catechin, showed a dramatic decrease after the canning process. Oligomeric and polymeric proanthocyanidins, which are relevant phenolics in peach, were not studied in the present project as they were not extracted with the solvents used. Overall, the unique

cellular matrix of each cultivar seems to modulate the degree of loss of bioactive compounds as well as the cellular degradation of the fruit tissues and thereby affecting the diffusion of biochemical components into the liquid media, thus rendering certain cultivars and packing liquids more appropriate for canning.

Results reported herein shed light on largely unexplored areas of research dealing with the canning industry. The established protocols that can be used for determination of sensorial and textural properties of canned peach products can be exploited both by the industry to evaluate a given product and additionally provides to breeders an excellent tool to select new advanced clingstone peach cultivars, amenable to canning with superior properties. Moreover, the proposed analytical toolkit would be valuable to establish appropriate thermal processing protocols aiming at desirable end-product quality characteristics as well as to monitor the shelf life of these processed fruit products. From the nutritional standpoint, the unique cellular matrix of individual peach fruit cultivars seems to modulate the degree of loss of bioactive compounds during the canning process. The present study was focused on those phenolic that could be absorbed in the small intestine and therefore can have direct systemic effects. The analysis of oligomeric and polymeric proanthocyanidins, which are relevant phenolics in peach, should be considered as a future perspective, as they interact with gut microbiota and are relevant (poly)phenols regarding health-promoting effects.

Keywords: *Prunus persica*, clingstone, texture, aroma, firmness, fruit processing, quantitative descriptive analysis, sensory evaluation, texture profile analysis, phenolics, carotenoids, nutrition, canning