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EVALUATION OF AN INTERNATIONAL DOUBLE Ph.D. RESEARCH DISSERTATION IN RESPECT OF **Ms. MARINA CANO LAMADRID**, UNIVERSITAS MUGUEL HERNÁNDEZ (SPAIN) AND WROCŁAW UNIVERSITY OF ENVIRONMENTAL AND LIFE SCIENCES (POLAND).

Supervisors:

Prof. Ángel Antonio Carbonell Barrachina

Prof. Aneta Wojdyło

The submission “**DEVELOPMENT AND INNOVATION OF HYDROSUSTAINABLE PRODUCTS BASED ON POMEGRANAT**” consists of *Doctoral thesis structure, List of Abbreviations, Abstract (in English, Spanish, and Polish), Introduction, Aim and objectives, Material and methods divided in Block I – IV, Results and discussion, Results and Discussion, Conclusions, References, Publications.*

On the first page of the Introduction, the Candidate presents the current problems of modern agriculture related to climate change and the irrigation deficit. This issue is particularly relevant to the Mediterranean countries, including Spain. According to the Candidate, pomegranate farming under deficit irrigation will improve its content of bioactives and its sensory profile at the same time that water-use efficiency will also be enhanced. Then, the Candidate described pomegranate in terms of the cultivation, presence of phenolic compounds such as tannins (especially punicalagin and punicalin) and flavonoids (especially anthocyanins). The Candidate emphasizes that punicalagins act as precursors of urolithins, which are the compounds that will finally benefit human health. Diabetes, cancer, and metabolic and cardiovascular diseases are listed as diseases that can be prevented by pomegranate consumption.

The overall aim of the PhD dissertation was to innovate, to develop and to characterize novel product based on pomegranate with an identity that includes the functional and organoleptic properties of hydrosustainable products which are adapted to the needs and requirements of European consumers. Seven specific objectives were established. They are listed on the pp. 32-33 of this dissertation. The structure and aim/objectives of this PhD thesis were formulated in a logical way and do not raise my doubts. I highly appreciate the quality of the Figure 1, which makes it very easy for the reader to understand the structure and aim/objectives of this PhD thesis.

Several methods were used by the Candidate in the study. Description of these methods includes:

- Morphological, physical, and chemical parameters
- Extraction and chromatographic analysis of volatile compounds.
- Mineral content
- Pectins and vitamin C content
- Sugar and organic acid content
- Antioxidant capacity and total polyphenols content (TPC)
- Identification and quantification of punicalagin and ellagic acid
- Polyphenols including procyanidins
- Sensory analysis
- Consumer study
- Statistical analysis

In the opinion of the reviewer, the selection of methods is correct. The methods are typical for this type of analysis. Modern analytical equipment was used in the research. At this point, I would like to emphasize the candidate's great analytical skills. In my opinion, in several places of paragraph "5.5. Measurements", corrections should be made:

P. 42 – It should be 1 mol L^{-1} instead of "1 N".

P. 42 – It should be 15 g/100 mL^{-1} instead of "15% ...".

P. 42/43 – It should be "gas chromatography ... mass spectrometer ...".

P. 43 – "a flame ionization detector".

P. 43 – It should be rather "macrominerals and microminerals".

P. 44 – It should be "DPPH method" or "DPPH radical method" or "DPPH• method".

P. 45 – It is not clear what was a sample for determination of punicalagin and ellagic acid.

P. 45 – The style of "polyphenols and procyanidin" is incorrect because procyanidins belong to polyphenols.

P. 45 – It should be "anthocyanins".

The main findings of the study are well described. This part of the study is easy in reading. In Discussion, the Candidate relevantly cites results of other scientific studies which confirm her comments and interpretations. The Candidate is able to lead scientific discussion using published literature data. The breadth of his knowledge pertaining to life science is extensive.

The results of this PhD thesis were published in journals:

Cano-Lamadrid M., Galindo A., Collado-González J., Rodríguez P., Cruz Z.N., Legua P., Burló F., Morales D., Carbonell-Barrachina, Á.A., Hernández F. (2018). Influence of deficit irrigation and crop load on the yield and fruit quality in *Wonderful* and *Mollar de Elche* pomegranates. *Journal of the Science of Food and Agriculture*, 98: 3098-3108.

Cano-Lamadrid M., Lipan L., Calín-Sánchez Á., Hernández F., Carbonell-Barrachina Á.A. A (2017) Comparative study between labeling and reality: the case of phytochemical composition of commercial pomegranate-based products. *Journal of Food Science*, 82: 1820-1826.

Cano-Lamadrid, M., Turkiewicz, I.P., Tkacz, K., Tkacz, K.b, Sánchez-Rodríguez, L., López-Lluch D., Wojdyło A. Sendra E., Carbonell-Barrachina A.A. (2019). A critical overview of labeling information of pomegranate juice-based drinks: phytochemicals content and health claims. *Journal of Food Science*, 84: 886-894.

Cano-Lamadrid, M., Lech, K., Michalska, A., Wasilewska M., Figiel A., Wojdyło, A., Carbonell-Barrachina, Á.A. (2017). Influence of osmotic dehydration pre-treatment and combined drying method on physico-chemical and sensory properties of pomegranate arils, cultivar Mollar de Elche. *Food Chemistry*, 232: 306-315,

Cano-Lamadrid M., Vázquez-Araújo L., Sánchez-Rodríguez L., Wojdyło A., Carbonell-Barrachina Á.A. (2018). Consumers' opinion on dried pomegranate arils to determine the best processing conditions. *Journal of Food Science*, 83: 3085-3091.

Cano-Lamadrid, M., Nowicka, P., Hernández, F., Carbonell-Barrachina, A.A., Wojdyło, A. (2018). Phytochemical composition of smoothies combining pomegranate juice (*Punica granatum* L) and Mediterranean minor crop purées (*Ficus carica*, *Cydonia oblonga*, and *Ziziphus jujube*). *Journal of the Science of Food and Agriculture*, 98: 5731-5741.

Cano-Lamadrid M., Hernández F., Nowicka, P., Carbonell-Barrachina A.A., Wojdyło A. (2018). Formulation and storage effects on pomegranate smoothie phenolic composition, antioxidant capacity and color. *LWT – Food Science and Technology*, 96: 322-328.

All journals were reputable whose IF (2019 JCR) is: *Food Chemistry* – **6.308**; *LWT – Food Science and Technology* – **4.006**; *Journal of the Science of Food and Agriculture* – **2.614**; *Journal of Food Science* – **2.479**,

In all publications, the Candidate is a first author. Her participation in research and publication preparation ranges from 25 to 45%. The participation was related to conceptualization, formal analysis, and original draft preparation. This was confirmed by the signatures of the co-authors of the publication.

The series of publications included in the PhD theses is thematically compact. It corresponds perfectly to the title of the dissertation. I have no criticisms of the publication. In reputable journals, they have passed the substantive assessment of reviewers and editors before being approved for publication.

The topic chosen for research by the author is interesting from fundamental and practical point of view. The title is adequate as well as relevant and indicates the work undertaken in the thesis. The Abstract summarizes the thesis well. The objectives of the study have been clearly set forth by the Candidate. The Ph.D. thesis is written in intelligible English.

All chemicals used by the Candidate were purchased from renowned chemical companies. For this study, the Candidate used standard methods and techniques of phytochemistry, analytical chemistry, and food science. In conclusion, I can state that all results obtained are credible.

The Candidate has presented in evaluated PhD thesis an up-to-date review of the literature pertaining to the topics. The bibliography is well prepared by the Author and include 107 references that are relevant to subjects of this study.

Conclusions are formulated correctly and correspond to the goals of the study. In my opinion the main and most important conclusions are as follows:

- The best treatment of *Wonderful* and *Mollar de Elche* pomegranate cultivars was T1A1, which consisted of the simultaneous application of soft deficit irrigation during fruit growth and ripening and the application of thinning.
- The “real and analyzed” contents of the key compounds should be declared on product labels, as indicators of the potential health benefits, and should be replace subjective or expected functional descriptions.
- The main liking drivers of developed dehydrate arils were high content of esters, low content of furans, high fruity notes, sweet taste and low seed hardness.
- A positive effect of the addition of minor crops was observed on the nutritional and functionality of the novel pomegranate smoothies.

An essential part of the work are “Implications in the agriculture and food industry”. They are very thoughtful and correctly presented. I am agree with the Candidate that improving the quality of dried pomegranate arils and smoothies based on pomegranate and minor Mediterranean crops must increase the popularity of these fruit. Novel pomegranate-based products prepared using fruits grown under environmental friendly practices should encourage both food industry and consumers to produce, but and consume these high-quality products.

In my opinion, suggestions about Future work are very valuable. It is worth emphasizing that it is worth to continue the research to know the effect of farming, types of commercial products, drying techniques, formulation of novel pomegranate products, blend of fruit, heat treatments but going further by studying the effects on human health, for instance starting by biological activities such as anti-diabetic, anti-obesity and anticholinesterase action.

Final conclusion

When taking into account all of my above comments, I would like to state that, the PhD thesis being assessed is distinguished by a very high scientific level, was made using modern research methods, and the obtained results were presented, analyzed and interpreted in a thorough manner. It should be emphasized that the Candidate has extensive chemical and biological knowledge and analytical skills. The content of the doctoral dissertation of Ms. Marina Cano Lambardid "Interactions of phenolic compounds with matrix components as a factor determining the quality of fortified food" and the resulting valuable application possibilities allow me to conclude that it meets all the requirements specified in Regulation of the Minister Of Science and Higher Education (Art. 261., January 19, 2018) on academic degrees and academic title as well as degrees and title in the field of art (Journal of Laws No. 261, as amended). Therefore, with full conviction, I submit an application to the Council of the Wrocław University of Environmental and Life Sciences for the admission of Ms. Marina Cano Lamadrid to the public defense of this thesis.

A handwritten signature in black ink, appearing to be 'A. C.', located at the bottom right of the page.