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Thesis report

Title: **Creation of high-quality plant-based powders with targeted health-oriented properties**

Doctoral dissertation submitted to the Wrocław University of Environmental and Life Sciences. Faculty of Biotechnology and Food Science (Wrocław, Poland) in the fulfilment of the requirements for the degree of Doctor in Philosophy, Nutrition and Food Technology Discipline, by **Jessica Brzezowska**.

Report by:

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The doctoral dissertation entitled ***Creation of high-quality plant –based powders with targeted health-oriented properties*** represents a contribution in the technological production of plant-based powders and their potential bioactivities. The study was performed in an international collaboration (Poland and Spain), which have imbibed of different disciplines such as engineering processing, the modelling of the plant-based powders and the assessment of the risks-benefits of the plant-based powders using different matrices.

Globally, consumers are demanding more plant-based products which at the same time are good, nutritional, affordable and beneficial for them, and sustainable with the environment. These plant-based products have to be safe, organoleptically acceptable and, if possible, bioactive for the consumer. Moreover, the production of plant-based products have to be feasible and profitable for industry and if possible, produce under circular economy principles. Therefore, the thesis described herein had the general research objective of assess the risk-benefit of the production of plant-based powders using different processing conditions and plant-matrices, including the study of their physicochemical and biological characterisation and recommendations for their production. The study was divided into 5 specific aims:

- (i) Conversion of pomace-originated phenolic preparations into soluble type products and characterisation of its physical attributes phenolic profile, antioxidant capacity and hydroxymethyl-*L*-furfural (HMF).
- (ii) Evaluation of matrix effect on phenolic and amino acid profiles during freeze-drying and study of their antidiabetic, antiglycation and antioxidant properties.
- (iii) Study of the formation of process contaminants employing model systems.
- (iv) Assessment of the carriers for drying and their impact on antimicrobial potential and *in vitro* anti-inflammatory properties.
- (v) Study of the impact of fermentation, drying technique and carrier type on phenolic composition, antioxidant activity, antiglycation and *in situ* antiproliferation.

The study was carried out in 3 stages, including a case study per stage:

Stage I included the study of chokeberry (*Aronia melanocarpa*) and cranberry (*Vaccinium macrocarpon*) pomace preparations. In this part, acetic and ethanolic extracts of the pomaces were obtained, combined with different carriers (maltodextrin, inulin and trehalose) and processed under freeze-drying and vacuum drying conditions.

The main results obtained for chokeberry indicated that the addition of maltodextrin and trehalose, as carriers, increased phenolic compound retention and reduce HMF formation. Moreover, all the samples showed antioxidant activity when TEAC ABTS and FRAP methods were assessed. In the case of extraction of cranberry pomace, extraction with 50% (v/v) ethanol would be the best option in order to obtain the plant-powder with the highest phenolic composition and the lowest HMF content. Moreover,

the author made a good use of the principal component analysis, which allow her to differentiate among samples and treatments, providing a lot of information in relation to the physicochemical properties, phenolic composition, antioxidant activity and HMF content.

Stage II included the study of blackcurrant (*Ribes nigrum*), rosehip (*Rosa canina*), haskap berry (*Lonicera caerulea*) and Japanese quince (*Chaenomeles japonica*) preparations. In this part, plant-powders were prepared using the following fractionation: whole fruits, juice, pomace and sugar-free juice preparations. In this study, only freeze-dried method was performed. The antidiabetic, antiglycation and antioxidant activities of the generated fruit powders were assessed. Furthermore, different simplified model systems were also prepared, using the sugars and organic acids presented in the juices combined with carriers, and dried using 4 different techniques (freeze-drying, vacuum-drying at 60 and 90 °C and spray-drying), in order to understand the effect of the food matrix on contaminants formation (HMF and furfural).

In the case of the different fractionation of fruits, overall, the main results showed an increased in phenolic compounds, antioxidant, antidiabetic (lower IC₅₀ for alpha-amylase and alpha-glucosidase inhibitory activities) and antiglycation activities in the sugar-free juice product, in comparison with the juice, pomace and fruit, indicating that there is a concentration of phenolic compounds. The findings obtained for the simplified models indicated that vacuum drying was the technique, which produced higher contents of furfural and hydroxymethyl-*L*-furfural, and that the content of ascorbic acid should be taken into account in relation to the formation of process contaminants.

Stage III included the study of 3 different varieties of blueberries (*Vaccinium corymbosum*), which were used for sugar free juice preparation in order to study the impact of the variety, carrier agent and the drying technique in the phenolic composition and antioxidant activity. The main results showed that the addition of a carrier agent and the type of cultivar had a strong influence in the phenolic composition and antioxidant activity. The impact of cultivar, drying technique and inulin as a carrier agent was also determined on the antibacterial properties against *Campylobacter jejuni* and *Helicobacter pylori* and on the anti-inflammatory activity. Data on

antimicrobial and anti-inflammatory activities indicated that the dilution factor of the presence of inulin decrease these activities.

Moreover, as a case study beetroot (*Beta vulgaris*) juice was fermented with *Lactobacillus plantarum* and dried using different prebiotic carriers and drying techniques. The physical attributes, phenolic composition, HMF formation, antioxidant, antiglycation and antiproliferation activity were determined.

The main results indicated that the initial matrix material and the carrier agent used during the drying process impacted the physicochemical properties, contaminants formation (HMF), antioxidant antiglycated and antiprofilferative activities.

All these findings are an important achievement of the PhD candidate as they are original, and have scientific soundness and industrial interest. I would like also to highlight the impressive curriculum of the candidate, with projects as a principal investigator and contractor, deep specific international training, 2 awards and 3 distinctions. Moreover, she has already 9 peer review publications in good international journals, as well as her participation presenting her research in scientific conferences and workshops.

Overall conclusion

The thesis presented in a mixed format (written explanations with already accepted or submitted publications) is satisfactory and comply with high European standards. The literature review, the gaps in the area of study, the hypothesis and aims are properly described and well-presented. The methodology applied to generate the results is of high quality including a myriad of techniques which went from processing to phycochemical characterisation as well as bioactivity. I also want to remark the impressive capacity of presenting such a complicated data (due to the amount of samples and conditions) in a simple and understanding way using radar diagrams and, tables and correlograms. The findings obtained together with the discussion and conclusions are well described and presented. The thesis makes a significant original contribution to the food science and processing area, giving even recommendations for their application in plant-based powder production highlighting its practical application in food industry and proposing the use of underutilised subproducts such as pomaces from fruits.

In my opinion, the doctoral dissertation prepared by M. Sc. Jessica Brzezowska fulfils all requirements posed on theses aimed for obtaining PhD degree and therefore I recommend acceptance of the thesis and the continuation of the doctoral proceedings. The doctoral dissertation meets the conditions set out in art. 187 ust. 1-4 ustawy z dnia 20 lipca 2018 r. Prawo o szkolnictwie wyższym i nauce (Dz. U. z 2023, poz. 742 ze zm. I also consider that the dissertation is outstanding due to the originality, good quality and variety of techniques used in the same together with the curriculum vitae of the PhD candidate, in case this can be considered for the distinction at the University level.



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