UNIVERSITY OF AGRICULTURE
IN KRAKOW

Kraków, 10.08.2023

Dr hab. inż. Emilia Bernaś, prof. URK
Department of Plant Products Technology and Nutrition Hygiene
Faculty of Food Technology
University of Agriculture in Krakow
Balicka 122 Str., 30-149 Krakow, Poland

DOCTORAL DISSERTATION REVIEW

Doctoral dissertation of **MSc Emel Hasan Yusuf** entitled **„Novel carrot snacks with desired health benefits"** done under the direction of Associate Professor Paulina Nowicka as a supervisor and PhD Ana Isabel Bourbon as a second supervisor in the Wrocław University of Environmental and Life Sciences, in the Faculty of Biotechnology and Food Science, in discipline: Nutrition and Food Technology.

1. Legal basis for the review

The doctoral dissertation review was prepared on the Resolution of the Scientific Council of the Discipline Food Technology and Nutrition of the Wrocław University of Environmental and Life Sciences of June 13, 2023, according to which I was appointed as the Reviewer of the doctoral dissertation Emel Hasan Yusuf, M.Sc. entitled „Novel carrot snacks with desired health benefits".

2. Justification of taking up the topic

Modern consumers prefer functional food that is beneficial for the body and contributes to a healthy lifestyle, and at the same time, they are also convenient for storage, handling and consumption. World Health Organization also promotes the preparation of innovative food products that symbolize nutritious and healthy choices for consumers. In this sense, ready-to-eat products, such as snacks, are the most appropriate option for consumers' healthy lifestyles. The creation and manufacturing of functional products are in the focus of attention of scientists and specialists involved in the development of modern technologies and food quality criteria.

Despite expert recommendations, most children consume sugary drinks and more sweet and salty snack foods than fruits and vegetables as snacks. Carrots, among the most important root vegetables in the *Apiaceae* family, are cultivated worldwide. The storage root is widely utilized

due to its richness in carotenoids, anthocyanins, dietary fiber, vitamins, minerals and other nutrients. Orange carrot is the best-known and most frequently used carrot variety in the food industry, while other varieties are used only to a small extent. Therefore, in my opinion the research topic undertaken by the PhD student regarding the assessment of the health-promoting properties of carrot snacks, depending on its variety (orange, yellow, white, purple), size and production method, is very important for the development of the food and nutrition technology discipline. The obtained results allowed to obtain products with strictly defined health-promoting properties and, at the same time, good sensory quality. The comprehensive approach of Emel Hasan Yusuf, M.Sc. to the subject deserves attention and emphasis. At the beginning, the PhD student characterized the raw material in terms of physicochemical and health-promoting properties, then assessed its suitability for the production of juices, smoothies and chips intended inter alia for children, and finally examined the functional properties of the obtained products. An important aspect of the research was also the use of Polish fruit juices (raspberry, apple, pear, strawberry, and sour cherry) for the production of snacks, which enriched the obtained snacks with bioactive compounds and, in many cases, improved their sensory qualities. The obtained results certainly contribute to the development of science in the field of food processing and human nutrition, but also, due to their application nature, to the development of the food industry.

3. Formal assessment of the dissertation

As his scientific achievement, Emel Hasan Yusuf, M.Sc. presented a series of 5 papers published in 2021- 2023 in journals included in the JCR database, i.e. published by Multidisciplinary Digital Publishing Institute (MDPI) (2 papers) – Foods and Antioxidants, Springer (1 paper) - European Food Research and Technology, John Wiley & Sons, Inc. (1 paper) - Journal of the Science of Food and Agriculture and Elsevier publishing house (1 paper) - Food Science and Technology (LWT). The total Impact Factor of articles of doctoral dissertation is 26.915, and the sum of points according to the score of the Ministry of Science and Higher Education, calculated according to the year of publication, is 470. According to Web of Science, the number of citations of these works as of July 21, 2023 is 19. All publications are team works in which the PhD student is listed as the first of the Authors, and his contribution consisted mainly in creating a research plan, preparing research material, conducting experiments and analysis, especially bioactive compounds and health-promoting properties, as well as statistical processing of the results obtained and co-editing the text of the manuscripts after reviews. The documentation includes statements of supervisor confirming participation of the PhD student in the creation of these publications, unfortunately there are no statements of the rest co-authors and there is no percentage share of Emel Hasan Yusuf, M.Sc., in their formation.

The work submitted for evaluation includes 58 pages of typescript and copies of published papers together with statements of the PhD student and supervisor. The dissertation has been divided into 6 main chapters: Introduction – 4 pages, Aim and hypothesis of the research - 1 page, Organisation of the research - 6 pages, Results and discussion - 26 pages, Conclusions - 2 pages, and Literature - 11 pages. It also includes abstracts in Polish and English, list of abbreviations and scientific achievements of PhD student. The layout of the work is typical for experimental studies. The form of the work is clear, and the table of contents placed at the

beginning facilitates the reader's orientation and quick access to the issues contained in individual chapters. The proportions of the individual chapters are reasonable. The list of literature contains 156 items, mostly original and English-language.

4. Substantive evaluation of the dissertation

The title of the dissertation is consistent with its content.

The thesis begins with an Introduction section, introducing the subject of the dissertation. It includes a review of the current state of knowledge on the issues described in the work, including the characteristics of carrot as a source of biologically active ingredients and a valuable raw material for the production of juices, smoothies and smacks. This part of the work is written very factually, based on properly selected literature, which proves the Author's knowledge of the literature on the subject. For this chapter, I have only one comment regarding the use of the phrase that carrot is abundant in vitamin C (p. 9). Carrots contain vitamin C, but its level is so low (approx. 5-10 mg/100 g) that it should not be treated as a raw material rich in this ingredient.

The next chapter is Aim and hypothesis of the research. The Author presented a scientific problem selected for solving, which was to investigate twelve carrot varieties with different sizes and colors as attractive raw materials for the development of innovative, functional snacks. The Author formulated 5 specific objectives: comparing 12 carrot varieties with different colors and sizes to find the variety with the highest health benefits for food processing (1), and in terms of chemical properties and antioxidant activities (2), comparing and identifying the best carrot varieties for juice production (3), utilizing four different carrot varieties in combination with Polish fruit juices to smoothies production (4), and assessment of possibilities of using osmotic dehydration, convective drying and microwave vacuum drying technologies to production of carrot snacks with health-promoting properties (5). For this chapter, I have only one comment: in my opinion it would be better to combine specific objectives 1 and 2 into one common objective, because they basically concern the same type of raw material, and differs only in the type of the analyzed determinant.

In the third chapter, Organisation of the research, the PhD student characterized and described the research methods used. Research tools have been very well selected for the conducted research. The PhD student used modern analytical techniques, such as Ultra Performance Liquid Chromatography with Photodiode Array Detector and Mass Detection, Atomic Absorption Spectrometry, in vitro methods for determination of antiageing, antidiabetic antiobesity activity and sensory analysis. This proves that Emel Hasan Yusuf, M.Sc. has great analytical skills and has a well-mastered research workshop necessary to conduct research in the area related to food technology and nutrition. A great facilitation for the reader is to present the course of the experiment using block diagrams. Nevertheless, I have a few questions about them:

- Figure 2. At what temperature was pressed the juices? Were the juices stored after production? If the juices were stored, for how long and under what conditions?
  I also have a comment regarding the preservation method used. In my opinion sterilization should have been used instead of pasteurization, because the pH of some juices was quite high (>5). An alternative could be their acidification to pH<4.5. At pH above 5 there is a risk that the juices may spoil quite quickly during storage.

- Figure 3. At what temperature was the carrot disintegration carried out?
  In Publication 4 there is information that the fruit juices were frozen, while there is no such information in the Fig. 3. In addition, in the case of carrot purees in Publication 4 it is stated that the purre was pasteurized, but there is no such information in the Fig. 3? Please clarify both issues by the PhD student during the doctoral defense.
- Figure 4. In Publication 5 there is information that the vacuum-microwave drying temperature was even 80°C, but in the Fig. 4 it is 50°C, please explain it during the doctoral defense.
  On page 18, the Author states that for determination of antiageing activity used method Gironés-Vilaplana et al. (2015), but in Publication 1 quotes the Ferreres method? Please explain it during the doctoral defense.
- Please specify the amount of fruit concentrates used for osmotic dehydration of carrots. Was 40 g the amount of concentrate used to produce 100 ml of solution, or was it the total extract of the solution used for osmotic dehydration? There is no such information in Publication 5.
- Both in Publications and in the Organization of the research chapter, the Author did not specify the varieties of carrots she used, she only specified the color of the roots. Please comment on this during the doctoral defense.

The next chapter Results and discussion contains a brief description and discussion of the obtained results during the analysis. The PhD student coped very well with the discussion of the results obtained, which was not an easy task due to the multitude of research objects and the number of analyzes. A great facilitation for the reader was to include a short summary at the end of the paragraph discussing a given parameter. In my opinion it was a good idea to use abbreviations of the names of the analyzed products, however, due to the use of similar letters, understanding the work often required checking their meaning, which made reading the work difficult.

The content of the chapter has been divided into four subchapters, according to the course of the experiment. In the first subchapter discussing the results of Publications 1 and 2, the PhD student compared 12 carrot varieties with different colors and sizes in terms of their chemical composition, including bioactive compounds and health-promoting properties. Based on the obtained results, she concluded that purple carrot is the best varieties for production of functional snacks due to due to high content of bioactive compounds such as pectins, vitamin C, and polyphenols. The second subchapter discussed the results of the Publication 3. PhD student compared the usefulness of 12 carrot varieties with different colors and sizes to production of juices with high health promoting activity and good quality, including the sensory evaluation. Based on the obtained results, it was proved that the best source of pro-healthy substances was juice from normal purple carrot, however, the best sensory quality had juices from orange carrot. In connection with the above, it would be necessary to look for a different application of purple carrot juices or to modify the production method to increase the color stability and improve the taste of juices. In the third part of the research, the suitability of carrots with different colors (purple, yellow, orange, white) were used for the production of functional carrot-fruit smothies. Raspberry, apple, pear, strawberry, and sour cherry juices were used for production. The analyzes showed that the smoothies made from purple carrots, raspberry, and sour cherry juice had the best functional activity, while the smoothie made from apple juice and white carrot had the highest sensory acceptance, but characterized low biological activity. Therefore, these products may constitute a new, functional component of children's diet. The

last subchapter discusses the research published in publication 5 concerning about using combination of osmotic dehydration, convective drying and microwave vacuum drying to prepare carrot snacks with high biological activity and good sensory quality. Based on the obtained results, it was proved that the use of osmotic dehydration using concentrated fruit juices in combination with convective and microwave vacuum drying allows obtaining tasty products with increased levels of polyphenolic compounds, especially when dehydrating in chokeberry concentrate was used. In addition, the use of sour cherry solution increased the antidiabetic, antiobesity and antiageing and activity of carrot snacks. The use of osmotic dehydration also allowed to shorten the drying time, and thus to reduce energy consumption, which is extremely important due to the constantly varying electricity prices.

Other notes on this chapter:

p. 23 What was the unit for determining the pectin content?

p. 25 In the case of correlations, the PhD student should discuss only those cases where found at least a strong relationship ($R^2 > 0.5$).

p.40 Why did the Author give the moisture content in dried carrot per 100 ml, instead of 100 g as is usually stated? After all, moisture content is a unit of mass, not volume.

p. 41 No explanation of the MR symbol used.

p. 41 Why in Publication 5 and Fig. 1 the Author uses the phrase "violet carrot", but in doctoral dissertation "purple carrot"?

p. 44 The PhD student quotes the range "from 4.99 to -20.31", and according to Publication 5 it should be 0.66-8.58 (OCSCS)? Please comment.

Based on the results presented in all 5 publications, 4 conclusions were drawn, presented in the Conclusions chapter, along with a short summary regarding the possibility of using the different carrot varieties for production of novel, functional food. Obtained data can be utilized for evaluating carrots as ingredients for developing innovative food products that are appealing to children.

The Literature is the last chapter. A significant part of this chapter are works published in international journals from JCR list. Most bibliographic items come from the last 10 years - 91 items, 58%. Some of the listed publications were not cited in the text of the dissertation: Blanco-Perez et al. (2021), Gharibzahedi and Jafari (2017), Jafari et al. (2017), Liu et al. (2016), Olszyk et al. (2020), Yang et al. (2021).

Copies of five publications constituting the doctoral dissertation are included at the end of the dissertation in the Annex.

5. Summary and final conclusion

To sum up, despite the indicated minor remarks, I believe that the doctoral dissertation of Emel Hasan Yusuf, M.Sc. was prepared very carefully, with great attention to the scientific and linguistic aspects. A series of publications constituting a doctoral dissertation, including the results obtained in the research cycle, allowed to confirm that carrots of different root color and size can be a valuable raw material for the production of functional and at the same time sensory attractive snacks for both children and adults. On the basis of the dissertation submitted, I express the opinion that the PhD student is a person prepared to conduct independent research, has multi-faceted knowledge in the area of the presented subject and is able to clearly present the results of her observations and formulate conclusions.

In the conclusion, I state that the doctoral dissertation Emel Hasan Yusuf, M.Sc. entitled „Novel carrot snacks with desired health benefits", combines scientific and practical aspects, making an important contribution to the field of food science and nutrition. I confirm that the doctoral dissertation submitted for review meets the requirements set out in Art. 187 sec. 1-4 of the Act of 20 July 2018 Law on Higher Education and Science (Journal of Laws of 2023, item 742), for candidates applying for a doctoral degree. For the above reasons, I am asking the members of the Scientific Council of the Discipline Food Technology and Nutrition, Wrocław University of Environmental and Life Sciences, to admit MSc Emel Hasan Yusuf to the next stages of the doctoral proceedings.

<u>An application for a distinction.</u>

Due to my high assessment of the reviewed work, resulting from a large scope of analyses, very good use of various research tools, including, among others Ultra Performance Liquid Chromatography with Mass Detection, obtaining valuable results and their skilful interpretation, correct writing of the doctoral dissertation and publication of the results obtained in highly rated scientific journals, I am submitting an application for distinction of the reviewed dissertation, which is the basis for the doctoral proceedings of Emel Hasan Yusuf, M.Sc.

EBernaś 10.08.2023

Dr hab. inż. Emilia Bernaś, prof. URK