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### **REVIEW of the doctoral dissertation**

A review of the submitted doctoral dissertation by MSc Emel Hasan Yusuf, entitled "Novel Carrot Snacks with Desired Health Benefits," prepared at The Faculty of Biotechnology and Food Science in the Wrocław University of Environmental and Life Sciences, consists of the assessment of the following elements:

1. Evaluation of the layout of the doctoral dissertation and the importance of the topic
2. Knowledge of literature
3. The aim of the study
4. Research material and methods
5. Discussion of the results and the conclusions
6. Possibility of practical use of research results
7. Originality of the obtained results and final evaluation

Legal basis: Regulation of the Minister of Science and Higher Education of July 20, 2018 (Journal of Laws of 2023, item 742).

Formal basis: Resolution No. 17.2023.TZZ of the Discipline Council Food and Nutrition Technology of the Wrocław University of Environmental and Life Sciences of June 13, 2023.

#### **1. Evaluation of layout and thematic relevance of the study**

MSc Emel Hasan Yusuf published five articles in international journals, which make up her doctoral dissertation. She evaluated the chemical composition and health-promoting effect



of 12 carrot varieties of different sizes and colors. She applied these carrots to develop innovative snack products described in the five publications.

The typical layout of such scientific works characterizes the work. It consists of the following chapters: abstract, introduction, the aim and hypothesis of the research, materials and methods, results and discussion, conclusion, literature, and scientific achievements. The work is logically laid out with correct proportions between the chapters. The paper complies with the requirements for a doctoral dissertation.

The candidate described the purpose of the work, the specific objectives, and the corresponding research hypothesis. The five publications for assessment included the formulation of individual specific objectives, their justification, and the answers to the research hypotheses. It is worth emphasizing here that the work in this field was consistent and well-designed. The scope of work included the evaluation of the chemical composition and biological activities of 12 carrot varieties, including the content of polyphenols, carotenoids, *in-vitro* biological activities against selected enzymes, and antioxidant capacity. In addition, the physicochemical properties (dry matter, ash, pectin, titratable acidity (TA), and pH) were analyzed. After assessing the chemical composition and biological activities in 12 carrot varieties, the authors applied carrots to produce carrot juice, carrot-based smoothies, and dried carrot snacks. Meanwhile, the authors also systematically studied the physicochemical properties, bioactive compounds, sensory attributes, and biological activities of new products. The authors utilized liquid chromatography or liquid chromatography coupled with mass spectrometry for the determination of specific phenolic compounds, carotenoids, chlorophylls, organic acids, and sugars, which deserved special emphasis due to the complexity of the research procedures and the limited amount of literature on this subject. In the next thirteen pages of the dissertation, the results of the work were discussed, and all obtained results were summarized in a short section. In the annexes are statements of co-authorship indicating her input to each publication, as well as all publications involved in the single thematic cycle of the doctoral dissertation. MSc Emel Hasan Yusuf's participation in creating these works was high, ranging from 55 to 70%, which the other co-authors confirmed. In all the works submitted for review, the candidate was the first author, which confirmed that she played a leading role in creating these works.

Utilizing ingredients containing important nutritional components to enrich food products is a hot topic. It is important for both science and practice. Using raw carrot material to produce



novel carrot snacks has many advantages and practical applications in developing the health-promoting effect of foods. The research topic of this thesis is relevant, important, and justified from both research and practical perspectives.

It is worth noting and emphasizing that the work was funded by the National Center for Research and Development, the European social fund under the operational program knowledge education development, which demonstrated a high level of activity in raising funds for the implementation of research.

### **Ad 2. Knowledge of the literature**

The doctoral dissertation consists of 58 pages, 11 lists of 156 items of literature, of which up to 60% are from the last 10 years. This is important and demonstrates knowledge of the most recent literature on the subject under study. The literature collected and researched is closely related to the research topic, demonstrating the diligence and scientific inquiry of the candidate. The reviewer did not dispute the knowledge of the subject matter, the scope of the scientific literature collected, and how it was used.

### **Ad 3. The aim of the study**

MSc Emel Hasan Yusuf's doctoral dissertation has been submitted for review based on five thematic publications. The study aimed to characterize and determine the chemical composition and biological activities of 12 carrot varieties of different sizes and colors and assess the possibility of using different carrot varieties (the source of the bioactive compounds) as raw materials to prepare novel carrot-based snacks. Although the physicochemical properties of normal orange carrots have been the subject of other studies, the systematic evaluation of different carrot varieties and the application of these carrots in the preparation of novel snacks is an important area of research, which provide new research directions and bring new knowledge to the discipline. The reviewers are open to the purpose and legitimacy of the conducted research. However, I would like to ask the candidate why, in the title of the doctoral dissertation, she used the term "snacks" to obtain products, whereas carrot juice and smoothies are drinks, not snacks.

### **Ad 4. The material and methods of the study**

MSc Emel Hasan Yusuf used 12 carrot varieties in her working different sizes: normal, mini, micro, and colors: purple, yellow, white, and orange. Furthermore, the authors used carrot puree with four colors mixed with raspberry, apple, pear, strawberry, and sour cherry juices to



produce smoothies and dried carrots snacks. These fruit juices were selected according to family, popularity, sensory attribute, and availability in the local market, which proves that this experiment was carefully prepared and planned. However, please explain the differences between purple (mentioned in the study) and black carrots (cited in the literature). Most of the cited references in the doctoral dissertation were about black carrots. In addition, the candidate investigated 12 carrot varieties of different sizes and colors in the first and second parts of the doctoral dissertation. Then, the candidate selected 4 carrot varieties (yellow, purple, orange, and white) to produce smoothies and dried carrots, avoiding information about carrots size. Please explain why?

The candidate used basic spectrophotometric analytical techniques in the work to determine antioxidant capacity and *in-vitro* biological activity. In addition, more advanced methods (high-performance liquid chromatography (HPLC) or HPLC coupled with mass spectrometry (MS)) were utilized to quantify and identify the phenolic compounds, chlorophylls, carotenoids, organic acids, and sugars in carrot products. The candidate planned and performed the physicochemical analyses correctly, and the results of the tests allowed her to draw conclusions and confirm the research hypotheses. All papers have been published in reputable scientific journals that have been reviewed by international experts, confirming the research's high quality. The used analytical methods are complex and time-consuming, requiring dedication, precision, and a great deal of work, and are fully capable of achieving the ambitious goals of the research. However, there is one suggestion from the reviewer. The shelf-life of novel snacks (smoothies and dried) could be investigated, thus promoting the production of novel snacks in the food industry.

#### **Ad 5. Results, discussion, and conclusion**

In the first part of the study, the candidate evaluated the physicochemical properties, chemical composition, and biological activities of different carrot varieties. The results indicated that the highest content of polyphenols and flavonoids was observed in normal purple carrots. The candidate mentioned that "the results showed that purple carrots are particularly intriguing due to their sensory appeal, sweetness, and vibrant color." Nevertheless, there are no results about sensory attributes in the first part of the study. In addition, the candidate showed that one of the inhibitory activities displayed a strong positive correlation with total vitamins ( $R^2=0.20$ ) and total minerals ( $R^2=0.28$ ). Are You sure that this correlation was significant?



In the next three parts of the study, carrots of different varieties were used to produce carrot juice, carrot-based smoothies, and dried carrot. The purple carrot as raw material performed best in preparing juice and smoothies. Meanwhile, the convective drying technique increased the polyphenolic content in the dried carrot samples. The dried yellow carrot-sour cherry sample had the highest polyphenolic content.

#### **Ad 6. Possibility of the practical application of study results**

The study results can be used in industrial practice to produce innovative carrot-based products with functional properties.

#### **Ad 7. The originality of the obtained results and final evaluation**

The work's concept, hypothesis, and experimental approach were correct and carried out professionally. The obtained results contributed to the scientific success of the dissertation submitted for review, a monothematic series of publications. The study's results made it possible to deepen the current state of knowledge on the application of different carrot varieties (purple, yellow, and white) in the production of novel products and their effect on biological activities.

MSc Emel Hasan Yusuf's research results have been published in prestigious international scientific journals, which proves the special value of these research results. These publications were subjected to rigorous international reviews. Their acceptance for publication attests to their high scientific value. They had to meet the highest standards of scientific publications regarding the presentation of methods, results, discussion, and conclusions. The obtained results of this study were published in a JCR-listed scientific journal with a total IF of 26.915 based on the date of publication and a total MEIN score of 470 based on the current list of scoring journals. These indicators are undoubtedly outstanding. It is also worth noting that all the work was supported by the funds of the National Center for Research and Development, Ministry of Science and Higher Education, and statutory funds of the EU in Wrocław, which indicates the high activity of the entire team, including the Promoters in obtaining funds for the implementation of research.

In summary, the reviewed dissertation is original and shows the valuable scientific achievement of the candidate. Moreover, the reviewer's comments do not influence its high scientific value. **The doctoral dissertation meets the conditions set out in Art. 187 sec. 1-4 of the July 20, 2018, Act on Higher Education and Science (Journal of Laws of 2023, item 742). Therefore, I am asking the High Council of the Discipline of Food Technology and**



**Nutrition of the Wrocław University of Environmental and Life Sciences to admit Emel Hasan Yusuf to the next stages of applying for a doctoral degree.**

*Krzysztof Marszałek*

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