

Response

official reviewer

candidate of technical sciences, associate professor,
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Sumy National Agrarian University

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for a dissertation (**Liu Yan**)

"Technology of semi-finished product from dried beetroot, pretreated by freeze-thaw method and food products using it",

applied for the degree of Doctor of Philosophy

from the field of knowledge (18)

by specialty (181)

1. Relevance of the topic of the dissertation.

The modern food market requires a constant expansion of the range of semi-finished products. This is due to the busy rhythm of life of many Ukrainians and the lack of time for the active population to prepare food, including dietary or preventive products. A convenient form of their use is dried products, they are quite affordable, light, nutritious and do not require special storage conditions.

There is growing interest in the biological activity of beets and their potential use as a dietary product for health promotion and disease prevention. Beetroot contains a huge amount of biologically active compounds that can be used as a functional food source for the treatment of various diseases.

In this context, rationalization of the drying process can be solved in two main ways: improvement of drying methods and development of pretreatment. Pretreatment significantly reduces energy consumption, affects physical properties, retention of bioactive compounds and antioxidant capacity of products.

The production of semi-finished products from vegetables occupies an important place in the food industry of Ukraine, because it allows to provide the population with these products evenly throughout the year. They are widely used in

the restaurant industry. The urgency also lies in the need to expand the range of specialized dietary and functional food products, including dried semi-finished products.

The choice of drying and pre-treatment methods has recently become more and more active.

Therefore, an urgent task is the development of methods of drying and pre-treatment of beets to substantiate the technology of semi-finished products made of freeze-thaw dried beets, as well as to study its effect on the organoleptic, physico-chemical and safety indicators of meat sausages and biscuits.

2. Connection of work with scientific programs, topics, plans.

The dissertation work was developed according to the plans of research work of the Sumy National Agrarian University, by research topics department of food technology and safety 0119 U 101237 "Innovative technological solutions in the production of food products" and 0122U201635 "Development of technical documentation for semi-finished products from plant raw materials of increased biological value for dual purpose". Scientific research of the dissertation work was carried out on the basis of the Department of Food and Bioengineering, Hezhou University (China).

3. Scientific novelty of the obtained results.

On the basis of analytical, scientific and experimental research and trends in the dissertation for the first time:

- experimentally obtained a set of data on the influence of different drying methods on beet quality indicators;
- the influence of different drying methods, namely heat pump drying (HPD), vacuum drying (VD), freeze drying (FD), microwave drying (MD), microwave vacuum drying (MVD) on the physical properties, bioactive compounds and antioxidant capacity of dried beets was investigated;

- it was established that microwave vacuum drying is the optimal microwave method of drying beets. Considering the quality indicators and drying time, microwave vacuum drying can guarantee high quality beets and short drying time;
- it was established that the best parameters of the microwave vacuum drying process were beetroot slices 5 mm thick, drying temperature 65 °C, loading density 2.0 kg/m². In addition, the most favorable conditions for vacuum microwave drying of beets were the microwave power of 500 W, the degree of vacuum -90 kPa, and the sample thickness of 2 mm;
- studied different freeze-thaw cycles, such as freeze-thaw once (T₁), freeze-thaw twice (T₂), freeze-thaw three times (T₃) and without pre-treatment freeze-thaw (T₀), different freezing temperatures (-4, -20, -50 and -80 °C);
- studied different methods of defrosting (microwave defrosting, water defrosting, air defrosting, refrigerator defrosting and ultrasonic defrosting) for physical properties, bioactive compounds and antioxidant capacity of dried beets;
- it was found that single freeze-thaw (T₁) was the best number of freeze-thaw cycles, and the optimum freezing temperature was -20 °C, and water thawing was the more acceptable way to thaw frozen beets;
- the possibility of using dry frozen-thawed beetroot powder in chicken sausages and biscuits was investigated;
- optimization of the recipe of meat sausages and biscuits using freeze-thaw dried beet semi-finished products;
- a complex of new data characterizing the chemical composition, organoleptic, microbiological and toxicological indicators, nutritional value was obtained, and the conditions and terms of storage of meat sausages and biscuits using freeze-thaw dried beet semi-finished products were scientifically substantiated ;
- found that beetroot powder can improve the physicochemical properties of chicken sausages, not only improving the sensory quality and increasing the protein content, but also inhibiting the lipid oxidation of chicken sausages. It was established that the addition of 2.0% beetroot powder improves the physical and chemical properties of chicken sausages.

– the results showed that frozen-thawed beetroot powder in cookies provides better sensory properties (color, taste, smell and taste) and increased the nutritional content (fat and protein) of the cookies. It was concluded that replacing wheat flour with a low gluten content in the cookie recipe with frozen-thawed beetroot powder up to 10% can increase the organoleptic properties and nutritional value of cookies.

acquired further development and generalization:

– ways of use semi-finished beetroot frozen- thawed dried in various food products groups.

4. Scientific and practical significance.

On the basis of fundamental and applied research, a freeze-thaw dried beet semi-finished product with a high content of bioactive compounds, antioxidant activity and improved physical-chemical properties was developed for its further use in the technology of meat sausages and biscuits, as a semi-finished product that increases food and biological value, and also has a positive effect on the physical-chemical, structural-mechanical and organoleptic characteristics of these products.

The results of the dissertation work can be used in the educational process when studying the disciplines "Fundamentals of physiology and food hygiene", "Nutritionology", "Quality and safety of food products", "General technologies of food production". At the same time, research results can be used in conducting fundamental and applied research in the direction of food technologies.

5. Completeness of presentation of the dissertation material in scientific publications.

The results of the dissertation are reflected in 18 printed works, including: 5 articles in scientific publications by specialty, included on the date of publication in the list of scientific specialized publications of Ukraine, 5 articles in periodical scientific publications, which are indexed in the Scopus / Web database of Science Core Collection , 3 of which are in the journal of the 3rd quartile (**Q3**), 2 of which are in the journal of the 4th quartile (**Q4**), 8 abstracts of reports at scientific,

scientific-practical and international conferences, 2 of which are indexed in the database Scopus/Web of Science Core Collection.

List of publications of the recipient by the topic of the dissertation

1. Liu, Y., Helikh, A., Filon, A., & Duan, Z. (2023). Sausage technology for food sustainability: recipe, color, nutrition, structure. *Eastern-European Journal of Enterprise Technologies*, 4 (11(124)), 47-58. DOI: <https://doi.org/10.15587/1729-4061.2023.286323>
2. Shang F., Kryzhaska T., Liu Y., Duan Z., Danylenko S., Stepanova T., Koshel O. (2022). Effects of different natural food coloring additives on the quality of chicken sausage. *Journal of Chemistry and Technologies*, 30 (2), 265-274. DOI: <https://doi.org/10.15421/jchemtech.v30i2.244538>
3. Liu, Y., Sabadash, S., Duan, Z., & Gao, D. (2022). Influence of different microwave-assisted drying methods on the physical properties, bioactive compounds and antioxidant activity of beetroots. *Eastern-European Journal of Enterprise Technologies*, 1 (11(115)), 15-25. DOI: <https://doi.org/10.15587/1729-4061.2022.251942>
4. Liu, Y., Sabadash, S.M., & Duan, Z. (2021). Effect of heat pump temperature on the physical properties, bioactive compounds and antioxidant capacity of beetroots. *Journal of Chemistry and Technologies*, 29 (4), 589 - 598. DOI: <http://doi.org/10.15421/jchemtech.v29i4.240470>
5. Liu, Y., Sabadash, S., Duan, Z., & Deng, C. (2022). The influence of different drying methods on the quality attributes of beetroots. *Eastern-European Journal of Enterprise Technologies*, 3 (11(117)), 60-68. DOI: <https://doi.org/10.15587/1729-4061.2022.258049>
6. Liu, Y., Sabadash, S., & Duan, Z. (2021). Effects of intermittent microwave drying conditions on characteristics and physical properties of beetroots. *Ukrainian Journal of Food Science*, 9 (1), 30 - 47. DOI: <http://doi.org/10.24263/2310-1008-2021-9-1-5>
7. Liu, Y., Sabadash, S., & Duan, Z. (2021). Research of physicochemical properties and antioxidant activity of beetroots as affected by vacuum microwave

drying conditions. *Technology Audit and Production Reserves*, 5 (3(61)), 40 - 45. DOI: <https://doi.org/10.15587/2706-5448.2021.243069>

8. Liu, Y., Sabadash, S., Gao, D., Shang, F., & Duan, Z. (2021). Influence of vacuum microwave drying parameters on the physicochemical properties of red beetroots. *Scientific Messenger of LNU of Veterinary Medicine and Biotechnologies. Series: Food Technologies*, 23 (96), 8 - 14. DOI: <https://doi.org/10.32718/nvlvet-f9602>

9. Liu, Y., Duan, Z., & Sabadash, S. (2021). Bioactive compounds and antioxidant activity of beetroots prepared by different drying methods. *Ukrainian Journal of Food Science*, 9 (2), 246-258. DOI: <http://doi.org/10.24263/2310-1008-2021-9-2-11>

10. Liu, Y., Duane, Z., Sabadash, S., & Shang, F. (2022). Study on the effect of intermittent microwave drying conditions on the bioactive compounds and antioxidant capacity of beetroots. *Technology Audit and Production Reserves*, 1 (3(63)), 6-13. DOI: <http://doi.org/10.15587/2706-5448.2022.251351>

6. The degree of validity of scientific statements.

The main scientific propositions and conclusions given in the dissertation work are logically justified and developed on the basis of multilateral research.

Research tasks were developed on the basis of a thorough analysis of 191 literary sources and own research. To achieve the goal of the dissertation, the author presented a step-by-step plan for conducting experimental work developed at a high scientific level. Methods of mathematical modeling and mathematical-statistical processing of results were used during the research.

Comprehensive solution of the tasks, modern and comprehensive experiment and analysis of the obtained results, industrial approbation of the proposed technological solutions and extensive discussion of research results at scientific conferences and in publications allow us to conclude about a high degree of validity of scientific statements and reliability of research results.

7. The structure and content of the dissertation, its completeness and compliance with the established requirements for design.

The dissertation consists of an abstract, an introduction, five chapters, conclusions, a list of used literary sources and appendices. The thesis is presented on 224 pages of main text, including 64 tables, 37 figures and 16 appendices.

In the dissertation work, the rules of planning and conducting scientific research are followed, and modern methods of research and processing of experimental results are used. The scientific novelty of the results of the work is based on comprehensive research, which was used at the appropriate level with the use of generally recognized research methods.

The dissertation is written in English and Ukrainian. The style and presentation of the work is logical, consistent and meets the requirements for printed works. The content of the work presents the results of scientific research and their approbation in practice. When presenting the text, modern scientific and lexical terminology is mainly used.

The freeze-thaw preliminary preparation method, with a high content of bioactive compounds, antioxidant activity and improved physicochemical properties, is scientifically substantiated which made it possible to successfully use the developed isolate in the technologies of meat sausages and biscuits.

The structure and content of the dissertation, the sequence, the presentation style meet the modern requirements used in scientific literature.

The conclusions in the dissertation contain the most important scientific and practical results obtained by the author while working on a scientific problem.

8. Discussion clauses and remarks to the dissertation.

In general, the dissertation work was performed at a high scientific and methodical level, meets the established requirements, although it is not without some shortcomings, and some provisions are of a debatable nature.

1. It is not clear why such an energy-intensive and complex drying technology should be used in the dissertation work? Were economics and carbon footprint

considered when choosing the best drying method? What advantages can this drying technology bring to Ukraine in wartime conditions with a significant shortage of energy resources and the lack of equipment for microwave vacuum drying? It is also unclear which drying method is better: combined or microwave vacuum drying?

2. The paper does not present data reflecting the calculation of the material and energy balance when using the freeze-thaw pretreatment method. So it is not clear what approximate weight loss figures you got? How long does the beet pretreatment method take?

3. The dissertation does not explain why exactly 65°C was chosen as the optimal temperature for microwave vacuum drying? Is the temperature too high? Is the nutritional value of beetroot powder preserved when used at this particular temperature?

4. From the text of the work and scientific articles, it is not clear what is the optimal amount of adding beetroot powder obtained by your technology to the recipe of meat sausages? How does this amount affect the organoleptic parameters, especially the smell?

5. There is no confirmation regarding the study of safety indicators in the obtained beetroot powder? What are the storage terms of beetroot powder obtained by means of preliminary processing by freezing-thawing?

6. Freeze-thaw pretreatment has a large carbon footprint and energy consumption, is it appropriate to use it in Ukraine? Do you generally realize how difficult the situation is in Ukraine? To what extent is your dissertation related to the priority directions of the development of science in Ukraine? Beetroot is produced in large quantities and is well stored in specialized warehouses, why is it so difficult to dry it?

These remarks and wishes do not reduce the overall positive impression of the dissertation work. These remarks and wishes do not reduce the overall positive impression of the dissertation work.

9. General conclusion.

Dissertation work (**Liu Yan**) "Technology of semi-finished product from dried beetroot, pretreated by freeze-thaw method and food products using it", which was submitted for defense to the specialized academic council for obtaining the degree of Doctor of Philosophy in the field of knowledge (18) in the specialty (181) according to its relevance, scientific and theoretical level, main results of validity, main provisions and results published in professional publications, novelty statement and practical meaning meets the requirements of the Order of the Ministry of Education and Culture of Ukraine No. 40 of January 12, 2017 "On approval of requirements for the preparation of a dissertation" and Resolution of the Cabinet of Ministers of Ukraine of January 12, 2022 No. 44 "On approval of the Procedure for awarding the degree of Doctor of Philosophy and cancellation of the decision of a one-time specialized of the academic council of the institution of higher education, scientific institution on awarding the degree of doctor of philosophy" with changes introduced in accordance with Resolution of the CM No. 341 dated 03/21/2022.

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