ASEC 2025 Conference

The 6th International Electronic Conference on Applied Sciences

09–11 December 2025 | Online

MDPI

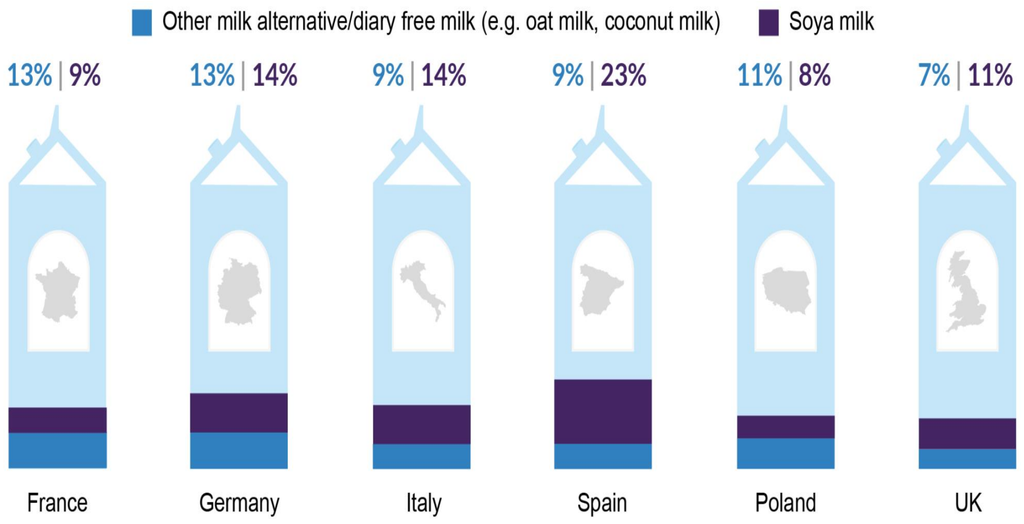
Exploring walnuts functional and nutritional potential: advancing the development of plant-based milk alternative

Cristina Popovici[1], Xin Mei Teng[2, 3], Ravi Jadeja[2, 3]

[1] Department of Food and Nutrition, Faculty of Food Technology, Technical University of Moldova, 168 Stefan cel Mare si Sfant blvd., Chisinau, MD 2004, Republic of Moldova
[2] Robert M. Kerr Food & Agricultural Products Center, Oklahoma State University, Stillwater, OK 74078, USA
[3] Department of Animal & Food Sciences, Oklahoma State University, Stillwater, OK 74078, USA

INTRODUCTION & AIM

The increasing trend of innovative plant-based milk alternatives (PBMAs) is driven by lactose intolerance, cholesterol risks, and ethical, environmental, religious and social beliefs [1, 2]. In this regard, walnuts can be considered a unique ingredient for the production of PBMAs due to their remarkable functional potential and nutritional value [3].



The objectives of this research:

- ❑ development of the walnut plant-based milk alternative with an emphasis on the product quality and processing techniques;
- ❑ improving the quality of the walnut plant-based milk alternative through physicochemical characteristics, antioxidant potential, color and texture parameters;
- ❑ optimization of the sensory acceptance of the walnut plant-based milk alternative, exploring the ingredients that influence product's texture, appearance, flavor and taste.

METHOD

Experimental materials

Raw walnuts, fibers, sugar, vanilla extract, salt, stabilizer were procured from the local market in Chisinau, Moldova. All chemicals used within this study were purchased from Eco-Chimie and Sigma-Aldrich (Chisinau, Moldova). All the chemicals used were of HPLC or analytical grade. Distilled water was used throughout.

Experimental processing flow diagram

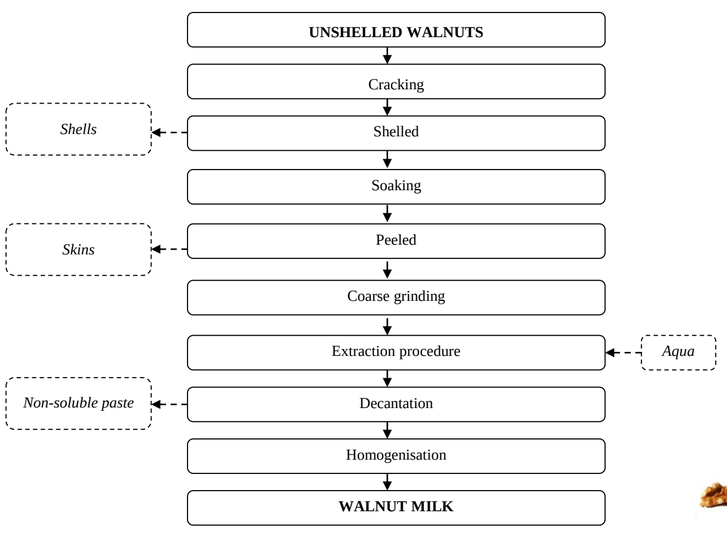


Fig. 1. *Walnut plant-based milk processing flow diagram*

Experimental design

Response Surface Methodology (RSM) was used to investigate the influence of three independent variables (Table1) on experimental response data, including pH, acidity, color attributes (L*, a* and b*), total polyphenol content, DPPH antioxidant activity, sensory properties. The goal was to develop predictive models that maximize or minimize modellable response variables, and thereby optimizing amount of ingredients for walnut plant-based milk alternatives production process(Table 1).

Table 1. *Variables for walnut plant-based milk formulations*

Variables	Units	Levels			
		Minimum	Maximum	Coded Low	Coded High
Walnuts/Water ratio	[c.u.]	0.07	0.39	0.14	0.33
Fibers	[%]	1.32	4.68	2.00	4.00
Emulsifier	[%]	0.01	0.18	0.05	0.15

FUTURE WORK / REFERENCES

This research was supported by the Institutional Project, subprogram 020405 "Optimizing food processing technologies in the context of the circular bioeconomy and climate change", Bio-OpTehPAS, implemented at the Technical University of Moldova.

RESULTS & DISCUSSION

Microstructure of walnut plant-based milk alternative

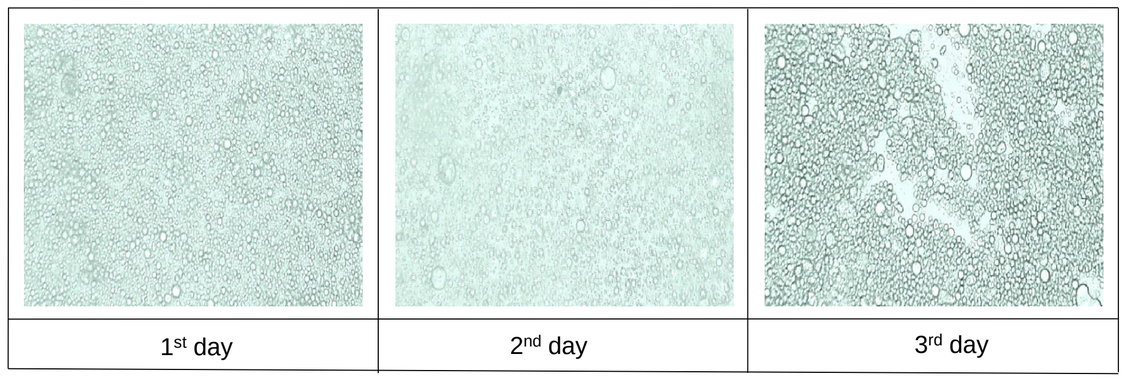


Fig.2. Evolution of walnut milk microstructure during storage

Particle size distribution & Rheological behavior of walnut plant-based milk alternative

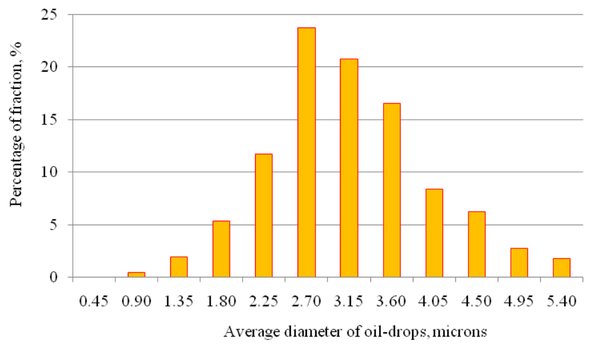


Fig. 3. *Particle size distribution in walnut plant-based milk*

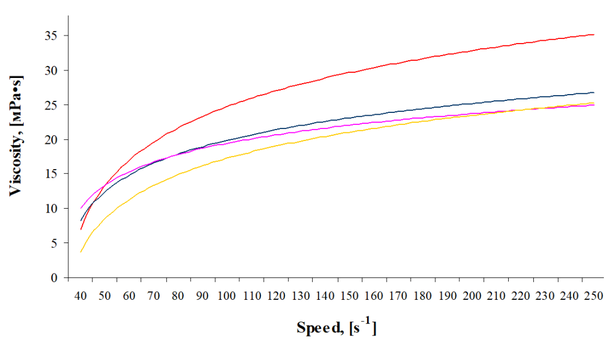


Fig. 4. *Up-flow curves of walnut plant-based milk at different storage times*

pH & Sensory attributes of walnut plant-based milk alternative formulations

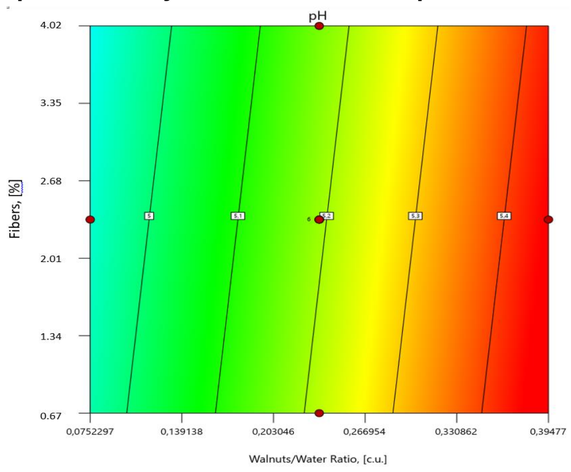


Fig. 5. Effect of different walnut plant-based milk formulations on the pH value

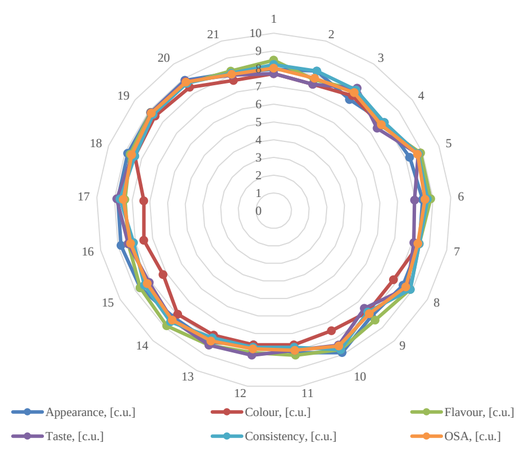


Fig. 6. Effect of different walnut plant-based milk formulations on the sensory attributes

TPC & DPPH antioxidant activity of walnut plant-based milk alternative formulations

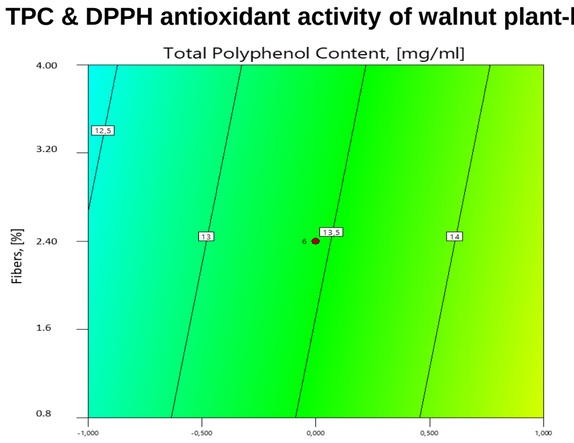


Fig. 7. Effect of different walnut plant-based milk formulations on the TPC

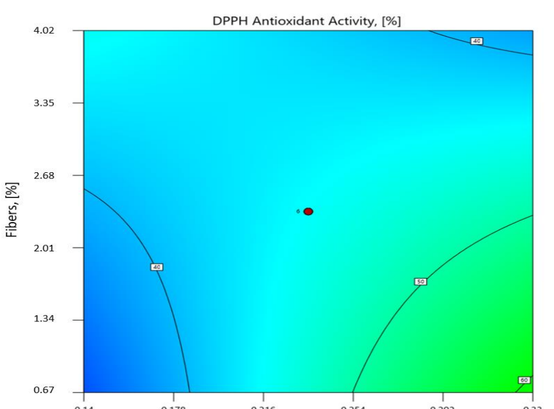


Fig. 8. Effect of different walnut plant-based milk formulations on the DPPH

CONCLUSION

In this study walnut plant-based milk alternative was formulated and evaluated, employing Design-Expert software. The findings showed that the optimal walnut plant-based milk alternative composition is walnuts (17%), water (79.8%), fibers (2%), sugar (0.5%), vanilla extract (0.5%), salt (0.1%), and stabilizer (0.1%). The proximate composition (g/100 g) of optimized walnut milk was proteins at 3.51 g, fats at 2.75 g, carbohydrates at 5.65 g and ash at 0.81 g. Furthermore, the microstructure analysis denoted that it is an oil-in-water emulsion with the particle size distribution of oil drops in walnut milk in the range of 0.45 … 5.40 microns. The largest part of the oil volume has an average diameter of 2.70 microns. A sensory study was also undertaken, where walnut plant-based milk alternative was highly acceptable to the panellists. This study shows the high potential and provides a positive view of walnut plant-based milk alternative production, which is in agreement with the current demand for sustainable alternatives to dairy milk.

REFERENCES

1. Kaur, H., Kaur, K., Arora, D. Advancing plant-based milk alternatives: Challenges, opportunities, and the role of innovative processing technologies, Food Control, Vol. 180, 2026, 111671, ISSN 0956-7135, https://doi.org/10.1016/j.foodcont.2025.111671.
2. Hu, Y., Acevedo-Fani, A., Singh, H., Ye, A. Colloidal properties of milk and plant-based milk alternatives: A structural perspective, Current Opinion in Colloid & Interface Science, Vol. 80, 2025, 101966, ISSN 1359-0294, https://doi.org/10.1016/j.cocis.2025.101966.
3. Popovici, C., Teng, X.M., Jadeja, R. Walnut cheese-like alternatives as an innovation among dairy analogues. In: Journal of EcoAgriTourism, 2024, ISSN 1844-8577, Vol. 20, no. 2 (49), p. 5-12.