●●● **ARTICLE 9**

DEVELOPMENT OF A VEGAN CHICKPEA BURGER (*CICER ARIETINUM* L.) WITH THE ADDITION OF *ORA-PRO-NOBIS* (*PERESKIA ACULEATA* MILLER)

Júlia Puppo Sintoni
Universidade de Ribeirão Preto
Ribeirão Preto - SP
http://lattes.cnpq.br/2635722462896093

Telma Maria Braga Costa
Universidade de Ribeirão Preto
Ribeirão Preto – SP
http://lattes.cnpq.br/1696043000056187

Nathália Pinto Bernardes
Universidade de Ribeirão Preto
Ribeirão Preto – SP
http://lattes.cnpq.br/1654235701299237

Josiane da Silva Garcia
Universidade de Ribeirão Preto
Ribeirão Preto – SP
http://lattes.cnpq.br/3958192843341316

Andresa de Toledo Triffoni-Melo
Universidade de Ribeirão Preto
Ribeirão Preto – SP
http://lattes.cnpq.br/4230830716881986

Abstract: The reduction in meat consumption and the growing number of vegetarian, vegan, and flexitarian consumers have intensified the demand for nutritionally adequate plant-based products made with natural ingredients and lower environmental impact. In this context, unconventional edible plants (PANC), such as *Pereskia aculeata* Miller (*ora-pro-nobis*), stand out due to their high content of proteins, fiber, and micronutrients. This study aimed to develop a vegan burger based on chickpea flour enriched with ora-pro-nobis powder and to evaluate its nutritional and sensory characteristics. After standardizing the formulation, containing 8.12% ora-pro-nobis, centesimal analyses identified 55.07% (±0.05) moisture, 3.26% (±0.01) ash, 10.31% (±0.05) protein, 8.11% (±0.01) lipids, 5.02% (±0.20) fiber, and 18.20% (±0.22) carbohydrates, enabling the elaboration of nutritional information in accordance with current regulations. Sensory analysis conducted with 76 participants showed good acceptance for flavor (78%), odor (89%), texture (78%), and overall impression (78%), while appearance received 67%, possibly due to the green coloration characteristic of the plant. Overall, the burger exhibited favorable nutritional and sensory characteristics, particularly in its protein and fiber content, which was achieved without supplementation, positioning it as an adequate and promising plant-based alternative. The formulation contributes to encouraging the use of PANC in food and meets the growing demand for healthier and more sustainable plant-based products.

Keywords: Vegan burger; chickpea; *ora-pro-nobis*; PANC; unconventional edible plants.

INTRODUCTION

Interest in diets with a lower proportion of animal-derived products has increased due to concerns related to health, well-being, and the environmental impact of food systems (Silva *et al.*, 2021; Gradinar, 2022). Meat production, especially beef, is recognized for its demand for large amounts of natural resources and for generating emissions associated with the greenhouse effect, which underscores the need for nutritionally adequate alternatives with a lower environmental impact.

Vegetarianism and veganism, adopted for ethical, cultural, religious, environmental, and health reasons (Denis, 2021; Hargreaves *et al.*, 2021), have grown globally and are associated with higher consumption of plant foods and lower prevalence of chronic diseases, although poorly planned diets may result in nutritional deficiencies (Bakaloudi *et al.*, 2020; Marrone *et al.*, 2021). This movement has expanded the market for plant-based products, although many still contain additives and low-quality ingredients (Moro *et al.*, 2021). Nevertheless, studies show a continuous increase in the number of vegetarian, vegan, and flexitarian consumers (Ipec, 2021; The Good Food Institute, 2021), driving demand for products that combine convenience, flavor, and adequate nutritional composition.

In this context, plant-based burgers formulated with legumes emerge as viable technological alternatives to reduce meat consumption without compromising sensory attributes (Boukid; Castellari, 2021). Chickpea (Cicer arietinum L.) stands out for its high protein content, neutral flavor, and technological functionality, which make it suitable for use in plant-based preparations (Jukanti *et al.*, 2012; Zhang *et al.*, 2024).

In parallel, there is an increasing interest in unconventional edible plants (PANC), valued for their nutritional potential, low production costs, and contribution to food biodiversity (Ranieri, 2017). *Ora-pro-nobis* (*Pereskia aculeata* Miller) has high concentrations of proteins, fiber, vitamins, and minerals, and is considered promising for enriching plant-based preparations (Almeida *et al.*, 2014; EMBRAPA, 2017).

The use of *ora-pro-nobis* flour in plant-based burgers represents an opportunity to add nutritional value and expand the diversity of products with lower environmental impact. However, its inclusion may alter texture, color, and flavor, making physicochemical and sensory evaluation of the formulation essential (Teixeira, 2009).

Therefore, this study aimed to develop a vegan burger based on chickpeas with the addition of *ora-pro-nobis* (*Pereskia aculeata* Miller), as a way to encourage the use of PANC by the population and as an alternative preparation for individuals who have reduced or stopped consuming meat.

MATERIALS AND METHODS

This study involved the development and evaluation of a vegan burger formulated with chickpea and enriched with *ora-pro-nobis* flour. The preparation steps, physicochemical analyses, and sensory evaluation were conducted at the Food Analysis and Technology Laboratory of the University of Ribeirão Preto (UNAERP), in Ribeirão Preto, São Paulo, Brazil. The study was approved by the Institutional Ethics Committee (CAAE nº 67914323.0.0000.5498), and all participants provided informed consent.

The centesimal composition of the formulation was determined through moisture analysis (oven drying at 105 °C), ash content (incineration in a muffle furnace at 550 °C), fiber content (Weende method), protein content (Micro-Kjeldahl method), lipid content (Goldfish method), and carbohydrate content by difference, according to methodologies described by the Instituto Adolfo Lutz (IAL, 2008) and by Galvani and Gaertner (2006). All determinations were performed in triplicate, and results were expressed as mean ± standard deviation. Based on the values obtained in the centesimal analysis, the nutritional information of the product was elaborated.

Subsequently, sensory analysis was conducted with 76 adult individuals of both sexes, voluntarily recruited on campus. Participants aged between 18 and 60 years were included, and those with smoking habits, respiratory problems, or wheat allergy/intolerance were excluded. The evaluations were conducted individually in sensory booths using a nine-point hedonic scale for sensory attributes and a seven-point purchase intention scale (IAL, 2008). The data were analyzed using the acceptability index (AI), calculated as the ratio of the mean score obtained to the maximum possible score, expressed as a %. Values equal to or greater than 70% were considered satisfactory (Teixeira, 2009).

RESULTS AND DISCUSSION

After standardizing the recipe, the centesimal analysis of the chickpea burger with the addition of *ora-pro-nobis* flour (8.12%) showed 55.07% (±0.05) moisture, 3.26% (±0.01) ash, 10.31% (±0.05) protein, 8.11% (±0.01) lipid, 5.02% (±0.20) fiber, and 18.20% (±0.22) carbohydrates, as shown in Table 1.

According to the results, the burger containing 8.12% *ora-pro-nobis* flour showed a higher proportion of moisture (55.07%), followed by carbohydrates (18.20%), protein (10.31%), lipids (8.11%), fiber (5.02%), and ash (3.26%). When comparing these values to those reported by Moro *et al.* (2021) for burgers containing 10% *ora-pro-nobis*, similar moisture content was observed (55.07% vs. 46.80%), along with higher protein and fiber contents in the present study. Differences in carbohydrate (18.20% vs. 36.21%) and lipid levels (8.11% vs. 3.82%) may be related to the proportions of ingredients used by the authors, influencing macronutrient distribution.

When compared to the vegan burgers evaluated by Marchi *et al.* (2021), similar moisture contents were observed (60.91% vs. 55.07%), as well as identical ash values (2.52% vs. 3.26%). The fiber content found (5.02%) corresponded to the highest value reported by the authors. The higher protein contents described in their formulations are attributed to the use of protein supplements, which were not included in the present preparation. The lipid content obtained (8.11%) was close to the lower limit reported by Marchi *et al.* (2021) for the samples evaluated.

In comparison to the burger without *ora-pro-nobis* developed by Lima (2018), a higher protein content (10.31% vs. 7.20%) and lower carbohydrate content (18.20% vs. 27.96%) were observed. The absence of rice flour in the present study may explain this difference.

The nutritional information, elaborated from the centesimal analysis data (Table 1), the Brazilian Food Composition Table (TBCA, 2020), and current regulations RDC nº 429/2020 and IN nº 75/2020 (ANVISA, 2020a; ANVISA, 2020b), is presented in Table 2.

The sodium content of the product (395 mg/100 g) is below the threshold that characterizes a "high sodium content," according to IN nº 75/2020 (ANVISA, 2020b), suggesting a favorable alternative when compared with animal-based burgers, which frequently show elevated levels of this mineral (Ambiel; Pinho, 2022). The saturated fat content (1.2 g/100 g) was also lower than that of several commercial vegetarian and vegan burgers, which may reach up to 13 g/100 g, especially when formulated with coconut oil (Boukid; Castellari, 2021). In the present study, the use of extra-virgin olive oil, rich in unsaturated fats, contributed to a lower saturated fat content. In contrast, Marchi *et al.* (2021) reported higher levels in formulations containing refined coconut oil.

The nutritional profile obtained aligns with characteristics valued by consumers of plant-based products, including adequate protein content, lower levels of saturated fat, and the use of natural ingredients (The Good Food Institute, 2021). Plant-based products of this nature are frequently associated with more sustainable food choices and reduced environmental impact, reinforcing the potential of the burger developed in the present study.

Sensory analysis conducted with 76 participants revealed good acceptance for flavor (78%), odor (89%), texture (78%), and overall impression (78%). In contrast, appearance presented a lower score (67%), reflecting the greenish color conferred by *ora-pro-nobis* (Figure 1).

Determinations (%)	Hambúrguer
Moisture	55.07 (±0.05)
Ash	3.26 (±0.01)
Proteín	10.31 (±0.05)
Lipíd	8.11 (±0.01)
Fiber	5.02 (±0.20)
Carbohydrate	18.20 (±0.22)

Table 1 – Centesimal composition of the chickpea burger with added *ora-pro-nobis*, performed at the Food Analysis and Technology Laboratory of the Nutrition Program at the University of Ribeirão Preto, Ribeirão Preto, 2024.

Note: Mean (± DP).

NUTRITIONAL INFORMATION			
Serving size: 80 g (1 unit)			
	100 g	80 g	%VD*
Energy value (kcal)	185	151	8
Carbohydrates (g)	18	15	9
Total sugars (g)	1.3	1	
Added sugars (g)	1	0.8	2
Proteins (g)	10	8.2	16
Total fats (g)	8.1	6.5	10
Saturated fats (g)	1.2	0.9	5
Trans fats (g)	0	0	0
Dietary fiber (g)	5	4	16
Sodium (mg)	395	316	16
*Percent daily values provided per serving.			

Table 2 – Nutritional information of the chickpea burger with added *ora-pro-nobis* flour, based on the centesimal analysis and the food composition table, Ribeirão Preto, 2024.
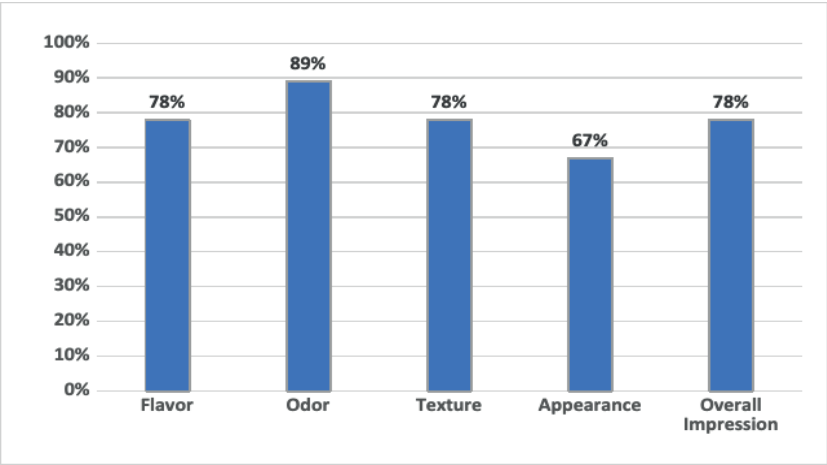

Figure 1 – Acceptance index of the chickpea burger with added *ora-pro-nobis* by participants (n = 76), obtained through sensory analysis, Ribeirão Preto, 2024.

Article 9

These findings are consistent with the results of Moro *et al.* (2021), who also reported higher acceptance in formulations containing 10% *ora-pro-nobis*, with reduced average scores when higher concentrations were used due to the characteristic bitterness of the plant. Appearance was cited by the authors as one of the most sensitive attributes to the inclusion of *ora-pro-nobis*, due to the color changes. In the study by Lima (2018), the chickpea burger without *ora--pro-nobis* showed higher visual acceptance (75.93%), reinforcing that the greenish color may negatively influence this attribute.

Purchase intention reached 57%, a value similar to that observed by Moro *et al.* (2021) in formulations with comparable proportions of *ora-pro-nobis*. Although part of the public does not have a regular habit of consuming alternative plant-based products, the nutritional profile of the formulation — with good protein content, lower saturated fat content, and no additives — makes the product attractive to flexitarian consumers, who seek healthy and convenient plant-based options (The Good Food Institute, 2021).

CONCLUSION

The standardization of the chickpea burger with added *ora-pro-nobis* flour (8.12%) (*Pereskia aculeata* Miller) demonstrated that the formulation presents good nutritional and technological potential as a plant-based alternative to traditional burgers. The product stood out due to its adequate protein and fiber contents, as well as its low saturated fat content and the exclusive use of natural ingredients. These characteristics align with the demands of con-

sumers seeking healthier options with lower environmental impact.

Sensory analysis indicated good acceptance for flavor, odor, texture, and overall impression, reinforcing the feasibility of the formulation. The lower acceptance of appearance and the moderate purchase intention may be related to the green color conferred by *ora-pro-nobis*, which may generate unfamiliarity among individuals who are not accustomed to this unconventional edible plant (PANC). Nevertheless, the results suggest that the product has potential to be incorporated into the daily diet of vegetarian, vegan, and flexitarian consumers, offering a nutritious and functional alternative.

Thus, the study highlights the nutritional and technological value of *ora-pro--nobis* in the development of plant-based products and reinforces its applicability in formulations aimed at consumers seeking more balanced, natural, and sustainable plant-based preparations that are aligned with current demands for environmentally friendly foods.

Role of Funding Sources

Conflict of Interest

All authors declare that there is no conflict of interest.

Article 9

REFERENCES

ALMEIDA, M. E. F.; JUNQUEIRA, A. M. B.; SIMÃO, A. A.; CORRÊA, A. D. Caracterização química das hortaliças não-convencionais conhecidas como *ora-pro-nobis*. **Biosci. J.**, Uberlandia, v. 30, Suppl. 1, p. 431-439, 2014.

AMBIEL, C.; PINHO, L. **Estudo nutricional**: análise comparativa entre produtos cárneos de origem animal e seus análogos vegetais. [s.l.] The Good Food Institute Brasil, 2022. p. 28.

ANVISA. Agência Nacional de Vigilância Sanitária. Resolução RDC nº 429, de 8 de outubro de 2020. Rotulagem nutricional de alimentos embalados. **Diário Oficial da União**, n. 195, de 9 de outubro de 2020, Brasília, DF, 2020a.

ANVISA. Agência Nacional de Vigilância Sanitária. Instrução Normativa - IN nº 75, de 8 de outubro de 2020. Estabelece os requisitos técnicos para declaração da rotulagem nutricional nos alimentos embalados. **Diário Oficial da União**, n. 195, de 9 de outubro de 2020, Brasília, DF, 2020b.

BAKALOUDI, D. R.; HALLORAN, A.; RIPPIN, H. L.; OIKONOMIDOU, A. C.; DARDAVESIS, T. I.; WILLIAMS, J; WICKRAMASINGHE, K.; BREDA, J.; CHOURDAKIS, M. Intake and adequacy of the vegan diet. A systematic review of the evidence. **Clinical Nutrition Journal**, v. 40, n. 5, p. 3503-3521, 2020. DOI: https://doi.org/10.1016/j.clnu.2020.11.035.

BOUKID, F.; CASTELLARI, M. Veggie burgers in the EU market: a nutritional challenge? **European Food Research and Technology**, v. 247, p. 2445-2453, 2021. DOI 10.1007/s00217-021-03808-9.

DENIS, L. **O que é veganismo,** v. 1, 1. ed. São Paulo: FiloCzar, 2021. 84 p. ISBN 9786587117669.

EMBRAPA. Ministério da Agricultura, Pecuária e Abastecimento. **Hortaliças não convencionais**. Hortaliças tradicionais: ora-pro-nóbis. maio 2017.

GALVANI, F.; GAERTNER, E. Adequação da metodologia de Kjeldahl para determinação de nitrogênio total e proteína bruta. **EMBRAPA**, Corumbá, p. 1-9, 2006. ISSN 1517-1965 *versão online.*

GRADINAR, A. L. T.; AGUIAR, J. A.; ALONSO, L.; SILVA, O. L. O.; MARTINS, R. C. B.; SILVA, S. L.; BAXTER, Y. C. **A Nutrição e os Objetivos de Desenvolvimento Sustentável**. Conselho Regional de Nutricionistas 3ª Região, 2022.

HARGREAVES, S. M.; RAPOSO, A.; SARAIVA, A.; ZANDONADI, R. P. Vegetarian diet: an overview through the perspective of quality of life domains. **International Journal of Environmental Research and Public Health**, v. 18, n. 8, p. 1-23, 2021. DOI: https://doi.org/10.3390/ijerph18084067.

IAL - INSTITUTO ADOLFO LUTZ. **Métodos físico-químicos para análise de alimentos**. 4. ed., São Paulo, Instituto Adolfo Lutz, 2008.

IPEC. Inteligência em Pesquisa e Consultoria Estratégica. **Pesquisa de opinião pública sobre vegetarianismo**. IPEC, 2021.

JUKANTI, A. K.; GAUR, P. M.; GOWDA, C. L. L.; CHIBBAR, R. N. Nutritional quality and health benefits of chickpea (Cicer arietinum L.): a review. **British Journal of Nutrition**, Cambridge, v. 108, n. 1, p. 11-26, 2012. DOI 10.1017/S0007114512000797.

LIMA, E. C. **Produção de hambúrguer vegano de grão-de-bico com resíduo agroindustrial de acerola.** Trabalho de Conclusão de Curso (Bacharel) – Curso de Engenharia Química, Universidade Federal do Rio Grande do Norte, Natal, 2018.

MARCHI, M.; COSTA, A.; POZZA, M.; GOI, A.; MANUELIAN, C. L. Detailed characterization of plant-based burgers. **Scientific Reports**, v. 11, n. 1, p. 2049, 2021.

MARRONE, G.; GUERRIERO, C.; PALAZZETTI, D.; LIDO, P.; MAROLLA, A.; DI DANIELE, F.; NOCE, A. Vegan diet health benefits in metabolic syndrome. **Nutrients**, v. 13, n. 3, p. 1-23, 2 mar. 2021. DOI: https://doi.org/10.3390/nu13030817.

MORO, G. L.; SANTOS, S. N.; ALTEMIO, A. D. C.; ARANHA, C. P. M. Development and characterization of chickpeas (Cicer arietinum L.) vegan hamburger with ora-pro-nóbis (Pereskia Aculeata Mill.) addition. **Research, Society and Development**, v. 10, n. 12, p. e361101220067, 2021. DOI 10.33448/rsd--v10i12.20067.

RANIERI, G. R. **Guia prático sobre PANCs:** plantas alimentícias não convencionais. 1. ed. São Paulo: Instituto Kairós, 2017.

SILVA, J. T.; GARZILLO, J. M. F.; RAUBER, F.; KLUCZKOVSKI, A.; RIVERA, X. S.; CRUZ, G. L.; FRANKOWSKA, A.; MARTINS, C. A.; LOUZADA, M. L. C.; MONTEIRO, C.A.; REYNOLDS, C.; BRIDLE, S.; LEVY, R. B. Greenhouse gas emissions, water footprint, and ecological footprint of food purchases according to their degree of processing in Brazilian metropolitan areas: a time-series study from 1987 to 2018. **The Lancet Planetary Health**, v. 5, n. 11, p. E775–E785, 1 nov. 2021. DOI 10.1016/S2542-5196(21)00254-0.

TBCA - **Tabela Brasileira de Composição de Alimentos**. Universidade de São Paulo (USP). Food Research Center (FoRC). Versão 7.1. São Paulo, 2020.

TEIXEIRA, L. V. Análise Sensorial na Indústria de Alimentos. **Rev. Inst. Latic**, Juiz de Fora, v. 64, n. 366, p. 12-21, 2009.

THE GOOD FOOD INSTITUTE**. O consumidor brasileiro e o mercado Plant-Based**. The Good Food Institute, 2021.

ZHANG, J.; WANG, J.; ZHU, C.; SINGH, R. P.; CHEN, W. Chickpea: its origin, distribution, nutrition, benefits, breeding, and symbiotic relationship with mesorhizobium species. **Plants**, v. 13, n. 3, p. 1-13, 2024.

Article 9