

Development and characterization of high-protein bars enriched with edible insect flour

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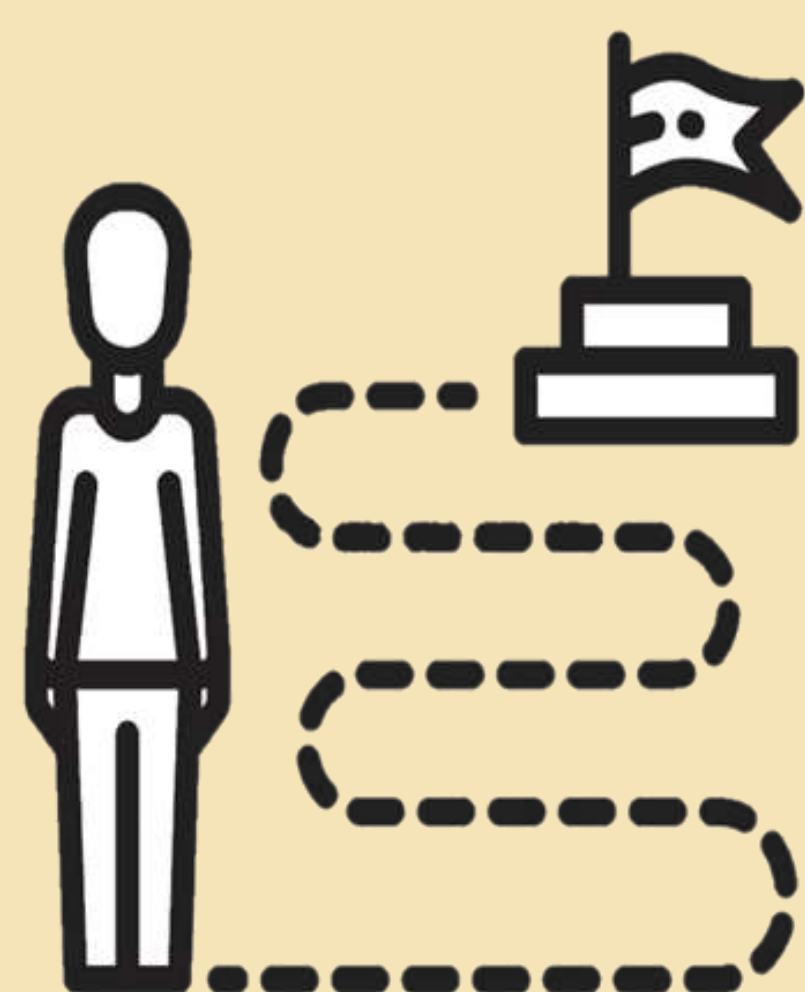
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Introduction

The transition towards future-ready sustainable food systems requires the development of innovative solutions that ensure safety, quality, and nutritional value. Edible insects, such as *Acheta domesticus* and *Tenebrio molitor*, represent alternative protein sources that are environmentally efficient and rich in essential nutrients. Their integration into innovative products, such as protein bars, reflects a promising direction in sustainable food innovation tailored to the needs of today's modern consumer.



Objectives

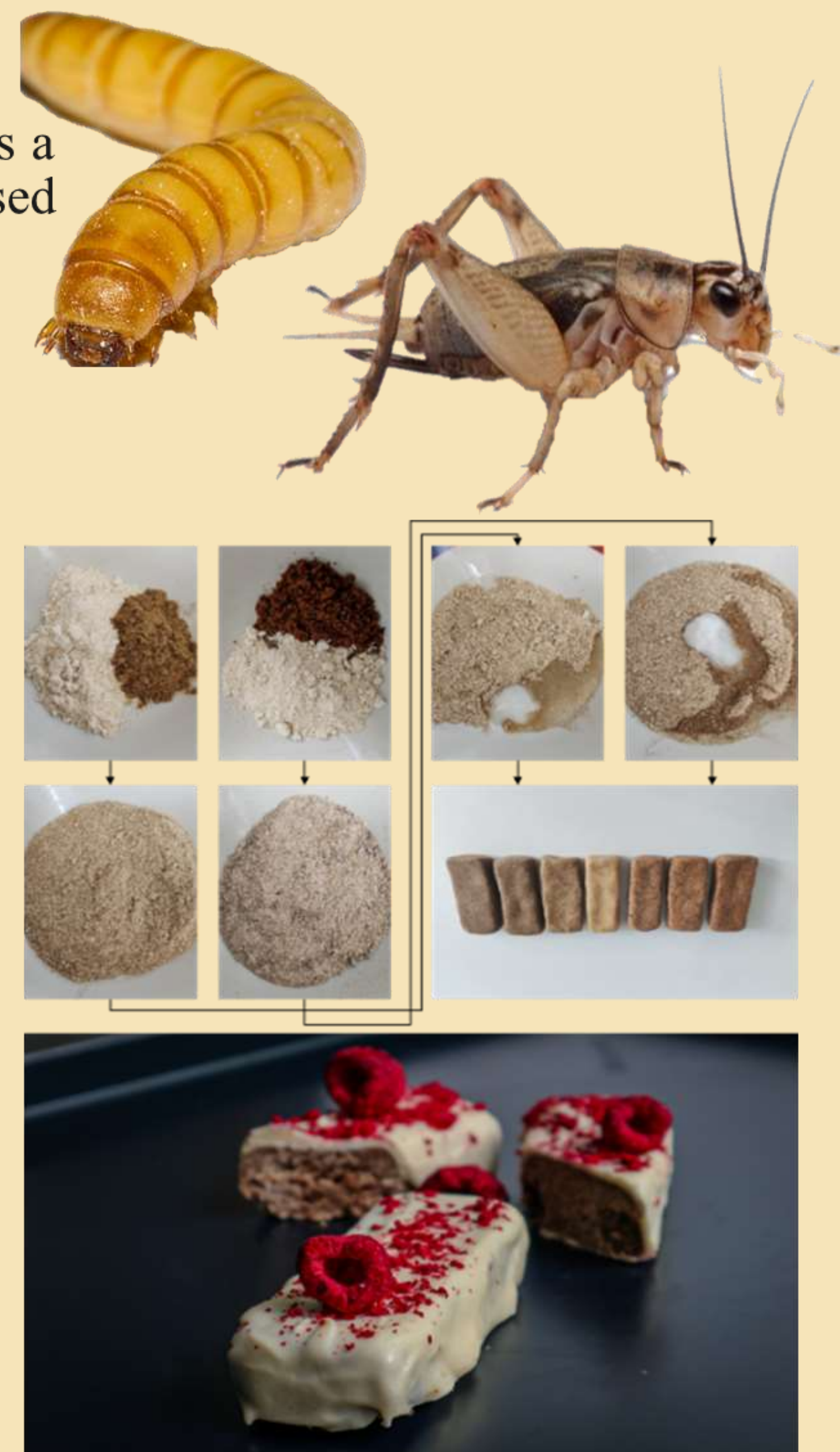
The main goal of this study was to develop a sustainable protein bar as a nutritious and eco-friendly alternative to conventional protein bars based on plant or dairy proteins.

The specific objectives were:

- To formulate and produce bars with different insect flour concentrations (10%, 20%, and 30%).
- To analyze the nutritional composition (proteins, lipids, carbohydrates, ash, moisture).
- To evaluate sensory acceptability using a hedonic scale.

Methods

The protein bars were prepared using oat flour and coconut oil, with additions of edible insect flour (*Acheta domesticus*, *Tenebrio molitor*) in varying concentrations, along with a control sample without insect flour. The products were formulated without applying any thermal treatment. In parallel, the raw materials used, oat flour, cricket flour, and mealworm flour, were also analyzed. Protein, lipid, carbohydrate, and ash contents were determined using standard analytical methods: Kjeldahl, Soxhlet, and gravimetric analysis. Sensory evaluation was conducted with an untrained panel using a 9-point hedonic scale to assess organoleptic attributes.



Nutritional value of protein bars and insect flours

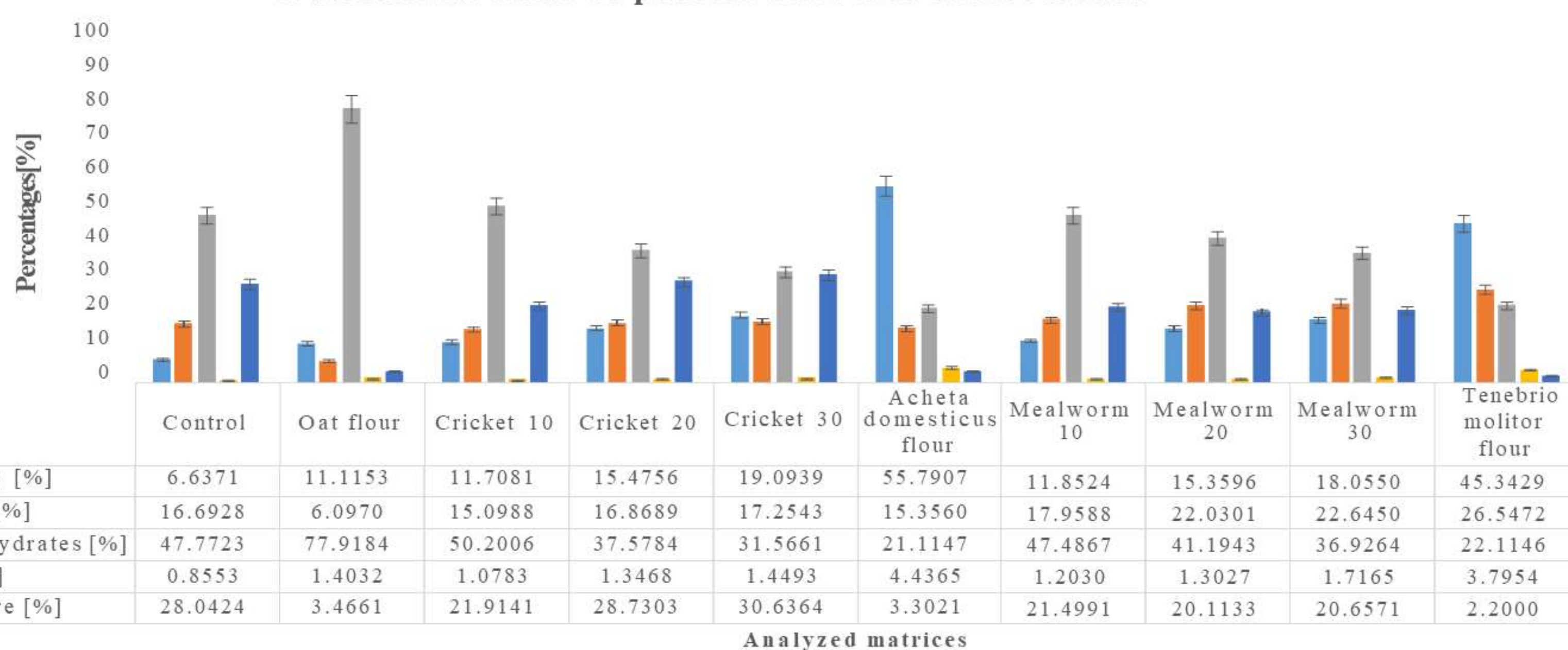


Figure 1. Nutritional composition of protein bars and raw flours

Hedonic score

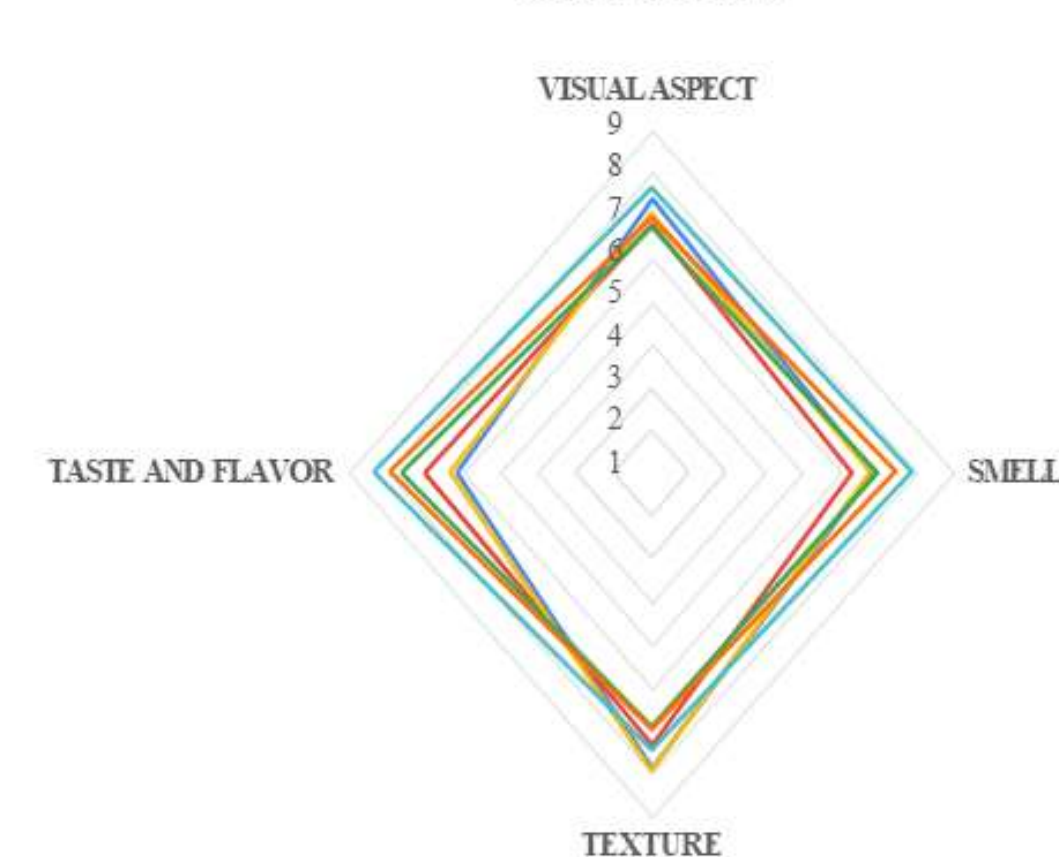


Figure 2. Hedonic evaluation of protein bars

Discussions / Conclusions

Increasing the proportion of insect flour led to a significant improvement in the protein content of the bars, contributed by both *Acheta domesticus* and *Tenebrio molitor* flours, with the latter also providing a higher lipid content. According to the scientific literature, proteins derived from these insects have a rich profile of essential amino acids, supporting the nutritional quality of the product. Carbohydrate content decreased proportionally with the addition of insect flour, indicating a clear nutritional impact. Sensory evaluation showed that the bars were well tolerated and accepted by the untrained panel, with a clear preference for the variant containing 30% *Tenebrio molitor* flour.

Moreover, the use of insects as a protein ingredient helps reduce pressure on conventional agricultural resources, thus supporting the transition towards more sustainable food systems. These results validate the feasibility of the product as a nutritious, eco-friendly, and consumer-attractive protein alternative. Future studies may explore flavor optimization and extended testing on a broader consumer base.

References:

1. Boulos, Samy, Anina Tännler, and Laura Nyström. 2020. 'Nitrogen-to-Protein Conversion Factors for Edible Insects on the Swiss Market: *T. Molitor*, *A. Domesticus*, and *L. Migratoria*'. *Frontiers in Nutrition* 7 (July):89.

2. Grzelczyk, Joanna, Iłona Gałązka-Czarnecka, and Joanna Oracz. 2023. 'Potentiality Assessment of the Acetylcholinesterase-Inhibitory Activity of Olive Oil with an Additive Edible Insect Powder'. *Molecules* 28 (14): 5535.