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BEYOND THE PLATE: EDUCATION AND THE TRANSITION TO VEGETABLE PROTEIN-BASED MEAT ANALOGUES

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ABSTRACT

The paper presents a preliminary study on the acceptability of meat analogues based on vegetable proteins. The bibliographic study, as a reference tool for the development of meat analogues based on vegetable proteins, highlights current concerns among researchers about finding alternatives to reduce the consumption of animal meat, which has negative environmental effects. The results obtained on the acceptability of meat analogues enriched with bioactive compounds, resulting from by-products of vegetable origin, open up opportunities and support in environmental sustainability, the achievement of a circular economy, ethical considerations, and animal welfare. More, integrating the study of vegetable protein-based meat analogues into modern education sits at the intersection of sustainability, biotechnology, and ethical global citizenship. In a pedagogical context, the topic becomes a crucial pillar of 21st century literacy.

Keywords: *sustainability, biotechnology, ethical global citizenship, meat analogues, environment, consumer acceptability, modern education*

INTRODUCTION

The harmful effects of animal production have gradually led to the need to find alternatives, with the development of technologies inherently involving the valorization of plant proteins (Szpicer et al., 2022; Estel et al., 2021; Lai et al., 2017). Those can be defined as textured food products made from plant-derived proteins that mimic or can replace meat (Wang et al., 2022; Lee et al., 2020). Appropriate technologies make it possible for the final product, referred to as an *analog*, to imitate the physical and organoleptic properties of animal-origin products through fibrous composition and a mixture of ingredients from plant sources, offering textures and flavors similar to those of animal products (Lima et al., 2022).

Although proteins are found in greater quantities in animal products (Singh & Krishnaswamy, 2022), the transition to plant-based proteins is still a significant trend in the food industry, with clear benefits for both human health and the environment (Sabater et al.,

2021). Plant-based diets and vegetable products are beneficial for health, reducing the risk of obesity, tumors, and cardiovascular diseases (Hassoun et al., 2022; Craig et al., 2021; Samtya et al., 2021), those changes being encouraged and promoted by the European Commission under the *Farm-to-Fork Program* (Prache et al., 2022). In addition to vegan and vegetarian trends, there are more and more consumers adopting flexitarian diets, by reducing the amount of food derived from animals to include more plant-based foods in their daily diet. Even those who avoid meat consumption for humanitarian reasons (vegans/ vegetarians) can enjoy nutritional benefits by using alternative or non-killing foods (Kazir & Livney, 2021). There is an increasingly profound awareness of the negative impact of animal farming, alongside the technological development in the field of obtaining plant-based proteins (Szpincer et al., 2022; Estel et al., 2021; Lai et al., 2017). In this context, the present work may serve as a positive review as well as a thorough analysis concerning the documentation of the characteristics of meat analogs and the new directions in the food sector, regarding the materials and methods used, to alter consumer perception of meat analogs and encourage the related sector.

1. METHODOLOGY

Testing the *acceptability* of meat analogues is a multi-dimensional process that bridges laboratory precision with human psychology. On the other hand, when we shift the focus from *sensory science* (the tongue) to *consumer attitudes and preferences* (the mind), acceptability is not just about whether a product tastes *good*, but whether consumers want to buy it, eat it, and integrate it into their identity.

In the present research, the acceptability testing of meat analogues was conducted using a questionnaire in which consumer attitudes and preferences were evaluated, as well as how decisions regarding the purchase of analogues and the options of a more sustainable diet based on the use of meat analogues can be influenced. The survey, based on a questionnaire with 12 items, targeted a sample of 226 individuals (72% women/ 28% men), aged from 18 to 60 years old (31.7% between 18-25, 13% between 26-30, 15.2% between 31-40, 26.3% 41-50, 13.8% between 51-60), with different professional backgrounds, coming from various backgrounds, who were encouraged to answer sincerely. 56.7% of the respondents live in an urban environment, while 43.3% live in a rural environment.

2. RESULTS AND DISCUSSION

The first question ("*Have you heard about meat analogues?*") aimed to identify the level of consumer awareness regarding meat analogues. Figure 1 illustrates that 5.8% of respondents have not heard of meat analogues, a significant proportion of 56.9% have heard of meat analogues, and 17.3% have heard of meat analogues but do not know what they are.

According to the non-profit *Good Food Institute*, the overall market for plant-based protein foods in the United States was reported to be $7 billion in 2020, with an annual growth rate of 27% (Hu et al., 2022). This reflects a growing consensus that efforts to improve the sustainability of food systems will benefit from a transition to increased reliance on plant-based foods and a decrease in the consumption of meat and other animal products (Graça et al., 2019).

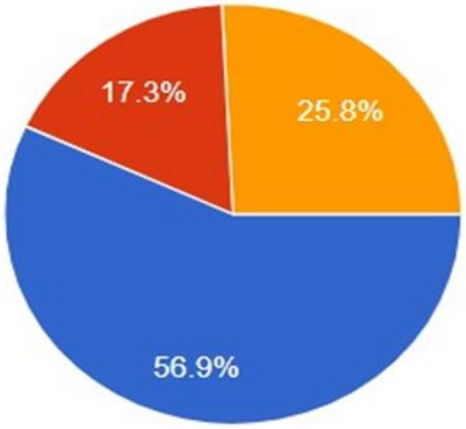

Figure no. 1. *Respondents' feedback (in percentages) to the question: "Have you heard about meat analogues?"*

The following question ("*How did you find out about those products?*") aimed to identify how consumers learned about plant-based meat analogues. From the graphical representation, it can be observed that 25.8% of the individuals (in the analyzed sample) learned about meat analogues through social media, 13.3% heard about meat analogues through friends/ family, 9.8% learned about meat analogues through grocery stores, 9.8% from advertising, 15.1% from other sources, while a significant proportion of 25.8% had not heard about meat analogues (figure 2).

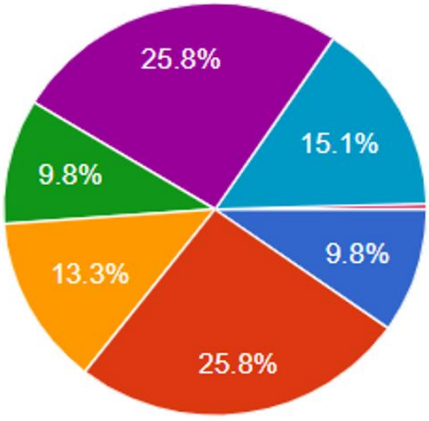

Figure no. 2. *Respondents' feedback (in percentages) to the question: "How did you find out about plant-based meat analogues?"*

Although some researchers question the assumption that the transition from animal meat consumption to plant-based meat analogues and cultured meat will bring benefits (Nezlek & Forestell, 2022), to the following question ("*Do you know what meat analogues are?*"), a significant proportion of 59.6% answered that they know what meat analogues are, while 40.4% do not know the answer (figure 3).

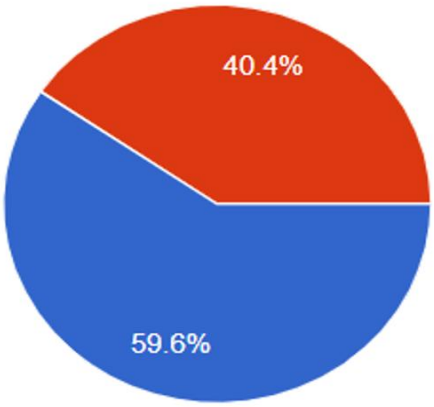

Figure no. 3. *Respondents' feedback (in percentages) to the question: "Do you know what meat analogues are?"*

Vegetable proteins obtained from various sources have been used to create meat analogues that mimic burgers, buns, and sausages (Shaghaghian et al., 2022). The most common ingredients in vegetable meat analogues are textured vegetable proteins (Lin et al., 2022). Meat analogues usually contain over 20 ingredients: vitamins, sugars, minerals, lipids, genetically modified pigments, phosphates, and organic acids (Nagapo, 2022). In response to the question "*Have you ever consumed meat analogues (vegetable burgers, plant-based sausages etc.)?*", it can be observed from the graphical representation (figure 4) that 51.6% of the respondents have consumed meat analogues based on plant proteins, a proportion of 44.9% have not consumed meat analogues, and 3.5% do not know if they have consumed meat analogues.

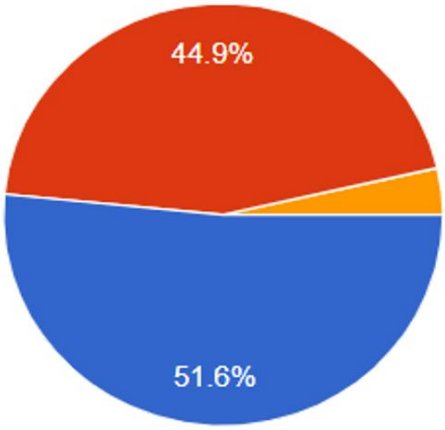

Figure no. 4. *Respondents' feedback (in percentages) to the question: "Have you ever consumed meat analogue (vegetable burgers, plant-based sausages etc.)?"*

Answering to the question "*In general, how willing/ reluctant are you to try products from this category?*", it can be observed that 37.3% of the respondents have a neutral disposition towards trying meat analogues, 25.3% are somewhat willing to try meat analogues, 18.2% are somewhat reluctant to try meat analogues, 13.3% are very willing to try

meat analogues, and 5.9% are very reluctant regarding the consumption of meat analogues (figure 5).

Evidence shows that consumers' emotional associations with food products can add additional information beyond general acceptance and even improve the prediction of food choices (Lagast et al., 2017).

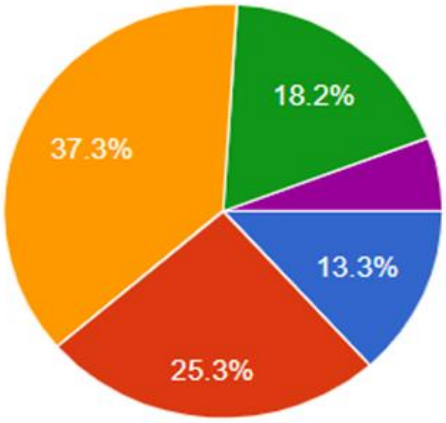

Figure no. 5. *Respondents' feedback (in percentages) to the question:*
"In general, how willing/ reluctant are you to try products from this category?"

To the question "*Have you regularly consumed meat analogues, knowing that it helps reduce environmental pollution?*", a significant proportion of 59.1% responded that they do not agree to regularly consume meat analogues to support environmental sustainability, while 40.9% responded that they agree to regularly consume meat analogues to support environmental sustainability. As can be seen from Figure 6, the choice to consume meat analogues is influenced by a number of factors. Despite the negative consequences of the global consumption of animal products, the consumer choices regarding meat analogues are not primarily determined by arguments such as environmental impact or ethics (Pater et al., 2022).

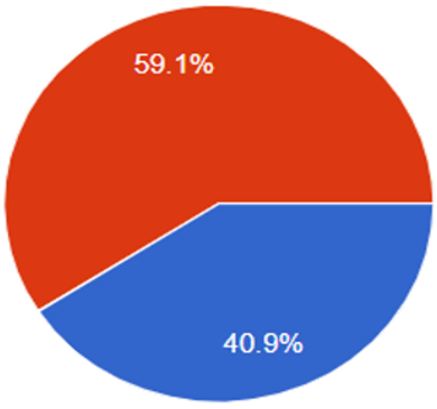

Figure no. 6. *Respondents' feedback (in percentages) to the question:*
"Have you regularly consumed meat analogues, knowing that it helps reduce environmental pollution?"

To the question "*Do you know that in the composition of the analogues, there can be by-products/ food waste resulting from the technological process of manufacturing other products, thereby contributing to the reduction of food waste?*", 38.8% of the respondents know that the composition of plant-based meat analogues may include by-products/ food waste, a proportion of 29.9% do not know this aspect, 23.7% do not know this aspect but are interested in the subject, and 7.6% do not know this and are not interested in finding out more information (figure 7).

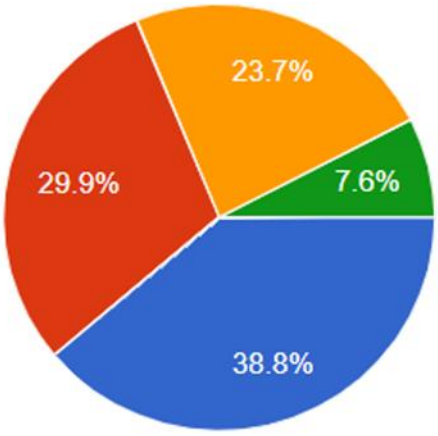

Figure no. 7. *Respondents' feedback (in percentages) to the question:*
"Do you know that in the composition of the analogues, there can be by-products/ food waste resulting from the technological process of manufacturing other products, thereby contributing to the reduction of food waste?"

Plantain-based meat analogues are gaining increasing importance, satisfying consumers' desires for meat-like products, and may facilitate future food supply (Jia et al., 2022). In this respect, to the question "*What factors would determine you to consume meat analogues/ green food?*", 65% of respondents answered that they want to consume meat analogues due to health benefits, 41.9% of respondents want to support environmental sustainability, 23% want to consume meat analogues for ethical and animal welfare reasons, 16.1% because meat analogues are tasty and appetizing, and 9.2% want to consume meat analogues for economic reasons (they are cheaper than meat) and are easy to find in stores (figure 8).

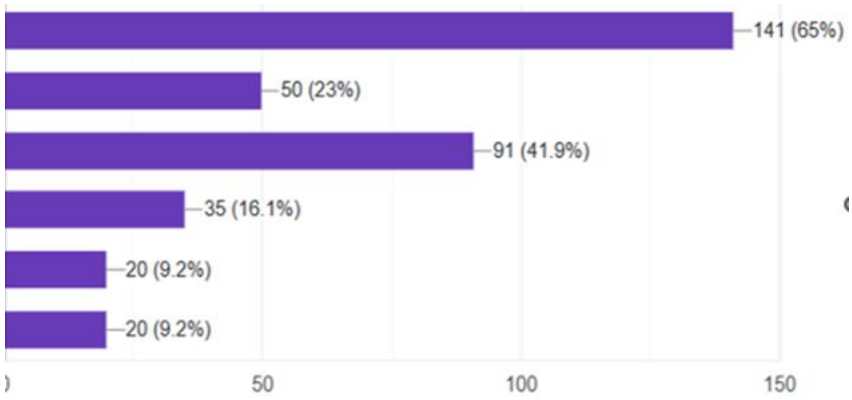

Figure no. 8. *Respondents' feedback to the question:*
"What factors would determine you to consume meat analogues/ green food?"

Replacing traditional meat with plant-based meat analogues could solve the main environmental problem, namely, reducing greenhouse gas emissions. The indirect benefit would be to design the production of meat analogues and cultured meat closer to markets, avoiding the negative environmental impacts of transportation (Nezlek & Forestell, 2022). Several studies highlighted that the main factors in choosing meat analogues are: sensory quality, health, price, convenience (Bryant, 2022), environmental sustainability, animal welfare, and familiarity with the product (Tyndall et al., 2022).

3. HOW THE TRANSITION TO VEGETABLE PROTEIN-BASED MEAT ANALOGUES CAN HELP EDUCATION?

Integrating the study of plant-based meat analogues into the modern curriculum transcends traditional instruction, where such topics are usually analyzed in particular content introduced at Biology, Chemistry, or even Economics. Practically, such content lives at the convergence of biotechnology, environmental sustainability, and ethical global citizenship. Within a pedagogical framework, this subject is emerging as a foundational pillar of 21st-century literacy, equipping students to navigate the complex scientific and moral landscape of future food systems: (a) a catalyst for STEAM Education and Biotechnology (understanding how plant proteins are restructured through extrusion to muscle fiber, calculating protein digestibility and compare the amino-acid profiles of legumes versus animal proteins); (b) support for environmental and related ethical issues (understanding responsible consumption and production, analyzing the *feed-to-food* ratio); (c) support for cultural and economic literacy (understanding food security as a major geopolitical issue, opening doors in food engineering, sustainable farming, and green tech, promoting affordable, plant-based alternatives as a solution for global hunger).

CONCLUSION

In general, *plant-based protein meat analogues* represent highly engineered food products designed to mimic the sensory experience of animal meat (taste, texture, smell, and appearance), using a series of ingredients derived from plants. They support environmental sustainability by utilizing plant by-products/ waste and offer several key-benefits: (a) environmental sustainability - producing plant-based meat typically requires 70% - 99% less water and over 90% less land than conventional beef, with significantly lower greenhouse gas emissions; (b) ethical impact - offering a pathway to protein security without animal slaughter, addressing growing concerns over animal welfare; (c) health literacy - most analogues are cholesterol-free and contain fiber (which real meat lacks) though they are often higher in sodium.

Unfortunately, they are not known to the public on a large scale. For example, a significant proportion of the respondents have heard few facts or have not heard anything about meat analogues (almost 43%), but a substantial percentage of them have consumed meat analogues (almost 52%). At the same time, opinions are divided regarding consumers' willingness/ reluctance to consume plant-based protein meat analogues - a significant proportion (59%) are not willing to regularly consume plant-based protein meat analogues to support environmental sustainability. Moreover, the consumers' knowledge about the composition of plant-based meat analogues varies, with almost 39% of the questioned participants being aware that by-products resulting from other technological processes may

be included in the composition of meat analogues. In this respect, analyzing the factors that would determine the consumption of meat analogues becomes an important aspect, as a significant proportion are willing to consume meat analogues due to their health benefits.

In education, considering various classroom settings and even extracurricular activities, plant-based analogues serve as a perfect *multidisciplinary case study*. In this sense, didactic activities allow students to explore: (a) in Biology lessons, the study of protein structures and amino-acid profiles; (b) Ethical issues offer the chance to analyze the philosophy of food and its sustainability; (c) in Economics and Agriculture lessons, the shift from traditional farming to *green-tech* food systems.

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