

# Utilization of Tofu in Nutritional and Sensory Improvement of Plant-Based Nuggets

Dr. Regine M. Manzanillo<sup>1</sup>, Ronald B. Isidro Jr<sup>2</sup>

<sup>1</sup>Associate Professor I, College of Business and Management, Isabela State University

<sup>2</sup>Assistant Professor 3, College of Business and Management, Isabela State University

## Abstract

This study proposes the usage of Tofu, containing lower meat, as an alternative to the growing demand of consumers for Plant-based foods that contribute to food security while saving the environment by mitigating the effects of environmental damages added from livestock farming. Sensory evaluation helps gain consumer feedback on taste, texture, aroma, appearance, and overall acceptance of the product developed. The significant factors that shape consumer preference are identified by conducting statistical analysis. Nuggets made from these tofu formulations achieve similar nutrition and sensory properties as meat-based products. Tofu can be used as a base for meat substitutes, which is one solution to provide an increasing demand for sustainable, nutritious alternatives. The development of Tofu nuggets is a productive way to decrease meat consumption without compromising the liked sensory properties. Such options can inform and compliment the growing diversity in plant-based protein offerings across the food supply as a whole, and move us closer to a healthier and a more sustainable food future for all. In this research, we used statistical analysis to identify the determinants of consumer preference.

**Keywords:** Product Development, Acceptability, Meat Substitute

## 1. Introduction

Plant Based Meat Alternatives (PBMA) research and development (R&D) has boomed in the field of food technology. This new concept has drawn the interest of both the food industry and the scientific community and a serious focus on sensory properties and market acceptance (Furchheim et al., 2022; He et al, 2020; Fiorentini et al., 2020; Lang, 2020;). PBMA is just as favourable considering the rise of veganism and the world's demand for sustainable and nutrient-dense dietary choices. (Seo, et al 2023; Singh, et. Al 2021; Safdar et al 2022; Schall 2022; Mishra et al 2022; Salomé et al 2023).

One specific example of PBMA development is the exploration of using tofu nuggets in place of regular meat nuggets. Tofu, which is made from soybeans, has emerged as a highly adaptable and protein-packed staple that can be masterfully modified to mimic the taste and texture of meat (Qin, et al, 2022; Ali, 2021; Kaczmarska, 2021; Kyriakopoulou, et al 2021; Pal et al, 2019;). Tofu nugget is a potential food product that will give consumers a gastronomic treat that appears to be both engaging and sustainable, keeping in mind the need for sustainable food habits for ecological preservation (Bryant, C. J. 2022; Ma, C. C., & Chang, H. P. (2022); Estell,et. October 5, 2023 (Chen, Al, 2021; Tyndall, et al, 2022).

As awareness of the significant negative environmental impact of traditional industrial livestock production systems widens (Chen et al. al, 2022; Röö, et. Al, 2022; Banovic, et al 2022; Tziva, et al, 2019; Hoek, et al 2017) PBMA, as illustrated by tofu nuggets, represents an opportunity to promote environmental awareness in dietary habits as these require less of nature's resources and have a lower greenhouse gas emission and ecological footprint when compared to meat products (Michelet al, 2021; Joshi, V. K., & Kumar, S. 2015; Lusk, et al 2022; Andreani, et al 2023).

The objective of this research is to highlight recent developments in functional food technology based on vegetal proteins, with an emphasis on the creation and potential as an innovative PBMA candidate of tofu nuggets (Chandran,et al 2023; Safdar, et al, 2022; FRANCHIN, 2021). This study seeks to explore the feasibility and acceptability of this sustainable meat alternative by providing a comparative analysis of tofu nuggets and commercially available meat alternatives on the market (White, et al, 2022; Wang et al., 2022). An interest further turns to how alterations in production methods can impact improving the structure and techno-functionality of PBMA, leading to designing more sustainable food options (Khan, A. W., & Pandey, J. 2023; Ammann,et al 2023; Pais, et al 2023).

Tofu nuggets products to replace meat nuggets have high potential to provide a sustainable and sensory rich solution in Plant-Based Meat Alternatives.As research continues to advance in this area, the potential benefits of PBMA, such as reduced environmental impact and improved health consciousness, further strengthen the case for embracing these innovative alternatives in the global pursuit of a more sustainable food future.

## **2. Objectives of the Study**

The main goal of the study is to develop meat-based products, especially nuggets, using tofu in order to lower the amount of meat in the finished product. Specifically aimed to:

1. Describe the sensory characteristics of developed products in terms of color, aroma, texture, and taste/flavor;
2. Determine the existence of significant differences on the sensory evaluation of panelists on the sensory characteristics of the developed products in terms of age and gender;
3. Determine the over-all acceptability of the developed meat products in different proportions of plant-based extenders;
4. Determine the existence of significant differences on the overall acceptability of the developed food products on the different treatments in terms of age and gender.

## **3. Materials and Methods**

### **Experimental Design**

Four nugget treatments were prepared differently based on the ratio and proportion of meat and plant-based ingredients, but there was no difference in the use of the newly developed marinade premixes (as shown in Table 1) and one reference were evaluated by the panel. The treatment was as T1- with 25% tofu and 75% meat content, T2- 50% tofu and 50% meat content, T3-75% tofu and 25% meat content and T4-100% tofu.

All of the experiments were carried out twice. In one session, each panel was asked to evaluate four treatment samples and one control sample. For identification purposes, each treatment was assigned a unique number code. However, control sample was excluded in the rating and was used as basis to the profile of the four treatments.

## Preparation of Food Samples

The process of nuggets preparation are as follows: Cutting the tofu into blocks and small pieces. Soaking in water to remove starch. Setting aside the tofu and draining. Mixing of meat, tofu and all ingredients using mixer paddle at speed 3 for 90 seconds. Packed in 7 x 14: x70 microns thick clear plastic. Flattened to make the block uniform in height. Removed air bubbles. Freeze. Manually mold the nuggets into desired shape (making sure that gram per piece is within 13-15 grams as standard set). Predust 1 kilo nuggets using 200 grams pre-dust. Sprinkle the nuggets then shake to removed excess predust. Batter-coated ( 1 part dry to 1.5 water dilution) using 200g dry batter diluted to 300 g chilled water. Dip nuggets for 10 seconds and removed excess batter. Roll into breadcrumb, making sure that all parts were fully coated. Par-fried/Flash frying of chicken nuggets in vegetable fat at 178°C for approximately 60 seconds, Freeze and packed into 6 x 10 for 200g. Stored at – 18 °C. On the day of sensory evaluation, chicken until was pre-fried in vegetable oil fat at 178C for 4 minutes until an internal temperature of 80°C was reached.

## Sensory Evaluation

Descriptive testing method was used to describe the sensory parameters of each treatment and investigate the acceptability of the chicken nuggets with tofu as plant-based ingredient. A total of 75 panelist recruited at Isabela State University Cauayan Campus (mostly students, players from other schools who joined SCUAA, business owner, sales representative, government employee, vendor, teacher and students). The panel age was ranging from age 13 to 54. Half of the 30 panelist were males and other half were females. Briefing regarding the evaluation was given at the beginning of each session, they were instructed to answer questionnaires regarding the data asked that was necessary in the evaluation. Each panel was assigned a number for identification purposes and was responsible to evaluate all the samples. Panelists were asked to fill out score sheet for each sample they evaluated in terms of color, texture, aroma and flavor for the descriptive test. Each sample except the control was rated using a 9-point Hedonic scale rating. Also, panelists were asked to answer voluntarily some demographic questions on the score sheet including gender & age.

The instruments used to evaluate sensory characteristics and acceptability of Tofu Nuggets are shown in figures 3 and 4 below.

## Semantic scale and sensory characteristic descriptors of Tofu Nuggets

Rate	Scale	Descriptor
<b>Color</b>		
4.50 – 5.00	5	Very desirable color of tofu nuggets
3.50 – 4.49	4	Desirable color of tofu nuggets
2.50 – 3.49	3	Slightly desirable color of tofu nuggets
1.50 – 2.49	2	Undesirable color of tofu nuggets
1.00 – 1.49	1	Indifferent
<b>Aroma</b>		
4.50 – 5.00	5	Very Pronounced tofu nuggets aroma
3.50 – 4.49	4	Pronounced tofu nuggets aroma
2.50 – 3.49	3	Recognizable tofu nuggets aroma
1.50 – 2.49	2	Slightly Noticeable tofu nuggets aroma

1.00 – 1.49	1	Undetectable tofu nuggets aroma
<b>Flavor/Taste</b>		
4.50 – 5.00	5	Very pronounced tofu nuggets taste and flavor
3.50 – 4.49	4	Pronounced tofu nuggets taste and flavor
2.50 – 3.49	3	Recognizable tofu nuggets taste and flavor
1.50 – 2.49	2	Slightly pronounced tofu nuggets taste and flavor
1.00 – 1.49	1	Undetectable tofu nuggets taste and flavor
<b>JUICINESS</b>		
4.50 – 5.00	5	Very juicy
3.50 – 4.49	4	Moderately juicy
2.50 – 3.49	3	Slightly juicy/dry
1.50 – 2.49	2	Moderately dry
1.00 – 1.49	1	Very dry

**Table 1. Semantic scale and sensory characteristic descriptors of Tofu Nuggets**

## Hedonic scale rating for the overall acceptability of Tofu Nuggets.

Range	Scale	Description
8.50 – 9.00	9	Like extremely
7.50 – 8.49	8	Like very much
6.50 – 7.49	7	Like Moderately
5.50 – 6.49	6	Like slightly
4.00 – 5.49	5	Neither like nor dislike
3.50 – 4.00	4	Dislike slightly
2.50 – 3.49	3	Dislike moderately
1.50 – 2.49	2	Dislike very much
1.00 – 1.49	1	Dislike extremely

**Table 2. Hedonic scale rating for the overall acceptability of Tofu Nuggets.**

## 4. Results and Discussion

**Table 3. Sensory Characteristics of the Developed Tofu Nuggets**

Sensory Characteristics	M	SD	Descriptive Interpretation
<b>Color</b>			
100% Tofu	4.34	0.71	Desirable color of tofu nuggets
75% Tofu and 25% Meat	4.44	0.79	Desirable color of tofu nuggets
50% Tofu and 50% Meat	4.22	0.86	Desirable color of tofu nuggets
25% Tofu and 75% Meat	4.19	0.90	Desirable color of tofu nuggets
Color Overall	4.21	0.66	Desirable color of tofu nuggets
<b>Aroma</b>			
100% Tofu	4.07	0.85	Pronounced tofu nuggets aroma
75% Tofu and 25% Meat	4.21	0.89	Pronounced tofu nuggets aroma
50% Tofu and 50% Meat	4.11	0.99	Pronounced tofu nuggets aroma
25% Tofu and 75% Meat	3.99	0.90	Pronounced tofu nuggets aroma

Aroma Overall	4.05	0.73	Pronounced tofu nuggets aroma
Flavor/Texture			
100% Tofu	3.99	0.87	Pronounced tofu nuggets taste and flavor
75% Tofu and 25% Meat	4.27	0.72	Pronounced tofu nuggets taste and flavor
50% Tofu and 50% Meat	4.30	0.89	Pronounced tofu nuggets taste and flavor
25% Tofu and 75% Meat	4.14	0.82	Pronounced tofu nuggets taste and flavor
Texture Overall	4.11	0.61	Pronounced tofu nuggets taste and flavor
Juiciness			
100% Tofu	3.81	0.96	Moderately juicy
75% Tofu and 25% Meat	4.03	0.90	Moderately juicy
50% Tofu and 50% Meat	4.14	1.01	Moderately juicy
25% Tofu and 75% Meat	3.95	1.06	Moderately juicy
Taste Overall	4.00	0.81	Moderately juicy

Table 3 presents the results of a sensory evaluation of four different formulations of tofu nuggets, which vary in the percentage of tofu and meat used in their preparation. The sensory characteristics evaluated include color, aroma, flavor/texture, juiciness, and overall quality.

The evaluation encompassed color, aroma, flavor/texture, juiciness, and overall quality. The results showed that all formulations of tofu nuggets were well-received, with high scores across sensory attributes. Notably, the 75% tofu and 25% meat formulation received the highest scores for color and aroma, while the 50% tofu and 50% meat formulation scored highest for flavor/texture and juiciness. However, varying input ratios of tofu and meat in the formulation of tofu nuggets that can cater to individuals of different preferences without compromising on quality attributes has been developed.

The positive sensory scores color, aroma, flavor/texture and juiciness confirm the versatility of tofu in mimicking olfactory and gustatory sensorial features typical of conventional meat, as affirmed in the study of Fiorentini, et al 2020. This could give food producers the freedom to meet different consumer needs and promote the rise of in sustainability and healthy diets (Hilton, J. (2017). The knowledge gained from this research might serve as a foundation for future studies and commercial production of tofu nuggets, supporting the world's transition to a more sustainable and health-friendly dietary system.

**Table 4. Sensory Evaluation of the Panelists on the Characteristics of the Developed Tofu Nuggets in terms of Age**

Sensory Characteristics	Age	M	SD	F	p
Color	Adolescence (12 to 18 years)	4.00	1.41	0.711	0.549
	Young Adulthood (18 to 35 years)	4.22	0.57		
	Middle Adulthood (36 to 55 years)	4.18	0.40		
	Late Adulthood (Above 55 years)	4.67	0.58		
Aroma	Adolescence (12 to 18 years)	3.86	0.90	1.756	0.163
	Young Adulthood (18 to 35 years)	4.11	0.63		
	Middle Adulthood (36 to 55 years)	3.73	1.01		
	Late Adulthood (Above 55 years)	4.67	0.58		
Texture	Adolescence (12 to 18 years)	4.29	0.49	0.340	0.796

Taste	Young Adulthood (18 to 35 years)	4.11	0.63		
	Middle Adulthood (36 to 55 years)	4.00	0.63		
	Late Adulthood (Above 55 years)	4.00	0.00		
	Adolescence (12 to 18 years)	3.86	0.69	0.337	0.799
Taste	Young Adulthood (18 to 35 years)	4.06	0.79		
	Middle Adulthood (36 to 55 years)	3.82	1.08		
	Late Adulthood (Above 55 years)	4.00	0.00		

Note:  $p < 0.05$

Table 4 presents the results of a sensory evaluation of the developed products based on different age groups. The evaluation focused on color, aroma, texture, and taste, with mean scores and standard deviations (SD) reported. While the late adulthood group showed higher mean scores for color, indicating a preference for it, statistical analysis (F and p values) revealed no significant difference in color perception among the age groups. Similarly, the aroma perception was highest among the late adulthood group, followed by young adulthood, with no significant difference among the age groups. Regarding texture, the adolescence group had the highest mean scores, followed by middle adulthood and young adulthood, while the late adulthood group awarded a perfect score of 4.00. However, like color and aroma, there was no significant difference in texture perception among the age groups. In contrast, for taste, the young adulthood group scored the highest, followed by late adulthood, and then adolescence and middle adulthood groups. However, no significant difference in taste perception was found among the age groups.

The sensory evaluation indicated that the developed products were well-liked across all age groups in terms of color, aroma, texture, and taste. Notably, the late adulthood group tended to have higher mean scores for color perception, while the adolescence and middle adulthood groups had higher mean scores for texture perception. However, these differences were not statistically significant.

**Table 5. Sensory Evaluation of the Panelists on the Sensory Characteristics of the Developed Tofu Nuggets in terms of Gender**

Sensory Characteristics		M	SD	t	p
Color	Male	4.17	0.76	- 0.685	0.496
	Female	4.27	0.52		
Aroma	Male	4.17	0.70	1.524	0.132
	Female	3.91	0.77		
Texture	Male	4.19	0.55	1.360	0.178
	Female	4.00	0.66		
Taste	Male	4.12	0.80	1.455	0.150
	Female	3.85	0.80		

Note:  $p < 0.05$

The finding from the sensory evaluation, which indicates that male panelists generally rated the sensory characteristics higher than female panelists, with the exception of color, where female panelists rated it slightly higher, aligns with the historical assumptions of gender-related preferences in product consumption. The earlier belief that women preferred low-calorie products and men were targeted for



alcoholic drinks may have influenced the initial observation of higher ratings from male panelists for certain sensory characteristics.

However, the subsequent analysis using t-tests, which yielded non-significant results ( $p > 0.05$ ) for all sensory characteristics, indicates that these gender-based differences are now considered insignificant. This finding suggests that the traditional gender-related preferences in product consumption have diminished over time, and most products are now liked equally by consumers, regardless of their gender. The results of this sensory evaluation support the notion of Sharif, et al, 2017 that gender differences have an insignificant influence on product perception, mirroring the current trend towards products being appreciated by both men and women without gender discrimination.

The conclusion that male and female panelists have similar perceptions of the sensory characteristics further reinforces the idea of a shift towards more inclusive product preferences, where gender-related factors play a lesser role Ye, et. Al 2017. Nevertheless, the call for further research is essential as it prompts an exploration of other potential factors that may still influence sensory perception, contributing to a more comprehensive understanding of consumer preferences. This finding reflects the contemporary landscape of product evaluation, which is moving towards a gender-neutral approach in sensory self-life studies.

**Table 6. Sensory Evaluation of the Panelists on the Sensory Characteristics of the Developed Products**

Proportion of Plant-based Extenders	M	SD	F	p
100% Tofu	4.05	0.57	1.583	0.194
75% Tofu and 25% Meat	4.24	0.58		
50% Tofu and 50% Meat	4.19	0.71		
25% Tofu and 75% Mean	4.06	0.66		

Table 6 presents the sensory evaluation scores for four different developed products with varying ratios of tofu and meat. The product with 75% tofu and 25% meat received the highest mean rating, followed by 50% tofu and 50% meat, 100% tofu, and 25% tofu and 75% meat. However, the differences in means among the products are small. The F-test results indicate no significant differences in sensory evaluation scores among the developed products ( $p > 0.05$ ). In conclusion, the study suggests that the different ratios of tofu and meat did not significantly impact the sensory evaluation scores. Nonetheless, other factors like nutritional content, texture, and overall acceptability should also be considered in understanding consumer preferences.

**Table 7. Acceptability of the Developed Meat Products in Different Proportions of Plant-based extenders**

Proportion of Plant-based Ex- tenders	M	SD	Descriptive Inter- pretation
100% Tofu	8.41	0.96	Like Very Much
75% Tofu and 25% Meat	8.47	0.91	Like Very Much
50% Tofu and 50% Meat	8.21	1.31	Like Very Much
25% Tofu and 75% Mean	7.96	1.46	Like Very Much

Table 7 presents the mean and standard deviation of the acceptability scores for developed meat products with different proportions of plant-based extenders, as well as a descriptive interpretation of the results. The study's results indicate that all developed products using different proportions of plant-based extenders are highly acceptable, with mean scores above 7.0, denoting a "Like Very Much" interpretation. The products with 100% tofu and 75% tofu with 25% meat received the highest mean scores, while those with 50% tofu and 50% meat and 25% tofu with 75% meat had slightly lower mean scores, but still indicating a strong preference.

The standard deviations of the acceptability scores were low, indicating that the comments of panelists on acceptability of the developed products were similar. The panelists considers meat products with plant-derived extenders, especially 100% tofu and 75% tofu and 25% meat, as acceptable. This study emphasizes the use of plant components, including tofu, as a meat extender capable of producing healthy and sustainable products with high acceptability.

**Table 8. Acceptability of the Different Treatments of Developed Tofu Nuggets with consideration to age.**

Sensory Characteristics	Age	M	SD	F	p
100% Tofu	Adolescence (12 to 18 years)	3.86	0.69	0.560	0.643
	Young Adulthood (18 to 35 years)	4.11	0.54		
	Middle Adulthood (36 to 55 years)	4.00	0.45		
	Late Adulthood (Above 55 years)	4.00	0.00		
75% Tofu and 25% Meat	Adolescence (12 to 18 years)	4.00	0.58	1.288	0.285
	Young Adulthood (18 to 35 years)	4.30	0.60		
	Middle Adulthood (36 to 55 years)	4.09	0.54		
	Late Adulthood (Above 55 years)	4.67	0.58		
50% Tofu and 50% Meat	Adolescence (12 to 18 years)	4.00	0.58	0.205	0.893
	Young Adulthood (18 to 35 years)	4.19	0.76		
	Middle Adulthood (36 to 55 years)	4.09	0.83		
	Late Adulthood (Above 55 years)	4.00	0.00		
25% Tofu and 75% Meat	Adolescence (12 to 18 years)	4.00	0.58	1.019	0.390
	Young Adulthood (18 to 35 years)	4.11	0.67		
	Middle Adulthood (36 to 55 years)	3.73	0.79		
	Late Adulthood (Above 55 years)	4.00	0.00		

Note:  $p < 0.05$

The table indicates the sensory evaluation results of tofu nuggets with varying amounts of tofu and meat according to the scale given by respondents of various age groups (adolescence, young adulthood, middle adulthood, and late adulthood).

The acceptance of the product tofu nuggets using a Likert scale was determined, with larger scores meaning higher acceptability. The acceptability results depended on the percentage of tofu and meat in the recipe and the age group of the participants.

The treatment consisting of 100% tofu nuggets, mean ratings ranged from 3.86 to 4.11 across age groups, with no significant differences between age groups ( $p > 0.05$ ). The mean ratings ranged from



4.00 to 4.67 for nuggets with 75% tofu and 25% meat, and a significant difference in ratings was noted between late adulthood grouping in comparison to other age groups ( $p < 0.05$ ). For the 50% tofu and 50% meat nuggets, mean ratings ranged from 4.00 to 4.19, and did not differ significantly by age group ( $p > 0.05$ ). Mean ratings for the 25% tofu and 75% meat nuggets ranged from 3.73 to 4.11, with no significant differences between age groups ( $p > 0.05$ ).

Findings indicate that increasing proportions of meat in the recipe increased the acceptability of the tofu nuggets. Yet acceptability differed among age groups, as those above 60 demonstrated higher acceptability towards the 75% tofu and 25% meat nuggets. This study had a small sample size and further studies are needed to confirm these results.

**Table 9. Acceptability of the Developed Food Products on the Different Treatments considering gender as variable.**

Proportion of Plant-based Extenders	Gender	M	SD	t	p
100% Tofu	Male	4.10	0.58	0.510	0.612
	Female	4.03	0.47		
75% Tofu and 25% Meat	Male	4.31	0.60	0.922	0.360
	Female	4.18	0.58		
50% Tofu and 50% Meat	Male	4.26	0.63	1.534	0.129
	Female	4.00	0.84		
25% Tofu and 75% Meat	Male	4.12	0.67	1.156	0.252
	Female	3.94	0.67		

Note:  $p < 0.05$

The table presents the sensory evaluation results of food products with different tofu-to-meat ratios, rated by male and female participants. Mean scores and standard deviations were reported. Although some mean scores varied slightly between genders, no significant differences were observed. The study suggests similar acceptability for the food products among male and female participants. To further validate these findings, it is suggested to have more sample size to support this research

**Table 10. Sensory Evaluation of the Panelists on the Sensory Characteristics of the Developed Products**

Proportion of Plant-based Extenders	M	SD	F	p
100% Tofu	8.41	0.96	2.842	0.038
75% Tofu and 25% Meat	8.47	0.91		
50% Tofu and 50% Meat	8.21	1.31		
25% Tofu and 75% Mean	7.96	1.46		

The table presents sensory evaluation results of food products with varying amounts of tofu and meat, assessing their acceptability through mean scores and standard deviations. The 75% tofu and 25% meat product received the highest mean score of 8.47, followed by the 100% tofu product with a mean score of 8.41. The 50% tofu and 50% meat product scored 8.21, and the 25% tofu and 75% meat product had the lowest mean score of 7.96.

Statistical analysis showed significant differences in mean ratings among the four treatments ( $F = 2.842$ ,  $p < 0.05$ ). The 100% tofu and 75% tofu with 25% meat products were preferred over the 50% tofu and

50% meat and 25% tofu with 75% meat products. The 100% tofu and 75% tofu with 25% meat products did not significantly differ in acceptability.

The panel favored the sensory characteristics of the food items, particularly the 75% tofu and 25% meat product, and the 100% tofu product.

### Conclusion

In conclusion, the results of the sensory evaluation suggest that the developed food products, which incorporated different ratios of tofu and meat, were well-received overall. The panelists showed consistency in their opinions regarding the acceptability of the products, and there were no significant differences in the acceptability of the products between male and female participants. However, there were variations in acceptability across different age groups, with older participants showing a higher level of acceptability for certain products. Further research is needed to confirm these findings, considering the limited sample size of the study. The results suggest that plant-based extenders, such as tofu, can be used to produce meat products with high acceptability scores, providing a range of options for consumers with different preferences.

Meat production is an important part of future food systems because it is one of the most important sources of dietary protein worldwide; however, its production, which has rapidly industrialized in recent decades, has been linked to significant negative environmental, health, and animal welfare impacts. Customers are turning to alternatives to meat or products produced with fewer negative externalities than conventional products as a result of these negative effects. Alternatives to popular processed meat products that is plant-based. The study had shown that the development of Tofu Nuggets have been acceptable among its possible consumers. The tofu nuggets developed in this study generally showed acceptable and comparable sensory characteristics as the control, which does not contain any eggplant as ingredient.

### Recommendation

Based on the sensory evaluation results, the following recommendations are proposed for further research and product development:

1. Conduct larger-scale studies to validate variations in acceptability among different age groups.
2. Explore the nutritional content and health benefits of the developed products to attract health-conscious consumers.
3. Investigate the feasibility of using plant-based extenders in other meat products, expanding the range of alternatives.
4. Conduct shelf-life testing for product safety and quality.
5. Validate findings through additional research with diverse consumer groups.
6. Utilize test marketing to assess the viability of the new product before commercialization.
7. Facilitate technology transfer to benefit the community and increase product accessibility.

### References

1. Ali, F., Tian, K., & Wang, Z. X. (2021). Modern techniques efficacy on tofu processing: A review. *Trends in Food Science & Technology*, 116, 766-785.
2. Ammann, J., Arbenz, A., Mack, G., Nemecek, T., & El Benni, N. (2023). A review on policy instruments for sustainable food consumption. *Sustainable Production and Consumption*.

3. Andreani, G., Sogari, G., Marti, A., Frolidi, F., Dagevos, H., & Martini, D. (2023). Plant-based meat alternatives: technological, nutritional, environmental, market, and social challenges and opportunities. *Nutrients*, 15(2), 452.
4. Banovic, M., Barone, A. M., Asiolli, D., & Grasso, S. (2022). Enabling sustainable plant-forward transition: European consumer attitudes and intention to buy hybrid products. *Food Quality and Preference*, 96, 104440.
5. Bryant, C. J. (2022). Plant-based animal product alternatives are healthier and more environmentally sustainable than animal products. *Future Foods*, 100174.
6. Chandran, A. S., Suri, S., & Choudhary, P. (2023). Sustainable plant protein: A recent overview of sources, extraction techniques and utilization ways. *Sustainable Food Technology*.
7. Chen, Y. P., Feng, X., Blank, I., & Liu, Y. (2022). Strategies to improve meat-like properties of meat analogs meeting consumers' expectations. *Biomaterials*, 287, 121648.
8. Estell, M., Hughes, J., & Grafenauer, S. (2021). Plant protein and plant-based meat alternatives: Consumer and nutrition professional attitudes and perceptions. *Sustainability*, 13(3), 1478.
9. Fiorentini, M., Kinchla, A. J., & Nolden, A. A. (2020). Role of sensory evaluation in consumer acceptance of plant-based meat analogs and meat extenders: A scoping review. *Foods*, 9(9), 1334.
10. He, J., Evans, N. M., Liu, H., & Shao, S. (2020). A review of research on plant-based meat alternatives: Driving forces, history, manufacturing, and consumer attitudes. *Comprehensive Reviews in Food Science and Food Safety*, 19(5), 2639-2656.
11. Hilton, J. (2017). Growth patterns and emerging opportunities in nutraceutical and functional food categories: Market overview. In *Developing new functional food and nutraceutical products* (pp. 1-28). Academic Press.
12. Jahn, S., Furchheim, P., & Strässner, A. M. (2021). Plant-based meat alternatives: Motivational adoption barriers and solutions. *Sustainability*, 13(23), 13271.
13. Joshi, V. K., & Kumar, S. (2015). Meat Analogues: Plant based alternatives to meat products-A review. *International Journal of Food and Fermentation Technology*, 5(2), 107-119.
14. Kaczmarska, K., Taylor, M., Piyasiri, U., & Frank, D. (2021). Flavor and metabolite profiles of meat, meat substitutes, and traditional plant-based high-protein food products available in Australia. *Foods*, 10(4), 801.
15. Khan, A. W., & Pandey, J. (2023). Consumer psychology for food choices: a systematic review and research directions. *European Journal of Marketing*, (ahead-of-print).
16. Kyriakopoulou, K., Keppler, J. K., & van der Goot, A. J. (2021). Functionality of ingredients and additives in plant-based meat analogues. *Foods*, 10(3), 600.
17. Lang, M. (2020). Consumer acceptance of blending plant-based ingredients into traditional meat-based foods: Evidence from the meat-mushroom blend. *Food Quality and Preference*, 79, 103758.
18. Lusk, J. L., Blaustein-Rejto, D., Shah, S., & Tonsor, G. T. (2022). Impact of plant-based meat alternatives on cattle inventories and greenhouse gas emissions. *Environmental Research Letters*.
19. Ma, C. C., & Chang, H. P. (2022). The effect of novel and environmentally friendly foods on consumer attitude and behavior: a value-attitude-behavioral model. *Foods*, 11(16), 2423.
20. Michel, F., Hartmann, C., & Siegrist, M. (2021). Consumers' associations, perceptions and acceptance of meat and plant-based meat alternatives. *Food Quality and Preference*, 87, 104063.
21. Mishra, A., & Miracle, L. M. (2022). Plant-based Meat Alternative products versus Conventional Meat: Exploring the. *Economics*, 39(2), 301-311.

22. Pal, M., Devrani, M., & Ayele, Y. (2019). Tofu: A popular food with high nutritional and health benefits. *Food & Beverages Processing*, 5, 54-55.
23. Pais, D. F., Marques, A. C., & Fuinhas, J. A. (2023). How to Promote Healthier and More Sustainable Food Choices: The Case of Portugal. *Sustainability*, 15(4), 3868.
24. Qin, P., Wang, T., & Luo, Y. (2022). A review on plant-based proteins from soybean: Health benefits and soy product development. *Journal of Agriculture and Food Research*, 7, 100265.
25. Rööß, E., de Groote, A., & Stephan, A. (2022). Meat tastes good, legumes are healthy and meat substitutes are still strange-The practice of protein consumption among Swedish consumers. *Appetite*, 174, 106002.
26. Salomé, M., Mariotti, F., Dussiot, A., Kesse-Guyot, E., Huneau, J. F., & Fouillet, H. (2023). Plant-based meat substitutes are useful for healthier dietary patterns when adequately formulated—an optimization study in French adults (INCA3). *European Journal of Nutrition*, 62(4), 1891-1901.
27. Safdar, B., Zhou, H., Li, H., Cao, J., Zhang, T., Ying, Z., & Liu, X. (2022). Prospects for plant-based meat: Current standing, consumer perceptions, and shifting trends. *Foods*, 11(23), 3770.
28. Schall, L. K. (2022). What factors shape German consumers' attitudes towards plant-based meat? An analysis of online conversations about vegan and vegetarian products in Germany and the corresponding aspects that arise out of them.
29. Seo, E. H., Jang, H. W., & Cho, M. (2023). Enabling the foodservice industry to transition consumers toward plant-based meat alternatives: A behavioral reasoning perspective. *International Journal of Hospitality Management*, 114, 103559.
30. Singh, M., Trivedi, N., Enamala, M. K., Kuppam, C., Parikh, P., Nikolova, M. P., & Chavali, M. (2021). Plant-based meat analogue (PBMA) as a sustainable food: A concise review. *European Food Research and Technology*, 247, 2499-2526.
31. Tziva, M., Negro, S. O., Kalfagianni, A., & Hekkert, M. P. (2019). Understanding the protein transition: The rise of plant-based meat substitutes. *Environmental Innovation and Societal Transitions*.
32. Tyndall, S. M., Maloney, G. R., Cole, M. B., Hazell, N. G., & Augustin, M. A. (2022). Critical food and nutrition science challenges for plant-based meat alternative products. *Critical Reviews in Food Science and Nutrition*, 1-16.
33. Wang, Y., Tuccillo, F., Lampi, A. M., Knaapila, A., Pulkkinen, M., Kariluoto, S., ... & Katina, K. (2022). Flavor challenges in extruded plant-based meat alternatives: A review. *Comprehensive Reviews in Food Science and Food Safety*, 21(3), 2898-2929.
34. White, S. K., Ballantine, P. W., & Ozanne, L. K. (2022). Consumer adoption of plant-based meat substitutes: A network of social practices. *Appetite*, 175, 106037.