Development and Acceptability of Nutritionally Enhanced Azolla (Azolla Pinnata) Flavored Kropek

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ABSTRACT

The study employed a developmental-experimental research design using five treatments arranged in a single-factor framework: Treatment A (10% Azolla), Treatment B (20% Azolla), Treatment C (30% Azolla), Treatment D (40% Azolla), and a control (commercial store-bought Kropek). A 9-point Hedonic Rating Scale was utilized to collect sensory data from 21 respondents. Statistical analysis included the computation of mean scores and the application of Welch's Analysis of Variance (ANOVA) followed by Tukey post hoc testing to determine significant differences among treatments. Results of the sensory evaluation revealed that Treatment D (40% Azolla) obtained the highest mean rating in flavor and demonstrated a statistically significant difference compared to Treatment B (20% Azolla). No significant differences were observed in appearance, aroma, texture, and sound. Based on overall consumer acceptability, Treatment D was the most preferred formulation, receiving qualitative ratings equivalent to "Like Very Much" to "Extremely Like." Storage observation indicated that the fried Azolla-Kropek remained stable for approximately three to four weeks under proper dry and airtight conditions, maintaining acceptable texture and sensory quality. Cost analysis further showed that the product is economically feasible for small-scale or school-based production. The findings indicate that Azolla (A. pinnata) can be successfully incorporated into Kropek without compromising sensory acceptability while potentially enhancing its nutritional value and sustainability as a snack alternative.

Keywords: Azolla, Azolla pinnata, kropek, sensory evaluation, shelf-life

INTRODUCTION

In today's fast-paced world, junk food has become a staple for many, captivating the taste buds of all ages with its crunchy allure. As students navigate their early years, establishing healthy eating habits is important for their overall development and academic performance. However, diets high in junk foods are often characterized by a lack of essential nutrients (Goel et al., 2023), leading to significant health issues such as obesity (Kumar et al., 2018; Musaiger, 2014), diabetes, and coronary heart disease (Kumar et al., 2018).

At Ilocos Norte Regional School of Fisheries (INRSF), among the 60 students surveyed from Grades 7 to 12, 25 (41.7%) reported consuming junk food daily, 15 (25%) consumed it weekly, 12 (20%) sometimes, and 8 (13.3%) did not consume junk food at all. The gender distribution included 36 males (60%) and 24 females (40%).

This prevalent practice of consuming junk food has raised significant concerns regarding student health, particularly with rising cases of obesity and related non-communicable diseases. The lack of nutritious snack options available within the school environment exacerbates this issue, as students often resort to easily accessible junk food instead of healthier alternatives. Despite various initiatives promoting healthier eating habits, there remains a critical gap in providing convenient and appealing nutritious snacks that cater to students' preferences. To address this gap, this research seeks to develop an innovative Kropek recipe using Azolla, a sustainable and nutrient-rich ingredient, as a healthier alternative to commercial store-bought Kropek.

The urgency for healthier snack alternatives is further underlined by the Department of Education (DepEd) Order No. 13, s. 2017, titled "Policy and Guidelines on Healthy Food and Beverage Consumption in Schools and DepEd Offices," which promotes healthy eating habits and the availability of nutritious food in schools. With 41.7% of students at INRSF consuming junk food daily, it is a policy priority to provide nutritious and sustainable snack options.

Given these health concerns, Azolla, specifically A. pinnata, is a free-floating aquatic fern known for its unique growth characteristics. It thrives under ideal conditions of 20–30°C, relative humidity between 85% and 90%, and a pH range of 5.5 to 7 (Raja et al., 2012). Recognized as one of the fastest-growing aquatic plants, Azolla does not require soil for cultivation, making it an excellent candidate for sustainable farming practices. Its cultivation is prevalent in countries like China, Vietnam, and the Philippines, where it serves various purposes including livestock feed, soil fertility enhancement, bioremediation, and feed for fish and shrimp (Amit et al., 2016; Roy et al., 2016). Despite its potential as a human food source being less well-known (Roy et al., 2016), research indicates that Azolla could be a viable option for human consumption (Yao et al., 2018).

Nutritionally, Azolla is rich in protein with levels comparable to soybeans (Roy et al., 2016) and contains approximately 21–23% crude protein (Kumar & Chander, 2017). It provides essential amino acids, particularly lysine (7–10% of dry weight) (Roy et al., 2016), surpassing levels found in corn and rice concentrates (Putra et al., 2022; Ting et al., 2022). Additionally, Azolla is abundant in minerals such as iron, calcium, magnesium, and potassium, as well as vitamins A and B-12 (Mathur et al., 2013). Among Azolla species, A. pinnata stands out for its ease of cultivation and low initial investment (Korsa et al., 2024).

In this study, the researcher aims to utilize A. pinnata as an ingredient in Kropek to enhance its nutritional profile and flavor specifically for INRSF students, providing a sustainable health-conscious snack while promoting environmental conservation.

Project Objectives

This study aimed to develop a healthier version of traditional Kropek using *A. pinnata* to enhance its nutritional value. The specific objectives are:

1. develop four Kropek samples with varying concentrations of Azolla except the Treatment E (control) (0% Azolla): Treatment A (10% Azolla), Treatment B (20% Azolla), Treatment C (30% Azolla), and Treatment D (40% Azolla);

2. conduct a sensory evaluation (organoleptic test) of the five Kropek samples to assess their sensory attributes such as appearance, aroma, flavor, texture, and sound;

3. measure the acceptability preferences of 21 respondents regarding the five Kropek preparations using a 9-point Hedonic Rating Scale;

4. perform an Analysis of Variance (ANOVA) on the sensory quality data collected to identify significant differences among the Kropek preparations; and,

5. determine the shelf life of Azolla pinnata Kropek under room temperature conditions.

METHODOLOGY

Research Design

This study employed the Completely Randomized Design (CRD) in which the Azolla-flavored Kropek was evaluated across five treatments: Treatment A (10% Azolla), Treatment B (20% Azolla), Treatment C (30% Azolla), Treatment D (40% Azolla), and Treatment E (Control – commercial store-bought Kropek). Three independent batches were prepared for each of the five treatments (15 batches total). Each of the 21 respondents evaluated one sample from each batch, providing 3 replications × 21 panels = 63 observations per treatment for statistical analysis.

Each treatment was randomly assigned to respondents to eliminate bias, and successive replications were conducted to determine the cause of variation in sensory quality. The experiment followed standardized sensory evaluation methods as described by Meilgaard, Civille, and Carr (2016) to ensure reliability and consistency. Samples were coded, and evaluation scorecards were used to maintain randomization and objectivity.

Flowchart of the Product Development Process

The Azolla-Kropek product development process is illustrated in the flowchart below, outlining the sequential steps in Azolla preparation and Kropek formulation. The flowchart provides a clear visual representation of the experimental procedures, from the cultivation and harvesting of Azolla to the final cooking, frying, and storage of the Kropek samples.

Kropek Treatment Formulations and Processing

Each Kropek treatment was prepared from a 100g dry formulation batch containing tapioca starch (6080g base), salt, spices, and Azolla powder at the following inclusion levels: Treatment A (10g Azolla powder, 90g base), Treatment B (20g Azolla powder, 80g base), Treatment C (30g Azolla powder, 70g base), Treatment D (40g Azolla powder, 60g base). Treatment E (control) used commercial store-bought Kropek sheets. Batches were mixed with water to form dough, sheeted to 2mm thickness, cut into 3×3 cm pieces, sun-dried for 2 days, then deep-fried at 180°C until golden and crisp.

Respondents of the Study

A total of 21 respondents participated in the study, consisting of students from Grades 7 to 12 at the Ilocos Norte Regional School of Fisheries (INRSF). The respondents were selected based on their availability and willingness to participate in sensory evaluation sessions. They evaluated the Kropek samples based on five sensory attributes: appearance, aroma, flavor, texture, and sound.

Data Gathering Instruments

Azolla Processing and Preparation. Fresh *Azolla pinnata* was harvested from school cultivation ponds, thoroughly washed with clean water to remove debris, and oven-dried at 50°C for 24 hours until constant weight was achieved. Dried Azolla was ground using a laboratory blender and sieved through a 500 µm mesh to obtain fine powder for incorporation into Kropek formulations.

The study utilized both fresh and powdered forms of Azolla (Azolla pinnata) as the experimental ingredient in the Kropek formulations. A 9-Point Hedonic Rating Scale was employed to evaluate the sensory attributes, where 9 = Extremely Like and 1 = Extremely Dislike. Data were gathered on the following sensory attributes: Appearance (visual appeal of the Kropek), aroma (fragrance and freshness), flavor (taste profile and aftertaste), texture (crispiness and mouthfeel), sound (auditory crunch when eaten).

The 9-point scale allowed for quantitative assessment of respondent preferences and acceptability.

Data Gathering Procedure

Permission to conduct the study was secured from the School Principal of INRSF and informed consent was obtained from all respondents. Respondents were briefed on the purpose of the study, assured of the confidentiality of their responses, and informed that participation was voluntary.

Kropek samples were prepared in the laboratory following the five treatment formulations. Each sample was coded to ensure respondent blindness to the treatment. The researcher personally distributed the samples for evaluation, collecting the completed scorecards immediately to achieve 100% retrieval.

Sensory evaluation sessions were conducted individually, with respondents rating each sample based on the 9-point Hedonic Scale. Observations on sample consistency, taste, and other qualitative notes were recorded by the researcher for further analysis.

Data Analysis Procedure

The data gathered from the sensory evaluation were analyzed using both descriptive and inferential statistics. Mean scores were calculated to determine the overall sensory qualities and general acceptability of each Kropek treatment, focusing on appearance, aroma, flavor, texture, and sound.

To identify whether statistically significant differences existed among the five treatments for each sensory attribute, a One-Way Analysis of Variance (ANOVA) was performed. Since some of the data did not meet normality and homogeneity assumptions, Welch's ANOVA was applied as a more robust alternative. When significant differences were detected, Tukey post hoc tests were employed to determine which specific treatments differed from each other.

The results of these analyses were interpreted to identify the most acceptable Kropek formulation and to provide evidence-based recommendations for improving product quality.

Ethical Considerations

Throughout the study, ethical protocols were strictly observed to ensure the rights, safety, and well-being of all respondents. Informed consent was secured from each student respondent and, where applicable, their parents or guardians prior to the sensory evaluation sessions. Confidentiality was maintained by anonymizing personal information, and respondents were assured that all data collected would be used solely for research purposes. Students were informed that participation was voluntary and that they could withdraw at any time without any consequences.

Additionally, the researcher took measures to minimize potential discomfort during sample tasting by providing clear instructions, labeling treatments to avoid bias, and supervising the sensory evaluation sessions to ensure a safe and supportive environment. Special attention was also given to hygiene and food safety throughout the preparation, cooking, and serving of the Azolla-Kropek samples to protect respondents from any risk of contamination or foodborne illness.

RESULTS AND DISCUSSION

Acceptability of Kropek samples in different treatments

The quality characteristics of Kropek were evaluated using a 9-point hedonic scale (9 = Extremely Like, 1 = Extremely Dislike) across five treatments: Treatment A: 10% Azolla, Treatment B: 20% Azolla, Treatment C: 30% Azolla, Treatment D: 40% Azolla, and Treatment E: Control (commercial store-bought Kropek). The results of the evaluation on quality characteristics of the five Kropek treatments are presented in Table 1.

Table 1. Sensory Evaluation of Kropek Treatments (N=21)

Sensory Attributes	Treatment	N	Mean	SD
Appearance	A	21	8.14	1.20
	B	21	7.57	1.63
	C	21	7.62	1.63
	D	21	8.43	0.87
	E	21	8.24	1.09
Aroma	A	21	8.38	1.36
	B	21	7.67	1.69
	C	21	7.71	1.68
	D	21	8.19	1.17
	E	21	8.14	1.11
Flavor	A	21	8.10	1.61

	B	21	7.10	1.64
	C	21	7.76	1.30
	D	**21**	**8.38**	**0.97**
	E	21	8.24	1.18
Texture	A	21	8.67	0.58
	B	21	7.95	1.32
	C	21	8.05	1.16
	D	21	8.38	0.97
	E	21	8.29	0.78
Sound	A	21	8.24	1.41
	B	21	7.86	1.88
	C	21	8.10	1.26
	D	21	8.33	1.35
	E	21	8.48	0.98

Note. Treatments: A=10% Azolla, B=20%, C=30%, D=40%, E=commercial control. D highlighted as highest flavor score ($p<0.05$ vs B).

From the data, Treatment D (40% Azolla) scored highest in flavor (Mean = 8.38, SD = 0.97), which emphasizes the critical role of flavor in consumer preference. The significant difference in flavor ratings between Treatment D and Treatment B ($p = 0.024$) suggests that increasing Azolla concentration improves flavor perception, supporting the idea that innovative flavor profiles can outperform commonly bought Kropek. This aligns with studies showing flavor as a primary determinant of consumer liking and acceptance (Cheng, Liu, & Feng, 2023; Huang, Fan, & Zhang, 2023).

Appearance ratings were highest for Treatment D (Mean = 8.43), suggesting that a higher Azolla concentration did not negatively impact visual appeal. Similarly, aroma, texture, and sound showed consistent high scores across treatments, with minor variations. The lack of significant differences in these attributes indicates that Azolla can be incorporated up to 40% without altering the overall sensory experience. This is consistent with research on multisensory perception, which shows that flavor integrates visual, olfactory, gustatory, and tactile cues while other attributes may remain stable (Spence, 2019; Roque, Auvray, & Lafraire, 2018).

Analysis of Variance (Welch's F-Test)

Given the non-normality and heterogeneity of variances, Welch's F-test was applied. Flavor was the only attribute showing significant differences ($F(4,49.5) = 2.672$, $p = 0.043$), while appearance, aroma, texture, and sound were not significantly different ($p > 0.05$) (Table 2). This finding emphasizes that flavor is the most sensitive and influential attribute in the acceptability of Azolla Kropek.

Table 2. Welch's F-Test Results for Sensory Attributes

Sensory Attributes	F	Df1	Df2	p-value
Appearance	1.722	4	49.3	0.160
Aroma	0.852	4	49.6	0.499

Flavor	**2.672**	**4**	**49.5**	**0.043**
Texture	2.224	4	48.8	0.080
Sound	0.577	4	49.5	0.680

Note. Flavor significant at $p<0.05$ (Treatment D > B, Tukey post-hoc, $p=0.024$).

Tukey post hoc testing confirmed that Treatment D was significantly preferred over Treatment B for flavor, while other pairwise comparisons were not significant. This reinforces the importance of unique and appealing flavor profiles in driving consumer acceptance (Zafra, Torregosa, & Chua, 2025).

These findings support the idea that flavor is the decisive factor in consumer acceptance for innovative food products like Azolla Kropek, while appearance, aroma, texture, and sound remain consistently acceptable across different Azolla concentrations. The combination of affordability, feasibility, and shelf stability demonstrates that this innovation is not only sensory appealing but also sustainable and practical for local implementation. This aligns with literature on multisensory perception, neurogastronomy, and the influence of unique flavors on consumer interest and product success (Weir, 2019; Ruiz-Capillas & Herrero, 2021; De Santis, 2024).

Cost Analysis / Feasibility

The production of Azolla-Kropek is economically feasible for small-scale or school-based operations. The total project budget of PHP 5,693 covered ingredients, materials, and processing costs, with personal funds used. Ingredients like tapioca starch, spices, and locally cultivated Azolla (*A. pinnata*) are low-cost and readily available, demonstrating that the innovation is sustainable, practical, and easily replicable in school laboratories or home kitchens.

Shelf-Life / Storage Stability

Fried Azolla-Kropek remained stable for 3–4 weeks under dry and airtight storage, retaining texture, flavor, aroma, and overall acceptability. This indicates that the product can be prepared in batches without immediate spoilage, though regular sensory checks are recommended to maintain quality over time.

CONCLUSION

The findings of this study highlight the pivotal role of flavor in shaping consumer preferences and driving the success of innovative food products, such as Azolla-flavored Kropek. Treatment D (40% Azolla) was significantly preferred over other samples, demonstrating that unique flavor profiles can outperform commercial store-bought alternatives in terms of consumer acceptance. Attributes such as appearance, aroma, texture, and sound remained consistently acceptable across all treatments, reinforcing that flavor is the most decisive sensory factor.

Furthermore, the innovation proved to be economically feasible, with a total production cost of PHP 5,693, using low-cost, locally available ingredients, and shelf-stable, remaining acceptable for 3–4 weeks under proper storage. These findings indicate that Azolla-Kropek is not only sensory appealing but also sustainable, practical, and easily replicable in school or home-based settings. Overall, the study demonstrates that combining nutritional enhancement with consumer-preferred flavor can lead to an innovative, feasible, and acceptable food product.

RECOMMENDATIONS

To further enhance the understanding of the nutritional and functional properties of Azolla Kropek, future studies may consider the following:

1. Quantify essential minerals such as iron, calcium, magnesium, and zinc to evaluate their contribution to dietary requirements.

2. Conduct a comprehensive proximate analysis, explicitly detailing methods, AOAC reference numbers, and equipment used, to provide quantitative data on moisture, protein, fat, carbohydrate, and ash content.

3. Determine total dietary fiber content and compare it against commercial Kropek brands to quantify the nutritional advantage of Azolla incorporation.

4. Examine the amino acid composition to assess protein quality and nutritional benefits more precisely.

5. Explore the potential of Azolla Kropek as a functional food within broader health or school-based nutrition programs.

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