Canrea Journal: Food Technology, Nutritions, and Culinary, 2025; 8 (1): 154–169 OPEN ACCESS

e-ISSN : 2621-9468

Type of the Paper (Article)

Organoleptic quality and shelf-life of dry noodle from maize flour and fish hydrolysate protein (Mizepi) for emergency food

Nina Resti[1], Fitriyono Ayustaningwarno[2], Gemala Anjani[2], Ahmad Syauqy[2], Nuryanto Nuryanto[2], Ekowati Chasanah[3], Endang Yuli Purwani[4], and Diana Nur Afifah[2,5,6]*

[1] Doctoral Study Program of Medical and Health Sciences, Universitas Diponegoro, Semarang, Indonesia
[2] Department of Nutrition Science, Faculty of Medicine, Universitas Diponegoro, Jl. Prof. Sudarto, Tembalang, Semarang 50275, Central Java, Indonesia
[3] Research Center for Marine and Inland Bioproducts, Research Organization (RO) of Earth and Maritime, National Research and Innovation Agency (BRIN), North Lombok 83352, Province of West Nusa Tenggara, Indonesia
[4] Research Center for Agroindustry, National Research and Innovation Agency (BRIN), KST Soekarno Cibinong, Jl. Raya Jakarta – Bogor KM 46, Cibinong 16911, Province of West Java, Indonesia
[5] SDGs Center, Diponegoro University, Jl. Prof. Sudarto, Tembalang, Semarang 50275, Province of Central Java, Indonesia
[6] Laboratory of Sustainable Diets and Biodiversity, Center of Research and Service – Diponegoro University (CORES-DU), Integrated Laboratory, Universitas Diponegoro, Semarang 50275, Central Java, Indonesia

Abstract

Natural disasters have crucial impacts on food aspects. This problem can be addressed by innovations in nutrient-dense products. However, the reality is that innovation in emergency food products is still minimal, especially in those with high protein content. This research created Mizepi products made from maize flour and Fish Protein Hydrolysate (FPH) for existing emergency food requirements. This organoleptic quality research was conducted on 112 consumer panelists with seven formulations of Mizepi and compared them with maize flour and FPH in grams such as F1 (1:1), F2 (4:7), F3 (4:11), F4 (7:4), F5 (7:11), F6 (11:4), and F7 (11:7) using the Hedonic Test and Just About Right (JAR) on nine scales. Selection of the best formulation was analyzed using the Effectiveness Index Test method. The shelf life test was carried out on the best formulation, namely F4 using the Accelerated Shelf-Life Testing (ASLT) method at temperatures of 35 °C, 45 °C and 50 °C respectively. Samples were observed every 7 days for 28 days. Parameters using water content and Free Fatty Acid (FFA). The organoleptic quality test with hedonic test explained that the product with the most preferred categories is in terms of aroma (F6), color (F1), texture (F4), flavor (F6 and F4), and overall (F4). The most favorable JAR test results for color of all samples were the same, namely yellow, savoriness (F4 and F6), typical savory aroma of corn (F5, F6, F7), typical savory aroma of fish (F3), and crunchy texture (F4). Test results for the shelf life of Mizepi products in the best formulation can be stored well for 46 days at a temperature of 35 °C with water content parameters. The best formulation of F4 meets emergency food requirements, namely it is acceptable in terms of taste, and acceptable.

Article History
Received February 7, 2024
Accepted June 26, 2025
Published June 30, 2025

Keywords
Fish Protein Hydrolysate (FPH),
Hedonic Test,
Maize Flour,
Noodle,
Shelf Life.

* Correspondence : **Diana Nur Afifah** d.nurafifah.dna@fk.undip.ac.id

ISSN 2621-9468 online, DOI 10.20956/canrea.v8i1.1262

1. Introduction

Indonesia is one of the countries that is prone to natural disasters (1). The occurrence of a disaster results in damage and loss in all areas including the health sector. In the health sector, natural disasters will result in damage to health facilities, lack of aid, and quality of food provided, which will directly affect the level of fulfillment of the nutritional needs of disaster victims (2). In such situations, emergency food can be an alternative food because it can be consumed immediately (ready to eat), is easy to distribute, and is nutritious (3).

Mizepi is an innovative ready-to-eat product in the form of cremes noodles that are prepared for emergency food with complete nutritional content in seven formulations. Mizepi is made from maize flour and Fish Protein Hydrolysate (FPH) with comparison in grams such as F1 (1:1), F2 (4:7), F3 (4:11), F4 (7:4), F5 (7:11), F6 (11:4), dan F7 (11:7). Mizepi is expected to offer advantages such as high protein content, which will help provide a filling effect. Mizepi is a product innovation that is expected to be accepted by the public; therefore, research on sensory testing and shelf life is required.

Sensory products are important factors in determining whether a product is acceptable and rated well by consumers. Organoleptic quality is a scientific method that generates, measures, analyzes, and interprets responses to products according to what human senses perceive, including touching, tasting, seeing, and smelling. Organoleptic tests are carried out by humans, who can also be called panelists, as measuring tools. In this study, organoleptic tests with 112 panelists used the hedonic test (color, flavor, aroma, texture, and overall) and the Just About Righ Scale/JAR test (yellow color, savoriness, typical corn aroma, typical savory fish aroma, and crunchy texture).

The best formulation was selected from 7 formulations that had been analyzed using the Effectiveness Index Test method and was selected with the highest score, namely Mizepi with formulation F4 (7:4). Mizepi formulations have physicochemical qualities in terms of nutrition that meet emergency food requirements, namely 15.62% protein, 34.93% fat, 46.3% carbohydrates, total calories 232.57 kcal, ash content 1.48%, water content 2.00%, and 56.18% protein digestibility. The shelf life of a food product is the time interval for it to be in a safe condition while maintaining the desired sensory, chemical, physical, and microbiological characteristics and meeting the nutritional value stated on the packaging label (4). The selection of the best formulation for Mizepi products will continue with shelf-life testing using the Accelerated Shelf-Life Testing (ASLT) method at temperatures of 35 ^{o}C, 45 ^{o}C, and 50 ^{o}C.

The ASLT method involves storing food products in an environment that causes the food to spoil at higher temperatures or humidity conditions in the storage room (5). The decline in product quality under storage conditions can be predicted using the relationship between the acceleration factor and degradation rate (6). The Arrhenius equation is used to determine the temperature dependence of the reaction rate, which has an important role in determining the rate of chemical reactions and calculating the activation energy (7). Shelf-life tests using metallized plastic packaging have been more stable for dry food products in several studies. The reason for this research is that innovative emergency food products are still rare and continue with shelf-life to fulfill emergency food requirements and avoid poisoning. This research aims to determine the organoleptic quality and shelf life of Mizepi for emergency food that can be accepted by consumers.

2. Materials and Methods

2.1. Materials and Tools

This study used a completely randomized design from the comparison of maize flour and FPH in grams, namely F1 (1:1), F2 (4:7), F3 (4:11), F4 (7:4), F5 (7:11), F6 (11:4), and F7 (11:7). Maize flour was used as the material and FPH was obtained from PT. Berikan Teknologi, Indonesia, salt, and coconut oil. Mizepi made use of a tool with the Oxone brand OX-357 Jumbo Noodle Maker by adding all the ingredients according to the measurements, starting from pressing the ingredient mixing button to the noodle maker menu to make noodles according to the desired mold. This research was carried out from November to December 2023 at the Chemistry, Organoleptic, Nutrition Science Laboratory, Diponegoro University, Semarang.

2.2. Sensory Profile

Organoleptic testing was carried out using a 9 scales hedonic test and a Just About Right (JAR) scale test with 112 consumer panelists for students aged 18–27 years, both female and male. The Ethical Clearance Number from the Health Research Ethics Commission, Faculty of Medicine, Diponegoro University is no. 001/EC/KEPK/FK-UNDIP/1/2024.

The procedure for conducting the hedonic and JAR tests begins with the preparation of tools and materials. Each "Mizepi" container is then assigned a specific code label: F1 (1:1), F2 (4:7), F3 (4:11), F4 (7:4), F5 (7:11), F6 (11:4), and F7 (11:7). Subsequently, seven samples of "Mizepi" are presented, each labeled according to its corresponding code. Finally, the panellists were provided with instructions regarding the procedure for completing the hedonic and JAR evaluation forms. The Just-About-Right (JAR) scale has been criticized for combining intensity and liking into a single measure. It assumes that the ideal point lies at the midpoint of the scale, which may introduce a bias. In contrast, ideal scaling separates intensity from preference and allows participants to indicate their ideal freely, without assuming equal spacing between "Too Little" and "Too Much." Constraining ideals to the center, as in JAR, may distort responses and exaggerate deviations from the perceived ideal (8). Then, panelists were invited to carry out a hedonic test by filling in a form that includes color, flavor, aroma, texture, and overall. The JAR scale test includes a yellow color, savoriness, typical aroma of corn, typical savory aroma of fish, and crunchy texture. Next, give water to the panelists during the testing process to neutralize the taste between the "Mizepi" samples. Then, we collected the hedonic test and JAR form and added up the scores for each sample category from all panelists.

2.3. Shelf Life

Mizepi were stored in incubators at 35 °C, 45 °C and 50 °C respectively. Samples were observed every seven days for 28 days. Each sample was tested at the storage incubator temperature from day 0 to day 28. The quality parameters observed were the water content and free fatty acids (FFA).

The calculation starts from the initial value of the quality of the sample before storage, which is obtained from the results of observations in 0 week at a temperature of 35 °C and the minimum limit for product quality, namely a maximum free fatty acid content of 0.21% (9). The sample analysis against time was plotted, and the equation calculated by linear regression with a graph that depicts the relationship between storage time (x-axis) and indicators of quality degradation of the selected product (y-axis) at each temperature used, and the slope (k) and intercept (constant) values were obtained. Then, the k value is determined for each temperature used for the selected product quality degradation indicator, where the k value increases as the temperature increases. Then, the Arrhenius equation was created, which shows the relationship between 1/T and ln k at each temperature using the following formula:

$$ln\,k = ln\,k0 - (Ea/R)\,1/T \quad (1)$$

Information:
K : Quality degradation rate constant
k0 : Constant
Ea : Activation energy
T : Absolute temperature (K)
R : Gas constant (1.986 cal/mol)

Then, the slope value (k) can be calculated, which is the rate of quality degradation per day at a desired storage temperature, using the formula:

$$k = k0.exp^{(-Ea/RT)} \quad (2)$$

Informations:

K : Quality degradation rate constant
k0 : Constant
Ea : Activation energy
T : Absolute temperature (K)
R : Gas constant (1.986 cal/mol)

In the final step, the shelf-life estimate can be determined using zero-order and first-order equations with the formula:

$$\text{Zero Order} \quad : t = \frac{At - A0}{k} \quad (3)$$

$$\text{One Order} \quad : t = l\frac{nAt - lnA0}{k} \quad (4)$$

Informations:
t : Shelf life (days)
At : Critical water content (%)
A0 : Initial water content (%)
k : Rate of quality decline

2.3.1. Free Fatty Acid

Analysis of free fatty acid levels using samples, benzene, and 5% cupric acetate pyridine solution. The tools used were a micropipette and a 715 nm spectrophotometer. Free fatty acid levels were measured by dissolving the first, 0.4 grams of sample is dissolved in 4.6 ml of benzene and vortexing for 30 s. In the second step, 1 ml of a 5% cupric acetate pyridine solution (pH 6.0 – 6.2) was added. In the third step, the mixture was vortexed for 2 minutes. The next step is to leave it for 5 min, after which two separate layers will form. The wavelength of the top layer was measured at 715 nm. A standard curve was prepared using oleic acid (0.07 M diluted to 10 mL with 96% ethanol. Then, 2 ml of the sample and cuprous acetate (0.5 ml of cuprous were vortexed for 1 min, and absorbance was measured at 715 nm.

2.3.2. Water Content

Water content using the oven method. The work is done by weighing a sample of 3 g and placing it in a porcelain cup that has been dried and the weight is known. The samples were then dried in an oven at 105 °C for 6 h. The cup was removed from the oven, cooled in a desiccator for 15 min, and then weighed (the drying and weighing process was carried out until it reached a constant weight). The water content was obtained from the following equation:

$$\text{Water content } (\%) = \frac{initial\ weight\ (g) - final\ weight\ (g)}{(initial\ weight)\ (g)} X\ 100\% \tag{5}$$

2.4. Analysis Data

Bivariate analysis with the Kruskal-Wallis test was carried out on organoleptic quality analysis, both hedonic and Just About Right Scale (JAR). Multivariate analysis of organoleptic quality for both hedonic and JAR was performed using the Mann–Whitney test.

3. Results and Discussion

3.1. Evaluasi Sensory

The organoleptic quality assessment of Mizepi products was divided into two parts: the hedonic test and the JAR test, which were carried out on 112 panelists and are presented in Tables 1 and 2. The data presented in Tables 1 and 2 are expressed as mean ± standard deviation (SD). Organoleptic quality assessment is very important in the processing industry and includes measurement techniques and human reactions to food ingredients, which can ultimately convince consumer perceptions. Sensory evaluation is a quantitative science that uses numerical data collected to examine specific product characteristics and human perception (10). Sensory evaluation is based on behavioral research to observe and measure human responses (10). Sensory evaluation provides guidance for sample preparation and presentation to control conditions, thereby minimizing bias factors (10).

The Mizepi hedonic test results consisted of color, flavor, texture, aroma, and overall categories using nine scales. The scale levels used were very strongly dislike (1), very dislike (2), somewhat dislike (3), slightly dislike (4), dislike (5), slightly like (6), somewhat like (7), really like (8), and very strongly like (9). Bivariate analysis of the categories of color, flavor, aroma, texture, and overall using the Kruskal–Wallis test yielded significant results (p=0.001). Multivariate analysis was performed using the Mann-Whitney test between Mizepi product formulations described in Table 1, which are displayed with different superscripts if there are very significant differences.

The JAR Mizepi test results consisted of the categories of yellow color, savory, typical fragrant aroma of corn, typical savory aroma of fish, and crunchy texture using nine scales. The scale levels used were very small (1), not enough (2), somewhat less (3), slightly less (4), just enough (5), little too (6), rather little (7), very much (8), and very enough (9). Bivariate analysis of the categories of yellow color, savoriness, typical aroma of corn, typical savory aroma of fish, and crunchy texture used the Kruskal–Wallis test, which explained that there was a significant difference (p=0.001), while for yellow, there was no significant difference (p=0.011). Multivariate analysis uses the Mann-Whitney test between Mizepi product formulations described in Table 2, which are displayed with different superscripts if there are very significant differences.

Table 1. Mizepi hedonic test results from maize flour: FPH.

Category hedonic test	Treatments						
	F1	F2	F3	F4	F5	F6	F7
Color*	7.36 ± 1.31^{ab} (somewhat like)	7.52 ± 1.16^{bcf} (somewhat like)	7.39 ± 1.23^{ace} (somewhat like)	7.73 ± 1.31^{bde} (somewhat like)	7.67 ± 1.02^{aef} (somewhat like)	7.4 ± 1.21^{acf} (somewhat like)	8.00 ± 0.82^{dg} (really like)
Texture*	5.00 ± 1.26^{a} (dislike)	1.9 ± 0.74^{b} (very strongly dislike)	3.6 ± 0.9^{c} (somewhat dislike)	7.78 ± 0.99^{d} (somewhat like)	5.53 ± 1.17^{e} (dislike)	6.63 ± 0.95^{f} (slightly like)	5.21 ± 1.4^{ae} (dislike)
Flavor*	4.94 ± 0.751^{a} (slightly dislike)	3.36 ± 0.91^{b} (somewhat dislike)	2.20 ± 0.72^{c} (very dislike)	7.46 ± 1.13^{d} (somewhat like)	5.58 ± 1.16^{e} (dislike)	6.88 ± 0.74^{f} (slightly like)	5.42 ± 1.25^{e} (dislike)
Aroma*	6.09 ± 0.69^{a} (slightly like)	3.32 ± 0.78^{b} (somewhat dislike)	2.27 ± 0.71^{c} (very dislike)	5.46 ± 0.99^{d} (dislike)	5.31 ± 1.17^{d} (dislike)	8.14 ± 0.79^{f} (really like)	7.01 ± 1.04^{g} (somewhat like)
Overall*	4.85 ± 1.13^{a} (slightly dislike)	3.5 ± 1.1^{bc} (somewhat dislike)	3.68 ± 1.1^{c} (somewhat dislike)	7.93 ± 0.85^{bd} (somewhat like)	5.82 ± 1.17^{eg} (dislike)	6.24 ± 1.1^{fg} (slightly like)	5.95 ± 1.21^{g} (dislike)

Numbers followed by different superscript letters (a, b, c, d, e, f, and g) indicate significant differences. n = 21 (seven experiments, three replicates) for proximate analysis. Comparison formula product with maize flour: fish hydrolysate protein (gram) is F1 (1:1), F2 (4:7), F3 (4:11), F4 (7:4), F5 (7:11), F6 (11:4) and F7 (11:7).
**Kruskall Wallis continued with Mann Whitney test*

The results of the hedonic test show that the panelists liked the colors F1-F6 somewhat, while for F7, they liked it, as described in Figure 1. F7 is very popular in terms of color level, namely with a ratio of more maize flour than FPH, so these data show that the higher the use of maize flour, the more it will produce a better/liked color level by the panelists. Table 1 shows that the colors between formulas have significant differences ($p<0.005$), namely (F1 and F7, F2 and F7, F3 and F7, and F5 and F7). The JAR test results regarding the yellow color category in Mizepi products indicate that there is no difference in the assessment of all formulas, namely, on a scale that is too yellow. This result was attributed to the yellow color of the Mizepi product. All the panelists rated it at almost the same point.

Color is an important factor in accepting or rejecting a product because it is the first impression that panelists see. Color is the first decision a person makes to determine whether they like or dislike a product (11). The color intensity of a product depends on the length and temperature of frying and the chemical composition of the outer surface of the food ingredient (12). The Maillard reaction occurs between reducing sugars and amino acid compounds from proteins during a high-temperature treatment process to form a brownish-yellow polymer (13).

Table 2. Mizepi Just About Right Scale (JAR) test from maize flour: FPH.

Category hedonic test	Treatments						
	F1	F2	F3	F4	F5	F6	F7
Color*	7.23 ± 1.29^{aef} (rather little yellow)	7.63 ± 0.96^{bde} (rather little yellow)	7.18 ± 1.18^{ace} (rather little yellow)	7.63 ± 1.12^{deg} (rather little yellow)	7.48 ± 1.11^{efg} (rather little yellow)	7.15 ± 1.29^{cfg} (rather little yellow)	7.52 ± 0.89^{abg} (rather little yellow)
Texture*	5.24 ± 0.94^{ag} (just enough)	3.61 ± 1.15^{b} (somewhat less savoriness)	2.20 ± 0.72^{c} (not enough savoriness)	7.46 ± 1.14^{d} (rather little savoriness)	5.58 ± 1.17^{ef} (just enough)	6.88 ± 0.74^{fg} (little too savoriness)	5.42 ± 1.25^{g} (just enough)
Flavor*	7.80 ± 0.81^{ad} (rather little)	2.81 ± 0.77^{b} (not enough)	3.38 ± 0.92^{c} (somewhat less)	7.80 ± 0.82^{df} (rather little)	7.44 ± 0.81^{e} (rather little)	7.63 ± 1.00^{af} (rather little)	8.29 ± 0.8^{g} (very much)
Aroma*	5.54 ± 1.05^{a} (just enough)	5.35 ± 1.17^{ab} (just enough)	8.29 ± 0.69^{c} (very much)	3.28 ± 0.9^{d} (somewhat less)	7.19 ± 0.77^{e} (rather little)	1.82 ± 0.71^{f} (very little)	2.58 ± 0.95^{g} (not enough)
Overall*	5.18 ± 1.23^{ag} (just enough)	2.13 ± 1.15^{b} (not enough)	3.78 ± 1.08^{c} (somewhatt less)	7.71 ± 1.07^{d} (rather little)	5.62 ± 1.33^{eg} (just enough)	6.62 ± 1.05^{fg} (little too)	5.24 ± 1.40^{g} (just enough)

Numbers followed by different superscript letters (a, b, c, d, e, f, and g) indicate significant differences. n = 21 (seven experiments, three replicates) for proximate analysis. Comparison formula product with Maize flour: fish hydrolysate protein (gram) is F1 (1:1), F2 (4:7), F3 (4:11), F4 (7:4), F5 (7:11), F6 (11:4) and F7 (11:7).
**Kruskall Wallis*
**Kruskall Wallis continued with Mann Whitney test*

The level of panelists' liking for the texture of Mizepi products in Table 1 indicates that the formulas that are very disliked are F2, disliked F1, F5, and F7. This explains why panelists increasingly dislike the use of FPH with greater comparisons. The higher the FPH used, the higher the hardness of the product, which can also be seen during the dough-making process, that is, it will be stiffer. Table 1 shows the textures between formulas that have significant differences ($p<0.005$) and formulas that do not have significant differences ($p>0.005$), namely F1 and F7 (F5 and F7).

The results of the JAR test for the level of crunchy texture showed that each formula had a very significant difference in value ($p=0.001$), so it was continued with the multivariate test. The results of the Mann Whitney test showed that there were significant differences in, but the formulas that had no real difference are (F1 and F7, F5 and F7, and F6 and F7). The crispy texture of Mizepi can be explained by the fact that the higher the use of maize flour, the higher the level of crispiness.

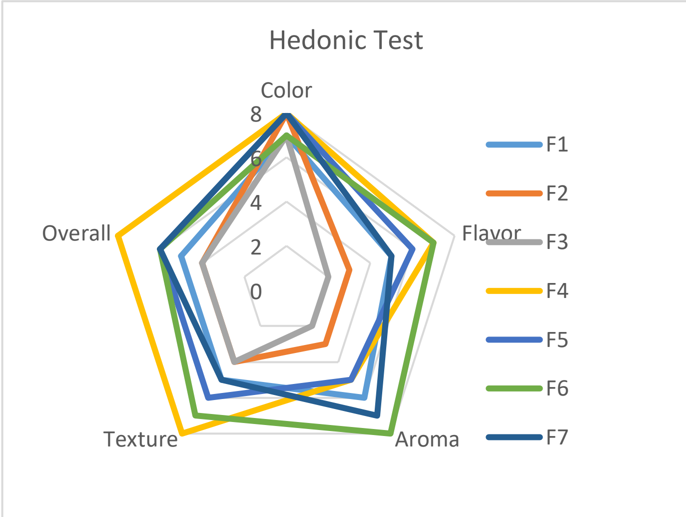


Figure 1. Spider web graph hedonic test.

The crispiness of food products is due to the very low water content of the fried foods. This is because the processing method of frying with oil at high temperatures causes the water in the food to evaporate, and the position of the water is replaced by oil as a heat conductor. This is in line with Chen et al., who found that in the frying process, the water contained in the food comes out and hydrolyzes the oil as a medium in frying (14). Hot conditions cause complex carbohydrates (starch) to undergo gelatinization, and the starch gel undergoes a dehydration process such that the gel forms a sturdy framework, causing the texture to become hard. Therefore, the product is quickly fried to achieve an attractive sensory impression (15). Protein is the main component of flour that influences texture, and the protein composition of flour is influenced by inulin (16). Each form of food, such as Mizepi, has textural properties that depend on the physical condition, size, and shape of the cells contained.

Texture is an assessment attribute that influences the acceptance of acceptability by panelists. Texture is complex with a material structure consisting of three elements: mechanical (hardness, elasticity), geometric (sandy, crumbly), and mouthfeel (oily, watery) (11, 17). Texture is influenced during the frying process because the frying time is longer. For a long time, it damages the protein, resulting in protein denaturation, which results in a hard texture in the final product. The results of the research indicate that the more maize flour the texture is used, the more preferred the texture is because the composition of maize flour has a high amylopectin content, which is chewy and elastic. The results of similar studies on cookies explain that the texture factor is influenced by the level of ingredients used; if the gluten content in the ingredients is higher, it will make the texture value more desirable because it is chewy and elastic (11).

The level of panelists' preference for the taste of Mizepi products in Figure 1 explains that they strongly dislike the formula, namely F3, dislike F5, slightly or somewhat dislike F1 and F2, and somewhat like F4 and F6. This explains why the panelists do not like the use of FPH with a higher ratio and prefer products that use more maize flour. The panelists stated that the product they did not like was a strong smell of fish, and they preferred the taste of the product with more maize flour use. Multivariate results explain the taste of formulas that have significant differences ($p<0.005$) and formulas that do not have significant differences ($p>0.005$), namely (F5 and F7).

The results of the JAR test analysis regarding the savory taste (savory) of Mizepi products are explained in Figure 2. The results of the bivariate test indicate that there are significant differences between the formulas, namely very less savory in F3, just right in F1, F5, and F7, and slightly or slightly too savory in F4 and F6. The results in Table 2 describe that multivariate test explained that the taste between formulas had a significant difference ($p<0.005$) and formulas that did not have a significant difference ($p>0.005$), namely (F1 and F5, F7; F5 and F7; F6 and F7). These results explain why the higher the FPH usage, the higher the tastier the product.

Taste is an important aspect in assessing a particular food using the five senses of taste and forming food choices, and each person has a different level of taste sensitivity to a product. Mizepi products that use more maize flour have a sweet savory taste, whereas products that use more FPH will give the fish a savory salty taste and a more intense bitter aftertaste. This is in line with research on biscuits, namely that the addition of fish meal with a higher concentration produces a savory taste and excessive fish taste so that the panelists do not like it (18). This research is also in line with sago noodle products with rebon shrimp protein hydrolysate, namely that the higher the addition of protein hydrolysate, the more savory sago noodles will be (19).

The level of panelists' liking for the aroma of Mizepi products in Table 1 indicates that they strongly dislike F3, dislike F4 and F5, slightly or somewhat dislike F1 and F2, somewhat like F7, and really like F6. The multivariate results showed that the aroma between the formulas was significantly different ($p<0.005$). This explains why the panelists do not like using FPH in a larger ratio because the product will have a more concentrated fish smell. This is in line with research on biscuits with toman fish: the greater the addition of toman fish flour, the more undesirable the aroma of the biscuits because it causes the fishy aroma of the biscuits to become stronger (18).

The panelists were able to accept a somewhat favorable product because the fish aroma was covered by maize flour. This is in line with research on sago noodles with rebon shrimp protein hydrolysate, namely, the higher the use of protein hydrolysate material, the more it will be covered by the original aroma of the noodle flour used (19). The aroma of a product is detected when volatile substances from the product are inhaled and received by the olfactory system, so that the panelists preferred the Mizepi standard made from maize flour more than the one with the addition of FPH.

The results of the JAR test analysis of Mizepi products showed that the highest characteristic aroma of corn was F7 and the lowest was F2, as described in Figure 2. The typical savory aroma of fish was highest at F3 and lowest at F7. The results of the bivariate test for the distinctive typical aroma of corn and the savory aroma of fish obtained a significant value ($p=0.001$); therefore, it was continued with the multivariate test. Multivariate results showed that the typical aroma of corn was significantly different, and some did not have a significant difference ($p>0.005$), namely F1 and F4, F6, F4 and F6, F5 and F6, and F6 and F7. Multivariate results explained that the aroma between formulas had a significant difference ($p<0.005$), and there were also those that did not have a significant difference ($p>0.005$), namely F1 and F2. This explains why the aroma is influenced by the ingredients used. The higher the FPH product used, the more intense the typical savory aroma of fish; conversely, the higher the maize flour used, the more distinctive the aroma of corn.

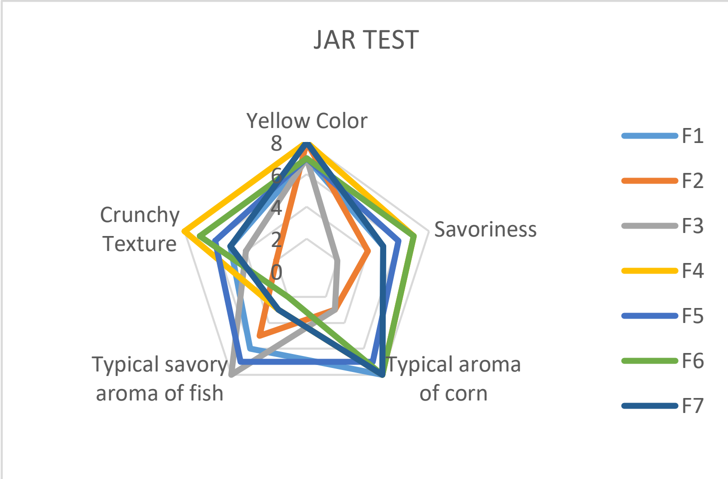


Figure 2. Spider web graph JAR test.

Typically, the savory aroma of fish from Mizepi is very strong when more FPH flour is used because the protein content of the ingredients used is very high from fish sources. This is supported by the Maillard reaction. Aroma can be formed from carbohydrates or sugars, free amino acids, peptides, nucleotides, and organic acids, which act as the main precursors in the formation of taste and aroma (12).

The level of panelists' liking for all Mizepi products in Table 1 explains that they dislike formulas F5 and F7, slightly or somewhat dislike F1, F2, F3, and F6, and somewhat like F4. Multivariate results explain that cases between formulas have significant differences ($p<0.005$) and some do not have significant differences ($p>0.005$), namely (F2 and F3, F4, F5 and F7, F6, and F7). This explains why the overall level of liking for Mizepi products is favored by the ratio of more maize flour and the right combination of FPH, because new properties will be formed, such as the level of sweet savory taste, the best typical Mizepi aroma, and a crunchy texture that the panelists can accept well.

The difference in sensory attributes between the Mizepi formulations is due to the variation in the proportion of fish protein hydrolysate to maize flour, which influences some of the key sensory determinants such as color, texture, aroma, and taste. The increased percentage of maize flour accounted for the more appealing yellow color and crunchier texture due to the maillard reaction and reduced moisture content when frying (20). Acceptance variations among panelists were also influenced by protein level, frying duration, and amylopectin content of maize flour, which dictate chewiness and texture structure. These traits collectively explain the statistical variations in the formulae and highlight the necessity for optimizing the ingredient ratio for consumer acceptability.

The selection of the best formulation is presented in Table 3. The best formulation was selected based on the highest productivity value, F4. F4 was chosen as the best formula with a higher ratio of maize flour than FPH, so it is very possible that the panelists prefer it because the characteristic taste of FPH can be well covered. The selection of the best formulation will continue with a shelf-life test at a predetermined temperature and with metalized plastic packaging.

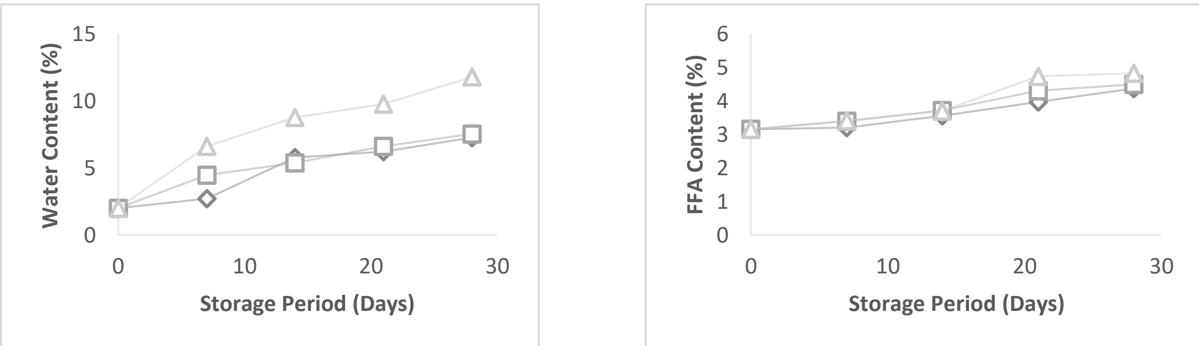
Table 3. Selection of the best Mizepi formulations.

Treatments	Score the best formulation	
	Score efectiveness	Score productivity
F1	1.70	0.46
F2	0.65	0.19
F3	0.34	0.04
F4	3.12	0.78
F5	2.26	0.57
F6	2.76	0.75
F7	2.98	0.74

Description: product formula from Maize Flour: FPH (grams), namely F1 (1:1), F2 (4:7), F3 (4:11), F4 (7:4), F5 (7:11), F6 (11:4) and F7 (11:7).

3.2. Shelf Life

The shelf life of food products (shelf life) is an important piece of information for consumers. The inclusion of shelf-life information is very important because it is related to the safety of food products and to providing quality assurance when the product reaches consumers, which has been emphasized by every food industry being required to include an expiry date. The product used in this analysis was Mizepi. The acceleration method and damage parameters were used to determine the shelf life of Mizepi products using water content and Free Fatty Acid (FFA) parameters to determine product rancidity during storage. In the Arrhenius model, temperature significantly influences changes in product quality. The first step in determining shelf life is to calculate the determinant coefficient (R^2) for the parameters of water content and free fatty acids, as shown in Figure 3.



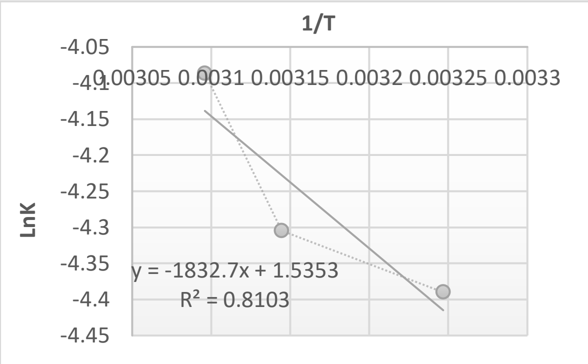
(a) (b)

Figure 3. Shelf-life parameter results (a) water content; (b) Free Fatty Acid (FFA) content. Symbol descriptions represent temperature 35 °C (◊), temperature 45 °C (□), and temperature 50 (Δ).

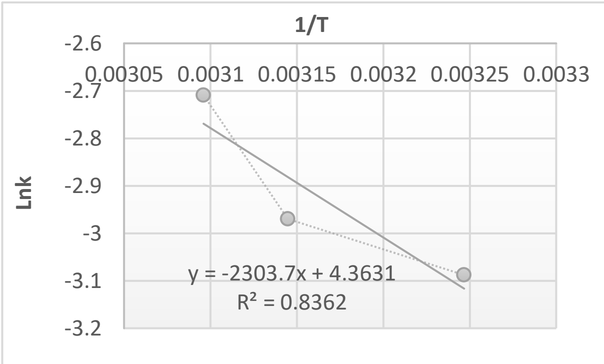
Table 4. Differences in the order of water content parameters and Mizepi FFA.

Parameter	Temperature (^{0}C)	Regression equation		R^2	
		Zero order	One order	Zero order	One order
Water content	35	y = 200x + 1996.4	y = 0.056x + 8.0228	0.9254	0.7769
	45	y = 188.66x + 2552.8	y = 0.0485x + 7.68	0.9582	0.8952
	50	y = 323.44x + 3249.8	y = 0.0434x + 7.8556	0.9259	0.8536
FFA	35	y = 0.0456x + 3.0106	y = 0.0124x + 1.1135	0.9539	0.9632
	45	y = 0.0513x + 3.09	y = 0.0135x + 1.1386	0.9731	0.9776
	50	y = 0.0666x + 3.028	y = 0.0168x + 1.1257	0.9186	0.9326

The results of calculating the R^2 value of the water content parameter show that the zero-order value was chosen because it has a larger R^2 value, namely, 0.9582, as shown in Table 4. Meanwhile, for FFA, the first-order value is used because R^2 is larger, that is, 0.9776. The R^2 value of order zero or one used for all parameters indicates that the rate of quality deterioration is constant or linear (21). The slope value of the zero order of each parameter was used to determine the linear regression equation for the relationship between 1/T and ln k, as shown in Figure 4.



(a)



(b)

Figure 4. Graph of the relationship between 1/T and ln k, such as (a) Description of water content parameters; (b) Description Free Fatty Acid (FFA) parameters.

Based on the linear regression analysis of the relationship graph of 1/T and ln k, we obtained the equation for the graph of the water content parameter $y = -2303.7x + 4.3631$ with $R^2 = 0.8362$ and the FFA parameter, namely $y = -1832.7x + 1.5353$ with $R^2 = 0.8103$. The slope value of the linear regression equation for the relationship between 1/T and ln k can be used to determine the activation energy (Ea) value, which is shown in Table 5.

Table 5. Activation energy value of each test parameter.

Parameter	Activation energy (kal/mol)
Water content	19152.96
FFA	15237.07

The activation energy is the minimum energy required to carry out a reaction in a molecule. Next, we calculated the shelf life of the product at each temperature, as shown in Table 6.

Table 6. Calculation of the shelf life of Mizepi.

Parameter	Temperature (^{0}C)	Quality reduction	Shelf-life (day)
Water Content	35	0.044	46
	45	0.056	36
	50	0.063	32
FFA	35	0.012	143
	45	0.014	118
	50	0.015	108

The hygroscopic nature of packaged food and the humidity level of the environment in food products can also contribute to the increase in the water content of Mizepi products. The results of this study indicated that the higher the temperature, the lower the shelf life of Mizepi products. The results of research on Mizepi's shelf life based on water content are lower than those of research on carrot noodles, which can reach 30 weeks or around 7 months (22).

Mizepi-free fatty acid levels increased during storage, with the highest increase occurring at 50 ^{o}C. Temperature is one of the factors that cause an increase in fatty acid values. Higher temperatures increase the levels of free fatty acids, resulting in a decrease in the quality of food containing oils and fats (23). This is in line with research on the shelf life of dried cassava corn noodle products, increasing free fatty acid levels; the higher the FFA content, the higher the rancid aroma smelled by panelists (9). The rancid aroma became more pronounced as the temperature and storage time increased. High temperatures accelerate the fat oxidation reaction so that the double bonds in fatty acids form peroxides and are degraded to form aldehydes, which cause a rancid aroma (18).

The storage temperature affects the quality and shelf life of a product because increasing the storage temperature increases the reaction rate of chemical compounds, which can cause food damage (24). The mechanism of the influence of temperature on the rate of chemical reactions in food spoilage is related to the activation energy. Increasing the storage temperature will increase the potential energy of a substance (in this case, fat oxidation), which can accelerate collisions between molecules of the substance, so that the rate of chemical reactions will increase. The results of the research on the shelf life of Mizepi products were selected from the lowest result parameters, namely, 32 days at a temperature of 50 °C, and it is more optimal to store it at a temperature of 35 °C to avoid further product damage.

The results of the research show that higher storage temperatures cause damage to occur more easily, while at lower temperatures, it slows down. The cause of product damage is usually the fat oxidation process, which occurs more easily at high temperatures owing to the formation of volatile off-flavor (rancid) compounds (25). Low temperatures inhibit rancidity-causing compounds such as aldehydes and monoaldehydes. However, the oxidation process is reduced in products with a high protein content, such as Mizepi, which is made from FPH. This process can be reduced by the interaction between monoaldehyde compounds (MDA) and proteins. MDA binds to functional groups on proteins, such as -SH (Cys), -OH (Ser, Tyr, Thr), $-NH_2$ (Lys, Arg), -COOH (Glu, Asp), -NH (His), dan $-SCH_3$ (Met) (26). This is in line with the study of Palupi et al., who reported that at a storage temperature of 25 ^{0}C corn substitute dry noodles had a shelf life of 5.21 months, whereas at a higher storage temperature of 30 ^{o}C the shelf life of the product was reduced to 4.19 months (27).

The strength of this study is the sound sensory test involving hedonic and JAR tests that were able to quantify panelists' preferences for color, texture, taste, and odor in different Mizepi samples. Among the weaknesses are the relatively small and non-random panelist sample and lack of realistic environmental testing conditions. Additional research must be conducted to scale up the manufacturing process, conduct randomized double-blind trials within a large population with diversity, and explore broader applications and storage stability to facilitate commercialization.

4. Conclusions

Among all formulations, F4 was the most preferred based on the hedonic test, particularly because of its crispy texture and balanced taste. F7 was rated the highest in color preference, whereas the yellow color intensity across all samples showed similar scores on the JAR scale. The most favored aroma was found in F7, which had a higher proportion of maize flour than fish protein hydrolysate (FPH). Shelf-life testing of the best formulation (F4) using metalized plastic packaging showed a storage stability of up to 32 days at 50 °C and up to 46 days when stored at 35 °C, indicating better preservation at moderately lower temperatures.

Acknowledgements

The study financially supported by The Directorate General of Higher Education, Research and Technology, Ministry of Education, Culture (DRTBM), Republic of Indonesia, collaborative with research team from *BRIN* (*Badan Riset Inovasi Nasional*) of Indonesia, and I have received support of your research work. This research was also supported by the Universitas Diponegoro with a research cluster development scheme under contract number 222-228/UN7.D2/PP/IV/2025, especially for publication funding.

Author Contributions

D.N.A. conceptualization, supervision, project administration, writing, and review; N.R. performed the experiments, wrote the manuscript, analyzed the data, and provided advice and consultation guidance on the course of the research; D.N.A., F.A., G.A., A.S., N.N., E.C. and E.Y.P. drafted the manuscript; All authors discussed the results and commented on the final version of the manuscript.

Funding

This research was funded by the PMDSU program under the Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia through a research grant (no. 601-82/UN7.D2/PP/VI/2024).

Institutional Review Board Statement

This research was approved by the Health Research Ethics Commission, Faculty of Medicine, Diponegoro University (No. 001/EC/KEPK/FK-UNDIP/1/2024).

Data Availability Statement

Data are available on reasonable request from the corresponding author and subject to the approval of the authors and research team.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

1. Asfirmanto WA, Osmar S, Fathia ZS, Ahmad R, Anggara SP, K R. Indonesia Disaster Risk Index. Jakarta: Disaster Data, Information, and Communication Center of the National Disaster Management Agency; 2021.

2. Husein A, Onasis A. Disaster Management. First ed. Jakarta: Ministry of Health of the Republic of Indonesia; 2017.
3. Zoumas, LE A, JR B, WL C, P C, BP K, et al. High-Energy Nutrient Dense Emergency Relief Food Product. Washington, editor: D.C: Institute of Medicine, National Academy Press; 2002.
4. Alfiyani N, Wulandari N, Adawiyah DR. Validation Method of Shelf Life Estimation of Dry Crisp Food Products by Using Critical Moisture Content Method. Food Quality Journal. 2019;6(1):1-8.
5. Abdul Mukhlis Ritonga, Masrukhi Masrukhi, Siswantoro S. Estimation of Shelf Life of Crystal Coconut Sugar Using Acceleration Method Based on Critical Water Content Approach. Journal of Agricultural Technology. 2020;21(1).
6. Niken Ayu Permatasari, Deofsila YK. Quality Changes of Natural Dyes Powder from Chinese Laurel Fruits *(Antidesma Bunius (L) Spreng)* during Storage by Using Accelerated Method. Journal of Agricultural Industrial Technology. 2021;31(2):176-89.
7. Haouet MN, Tommasin M, Mercuri ML, Benedetti F, Bella SD, Framboas M, et al. Experimental accelerated shelf life determination of a ready-to-eat processed food. Italian Journal of Food Safety. 2018;7(4):6919.
8. Li B, Hayes JE, Ziegler GR. Just-About-Right and ideal scaling provide similar insights into the influence of sensory attributes on liking. Food Quality and Preference. 2014;37:71-8.
9. Kumalasari R, Desnilasari D, P.Wadhesnuriba S, Sumartini. Estimation of shelf life of dry noodles from composite flour *(corn-cassava)* using the Arrhenius acceleration method Jurnal Litbang Industri. 2022;12(2).
10. Harry T. Lawless, Heymann H. Sensory Evaluation of Food. second edition ed. Heldman DR, editor. USA: Cornell University; 2010.
11. Nadimin, Sirajudin, Fitriani N. Organoleptic Quality of Cookies with the Addition of Rice Bran Flour and Mackerel. Food Nutrition Media. 2019;26(1).
12. Nurina Rahmawati, Irawan AC. The Effect of Red Bean Flour Addition on Organoleptic, Physical and Chemical Quality of Free-Range Chicken Nuggets. Scientific Journal of Fillia Cendekia. 2021;6(1).
13. Jia Xiang, Fenglin Liu, BoWang, Lin Chen, Wenjie Liu, Tan S. A Literature Review on Maillard Reaction Based on Milk Proteins and Carbohydrates in Food and Pharmaceutical Products: Advantages, Disadvantages, and Avoidance Strategies. Foods. 2021;10.
14. Haiying Chen, Yamei Jin, Xiangli Ding, Fengfeng Wu, Mohanad Basharil, Feng Chen, et al. Improved the emulsion stability of phosvitin from hen egg yolk against different pH by the covalent attachment with dextran. Food Hydrocolloids. 2014;39(104-112).
15. Bhattacharya S. Conventional and Advanced Food Processing Technologies. USA: Central Food Technological Research Institute; 2015.
16. Yixuan Liu, Yue Leng, Shensheng Xiao, Yudong Zhang, Wenping Ding, Beibei Ding, et al. Effect of inulin with different degrees of polymerization on dough rheology, gelatinization, texture and protein composition properties of extruded flour products. LWT_Food Science and Technology. 2022;159.

17. Caroline Bondu, Christian Salles, MagalieWeber, Elisabeth Guichard, Visalli M. Construction of a Generic and Evolutive Wheel and Lexicon of Food Textures. Foods. 2022;11:3097.
18. Hermanto, Susanty A. Physicochemical and Sensory Characteristics of Biscuits with the Addition of Toman Fish Flour *(Channa micropletes)*. Journal of Industrial Technology Research. 2020;14(2).
19. Purba TO, Suparmi, Dahlia. Study of Hydrolyzed Shrimp Protein Fortification *(Mysis relicta)* in Sago Noodles. Jurnal Agroindustri Halal. 2020;6(1).
20. Singh A, Wani SA, Kumar P. Frying Technology Recent Development, Challenges, and Prospects: CRC Press; 2024.
21. Anastasya Khalif Wiyani, Siti Ari Budhiyanti, Adisetya E. Estimation of Shelf Life of Fatty Acids (Ulva lactuca) with Metode Accelerated Shelflife Testing. Journal of Bioenergy and Food Technology. 2022;1(1).
22. Putri Wahyuni, Ni Ketut Sumarni, Prismawiryanti, Hardi J. Retention of Carotene Extract in Carrot Noodle Processing *(Daucus carrotaL.)*. Jurnal Riset Kimia. 2020;6(2).
23. Muhammad Nazly Hasibuan, Eti Indarti, Erfiza NM. Organoleptic Analysis (Aroma and Color) and TBA Value in Estimating the Shelf Life of Aceh Noodle Seasoning with the Accelerated Shelf-Life Testing (ASLT) Method Using the Arrhenius Equation. Indonesian Journal of Agricultural Technology and Industry. 2019;11(2).
24. Evy Puspitasari, Sandra Malin Sutan, Lastriyanto A. Estimation of Shelf Life of Coconut Chips *(Cocos nucifera L.)* Using Accelerated Shelf-Life Testing (ASLT) Method Arrhenius Equation Approach Model. Journal of Tropical Agricultural Engineering and Biosystems. 2020;8(1).
25. Salma Shafrina Aulia, Budi Setiawan, Tiurma Sinaga, Sulaeman A. Quality degradation and shelf life estimation of instant cream of pumpkin soup enriched with tempeh for the elderly using the accelerated shelf life testing (ASLT) method. Indonesian Nutrition Journal. 2020;8(2):134-42.
26. Antonios Papastergiadis, Edward Mubiru, Herman Van Langenhove, Meulenaer BD. Malondialdehyde measurement in oxidized foods: evaluation of the spectrophotometric thiobarbituric acid reactive substances (TBARS) test in various foods. Journal of agricultural and food chemistry. 2012;60:9589-94.
27. Nurheni Sri Palupi, Feri Kusnandar, Dede Robiatul Adawiyah, Syah D. Determination of Shelf Life and Development of Dissemination Model in the Framework of Accelerating the Adoption of Corn Noodle Technology for MSMEs. Journal of Small and Medium Industry Development Management. 2010;5(1).