Physicochemical, Organoleptic and Nutritional Properties of Nila (*Oreochromis niloticus*) *Pekasam* at Different Concentrations of Cooked Rice

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Abstract

Pekasam is a traditional fermented fish dish from West Kalimantan, prepared using salt and cooked rice. However, the optimal concentration of cooked rice for making *pekasam* is unknown. This study aims to determine the effect of variations in cooked rice concentration on physicochemical properties, organoleptic characteristics and nutritional composition of Nila or Tilapia *(Oreochromis niloticus) pekasam.* The study used a Completely Randomized Design (CRD) with three cooked rice concentration treatments, namely 40%, 70% and 100% of the fish weight. A 1 kg Nila, covered with salt and cooked rice, was fermented in an airtight glass jar for 7 days. Physicochemical, organoleptic, and proximate tests were conducted at the Tanjungpura University Laboratory. Organoleptic testing involved 30 untrained panelists using a line scale. Data were analyzed using ANOVA. The results showed that *pekasam* with a 70% cooked rice concentration had a brighter color (L = 26.84), higher water content (57.83%), and the highest salt content (23.00%) and pH (5.79). *Pekasam* with a 70% cooked rice also had a distinctive aroma, attractive color, medium chewy texture, and a balanced tart and salty taste. Proximate tests showed that *pekasam* with a 70% cooked rice concentration had the highest protein (9.527%), carbohydrates (18.358%) and calorific (138.378 Cal.g^{-1}) content. The 70% cooked rice concentration produced *pekasam* with an optimal physicochemical, organoleptic and nutritional quality.

Keywords: Nila *pekasam*; Cooked rice concentration; Physicochemical test; Organoleptic test; Proximate test

1 Introduction

Fish is a significant food source in many countries, including Indonesia and Japan. In Japan, annual per capita fish consumption reached 45.12 kg per person in 2017 (Rinto et al., 2022). High fish consumption in Japan results from a long-standing cultural tradition of eating fish, which has contributed to improved public health (Kasahara et al., 2024). Indonesia, the world's largest archipelago with over 17,000 islands and extensive marine waters covering 6.4 million km^2, is a leading global producer in the fisheries sector. In 2019, Indonesia's fisheries production reached 6.6 million tons, showing a consistent increase since 2000 (Secretariat Southeast Asian Fisheries Development Center, 2024). However, despite abundant fish production, Indonesia's annual per capita fish consumption in 2020 was only 56.39 kg per person, lower than in neighboring coun-

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tries such as Malaysia and Singapore (Djunaidah, 2017). The data suggest that fish constitutes a crucial component of food systems in various countries, both in terms of production and consumption.

West Kalimantan Province, a part of Indonesia, has abundant fisheries resources. In 2018, captured fisheries production in West Kalimantan reached 165 thousand tons per year, close to the local government target of 175 thousand tons per year. In addition, the fish farming sector in the province has exceeded the set target of 85 thousand tons per year. This increase in production shows the great potential of West Kalimantan in supporting food security and the local economy through the fisheries sector.

According to the 2020 data from the Central Bureau of Statistics (BPS) of West Kalimantan, the production of freshwater fish in the province reached approximately 2.3 million tons. Fattah et al. (2021) stated that the leading fish commodity in West Kalimantan is Nila.

Nila or tilapia (*Oreochromis niloticus*) is a good source of protein, making it a good choice to fulfill daily protein needs. The protein content of Nila increases with age, and is influenced by factors such as water quality, feed and other environmental conditions (Wulanningrum & Subandiyono, 2019).

Abundant fish production needs to be accompanied by effective management. Proper handling is essential to prevent food waste because fish has a relatively short shelf life, approximately 1 to 2 days after harvest when properly refrigerated (Jimenez-Ruiz et al., 2020). An effective management strategy involves appropriate marketing and product preservation. Fermentation, such as in making *pekasam*, is one method of fish preservation (Ratnasari et al., 2022)

Food fermentation is one of the traditional food processes to produce more durable products. In addition, food fermentation not only creates unique flavors but also increases nutritional content (Sanlier et al., 2019). The breakdown of carbohydrates, proteins and fats, the water content, along with the influence of additives such as salt, enhances the nutritional properties and health benefits of the food (Sanlier et al., 2019). In addition, many experts consider Nila *(Oreochromis niloticus)* one of the best fish species for making *pekasam* due to its dense meat texture and neutral taste, which allows it to absorb seasonings easily and produce the desired flavor. In addition, Nila has a high protein content (Rinto et al., 2022), which supports the fermentation process and increases the nutritional value of the final product.

Pekasam is commonly made in regions such as Sumatra, Kalimantan and Sulawesi, and in some islands of Indonesia (Setiarto & Herlina, 2024). In West Kalimantan, the carbohydrate source for nila *pekasam* is cooked rice. The manufacturing process involves the fermentation of fish with the addition of salt and cooked rice, which provides a soft texture and a distinctive tart and savory taste (Setiarto & Herlina, 2024). Cooked rice provides carbohydrates that serve as a substrate for lactic acid bacteria, facilitating the fermentation process and enhancing the development of desirable flavors and textures in fermented fish products (Khudair et al., 2023).

The primary difference between Indonesian *pekasam* and similar fish fermentation products in other countries arises from the use of fish types and ingredients. In the Philippines, burong isda uses milkfish mixed with cooked rice and salt, resulting in a tart and savory taste after fermentation for 5-7 days. In Thailand, *pla-ra* and *som-fak* use fresh fish mixed with salt and glutinous cooked rice, with fermentation lasting from a few weeks to a year, resulting in a salty flavor and distinctive aroma of fermentation. In Japan, *shiko* and *nakazuke* are made by marinating fish using cooked rice bran (*nuka*), salt, and sometimes *sake kasu* (sake dregs), with fermentation lasting from several months to more than a year, creating a complex umami flavor and soft texture (Setiarto & Herlina, 2024; Wikandari, 2012). The availability of local raw materials and the taste preferences of local communities influence these variations. Additionally, the fermentation methods employed vary, both in fermentation duration and in the type and quantity of used additives.

One essential factor in the *pekasam* fermentation process is the amount of cooked rice added as a source of carbohydrates. Cooked rice serves as the primary substrate for lactic acid bacteria, such as *Lactobacillus plantarum* and *Pediococcus acidilactici*, which play a role in lowering pH and producing organic compounds that give *pekasam* its distinctive flavor (Huda, 2018). Cooked rice concentrations that are too low can cause less than optimal fermentation, while too high can increase excess carbohydrates levels which risk causing unwanted microbial growth (Yulvizar et al., 2021). In local society, *pekasam* is usually mixed with cooked rice for a concentrtaion of about 40%. In our preliminary research of making *pekasam*, using cooked rice concentrations of 40%, 50% and 60%, products of similar quality resulted. Further research can identify the optimal concentration of cooked rice for making *pekasam*, helping to achieve a balance between flavor, texture and microbial content that supports maximum fermentation.

Physicochemical properties such as color, pH, acid and water content play an essential role in determining the success of fermentation and product safety (Putri et al., 2020). Color, aroma, texture and taste are key organoleptic factors that influence consumer acceptance of *pekasam* (Nugraheni et al., 2021). Nutritional composition, which includes calorie content, amino acids, carbohydrates, protein, fat and ash, also needs to be analyzed to understand the nutritional content of the *pekasam* produced (Atun et al., 2024).

Variations in the concentration of cooked rice during the fermentation process are believed to significantly influence various quality parameters of *pekasam*. Using the right cooked rice concentration can produce optimal *pekasam*, with a balanced blend of tart and savory flavors, a soft but not too wet texture, and a mild fermentation aroma. In the optimal *pekasam*, the tart and salty flavors will be balanced, with the texture of the fish soft but dense and easy to chew. In addition, the resulting fermentation aroma will provide a distinctive sensation without seeming rancid or overpowering (Purwanto et al., 2019).

Therefore, this study aims to analyze the effect of cooked rice concentration on physicochemical properties, organoleptic characteristics and nutritional composition of Nila *(Oreochromis niloticus) pekasam*. This study aims to provide insights into the optimal concentration of cooked rice required to produce high-quality *pekasam*, and to enhance the added value of Nila in the fermented food industry. The results of this study may contribute to the development of higher-quality *pekasam* products by extending the shelf life, enhancing taste and nutritional value, and promoting the utilization of Nila based *pekasam* in local markets.

2 Material and methods

This study employed a Completely Randomized Design (CRD) with three treatments involving different concentrations of cooked rice at 40%, 70% and 100%. The 40% concentration of cooked rice is usually used by local society and therefore it was referred to as the control. The percentages were calculated based on the ratio between the weight of cooked rice and Nila meat, namely 40:100; 70:100; and 100:100. The study population was raw nila meat fermented in a glass jar with a capacity of 5 L for 7 days.

To make *pekasam*, Nila fish is first cleaned by removing the head, scales and viscera, then rinsed with running water. After that, the fish was drained and weighed approximately around 1 kg per treatment. Next, the fish was sprinkled with iodized salt at 40% of the weight of the fish, then covered with cooked rice at different concentrations according to the treatment. The cooked rice used in this study was prepared using a rice cooker, with a water to uncooked rice ratio of 1:1, and was allowed to cool before use. Figure 1 shows the material preparation before making *pekasam*. The fish, after being coated with salt and cooked rice, were placed in a 5-liter glass jar in a horizontal position, then sealed with plastic and tied securely using a raffia string (Figure 2). To prevent light exposure, the jar was put in a cardboard box and placed in a cabinet for 7 days of fermentation. The air temperatures in the cabinet were between 28-29^{o}C. After completing fermentation, the fish were removed from the jar and cleaned from the remaining cooked rice.

Laboratory tests measured physicochemical (color, pH, salt and water content) and organoleptic properties (color, texture, aroma, tart and salty taste) using a line scale. In this study, physicochemical and organoleptic analyses were performed only for fermented fish components. Nila *pekasam* is commonly consumed only after removing cooked rice and salt. This decision was based on the role of fish as the primary substrate that undergoes significant biochemical changes during fermentation. Throughout the fermentation process, fish proteins are broken down by endogenous enzymes and lactic acid bacteria (LAB), resulting in the formation of amino acids, lactic acid and other metabolites that directly influence the pH, color, aroma, texture and flavor of the final product. Therefore, analyzing only the fish provides a more accurate representation of the fermentation's impact on product quality and safety. Similar approaches have been adopted in previous studies on fermented fish products (Cintya et al., 2022; Karim, 1993), where evaluations were concentrated on the fish matrix due to its central role in flavor and safety development.

Figure 1: The amount of salt, fish and cooked rice with different ratio to make nila *pekasam*

Figure 2: After making the *pekasam* before the laboratory tests

2.1 Physicochemical tests

The first physicochemical test involved measuring the color of the fish meat using a calibrated hand-held color meter WR10. The L value indicates the brightness level from black (0) to white (100), the a value indicates the red (+) to green (-) color spectrum, and the b value indicates the yellow (+) to blue (-) color spectrum. The water content of samples was measured at 80 ^{o}C in a drying oven for 48 hours or until constant weight. The water content was calculated using the formula: Water content (dry basis) = (B -C)/(B-A) $\times$ 100%, where A is the weight of the cup, B is the initial weight of the sample with the cup, and C is the weight after drying. The sample of 10 g was diluted in 20 ml distilled water before measuring its pH with a calibrated pH meter. The fish sample of 5 g was crushed and dripped filtered water onto a refractometer to measure salt content.

2.2 Organoleptic tests

Organoleptic testing involved 30 Biology Education students of Faculty of Teacher Training and Education Tanjungpura University class of 2020 as untrained panelists that were healthy and not allergic to fish. Each panelist functions as a replication in Completely Randomized Design (CRD) with *pekasam* percentages as three treatments. Each panelist consumed ± 15 grams of fermented Nila *pekasam* meat without further processing from each treatment. The panelist evaluated color, aroma, texture, tart and salt taste using a line scale for each attribute on a sheet of paper.

2.3 Proximate tests

Proximate testing is a chemical analysis used to determine the primary content in a material, including ash content, fat, protein, carbohydrates,

Table 1: Organoleptic Test Assessment Criteria

Score	Category				
	Aroma	Color	Texture	Tart Taste	Salty Flavor
0≤20	Foul smell	Flesh-colored/pink	Very loud	Unsalted	Unsalted
20≤40	Typical fish aroma	Slightly pale	Hard	Slightly tart	Slightly salty
40≤60	Slight fish aroma	Pale	Medium chewy / slightly firm	Medium	Medium
60≤80	Slight aroma of *pekasam*	Somewhat bright pale	Soft chewy	Tart	Salty
80≤100	Aroma of *pekasam*	Bright pale	Crumbly	Very tart	Very salty

amino acids and calories. The ash content was measured by burning the sample in a furnace at 550^{o}C for 4-6 hours until inorganic residue remains (Latimer, 2019). The Soxhlet method was used to measure the extracted sample with an organic solvent such as hexane for several hours before evaporating it and reweighing it (Latimer, 2016). Protein content was determined using the Kjeldahl method, which measures the nitrogen content in the sample; the result was then converted to protein using a conversion factor of 6.25 for food (Latimer, 2016). Carbohydrates were calculated using the by-difference method, which subtracts the total content of other substances from 100% (Food and Agriculture Organization, 2004). To determine the amino acid content, the samples were hydrolyzed using 6N HCl for 24 hours and then analyzed using high-performance liquid chromatography (HPLC), in accordance with Latimer (2019) guidelines. The calories were measured using a bomb calorimeter, where the sample was in a closed environment containing oxygen, under high pressure, and used the change in water temperature around the bomb to calculate the energy produced (Latimer, 2019). Proximate testing is essential to determine the quality and nutritional value of the *pekasam*. Proximate testing was conducted at the Integrated Science Laboratory of Tanjungpura University.

2.4 Data Analysis

The data obtained from the physicochemical and organoleptic test results were analyzed by ANOVA using SAS. The model used CRD with three treatments as follows:

$$Y_{ij} = \mu + \tau_i + \varepsilon_{ij}$$

Y_{ij} = represents the observed value or response for the i-th treatment and j-th replication.
μ = is the overall mean or grand mean of the experiment.
τ_i = represents the effect of the i-th treatment.
ε_{ij} = represents the random error or experimental error associated with the i-th treatment and j-th replication.

$$\sum_{i}^{n=3} = \text{for treatment} \qquad \sum_{i}^{n=30} = \text{for panelist}$$

The replications for physicochemical and organoleptic tests were three and 30, respectively. If the treatment was significant, the LSD test was performed at $\alpha = 5\%$. The average results of each parameter were then analyzed using modified score interpretation criteria from Riduwan (2012), as listed in Table 1.

3 Results and Discussion

pekasam Nila is a traditional fermented food from West Kalimantan, made using Nila, cooked rice and salt. During fermentation for 7 days, the fish before and after fermentation experienced physical and chemical changes (Table 2.
The results of Nila fermentation into *pekasam* showed changes in characteristics from different cooked rice concentration treatments. At 40%, the Nila *pekasam* looked brighter with less water in the jar. The distinctive aroma of *pekasam* began to smell, although not too strong, resembling

Table 2: *Pekasam* before and after fermentation

Treatment	**Before**	**After**
40%		
70%		
100%		

the aroma of salted fish. At the 70% cooked rice concentration, the color of the Nila *pekasam* appeared darker, and a noticeable amount of water was observed surrounding the cooked rice. The distinctive aroma of *pekasam* was more pronounced than the previous treatment. Meanwhile, in the 100% treatment, the color of the *pekasam* looked bright with little water around the cooked rice. The fish aroma was still present, but it was less pungent than those of 40% and 70% treatments. This difference showed that the variation of cooked rice treatment in the fermentation process affected the color, water content and aroma intensity of the Nila *pekasam* produced.
After fermenting for seven days, the Nila *pekasam* was taken out of the jar, and the fish were cleaned to remove the cooked rice that had adhered to them. Furthermore, Physicochemical and organoleptic tests were conducted in the Education Biology Laboratory while the proximate testing was conducted in the Integrated Science Laboratory of Tanjungpura University.

3.1 Physicochemical results

The Physicochemical data first underwent normality and homogeneity testing. If the test results were not normal, nor homogeneous, then transformation was necessary. The distribution of data showed positive skewness; therefore, a square root (SQRT) transformation was applied to normalize the data.
The results of normality and homogeneity tests showed that the color parameter a and water content were normally distributed, whereas the color parameters L and b, as well as pH and salt content, were not normally distributed. The data were then transformed. The transformation results showed that the data were normal

Table 3: ANOVA Results of Physicochemical Test Data of Nila (*Oreochromis niloticus) Pekasam*

Parameter		Treatment			Significance
		40% ±sdev	70% ±sdev	100% ±sdev	
Color	L	28.65 (5.34^b) ±2.59	26.84 (5.17^c) ±0.84	32.73 (5.71^a) ±1.65	S
	a	0.49 ±1.94	1.24 ±0.87	0.27 ±0.97	NS
	b	3.10 (1.52) ±3.39	2.45 (1.39) ±2.08	0.86 (0.77) ±1.57	NS
pH		5.57 (2.36^b) ±0.03	5.79 (2.40^a) ±0.03	5.65 (2.37^{ab}) ±0.13	S
Water content (%)		53.16^{ab} ±3.68	57.83^a ±4.54	49.16^ba ±6.06	S
Salt content (%)		20.77 (4.55^b) ±1.30	23.00 (4.79^a) ±0.86	20.11 (4.48^b) ±0.78	S

Notes. S = significan; NS = non-significant; Numbers in parentheses were the result of transformation; Letters behind the average on the same line indicated the difference among treatments when tested with LSD at $\alpha = 5\%$

and homogeneous with SQRT. Table 3 presents the ANOVA results for color (L, a and b), pH, water content, and salt content including LSD result for significant treatment.

The results for measured physical and chemical parameters of Nila *pekasam* showed that two of the six parameters were not significant, namely the color of factor a and factor b (Table 3). The color factor L shows significant brightness at p=0.0001 and the brightness in the 100% treatment. On the other hand, pH increased from the 40% to 70% treatment and was significant at p=0.0001, and decreased at 100%. The pH reduction at 100% concentration was similar to that of the 40% Concentration; however, it was also similar to that of the 70% concentration. Additionally, water content increased from the 40% to 70% treatment, but decreased significantly at p=0.0037. Similarly, salt content increased from the 40% to 70% treatment and decreased significantly at p=0.0001 (Table 3)

The results for the measured physical and chemical parameters of Nila *pekasam* were presented as a graph to visualize the data more clearly and informatively. Figure 3, 4, 5 and 6 shows the comparison among treatments with different cooked rice concentrations (40%, 70% and 100%) and illustrated trends in parameters such as color, acid content, water content and salt content.

Final results for each parameter is illustrative of the fermentation process in fish that occurs with different cooked rice treatments (Figure 3, 4, 5 and 6). The pH parameter in Figure 4 shows that the 40% treatment had the lowest pH, reflecting the highest acidity. Less cooked rice concentration causes microorganisms, especially lactic acid bacteria (LAB), to consume glucose quickly, producing a lot of lactic acid quickly. This acid accumulation drastically lowers the pH to 5.57. However, excessively rapid fermentation can cause a metabolic imbalance, reducing process efficiency, as rapid acidification may inhibit microbial activity and lower product quality (Liu et al., 2020). In the 100% cooked rice treatment, the higher substrate availability derived from the greater amount of cooked rice facilitated faster acid production through microbial fermentation. However, the excess substrate increased osmotic pressure, which could inhibit some LAB strains, leading to unbalanced fermentation. The buffering effect of the substrate was also insufficient to stabilize the pH, so the fermentation environment became more acidic with a pH of 5.65. Although acid production was faster, a metabolic imbalance still occurred due to osmotic pressure, which limited the activity of microorganisms (Liu et al., 2020; Peyer et al., 2017). In the study of nila *pekasam*, the average pH at 100% concentration reduced to a pH similar to that of 40% concentration. However, the small number of samples resulted in huge variation. Therefore, research with a lot more samples is recommended to reduce the variation.

In contrast, the 70% cooked rice treatment ap-

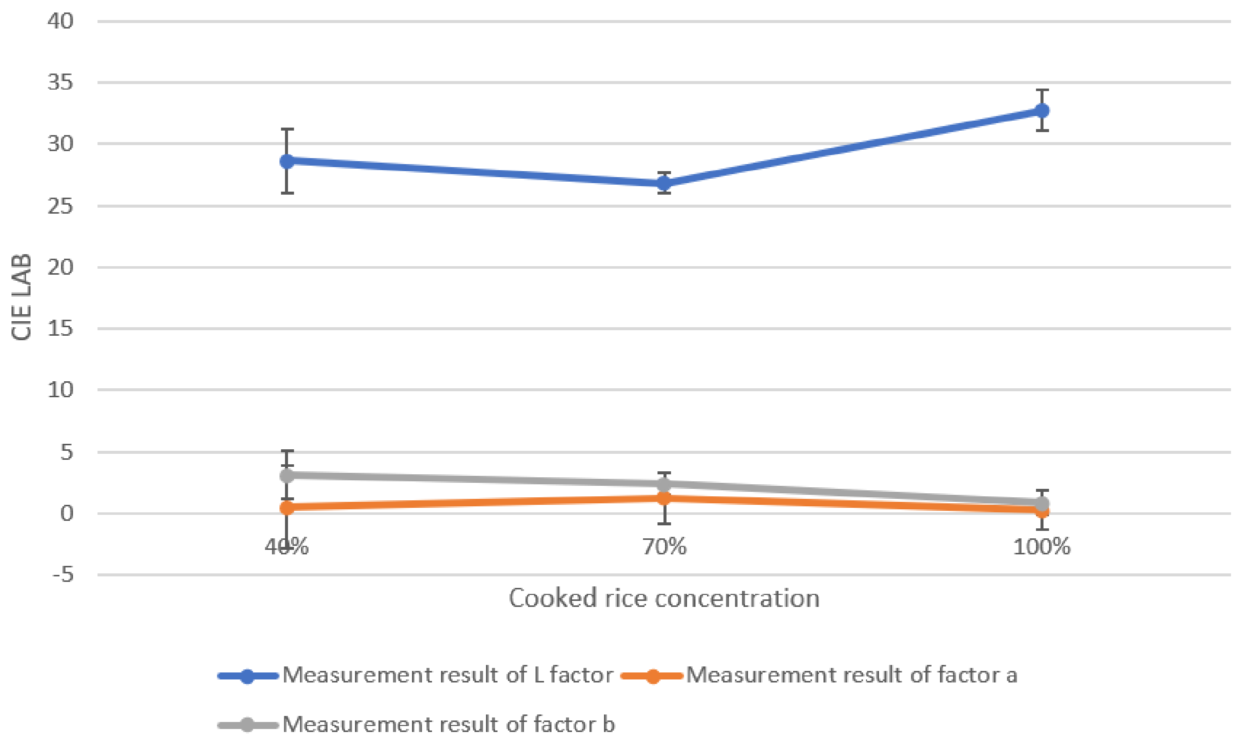

Figure 3: Graph of Physicochemical test results showing parameters: Color L, a and b

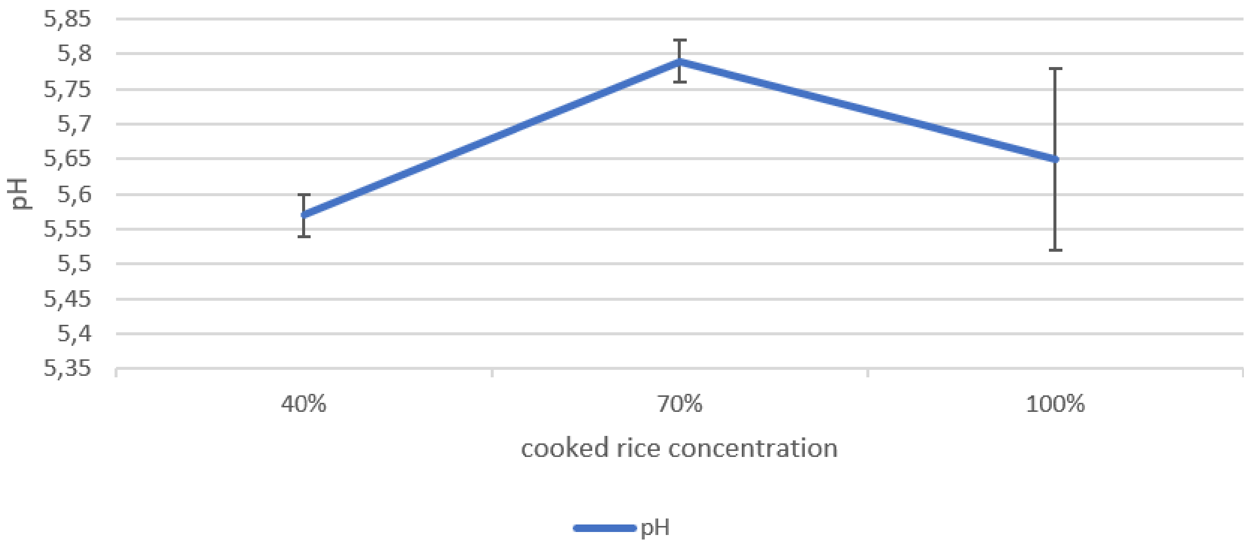

Figure 4: Graph of Physicochemical test results showing parameters: pH

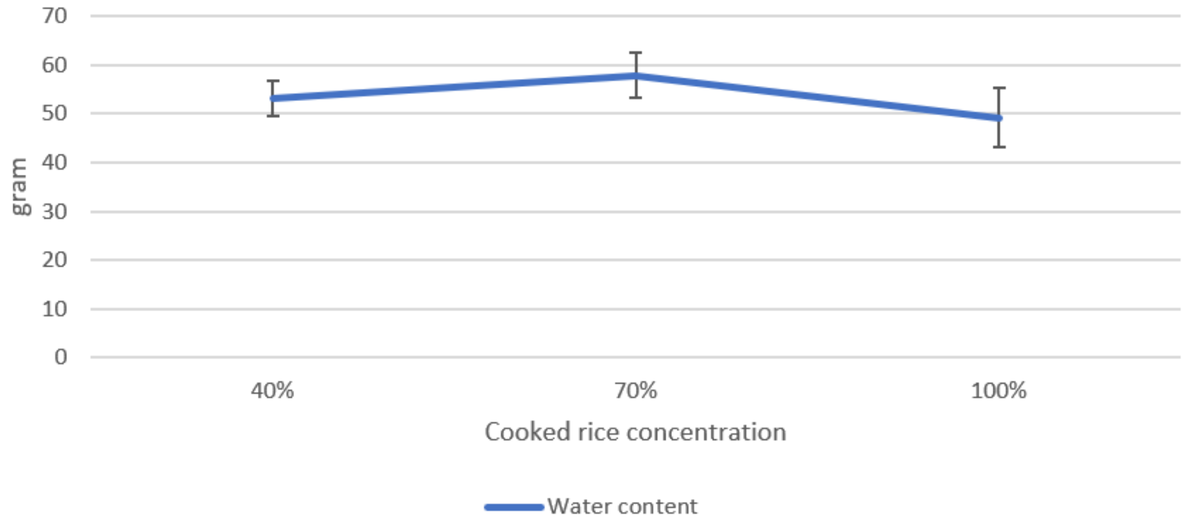

Figure 5: Graph of Physicochemical test results showing parameters: Water content

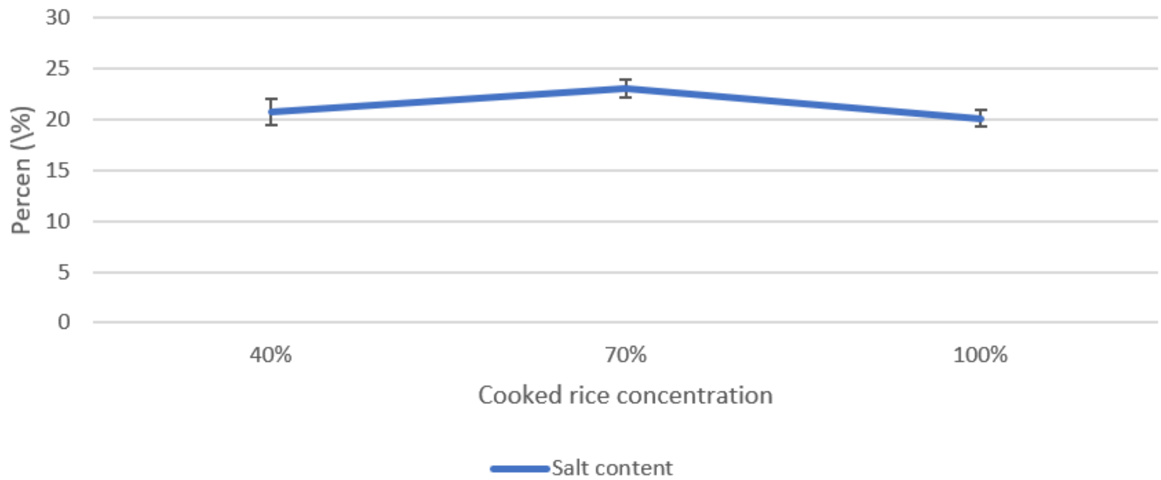

Figure 6: Graph of Physicochemical test results showing parameters: Salt content

peared to support a more stable fermentation process, potentially indicating a better balance of microbial activity and acid production. The moderate availability of glucose allows fermentation to proceed in a controlled manner, producing a balanced amount of acid without a sharp drop in pH. This creates stable fermentation conditions, with a pH in the range of 5.5–6.0, which is ideal for *pekasam* quality, including optimal texture and flavor (Abbasiliasi et al., 2017; Sionek et al., 2024). Thus, fermentation at 70% cooked rice concentration is more stable and optimal than those of the 40% and 100% treatments, which experience an imbalance in acid production and an uncontrolled drop in pH (Liu et al., 2020; Peyer et al., 2017).

As shown in Figure 5, the water content in the 70% cooked rice treatment was significantly different from the 100% cooked rice treatment but the same as the 40% cooked rice treatment (Table 3), likely due to the balanced role of cooked rice as both a fermentation substrate and a water-absorbing agent, along with the uniform addition of 40% salt across all treatments. Salt plays a role in inhibiting proteolytic enzymes of spoilage microorganisms while supporting the growth of lactic acid bacteria, which are essential in *pekasam* fermentation (Margiati et al., 2024; Rinto et al., 2022). At 70% cooked rice concentration, sufficient substrate allows optimal growth of lactic acid bacteria, which produce organic acids and exopolysaccharides to maintain a high water content (Tinzl-Malang et al., 2020). In contrast, at 100% treatment, excess substrate causes less efficient fermentation, inhibits bacterial activity, and reduces the water content (Abbasiliasi et al., 2017). Meanwhile, in the 40% treatment, the limited amount of substrate restricts bacterial growth and metabolite production, resulting in a lower water content. Although a 40% salt concentration draws water from the fish tissue through osmosis, cooked rice has the ability to retain water at a 70% cooked rice concentration resulting in the highest water content. Although the high water content at the 70% treatment can shorten the shelf life, as it favors the growth of microorganisms, *pekasam* with a high water content has a softer and chewier texture and fresher taste, which is preferred by consumers (Cai et al., 2024; Macori & Cotter, 2018). Generally, *pekasam* with a high water content can last 1-2 weeks at room temperature or several months if stored in cold conditions (Khandelwal et al., 2015). Thus, the 70% treatment provided optimal water content, texture and sensory quality in the *pekasam*.

The salt content parameter in Figure 6 shows a significantly higher level in the 70% treatment than those of the 40% and 100% treatments. In the 40% cooked rice treatment, the relatively lower salt amount, resulting from the smaller proportion of rice used, may have contributed to the higher acidity due to a reduced inhibition of microbial fermentation. This is due to the efficient conversion of cooked rice, which serves as a substrate, into lactic acid by lactic acid bacteria (LAB). High lactic acid production creates a low pH (acidic) environment, which affects salt distribution in the *pekasam* matrix. This acidic environment can decrease the product's ability to retain salt, as osmotic processes predominantly attract water rather than retain salt ions in the system (Anggraeni et al., 2021; Margiati et al., 2024). In addition, the lower cooked rice content (40%) limits the capacity of the substrate to optimally bind salt. With less cooked rice available, the contribution of cooked rice in absorbing and distributing salt is limited, so the salt content tends to be lower, even though the initial salt added was the same in all treatments (Khandelwal et al., 2015).

In the 100% cooked rice treatment, the salt content appeared lower, likely due to dilution caused by the higher amount of cooked rice used in the formulation. An excessive amount of cooked rice, used as a substrate, led to inefficient fermentation, as the bacteria were unable to utilize it effectively. As a result, lactic acid production was lower than the 40% treatment, but the large volume of cooked rice diluted the salt distribution in the product. This makes the overall salt content appear lower. Saturation of the substrate can also slow down the activity of microorganisms, so that the process of binding salt ions is not maximized (Desniar et al., 2009; Koesoemawardani et al., 2020).

The 70% treatment showed the highest salt content (23.00%) due to the optimal balance between the amount of cooked rice substrate and fermentation activity. At this cooked rice concentration, the substrate is sufficient to support the efficient growth of lactic acid bacteria, without leaving excess material that could disrupt the fermentation process. Bacterial activity produces a moderate amount of organic acids, creating a less acidic environment that does not reduce salt retention in the *pekasam* matrix. In addition, cooked rice at the 70% concentration has an optimal capacity to absorb and retain salt, contributing to product stability (Koesoemawardani et al., 2020; Margiati et al., 2024). In the 70% cooked rice treatment, the relatively higher salt concentration may help extend the product's shelf life by inhibiting microbial spoilage. Salt plays an essential role in inhibiting the growth of spoilage microorganisms, thus slowing down the product deterioration process.

3.2 Organoleptic results

The results of normality and homogeneity tests-ing indicate that the organoleptic data for aroma, color, texture, tart taste and salty taste do not follow a normal distribution. Therefore all parameters were transformed using a SQRT transformation because the distribution was positively skewed. Table 4 presents the ANOVA results for the organoleptic data of aroma, color, texture, tart taste and salty taste.

The organoleptic test results are presented in a graph that shows the average ratings given by the panelists for each parameter tested. Figure 7, 8, 9, 10 and 11 visualizes the trends and differences between treatments, although these differences are statistically insignificant.

The cooked rice treatment had no effect on the aroma, color, texture, tartness and saltiness parameters of Nila *pekasam*. One factor that may have influenced these results is the limited number of panelists, with only 30 untrained individuals. In studies involving untrained panelists, a larger sample size is necessary to ensure that the results are more representative and statistically valid. According to recent guidelines by Advancing Standards Transforming Markets International (n.d.), the ideal number of panelists for hedonic tests with untrained consumers ranges from 50 to 100 individuals. This range is adequate to provide a broader range of perceptions, minimize subjective bias, and detect subtle differences that a smaller panel might miss. An increased number of panelists could improve precision and reduce variation, thereby allowing differences due to treatment to be detected more significantly.

Nevertheless, Nila *pekasam* made with a 70% cooked rice concentration on average produced more optimal characteristics. The *pekasam* with a 70% cooked rice concentration had a strong aroma (Table 5), receiving an average rating of 64.96 (Table 4). The bright pale color with yellowish-reddish tones, with a CIELAB value of 75.13, indicates a visually appealing product and is typical of fermented *pekasam*, as reported by Khudair et al. (2023). The medium chewy texture, with a score of 42.90, indicates successful fermentation, resulting in a well-structured product, as noted by Setiarto and Herlina (2024). The tart taste (25.06) and salty taste (66.26) in this treatment were well-balanced, giving the *pekasam* a pleasant overall flavor. Jay (2000) stated that good *pekasam* has a balance of tart and salty tastes. The 70% cooked rice concentration creates an optimal substrate balance to support the activity of fermenting microorganisms, such as lactic acid bacteria, which play an essential role in the formation of the characteristic flavor, aroma and texture of *pekasam* (Steinkraus, 1995). The fermentation process at this concentration produces metabolites such as organic acids and exopolysaccharides (polysaccharides produced and released by microorganisms into the external environment) that not only enrich the taste and aroma but also improve product stability through inhibiting the growth of spoilage microorganisms (Hutkins, 2018).

The evaluation of various parameters showed that the 70% treatment met the Standar Nasional Indonesia standards, while the 40% and 100% treatments did not fully comply with the required criteria. In the 40% treatment, the texture produced was still hard, which did not meet the characteristics of a fish paste texture, which should be chewier and softer after the fermentation process (Standard Nasional Indonesia, 2016). In addition, in the 100% treatment, the aroma identified was still too typical of fish, indicating that the fermentation process was not optimal to produce a distinctive fish *pekasam* aroma, which tends to be more subtle and fermentative (Purba et al., 2024). Although the 100% treatment showed suitability in several other parameters, such as salty and slightly tart taste, the overly dominant aroma indicated that the processing had not reached the ideal *pekasam* stage. Therefore, the 70% treatment is the most suitable treatment according to Standar Nasional Indonesia standards, given the slightly *pekasam* aroma, chewy texture, and the desired balance of tart and salty flavors in Nila *pekasam* products (Purba et al., 2024; Standard Nasional Indonesia, 2016).

Table 4: ANOVA Results for Organoleptic Test Data of Nila *pekasam*

Parameter Averages	Treatment			Significance
	40% ±sdev	70% ±sdev	100% ±sdev	
Aroma	64.43 (7.93) ±19.14	64.96 (7.93) ±21.23	55.13 (7.27) ±21.59	NS
Color	71.63 (8.33) ±23.17	75.13 (8.59) ±18.22	72.60 (8.43) ±19.32	NS
Texture	34.16 (5.58) ±19.27	42.90 (6.41) ±16.00	43.00 (6.32) ±23.28	NS
Tart taste	22.50 (4.12) ±18.33	25.06 (4.26) ±21.79	25.86 (4.70) ±15.76	NS
Salty taste	67.53 (8.14) ±17.30	66.26 (7.91) ±23.00	63.60 (7.85) ±20.71	NS

Notes. S : Significant at $\alpha = 5\%$; NS : Non Significant at $\alpha = 5\%$; The value in parentheses is the value of Data Transformation.

Table 5: Descriptive Results for Organoleptic Testing

Treatment	Interpretation Criteria for Each Parameter Score				
	Aroma	Color	Texture	Tart	Salty
40%	Slight aroma of *pekasam*	Somewhat pale bright	Hard	Slightly tart	salted
70%	Slight aroma of *pekasam*	Somewhat bright pale	Medium chewy	Slightly tart	salted
100%	Slight fish aroma	Somewhat bright pale	Medium chewy	Slightly tart	salted

3.3 Proximate Testing

As part of the product composition evaluation, proximate testing was carried out to determine the levels of moisture, ash, protein, fat and carbohydrates in the sample. Table 6 presents the detailed results of these measurements.

Table 6: Proximate test results of Nila *pekasam*

No.	Parameters	Units	Treatment		
			40%	70%	100%
1.	Ash content	%	14.947	18.911	21.994
2.	Fat	%	2.011	2.982	3.292
3.	Protein	%	9.444	9.527	7.100
4.	Carbohydrates	%	16.788	18.358	13.677
5.	Amino Acid	%	0.545	0.547	0.602
6.	Calories	kcal/g	123.027	138.378	112.739

Based on the proximate test results of Nila *pekasam* with three different cooked rice treatments (40%, 70%, and 100%), variations in chemical composition affecting product quality can be observed. The increase in ash content in the Nila *pekasam* meat with the increase in cooked rice concentration indicates an increase in mineral content. In the 40% cooked rice treatment, the ash content was recorded at 14.947%, while in the 100% cooked rice treatment, the ash content increased to 21.994%. The increase in ash content is likely due to mineral contributions from the cooked rice and salt added during the fermentation process. Although the ash content was higher in the 100% cooked rice treatment, the 70% cooked rice treatment (18.911%) was considered ideal. At this concentration, the Nila *pekasam* retains sufficient mineral content while maintaining the desired flavor and texture in the final product. This is consistent with the findings of Khairina et al. (2021), which showed that moderate cooked rice concentrations provided better results in terms of organoleptic quality and mineral content in Nila *pekasam* meat.
The highest fat content was found in the 100% cooked rice treatment (3.292%), while in the 40% cooked rice and 70% cooked rice treatments, the fat content was lower at 2.011% and 2.982%, re-

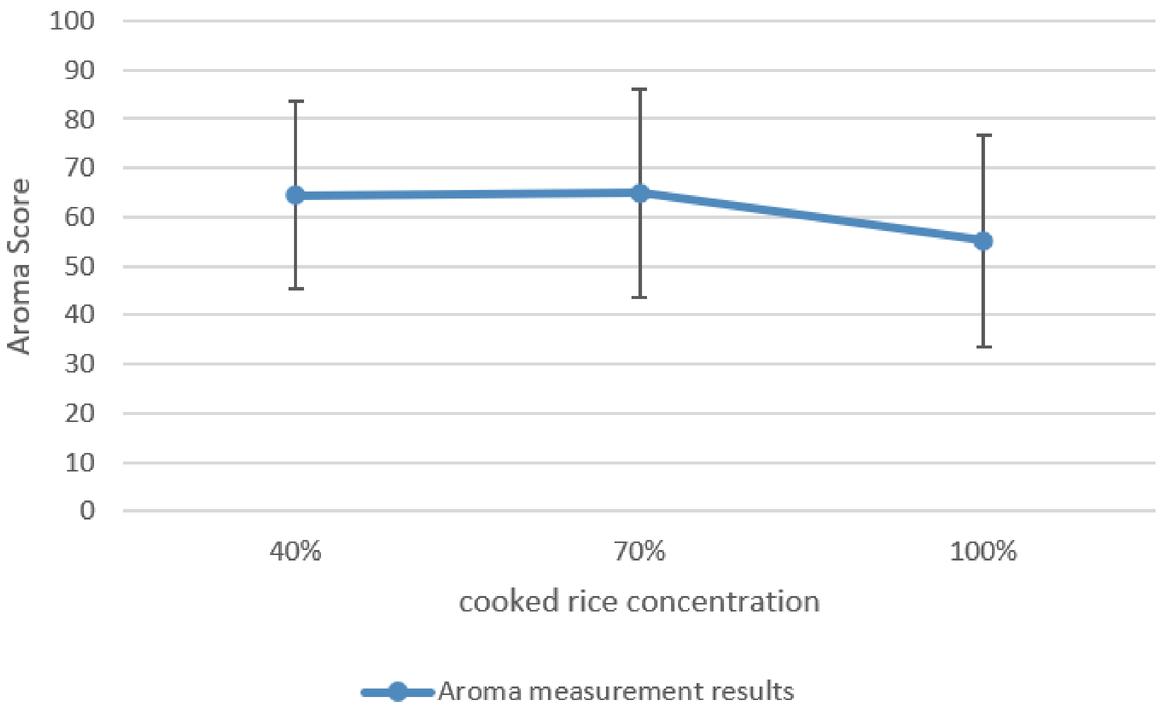

Figure 7: Graph of organoleptic test results: Aroma

spectively. Excessive fat in 100% cooked rice may increase the risk of rancidity or undesirable flavor changes. In contrast, in the 70% cooked rice treatment, the stable fat content provides a good balance of flavor without the risk of rancidity (Cintya et al., 2022).

Protein content showed a decrease in the 100% cooked rice treatment (7.100%), compared to 9.444% in 40% cooked rice and 9.527% in 70% cooked rice. The decrease in protein content at 100% cooked rice was likely due to excessive microbial activity that utilized protein as an energy source during fermentation. In contrast, the 70% cooked rice treatment was more optimal in maintaining *pekasam* protein levels which are essential for the texture and nutritional quality of the product (Cintya et al., 2022).

Regarding carbohydrates, the 70% cooked rice treatment (18.358%) had the highest carbohydrates content, which supported fermentation by providing enough energy for microorganisms without causing excessive protein degradation. The 100% cooked rice treatment showed a decrease in carbohydrates content (13.677%) as the microorganisms consumed more substrate, while in the 40% cooked rice treatment, the lower carbohydrates content led to less optimal fermentation (Rajendran & Ramesh, 2024).

Amino acid levels increased slightly, from 0.545% with 40% cooked rice to 0.602% with 100% cooked rice. However, this increase was accompanied by a reduction in total protein, which may negatively affect the taste of *pekasam*. The 70% cooked rice treatment, with an amino acid content of 0.547%, maintained a balance between the degraded protein and the sensory quality of the product (Liyanaarachchi et al., 2022).

Finally, the 70% cooked rice treatment had the highest calorific content, at 138.378 Cal.g^{-1}. This suggests that the 70% concentration provided the best balance of carbohydrates, fats and protein, resulting in an optimal energy value. The 40% cooked rice treatment produced lower calories (123.027 Cal.g^{-1}), and the 100%

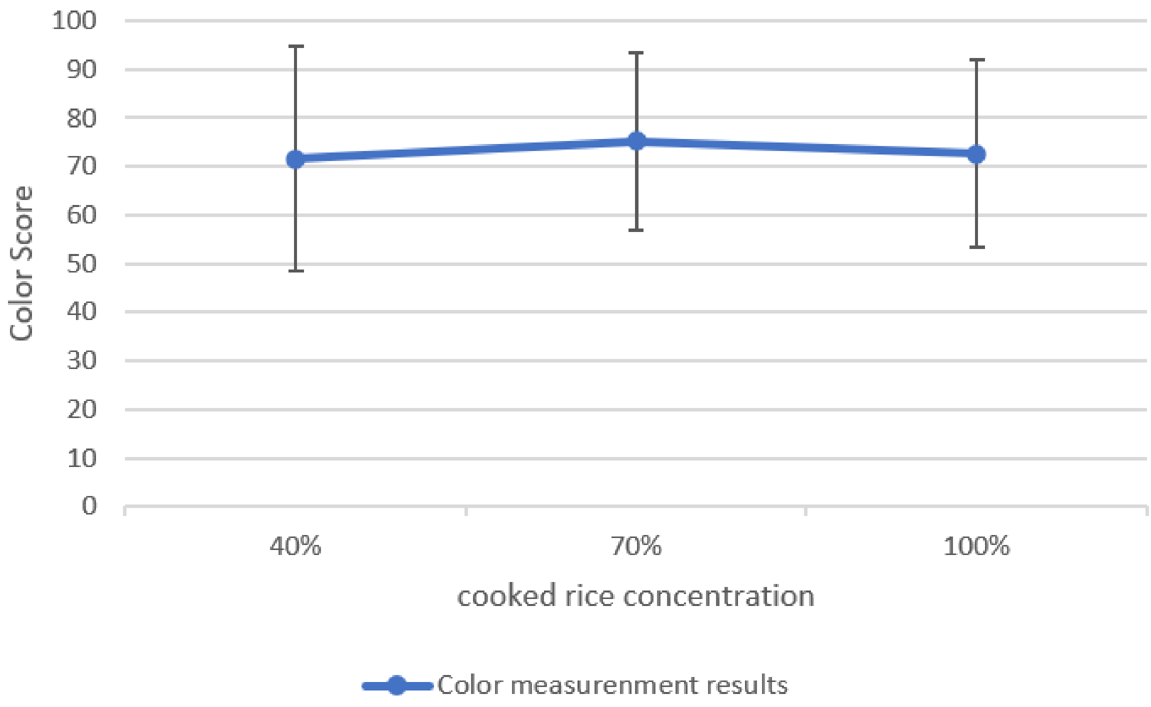

Figure 8: Graph of organoleptic test results: Color

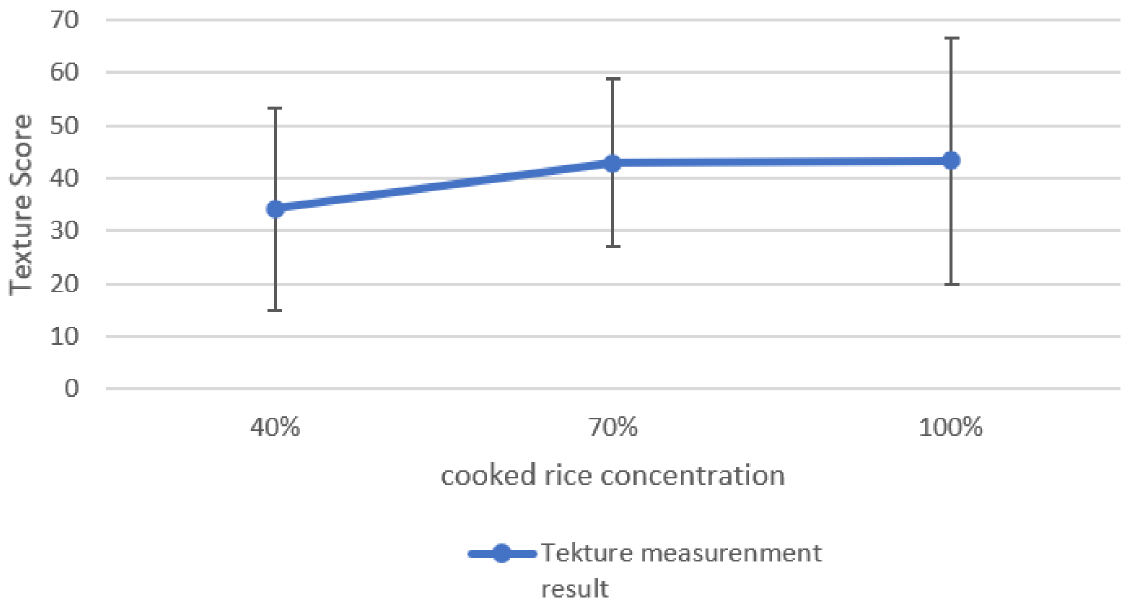

Figure 9: Graph of organoleptic test results: Texture

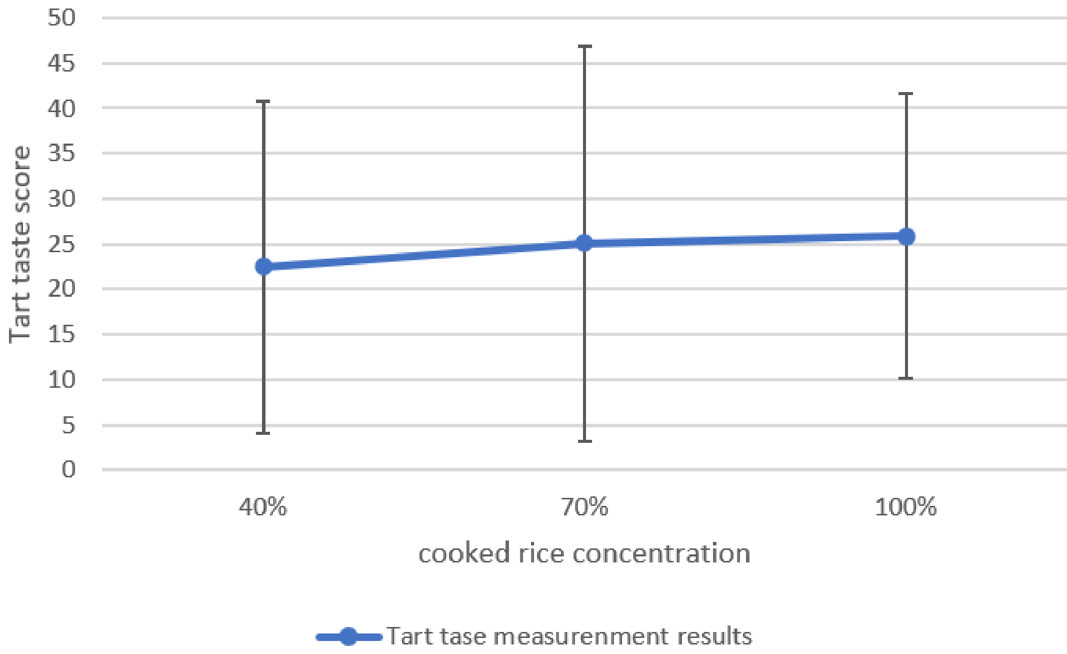

Figure 10: Graph of organoleptic test results: Tart taste

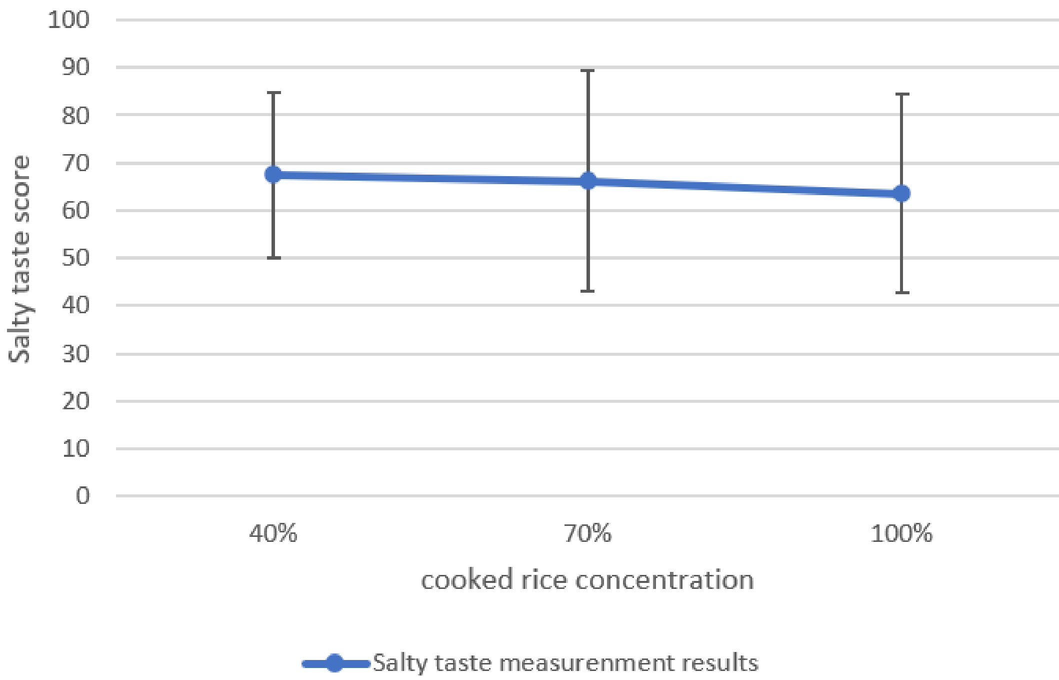

Figure 11: Graph of organoleptic test results: Salty taste

cooked rice produced even lower calories (112.739 Cal.g^{-1}) due to a significant decrease in protein and carbohydrates content (Cintya et al., 2022). Based on the results of all proximate analyses, the 70% cooked rice treatment proved to be the most effective in producing high-quality Nila *pekasam*. This treatment produces an optimal nutritional balance, with balanced levels of protein, fat, carbohydrates, amino acids and calories, resulting in a *pekasam* with good flavor, high nutritional value, and more stable quality during storage.

4 Conclusion

The results of the study indicate that a 70% cooked rice treatment is the most effective treatment for producing Nila *pekasam*. The physicochemical test results show that this treatment produces good color brightness, appropriate pH level, ideal water content and sufficient salt content, which support the physical and chemical quality of *pekasam*. In addition, the 70% cooked rice treatment also produced a chewy texture, balanced taste and attractive color, making it the optimal choice for the fermentation process. Although there was no significant difference in the organoleptic test results among the 40%, 70% and 100% cooked rice treatments, the *pekasam* with 70% cooked rice treatment showed better characteristics, with a strong *pekasam* aroma and a balanced salty and tart taste. The results of the chemical, physical and organoleptic tests were consistent with the nutritional composition obtained from the proximate analyses, which showed optimal levels of ash, fat, protein and carbohydrates. Additional analyses also confirmed favorable amino acid and calorie content. This indicates that using a 70% concentration of cooked rice not only enhances the flavor of Nila *pekasam*, but also contributes to its overall nutritional balance and quality. Overall, a 70% cooked rice concentration resulted in the most favorable quality of Nila *pekasam*, including optimal physical, chemical, organoleptic and nutritional properties, along with enhanced storage stability.

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