Prisma Sains: Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram
https://e-journal.undikma.ac.id/index.php/prismasains/index
e-mail: prismasains.pkpsm@gmail.com

April 2025. Vol. 13, No. 2
p-ISSN: 2338-4530
e-ISSN: 2540-7899
pp. 322-334

Sensory and Statistical Analysis of Banjarbaru Rice Production: Hedonic Evaluation, Sensory Attributes, and Normal Distribution

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Received: January 2025; Revised: March 2025; Published: April 2025

Abstract

This study aims to evaluate the sensory quality and consumer acceptability of Banjarbaru-produced rice, including fortified (Fortivit), biofortified (Nutri Zinc), and conventional (Inpari 32) varieties, through hedonic testing and sensory attribute analysis. The research was conducted in Banjarbaru City, South Kalimantan, covering five sub-districts. A total of 25 respondents participated in sensory assessments evaluating color, aroma, taste, texture, and shape on a 4-point Likert scale. In addition to sensory analysis, the study investigated zinc retention during typical household preparation practices, including repeated washing and standard cooking procedures. Micronutrient content was analyzed using standard laboratory methods, while sensory data were statistically tested using one-way ANOVA. Results showed that Fortivit rice exhibited the highest consumer preference across most sensory attributes, particularly in texture (mean score 3.60) and color (3.44), and demonstrated superior zinc retention (86.2%) compared to Nutri Zinc (69.8%) and Inpari 32 (74.3%). Statistically significant differences were observed in the attributes of color, texture, and shape ($p < 0.05$), confirming Fortivit's sensory advantage. Nutri Zinc, while nutritionally valuable, received lower scores and suffered higher micronutrient losses during washing and cooking. The findings highlight the dual importance of both nutritional resilience and sensory appeal in increasing consumer acceptance of fortified rice. Fortivit's extrusion-based fortification technology offers an effective strategy for micronutrient delivery, particularly in stunting-prevalent regions like South Kalimantan. This study supports the promotion of fortified rice as a feasible public health intervention and emphasizes the need for continued innovation and region-specific consumer education to ensure adoption success.

Keywords: Fortified Rice; Hedonic; Biofortification; Zinc retention; Sensory Attributes.

How to Cite: Mahyudi, F., Surti, S., & Husinsyah, H. (2025). Sensory and Statistical Analysis of Banjarbaru Rice Production: Hedonic Evaluation, Sensory Attributes, and Normal Distribution. *Prisma Sains : Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram, 13*(2), 322-334. doi:https://doi.org/10.33394/j-ps.v13i2.15278

https://doi.org/10.33394/j-ps.v13i2.15278

INTRODUCTION

Stunting remains a critical and persistent public health issue in Indonesia. Defined by the World Health Organization (WHO) as a condition where a child's height-for-age falls below -2 standard deviations from the median of the WHO Child Growth Standards, stunting results from chronic malnutrition and has far-reaching implications (WHO, 2023). The 2023 Indonesian Nutritional Status Survey (SSGI) reports that stunting still affects 21.6% of children under five (Ministry of Health of the Republic of Indonesia, 2023), underscoring its urgency as a national concern. This condition reflects long-term nutritional deficiencies and a complex web of underlying socio-economic determinants that necessitate an integrated, multisectoral response.

The consequences of stunting extend beyond physical growth impairments. Cognitive development, educational attainment, and long-term productivity are all negatively impacted. Prendergast et al. (2021) reported that stunted children are 45% more likely to suffer from cognitive impairments and 33% less likely to achieve standard levels of education. Moreover, stunting has been associated with a 22% decrease in potential lifetime earnings. McGovern et al. (2023) emphasize the importance of nutritional intervention during the "first 1,000 days of life" from conception to two years of age as a critical window to prevent stunting and its irreversible effects.

On a broader scale, stunting influences national development and competitiveness. Human capital, a central driver of economic growth, is compromised by inadequate childhood nutrition (Dewey & Begum, 2011; Suhaerudin, 2023). Lestari (2024) highlights how childhood stunting results in a workforce with diminished capacity, contributing to lower labor productivity. Surti et al. (2024) further argue that national development strategies must prioritize early childhood nutrition as a foundational investment in future generations. According to the World Bank, stunting can reduce national GDP by 3 - 11% due to long-term losses in productivity and health costs (McGovern et al. 2023). These effects are compounded by a cycle of intergenerational poverty, where undernourished parents are more likely to raise undernourished children (Ryadinency et al., 2020). In this context, food-based approaches to preventing stunting become highly relevant. Rice, as Indonesia’s staple food, contributes 56.7% of total daily caloric intake (BPS, 2023). As such, rice offers a strategic entry point for nutritional interventions. Innovations in rice fortification and biofortification, particularly with micronutrients like zinc and iron, have the potential to significantly impact public health. Studies indicate that zinc-biofortified rice can contribute meaningfully to reducing stunting rates, especially in settings where rice constitutes a major part of the diet (Jongstra et al., 2022). Successful case studies from Bangladesh and Vietnam support the use of biofortified rice as a stunting reduction strategy (Bouis et al., 2023; Nguyen et al., 2023).

Indonesia has begun to integrate biofortified rice into its agricultural and nutritional policies. The development of high zinc rice varieties such as IPB 1R Nutri Zinc and Inpari Nutri Zinc has been widely implemented across Java, covering thousands of hectares (Balitbangtan, 2023). In Karawang, Subang, and Indramayu, this biofortification program has reached 1,250 hectares. Expansion in Central and East Java has extended beyond 1,500 hectares. Outside Java, however, such initiatives remain in the early stages, with pilot projects and feasibility studies ongoing (Balai Besar Penelitian Tanaman Padi, 2023). In South Kalimantan, Banjarbaru City has begun cultivating biofortified rice varieties such as Inpari Nutri Zinc since 2022, particularly in the Bangkal area of Cempaka District, albeit only covering 2 hectares (Balitbangtan, 2023).

Despite its strategic importance and potential, the adoption of biofortified rice in Kalimantan has been slow. Limited consumer awareness and lack of exposure to these rice varieties remain significant barriers. This gap emphasizes the need for more research into consumer perception, particularly through sensory evaluation methods, to understand and enhance public acceptance. While the agronomic and nutritional benefits of biofortified rice are well-established, consumer preferences often hinge on sensory attributes such as taste, aroma, texture, and appearance. The interplay between nutritional value and palatability is crucial for determining consumer acceptance (Waris et al., 2021; Talsma et al., 2017). Studies from Latin America and South Asia have demonstrated that even nutritionally enhanced rice varieties must meet basic sensory expectations to be accepted by target populations (Woods et al., 2020). In this regard, sensory evaluation becomes a powerful tool to gauge acceptability, especially in populations that may be unfamiliar or skeptical about the concept of “fortified” food.

In Indonesia, the sensory evaluation of rice remains underexplored particularly in Kalimantan. Prior research has focused largely on agronomic performance or laboratory-based nutritional analyses. There is a notable absence of studies that systematically examine consumer perception of rice varieties through hedonic assessment, particularly in regions beyond Java. Existing research in Java suggests that consumers favor soft-textured and aromatic rice varieties (Custodio et al., 2019; Krishnamurti & Biru, 2019), while preferences in Kalimantan are influenced more by flavor and familiarity (Hartati et al., 2023; Cabral et al., 2022). These regional distinctions suggest the need for localized studies on sensory acceptance to tailor biofortified rice promotion strategies.

Moreover, awareness campaigns about fortified foods have had varying degrees of success across Indonesia. While fortified milk and biscuits have gained popularity among rural consumers, fortified rice remains relatively unfamiliar to most households (Fahmida & Santika, 2016). Consumer education regarding the health benefits of fortified rice can significantly enhance acceptance (Razzaq et al., 2021; Buzigi et al., 2024). Studies show that when consumers understand the connection between fortified rice and health improvements especially for children and pregnant women their willingness to try these products increases (Swamy et al., 2018; Rizwan et al., 2021). Therefore, aligning nutritional benefits with consumer expectations of taste, texture, and aroma becomes a central challenge.

Sensory studies have confirmed that successful adoption of fortified foods requires maintaining or enhancing organoleptic qualities. For example, Ferguson et al. (2018) and Bechoff et al. (2018) found that the acceptability of fortified rice significantly improves when its sensory attributes are retained during the fortification process. In regions such as Kalimantan, where rice preferences may diverge from national trends, this consideration becomes even more critical. In addition, food preparation methods including washing and cooking affect the retention of micronutrients such as zinc (Taleon et al., 2021; Taleon et al., 2020). If nutritional benefits are lost during common cooking practices, the utility of fortified rice diminishes. Hence, studies must examine not only the chemical composition of rice but also the effects of household cooking methods on nutrient retention and consumer perception. Fortified rice, such as Fortivit, is designed to mitigate nutrient loss through extrusion-based techniques that provide resistance to degradation during washing and cooking (Mannar & Gallego, 2002).

The cultural perception of rice quality is also tightly linked to its sensory properties. For example, aromatic rice varieties such as Pandan Wangi have become popular due to their distinctive sensory traits, rather than their nutritional profile (Arroyo et al., 2020). This highlights the potential of sensory-based marketing strategies for promoting fortified rice. If consumers associate biofortified or fortified rice with desirable sensory attributes, their adoption rates could rise significantly. Finally, differences in consumer preference between Java and Kalimantan suggest that one-size-fits-all approaches may be ineffective. In Java, strong traditions around culinary quality favor sensory-rich varieties (Gondal et al., 2021), whereas in Kalimantan, consumer choices are influenced more by community knowledge, nutritional awareness, and familiarity (Jeesan & Seo, 2020; Roni et al., 2021). Therefore, region-specific sensory studies are necessary to support effective public health interventions and marketing strategies.

In light of the gaps identified, this study aims to analyze the sensory quality and consumer acceptability of Banjarbaru-produced rice, including fortified and biofortified varieties. Using hedonic evaluation and statistical validation, the study investigates the extent to which Banjarbaru consumers accept fortified rice varieties such as Fortivit and Nutri Zinc, in comparison with a conventional variety, Inpari 32. By incorporating local sensory preferences and assessing nutrient retention post-cooking, this study seeks to provide evidence-based recommendations for promoting biofortified rice in South Kalimantan as part of broader anti-stunting efforts. The current study is important to examine the level of public acceptance of certain rice varieties. Hedonic evaluation and sensory attributes such as aroma, taste, texture, and color greatly determine consumer preferences for food products. Therefore, this study aims to analyze the sensory quality of Banjarbaru-produced rice comprehensively through a hedonic evaluation approach, sensory attributes, and normal distribution, in order to support the development of biofortified rice as a long-term nutritional solution. This study aims to analyze Banjarbaru-produced rice sensorily and statistically through hedonic evaluation, sensory attributes, and normal distribution tests to determine the level of consumer acceptance and sensory quality characteristics of rice.

METHOD

This study used a quantitative approach with a combination of experimental methods and descriptive statistical analysis. The main objective of this study was to evaluate the sensory quality of Banjarbaru rice through hedonic tests and sensory attributes. This study was conducted in Banjarbaru City, South Kalimantan, with a coverage area covering 5 sub-districts in Banjarbaru City. Sensory data collection was carried out through two types of tests: hedonic and sensory attribute tests. The hedonic test was conducted to determine the level of panelists' preference for rice samples produced from Banjarbaru rice. The hedonic test parameters include five main sensory attributes, namely color, aroma, taste, texture, and shape, using a Likert scale of 1-4 (Table 1). Specifically for the color and texture attributes, an additional scale was used to assess the level of whiteness (1 = less white to 4 = very white) and the level of softness (1 = hard to 4 = very soft). This hedonic test was conducted on 25 respondents with a milling degree of 95% and 100%, and one fortified rice (Fortivit).

Table 1. Categories of Rice Sensory Attribute

Sensory Attributes	Rating Scale	Rating Category
Color	1 – 4	1 (Strongly dislike); 2 (Dislike); 3 (Like); 4 (Very like)
	1 – 4	1 (Less white); 2 (Slightly white); 3 (White); 4 (Very white)
Aroma	1 – 4	1 (Strongly dislike); 2 (Dislike); 3 (Like); 4 (Very like)
Taste	1 – 4	1 (Strongly dislike); 2 (Dislike); 3 (Like); 4 (Very like)
Texture	1 – 4	1 (Sangat tidak suka); 2 (Tidak suka); 3 (Suka); 4 (Sangat suka)
	1 – 4	1 (Hard); 2 (Fairly hard); 3 = (Soft); 4 (Very soft)
Shape	1 – 4	1 (Strongly dislike); 2 (Dislike); 3 (Like); 4 (Very like)

This study also analyzed the micronutrient content, sensory evaluation, and consumer preferences for three types of rice, namely Nutri Zinc (biofortification), Fortivit (fortification), and Inpari 32 as a control. Analysis of micronutrient content, especially zinc (Zn), and proximate components was carried out in the laboratory by referring to validated standard analysis methods. The rice samples were first washed four times, by soaking in water, followed by gentle stirring, then the water was discarded. This process aims to simulate rice washing as is done in everyday household practices. After that, the cooking process was carried out with a rice and water ratio of 2:2.5 until the rice was ready to be tested. The purpose of this stage was to assess the impact of the washing and cooking processes on the loss of micronutrients, especially zinc, which is known to be sensitive to dissolution and degradation during thermal treatment. Hedonic and sensory attribute test data were statistically analyzed using one-way analysis of variance (ANOVA) with the Scheffe test to determine significant differences between treatments. The results of this statistical test were used to evaluate differences in consumer preferences and sensory quality between types of rice objectively and significantly.

RESULTS AND DISCUSSION

Analysis of Rice Content Produced by Banjarbaru City

Rice is a strategic food commodity because it is the staple food of most Indonesian people. Rice comes from rice grains which consist of two parts, namely the skin part called chaff and edible rice grains (caryopsis). The chaff part ranges from 18-28 percent of rice

(Juliano, 1972). Caryopsis or broken rice consists of 1-2 % pericarp, 4-6 % aleurone and testa, 2-3 % embryo and 89-94 % endosperm. The embryo consists of 0.26 % epiblast, 0.18 % coleorhiza, 0.34 % plumule, 0.18 % radicle, and 1.18-1.4 % scutellum. The method used to analyze the nutritional and micronutrient content of rice refers to the analysis method used by the laboratory.

The process of washing rice and cooking rice or cooking rice is included in the analysis of the effect of washing or cooking on Zn content. The rice washing process is carried out by soaking the rice in water in a container and stirring it slowly for a short time. The water is then discarded. The rice washing process is carried out four times. The rice cooking process is carried out with a ratio of rice to water of 2: 2.5. To cook 267 mL or 214 grams of rice requires 334 mL of water. Cooking 267 mL or 214 grams of rice will produce 400 grams of rice. The process of washing rice four times before cookingcommon in Indonesian households was shown to cause considerable nutrient losses. The test results data can be seen in Table 2.

Table 2. Zinc Loss During Washing and Cooking

Rice Type	Zn Loss during Washing (%)	Zn Loss during Cooking (%)	Total Loss (%)
Fortivit	9.1%	4.7%	13.8%
Nutri Zinc	17.2%	13.0%	30.2%
Inpari 32	11.6%	14.1%	25.7%

As illustrated in Table 2, average Zn losses during washing reached up to 17% for Nutri Zinc and 9% for Fortivit. Similar results have been documented by Shahriar et al. (2022) and Liu et al. (2018), who emphasized the vulnerability of surface-distributed micronutrients to water leaching. Cooking introduced additional losses. Fortivit showed the best resilience (86% retention), followed by Inpari 32 (74%), and Nutri Zinc (69%). These differences are attributed to the encapsulation of nutrients within Fortivit's extruded kernels versus the more diffuse nutrient location in Nutri Zinc (Losso et al., 2017; Jada et al., 2022).

Hedonic Test

A total of 25 respondents, who are people who often consume rice, underwent a hedonic rice test. Respondents were asked to try 3 types of rice namely fortivit, nutri zinc, and inpari 32, each with a milling level of 95 to 100 percent. Then the respondents assessed the sensory attributes of the sample rice including color, aroma, taste, texture and shape. The scale used to evaluate the rice from each type of grain ranged from 1 to 4, with criteria ranging from strongly dislike to strongly like. To avoid bias in the rice tasting process, respondents were asked to try the rice and immediately fill out the questionnaire. Results are summarized in Table 3.

Table 3. Mean Sensory Attribute Scores for All Rice Types

Rice Type	Color	Aroma	Taste	Texture	Shape
Fortivit	3.44	3.28	3.32	3.60	3.40
Nutri Zinc	2.88	3.00	2.96	3.04	3.00
Inpari 32	3.08	3.04	3.20	3.08	3.00

Fortivit consistently scored the highest across all attributes, particularly texture (mean = 3.60). This suggests that consumers prefer the softness and fragrance offered by Fortivit. This is due to the standardized grain size and flavor profile of Fortivit rice achieved through extrusion-based kernel engineering. (Mamoriska et al., 2022; Kim, 2020).

In contrast, the Nutri Zinc sample scored lower, especially at 100% milling level, where the average score for all attributes ranged from 2.88 to 3.04. This supports the findings of Woods et al. (2020), who noted that while biofortified rice was acceptable, its sensory appeal often lagged behind fortified rice. Inpari 32 was rated fairly good despite being familiar to consumers (average scores ranging from 3.00–3.20), reflecting a balance between sensory familiarity and blandness. Overall, the quality of all three types of rice in terms of sensory attributes was good, but consumer acceptance was higher fortified rice.

Based on the hedonic test result approach to various characteristics of rice, several key parameters have been evaluated to determine the quality and level of consumer acceptance. The overall color parameter of rice is the first visual indicator that influences consumer perception, where attractive and uniform colors are generally preferred. The level of whiteness of rice is also an important factor in the assessment, because rice with a bright and clean white color tends to get a higher preference value from the assessors. The taste aspect of rice is a crucial parameter that includes an evaluation of the natural taste of rice, the level of savoryness, and the presence or absence of unwanted foreign flavors. In terms of aroma, the assessment focuses on the natural fragrance of rice that can affect appetite, where the fragrant and distinctive aroma of fresh rice is preferred over a neutral or unpleasant aroma. The texture of rice is a parameter that determines physical quality, including an assessment of the level of elasticity, uniformity of grains, and sensation in the mouth when chewed. Meanwhile, the fluffiness of rice is a very important characteristic in determining the overall quality of rice, including an evaluation of the level of softness, elasticity, and ease of rice to be separated and eaten. All these parameters were assessed using a hedonic scale that allows panelists to provide ratings based on their level of liking, ranging from very dislike to very like, so that a comprehensive picture can be obtained regarding consumer acceptance of the rice samples tested.

Statistical Analysis

Next, to find out whether there are significant differences or not in the sensory attributes of the three types of rice, based on the assessments of 25 consumers, a parametric statistical test was carried out. The statistical analysis conducted was a statistical test with 1-way ANOVA. 1-way analysis of variance was used to determine the effect of cooking methods on the quality of 3 types of rice seen from their sensory attributes (Table 4).

Table 4. ANOVA Test Results Related to Sensory Attributes

Sensory Attributes	Rice Type	Mean Score	Sig. Anova
Color	Fortivit	3.44	
	NutriZinc	2.88	0.009
	Inpari 32	3.08	
Aroma	Fortivit	3.28	
	NutriZinc	3.00	0.282
	Inpari 32	3.04	
Taste	Fortivit	3.32	
	NutriZinc	2.96	0.162
	Inpari 32	3.20	
Texture	Fortivit	3.60	
	NutriZinc	3.04	0.000
	Inpari 32	3.08	
Shape	Fortivit	3.40	
	NutriZinc	3.00	0.030
	Inpari 32	3.00	

The results of the ANOVA test on the sensory attributes of three types of rice, namely Fortivit, NutriZinc, and Inpari 32, showed significant differences in several observed sensory aspects. The color attribute showed a significance value of 0.009 ($p < 0.05$), which indicated that there were significant differences between types of rice in terms of color perception. Fortivit obtained the highest score (3.44), followed by Inpari 32 (3.08) and NutriZinc (2.88), so it can be concluded that the color of Fortivit rice is preferred by respondents. In the aroma attribute, the analysis results showed no significant difference (p = 0.282), with relatively close average scores between the three types of rice, namely between 3.00 and 3.28. This shows that in terms of aroma, all types of rice are considered to have similar quality by respondents. The taste attribute also did not show any significant difference (p = 0.162), although Fortivit again obtained the highest average score (3.32) compared to Inpari 32 (3.20) and NutriZinc (2.96). This indicates that taste preferences between types of rice do not differ significantly in consumer perception. In contrast, the texture attribute showed a very low significance value (p = 0.000), indicating a very significant difference. Fortivit again excelled with the highest score of 3.60, while NutriZinc and Inpari 32 obtained lower and almost the same scores (3.04 and 3.08, respectively). This finding indicates that Fortivit has more preferred texture characteristics, possibly related to the level of softness or chewiness when consumed. The shape attribute also showed a significant difference (p = 0.030), where Fortivit obtained the highest score (3.40), while NutriZinc and Inpari 32 obtained the same value (3.00). This shows that, visually, the shape of Fortivit rice grains is considered more attractive or uniform by respondents.

Overall, Fortivit showed consistent superiority in attributes that had significant differences, namely color, texture, and shape. Meanwhile, for aroma and taste, although Fortivit also obtained the highest scores, the differences were not statistically significant. This finding indicates that consumer preferences are more influenced by visual and textural attributes, compared to aroma and taste, which are relatively similar between products. Therefore, to increase the competitiveness of biofortified rice products such as NutriZinc and Inpari 32, more attention is needed to develop more attractive visual and textural characteristics, to be able to compete with superior products such as Fortivit in the consumer market.

Micronutrient Retention Post-Processing

Zinc concentrations before and after cooking. Fortivit rice retained approximately 86.2% of its original Zn content, consistent with Wahengbam et al. (2019), who observed similar results for fortified low-amylose rice. In contrast, Nutri Zinc retained only 69.8%, aligning with findings from Kuong et al. (2016), which indicated higher micronutrient leaching in biofortified grains due to their reliance on intrinsic nutrient distribution rather than physical encapsulation.

This suggests that Fortivit's extrusion method offers protective advantages during washing and cooking, minimizing Zn leaching compared to the agronomic biofortification in Nutri Zinc, where nutrients are more exposed to degradation (Azam et al., 2021; Mannar & Gallego, 2002). The findings underline the important role of fortification techniques in ensuring the availability of nutrients at the point of consumption, as can be seen in Table 5.

Table 5. Zinc Content Before and After Cooking by Rice Type

Rice Type	Zn Before Cooking (mg/100g)	Zn After Cooking (mg/100g)	Retention (%)
Fortivit	0.55	0.47	86.2%
Nutri Zinc	0.51	0.36	69.8%
Inpari 32	0.39	0.29	74.3%

Rice fortification such as Fortivit rice, can not only restore and add a number of micronutrients that have been lost in the milling process but can also add new micronutrients. The micronutrients contained in Fortivit rice consist of 8 micronutrients, namely Vitamin B1, Vitamin B3, Vitamin B6, Vitamin B9, Zn and Fe. As a food that receives fortification treatment, the vitamin and mineral content of fortified rice will be higher than ordinary milled rice. In line with that, fortified rice can be enriched with various micronutrients, including vitamins B1 (thiamine), B3 (niacin), B6 (pyridoxine), B9 (folic acid), B12 (cobalamin), iron (Fe), and zinc (Zn). This fortification aims to increase the nutritional value of rice, especially in overcoming micronutrient deficiencies in the community (Deepa et al., 2023). Rice fortification can be a solution to overcome micronutrient deficiencies. Rice can be fortified with various micronutrients such as iron, zinc, calcium, selenium, iodine, and vitamins. This fortification has shown success in reducing micronutrient deficiencies (Saha & Roy, 2020).

Comparison of Micronutrient Content and the Effect of Washing and Cooking on Micronutrient Content of Rice

Fortified rice, such as Fortivit, plays a pivotal role in combating micronutrient deficiencies, particularly in regions where rice is a dietary staple. Fortivit rice is produced by blending fortified rice kernels (FRK) with milled rice at a 1:99 ratio, using a hot extrusion method. This technology enhances the stability of micronutrients, making the kernels more resistant to losses during washing and cooking compared to coating or dusting methods (Mannar & Callego, 2002). As consumers typically rinse rice multiple times and cook it using various methods, understanding the impact of these domestic practices on micronutrient retention is crucial.

Micronutrient retention during preparation is central to the effectiveness of rice fortification programs. The processes of washing and cooking can significantly reduce the levels of essential micronutrients particularly water-soluble vitamins and surface-applied minerals. While hot extrusion provides a protective matrix that encapsulates nutrients, other methods such as coating and dusting are less stable. Studies have shown that nutrients like iron, zinc, vitamin B12, and folic acid are particularly susceptible to leaching or degradation when rice is subjected to conventional household processing. Research by Jyrwa et al. (2020) demonstrated that while rinsing fortified rice can result in folic acid losses of up to 74%, cooking preserved up to 89% of vitamin B12. Similarly, Silveira et al. (2016) found that boiling and steaming, although they follow rinsing, resulted in minimal additional losses. These findings indicate that cooking can mitigate nutrient loss, especially when the fortified components are well-encapsulated, as in the case of Fortivit rice.

The retention of iron and zinc also depends on cooking practices. According to Azam et al. (2021), boiling rice in excess water followed by soaking can result in apparent retention rates exceeding 100% due to matrix breakdown and better mineral accessibility. Conversely, excessive washing enhances nutrient leaching. Thus, cooking methods that retain water or that use minimal water are generally more effective at preserving micronutrient content. Technological choices in fortification significantly influence nutrient outcomes. Fortified rice produced via extrusion technology has been repeatedly shown to retain nutrients better than rice treated with coating or dusting methods (Yogeshwari et al., 2018). The extrusion method binds micronutrients within a stable kernel structure, providing better protection during storage and cooking.

The impact of high-heat cooking methods such as frying can further degrade heat-sensitive vitamins like vitamin A, compromising the intended nutritional benefits. Thus, not only the fortification technique but also consumer cooking habits are essential to achieving desired public health outcomes. Washing rice, while culturally ingrained, has been shown to cause considerable nutrient loss. For instance, Lee et al. (2017) reported that up to 73.86% of vitamin C could be lost during cooking due to its solubility and thermal sensitivity, and Kuong et al. (2016) observed vitamin A losses reaching 80%. These results underline the need to educate consumers on optimal preparation techniques to preserve fortified nutrients. On a broader level, studies confirm that nutrient retention ranges from 75% to 100% depending on both the cooking method and the stability of the fortified components (Losso et al., 2017). For instance, steaming and microwave cooking tend to retain more water-soluble vitamins compared to boiling (Lee et al., 2019; Hummel et al., 2020). Thus, public education campaigns on appropriate cooking methods can significantly enhance the effectiveness of fortified rice consumption.

Further, Pinkaew et al. (2012) demonstrated that cooking techniques such as rice cookers versus open boiling have only minor effects on the retention of certain nutrients like vitamin A (13%–25% loss), indicating a robust preservation across standard practices. Moreover, intrinsic factors like phytic acid in rice can affect micronutrient bioavailability. Kumar et al. (2017) found that although milling reduces phytic acid, cooking still decreases the absorption potential of zinc and iron. Finally, innovations in edible coatings have shown promise in maintaining micronutrient levels during storage and cooking. Ahmed et al. (2015) illustrated that such coatings could enhance bioavailability, especially for iron and zinc, in fortified rice. These findings highlight the potential of advancing fortification technologies to optimize both retention and bioavailability of critical nutrients.

CONCLUSION

The study highlights that Fortivit rice, a fortified variety produced using hot extrusion technology, exhibits the most favorable combination of nutritional resilience and consumer sensory preference among the three rice types evaluated. It consistently received the highest scores in texture, color, and shape, and showed the lowest zinc loss (13.8%) during washing and cooking processes common in Indonesian households. This indicates that Fortivit is both nutritionally effective and organoleptically superior, making it a strong candidate for large-scale adoption to combat stunting in South Kalimantan. In contrast, while Nutri Zinc rice provides a valuable example of biofortification through agronomic means, it suffers greater zinc degradation (30.2%) during processing and ranks lower in sensory evaluation, especially in terms of texture and visual appeal. These deficiencies limit its potential acceptance and effectiveness in real-world settings.

The results also reaffirm the significant role of consumer perception in the success of food-based nutritional interventions. The hedonic evaluation revealed that sensory factors particularly texture, color, and grain shape play a more prominent role than taste and aroma in influencing consumer preferences. This insight is vital given the cultural importance of rice in Indonesia and suggests that any nutritional improvements must also align with consumer expectations and eating habits. Moreover, current adoption levels of biofortified rice in Kalimantan remain limited, primarily due to low awareness and unfamiliarity among consumers.

RECOMMENDATION

Fortivit’s superior sensory qualities particularly its soft texture, appealing color, and uniform shape combined with its high zinc retention during common cooking practices, make it an ideal candidate for integration into public nutrition programs. Raising public awareness about its health benefits and sensory appeal can significantly enhance consumer acceptance, particularly among households with young children. Expanding localized sensory studies is equally critical. Regional differences in rice preferences highlight the need for tailored approaches. Understanding consumer expectations regarding texture, aroma, taste, and appearance allows for more targeted development and marketing of biofortified rice varieties like Nutri Zinc. These studies can also help identify the factors limiting acceptance and inform improvements in breeding or processing techniques.

Effective consumer education must accompany these efforts. Public campaigns should clearly link fortified rice consumption to improved child health outcomes, particularly in terms of cognitive development and growth. Using culturally relevant messaging, education efforts can dispel misconceptions and increase familiarity with fortified products. Collaboration across sectors including public health, agriculture, education, and local governance is essential for scaling up fortified rice initiatives. Embedding fortified rice into school feeding programs and regional nutrition strategies can accelerate impact. Finally, continued innovation in biofortification methods is needed to enhance both nutrient retention and sensory appeal. This ensures biofortified varieties meet consumer preferences while delivering essential micronutrients, making them a sustainable solution for long-term nutritional improvement.

ACKNOWLEDGMENT

All author would like to extend my heartfelt gratitude to all individuals and institutions who have supported the completion of this study. Special thanks go to the respondents who generously took the time to participate in the sensory evaluations and provided invaluable feedback that enriched the research findings. Appreciation is also due to the research team, laboratory staff, and local agricultural authorities in Banjarbaru City for their collaboration, technical assistance, and logistical support throughout the research process. Your dedication and professionalism were instrumental in ensuring the smooth execution of this study.

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