CHARACTERISTICS OF SHRIMP PASTE WITH RED YEAST RICE AS A NATURAL COLORANT

KARAKTERISTIK TERASI UDANG DENGAN ANGKAK SEBAGAI PEWARNA ALAMI

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ABSTRACT

The use of synthetic dyes in food raises various health concerns, so the use of natural dyes as a substitute for synthetic dyes is a safer and more beneficial solution. One potential natural dye is red yeast rice produced by the fungus *Monascus* sp. This dye is not only safe but also improves the quality of food products. The research aims to determine the optimal concentration of red yeast rice as a coloring agent in the production of shrimp paste. The concentrations of red yeast rice tested include 0.5%, 1%, 1.5%, and 2%. Shrimp paste is made from fresh *Acetes* sp. shrimp and other shrimp heads with a ratio of 1:1, and is fermented for 20 days. The results showed that the addition of red yeast rice significantly affected the characteristics of shrimp paste, especially in improving color without changing the taste, aroma, and texture. The hedonic test identified that the addition of 2% red yeast rice produced the best product according to the panelists. Shrimp paste products with 2% red yeast rice meet the requirements of SNI 2716:2016 and are most preferred, with an average preference value of 3.27 for shrimp paste with red yeast rice powder and 3.67 for shrimp paste with red yeast rice extract.

Keywords: *Monascus* sp., natural dyes, red yeast rice, shrimp paste

ABSTRAK

Penggunaan pewarna sintetis dalam pangan menimbulkan berbagai kekhawatiran kesehatan, sehingga penggunaan pewarna alami sebagai pengganti pewarna sintetis merupakan solusi yang lebih aman dan bermanfaat. Salah satu pewarna alami yang potensial adalah angkak yang dihasilkan oleh kapang *Monascus* sp. Pewarna ini tidak hanya aman, tetapi juga meningkatkan kualitas produk pangan. Penelitian ini bertujuan untuk menentukan konsentrasi optimal angkak sebagai pewarna dalam pembuatan terasi. Konsentrasi angkak yang diuji meliputi 0,5%, 1%, 1,5% dan 2%. Terasi dibuat dari bahan baku rebon dan kepala udang segar dengan rasio 1:1 yang kemudian difermentasi selama 20 hari. Hasil penelitian menunjukkan bahwa penambahan angkak secara signifikan memengaruhi karakteristik terasi, terutama dalam meningkatkan warna tanpa mengubah rasa, aroma, dan tekstur. Uji hedonik mengidentifikasi bahwa penambahan 2% angkak menghasilkan produk terbaik menurut panelis. Produk terasi dengan 2% angkak memenuhi syarat SNI 2716:2016 dan paling disukai dengan nilai rata-rata kesukaan 3,27 untuk terasi dengan serbuk angkak, serta 3,67 untuk terasi dengan ekstrak angkak.

Kata kunci: angkak, *Monascus* sp., pewarna alami, terasi

INTRODUCTION

Indonesia is known as a maritime country because its territory consists of 70% ocean and 30% land. Indonesia is a country that is blessed with abundant natural resources, both biotic and abiotic (Chairunnisa *et al.* 2022). The vastness of Indonesian waters gives this country great potential in the marine and fisheries sector (Rahmawati and Marpaung 2023).

One of Indonesia's abundant marine and fisheries biological resources that has high economic value is shrimp. Shrimp remains a leading product of the Indonesian fisheries sector, which offers very promising business opportunities to this day (Rezki *et al.* 2014). Shrimp is an important basic ingredient in various food products because of its high nutritional content and good consumer acceptance. One of the most popular shrimp dishes is shrimp paste, which is often used as a spice in Indonesian cuisine (Fahlevi 2021).

Shrimp paste is one of the traditional foods as a seasoning made from fish, shrimp, or a mixture of both, which is added with salt as a preservative. This fermentation process not only enriches the taste and aroma of shrimp paste but also helps extend the shelf life of the product through natural preservation. This product plays an important role in Southeast Asian cuisine, namely providing a deep, distinctive taste to various traditional dishes (Permatasari *et al.* 2018).

Acetes sp. shrimp is the type of shrimp most often used as a basic ingredient in making shrimp paste. The use of *Acetes* sp. shrimp is not only because of its abundant availability *Panaeus meguiensis*, but also because it provides the desired distinctive taste and aroma in shrimp paste products. In addition to *Acetes* sp. shrimp, there are various species of shrimp from various families that live in freshwater and have high economic value and nutritional content. There are two main species, namely *Caridina nilotica* and *C. gracilirostris* from the Atyidae family. Meanwhile, from the Palaemonidae family, there are two commonly found species, namely *Macrobrachium equidens* and *Palaemon concincus*. From the Panaidae family, four species are recorded, namely *Panaeus monodon*, *Panaeus meguiensis*, *Panaeus joyneri*, and *Metapanaeus affinis*. Freshwater shrimp are also known to have a fairly high protein content, reaching 12.28%, making them one of the nutritious food sources that have the potential to be developed to meet the nutritional needs of the community.

Shrimp paste is generally used as a complementary seasoning in cooking because it has a distinctive and strong taste and aroma (Sumardianto *et al.* 2022). Hadi *et al.* (2019) emphasized that the aroma of shrimp paste is known to be very strong and sharp, providing unique characteristics that stand out in various dishes. In addition to the distinctive aroma and taste, color is also an important factor that attracts consumer interest. Original shrimp paste has a dark brown color that resembles the color of soil, which can make it less attractive to consumers (Permatasari *et al.* 2018). Shrimp paste, which is given red yeast rice coloring, can increase visual appeal and attract consumers' attention.

Red yeast rice is a red dye obtained from the fermentation of solid substrates in the form of rice by the mold *Monascus* sp. (Yuliana and Apriyani 2018). Red yeast rice, as a natural dye, has long been used in the food industry, especially in various countries in southern Asia and China (Yuliana *et al.* 2017). In addition to being a source of natural dyes derived from microorganisms, red yeast rice also has additional benefits, including as an anti-cholesterol drug. The natural dyes contained in red yeast rice can be an attractive option as a substitute for synthetic dyes in the process of making shrimp paste (Yuliana *et al.* 2020). Synthetic dyes such as rhodamine B and metanil yellow are often misused. Rhodamine B can cause liver dysfunction and is carcinogenic, while metanil yellow has the potential to cause kidney damage, gastrointestinal irritation, and other toxic effects if consumed continuously (BPOM 2012). Therefore, the use of natural dyes such as red yeast rice is a safer and more sustainable alternative for the traditional food industry.

Based on the information explained previously, this study used Acetes sp. shrimp and freshwater prawns of the giant prawn type (*Macrobranchium rosenbergii*) as the main ingredients in making shrimp paste. This study focuses on the use of red yeast rice as a natural dye in shrimp paste from *Acetes* sp. shrimp and freshwater prawns against the physical characteristics of both. This study aims to determine the optimal concentration of red yeast rice as a coloring agent in making shrimp paste.

METHODS

Materials

The materials needed for this study include freshwater prawn, salted *Acetes* sp. shrimp (CV Garam Jaya®), red yeast rice powder and extract (CV Herbalindo®), 96% ethanol (Brataco®), sterile distilled water (Ikapharmindo®), and Potato Dextrose Agar media (Oxoid®).

Equipment

Autoclave (Biobase® brand), Moisture Analyzer (B-One® brand), Incubator (B-One® brand), pH meter (Biobase® brand), Erlenmeyer flask (Pyrex® brand), Petri dish (Pyrex® brand), Colony Counter (Rocker Galaxy 230® brand), Rotary Evaporator (IKA® brand), water bath (B-One® brand), beaker (Pyrex® brand), analytical balance (Mettler Toledo® brand), plastic wrap, and aluminum foil.

Preparation of materials

The materials that are the focus of this study are freshwater prawns and *Acetes* sp. shrimp, which are obtained from the traditional market in Ciamis, West Java. In addition, red yeast rice powder produced from the fermentation of rice with *Monascus* sp. mold was also used. Every stage involving microorganisms must be carried out with aseptic procedures (Yuliana *et al.* 2020).

Making red yeast rice extract

Red yeast rice powder was extracted using the maceration method in 96% ethanol solvent. A total of 200 g of dried red yeast rice powder was placed in a macerator and then soaked in 2 L of 96% ethanol solvent. This maceration process was carried out for 3×24 hours (a total of 72 hours) with stirring occurring daily. Every 24 hours, the mixture was filtered through a Buchner funnel, and the remaining red yeast rice was subjected to two additional extractions with fresh solvent. The filtrate from the three maceration stages was then combined and subjected to evaporation using a rotary evaporator for 120 minutes to eliminate the solvent, resulting in a thicker, more concentrated red yeast rice extract. The maximum temperature was set at 50°C. This procedure continued until a slightly thick extract was achieved, after which it was further evaporated using a water bath until a thick red yeast rice extract was obtained.

Testing of nonspecific parameters of extracts

Determination of drying shrinkage

One gram of extract is placed in a crucible that has been heated for 30 minutes at 105°C until it reaches a stable weight. Furthermore, the extract attempts to get a constant weight at the specified determination temperature. After the drying process is complete, the crucible and its extract are stored in a desiccator to equilibrate a room temperature. The next step is to reweigh the crucible and its extract and record the weight obtained (Ministry of Health of the Republic of Indonesia 2000). The percentage of weight loss due to drying is calculated using a predetermined formula, as follows:

$$Drying\ shrinkage = \frac{A - B}{A} \times 100\%$$

Description
A = Weight before heating (g)
B = Weight after heating (g)

Determination of water content

Water content analysis was carried out using the azeotropic method, also known as toluene distillation. The toluene used was first saturated with water so that after the distillation process, the water and toluene layers would be separated. This method allows for accurate measurement of water content in the sample. A total of 5 g of extract was weighed and placed in a round-bottom flask filled with saturated toluene. The flask was then heated carefully. When the toluene began to boil, the heating process was continued to ensure that the extract was completely mixed with the toluene. The distillation rate was set to 2 drops/second, then increased to 4 drops/second. After the toluene had completely boiled away, heating was continued for 5 minutes. The flask was then cooled to room temperature. The volume of water was recorded after the toluene and water were completely separated. Water content analysis was carried out 3 times, and the percentage was calculated using the formula (Maryam *et al.* 2020).

$$Water\ content = \frac{A - B}{C} \times 100\%$$

Description:
A = Final volume (mL)
B = Initial volume (mL)
C = Extract weight (g)

Determination of total ash content

One gram of extract was weighed in a previously heated crucible and weighed carefully to ensure the accuracy of the measurement. The next step was to slowly heat the extract using a furnace until all carbonization residues were burned out. After the annealing process was complete, the extract was cooled in a desiccator to reach a stable temperature and then reweighed until a constant weight was achieved (Department of Health of the Republic of Indonesia 2000). The total ash content was calculated using a predetermined formula and expressed as a percentage of the sample weight.

$$Total\ ash\ content = \frac{Ash\ weight\ (g)}{Extract\ weight\ (g)} \times 100\%$$

Making red yeast rice paste

The production of shrimp paste follows the standard procedure outlined in SNI 2716:2016. Initially, *Acetes* sp. shrimp and freshwater prawn heads are washed in a 1:1 ratio, then dried for approximately five hours. Subsequently, any remaining impurities in the shrimp batch are removed, and the first refining stage begins with the addition of 15% salt and 50 mL of water, followed by a 12-hour fermentation to initiate the process. The next step involves a second grinding to obtain a smoother texture, after which the tejh mixture is stored for another 12 hours. This initial fermentation is marked by a change in aroma to a typical fermentation scent and a denser dough texture, similar to traditional fermentation methods (Hudayati *et al.* 2021). The third refining stage involves adding red fermented rice, both in powder and extract form, dissolved in water at varying concentrations for each dough batch, followed by molding. The concentration of red yeast rice added to the shrimp paste dough is 0.5, 1, 1.5, and 2%. The subsequent step is drying, where the molded shrimp paste dough is dried for one hour. In the final stage, the shrimp paste is wrapped in banana leaves and undergoes a 20-day fermentation period, which is crucial for developing its unique aroma and flavor (Hudayati *et al.* 2021; Ma'ruf *et al.* 2022).

Sample analysis

Organoleptic test

Organoleptic testing is an evaluation process using human senses to assess the sensory characteristics of a product. This method involves observing and assessing properties such as color, aroma, taste, and texture. The assessment was conducted in accordance with the SNI 2716:2016 standard for shrimp paste products. The organoleptic assessment score follows the score sheet that has been adjusted from the SNI and is developed based on the sensory evaluation guidelines used by the National Standardization Agency (BSN 2016).

Hedonic test

Hedonic testing, also known as satisfaction testing, is an evaluation method used to assess the level of satisfaction with a product. This approach is rooted in the results of previous research conducted by Ningtyas and Erwiyani (2023), which was then modified according to the needs of this study. The products to be tested were prepared in uniform quantities and conditions with a random code to avoid bias. The test was conducted by involving 30 untrained respondents who assessed the parameters of the shape, taste, color, and aroma of the product according to each respondent's preferences. Respondents were given simple instructions and were not allowed to communicate with each other during the test. Respondents tasted the samples one by one and gave a score for each attribute according to personal preference. Water and tissues were provided to neutralize the taste before tasting the next sample. The assessment data were collected in the form of a numeric score using a scale of 1-4, which was previously determined in Table 1.

pH test

The pH test was carried out on shrimp paste samples from freshwater prawn and *Acetes* sp. shrimp, referring to the method described in the study by Silvia *et al.* (2022). The testing process began by grinding each shrimp paste sample weighing 2 g, which was then mixed with distilled water until it reached a volume of 10 mL and stirred until homogeneous. The filtrate was then taken, and its pH value was measured using a pH meter. The endpoint of pH measurement was reached when the pH meter value showed constant stability.

Water content test

A two-gram sample of shrimp paste was placed in a prepared aluminum cup and then spread evenly over the entire surface of the cup. The device was then set at a temperature of 105°C to run the test, which would produce a water content value when the test was complete. The results of the water content values obtained will be compared with the provisions stipulated in the SNI 2716:2016 standard. The established standard states that the maximum amount of water content in dry solid block shrimp paste is 35%, while for dry powder and granular shrimp paste, it is 10%.

Microbial contamination

In the sample preparation stage, 10 g of the sample was finely ground and put into a 250 mL Erlenmeyer flask, and 90 mL of sterile distilled water was added. This mixture was then shaken until homogeneous to produce a 10^{-1} dilution. Furthermore, three tubes were prepared for the gradual dilution process. From the 10^{-1} dilution, 1 mL was put into the first tube and shaken until homogeneous to produce a 10^{-2} dilution. This procedure was repeated to obtain a 10^{-3} dilution, so that the sample was ready for further testing according to the established method (Department of Health of the Republic of Indonesia 2000).

Total plate count (TPC)

Samples from each dilution were pipetted as much as 1 mL into two sterile petri dishes (duplo), using a sterile pipette for each dilution. Each petri dish was then filled with 10 mL of sterile, diluted PDA media. The petri dishes were shaken slowly to ensure that the samples and media were homogeneous. Next, let the mixture of samples and media in the petri dishes harden. The petri dishes were placed upside down and covered with safety paper, then placed in an incubator at 36°C for 48 hours. Thereafter, record the growth of colonies in each petri dish after the incubation period. The calculation of the number of colony-forming units (CFU) per milliliter of the sample was done by multiplying the average number of colonies in each dish by the appropriate dilution factor (Department of Health of the Republic of Indonesia 2000).

Data analysis

Data were analyzed descriptively by comparing the results of each treatment on pH, water content, and microbial contamination parameters with SNI 2716:2016 standards and previous research results. Organoleptic and hedonic data were also analyzed descriptively based on the average panelist scores without inferential statistical tests, as was done in similar studies with initial exploratory designs.

RESULTS AND DISCUSSION

This study has passed the code of ethics test from the Health Research Ethics Commission of Bakti Tunas Husada University, Tasikmalaya, with Number 013-01/E.01/KEPK-BTH/II/2024. *Acetes* sp. shrimp and freshwater prawn used in this study were obtained from the traditional market of Ciamis Regency. Red yeast rice used as a natural dye in this shrimp paste is in the form of powder and extract.

Red yeast rice extract

From the initial weight of 2 kg of red yeast rice powder, 226.81 g of thick red yeast rice extract was obtained, and the yield of red yeast rice extract was 11.34%. The extraction results can be seen in Figure 1.

Table 1. Hedonic scales and numeric scales for assessing product satisfaction.

Hedonic Scale	Numeric Scale
Like	4
Just like it	3
Do not like it	2
Very disliked	1

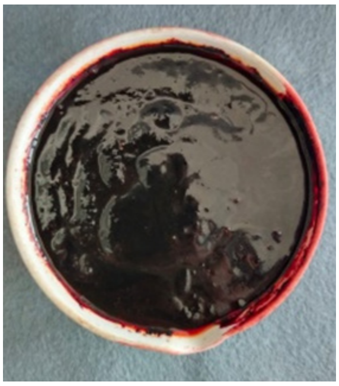

Figure 1. Results of thick red yeast rice extract as a natural dye for shrimp paste.

Nonspecific characteristic of extracts

The non-specific characterization process of red yeast rice extract involved examining drying loss, water content, and total ash content. Detailed results of this analysis are presented in Table 2.

The drying loss parameter measures the residual material after drying at 105°C for 30 minutes or until a constant weight is achieved, expressed as a percentage. The average drying loss was 0.352%, indicating the proportion of water and other compounds that evaporated during drying, which amounted to 0.352%. Ideally, the drying loss should be below 10%, as a high drying loss suggests a significant amount of water content is lost during the process (Maryam *et al*. 2020).

Water content measurement is an important step to assess the amount of water remaining after the concentration or drying process. The results of the measurement of the water content of the thick red yeast rice extract showed 16.65%. This figure meets the established quality standards, where the water content requirements in the concentrated extract are 5-30%. This control is crucial to maintaining the quality and safety of the resulting product (Voigt 1994; Utami *et al*. 2020). The next step is to test the total ash content. The measurement of total ash content aims to provide a comprehensive picture of the mineral content in a material. This measurement covers both internal and external aspects that occur during the extraction process, so that it can provide a comprehensive understanding of the contribution of minerals to the material. The purpose of this is to gain a comprehensive understanding of the extraction process being carried out. According to the 2023 Indonesian Herbal Pharmacopoeia (Department of Health of the Republic of Indonesia 2023), the ash content of the extract should not exceed 10.2%. The total ash content measured from the thick red yeast rice extract was 0.6464%. This figure confirms that the red yeast rice extract meets the established ash content standards. In general, higher ash content in a material reflects higher mineral content. In other words, the measured ash content value can be used as an indicator to determine the amount of minerals contained in the material (Ditjen POM 2000).

Table 2. Results of non-specific parameter analysis of red yeast rice extract.

No	Test Parameter	Results (%)	Average±SD
1	Drying loss	0.2713 0.3749 0.4101	0.3521±0.0721
2	Moisture content	19.975 14.989 14,985	16.65±2.8798
3	Drying loss	0.8497 0.4101 0.5794	0.6464±0.1760

Production of red yeast rice paste

In the formula with a concentration of 0%, namely as a negative control, which is not added with red yeast rice powder or extract. At each concentration of 0.5, 1.0, 1.5, and 2%, 0.5, 1.0, 1.5, and 2 g of red yeast rice powder and extract were added, respectively. In the mixing process, the red yeast rice powder and extract were dissolved using water solvent first to ensure that the color produced in the dough was evenly mixed. The stability of red yeast rice's color is the result of a complex interaction between several factors, such as temperature, heating duration, exposure to sunlight, oxidation, and pH level. The resulting color is influenced by the amount of color pigments contained in red yeast rice (Alsuhendra and Ridawati 2021). During the mixing process, each shrimp paste dough, with the addition of different red yeast rice concentrations, will produce a different shrimp paste dough color. The results of making red yeast rice paste products can be seen in Figure 2.

The use of red yeast rice in the process of making shrimp paste is not only to provide a more attractive color; the red yeast rice content can also act as an anti-cholesterol and antibacterial. Red yeast rice contains a compound called lovastatin, which can lower blood cholesterol in the body (Wahid *et al.* 2019). Lovastatin acts by increasing catabolism and inhibiting LDL synthesis, resulting in decreased LDL and total cholesterol levels and increased HDL levels. This compound, which is present in red yeast rice, is responsible for inhibiting the HMG-CoA reductase enzyme. In addition, *Monascu*s sp. can also trigger an increase in the number of platelets because the lovastatin content in *Monascus* sp. has the potential to oxidize low-density lipoprotein (LDL) and stimulate monocytes. Previous studies on experimental animals infected with the DEN-3 virus have shown an increase in the number of platelets after administration of *Monascus* sp. This shows the potential of Monascus sp. to increase the body's immune response (Wahid *et al.* 2019; Triyono 2020).

In addition, red yeast rice contains an active compound known as monascidin, which has antibacterial properties (Yuliana *et al.* 2017). This property adds value to red yeast rice as a natural dye because, in addition to providing color, red yeast rice can also contribute to the microbiological safety of food products. The presence of this compound provides added value to the potential use of red yeast rice in the context of antimicrobial activity. This is supported by Pakpahan and Dewi (2022), who stated that the addition of red yeast rice in making tempeh is also known to have an impact on increasing the antibacterial activity of the product against *Bacillus* sp. and *Escherichia coli.* The results of the study showed that red yeast rice extract with a concentration of 15% was able to produce an inhibition zone of 8.5 mm against *Bacillus* sp. and 10.2 mm against *Escherichia coli.* These findings prove that red yeast rice not only functions as a natural dye but also has the potential as an antimicrobial agent that can improve food safety. This shows that red yeast rice not only functions as a natural dye but can also improve food safety through its antibacterial properties.

Organoleptic examination

Based on SNI 2716:2016, the organoleptic parameters required for shrimp paste products are normal color, normal taste, non-rancid aroma, and texture in the form of paste, solid block dry shrimp paste, or powder and granular dry shrimp paste. The results of the organoleptic examination carried out can be seen in Table 3.

(a) (b) (c) (d) (e)

Figure 2. Shrimp paste products using red yeast rice extract with various concentration variations: (a) 0% concentration, (b) 0.5% concentration, (c) 1% concentration, (d) 1.5% concentration, and (e) 2% concentration.

Table 3. Results of organoleptic examination of shrimp paste using red yeast rice extract.

Organoleptic Properties	0%	0.5%	1%	1.5%	2%
Color	Brownish	Brownish, slightly pink	Reddish, slightly brown	Slightly red	Reddish
Taste	Symptoms of shrimp paste, slightly bitter	Symptom of shrimp paste, slightly bitter	Typical of shrimp paste	Specialty of shrimp paste	Typical of shrimp paste, slightly sweet
Aroma	Symptoms of shrimp paste	Symptoms of shrimp paste	Typical of shrimp paste	Specialty of shrimp paste	Typical of shrimp paste
Texture	Dry, smooth	Dry, smooth	Dry, smooth	Dry, smooth	Dry, smooth

Shrimp paste enriched with red yeast rice has highly recommended advantages. One of them is better color stability. In this context, the resulting pigment can dissolve in water and can be mixed with other pigments homogeneously. This shows the flexibility in the use of these pigments in various applications, including in the food production process. In addition, this product is also considered safe for consumption (Pamungkas *et al.* 2022).

Hedonic test

In testing this red yeast rice paste, there are four levels of preference used to assess the product, namely like, quite like, dislike, and dislike very much. The panelists involved in this study were students of Bakti Tunas Husada University, with a total of 15 semi-trained panelists aged between 20 and 30 years (Kariawan and Pastini 2023).

Analysis using the Duncan test showed several formulas that were most preferred based on the assessment of each parameter. In terms of color and taste, the most popular shrimp paste was the one containing a concentration of red yeast rice of 2%. Meanwhile, in terms of texture, the shrimp paste treated as a control (0%) was the most preferred. Meanwhile, based on aroma, all shrimp pastes had the same aroma. The results of the average value of the hedonic test can be seen in Figure 3.

The test results showed that the red yeast rice paste that was most preferred by the panelists was the one containing red yeast rice extract, showing the highest preference of all the samples tested. This could be because the color produced by the red yeast rice extract is more concentrated, thus providing more appeal to the panelists. The color pigment of the red yeast rice extract is quite stable compared to red yeast rice, which is still in powder form. An additional advantage of the red yeast rice pigment is its ability not to affect physiological functions or the body's immune system. In addition, red yeast rice pigment does not contain toxins, so it is safe for consumption (Puspita *et al.* 2023; Salman *et al.* 2023).

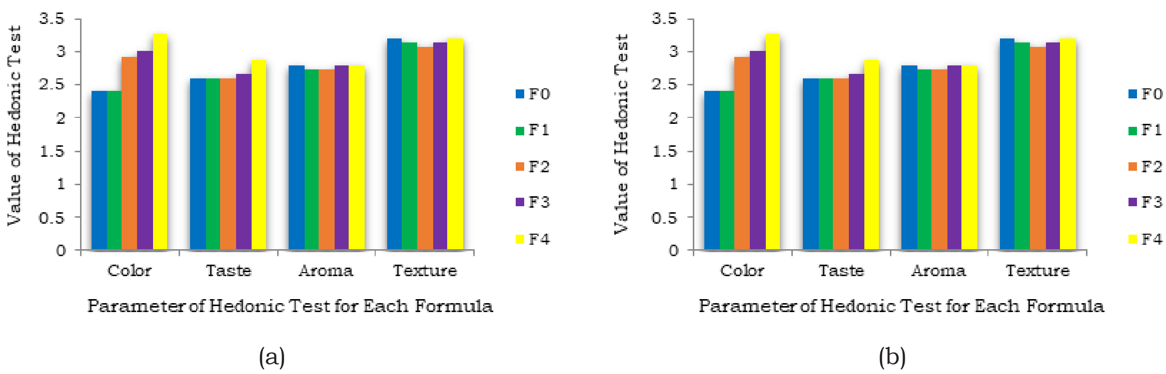

Figure 3. The average value of the hedonic test of Acetes sp. shrimp paste: (a) sample of shrimp paste + red yeast rice powder; (b) sample of shrimp paste + red yeast rice extract (concentrations for red yeast rice extract and powder, respectively: F0 0%, F1 0.5%, F2 1%, F3 1.5%, F4 2%).

pH value

The red pigment from red yeast rice extract is more stable in neutral conditions than in acidic conditions. A relatively low pH value will damage the chromophore group, so the lower the pH value, the greater the loss of color. In addition, at low pH conditions, bacterial growth can be inhibited and even cause damage and loss of vitality (Rizal and Nurainy 2022). The results of the pH test of red yeast rice paste products can be seen in Table 4.

Based on the results of the pH test that was carried out, it was found that the pH range obtained was in the range of 7.91 to 6.36. These results confirm that the shrimp paste produced from various treatments has neutral properties. Based on the results of the initial pH measurements of red yeast rice which ranged from 7.00 to 6.5, it explains that the results of this study are in line with previous studies conducted by Sumardianto *et al.* (2022), which noted that the pH of shrimp paste produced with natural dyes from purple sweet potatoes tends to be neutral, with a pH ranging from 7.80 to 7.35. This finding is supported by the results of a study conducted by Rumondor *et al.* (2018), which concluded that increasing the concentration of red yeast rice in the shrimp paste-making process is related to changes in pH to the neutral range. Meanwhile, research by Permatasari *et al.* (2018) shows that the addition of natural dyes derived from dragon fruit skin extract gives significant results to shrimp paste, which causes pH fluctuations ranging from 6.40 to 7.20. Similarly, Hudayati *et al.* (2021) also observed pH variations in mackerel shrimp paste enriched with red beet powder, with the highest value reaching 6.76 and the lowest 6.46.

Water content test

SNI 2761:2016 stipulates that the maximum water content allowed for dried shrimp paste products is 10%. The water content in food products has a direct impact on the durability of the product. Changes in water content can be a key factor affecting the quality of food products, so measuring water content is important to ensure the quality and safety of the resulting product.

Based on the results obtained from various samples of red yeast rice paste powder with varying concentrations of red yeast rice, the water content values ranged from 4.14 to 9.65%. This value is still below the maximum water content limit for powdered shrimp paste permitted by SNI 2761:2016. The use of higher red yeast rice concentrations tends to increase the water content in shrimp paste. This study is in line with the findings of Sumardianto *et al.* (2022), which link increased water content to increased concentrations of natural dyes from purple sweet potato extract in making shrimp paste. The presence of high water content can trigger product damage, such as reduced shelf life and physical changes to the product (Amelia *et al.* 2023).

Total plate count (TPC)

Total plate count (TPC) testing is a method for measuring the number of aerobic mesophilic bacteria that have the potential to contaminate various types of products, including food, beverages, traditional medicines, and cosmetics. Although TPL is generally not directly related to food safety risks, it is often useful in assessing quality, shelf life, contamination levels, and hygienic conditions during the production process, as well as the safety of the product (BPOM 2012).

Table 4. Effect of adding red yeast rice powder and extract on the pH of shrimp paste with various concentrations.

Concentration (%)	Shrimp Paste + Red Yeast Powder		Shrimp Paste + Red Yeast Extract	
	Head Powder	*Acetes* sp. Powder	Head Powder	*Acetes* sp. Powder
0	7.50±0.05	7.53±0.04	7.50±0.05	7.53±0.04
0.5	7.03±0.03	7.91±0.06	7.83±0.02	7.68±0.05
1	6.76±0.04	7.61±0.03	7.74±0.04	7.63±0.02
1.5	6.81±0.02	7.29±0.05	7.55±0.03	7.41±0.03
2	6.36±0.06	7.53±0.04	7.42±0.03	7.28±0.02

The concept of food safety itself refers to the efforts needed to prevent food products from possible contamination by biological, chemical, or physical materials that have the potential to harm or even endanger human health, including a series of strict protection and supervision measures (Regulation of the Head of the Food and Drug Supervisory Agency 2012). Based on the results of the tests carried out, the results of a number of colonies of all red yeast rice paste products were obtained, which can be seen in Tables 5 and 6. The results of the calculation of the total number of colonies from both freshwater prawn paste and *Acetes* sp. shrimp added with red yeast rice extract and powder with various concentration variations showed numbers in the range of 3×10^3 or less, so that overall, the results obtained showed that red yeast rice paste showed a quality that produced satisfactory products and met the standards set by SNI 2716:2016. The maximum limit of microbial contamination set by SNI 2716:2016 and BPOM (2019) is $<2\times10^5$ CFU/mL (BSN 2016; BPOM 2019).

Research conducted by Hestiani *et al.* (2019) reported that during the fermentation period of anchovy paste for 21 days, there was an increase in the total number of microbes, ranging from 3×10^7 CFU/mL to 2.64×10^{11} CFU/mL. Meanwhile, a study conducted by Hudayati *et al.* (2021) on the total plate count in mackerel shrimp paste with the addition of red beet powder recorded a figure of around 5.7×10^6 CFU/mL for treatment A, 6.8×10^6 CFU/mL for treatment B, 6.4×10^6 CFU/mL for treatment C, and 5.6×10^6 CFU/mL for treatment D. These results support this study, which shows that the addition of natural dyes to shrimp paste does not have a significant impact on the increase in the total number of microbes.

CONCLUSION

The addition of red yeast rice as a natural dye in red yeast rice paste can affect the characteristics of the shrimp paste. The higher the concentration of red yeast rice added, the lower the pH produced by the shrimp paste tends to be, while the water content is higher. The total plate count for microbial contamination complies with the standard, being less than 2×10^5 CFU/mL. The optimal concentration of red yeast rice that meets the requirements of SNI 2716:2016 is 2%. Based on hedonic testing, products with a 2% concentration of red yeast rice are the most in-demand, with an average preference value of 3.27 for shrimp paste with red yeast rice powder and 3.67 for shrimp paste with red yeast rice extract. The resulting shrimp paste has met the criteria set by SNI 2716:2016.

Table 5. Total number of colonies of red yeast rice paste of shrimp.

Concentration (%)	Total Plate Count (CFU/mL)		Note
	Shrimp Paste + Powder	Shrimp Paste + Powder	
0	$<30\times10^{-2}$	$<30\times10^{-2}$	Qualify
0.5	$<30\times10^{-2}$	3×10^3	Qualify
1	$<30\times10^{-2}$	3×10^3	Qualify
1.5	$<30\times10^{-2}$	3×10^3	Qualify
2	3×10^3	$<30\times10^{-2}$	Qualify

Table 6. Total number of colonies of red yeast rice of *Acetes* sp. shrimp.

Concentration (%)	Total plate count (CFU/mL)		Note
	Shrimp Paste + Powder	Shrimp Paste + Powder	
0	$<30\times10^{-2}$	$<30\times10^{-2}$	Qualify
0.5	$<30\times10^{-2}$	$<30\times10^{-2}$	Qualify
1	3×10^3	$<30\times10^{-2}$	Qualify
1.5	3×10^3	$<30\times10^{-2}$	Qualify
2	4×10^3	$<30\times10^{-2}$	Qualify

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