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# Sensory Quality of Fresh Noodles with Pandan Leaf Extract as a Natural Colorant

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**Abstract**

Fresh noodles are widely consumed food products; however, their production commonly involves synthetic additives, including artificial colorants, which may pose potential health risks. Therefore, natural ingredients are needed as safer alternatives, one of which is pandan leaf extract, known for its natural green color and distinctive aroma. This study aimed to analyze the effect of pandan leaf extract substitution on the sensory quality of fresh noodles, including color, aroma, texture, resistance to breakage, and taste. An experimental method was applied using two treatments: 150 mL of water as the control treatment ($X_1$) and 150 mL of pandan leaf extract as the substitution treatment ($X_2$). Organoleptic evaluation was conducted by 30 panelists using a sensory assessment scale covering color, aroma, texture, and taste attributes. The collected data were analyzed using a pooled variance t-test, also referred to as an independent samples t-test, with SPSS version 22. The findings indicate that pandan leaf extract substitution had a significant effect on all sensory attributes of fresh noodles. Treatment $X_2$ obtained the highest mean scores across all assessed parameters, including color (5.36; light green), aroma (5.70; highly fragrant), chewy texture (5.17), resistance to breakage (5.00), and taste (5.04; savory). These results demonstrate that pandan leaf

extract can improve the sensory quality of fresh noodles while functioning as a natural colorant and aroma-enhancing ingredient. The study concludes that substituting 150 mL of pandan leaf extract produces better overall sensory quality in fresh noodles and may support the development of food products using natural ingredients.

**Keywords:** Fresh Noodles; Pandan Leaf Extract; Sensory Quality; Hedonic Test; Natural Colorant

## INTRODUCTION

Noodles are one of the foods that are in great demand by Indonesian people of various ages, the high consumption of noodles in Indonesia reaches 14.54 billion servings per year or around 12% of consumption Fahira, Putri, & Taufhan (2024); N. Fitri, Putri, Rahayu, Setyaning, & Zuhri (2023), encourages an increase in product innovation, especially in fresh noodles that have softer texture characteristics and are preferred by the public. However, fresh noodles have a main disadvantage in the form of a relatively short shelf life due to high moisture content, making them susceptible to the growth of microorganisms and decreased sensory qualities such as color, scent, and texture (Fitri & Siregar, 2024; Kurnia, 2021). This problem does not only occur in Indonesia, but also becomes a global issue in the development of cereal-based fresh food products that are safe, quality, and have high sensory appeal (Putri, 2024; Selvianti & Hastuti, 2021; Susanto, Karningsih, Susanto, Suef, & Karningsih, 2023).

In industrial practice, efforts to maintain the quality of fresh noodles are often done through the use of synthetic additives, such as dyes and preservatives. Synthetic dyes such as tartrazin and sunset yellow are considered effective in increasing visual appeal, but have the potential to have negative health impacts, including allergic reactions and hyperactivity in children (Sahid, 2023; Yani et al., 2022). As consumer awareness of food safety increases, the use of synthetic materials is starting to be abandoned and switched to natural materials that are safer and more environmentally friendly (Anggrahini, 2022; Kusnadi, 2021). Therefore, an innovative alternative based on natural ingredients is needed that not only functions as a dye, but is also able to improve overall sensory quality.

One potential natural ingredient is pandan leaves (*Pandanus amaryllifolius Roxb*), which has long been used in traditional Indonesian culinary as a natural coloring and scent

provider (Sa'diah, 2025). Pandan leaf extract contains the compound 2-acetyl-1-pyrroline as the main component of scent as well as chlorophyll as a natural green pigment (Nurfadhila et al., 2023; Parsih, 2021). In addition, the content of flavonoids and essential oils has antioxidant and antimicrobial activities that have the potential to improve the quality and shelf life of food products (Hutagaol, 2022; Rozi, 2024). However, according to (Wijayanti, 2024), low chlorophyll stability to heat, light, and pH is a challenge in its application to processed products, so the right formulation is needed so as not to reduce product quality.

Previous research has shown that the use of pandan leaves is more widely applied to beverage products, traditional cakes, and non-gluten products, which have been proven to be able to increase the attractiveness of colors and scent (Nuralfiana, 2024; Wijayanti, 2024). However, studies on the use of pandan leaf extract in wheat flour-based products such as fresh noodles are still limited. This shows a research gap, because the interaction between the active compounds in pandan leaves and the gluten structure in noodle dough has the potential to affect the texture characteristics, elasticity, and acceptance of food consumers (Wijayanti, 2025; Wijayanti, 2023). In addition, previous research has tended to focus on just one sensory attribute, without comprehensively examining its effect on overall sensory quality. Thus, this research occupies a position as a study development that integrates aspects of color, aroma, taste, and texture in one integrated analysis.

Based on these problems, this study focuses on the analysis of the effect of 150 ml of pandan leaf extract substitution on the sensory quality of wet noodles which includes color, scent, texture, and taste. In this study, the hypothesis proposed is that there is no effect of 150 ml of pandan leaf extract substitution on the sensory quality of fresh noodles ($H_0$), while the alternative hypothesis states that there is a significant effect on the color, scent, texture, and taste of fresh noodles ($H_a$). Thus, this research is expected to make a scientific contribution to the development of fresh noodle innovation based on natural ingredients as a safer, more functional, and sustainable alternative.

## METHODS

This study uses a quantitative experimental approach with a true experimental design through a Complete Random Design (RAL) which aims to analyze the effect of the addition of pandan leaf extract on the sensory quality of fresh noodles. The treatment applied consisted of two groups, namely without the addition of pandan leaf extract ($X_0$) as

a control and the addition of 150 ml ($X_1$) of pandan leaf extract as a treatment, with each treatment being carried out three times. The observed parameters include the sensory aspects of fresh noodles, namely color, aroma, texture, and taste. Sensory testing was carried out using a hedonic test to determine the level of preference of panelists on a scale of 1–7, ranging from very dislike to very much like Manuhutu (2019), involving 30 untrained panelists who were selected based on good health conditions, did not have food allergies, and had normal taste and smell functions.

**Tools and Materials**

This research uses various equipment and materials that are tailored to the needs of making fresh noodles and the pandan leaf extraction process. The equipment used includes a digital scale to accurately measure ingredients, a blender to crush pandan leaves, a *mixing bowl*, a noodle *maker*, a gas stove, *a stainless steel* pot, a measuring cup, a fine cloth strainer, and *a food-grade* plastic container as a storage place. Meanwhile, the ingredients used consist of high-protein wheat flour, chicken eggs, salt, vegetable oil, water, and fresh pandan leaves. Pandan leaf extract is obtained through the stages of washing, cutting, then crushing using a blender with a ratio of pandan leaves and water of 2,5 :1, then filtered using a fine cloth until a filtrate is obtained. The composition of ingredients in the manufacture of fresh noodles with the substitution of pandan leaf extract in detail can be seen in Table 1.

**Table 1. Composition of Ingredients for Making Fresh Noodles with Pandan Leaf Extract Substitution**

| No | Ingredients | $X_0$ (0 ml) | $X_1$ (150 ml) |
|---|---|---|---|
| 1 | Wheat flour | 500 g | 500 g |
| 2 | Eggs | 50 g | 50 g |
| 3 | Salt | 10 g | 10 g |
| 4 | Water | 150 ml | 0 ml |
| 5 | Vegetable oil | 20 ml | 20 ml |
| 6 | Pandan leaf extract | 0 ml | 150 ml |

Description:

$X_0$ = control (without the addition of pandan leaf extract)

$X_1$ = Addition of pandan leaf extract by 150 ml

**Research Implementation**

How to make fresh noodles with pandan leaf extract substitution is as follows.

1. The initial stage of research begins with cleaning all tools and materials to maintain hygiene during the processing process.

2. Pandan leaves are washed clean, then cut into small pieces to facilitate the processing process.

3. Pandan leaves that have been cut into small pieces are mashed using a blender with the addition of water (ratio 2.5:1) until smooth.

4. The blender results are filtered using a filter cloth to separate the pulp and pandan leaf extract is obtained.

5. Wheat flour (500 g), eggs (50 g), and salt (10 g) are put in a mixing bowl, then mixed until homogeneous.

6. Water (for control) or pandan leaf extract (for treatment) is added little by little while the dough is kneaded until well mixed and forming a dough.

7. Vegetable oil (20 ml) is added to the dough, then kneaded again until smooth and homogeneous.

8. The dough is ground using a noodle grinder until it reaches the desired thickness, then molded into noodle strips.

9. The noodles are boiled in boiling water for ±1–3 minutes until cooked, then removed and drained.

10. The cooked noodles are cooled at room temperature (±28°C). If not tested immediately, the sample is stored in a sealed container at a cold temperature (±4°C).

11. The resulting fresh noodles are then used for sensory quality testing which includes color, aroma, texture, and taste.

The stages or procedures for producing wet noodles with pandan leaf extract substitution are illustrated in the research process diagram shown in Figure 1.

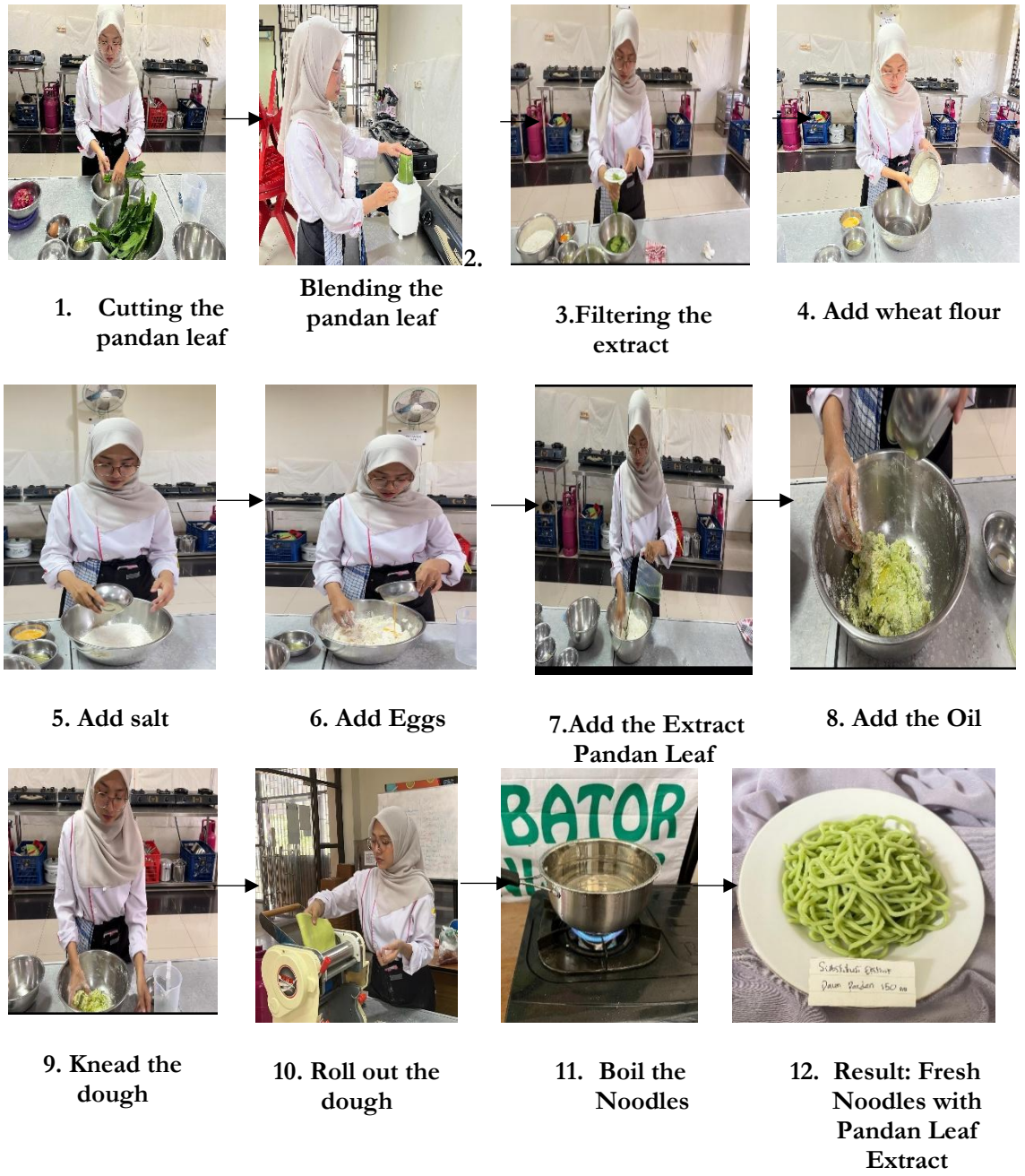


**Figure 1. Research Stage Process of the Effect of Pandan Leaf Extract Substitution on the Sensory Quality of Fresh Noodles**

## Observational Design

This study was compiled using Complete Random Design (RAL) which consisted of two treatments, each carried out three times, and involved 30 panelists in each treatment to assess the sensory quality of the product. The parameters observed include color, scent,

texture, and taste as indicators of the quality of fresh noodles with the addition of pandan leaf extract. The observation design used in this study can be seen in detail in Table 2.

**Table 2. Fresh Noodle Observation Design with Pandan Leaf Extract Substitution**

| Treatment | Color ($Y_1$) | Scent ($Y_2$) | Texture ($Y_3$) | Taste ($Y_4$) | Panelists | Detestation |
|---|---|---|---|---|---|---|
| $X_0$ | $X_0Y_1$ | $X_0Y_2$ | $X_0Y_3$ | $X_0Y_4$ | 30 | 3 |
| $X_1$ | $X_1Y_1$ | $X_1Y_2$ | $X_1Y_3$ | $X_1Y_4$ | 30 | 3 |

Description:

$X_0$ = without the addition of pandan leaf extract (control)

$X_1$ = Addition of pandan leaf extract by 150 ml

$Y_1$ = Color, $Y_2$ = Scent, $Y_3$ = Texture, $Y_4$ = Taste

### Data Analysis

The data obtained from the hedonic test was first compiled in the form of a table, then analyzed using *an independent sample t-test* with the help of SPSS software version 22. Before hypothesis testing, the data is tested first through normality and homogeneity tests as a prerequisite in parametric analysis. Hypothesis testing was performed at a significance level of 5% ($\alpha = 0.05$).

The zero hypothesis ($H_0$) states that the substitution of pandan leaf extract has no effect on the sensory quality of fresh noodles which includes color, scent, texture, and taste, while the alternative hypothesis ($H_1$) states that there is a significant influence on these four aspects. The basis for decision-making is that $H_0$ is rejected if the significance value (Sig.) is less than 0.05 or the value |t calculated| is greater than the t table, which indicates that the treatment has a significant effect on the sensory quality of fresh noodles.

## RESULTS

### Organoleptic Test

Based on the results of the study, the organoleptic evaluation of fresh noodles with pandan leaf extract substitution includes several quality indicators, namely, color, scent, chewy texture, texture that does not break easily, and taste. Data were obtained through three repetitions for each of the two treatments, namely, treatment using 150 ml of water

and 150 ml of pandan leaf extract substitution treatment. The results of the visual quality observation of wet noodles are presented in Figure 2.

**Substitution Without Pandan Leaf Extract 150 ml**

**Pandan Leaf Extract Substitution 150 ml**

**Figure 2. Visual Comparison of Fresh Noodles Without Substitution and with Pandan Leaf Extract Substitution 150 ml**

Visually, noodles without substitutions are yellowish-white, while noodles with pandan leaf extract are lighter green in color. The shape of both is the same, but the substituted noodles look fresher, thus increasing the visual appeal of the product.

Based on the results, the mean quality of fresh noodles with pandan leaf extract substitution is illustrated in the radar chart presented in Figure 3.

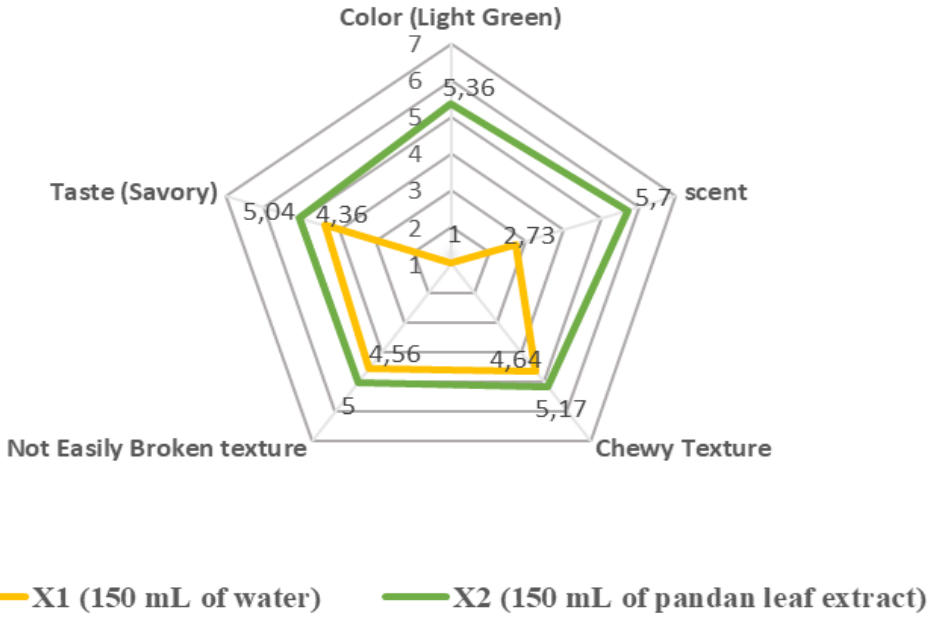


**Figure 3. Sensory Radar Graph of Fresh Noodles Pandan Leaf Extract Substitution**

Based on the results presented in Figur 3, it is known that the average sensory assessment score on the quality of fresh noodles shows a difference in each treatment. The X1 (using 150 ml of water) and X2 (150 ml of pandan leaf extract substitution) treatments gave varying results on each parameter. The highest overall average score was obtained at the X2 treatment. In terms of color, the X2 treatment obtained an average score of 5.36 which was included in the light green category and showed a more attractive appearance than the control treatment. In terms of scent, the X2 treatment also showed the highest value of 5.70 which is classified as very fragrant typical of pandan leaves. For chewy textures, the X2 treatment obtained a score of 5.17 which was categorized as chewy, while for the texture that did not break easily, a value of 5.00 was obtained, which showed that the noodles did not break easily. Meanwhile, in terms of taste, the X2 treatment obtained an average score of 5.04 which is included in the savory category. Thus, the substitution of pandan leaf extract as much as 150 mL has a positive effect on improving the sensory quality of fresh noodles.

**Data Description Difference in Sensory Quality of Fresh Noodles Using Water 150 ml and Pandan Leaf Extract Substitution 150 ml**

Based on the results of the analysis of organoleptic test data on fresh noodles with the use of 150 ml ($X_1$) water and fresh noodles with 150 ml ($X_2$) substitution of pandan leaf extract, the data were presented in the form of average values to compare sensory qualities which included color, scent, chewy texture, non-breakable texture, and taste. The difference in mean values between the two treatments showed a variation in sensory quality in each of the parameters observed in figure 3 of the radar graph. Radar graphs are used to provide a comprehensive visual representation of the difference in the mean values of each sensory parameter between the two treatments.

**1. Color (Light Green)**

Based on the radar graph on the color parameters, it can be seen that the analysis results show that the average color value in fresh noodles with 150 ml ($X_1$) of water is 1.00, while in fresh noodles with 150 ml ($X_2$) of pandan leaf extract substitution is 5.36. This shows that fresh noodles without pandan leaf extract do not have a light green color, while the substitution of pandan leaf extract results in a pronounced light green color on the product.

**2. Scent**

In the aroma parameters, the average aroma value in fresh noodles with 150 ml ($X_1$) of water was 2.73 which indicated a somewhat fragrant category, while in the substitution treatment of 150 ml ($X_2$) pandan leaf extract substitution, an average value of 5.70 was obtained which was included in the category of very fragrant with a typical aroma of pandan leaves. This shows that the addition of pandan leaf extract improves the quality of the scent of fresh noodles.

**3. Chewy Texture**

Based on the radar graph of chewy texture parameters, the average value of chewy texture in fresh noodles with 150 ml ($X_1$) of water was 4.64, while in fresh noodles with 150 ml ($X_2$) pandan leaf extract substitution was 5.17. Both treatments are included in the chewy category, but the value of the treatment with pandan leaf extract is higher, so it shows increased suppleness.

**4. Texture Doesn't Break Easily**

The results on the radar graph showed that the average value in fresh noodles with 150 ml ($X_1$) of water was 4.56 and in the substitution treatment of 150 ml ($X_2$) of pandan leaf extract was 5.00. Both treatments are in the category of not easy to break, but the treatment with pandan leaf extract shows a higher value.

**5. Taste (Savory)**

Based on the radar graph, the average taste value of fresh noodles with 150 ml ($X_1$) of water is 4.36 which is classified as quite savory, while fresh noodles with a substitution of 150 ml ($X_2$) pandan leaf extract are 5.04 which is included in the savory category. This shows that the addition of pandan leaf extract provides an increase in the taste of fresh noodles.

Overall, the shape of the radar graph area showed that the pandan leaf extract substitution treatment of 150 ml ($X_2$) had a larger area compared to the treatment without substitution or using water ($X_1$). This shows that the substitution of pandan leaf extract provides a comprehensive improvement in the sensory quality of fresh noodles on all observed parameters, namely color, scent, chewy texture, non-breakable texture, and taste.

## Hypothesis Testing

Hypothesis tests were carried out to determine whether there was a difference in sensory quality which included color, scent, chewy texture, texture that does not break easily, and taste between fresh noodles using 150 ml ($X_1$) water and fresh noodles with 150 ml ($X_2$) pandan leaf extract substitution. Based on the data analysis, the results of the comparison of the mean values of each treatment are presented in the summary of t-test statistics in table 3 below.

**Table 3. Summary of Statistics of t-Tests on the Quality of Fresh Noodles**

| No | Sensory Quality | $X_1$ | $X_2$ | df | t count | t table | Sig. |
|---|---|---|---|---|---|---|---|
| 1 | Color (light green) | 1,00 | 5,36 | 58 | -64,168 | 2,00172 | 0,05 |
| 2 | Scent | 2,73 | 5,70 | 58 | -14,821 | 2,00172 | 0,05 |
| 3 | Chewy Texture | 4,64 | 5,17 | 58 | -3,377 | 2,00172 | 0,05 |
| 4 | Texture Doesn't Break Easily | 4,56 | 5,00 | 58 | -2,832 | 2,00172 | 0,05 |
| 5 | Taste (Savory) | 4,36 | 5,04 | 58 | -4,761 | 2,00172 | 0,05 |

Based on Table 3, decision making in the hypothesis test is carried out by comparing the *value of t calculated* with *the t table*. The criteria used are if |t count| is smaller than *t table* then $H_0$ is accepted and $H_1$ is rejected, while if |t calculates| is greater than *t table* then $H_0$ is rejected and $H_1$ is accepted. In addition, the difference between treatments can also be seen from the significance value, where the value of sig. greater than 0.05 indicates no significant difference, while the value of sig. smaller than 0.05 indicates a significant difference (Sugiyono, 2019). The results of the analysis show that the value |t calculates| in all sensory quality indicators are greater than in *the t table*, so it can be concluded that $H_0$ is rejected and $H_1$ is accepted, which means that there is a significant effect of 150 ml pandan leaf extract substitution on the sensory quality of fresh noodles.

## DISCUSSION

This research aims to obtain valid and scientifically accountable data. The data obtained is considered valid because it is produced through a systematic research procedure and will provide consistent results if the research is repeated with the same method. This study was carried out with three repetitions to compare the sensory quality of fresh noodles using 150 ml of water and fresh noodles with 150 ml of pandan leaf extract substitution. The results of the study are described as follows.

**1. Color Sensory Quality in Fresh Noodles**

Color is the first aspect that is visually observed by consumers in judging a food product. This is supported by the opinion (Sudiarta, 2022) which states that color is the initial factor that consumers pay attention to. In addition, Kusumastuti, Kusumah, & Tatang (2022) also stated that color has an important role in determining the attractiveness of a product, while Yuanda, Slamet, & Kanetro (2024), added that color can provide information about the characteristics of a food. The use of pandan leaf extract which has natural green pigments and a distinctive aroma can affect the sensory quality of fresh noodles so that the product becomes more attractive and increases the level of consumer liking.

The results showed that the average color value of fresh noodles using 150 ml ($X_1$) of water was 1.00, while fresh noodles with 150 ml ($X_2$) pandan leaf extract substitution were 5.36, with a difference of 4.36. This difference is reinforced through statistical tests with the results |t calculate| > t table (|-64,168| > 2.00172), so that $H_a$ is accepted. This shows a significant difference between the two treatments. Fresh noodles without pandan leaf extract tend not to have a green color, while noodles with the addition of pandan leaf extract have a clearer and more attractive green color. Thus, $H_0$ is rejected and $H_a$ is accepted, which means that there is an effect of pandan leaf extract substitution on the color quality of fresh noodles.

The difference in color is influenced by the ingredients used, especially pandan leaf extract which contains chlorophyll as a natural pigment that gives the green color (Riansyah, Maharani, & Nugroho, 2021). In addition, Holinesti & Sartika (2022), stated that the base material greatly determines the final color of the product, and Nurfina (2022) added that the processing process can also affect the intensity of the color produced.

**2. Sensory Quality of Scent in Wet Noodles**

Aroma is a sensory attribute that can be detected by the sense of smell and plays an important role in determining the deliciousness of a product (Rahmadhanimara, Purwinarti, & S, 2022). In this study, the smell of fresh noodles was influenced by the use of pandan leaf extract which has a distinctive and natural aroma. Setiyoko & Awaliya (2023), also stated that scent is an important parameter in sensory tests because it affects consumers' perception of taste.

The results showed that the average aroma value in fresh noodles using 150 ml ($X_1$) water was 2.73, while in noodles with 150 ml ($X_2$) pandan leaf extract substitution was 5.70, with a difference of 2.97. The results of the statistical test show that |t counts| > t table (|-14.821| > 2.00172), so $H_a$ is accepted. This indicates a significant difference between the two treatments. Fresh noodles with pandan leaf extract have a more fragrant and distinctive scent than noodles without extract. Thus, $H_0$ is rejected and $H_a$ is accepted.

This difference is caused by the content of aromatic compounds such as 2-acetyl-1-pyrroline in pandan leaves that give it a distinctive scent (Winarno, 2023), thereby increasing the sensory appeal of the product.

**3. Chewy Texture Quality in Fresh Noodles**

The chewy texture is one of the main indicators in determining the quality of fresh noodles and the level of consumer acceptance (Nawawi, Ansori, & Fathonah, 2025). Noodles that have a chewy, elastic, and soft texture tend to be preferred (Sihmawati, Rosida, Wiliana, & Panjaitan, 2020). In addition, Nurhamidah (2022) stated that texture plays an important role in product acceptability because it is related to the sense of touch.

The results showed that the average value of chewy texture in fresh noodles using 150 ml ($X_1$) water was 4.64 and in noodles with 150 ml ($X_2$) pandan leaf extract substitution was 5.17. The results of the statistical test show |t count| > t table (-3.377 > 2.00172), so $H_a$ is accepted. This shows a significant difference, where noodles with pandan leaf extract have a higher level of chewiness. Thus, $H_0$ is rejected and $H_a$ is accepted.

This difference is influenced by the water and fiber content in pandan leaf extract which helps in water binding and interaction with elasticity-forming proteins (Azzahra, Koesoemawardani, Winanti, & Nurainy, 2025). Paidah (2022) also stated that this content can increase the elasticity and elasticity of fresh noodles.

**4. Texture Quality Not Easily Broken on Fresh Noodles**

The texture does not break easily, indicating the elasticity and structural strength of noodles, which is one of the important indicators of product quality (Wasalamah, 2024). Lestari (2021), stated that this texture provides the supple and elastic sensation expected in Fresh noodles.

The results showed that the average value of texture was not easy to break in fresh noodles using 150 ml ($X_1$) water of 4.56 and in noodles with 150 ml ($X_2$) pandan leaf extract substitution of 5.00. The results of the statistical test show |t count| > t table (-2.832 > 2.00172), so $H_a$ is accepted. This shows a significant difference between the two treatments, where noodles with pandan leaf extract have a stronger texture and are not easy to break. Thus, $H_0$ is rejected and $H_a$ is accepted.

This difference is due to the water and fiber content in pandan leaf extract which increases the water binding power and forms a more elastic dough structure (Paidah, 2022). In addition, Muliana, Yasa, & Nofrida (2026), stated that the moisture content and boiling process also affect the texture of noodles, while A. R. Sari & Siqhny (2022). And Rohman (2022), added that excessive water absorption can cause noodles to become soft and break easily.

**5. Savory Taste Quality in Fresh Noodles**

Taste is one of the main parameters in organoleptic tests that determine the quality and acceptance rate of the product. The results showed that the average taste value in fresh noodles using 150 ml ($X_1$) water was 4.36, while in noodles with 150 ml ($X_2$) pandan leaf extract substitution was 5.04. The results of the statistical test show |t count| > t table (-4.761 > 2.00172), so $H_a$ is accepted. This shows a significant difference, where noodles with pandan leaf extract have a more savory taste and are preferred. Thus, $H_0$ is rejected and $H_a$ is accepted.

The difference in taste is influenced by the ingredients used, where Holinesti & Sartika (2022), state that the taste is influenced by the basic ingredients of the product. The use of pandan leaf extract gives a distinctive taste, while the savory taste is obtained from the addition of salt. Nero, Rahmawan, & Nurfadila (2023), stated that the right amount of salt will produce a savory taste, while excess salt can cause a taste that is too salty.

## CONCLUSION

This study shows that the substitution of pandan leaf extract as much as 150 ml has a significant influence on the sensory quality of fresh noodles which includes color, scent, texture, and taste, so that the research objectives have been achieved and an alternative hypothesis ($H_a$) is accepted. Overall, the addition of pandan leaf extract is able to increase

visual appeal through the natural green color due to the chlorophyll, strengthen the distinctive aroma due to the presence of the typical fragrance compounds of pandan leaves, and improve texture and taste through the contribution of water and fiber content that supports the elasticity and taste of the product. These findings make a scientific and practical contribution to the development of wet noodles based on natural ingredients as a safer alternative to synthetic materials, while enriching studies related to the comprehensive integration of sensory attributes in one study. However, this study has limitations in the number of treatments that are still limited and has not examined the aspects of shelf life and stability of the active compounds of pandan leaves. Therefore, it is suggested that further research can develop variations in extract concentrations, test storage resistance, and analyze chemical and microbiological aspects to obtain more comprehensive and applicable results.

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