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Application of various statistical approaches for sensory evaluation of seaweed dodol mixed agarwood infusion

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ABSTRACT

Seaweed dodol mixed agarwood infusion is an innovative culinary product from Lombok Island made primarily from seaweed flour. This study aims to evaluate the sensory characteristics of seaweed dodol enriched with agarwood infusion using the 9-point hedonic scale with different statistical approaches for the analysis. Four different seaweed concentrations were applied in this research as treatments: S1(seaweed flour 8% w/v), S2 (seaweed flour 10% w/v), S3 (seaweed flour 12% w/v), S4 (seaweed flour 14% w/v). The proximate analysis measures total protein, lipid, ash, water, and carbohydrates. This study used a Nine-point hedonic scale ranging from 9 (like extremely) to 1 (dislike extremely) on the appearance, aroma, taste, and texture. Non-parametric statistics (Kruskal-Wallis and Friedman Test) and parametric statistics (ANOVA-CRD and ANOVA-RCBD) are the statistical approaches in this study, which are continued by DMRT ($\alpha = 0.05$). Proximate analysis shows that dodol has high moisture with medium carbohydrate content. The result indicate that different statistical approaches have a consistent critical P-value, which indicate the highly significant effect of treatment on the sensory evaluation value. DMRT analysis shows that the higher seaweed flour concentration results in a higher numerical hedonic value. The spider web chart shows respondents give a more sensitive evaluation of taste and texture than appearance and aroma. It could be concluded that different statistical approaches are reliable for analysing the significant effect of different seaweed flour concentrations on the sensory evaluation value of seaweed dodol mixed agarwood infusion. This study can give novel insight on sensory evaluation of dodol as Indonesian traditional culinary product.

Keywords: agarwood infusion; seaweed flour; sensory evaluation; statistical approach

INTRODUCTION

Seaweed dodol is one of the popular culinary products on Lombok Island and makes this island one of the centres of seaweed dodol production in Indonesia (Andjani et al., 2021; Nazaruddin & Ansar, 2017). These products are primarily sold in tourist spot areas as souvenirs for tourists who visit this island (Singawinata et al., 2020). Dodol seaweed's main ingredient is seaweed flour (agar) made from red algae (Sinurat et al., 2024). Several types of sugar are then added as a natural sweetener (Harun & Rosnita, 2023). This product is classified as plain dodol seaweed.

Additional ingredients other than sugar can be mixed in plain seaweed dodol as an innovation for developing this product in Indonesia. Several studies improve the taste of seaweed dodol by incorporating flesh of the fruit, including tomato (M. W. Lukito et

al., 2017), Pineapple (Setha et al., 2019), yellow pumpkin (Rahmayuni et al., 2023), and mango (Pasaribu et al., 2015). The texture of seaweed dodol also can be improved by the addition of starch from tubers such, taro (Warkoyo, Yuliarie Wulandari, 2018), sweet potato (Vitriasari & Suyanto, 2012), and glutinous rice (Elfahira et al., 2022). The nutritional value of seaweed dodol can be improved by adding vegetable ingredients such as green okra (Musrianti & Hutasoit, 2023). However, no study about additional ingredients of seaweed dodol was reported to be conducted on Lombok Island. Further research about exploring potential additional ingredients of seaweed dodol using local ingredients from Lombok Island is essential.

Gyrinops versteegii is an endemic agarwood species from Lombok Island which can potentially be used as an additional ingredient of seaweed dodol. Leaves infusion of this species can be an additional ingredient in some traditional foods and beverages of Lombok Island, such as palm sugar (Wangiyana et al., 2024) and lemongrass beverages (Aini et al., 2024). The addition of agarwood infusion can have a beneficial effect on seaweed dodol in terms of both taste and nutrition. The hedonic test result shows that agarwood leaf infusion has unique taste characteristics well accepted by the respondent (Wangiyana, Triandini, et al., 2021). Several studies have revealed the antioxidant and antibacterial activity of agarwood leaves infusion from *G. versteegii* species (Parwata et al., 2018; Prihantini & Rizqiani, 2019; Wangiyana et al., 2020; Wangiyana, Supriadi, et al., 2021). Thus, agarwood infusion can be a promising additional ingredient for developing seaweed dodol on Lombok Island.

Seaweed dodol mixed agarwood infusion is a promising culinary product from Lombok Island that has the potential to be further developed. A scientific approach should be used to develop this culinary product. Sensory evaluation using a hedonic scale is one of the ideal measurement tools in this case (Świąder & Marczewska, 2021). Sensory evaluation can estimate consumer perception and acceptance, an essential parameter for developing culinary products (Mazur et al., 2018).

The hedonic scale used in the sensory evaluation can become a quantitative standard to measure the degree of respondent acceptance of a particular culinary product (Wichchukit & O'Mahony, 2022). A hedonic scale with nine levels of measurement is commonly used for high accuracy and precision (Wichchukit & O'Mahony, 2015). However, since this hedonic scale uses a wide range of measurement levels, there is the possibility of some bias in the analysis (Triandini & Wangiyana, 2022). That bias can be minimised by adopting various statistical approaches in data analysis (Wangiyana & Triandini, 2022).

Parametric and non-parametric statistical approaches are commonly used in hedonic scale analysis (Asmare & Begashaw, 2018). Some studies only focus on non-parametric statistical approaches for hedonic scale analysis, including Kruskal-Wallis (Sirajuddin et al., 2021) and Friedman-Conover (Widyatsih & Jaya, 2017). Meanwhile,

another study only focused on parametric statistical approaches for hedonic scales, including ANOVA (Fajriyah & Oktafa, 2020). However, most studies about sensory evaluation on culinary products use a combination of non-parametric and parametric statistical approaches for better accuracy and precision of the analysis (Asfan et al., 2017; Baharudin et al., 2023; Citrawati & Pratama, 2024; Triandini et al., 2024). Thus, this research aims to conduct a sensory evaluation of seaweed dodol mixed agarwood infusion using the 9-point hedonic scale with different statistical approaches for the analysis.

METHODOLOGY

Figure 1 summarises the processing method used to produce seaweed dodol mixed with agarwood infusion. The processing involves three primary steps: making the agarwood infusion, preparing the seaweed flour, and mixing the seaweed flour with the agarwood infusion. Moulding and cooling are the finishing processes to obtain a solid seaweed dodol product.

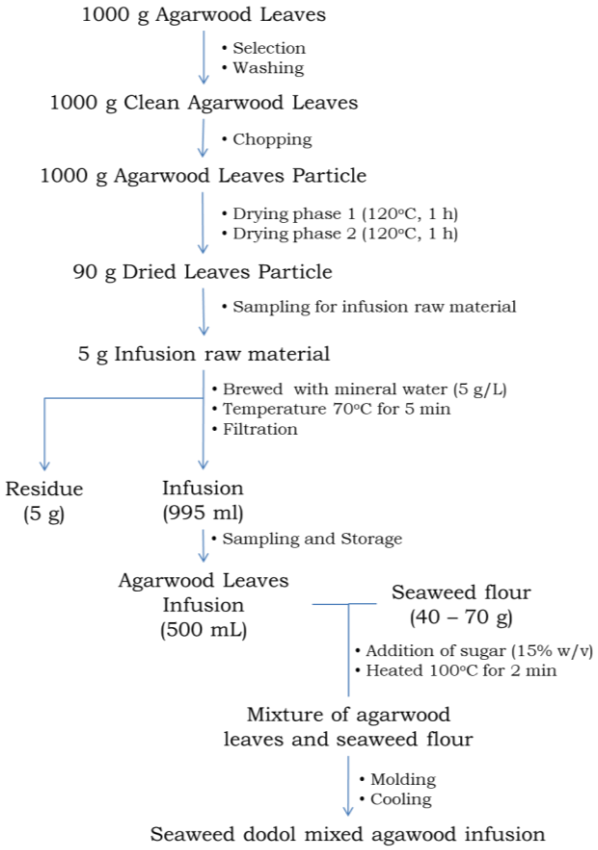

Figure 1. Summary of processing method to produce seaweed dodol mixed agarwood infusion

1. Research material

Agarwood (*Gyrinops versteegii*) leaves were taken from Lingsar, West Lombok. Seaweed flour (Satelit) from red alga (SNI 2802-2015) mixed with dodol ingredient. Chemicals for total protein and lipid content in proximate analysis: $CuSO_4$, NaOH, K_2SO_4, HCl and H_3BO_3 (Merck). Mineral water and

qualitative filter paper are used to extract agarwood infusion. This study uses several instruments, including an electric furnace, Kjeldahl equipment (Kjeldahl Buchi EasyK), Soxhlet equipment (Pyrex), an electric oven (Eastern Electric), stainless steel bowl, electric stove (Olike), grinding machine (Miyako BL-22 PLY), analytical scale (Jadever), and silicon dodol mould.

2. Agarwood infusion processing

Agarwood leaves from the *G. versteegii* population in the Lingsar plantation was selected based on size, shape and condition. Leaves from 8-15 cm with elliptic-oblong shape and free from pests and disease were picked as the raw material for agarwood infusion (Wangiyana & Triandini, 2021).

Selected agarwood leaves were washed with flowing water. The leaves were then ground using a grinding machine into particles ranging from 1 mm to 2 mm. The leaf particles were dried in an oven with 2 phases of drying at 120°C for 1 hour each (Wangiyana et al., 2019).

Dried leaves were brewed using mineral water with a 5 gr/L concentration. The brewed process was conducted at 70°C for 5 minutes. Filtration was then conducted using qualitative filter paper to separate filtrate and residue. The filtrate from this process is the agarwood leaves infusion (Wangiyana et al., 2018).

3. Seaweed flour mixed agarwood infusion

The primary treatment in this research is the concentration of seaweed flour used to make seaweed dodol mixed agarwood infusion (Table 1). Each treatment was added with sugar (sucrose) at a concentration of 15% w/v. The mixture was then heated to 100°C with stirring for 2 minutes. The mixture was poured into a silicon mould and let to cool.

Table 1.
Formulation of seaweed dodol mixed agarwood infusion

Code	Treatment Description
S_1	Seaweed flour 8% w/v
S_2	Seaweed flour 10% w/v
S_3	Seaweed flour 12% w/v
S_4	Seaweed flour 14% w/v

4. Proximate Analysis

Seaweed dodol mixed agarwood infusion with average seaweed flour concentration subjected to proximate analysis. This analysis measures Total water content, total ash content, total protein content, total lipid content, and total carbohydrate content (Thangaraj, 2016).

Proximate analysis conducted according to the standard of INS 01-2891-1992. Total water content was measured by thermogravimetric assay. Total ash content was measured by drying ash protocol with furnace combustion. Total fat content was measured using the soxhlation method. Kjeldahl method was used to measure total protein

content. The total carbohydrate content is estimated based on the calculation (Eden & Rumambarsari, 2020):

$$\%\,C = 100\% - (\%P + \%L + \%A + \%W)$$

Note:
C = total carbohydrate
P = total protein
L = total lipid
A = total ash
W = total water

5. Sensory Evaluation

Sensory evaluation is performed using a 9-point hedonic scale, which can be divided into verbal and numerical scales (Table 2). The verbal hedonic scale directly expresses the preference level of the respondent after the test. The numerical scale is the conversion of the verbal hedonic scale for quantitative statistical analysis purposes (Xia et al., 2021).

Thirty people, ranging in age from 20 to 24, were selected as respondents in this study. They are food sensory respondents from Universitas Pendidikan Mandalika who have already participated in 9-point hedonic scale training (Wangiyana et al., 2023). Respondents evaluated the seaweed dodol based on its appearance, aroma, taste, and texture.

Table 2.
Verbal and numerical hedonic scale in this study

Verbal Hedonic Scale	Numerical Hedonic Scale
Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like or dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

6. Analysis Data

Analysis of data using descriptive and inductive statistical methods. The proximate data of seaweed dodol was analysed using descriptive statistics with pie chart representation. A brief comparison of appearance, aroma, taste, and texture was also analysed using descriptive statistics with a spider web chart representation.

Inductive statistics in this study were based on different approaches. The first approach is the non-parametric statistic approach, including the Kruskal-Wallis test and Friedman test. The second approach is the parametric statistic approach, including Analysis of Variance-Completely Randomised Design (ANOVA-CRD) and Analysis of Variance-Completely Randomised Block Design (ANOVA-RCBD). The assumptions of each statistical approach are described in Table 3 (Baharudin et al., 2023).

The treatment effect on the numerical hedonic scale was significantly analysed at α = 0.05. Further, a Multiple mean comparison test was conducted using the Duncan Multiple Range Test (DMRT). All data analyses were performed using Co-Stat for Windows.

Table 3.
Assumptions in different statistical approaches

Statistical approach	Assumption	Linear model	Description
Kurskal-Wallis	Seaweed dodol and respondents are homogenous	$H = \frac{12}{N(N+1)}\sum_{i=1}\frac{R_i^2}{n_i} - 3(N+1)$	Ri = ranking in the column N = Total Number of Sample ni = Number of treatments
Friedman Test	Respondents are heterogeneous (become group)	$X^2 = \frac{12}{bt(t+1)}\sum r^2 - 3b(t+1)$	b = Number of Group t = Number of Treatments r = Number of ranking
ANOVA CRD	Normal distribution of numeric scale and respondents are homogenous	$Y_{ij} = \mu + \tau_i + \varepsilon_{ij}$	Y_{ij} = An observation μ = The Experimental Mean τ_i = The Treatments Effect ε_{ij} = The Experimental Error
ANOVA RCBD	Normal distribution of numeric scale and respondents are heterogeneous (become block)	$Y_{ij} = \mu + \tau_i + \beta_j + \varepsilon_{ij}$	Y_{ij} = An observation μ = The Experimental Mean τ_i = The Treatments Effect B_j = The Block Effect ε_{ij} = The Experimental Error

RESULTS AND DISCUSSION

Seaweed dodol mixed agarwood infusion is a unique culinary product (Figure 2). This product is made primarily from infusion based on a water extraction process. Furthermore, this product purely uses seaweed flour without adding starch or other flour ingredient sources like most other dodol products. Thus, the seaweed flour and agarwood infusion are the primary factors responsible for the characteristics of the dodol product.

Figure 2. Seweed dodol mixed agarwood infusion. (S1 = seaweed flour 8% w/v, S2 = seaweed flour 10% w/v, S3 = seaweed flour 12% w/v, S4 = seaweed flour 14% w/v)

Agarwood infusion, which is primarily dominated by water, has affected the high moisture of the dodol product. Based on the proximate analysis, it is indicated that the water content is 81% (Figure 3). This total water content is twice as much as the water content in a typical seaweed dodol product that uses additional starch as an ingredient (Karina & Desrizal, 2021; Setha et al., 2019). Food products

with high moisture can be easier to chew, which is more pleasant to a particular targeted population with chewing difficulty or limitations (Cichero, 2020; Park et al., 2021; Wattanapan et al., 2021). However, the high water content in the product potentially affects the shelf life (Moschopoulou et al., 2019). This is an essential consideration for the feasibility of the product to compete in the food industry marketplace.

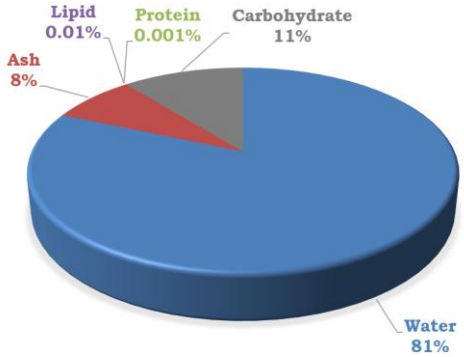

Figure 3. Proximate analysis result of seaweed dodol mixed agarwood infusion

The proximate analysis shows that seaweed dodol mixed with agarwood infusion contains carbohydrates with much higher concentrations than lipids and protein. The carbohydrate content in this product is slightly lower than the carbohydrate content of a typical seaweed dodol product. (Karina & Desrizal, 2021; Setha et al., 2019). The primary reason for this result is that the carbohydrate source in seaweed dodol mixed agarwood solely comes from seaweed flour without adding starch like typical seaweed dodol. The medium content of carbohydrate level reveals the potency of this product to be consumed by the particular population who is reducing carbohydrate consumption in their diet program (Ebbeling et al., 2018).

Different statistical approaches result in the reliability of the data analysis. The critical P-value, which indicates the significant level of impact of the treatment on the respondent evaluation, shows the consistent measurement of different statistical approaches (Shrestha, 2019). The result between the non-parametric approach (Kruskal-Wallis and Friedman Test) and the parametric approach (ANOVA-CRD and ANOVA-RCBD) also shows identical results. This can be a good indication of a comprehensive best fit of different statistical approaches to the data analysis (Andrade, 2019).

The critical P-value in this study is more consistent compared to other studies that also use different statistical approaches (Aini et al., 2024; Baharudin et al., 2023; Triandini et al., 2024). This indicates that different seaweed flour concentrations are a treatment with very sensitive values. The respondent expressed a slightly different concentration of seaweed flour as a very significant difference in the hedonic scale. Thus, this parameter must be considered for developing

future seaweed dodol mixed agarwood infusion.

Table 4.
The comparison of critical P-value of different statistical approaches

Parameter	**Critical P-value**			
	Kruskal-Wallis	**Friedman Test**	**ANOVA-CRD**	**ANOVA-RCBD**
Appearance	0.0001 ***	0.0001 ***	0.0001 ***	0.0001 ***
Aroma	0.0005 ***	0.0001 ***	0.0001 ***	0.0001 ***
Taste	0.0001 ***	0.0001 ***	0.0001 ***	0.0001 ***
Texture	0.0001 ***	0.0001 ***	0.0001 ***	0.0001 ***

Note: *** = very significant with a P-value less than 0.001

Table 5.
DMRT result of treatment effect on the numerical hedonic scale

Treatment	**Numerical hedonic scale (mean ± error)**			
	Appearance	**Aroma**	**Taste**	**Texture**
S_1	4.33 ± 0.38 (c)	3.97 ± 0.29 (d)	2.90 ± 0.29 (d)	2.10 ± 0.20 (d)
S_2	5.87 ± 0.25 (ab)	5.00 ± 0.28 (c)	3.77 ± 0.28 (c)	3.03 ± 0.34 (c)
S_3	5.47 ± 0.22 (b)	5.30 ± 0.22 (b)	4.43 ± 0.31 (b)	4.80 ± 0.29 (b)
S_4	6.37 ± 0.19 (a)	5.67 ± 0.27 (a)	5.57 ± 0.24 (a)	5.90 ± 0.22 (a)
LSD 0.05	0.71	0.69	0.63 ±	0.72

Note: Different mean values followed by the same letters differ significantly ($p<0.05$). (S_1 = seaweed flour 8% w/v, S_2 = seaweed flour 10% w/v, S_3 = seaweed flour 12% w/v, S_4 = seaweed flour 14% w/v)

The DMRT analysis shows that respondents give consistent evaluation patterns in parameter appearance, aroma, taste and texture (table 5). The higher concentration of seaweed flour resulted in a higher numerical hedonic scale value in all parameters. Treatment S_4, which has the highest concentration of seaweed flour, has the highest numerical hedonic scale value and is significantly different from other treatments. The concentration value of the S4 treatment is similar to the concentration of seaweed flour in typical seaweed dodol products (M. S. Lukito et al., 2017). This result implies that for further development of seaweed, dodol mixed agarwood infusion should use at least 14% w/v of seaweed flour in the ingredient.

Treatment has various numerical hedonic values, which can be higher or lower than the threshold value of the 9-point hedonic scale sensory evaluation (numerical hedonic value = 5) (Aini et al., 2024; Baharudin et al., 2023). Treatment S_1 (seaweed flour 8 % w/v) has a numerical hedonic value below the threshold value in all parameters. Treatment S_2 (seaweed flour 10% w/v) and S_3 (seaweed flour 12% w/v) have numerical hedonic values higher than the appearance and aroma parameters threshold. However, these two treatments have numerical hedonic values lower than threshold values in taste and texture parameters. Meanwhile, S_4 (seaweed flour 14% w/v) is the only treatment with a numerical hedonic value higher than the threshold in all parameters. This result

indicates that the increase of seaweed flour can increase the quality of the sensory parameter. Seaweed, especially red alga, is a gelatinous polysaccharide commonly used as a thickening and stabilising agent (Lee et al., 2017). The higher concentration of seaweed impacts the higher stabilisation of the structure, which is shown in the appearance parameter of the dodol. Red seaweed also contains unique galactose-rich hydrocolloids, which can affect the rheological properties of particular food products (Rhein-Knudsen et al., 2017). The higher concentration of seaweed flour can cause better rheological properties, as shown in the dodol textural parameter.

The spider web chart compares each treatment's profile parameter (figure 4). The comparison of respondent evaluation scores on different parameters can also be seen clearly by calculating the area under the curve of this chart (Kayali et al., 2023). It is shown that S4 have the largest area under the spider web chart, which indicates the highest acceptance level of this treatment among all other treatments. This treatment also has the most consistent evaluation score profile in all parameters among the other treatments. After treatment S4, the rank of acceptance level based on the area under the curve from the highest to the lowest are S3, S2, and S1.

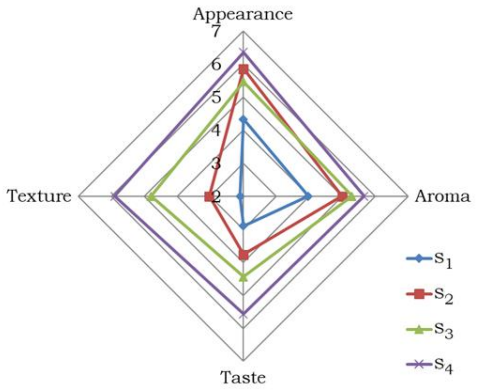

Figure 4. Spider web chart for comparison of the parameters in all treatments. (S1 = seaweed flour 8% w/v, S2 = seaweed flour 10% w/v, S3 = seaweed flour 12% w/v, S4 = seaweed flour 14% w/v)

The spider chart can be used to investigate the indication of different sensitivity of sensory evaluation parameters based on respondent score value (Puleo et al., 2020). It is indicated that respondents are less sensitive to evaluating the treatment on appearance and aroma parameters. This is because the positions of each treatment under the curve area of the chart are close to each other in these two parameters. However, respondents tend to be more sensitive when evaluating texture and taste parameters. This is shown by the clear gradation position of each treatment under the curve area of the chart in these two parameters.

CONCLUSION

Different statistical approaches used in this study, including the Kruskal-Wallis, Friedman Test, ANOVA-CRD,

and ANOVA-RCBD, confirm the consistent result about the significant effect of different seaweed flour concentrations on the numerical hedonic score. DMRT and spider web chart further indicate that the higher the seaweed flour concentration, the better the numerical hedonic score given by the respondent in parameters: appearance, aroma, taste, and texture. The optimum concentration of seaweed flour is 14 % w/v to make the seaweed dodol mixed agarwood infusion product, with the highest acceptance by the respondents.

Future research about the shelf-life assessment of seaweed dodol mixed agarwood infusion is needed to provide essential data for further development of this product to meet the quality requirements of modern food industry standards.

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