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Optimization of Fishery Product Quality Assessment in Dumai through Multivariate Analysis Based on Organoleptic Testing

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Abstract

The quality of fishery products is a critical factor influencing competitiveness and market acceptance, particularly for the fishery industry in Dumai City. However, assessing fishery product quality remains challenging, primarily due to the subjective nature of organoleptic testing, which is often influenced by variability in panelists' evaluations. This subjectivity can lead to inconsistencies in assessment results and reduce the reliability of quality evaluations. This study aims to optimize the quality assessment of fishery products by applying discriminant analysis, a multivariate analysis method based on organoleptic testing. We conducted the organoleptic test by evaluating six key sensory parameters: appearance, odor, taste, texture, mold presence, and slime. This approach seeks to minimize subjectivity in assessments and enhance the objectivity of results. The fishery product samples tested included a variety of local products, such as smoked catfish, shrimp paste, smoked patin fish, shrimp crackers, salted tonguefish, fish crackers, swordfish nuggets, patin nuggets, swordfish meatballs, catfish meatballs, and patin meatballs. Evaluations were conducted by trained panelists with the support of digital tools to improve the consistency and accuracy of results. The discriminant analysis results indicated that the model could classify product quality with an accuracy of up to 83.3%. Taste was identified as the most significant sensory factor in distinguishing high-quality products from lower-quality ones.

Keywords: Organoleptic Testing, Discriminant Analysis, Sensory Parameters, Fishery Product Quality, Classification Accuracy

Introduction

Dumai City, located on the eastern coast of Sumatra, holds significant potential in fisheries. Approximately 93% of the total fishery production comes from marine fisheries, while the remaining portion is derived from aquaculture and other fishing activities. Dumai has become one of Indonesia's rapidly growing fishery industry hubs (Arif & Pradini, 2020). Fishery products such as smoked fish, shrimp paste, shrimp crackers, and various fishball preparations (Saputra et al., 2024) are key commodities produced by small and medium-sized enterprises in the region (Mulyani et al., 2023). These products are marketed locally and have substantial export potential, particularly to Southeast Asian and European countries (Amri et al., 2023). However, quality remains crucial for broader market acceptance (Jananta et al., 2024).

The primary challenge faced by the fisheries sector in Dumai is maintaining consistent product quality (Nursia et al., 2024). Fishery products are highly susceptible to quality degradation due to suboptimal handling, storage, and processing practices (Maghfira et al., 2024). This can lead to physiological changes in the products, ultimately affecting their freshness, taste, and safety, making them unfit for consumption and posing risks to consumers (Pangesti et al., 2023). Microbial contamination and the presence of slime (Khairunnisa & Asmaq, 2024) are often critical indicators of quality deterioration, especially in poorly preserved products (Anggo et al., n.d.).

The current assessment of fishery product quality generally involves sensory parameters (May & Tega, 2024) such as appearance, odor, taste, texture, and mold and slime (Triguna et al., 2024). However, this method is subjective and heavily reliant on panelists' perceptions, resulting in inconsistent and variable evaluation outcomes, making it challenging for producers to establish objective quality standards. An analysis capable of identifying sensory parameters that allow producers to focus on key aspects contributing to consumer acceptance is required to address this issue. Discriminant analysis is one such method that can be employed.

This analysis offers a solution through statistical techniques that identify and classify products based on the most influential sensory parameters. Various studies have applied discriminant analysis to evaluate the quality of food and beverage products, demonstrating its effectiveness in reducing subjective bias in assessments. Research conducted by (Rijajami, 2024) revealed that discriminant analysis could classify the performance of food and beverage companies effectively. Additionally, a study (Anggraini & Hanoum, 2024) found that using Discriminant Analysis for digital leadership and business transformation significantly aids business sustainability, including digital transformation efforts. This method enables a more systematic and objective evaluation, providing more consistent results than conventional methods often used in the fisheries industry.

The application of discriminant analysis in this study is expected to identify critical sensory parameters that most significantly influence the quality of appearance, odor, taste, texture, and mold and slime. Thus, the findings of this study can assist producers in improving processing and preservation techniques, resulting in higher-quality and more consistent products in the market. This research introduces a novel approach by evaluating fishery product quality in Dumai, an area that has previously relied on subjective assessments from conventional organoleptic testing. It enables the identification and classification of product quality based on specific sensory parameters. It encompasses various local fishery products such as smoked fish, shrimp paste, crackers, and fishball preparations. These aspects have been underexplored in previous research on fishery product quality assessment.

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Literature Review

1. Quality of Fishery Products

The quality of fishery products is critical in determining competitiveness and market acceptance. These products are highly susceptible to quality degradation due to external factors such as inadequate handling, storage, and processing (Maghfira et al., 2024). Key parameters influencing the quality of fishery products include freshness, texture, odor, taste, mold, and slime (Triguna et al., 2024). Reliable quality assessment is essential to ensure safe and high-quality products for consumers (Pangesti et al., 2023).

2. Organoleptic Testing in Quality Assessment

Organoleptic testing has been a standard method for evaluating the quality of food and fishery products. This method involves sensory evaluation based on appearance, odor, taste, and texture (May & Tega, 2024). However, the subjective nature of this test often leads to significant variations in results among panelists, reducing consistency and reliability in evaluations (Khairunnisa & Asmaq, 2024). Therefore, a more systematic approach is needed to enhance objectivity in organoleptic assessments.

3. Application of Multivariate Analysis in Product Evaluation

Multivariate analysis is a statistical approach that systematically evaluates multiple parameters. Discriminant analysis, a method within multivariate analysis, has been widely used to assess the quality of food and beverage products (Rijajami, 2024). This method effectively identifies key parameters influencing quality and provides more objective and consistent classification results than traditional methods. Research (Anggraini & Hanoum, 2024) demonstrated that discriminant analysis improves reliability in evaluation processes by reducing subjective bias.

4. Local Fishery Products of Dumai

Local fishery products from Dumai, such as smoked fish, shrimp paste, shrimp crackers, and various fishball preparations, are key commodities small and medium enterprises produce. These products hold great potential for export markets but often face challenges maintaining quality consistency (Nursia et al., 2024). By utilizing a multivariate analysis approach, the quality of these products can be enhanced to meet local and international market standards.

5. **Novelty of the Study**

   This study offers novelty by employing discriminant analysis to evaluate the quality of fishery products in Dubai. This approach enables the identification of significant sensory parameters and the classification of products based on quality. Previous studies have not extensively explored the application of multivariate analysis to local fishery products, making this research valuable to improving the quality and competitiveness of Dumai's fishery products.

Research Method

The data source for this research is secondary data obtained from laboratory test results conducted by UPT PMHP of the Department of Marine and Fisheries of Riau Province on fishery products from Dumai City. The research population comprises Small and Medium Enterprises (SMEs) in Dumai City that produce fishery products. These SMEs include Arum Sari, Pasar Bundaran, and Cita Rasa. The fishery products include smoked catfish, shrimp paste, smoked patin, shrimp crackers, dried tongue fish, fish crackers, swordfish nuggets, patin nuggets, swordfish meatballs, catfish meatballs, and patin meatballs.

The dependent variable in this study is the category of products classified into high- and low-quality groups. Meanwhile, the independent variables are the indicators influencing sensory quality parameters, including appearance, odor, taste, texture, presence of mold, and slime. The steps in conducting discriminant analysis are as follows:

1. Describing data through a descriptive statistical approach.
2. Conducting discriminant assumption testing, which includes:
   a. Normality test

      H_0 : Residuals are normally distributed.

      H_1 : Residuals are not normally distributed.

   b. Testing criteria: H_0 rejected if P-Value $\leq \alpha$ or Sig. $\leq$ (0,05)

   c. Homogeneity test

      H_0 : Both groups of data have homogeneous variance.

      H_1 : Both groups of data do not have homogeneous variance.

      Testing criteria: H_0 rejected if P-Value $\leq \alpha$ or Sig. $\leq$ (0,05)

   d. Multicollinearity test

      H_0 : There is no multicollinearity.

      H_1 : There is multicollinearity.

Testing criteria: H_0 rejected if $VIF > 10$.

3. Classifying the variables used in the research into dependent and independent variable groups.
4. Choosing the method used to form the discriminant function. In discriminant analysis, there are two main methods: the simultaneous method and the stepwise method. The simultaneous method involves all independent variables being included to form the discriminant function, after which the discrimination process is carried out. Meanwhile, the stepwise method involves gradually adding independent variables to the discriminant model to identify the most effective variables for distinguishing each group of dependent variables.
5. Testing the significance or accuracy level of the discriminant model created using methods such as Wilk's Lambda, Pillai, F-test, and other techniques.
6. Analyze and interpret the discriminant function.

Result

Before conducting discriminant analysis, the data used in the study is presented in a table obtained from the SPSS output, as follows:

Table 1. Descriptive Statistics Results

Variable	N	Minimum	Maximum	Average	Std. Deviation
Appearance	12	5.00	8.00	7.3333	.98473
Smell	12	6.00	8.00	7.4167	.66856
taste	12	6.00	8.00	7.4167	.66856
Texture	12	6.00	8.00	7.4167	.66856
Mold	12	9.00	9.00	9.0000	.00000
Slime	12	8.00	9.00	8.6667	.49237
Product Type	12	0	1	.67	.492
Lots of Data	12				

Table 1 shows that the number of fishery products used in this study is 12, along with information on the minimum, maximum, average, and standard deviation values for each variable. The maximum value is observed in the Mold and Slime variable at 9.00, while the minimum is found in the Appearance variable at 5.00. The highest average value is observed in the Mold variable at 9.00, and the lowest average is in the Appearance variable at 7.33. The highest standard deviation is recorded in the Appearance variable at 0.984, while the lowest is in the Mold variable at 0.00. Subsequently, a discriminant assumption test was conducted to ensure the discriminant analysis process could proceed. The first assumption test is the normality test, and the results are as follows:

Table 2. Residual Test Results

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Residual Test Results	.186	12	.200*	.912	12	.223

Table 2 shows the results of the normality test with an asymptotic. Sig. (2-tailed) or P-value of 0.200. With a significance level (alpha) of 0.05, the decision is to fail to reject H_0 . Therefore, it can be concluded that the data used follows a normal distribution and is suitable for discriminant analysis. The next assumption test is the homogeneity test, which shows that the variance is not homogeneous, leading to an overall nonsignificant mean difference. To address this assumption, a statistical test was conducted to confirm whether the overall difference in means remains significant despite non-homogeneous data. The statistical test used is Welch ANOVA, presented as follows:

Table 3. Welch ANOVA Results

		Statistic[a]	df1	df2	Sig.
Appearance	Welch	1.285	1	3.363	.331
Smell	Welch	1.952	1	4.253	.231
taste	Welch	11.200	1	5.676	.017
Texture	Welch	1.952	1	4.253	.231
Mold	Welch	.	.	.	.
Slime	Welch	.568	1	5.016	.485

Table 3 indicates that the significance value for the taste variable is 0.017 (<0.05), demonstrating a significant difference in the mean across groups; however, no significant differences are observed among the other groups. The next step is to conduct the third assumption test, the multicollinearity test. The results of the multicollinearity test are presented as follows:

Table 4. Multicollinearity Test Results

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	Constant	-11.042	1.798		-6.140	.000		
	Appearance	.305	.065	.611	4.720	.002	.699	1.430
	taste	.203	.113	.276	1.804	.114	.501	1.997
	Texture	.531	.108	.721	4.897	.002	.541	1.850
	Slime	.465	.161	.465	2.880	.024	.450	2.224

Table 4 presents the results of the multicollinearity test, with VIF values less than 10. Based on the established testing criteria, the decision is to accept H_0 , concluding that there is no multicollinearity among the independent variables. The second method for testing independent variables is the F-test. The following table shows the Tests of Equality of Group

Means:

Table 5. Results of Tests of Equality of Group Means

	Wilks' Lambda	F	df1	df2	Sig.
Appearance	.809	2.367	1	10	.155
Smell	.788	2.688	1	10	.132
taste	.458	11.852	1	10	.006
Texture	.788	2.688	1	10	.132
Mold	.[a]				
Slime	.938	.667	1	10	.433

The results of the analysis to evaluate the equality of means for the tested variables are presented in Table 5. Since the significance value is less than 0.05, the taste variable indicates a difference within its group. On the other hand, the remaining four variables show no significant differences within their groups, as their significance values are greater than 0.05. After completing all discriminant assumption tests and meeting the necessary criteria, the analysis can proceed to the next stage. The results of the subsequent discriminant analysis are displayed in Table 6.

Table 6. Group Statistics Test Results

Product Type		Mean	Standard Deviation	Valid N (listwise)	
				Unweighted	Weighted
Low	Appearance	6.7500	1.50000	4	4.000
	Smell	7.0000	.81650	4	4.000
	taste	6.7500	.50000	4	4.000
	Texture	7.0000	.81650	4	4.000
	Mold	9.0000	.00000	4	4.000
	Slime	8.5000	.57735	4	4.000
High	Appearance	7.6250	.51755	8	8.000
	Smell	7.6250	.51755	8	8.000
	taste	7.7500	.46291	8	8.000
	Texture	7.6250	.51755	8	8.000
	Mold	9.0000	.00000	8	8.000
	Slime	8.7500	.46291	8	8.000
Total	Appearance	7.3333	.98473	12	12.000
	Smell	7.4167	.66856	12	12.000
	taste	7.4167	.66856	12	12.000
	Texture	7.4167	.66856	12	12.000
	Mold	9.0000	.00000	12	12.000
	Slime	8.6667	.49237	12	12.000

In Table 6, information is presented regarding the number of 12 fishery products, consisting of 4 products with low quality and 8 products with high quality. This table also includes key statistical data, namely both categories' mean and standard deviation.

Stepwise analysis was conducted to determine the variables to be included in the discriminant function. The results of the stepwise analysis show that there is only one step, indicating that only one variable was included in the model. The F-value is considered insignificant due to these variables. According to the analysis, taste is the only variable remaining in the model, while the other four variables, namely Appearance, Odor, Texture, and Sliminess, were excluded from the model because their significance values were greater than 0.05. On the other hand, the taste variable was included in the model for discriminant analysis, as its significance value was less than 0.05.

Previous studies by (Firnanda & Prastiwi, 2024), (Rozak & Utami, 2024), and (Wahyuni et al., 2024) also demonstrated a correlation between taste and product quality. This indicates that the quality of fishery products can be predicted based on the taste of the product.

The next step is to analyze the eigenvalues obtained, as shown in Table 7.

Table 7. Eigen Value

Function	Eigenvalue	% Variance	% Cumulative	Canonical Correlation
1	1.185[a]	100.0	100.0	.736

Table 7 presents the eigenvalues, where the canonical correlation is recorded at 0.736. This indicates that the established discriminant model can explain 54.2% of the variance in the predictor variables.

Table 8. Wilks' Lambda Value

Function Test	Wilks' Lambda	Chi-square	Degrees of Freedom	Sig.
1	.458	7.426	1	.006

Table 8 shows the Wilks' Lambda value is 0.458, with a Chi-square value of 7.426. The obtained Sig. The value is 0.006, which is less than 0.05. Based on the six independent variables analyzed, this indicates a significant difference between the two groups.

Table 9. Variables Entered into the Discriminant Function

Step	Entered	Wilks' Lambda							
		Statistic	df1	df2	df3	Exact F			
						Statistic	df1	df2	Sig.
1	taste	.458	1	1	10.000	11.852	1	10.000	.006

The variables to be used in the discriminant function are listed in Table 9. Only the taste variable is included in the discriminant function from the six independent variables used in this study, as shown in Tables 10 and 11.

Table 10. Canonical Discriminant Function Coefficients

	Function
	1
taste	2.108
Constant	-15.636

Table 10, which contains the canonical discriminant function coefficients, shows the coefficient values for each variable that forms the discriminant function. The effect of a variable on the quality of fishery products is positively correlated with the coefficient value of that variable.

$$Y = 15.636 + 2.108(Taste)$$

Based on the table, the resulting discriminant model is as follows:

Table 11. Function at Group Centroids

Product Type	Function
	1
Low	-1.405
High	.703

The mean centroid values of the two groups are shown in Table 10. The low-quality product group has a negative mean centroid value, while the high-quality product group has a positive mean centroid value.

Table 12. Classification Results

		Product Type	Predicted Group Membership		Total
			Low	High	
Original	Count	Low	4	0	4
		High	2	6	8
	%	Low	100.0	.0	100.0
		High	25.0	75.0	100.0

Table 12 shows that in the low-quality fishery product group, 4 products are correctly classified into this group, with a classification percentage of 100%. Meanwhile, in the high-quality fishery product group, 8 products were predicted to belong to this group, but only 6 products were correctly classified, with a classification percentage of 75%.

The taste factor influences the quality of fishery products because the sense of taste directly experiences taste and creates a strong personal experience. Consumers tend to choose products that provide taste satisfaction according to their preferences. Additionally, consumers often use taste as a primary indicator of product quality. A pleasant taste indicates the product was made with suitable materials and processes. The discriminant model used in this analysis has a classification accuracy rate of 83.3%, making it reliable for analyzing the quality of fishery products based on taste.

Based on Table 12, the APPER (Apparent Error Rate) can be calculated to determine the error rate in classification. The result of this calculation is 16.7%. Since the APPER value approaches 0, it can be stated that the classification model is accurate, and the discriminant function is effective enough in classifying the data.

Conclusion

1) Based on the results of the discriminant analysis, the following conclusions can be drawn:
2) There is a significant difference between high-quality fishery products and low-quality fishery products based on the six independent variables analyzed.
3) The taste variable is the main factor that differentiates the two groups.
4) The discriminant function equation derived is:

$$Y = 15.636 + 2.108(Taste)$$

   The centroid for the high-quality fishery product group was 0.703, and for the low-quality fishery product group, it was -1.405.

5) The accuracy of the discriminant function in classifying the quality of fishery products reaches 83.3%, indicating that this model is reliable for predicting the quality of fishery products.

Declaration of conflicting interest

The author declares that there is no conflict of interest regarding the publication of this article. The research was conducted independently, and no financial, personal, or professional relationships influenced the outcomes of this study. The findings and conclusions presented in this article are those of the author(s) alone.

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