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EVALUATION OF THE EFFECT OF DIFFERENT OVEN-DRYING DURATIONS ON THE DEFECT RATE OF MACKEREL CRACKERS USING A ONE-WAY ANOVA APPROACH

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Abstract

Mackerel crackers are a fish-based food product whose quality depends on a consistent production process, especially during oven drying. Inappropriate drying duration may cause defects such as cracking, poor expansion, excessive hardness, and non-standard color. This study evaluated the effect of oven-drying duration on the defect rate of mackerel crackers and identified the most effective drying time. A quantitative experimental design was used with one treatment factor: oven-drying duration at 180, 210, and 240 minutes. Each treatment had 10 replications, with 50 products observed in each replication, resulting in 1,500 samples. Data were analyzed using descriptive statistics, Shapiro-Wilk normality test, Levene's homogeneity test, One-Way ANOVA, and Tukey HSD at a 5% significance level. The results showed average defect rates of 18.8% at 180 minutes, 7.4% at 210 minutes, and 15.2% at 240 minutes. One-Way ANOVA showed a significant difference among the three drying durations, with $F = 53.434$ and $p = 0.000$. Tukey HSD confirmed that all treatment pairs differed significantly. The 210-minute duration produced the lowest defect rate and is recommended as the most effective oven-drying setting. This study supports practical quality control and strengthens the application of One-Way ANOVA in food product defect analysis.

Keywords: One-Way ANOVA, Tukey HSD, Oven-drying Duration, Mackerel Crackers

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INTRODUCTION

The fish-based processed food industry is facing increasing pressure to produce products that are not only acceptable in terms of taste but also consistent in physical quality. In mackerel cracker production, process consistency becomes an important issue because even slight variations in production stages may lead to defects, such as cracking, poor expansion, excessive hardness, or non-standard color. In the context of workplace practice and production activities, these conditions directly affect efficiency, as defective products reduce selling value, increase material waste, and make it more difficult for producers to maintain quality standards. Therefore, controlling the drying process is an important aspect that needs serious attention, particularly when drying is carried out using an oven with a specific duration.

Mackerel crackers are dry food products whose final quality is largely determined by the balance between raw materials and processing stages. Studies on fish crackers show that product quality can be assessed through moisture content, protein content, expansion ability, texture, color, crispness, and sensory acceptance. (Fauzi et al., 2022) emphasized that the characteristics of mackerel-based crackers are closely related to ingredient composition and the physical properties of the final product. Regarding raw materials, (Yuniarti et al., 2022) also demonstrated that different fish ingredients may produce different cracker characteristics, indicating that production variation must be controlled to maintain product uniformity.

Drying is one of the most important stages because it is directly related to moisture content, product expansion ability, and texture stability after further processing. In cracker products, insufficient drying may cause the product to fail to expand properly, while excessive drying may result in an overly hard texture. (Mulita et al., 2024) showed that variations in oven-drying temperature affected the quality of seaweed crackers, indicating that drying parameters must be carefully determined. (Rinaldi et al., 2023) also demonstrated that the cabinet drying method is relevant in cracker processing because it allows the drying process to be controlled more systematically. These findings strengthen the view that drying is not merely a technical stage, but a process factor that determines final product quality.

Although many studies have examined cracker quality in terms of ingredient formulation, moisture content, protein content, expansion ability, crispness, and organoleptic properties, research that specifically places oven-drying duration as the main factor affecting the defect rate of mackerel crackers remains limited. This gap is important because product defects are closely related

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to production practice, as they are directly visible in the final product and are associated with potential production losses.

Based on this research gap, this study aims to evaluate the effect of different oven-drying durations on the defect rate of mackerel crackers using the One-Way ANOVA approach. The drying durations tested were 180 minutes, 210 minutes, and 240 minutes, with defect indicators including cracking or breaking, poor expansion, excessive hardness, and non-standard color. Theoretically, this study strengthens the application of industrial statistics in food product quality control, particularly the use of One-Way ANOVA to compare defect rates across more than two treatments. Practically, the findings are expected to help producers determine a more appropriate oven-drying duration so that process decisions are not based solely on production habits, but are also supported by empirical data and statistical analysis.

LITERATURE REVIEW

Mackerel crackers are dry fish-based food products made from starchy ingredients with the addition of mackerel fish as a source of flavor and protein. Conceptually, cracker quality is determined not only by ingredient composition but also by the stability of each processing stage. The quality characteristics of crackers generally include shape, color, expansion ability, crispness, texture, moisture content, and product uniformity. (Fauzi et al., 2022) explained that mackerel-based crackers have physical, chemical, and sensory characteristics that are influenced by ingredient formulation and the type of substitution used. (Muchtar, 2023) also showed that different fish concentrations in cracker sticks can affect moisture content, protein content, and organoleptic characteristics. Therefore, mackerel crackers can be understood as products whose quality strongly depends on the integration of raw materials, production processes, and controlled processing conditions.

Drying is the process of reducing moisture content in food materials so that the product becomes more stable and ready for further processing. In cracker production, drying plays an important role because it determines the product structure before frying, particularly in relation to expansion ability, texture, and color stability. Oven drying is considered more controllable than sun drying because both temperature and processing time can be regulated more consistently. However, inappropriate drying duration may still lead to quality problems. (Mulita et al., 2024) found that variations in oven-drying temperature affected the quality of seaweed crackers, indicating that drying parameters must

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be carefully determined. (Rinaldi et al., 2023) also showed that the cabinet drying method is relevant in cracker processing because it supports a more controlled drying process. The findings of (Yusnayadi et al., 2023) on dried food products further strengthen the view that drying methods can influence drying rate and final product quality.

Product quality refers to the ability of a product to meet predetermined standards, whether in terms of physical, chemical, or consumer acceptance aspects. In the context of mackerel crackers, quality can be observed through a low level of product defects, such as cracking or breaking, poor expansion, excessive hardness, and non-standard color. These defects indicate deviations from the expected product characteristics and may reduce selling value. (Purnama et al., 2022) emphasized that expansion ability and crispness are important indicators in evaluating the quality of fish crackers, while (Wiyono et al., 2023) positioned moisture content, expansion ability, and organoleptic testing as essential aspects of cracker quality assessment. (Suna et al., 2024) also used physicochemical and organoleptic indicators, such as moisture content, ash content, fat content, expansion ability, and sensory acceptance, to evaluate the quality of fish crackers. Based on these concepts, the defect rate can be positioned as a practical indicator that represents process failure in producing physical quality that meets the expected standard.

Production quality control is needed to ensure that the process runs consistently and produces products that meet specifications. In this study, quality control is directed toward identifying the effect of oven-drying duration on the defect rate of mackerel crackers. Theoretically, changes in production treatment may lead to differences in product characteristics, so they need to be tested quantitatively. (Alfatina et al., 2023) used One-Way ANOVA to analyze the effect of sodium tripolyphosphate concentration on payus fish crackers, while (Sumandiarsa et al., 2025) applied One-Way ANOVA to examine differences in proximate characteristics of fish-based products. (Masengi et al., 2025) also used One-Way ANOVA and Tukey's test to assess the effect of adding tuna fish protein concentrate on the characteristics of stick products. These studies indicate that statistical approaches can serve as an objective basis for comparing the effects of treatments on the quality of food products. (Novita et al., 2026) use One-Way ANOVA to shows that fish comparison affects the protein content of brittle products.

One-Way ANOVA is a statistical method used to compare the means of three or more groups based on one treatment factor. In this study, the treatment factor is oven-drying duration, consisting of 180 minutes, 210 minutes, and 240

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minutes, while the response variable is the defect rate of mackerel crackers. The use of One-Way ANOVA is appropriate because this study involves only one main factor but includes more than two treatment levels. If the ANOVA results show a significant difference, the analysis can be continued with the Tukey HSD test to identify which pairs of groups differ significantly. (Yuniarti et al., 2022) used one-factor ANOVA and post hoc testing in a study on fish cracker characteristics from different raw materials, while (Yuliantini et al., 2026) showed that One-Way ANOVA can be used to examine the effect of different cooking methods on the proximate composition of cracker-based products. Thus, the theoretical framework of this study positions oven-drying duration as the process factor, defect rate as the quality indicator, and One-Way ANOVA as the analytical tool to determine whether differences in defect rates among treatments are statistically significant.

RESEARCH METHOD

This study used a quantitative approach with an experimental research design. The experiment was designed to examine the effect of different oven-drying durations on the defect rate of mackerel crackers. The population in this study consisted of all mackerel cracker products processed through oven drying, while the observed samples were mackerel crackers produced under three drying-duration treatments: 180 minutes, 210 minutes, and 240 minutes. Since the research object was a food product rather than human respondents, the unit of analysis was each observed cracker product. Each treatment was repeated 10 times, with 50 products observed in every replication, resulting in 500 products for each treatment group and 1,500 total samples. The sampling technique used in this study was purposive experimental sampling, in which samples were selected based on predetermined treatment conditions that represented the drying durations being tested. Data were collected through direct observation by recording the number and type of defective products after each drying treatment. The observed defect categories included cracking or breaking, poor expansion, excessive hardness, and non-standard color.

The independent variable in this study was oven-drying duration, consisting of three treatment levels: 180 minutes, 210 minutes, and 240 minutes. The dependent variable was the defect rate of mackerel crackers, measured as the percentage of defective products by dividing the number of defective products by the total number of observed samples and multiplying the result by 100%. This study did not use an intervening variable because the analysis focused directly

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on the relationship between drying duration and product defect rate. The hypothesis tested in this study consisted of the null hypothesis (H0), which states that there is no significant difference in the mean defect rate of mackerel crackers among the oven-drying durations of 180 minutes, 210 minutes, and 240 minutes, and the alternative hypothesis (H1), which states that there is a significant difference in the mean defect rate in at least one of the oven-drying duration groups. The collected data were analyzed using descriptive statistics to summarize the defect rate in each treatment group. Before hypothesis testing, the Shapiro-Wilk normality test was applied to examine data distribution, and Levene's test was used to assess variance homogeneity. The main statistical test used was One-Way ANOVA at a 5% significance level to determine whether there were significant differences in defect rates among the three drying durations. When a significant difference was found, the analysis was continued with the Tukey HSD post hoc test to identify which treatment pairs differed significantly.

RESULTS AND DISCUSSION

The research data consisted of 30 observations divided into three groups of oven drying duration. Each group has 10 replicas and each replica consists of 50 products. Thus, each duration has 500 observed products and a total of 1,500 products observed.

Table 1
Product Defect Rate Recapitulation

Oven Duration	Number of Repetitions	Total Sample	Total Defects	Average	Standard Deviation	Minimum	Maximum
180 Minutes	10	500	94	18,8 %	3,01 %	14,0 %	24,0 %
210 Minutes	10	500	37	7,4 %	1,90 %	4,0 %	10,0 %
240 minutes	10	500	76	15,2 %	2,53 %	12,0 %	20.0 %

Source: Processed data by Excel. 2026

Table 4.1 show that oven-drying duration had a direct and significant effect on the defect rate of mackerel crackers. The 180-minute drying duration produced the highest average defect rate, namely 18.8%, with 94 defective products out of 500 observed samples. The 210-minute duration resulted in the lowest average defect rate of 7.4%, with 37 defective products, while the 240-minute duration showed an increased defect rate of 15.2%, with 76 defective products. These results indicate that the effect of drying duration on product

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defects was significant, but not linear in a purely positive direction. Increasing the drying time from 180 minutes to 210 minutes reduced the defect rate, whereas extending the duration to 240 minutes increased defects again. The One-Way ANOVA result confirmed this difference statistically, with F = 53.434 and Sig. = 0.000, which is below the 0.05 significance level. Therefore, the null hypothesis was rejected, meaning that there was a significant difference in the mean defect rate among the three oven-drying durations.

Table 2
ANOVA One-Way Test Results

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0,06792	2	0,03396	53,434	0,000
Within Groups	0,01716	27	0,000636	-	-
Total	0,08508	29	-	-	-

Source: Processed data by Excel. 2026

This study did not examine an intervening variable; therefore, no indirect effect was tested between oven-drying duration and the defect rate of mackerel crackers. The relationship analyzed in this research was limited to the direct effect of the independent variable, namely oven-drying duration, on the dependent variable, namely product defect rate. Since there was no mediating mechanism included in the research model, the comparison between direct and indirect effects could not be performed. However, the direct effect was sufficiently clear from the descriptive data, ANOVA results, and Tukey HSD post hoc test. The Tukey HSD results showed that all treatment pairs were significantly different: 180 minutes and 210 minutes differed by 11.4% with Sig. = 0.000, 180 minutes and 240 minutes differed by 3.6% with Sig. = 0.010, and 210 minutes and 240 minutes differed by 7.8% with Sig. = 0.000. These findings confirm that each drying duration produced a different level of product defects.

Table 3
Tukey HSD Advanced Test Results

Comparison of Drying Duration	Mean Difference	Sig.	Interpretation
180 minutes – 210 minutes	11,4 %	0,000	Significantly different
180 minutes – 240 minutes	3,6 %	0,010	Significantly different

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210 minutes – 240 minutes	7,8 %	0,000	Significantly different

Source: Processed data by Excel. 2026

The findings indicate that oven-drying duration is an important process factor in determining the physical quality of mackerel crackers. In the theoretical framework of food product quality control, drying is closely related to moisture reduction, texture formation, expansion ability, and product stability. The high defect rate at 180 minutes suggests that the crackers had not reached an optimal drying condition, which caused poor expansion to become the dominant defect. In contrast, the 240-minute duration showed a higher tendency toward excessive hardness, indicating that over-drying can reduce physical quality even though the product becomes drier. The 210-minute duration provided the most balanced drying condition because it produced the lowest defect rate. This supports the idea that process quality should be controlled through measurable parameters rather than relying only on production habits.

These findings are consistent with several previous studies showing that drying parameters and processing treatments affect cracker quality. (Mulita et al., 2024) found that oven-drying temperature influenced the quality of seaweed crackers, while (Rinaldi et al., 2023) showed that controlled drying through cabinet drying was relevant in cracker processing. The results also align with (Yusnayadi et al., 2023), who reported that drying methods affected the drying rate and quality of dried food products. In terms of quality indicators, the present findings are also in line with (Purnama et al., 2022; Suna et al., 2024; Wiyono et al., 2023) who emphasized moisture content, expansion ability, texture, and organoleptic characteristics as important aspects of cracker quality. However, this study differs from many previous studies because it focuses specifically on product defect rate as the main quality indicator, rather than formulation, protein content, sensory acceptance, or proximate composition.

Theoretically, this study strengthens the application of industrial statistics in food product quality control, particularly by using One-Way ANOVA to evaluate differences in defect rates across more than two treatment levels. The findings also extend the discussion of cracker quality by positioning product defects as a practical indicator of process performance. From a practical perspective, the results suggest that mackerel cracker producers should use an oven-drying duration of approximately 210 minutes under similar process conditions, as this duration produced the lowest defect rate. The study also highlights the need for producers to control drying time and oven temperature consistently to avoid under-drying and over-drying. By using defect data and

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statistical testing, production decisions can become more objective, efficient, and aligned with quality control principles.

Synthesis of Main Discussion Points

The analysis indicates that different oven-drying durations produce different effects on the defect rate of mackerel crackers. And also from a statistical perspective, the main objective of this study has been achieved. Therefore, this study not only identified differences in defect rates across drying durations, but also determined the most appropriate drying duration based on experimental data.

The synthesis of the discussion suggests that oven-drying duration should not be determined merely by production habits or informal estimation. Instead, it should be managed through measurable process control. The recommended production policy is to apply an oven-drying duration of approximately 210 minutes under a similar temperature range, namely 59–61°C, because this duration provides a better balance between moisture reduction and texture formation. In addition, producers are advised to record product defects consistently so that quality deviations can be detected and corrected more quickly.

CONCLUSION

This study concludes that differences in oven-drying duration lead to significant variation in the defect rate of mackerel crackers. The 180-minute drying duration produced the highest defect rate at 18.8%, mainly because the product had not reached an optimal drying condition and was more likely to show poor expansion. Meanwhile, the 240-minute duration resulted in a 15.2% defect rate, with excessive hardness becoming the main tendency. Among the three treatments, the 210-minute drying duration provided the most favorable outcome, as it generated the lowest defect rate at 7.4%. The One-Way ANOVA result, with F = 53.434 and a significance value of 0.000, confirms that the mean defect rates among the three drying durations differed significantly. From a theoretical perspective, this study strengthens the use of One-Way ANOVA in food product quality control, particularly for comparing the effects of processing treatments on product defects. In practical terms, the findings offer a data-based recommendation for mackerel cracker producers to apply an oven-drying duration of approximately 210 minutes under similar processing conditions. Future studies are encouraged to include additional variables, such as oven temperature, dough thickness, initial and final moisture content, ingredient

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composition, frying duration, and consumer organoleptic evaluation. A mixed-method approach may also be considered so that quantitative defect analysis can be complemented by consumer-based quality assessment.

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