The socio-economic effect on microplastic pollution of boiled salted fish

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Abstract. Boiled salted fish is one of the favorite fish processing commodities in Bogor. Every year its production increase in line with potential health hazards for consumers, one of which is caused by contamination of raw materials by microplastics. The socio-economic of people were suspected of having influenced the occurrence of the contamination. The study area took place in Bogor, aiming to analyze the correlation between socio-economic and microplastic contamination in boiled salted fish. The purposive sampling method was used in this study on 150 consumers representing gender, age, education, occupation, and income. The result was analyzed with descriptive and inferential statistics using the likelihood ratio, wald, and odds ratio test to determine which variables had the most influence. The analytical results showed that the variables of gender and education had a significant correlation (95%) with 0.5-7 times of risk. It is shown in the wald result, and the odds ratio is 2.619-17.182 (more than $\chi^2$ value) and 0.453-7.044. It can be concluded that the potential of microplastic contamination in boiled salted fish correlated with gender and level of education and can be controlled by enhancing the understanding of gender groups through improving public education to a higher level.

1. Introduction
Boiled salted fish is fish processed by boiling and adding salt as a flavor enhancer. It is prevalent among the wider Bogor community because of its delicious taste and low price. Boiled salted fish production reached 16,363.47 tons in 2018 [1,2]. Increasing production of boiled salted fish followed by potential consumer health hazards due to contamination of raw materials, such as microplastic, reported by [3] Microplastic intake in humans can impact the immune system and cell condition [4,5] even in low doses [6]. Microplastics are degradation products of macroplastics due to exposure to sunlight and reactions to the aquatic environment [7]; they have a particle size lower than 5 mm.

Indonesian waters are polluted with plastic [8,9,10], accumulating 0.48-1.29 million tons/year [11]. Dwiyitno et al. [12] added that plastic waste in Indonesian waters was dominated by packaging and consumer products waste with a concentration of around 257-1,280 items/km². The socio-economic...
conditions of people affect consumption patterns and behavior, such as the way people choose packaging materials and dispose of them. It will contaminate boiled salted fish in two ways. The first way is that fish will consume microplastic waste because fish consider it food. The second way is that flakes of microplastics waste will be carried into the salt as raw material for boiled salted fish and stick to and enter the fish body [3]. Research by Gunawan et al. [3] reported that as much as 0.02-0.07 MP/g of microplastics were migrated to boiled salted fish due to the addition of salt during the production process. It is higher about 10-19% than that found in raw fish [6].

Socio-economic related to people's concern for the environment need various tools to make this happen, such as law enforcement, adequate infrastructure, and educational programs [13]. The behavior and understanding of the community in managing plastic waste, especially in Bogor, which is still not environmentally friendly, is thought to be due to several socio-economic factors such as age, gender, education level, occupation, income, and knowledge about the environment. Socio-economic factors play an essential role in the emergence of pollution through waste disposal. Concerning the microplastic contamination studied in this research, socio-economic factors trigger the emergence or reduction of the potential for microplastic contamination in boiled salted fish. This study aimed to find out the correlation between socio-economic and microplastic contamination in boiled salted fish.

2. Research Methods

Quantification of microplastic in boiled salted fish is not carried out here, instead referring to the research that has been carried out by Gunawan et al.[3], Barboza et al. [6], and Dwiyitno et al.[14].

2.1. Time and study area

This research was carried out in Bogor (City and Regency), West Java Province, to consumers of boiled salted fish from August 2020 - March 2021.

2.2. Questionnaire design

The variables that affect the relationship between socio-economic factors and the potential for microplastic pollution need to be analyzed first. Then these variables are translated into questionnaire questions to make it easier to record the expected socio-economic information.

Each variable was grouped into independent and dependent variables. The independent variables consist of gender, age, education, occupation, and income per month of the respondent. Gender was grouped into man and woman. Age was divided into 25-34 years, 35-44 years, and 45-54 years. Education was grouped into basic (primary school), middle (secondary school), and high (university). Occupations were grouped into formal (permanent workers/employees) and non-formal (self-employed/independent workers). Income was grouped into low (< IDR 2,000,000), middle (IDR 2,000,001 - 4,000,000) and high (> IDR 4,000,000) [15]. Knowledge variable was added to know the basic knowledge of respondents related to microplastics contamination. It is defined into category 0 represents poor knowledge, and category 1 indicates good knowledge (Table 1).

| No | Environmental Knowledge | Yes | No |
|----|--------------------------|-----|----|
| 1  | Know about microplastic  | 1   | 0  |
| 2  | Know the difference between plastic and microplastic | 1 | 0 |
| 3  | Attend training/seminar about plastic pollution | 1 | 0 |
| 4  | Finding out independently about the use of plastic | 1 | 0 |
| 5  | Knowing the negative impact of plastic on the environment and health | 1 | 0 |
| 6  | Knowing the presence of contamination (microplastic) in food | 1 | 0 |
| 7  | Perform pretreatment food to ensure no contamination | 1 | 0 |
| 8  | Knowing the presence of contaminants on food | 1 | 0 |
| 9  | Knowing the source of plastic pollution | 1 | 0 |
| 10 | Know how to prevent plastic contamination | 1 | 0 |
The dependent variable will measure people's behavior related to microplastic contamination. In this research, the dependent variable will be defined into two categories (0 and 1), where category 0 represents bad behavior, and category 1 expresses good behavior. Categorization of measurement scale the behavior of people is in Table 2.

| No. | Behavior related to microplastic contamination | Yes | No |
|-----|-----------------------------------------------|-----|----|
| 1   | Reducing using of goods that contain plastic materials | 1   | 0  |
| 2   | Use eco-friendly bags when carrying goods or shopping | 1   | 0  |
| 3   | Reused waste after sorting | 1   | 0  |
| 4   | Recycling plastic waste | 1   | 0  |
| 5   | Sold to second hand goods buyer | 1   | 0  |
| 6   | Directly disposed waste to garbage dump | 0   | 1  |
| 7   | Hoarded waste | 0   | 1  |
| 8   | Burned waste | 0   | 1  |
| 9   | Thrown into the sea/river/seat | 0   | 1  |
| 10  | Disposed of carelessly will pollute the environment | 0   | 1  |

2.3. Reliability and validation testing of questionnaires
The prepared questionnaire was then tested for reliability and validity. Question items are reliable if the answers of respondents are consistent. Measuring the question reliability using the Cronbach Alpha ($\alpha$) tools facility of SPSS software. A question or variable is reliable if it gives a Cronbach Alpha value > 0.60 [16]. Validity testing was used to measure the validity of the questionnaire items. The questionnaire is said to be valid if the questionnaire questions can reveal something to be measured. Measurement level of validity can be done by looking for a correlation between the scores of each question item and the total score.

2.4. Respondent survey
The respondent survey was conducted on 150 consumers of boiled salted fish. The number of respondents was calculated by following guidelines of Roscoe [17] for determining sample size, that is: (1) sample size is between 30 and 500; (2) If the sample is broken down into subsamples (male/female, junior/senior, etc.), the minimum sample size is 30 for each category. Additionally, Fraenkel et al. [18] suggest a minimum sample size of 50 for correlational research.

2.5. Data analysis
Using IBM SPSS version 19 software.

2.5.1. Descriptive analysis
The descriptive analysis is presented in the form of a cross-tabulation between the dependent variable and the independent variable. Descriptive analysis will generally explain the relationship between age, gender, education, occupation, and income with microplastic pollution related to boiled salted fish.

2.5.2. Inferential analysis
Inferential analysis to explain the effect on each of the dependent variables used on the independent variables. Inferential analysis in this study uses a logistic regression approach. Its approach was to see how gender, age, education, occupation, and income influence microplastic pollution in boiled salted fish.

The Likelihood method uses to estimate the parameters (value) by maximizing the likelihood function. In estimating these parameters, the G test statistic is used for the simultaneous test and the Wald test statistic for the partial test with 5% alpha [19]. The hypotheses used are $H_0 : \beta_1 = \ldots = \beta_p = 0$, it means that there is no effect of the explanatory variable on the response variable; and $H_1$: at least one
\( \beta_p \neq 0 \), it means that at least one explanatory variable affects the response variable, for \( j = 1,2,\ldots,p \). \( H_0 \) is rejected if \( G > \chi^2(p, \alpha) \) or \( p\text{-value} < \alpha \) [19]. If the simultaneous test results in a decision to reject \( H_0 \), it will be continued with partial parameter testing. The \( W \) statistic follows a standard normal distribution. The decision rule is: \( H_0 \) is rejected if \( |W_{\text{count}}| > Z_{\alpha/2} \). If \( H_0 \) is rejected, the parameter is statistically significant at the significance level is \( \alpha \).

2.5.3. Odds Ratio

The odds ratio is used to determine the risk of the tendency to experience certain events between one category and another on a variable. The odds ratio is defined as the ratio of the direction of the influence of variables in the category \( x = 1 \) is \( n \) times compared to variables with the category \( x = 0 \). In contrast, for the explanatory variable on a continuous scale, the coefficient \( \beta \) shows a change in the log odds for each change of one unit \( x \) variable.

In this study, the odds ratio was used to determine socio-economic variables that influenced the behavior of Bogor people related to the emergence of microplastic contamination in boiled salted fish.

3. Result and Discussion

3.1. Socio-economic condition of respondents

Respondents interviewed were resided around Bogor (City and Resident), which are spread over 32 sub-districts. The composition of respondents from the descriptive analysis results is in Table 3.

| Table 3. Percentage of respondents by the independent variable |
|-------------------------------------------------------------|
| Gender | Age (year) | Education | Occupation | Income |
|--------|------------|-----------|------------|--------|
| Man    | 25-34      | Low       | Formal     | Low    |
| 75     | 64         | 36        | 73         | 38     |
| Woman  | 35-44      | Mid       | Non-Formal | Mid    |
| 75     | 63         | 56        | 77         | 77     |
|        | 45-54      | High      |           | High   |
|        | 23         | 58        |           |       |
|        |            |           |           |        |
| Amount (people) | 64 | 36 | 73 | 38 |
| Percentage (%) | 43 | 24 | 39 | 51 |

Based on Table 3, if the respondents were categorized by gender, each has the same percentage of 50%. The percentage range of respondents based on age, education, occupation, and income were 15-43%, 24-39%, 38-51%, and 35-77%.

![Knowledge level of microplastic contamination in general by education](a)

![Knowledge level of microplastic contamination by education](b)

**Figure 1** (a). Knowledge level of microplastic contamination in general (b) by education

In addition to socio-economic conditions, knowledge about microplastic contamination was also recorded. At this stage, respondents (for \( N=150 \)) still lacked knowledge or were unaware of microplastic contamination and its potential sources, especially in boiled salted fish (Figure 1a). The average value
of positive answers (=1) is indicated by as much as 40% (60 out of 150). However, suppose the survey results are categorized by education level, it can be seen that the group with poor knowledge of microplastics contamination is respondents with basic (primary school) and secondary (high school) education levels, with the number of positive answers being 6% (2 of 36) and 30% (17 of 56). Respondents obtained the highest score with a higher education group (university) with a percentage value of 71% (41 out of 58). Based on this information, it can conclude that higher education will increase respondents’ knowledge about microplastic contamination and all its potential source, as shown in Figure 1b.

3.2. Inferential analysis

3.2.1. Simultaneous test (Likelihood ratio test)

The respondent survey data was processed to determine the effect of several independent variables (socio-economic) on the dependent variable (people's behavior that can be a source of pollution in boiled salted fish). The effect of the independent variable on the dependent variable was tested with a simultaneous test. The test results are presented in Table 4.

| Model     | -2 Log likelihood | Chisquare | df | Sig. |
|-----------|-------------------|-----------|----|------|
| Logistic  | 170,987           | 23,859    | 5  | 0.000|

Based on the simultaneous test output shown in Table 4, we can be seen a significant value is 0.000 (less than 0.05). If we relate to the hypothesis, the conclusion is $H_0$ is rejected. It means that at least one independent variable influences people's behavior with sources of microplastic contamination.

3.2.2. Partial test (Wald test)

Furthermore, to determine which independent variables (socio-economic) affect the response variable (people behavior), a partial parameter coefficient test is carried out, namely the Wald test. The Wald statistics results can be seen from the table of output variables in the equation in the SPSS output windows. The Wald value output is briefly shown in Table 5.

| Independent sub-variable | $\beta$ | Wald  | df | Sig. |
|--------------------------|--------|-------|----|------|
| Man                      | 0.791  | 4.455 | 1  | 0.035|
| Woman                    | 0      | >0.05 |    |      |
| 45-54 years              | 4.948  | 2     | 0.084|
| 35-44 years              | 2.784  | 1     | 0.095|
| 25-34 years              | 0.596  | 1     | 0.440|
| Higher education         | 15.564 | 2     | 0.000|
| Middle education         | 1.952  | 15.564| 1  | 0.000|
| Basic education          | 0.961  | 4.607 | 1  | 0.032|
| Non-formal               | 0.009  | 1     | 0.922|
| Formal                   | 0.003  | 1     | 0.958|
| High income              | 4.545  | 2     | 0.103|
| Middle income            | 3.728  | 1     | 0.054|
| Low income               | 3.335  | 1     | 0.068|

Based on Table 5, the sub-variable Man has a significance value smaller than $\alpha = 0.05$ and value of the Wald greater than $\chi^2_{(1;0.05)} (=3.841)$, it meant sub-variable Man has a significant effect and correlates with microplastic contamination in boiled salted fish. The sub-variables 25-34 years, 35-44 years, and 45-54 years have a significant value higher than $\alpha=0.05$ and the Wald smaller than the value of $\chi^2_{(1;0.05)}$.
(=5.991), it meant variable age for all sub-ranges has not a significant effect and does not correlate with microplastic contamination in boiled salted fish. The sub-variables High, Middle, and Basic education has a significant value more petite than $\alpha = 0.05$ Wald values are greater (High and Middle education) when compared to the value of $\chi^2_{(2;0.05)} (=5.991)$, it means the education variable (middle and high) has influence and correlates with microplastic contamination in boiled salted fish. All the occupation and income sub-variable have a significance value higher than $\alpha = 0.05$ and Wald value smaller than the value of $\chi^2_{(1;0.05)} (=3.841)$, it means the all occupation and income sub-variable has no significant effect, and not correlates with microplastic contamination in boiled salted fish.

Based on the overall Wald test result, the chances of the emergence of better behavior in the Bogor community regarding the potential for microplastic contamination in boiled salted fish will be of high value if public education increases (middle and high school will be much better) or in other words, people with higher education and understand the dangers of microplastic contamination will reduce the potential danger in case of microplastic contamination in boiled salted fish.

### 3.2.3. Risk comparison (Odds ratio)

The value of the odds ratio in this study shows the magnitude of the tendency of peoples, in this study which has the potential to be a source of microplastic contamination in boiled salted fish. The value of the odds ratio can be seen from Exp ($\beta$) in Table 6.

| Independent sub-variable | $\beta$ | Exp($\beta$) |
|--------------------------|--------|--------------|
| Man                      | -0.791 | 0.453        |
| High education           | 0      | 0            |
| Middle education         | 1.952  | 7.004        |
| Basic education          | 0.961  | 2.614        |

The statistical tests show that the sub-variable Man influences community behavior, especially the source of microplastic contamination in boiled salted fish. The value of ($\beta$) is less than one means that the Man tends to have a risk of bad behavior $0.453 (\approx 0.5)$ times when compared to the woman group.

This result is different from Beni et al. [13], which concludes that the behavior of respondents towards environmental pollution is not influenced by gender and is in line with the concept of Lippa [20], which says that stereotypes about men and women differ on some personality traits. Women appear more puts forward feelings; men appear more logical [21]. Lippa [20] stated that women's characteristics are closer to caring for the environment, such as concern for the environment, diligence in caring for the environment, responsiveness to environmental needs, and compliance with future sustainable environmental regulations. Very different from the man characteristics, which are contrary to environmental conditions and problems.

According to Kerlinger [22], interaction means cooperation between two independent variables influencing a dependent variable. In this study, there was an interaction between gender differences and knowledge about environmental concerns, which affected microplastic contamination to occur in food. It shows that knowledge about the environment is closely related to the gender of respondents.

All educational sub-variable influence people's behavior concerning microplastic contamination in boiled salted fish, as shown in Table 6. The High education sub-variable has Exp ($\beta$) valueless than 1.000, which means that the High education sub-variable (university) has a behavioral tendency to become an influencer a source of microplastic contamination with low risk ($\approx 0$ times) compared to the Basic and Middle education groups. Middle and Basic Education sub-variable have a $\beta$ coefficient value and an Exp ($\beta$) value greater than 1, and it means that the Middle and Basic Education sub-variable tends to have more risky behavior as a source of microplastic contamination when compared to the High Education group with the potential $7.004 (\approx 7)$ and $2.614 (\approx 3)$ times of microplastic contamination.

The results of this study in the education variable are in line with the results of research by Beni et al. [13], which explains that respondents with a high level of education tend to have better behavior...
towards the environment when compared to respondents with a low level of education. Research by Saputro et al. [23] also concludes a positive and significant relationship between the level of education and the attitude of society's concern for the environment. The level of education will indirectly shape the character and behavior of the community. Dimyati and Mudjiono [24] suggest that education can improve people's cognitive, affective, and psychomotor abilities. Educated people will have more knowledge about pollution, determine attitudes, and prepare themselves and carry out movements to reduce the risk of pollution. Educated people will have knowledge that will influence their behavior [24].

4. Conclusion
The potential for microplastic contamination in boiled salted fish as much as 10-19% (compared to raw fish) positively correlates and has a significant effect with socio-economic factors (gender and education) with 0.5-7 times the potential risk in 95% significance. This condition can be controlled by increasing the understanding of gender groups by increasing public education quality to a higher level.

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