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The Properties of Waste Cooking Oil Soap with Avocado Waste Extract as Filler

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Abstract: The research investigated the production of bar soap formulation using waste cooking oil (WCO) and avocado waste extract as a filler to enhance its functional properties and provide additional benefits for human skin. The research involved refining WCO, extracting avocado seed and peel bioactive compounds, preparing the solid soap formulation, and conducting various tests to evaluate its pH, cleansing ability, organoleptic properties, and irritation potential. The results indicated that all of the soap formulations met Indonesia National Standard (SNI) for pH and exhibited comparable cleansing power to commercial soaps. Organoleptic tests revealed moderate levels of hardness, foam, odor, texture, and tight impression. Irritation tests identified WCO bar soap that four of six formulations did not cause skin irritation. Overall, the WCO bar soap containing 10% (w/w) avocado peel extract, demonstrated promising properties and met all the established criteria. Future research should focus on characterizing specific chemical compounds in the soap, exploring additional natural extracts with antioxidant and anti-allergic activities, and further analysis quantitatively is required to ensure the product's quality and clinical efficacy.

Keywords: Avocado waste extract, Cleansing ability, Organoleptic test, Soap formulation, Waste cooking oil.

Introduction

Waste cooking oil (WCO) notably resulted from a product of used oil derived from domestic and industrial culinary (Azhar et al., 2024; Azme et al., 2023). WCO is produced from the frying process at high temperatures after several cycles of utilization. WCO contains hazardous chemicals that, when handled inappropriately, potentially pollute the water and soil environment and cause human health problems. WCO is widely produced by countries with high populations (Azhar et al., 2024; Foo et al., 2022). WCO has been utilized to recycle environmentally friendly and economical products with special techniques to overcome the impact of this waste. Some of the reported utilisations of WCO include being used as a green solvent, raw material for making biodiesel, bio-asphalt, and surfactant (Foo et al., 2022). The use of waste cooking oil to make soap is a sustainable option because it creates no waste and requires minimal energy (Azme et al., 2023). Soap is biodegradable, which can generate income for villagers and homemakers. Soap production has economic and environmental benefits and can educate the community about environmental awareness and waste recycling (Azme et al., 2023).

One of the products produced by WCO is an environmentally friendly soap for personal hygiene purposes (Azhar et al., 2024). Several prior studies show waste cooking oil-based soaps have advantages regarding stain-cleaning ability. Therefore, waste cooking oil soap is applied to soap for washing clothes or cutlery (Abera et al., 2023; Hartini et al., 2021). Waste cooking oil soap will have another beneficial value when added with bioactive substances from natural products, so waste cooking oil soap is not only applied as a cleaner for clothes or cutlery, but also safe and has more benefits for human skin such as antioxidants, anti-aging, and emollient (Ahmed et al., 2020).

Avocado peels and seeds are disposed of during industrial processing and daily consumption (Zaki et al., 2020). However, peels and seeds appeared typically disposed of as useless when consumed or processed, causing environmental waste problems (Zaki et al., 2020). Recovering valuable plant compounds from food industry waste, such as avocado peels and seeds, is an economical and eco-friendly approach (Zaki et al., 2020). These by-products are abundant in antioxidants such as phenolics, carotenoids, and flavonoids, making them valuable resources for producing functional foods, nutritional supplements, or cosmetics (Zaki et al., 2020). Avocado seed and peel waste have some fatty acid content. Avocado seeds are composed of 17-19% palmitic acid, 22-24% oleic acid, and 35-38% linoleic acid, whereas avocado peels contain 15-16% palmitic acid, 4.8-5.7% palmitoleic acid, 0.2-0.4% stearic acid, 68-69% oleic and vaccenic acids, 8-10% linoleic acid, and 0.16-1.1% linolenic acid (Ramadan & Farag, 2022). The oleic acid in avocado seeds can improve skin permeability, aiding in the delivery of additional nutrients or moisturizers in soaps (Charles et al., 2022).

It is widely recognized that avocado waste is a material that contains bioactive compounds with biological properties such as polyphenolic compounds and antioxidant activity (Jimenez et al., 2020; Ong et al., 2022). Phenolic compounds are more abundant in the avocado seed and peel (Jimenez et al., 2020). Avocado seed contains procyanidin B1, hydroxycinnamic acid, while avocado peel contains procyanidin B2, chlorogenic acid (Jimenez et al., 2020; Ramadan & Farag, 2022). Phenolic compounds in seeds are grouped into many classes, such as phenolic acids (hydroxybenzoic and hydroxycinnamic acids), phenolic alcohol derivatives, flavonoids, catechins, and tannins (Jimenez et al., 2020; Ramadan & Farag, 2022). Other non-polar compounds contained in the seeds are polyhydroxylated fatty alcohols. It has been shown that polyhydroxylated fatty alcohols in avocado seeds can play an essential role as photoprotective agents in skin damage caused by UV rays (Martín-del-Campo et al., 2023). It is noted that the concentration of phenolic compounds in avocado skin is higher than in avocado seed in raw extract. The polyphenolic compounds contained in avocado peels are hydroxybenzoic acid, hydroxycinnamic acid, flavan-3-ols, catechins and epicatechins, procusinidin dimer, and quercetin (Martín-del-Campo et al., 2023; Ramadan & Farag, 2022).

This study aims to determine the optimum formulation of solid soap made from waste cooking oil with avocado waste extract added as a filler. Avocado waste is extracted simply by utilizing the waste cooking oil solvent. Furthermore, the soap was made based on several formulations, and several tests were carried out, such as pH, cleansing ability test, organoleptic test, and irritation test. This solid soap formulation is expected to contribute to developing a high-value product from waste cooking oil soap.

Method

Refining of Waste Cooking Oil

Waste cooking oil refining aims to remove impurities and carcinogenic substances contained in waste cooking oil. This waste cooking oil is then used to extract the oil content in avocado seeds and peels. The refining of waste cooking oil follows this procedure. Waste cooking oil is obtained from waste oil used by households and fried food vendors. Waste cooking oil is filtered to separate the oil from food residue, then heated until 80℃. The heating of the waste cooking oil was continued with the addition of activated carbon and cooked for 30 minutes. After that, the heating was stopped, and the activated carbon was left submerged in the oil for 24 hours to adsorb the dirt. Then, the oil and activated carbon were filtered using filter paper (Hartini et al., 2021). Waste cooking oil refining continued using Na_2CO_3 to absorb some of the oil color and residual impurities with the help of heating until the foam from the Na_2CO_3 disappeared. After that, the oil and Na_2CO_3 sediment is filtered again using filter paper (Gharby, 2022).

Extraction of Avocado Seeds and Peels Using Waste Cooking Oil Solvent

Extraction is one of the chemical separation techniques used to separate one or more compounds in a sample based on phase differences or solubility using a suitable solvent as a separating agent. Avocado peels and seeds waste is obtained from fruit juice sellers, which is then extracted conventionally with waste cooking oil (WCO) as the solvent. The production of avocado peels and seeds extract utilizes WCO as an organic solvent to extract the fatty acid and bioactive compounds in avocado seeds and peels. The conventional method used in extracting avocado seeds and peels waste is through a heating process with the following steps. First, the avocado peels and seeds are washed with water and cut into small pieces. Next, avocado peels and seeds are dried in an oven for 6 hours at 70-75^{o}C or roasted first and then dried in the sun for about three days. The dried avocado peels and seeds are blended into powder and put into WCO until soaked. The mixture is cooked for 30 minutes until the WCO changes color. After that, the oil was filtered using filter paper, and avocado waste extract was obtained.

Production of Bar Soap from Waste cooking oil with Avocado Seeds and Peels Extract

The preparation of bar soap from waste cooking oil with avocado seeds and peel extract involves a saponification reaction between oils with sodium hydroxide lye solution; then, the product is bar soap. The production of this soap uses the cold process method (without heating process), so it requires a curing process for 2-4 weeks until the soap solidifies and is not overly alkaline. In this study, several formulations of the bar soaps are shown in Table 1. Bar soap production uses a cold process. Various types of oils are then mixed and stirred until evenly blended according to the specified formulation. Then, a certain amount of sodium hydroxide solution was added as a reaction and stirred quickly until thick and well-blended. Finally, fragrance oil was added and stirred until well mixed (Sukeksi et al., 2021).

Table 1. WCO soap with avocado waste extract formulations

No.	Formulation 1	Formulation 2	Formulation 3	Formulation 4	Formulation 5	Formulation 6
1.	10% (w/w) WCO+ Avocado seeds extract	10% (w/w) WCO+ Avocado peels extract	10% (w/w) WCO+ Avocado seeds and peels extract	20% (w/w) WCO+ Avocado seeds extract	20% (w/w) WCO+ Avocado peels extract	20% (w/w) WCO+ Avocado seeds and peels extract
2.	70% (w/w) WCO	70% (w/w) WCO	70% (w/w) WCO	50% (w/w) WCO	50% (w/w) WCO	50% (w/w) WCO
3.	20% (w/w) Coconut oil	20% (w/w) Coconut oil	20% (w/w) Coconut oil	30% (w/w) Coconut oil	30% (w/w) Coconut oil	30% (w/w) Coconut oil
4.	25% (w/w) NaOH (*aq*)	25% (w/w) NaOH (*aq*)	25% (w/w) NaOH (*aq*)	25% (w/w) NaOH (*aq*)	25% (w/w) NaOH (*aq*)	25% (w/w) NaOH (*aq*)
5.	Fragrance Oil	Fragrance Oil	Fragrance Oil	Fragrance Oil	Fragrance Oil	Fragrance Oil

pH Test

The pH measurement of bar soap was carried out using the following steps. One gram of bar soap sample was measured and dissolved in 10 mL of water. The soap solution was then tested for pH using a digital pH meter (LAQUA Horiba PH-2000 Series). The pH value is recorded and adjusted to the applicable standard according to the Indonesian National Standard (SNI). According to SNI, the pH standard of bar soap is 9-11 (Diningsih et al., 2022; Sukeksi et al., 2021).

Soap Cleansing Ability Test

To assess the cleaning effectiveness of the prepared soaps, three drops of lubricant oil were applied to strips of filter paper. Each piece of filter paper was then immersed in a beaker glass containing each soap solution formulation. The filter paper was stirred vigorously for one minute, after which the filter papers were removed, rinsed with distilled water, and visually inspected for cleanliness. This process was repeated using commercial soap samples and regular WCO soap for comparison (Usman & Mukhtar, 2021).

Soap Organoleptic and Irritation Test

To evaluate the sensory properties and potential skin irritation of the solid soap made from waste cooking oil and avocado waste extract, a small-scale organoleptic and irritation test was conducted involving ten non-standard panelists. The panelists assessed the soap's odor, texture, tight impression, hardness, and foam production. The irritation test was conducted by panelists to provide information related to the effects felt after using solid soap from waste cooking oil and avocado waste extract. An irritating effect occurs if the panelist feels symptoms such as skin dryness, redness, itching, or burning 30 minutes after using the solid soap (Ircham et al., 2022; Sany et al., 2019).

Results and Discussion

Characteristic of Refined Waste Cooking Oil (WCO)

WCO refining involves two essential processes: neutralization using Na_2CO_3 and bleaching using activated carbon (Sukmawati & Sunarto, 2020). The results of oil blanching by activated carbon are observed based on checking the peroxide value using the titration method according to the AOCS-AOAC 965.33 standard (Abera et al., 2023; Mariana et al., 2020). The results of neutralization of waste cooking oil using Na_2CO_3 are observed based on checking the pH of the oil using a universal indicator. Data of the pH and peroxide values before and after refining waste cooking oil using activated carbon can be seen in Table 2.

Table 2. The WCO pH and peroxide value

Aspects	Before refining	After refining
pH	5	8
Peroxide value	22 meq O_2/kg	10 meq O_2/kg

The pH data indicates that the neutralization process effectively reduces the acidity of waste cooking oil. This occurs because the alkaline solution reacts with the free fatty acids present in the oil. Neutralization aims to separate the free fatty acids contained in waste cooking oil with the help of Na_2CO_3. By adding sodium carbonate (Na_2CO_3), the free fatty acids are separated and removed as a sediment, resulting in a less acidic oil. (Sukmawati & Sunarto, 2020). The bleaching process, specifically using activated carbon, effectively reduces the peroxide value of waste cooking oil. This indicates a decrease in free radical compounds like peroxide compounds. Activated carbon functions through adsorption, capturing and removing various substances, including peroxide compounds, metal particles, and other toxic compounds, from the waste cooking oil (Sukmawati & Sunarto, 2020). The appearance of waste cooking oil before and after refining can be seen in Figure 1.

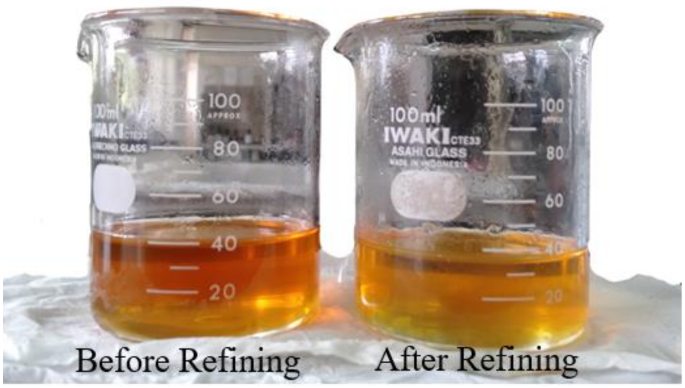


Figure 1. Discolouration of waste cooking oil in refining process.

The effectiveness of adsorption is directly linked to the surface area of the adsorbent. A larger surface area allows for greater adsorption capacity, leading to increased adsorption. By reducing the particle size of the carbonized adsorbent, its surface area can be significantly increased. This, combined with suitable surface functional groups, enhances the overall adsorption capacity (Haryanto et al., 2024). The adsorption process by activated carbon in the refining process of waste cooking oil involves physical adsorption. In chemistry, this interaction arises due to van der Waals forces. These van der waals forces are weak. When interacting with components in oil, adsorbents can adsorb organic contaminants with three types of interactions. First, activated carbon can experience electrostatic interactions with organic contaminants. Second, activated carbon can interact with parts of organic compounds that are polar (hydrophilic). Third, activated carbon can interact with parts of organic compounds that are nonpolar (hydrophobic) (Adegoke et al., 2023).

Characteristic of Avocado Seeds and Peels Extract

The appearance of several variations of avocado waste extract using WCO as the solvent can be seen in Figure 2. The description of each part in Figure 2 is: a) avocado seed extract; b) avocado seed and peel extract; c) avocado peel extract.

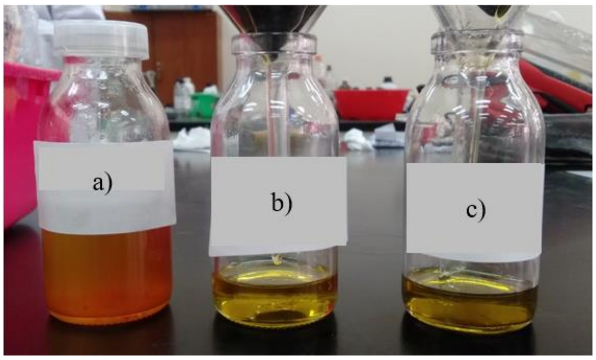


Figure 2. WCO with the addition of avocado waste extract.

The avocado waste extraction is a simple extraction marked by a change in the color of waste cooking oil (yellow) to an orange color in the extraction of the avocado seeds sample and a greenish color in the extraction of avocado peels and avocado seeds+peels sample. The difference in the apparent color between avocado seeds and avocado peels extract sample is due to the difference in the dominance of pigment compounds contained in avocado seeds and peels. Avocado seeds contain more carotenoid compounds that contribute to the orange color, while avocado skin contains more chlorophyll compounds that contribute to the greenish color (Oliveira et al., 2022; Tesfaye et al., 2022). Extracting bioactive compounds and other ingredients from plant materials is a crucial step in the process. Avocado waste extraction is included in solid-fluid extraction, which is the extraction or separation of metabolite compounds from solid material in the form of certain parts or all parts of plant material using certain solvents (Ong et al., 2022).

Analysis of Bar Soap from Waste Cooking Oil and Avocado Waste Extracts Tests

This soap made from avocado waste oil involves a saponification reaction between the triglycerides in the oil and NaOH lye solution, and the product is bar soap (Arasaretnam & Venujah, 2019). The bar hand soap samples from three variations of avocado waste extract are shown in Figure 3.

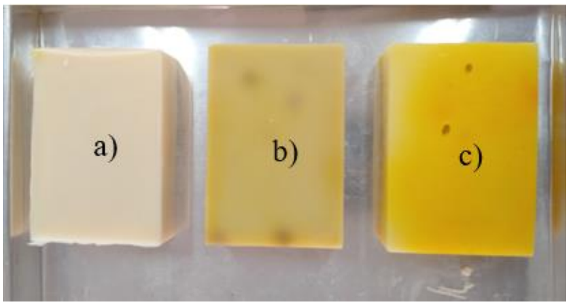


Figure 3. Sample of wco soap with avocado waste extract.

The description of each part in Figure 3. is: a) WCO soap with avocado seed extract; b) WCO soap with avocado peel extract; c) WCO soap with avocado seed and peel extract. Based on Figure 3, the addition of avocado waste extract in cooking oil soap does not actually cause a difference in the color of each soap sample. The original color of each soap is as in the soap labeled a). This was observed when the soap batter was formed. Therefore, the samples were given additional synthetic dyes to differentiate each sample based on its formulation so that the yellow and green colors in soaps b) and c) came from synthetic dyes.

Soap pH Testing

The soap pH test is conducted to ensure that the solid soap made is within the acidity level that is safe for the skin. According to the Indonesian National Standard (SNI), the pH of bar soap that is safe for the skin is 9-11

(Sukeksi et al., 2021). The pH value data obtained from each bar soap formulation from waste cooking oil and avocado waste extract are shown in Table 3.

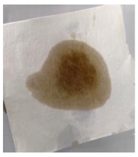
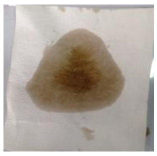
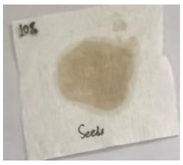
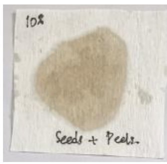
Table 3. pH of wco soap with waste avocado extract

Soap Compositions	pH	
	10% (w/w)	20 % (w/w)
WCO + Avocado Seeds Extract	9.88	9.80
WCO + Avocado Peels Extract	10.03	9.83
WCO + Avocado Seeds and Peels Extract	10.09	9.96

Based on the data in Table 2, all six bar soap samples have pH values that comply with SNI standards. Knowing the pH of soap is essential because soap with a high pH will cause dry skin and irritation. Under normal conditions, the skin's pH will return to normal 30 minutes after rinsing the skin from soap foam with water (Sany et al., 2019).

Qualitative Test of Soap Cleansing Ability

Table 4. Qualitative results of soap cleansing ability

Percents of WCO and waste avocado extract (w/w)	Cleansing Ability				
	WCO + Avocado Seeds Extract	WCO + Avocado Peels Extract	WCO + Avocado Seeds and Peels Extract	Commercial Soap	WCO Soap
0%	-	-	-	Before 	Before 
	-	-	-	After 	After 
10%	Before 	Before 	Before 	-	-
	After 	After 	After 	-	-
20%	Before 	Before 	Before 	-	-
	After 	After 	After 	-	-

The test of the cleansing ability of bar soap from waste cooking oil and avocado waste extract was carried out qualitatively by comparing the results of cleaning stains in the form of lubricant oil droplets using samples of WCO with avocado waste extract soap solution with the results of cleaning stains using commercial soap and regular WCO soap (without the addition of avocado waste extract) (Usman & Mukhtar, 2021). Each sample was tested for cleanliness on filter paper within 1 minute. The qualitative soap cleansing ability test results can be seen in Table 4.

Based on Table 3, the cleansing ability for all variations of solid soap from waste cooking oil and avocado waste extract shows results that are similar to waste cooking oil soap (without the addition of avocado waste extract). As for commercial soap, it looks cleaner (lifts more stains) than other soap samples, except for the sample with the formulation of 1) Waste cooking oil and 20% avocado peel and seed extract, and 2) Waste cooking oil and 10% avocado peel extract. Both waste cooking oil soap and 20% avocado peel and seed extract, as well as waste cooking oil and 10% avocado peel extract, have a cleansing ability that is close to the cleansing ability of commercial soap when viewed from the remaining stains that remain on filter paper.

Soap Organoleptic Test

Organoleptic tests were conducted on ten panelists aged 19-27 using a questionnaire with a 3-point Likert scale. Table 5 shows the results of the organoleptic test of soap from waste cooking oil and avocado waste extract.

Table 5. Organoleptic test of each soap formulation

Aspects	Soap Formulation						Description
	F1	F2	F3	F4	F5	F6	
Hardness	2,1	2,4	2,4	1,9	1,9	1,9	Low Level:
Amount of foam produced	2,2	2,2	2,3	2,4	2,2	2,1	$\bar{x} < 1,5$ Medium Level:
Odor	2,0	1,9	2,0	1,8	1,6	1,9	$1,5 \leq \bar{x} \leq 2,5$
Texture	1,9	2,0	2,3	1,6	1,9	2,0	High Level:
Tight Impression	2,0	2,3	2,4	2,0	1,9	2,0	$\bar{x} > 2,5$

The good and preferred waste cooking oil soap with avocado waste extract filler is a soap that has a medium level of hardness, amount of soap produced, odor, texture, and tight impression. In this organoleptic test, all soap formulations fell into the medium category for all aspects assessed. The hardness of the soap is affected by the amount of water in the soap. The more water in the soap, the softer the soap. Hard soap is more durable than soft soap. The amount of foam produced on the soap affects the process of transferring the scent from the soap to the human skin. Too much foam does not always indicate that the soap has a high cleansing power; it can cause the skin to become dry.

Conversely, too little foam is an indication of low cleansing power. Fragrance influences panelists' preference for the soap used. Overall, panelists reported that all soap formulations had a mild scent. In addition, the texture of the soap also affects the panelists' preference for the soap. Cold-process soap has a texture that is neither soft nor rough. A tight impression is assessed to ensure that there is no slippery or greasy feeling and that the skin of the hands feels tight after using the soap. Tight impression is one of the most critical parameters in soap as it affects the consumer's interest in choosing a soap.

Soap Irritation Test

Based on the soap irritation test results, 2 out of 10 panelists experienced symptoms of irritation with the soap used. One panelist reported that the Formulation 6 soap sample experienced slight itching symptoms 30 minutes after using the soap. The other panelist reported experiencing symptoms of slight redness on the skin 30 minutes after using the Formulation 5 soap sample. A person can experience allergic symptoms to soap products or surfactants based on the last product used (Ilomuanya et al., 2020). Based on these reports, it can be concluded that soap samples in certain formulations cause irritating effects on some people with a history of allergies. Several factors cause soap products to potentially cause irritating effects on the skin, including the overly strong alkaline nature of soap and fragrance oils incorporated into soap formulations (Ilomuanya et al., 2020).

The addition of quercetin compound concentration in soap formulations from waste cooking oil and avocado waste extract can be suggested to provide anti-allergic effects for the skin. Quercetin is one of the substances from the flavonoid polyphenol group, which is not only an antioxidant but also acts as an anti-inflammatory and anti-histamine (Jafarinia et al., 2020).

Conclusion

The production of solid soap from waste cooking oil and avocado waste extract filler has undergone a series of quantitative and qualitative test processes. Based on the soap pH test results, all soap samples started from formulations 1-6 meet SNI standards. Based on the results of the soap cleanability test, Formulation 2 (WCO soap with the addition of 10% (w/w) avocado peel extract) and Formulation 6 (WCO soap with the addition of 20% (w/w) avocado peel and seed extract) have almost the same cleanability as commercial soap. The results of the soap organoleptic test show that all soaps fall into the moderate category in terms of hardness level, foam produced, odor, texture, and tight impression. The results of the irritation test show that soap formulations that do not irritate are soaps with formulations 1-4. Overall, it can be concluded that solid soap with Formulation 2 is a soap that fulfills all the criteria of the pH test, cleansing ability test, organoleptic test, and irritation test.

Recommendations

The research is limited to the production of bar soap from WCO and avocado waste extract and qualitative tests, including small-scale cleansing ability tests and organoleptic and irritation tests. Future research is expected to be related to the characterization of specific chemical compounds, such as quercetin from waste cooking oil soap and additional natural product extracts with antioxidant and anti-allergic activities. In addition, quantitative testing of bar soap also needs to be further investigated so that the quality of bar soap can be more clinically tested and according to standards.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPSTEM Journal belongs to the authors.

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