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The efficacy of home-made soap from used cooking oil and pineapple waste for eco-friendly household product

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Abstract

As the human population increases globally, the waste production rate from various types of waste such as used cooking oil and fruit waste also increases. The development of this dish soap bar helps in spreading awareness for people not to discharge used cooking oil and fruit waste into the drainage system. Instead, one can opt to transform these waste products into soap. This study aims to develop a dish soap bar using used cooking oil and pineapple waste. The efficacy of the soap was evaluated following the eco-friendly product criteria. In this study, eight types of dish soap bars were developed with two variables namely concentration and type of pineapple parts. The whole parts of pineapple waste were prepared with 100%, 75%, 50%, and 0% concentration. Different parts with 100% concentrations were developed from peel, core, stem, and crown parts. The dish soap bar samples were evaluated for their efficacy based on pH value, moisture content, and foam height. It has been compared among samples, control, and commercial soaps. The commercial brand, Labour, has the highest foam height (6.61 cm) and pH value (10.53) and the sample core (Conc. 100%) showed the highest moisture content (12.19%). The significant value among samples, control, and commercial soap for each pH value, foam height, and moisture content was determined by using SPSS21 software. The pH value and foam height of the samples were highly significant ($F_{1,32} = 16.275$, $p < 0.001$). The moisture content also showed a significant difference ($F_{1,32} = 2.889$, $p < 0.05$). The Dunnett multiple methods were used to determine the most samples that were closed to control. Five samples were close to the control. Brine shrimp test the toxicity of the sample. The average survival rate of brine shrimp for the whole part (Conc. 50%) dish soap bar sample was 36.7%. The sensory evaluation proceeded to look at the overall acceptance of the sample among 50 respondents and from the evaluation, 36 respondents (72%) were very satisfied with the final product sample whole part (Conc. 50%).

1. Introduction

As the population of people around the world increases their capacity, it contributes to the increase of waste products that come from various types of waste such as used cooking oil (Avagyan and Singh, 2019). During the pandemic, the waste products from Malaysia contributed about 80% to the food and beverage industry whereas another 20% is left over from people's consumption (Jribi *et al.,* 2020). This trend an increased because of the demand for human consumption for their daily life through household and commercial kitchens. According to the National Report of Malaysia, the overall Malaysia contribution towards water pollution is about 79.56% and 8.28% of it comes from palm oil sources. Many food and beverage industries like hotels, restaurants, caterers, and many more produce hundreds of tons of used cooking oil without any planning or scientific methods to dispose of it properly (Filimonau and Gherbin, 2017).

In addition, the Food and Agriculture Organization (2011) stated that about 44% of global fruit waste is from fruits and vegetables. Because of these concerns, this study tried to reduce food waste by finding possible alternatives to produce new products. In other words,

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converting these wastes will help to reduce a negative impact on the environment by decreasing waste production. Recycling used cooking oil and fruit waste from household and commercial kitchens is one of the approaches to managing waste sustainably (Haldar *et al.,* 2022). Thus, the development of dish soap bars from used cooking oil and fruit waste as additive ingredients towards an eco-friendly household product can potentially help in recovering the environmental impacts.

Soap is a cleaning agent that can be produced by the hydrolysis process of fats in a chemical reaction known as saponification (Maotsela *et al.,* 2019). It is usually known as a worldwide advance that contributed to the basis of beauty products and cleanliness among people. Dish soap is one type of soap that is widely used in the community. Dish soap is a soap that is used to wash and clean up cutlery such as bowls, cups, spoons or forks, and other kitchen utensils in general.

The efficacy of dish soap bars developed from used cooking oil and pineapple waste towards eco-friendly household products is to recognize the consequences of developing dish soap bars on ecological, social, and economic benefits. The idea of this dish soap bar can help in spreading awareness for people not to discharge used cooking oil into the river instead of transforming it into soap. This is because the discharge of used cooking oil into the river will contaminate the water and disrupt the flora and fauna in the rivers (Singh *et al.,* 2019). This happens when the cooking oil floats on the surface of the water and a consequence of the shortage of oxygenation that prevents the passage of sunlight and photosynthesis cannot occur (Ratna *et al.,* 2021).

The development of dish soap bars also can help in biodiversity conservation (Tizzano, 2022). The used cooking oil and fruit waste become a problem to our environment because they can be recycled as the people are aware of the use of this waste which can generate their income. The discovery impact of this dish soap and its relationship with the waste can promote and increase awareness of the conservation of our environment. It also has an economic impact especially on the government in terms of reducing the cost to solve the rivers and water problems because of the pollution and contamination due to the oil and waste (Singh *et al.,* 2020). Besides, a lot of people can produce eco-friendly dish soap products by using this idea as an alternative to gain some money because it is a very easy and lower cost of production.

This study aimed to develop a dish soap bar using used cooking oil and pineapple waste from household products and to evaluate the efficacy of the soap following the good criteria of an eco-friendly product. The dish soap bar was developed from eight different formulations and the efficacy were tested on pH, foam height, and moisture content. The eco-friendly criteria were followed by the SIRIM eco-labelled from the SIRIM Eco-Labelling scheme criteria and the toxicity test was performed to prove the non-toxic criteria. The sensory evaluation ran to get the overall satisfaction among fifty respondents towards the soap.

2. Materials and methods

2.1 Raw materials preparation

The used cooking oil and pineapple waste were collected from the household and stored at Kuala Lipis, Pahang. The used cooking oil underwent treatment to increase the quality of the soap product. All the solid, inorganic materials and other contaminants were removed from the oil. First, the used cooking oil was heated at 60°C, and then the oil was allowed to cool at room temperature and proceed with the filtration process by removing larger materials with a tissue paper or cheesecloth-lined kitchen strainer lying on a container. The pineapple waste collected from the household kitchen and the parts of the fruit waste were rinsed with tap water followed by distilled water to remove the dirt on the surface of the fruit waste. Pineapple waste collected from the household was identified according to its appearance such as peel and crown. The pineapple waste was separated into different parts peel, core, crown, and stem. Next, the sample was stored at 4°C for the extractions.

2.2 Pineapple waste extraction

Pineapple waste was separated into peel, core, crown, and stem cut into small pieces (Gul *et al.,* 2021). A total of 500 g waste each part blended with 5 g of water to form 4 samples. Then, the step was repeated for the mixture of part wastes and 4 samples. The waste extraction was filtered and put into containers. The samples were put into the chiller while preparing the dish soap bar.

2.3 Dish soap bar preparation

All the sodium hydroxide (NaOH) flakes, pineapple waste extraction, and treatment used cooking oil were weighed according to Table 1 to form four types of samples with different concentrations. For different concentrations, the pineapple wastes were used from the combination of all parts including peel, core, stem, and crown (Table 2). The difference was only in their concentration of the pineapple wastes which were 100%, 75%, 50%, and 0% as shown in Table 1.

Dish soap bars develop by weighing sodium hydroxide (NaOH) flakes on a scale balance. Then, the

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flakes were put into the extract of pineapple waste slowly in the container. The solution was stirred using a whisk and spatula until it dissolved uniformly. The solution was kept cool for a while at a temperature of 45°C for 30 mins. Then, the solution was poured into the treatment using cooking oil. The mixture was stirred using a whisk followed by the mixer for around 10 mins. The mixture changed the colour to yellowish. Then, the mixture was weighed and transferred into the recycled plastic container. Lastly, the soaps were placed in the open air for 4 weeks before being tested and used (Félix *et al.,* 2017).

Table 1. The formulation of different concentrations of pineapple waste.

	Whole part (100%)	Whole part (75%)	Whole part (50%)	Whole part (0%)
Used Cooking Oil	300 g	300 g	300 g	300 g
NaOH Flakes	44 g	44 g	44 g	44 g
Water (W)	0 g	22 g	44 g	88 g
Pineapple Waste Extraction (PWE)	88 g	66 g	44 g	0 g

Table 2. The formulation of different parts of pineapple waste.

	Peel part (100%)	Core (100%)	Crown (100%)	Stem (100%)
Used Cooking Oil	300 g	300 g	300 g	300 g
NaOH Flakes	44 g	44 g	44 g	44 g
Water (W)	0 g	0 g	0 g	0 g
Pineapple Waste Extraction (PWE)	88 g	88 g	88 g	88 g

2.4 Dish soap bar efficacy test

Eight different samples of the dish soap bar and two types of commercial soaps were tested for their efficacy including foam height, moisture content, and pH. The eight samples included different parts such as the peel part (100%), core (100%), crown (100%), stem (100%), and different concentrations of whole part (100%), whole part (75%), whole part (50%), whole part (0%). This efficacy test was run triplicated.

2.5 Foam height test

According to the Ross-Miles foam height test method, 5 g of dish soap were grated into a piece and put into the grinder with 100 mL distilled water to form a lather. Then it was transferred into the beaker and the height of the foam was measured (Müller and Schiedeck, 2018).

2.6 Moisture content test

By using moisture analyzer MX-50, the sample soap with pineapple waste was analyzed and data moisture content was recorded. 2 g of solid soap was grated into the aluminum pan and was set up for 110˚C (Benjamin and Abbass, 2019).

2.7 pH test

For pH measurement, 1 g of solid soap was dissolved in 10 mL distilled water. This was designed to prepare 10% of the soap solution. The pH of the soap solution was calculated using a pH meter (Arasaretnam and Venujah, 2019).

2.8 Statistical analysis

Statistical analysis was carried out using one-way ANOVA in SPSS 21 to assess the efficacy of the dish soap bar compared to the commercial dish soap (Labour and Axion) and control. The control data were taken from a literature review and the commercial dish soap bar underwent a survey to figure out two types of common dish soap bars used by people. Descriptive statistics (mean, standard deviation, and percentages) were performed, and statistical differences were tested between the samples. The significance value was set as $P<0.05$.

2.9 Dish soap bar eco-friendly test

Brine shrimp tests were referred from Iqbal *et al.* (2017) with a slight modification of the volume of the water waste sample. By using the brine shrimp lethality test, the sample that showed significance with control proceeded with this test. To hatch the brine shrimps, 8 g of salt was mixed with 200 mL of distilled water to act as artificial seawater. Then, 100 mL of that artificial seawater was poured into an 8oz cup, and a spoonful of eggs was added. The cup was covered with the lid and the eggs hatched for 24 hrs. Brine shrimps were transferred to each testing plate by adding 10 mL of artificial water. The brine shrimps counted for 10 and were recorded for each plate by using a magnifier. The shrimp were left to adapt to the environment. A drop of samples (1g of soap diluted with 10 mL of distilled water) was dropped into the test tube. The other test tube was also involved and served as a control without adding any samples. The number of shrimps recounted for 2 hrs, 20 hrs and 24 hrs. Data on the number of brine shrimp was recorded. Live shrimps' percentages were calculated by using a formula as in Formula 1 to indicate the best sample that has a higher survival rate percentage to proceed with sensory evaluation for the final product. S was the number of brine shrimp after 24 hrs and C was the initial number of brine shrimps, 0 hrs.

$$\frac{\%\ of\ live\ shrimps\ (s)}{\%\ of\ live\ shrimps\ (c)} \times 100$$

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2.10 Sensory evaluation

The dish soap bar with the pineapple waste extract fulfilled the criteria of being significantly different from the control and a high percentage of shrimps was evaluated among fifty respondents among students in Universiti Tun Hussein Onn, Pagoh. The sensory evaluation was organized, and the respondents were placed in different places near the sink. The respondents were required to answer the online survey that included attributes of solid soap such as hardness, texture, fragrance, colour, lathery, size, shape, and packaging of soap. The overall acceptance also was evaluated among the respondents followed by a questionnaire on the awareness of the eco-friendly product.

3. Results and discussion

3.1 Dish soap bar product

From this research study, the first objective achieved is developing a dish soap bar using used cooking oil from a household. The dish soap bar product with pineapple waste extract. The pineapple fruit wastes were identified, according to the Malaysian Pineapple Industry Board, there were three varieties of pineapple Moris, Sarawak, and Keningau Diamond. The pineapple wastes were identified from their appearance especially their crown and peel. There were many varieties of pineapple under the same species *Ananas cosmos*, registered and classified by the Malaysian Pineapple Industry Board. The pineapple that has been used by the communities is very familiar and always available in Malaysia. Thus, it was easier to make the pineapple waste extracted to add as additives to the soap.

The samples were developed from two variables which were different pineapple waste parts (crown, peel, core, stem) and different concentrations. Different concentrations were developed from the whole parts of pineapple waste with 100%, 75%, 50%, and 0% concentrations. Different parts with 100% concentrations were developed from peel, core, stem, and crown parts. The soaps were made at home by using a recycled plastic container (Figure 1) before being packed into eco-friendly honeycomb wrapping which was biodegradable (Figure 2).

The chemical analysis of the dish soap bar with pineapple waste in terms of moisture content, pH, and foam height was compared to common commercial soap and control. The data was collected among people in Pagoh Malaysia through an online survey to choose to most common dish soap bar used by people here. According to data collected (Figure 3), the most common dish soap bar used by people in Pagoh, Malaysia was

Figure 1. The samples of the dish soap bar in recycled plastic containers for the curing process.

Figure 2. The samples of the dish soap bar packed into eco-friendly wrap.

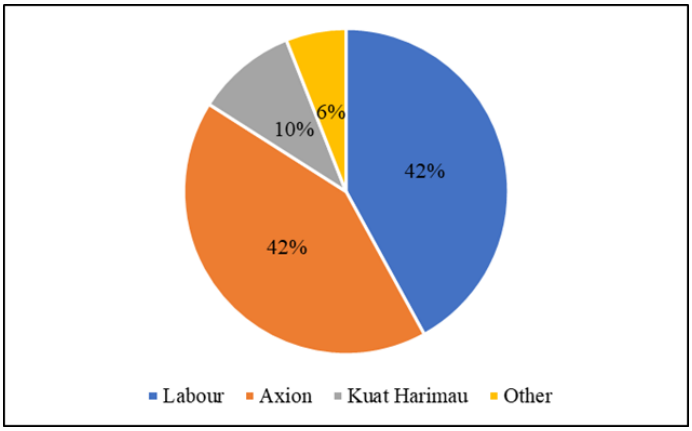

Figure 3. Data collected among people in Pagoh, Johor on the common dish soap bar.

Axion and Labour where both contributed 42%, followed by Kuat Harimau 10%, and the rest only contributed about 6%.

The brand of Axion received the highest common user due to the preference and acceptance of the consumer. According to Vera (2016), studies show that Axion scored the highest product performance criteria including fat removal, gentleness to hands, and long-lasting criteria. In Mexico, Axion got the highest scores in an exhaustive quality implemented by the government (Vera, 2016). Thus, Axion showed the reason for the acceptance of consumers besides the price is not too pricey, it also has a good criterion on dishwashing.

For the control, the data of pH value, moisture content, and foam height were collected from the literature review. According to Arasaretnam and Venujah (2019), the standard for dish soap bars is mainly

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composed of the alkali salts of long-chain fatty acids and have a pH of 10.0. The standard moisture content for a dish soap bar should be 11.80% (Habib *et al.,* 2016). According to Indian Standards Soap, the foam should produce at least 200 ml equal to 5.85 cm.

3.2 Dish soap bar efficacy test

From the result (Table 3), the data of the sample dish soap was slightly different from commercial soap (Labour and Axion) in terms of foam height, pH value, and moisture content. The data below was the mean value for triplicate.

The dish soap bar with the highest foam height was Labour (6.63 cm). As this sample is a commercial soap, there was a possibility of the added chemical substances to increase the foam height to achieve consumer satisfaction. Previous studies by Rieger (2017), investigate the effect of the added substances to increase foam height. Many electrolytes, nonelectrolytes, alcohols (except ethyl alcohol), vegetable gums, and pectic materials greatly increase the foam time of foams from soap and detergent solutions in their studies.

Labour also showed the highest pH value (10.53). This data is related to study by Preisig *et al.* (2019) where the maximum foam height would rise into the range of pH 10.6. The pH value was at a maximum condition to help in the removal of dirt. Besides, the pH value is also suitable for consumer skin where it would not irritate the skin. The core (Conc. 100%) showed the highest moisture content (12.19%). According to Chaudary *et al.,* (2019), the pineapple fruit itself is composed of a higher water level, therefore the core part, which was closer to the fresh fruits of the pineapple recorded the highest moisture content.

3.3 Statistical analysis

The significance among samples, control, and commercial soap for each pH value, foam height and moisture content were shown in Figure 4. The pH value and foam height of the samples were highly significant ($F_{1,32} = 16.275$, $p < 0.001$). The moisture content also showed significant difference ($F_{1,32} = 2.889$, $p < 0.05$).

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
pH value	Between Groups	.949	10	.095	16.275	<.001
	Within Groups	.128	22	.006		
	Total	1.078	32			
Foam Height	Between Groups	3.319	10	.332	47.752	<.001
	Within Groups	.153	22	.007		
	Total	3.471	32			
Moisture Content	Between Groups	25.660	10	2.566	2.889	.018
	Within Groups	19.544	22	.888		
	Total	45.204	32			

Figure 4. The data of foam height, pH value and moisture content of samples, commercial soaps, and control.

From Figure 5, the data showed the comparison of the mean (+1SE) on pH value, foam height, and moisture among the samples, control, and commercial dish soap bar. Most of the samples showed a significant difference from the control. The mean graph not labelled with the letter (Aa) is significantly different from the control level mean.

The mean pH value shown sample whole part (Conc. 100%) was significant with the control. Supporting the findings, the mean pH value showed the sample whole part (Conc. 100%) was significant with control because the sample was considered to have a complete hydrolysis process as stated by Iqbal *et al.* (2014), high pH values showed the presence of incomplete hydrolysis. It can be overcome by adding excess fat or oil or any other super fatting agent to reduce the harshness of soap.

Mean foam height showed sample whole part (Conc. 50%), stem part (Conc. 100%), peel part (Conc. 100%), and crown part (Conc. 100%) were significant with control. According to Petkova *et al.* (2020), the increase in foaming ability with concentration is due to increased

Table 3. The data of foam height, pH value and moisture content of samples, commercial soaps, and control.

Samples Variables	Foam Height (cm)	pH Value	Moisture Content (%)
Peel (Conc. 100%)	5.78	10.42	11.58
Core (Conc. 100%)	5.60	10.39	12.19
Stem (Conc. 100%)	5.88	10.44	11.13
Crown (Conc. 100%)	5.76	10.48	10.40
Whole part (Conc. 100%)	6.10	10.00	11.52
Whole part (Conc. 75%)	6.14	10.32	10.11
Whole part (Conc. 50%)	6.05	10.29	10.78
Whole part (Conc. 0%)	6.15	10.37	8.88
Labour	6.63	10.53	10.57
Axion	6.61	10.43	11.23
Control	5.85	10.00	11.80

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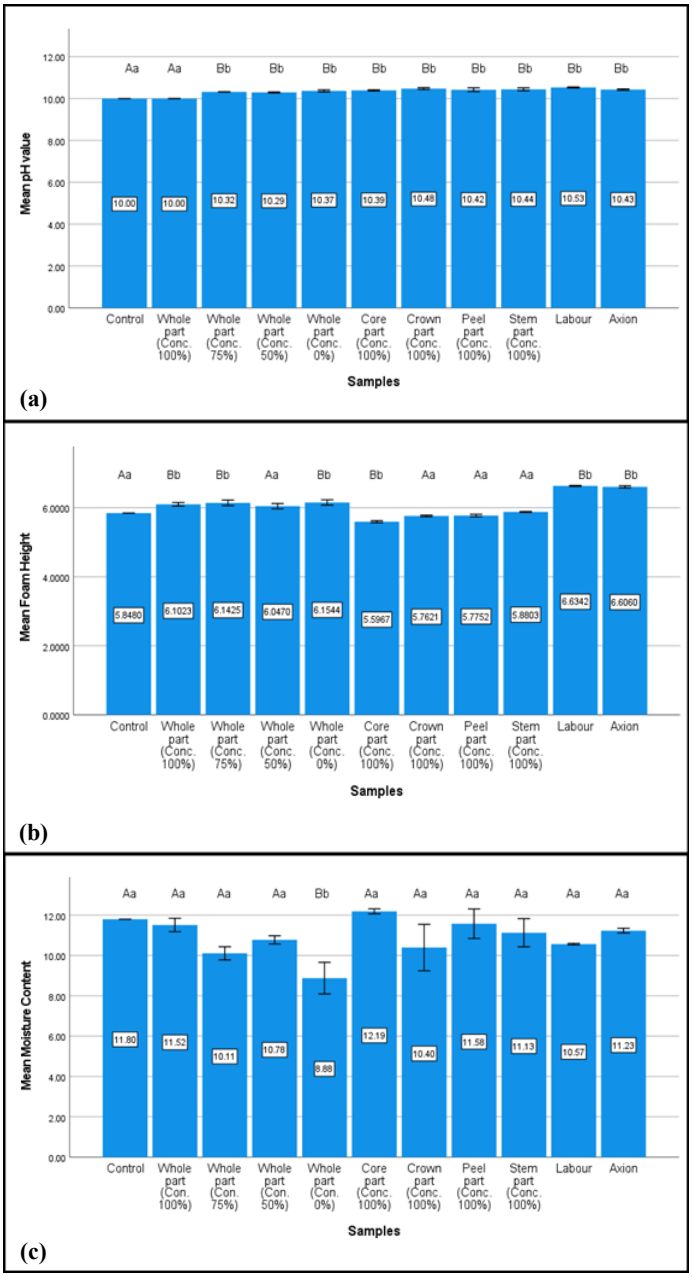

Figure 5. Comparison of the mean ±1SE on a) pH value, b) foam height, c) moisture content for the samples, control, and commercials dish soap bar. Bars with notations Aa are statistically significantly different from the control level mean.

adsorption at the air-water interface, which causes more surfactant to be present in the foam layer to stabilize the foam.

Mean moisture control showed all the samples were significant with control except for the whole part (Conc. 0%). This is because in the whole part (Conc. 0%) the amount of water (88 g) was higher compared to other samples.

The Dunnett multiple comparisons with a control method were used to determine the most samples that were closest to the control. The sample whole part (Conc. 100%), whole part (Conc. 50%), peel part (Conc. 100%), stem part (Conc. 100%), and crown part (Conc. 100%) were closed to the control and these samples were chosen to proceed with the toxicity test.

3.4 Dish soap bar eco-friendly test

The brine shrimp test showed a significant effect of the sample dilution towards the nauplii. The percentage of lethality was shown in Table 4 where the highest percentage among the sample was sample whole part (Conc. 50%), (36.7%) followed by sample whole part (Conc. 100%) (30%), peel part (Conc. 100%) (23.3%), stem part (Conc. 100%) (16.7%) and crown part (Conc. 100%). (3.3%). The control which has no sample dilution showed the highest percentage (83.3%) and the lowest was the commercial soaps, Axion and Labour).

Table 4. Survival rates of brine shrimp towards the sample.

Samples	Survival rate of Brine Shrimp (%)
Whole part (Conc. 100%)	30
Whole part (Conc. 50%)	36.7
Peel part (Conc. 100%)	23.3
Stem part (Conc. 100%)	16.7
Crown part (Conc. 100%)	3.3
Control	83.3
Labour	0
Axion	0

The control acts as the parameter to all samples whether they were suitable in that environment or not. With no addition of a soap sample, the brine shrimp survived as shown in Figure 6. This happened because there was no toxicity waste contributing to the control. Compared to the commercial soap (Axion and Labour), all the brine shrimps died within 2 hrs due to the chemical substances included in the soaps such as additives and fragrance. In previous studies, the properties of the soaps are readily biodegradable in the environment and pose minimal risk to aquatic life. Some detergents, such as cationic detergents, are highly persistent in the environment and pose serious risks to aquatic wildlife (Vera, 2016).

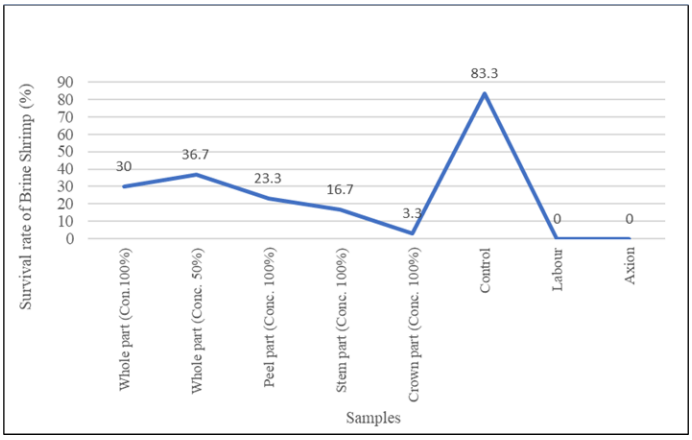

Figure 6. The survival rate percentage graph of brine shrimp lethality test against samples.

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3.5 Sensory evaluation on the efficacy of the soap

Results of the sensory evaluation of the survey on the efficacy of dish soap bars developed from used cooking oil and pineapple waste towards eco-friendly products by 50 respondents from Universiti Tun Hussein Onn Malaysia, Pagoh are shown below. The sensory experience of a dish soap bar product was based on its hardness, lathery, size, colour, shape, texture, fragrance, and overall acceptance among the respondents. The acceptance of dish soap with pineapple waste extract was largely based on the physical characteristics, mainly the way it feels by the touch such as attributes of hardness, texture, and lathery. A key attribute for consumer acceptance of personal cleansing products such as solid soap is the fragrance, texture, colour, and size of the soap (Abedin *et al.,* 2017).

From the chart in Figure 7, more than half of the respondents accepted the overall dish soap bar product whereas 36 respondents (72%) were very satisfied.

Figure 8 shows the summary of overall sensory evaluation of the formulated soap. The evaluation of the hardness showed 32 respondents (64%) who were very satisfied. 34 (68%) out of 50 respondents were satisfied with the texture of the soap and with the fragrance only 13 respondents (26%) were satisfied. The data showed

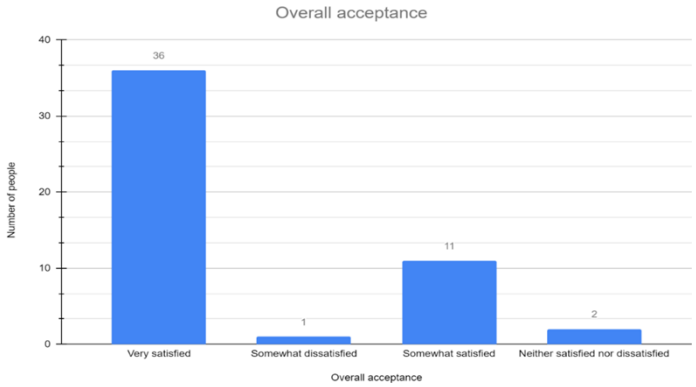

Figure 7. The google form summary for overall acceptance of the dish soap bar product.

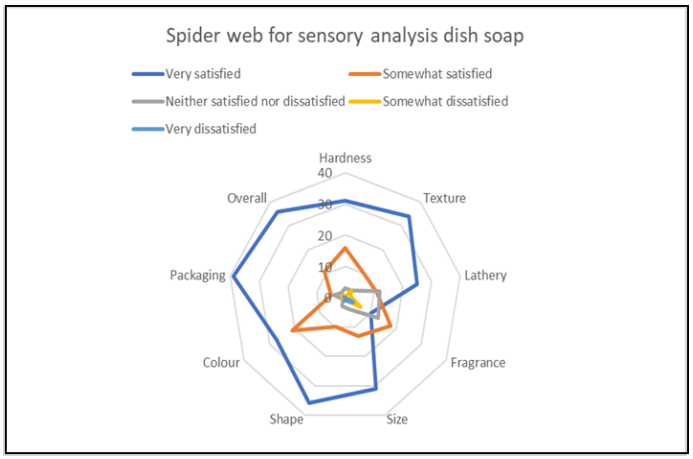

Figure 8. The google form summary in spider web graph for overall, hardness, texture, fragrance, lathery size, shape, packaging, and colour of the dish soap bar product.

half (50%) or 25 respondents were satisfied with the lathery attribute, and the size showed (62%) which was about 31 respondents. The shape was 72%, colour was 54% and the most satisfaction among respondents was the packaging which was 78%.

From the survey on sensory evaluation, all those attributes (hardness, texture, fragrance, lathery, size, shape, colour, and packaging) were important in determining dish soap bar efficacy and quality which can influence consumer preference and acceptance. The right combination of these factors such as colour is an important factor to consider in the design and manufacture of natural soaps with the ideal characteristics and sensory appeal to meet consumer demands of the consumer (Habib *et al.,* 2016).

4. Conclusion

The dish soap bars were formulated into two variables, different concentrations, and different parts. Different concentrations were developed from the whole parts of pineapple waste with 100%, 75%, 50% and 0% concentration. Different parts with 100% concentrations were developed from peel, core, stem, and crown parts.

All the soap samples proceeded with the evaluation of the efficacy of the soap showing the pH value, moisture content and foam height were slightly different from commercial soap (Labour and Axion) and control. From statistical analysis, the pH value and foam height of the samples were highly significant ($F_{1,32} = 16.275$, $p < 0.001$). The moisture content also showed a significant difference ($F_{1,32} = 2.889$, $p < 0.05$). The Dunnett multiple comparisons with a control method were used to determine the samples that were closest to the control. The sample whole part (Conc. 100%), whole part (Conc. 50%), peel part (Conc. 100%), stem part (Conc. 100%), and crown part (Conc. 100%) were closed to the control and these samples were chosen to proceed with the toxicity test.

The dish soap bar was developed following eco-friendly criteria by SIRIM eco-label which uses recycled materials and is non-toxic to the environment. The used cooking oil and pineapple waste to develop the dish soap bar were recycled materials including the packaging and the dish soap bar itself is non-toxic to the environment as proved by the toxicity test. The toxicity test on dish soap bar samples showed the brine shrimp could survive as compared to the commercial Labour and Axion did not survive. The average survival rate of brine shrimp for the whole part (Conc. 50%) dish soap bar sample was 36.7% the compared to control which was 83.3% and commercial was 0%.

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The dish soap bar product with pineapple waste extract was successfully developed and acceptable among the 50 respondents and safe to be used on the skin under the standard soap quality control. The developed dish soap bar from used cooking oil and pineapple waste is one of the effective alternative ways to tackle issues on environmental problems.

Conflict of interest

The authors declare no conflict of interest.

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