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The Physical Characteristics of Handmade soap with Plant-Based Additives

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Abstract: The application of soap is very significant in daily lives to eliminate any dirt which cannot be completely remove by water alone. The production of soap is mainly consisting of harmful chemical substance which can deliver bad effect on human skin for long term use. Moreover, the commercial soap focuses on increasing the mass production of the soap which can reduce the physical characteristics of the soap such as hardness, pH value and resistance of dissolvement. Accordingly, there is a need for improved physical characteristics of the soap. The objective of this research is to use virgin cooking oil and different types of herbs in soap making process and to identify the physical characteristics of the soap which is made using virgin cooking oils and herbs additives. This study also needs to prepare simple and attractive information using brochure for distribution among small and medium enterprise (SME) for soap making process. The production of handmade soap involves virgin cooking oil, lye, and plant-based additives by using cold process method. Three types of tests were conducted to determine physical characteristics of handmade soap with plant-based additives which is Scratch Resistance test, pH test, and Swelling test. The scratch resistance test was carried out by using pencil hardness method to ascertain the hardness, pH test for pH value, and the swelling test for resistance of dissolvement in four different solutions including oil, vinegar, salt, and sugar. The results indicates that the handmade soap with plant-based additives produced acquire strong hardness and a safe range of pH value 9 to 10. To conclude, this study revealed that handmade soap with plant-based additives significantly enhance the physical characteristics of the soap and can be improve for next research with some recommendations.

Keywords: Handmade Soap, Plant-Based Additives, Virgin Cooking Oil, Lye, Cold Process Method

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1. Introduction

Soaps primarily defined as any cleaning agent which produced in granules, bars, flakes, or liquid form obtained by reacting salt of sodium or potassium with various of fats or oils [1]. Soap is mainly used for cleansing, by solubilizing the insoluble contaminants of dirt, grease, and oil in water, thus allowing them to be washed away. This works because soap is a surfactant which is mean by a substance that lowers the surface tension between the water-oil interface [2]. Soap is mainly produced by using saponification process. Saponification process is a process which triglyceride in oils or free fatty acids are react with the presence of a base which is commonly used between sodium hydroxide (NaOH) and potassium hydroxide (KOH) to produce soaps and glycerol [3]. Thus, when it reacts with a strong mineral base like sodium hydroxide (NaOH) in aqueous medium, opaque soap and glycerol are produced. Figure below shows the common saponification reaction between triglyceride and alkali to produce fatty acid salts which is known as soap and glycerol.

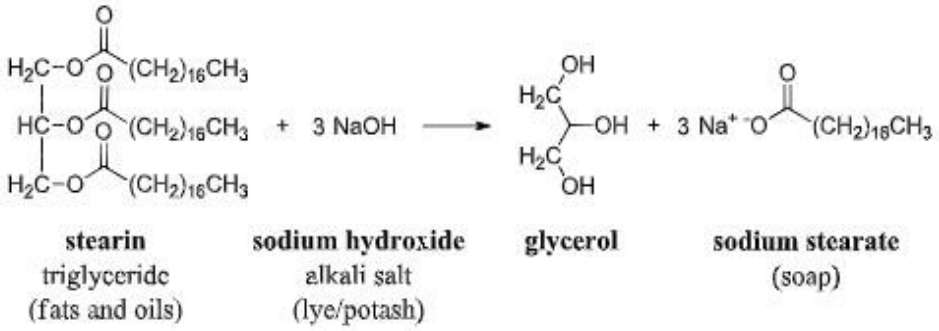

Figure 1: Saponification reaction [2]

Generally, four types of method are used in the production of soap. The methods include cold process, melt and pour, hot process, and rebatch. The cold process method is the principal method for soap production which undergoes saponification reaction with the combination of triglyceride and an alkali salt to produce sodium stearate or also known as soap. Triglycerides can be found in fats as well as in various type of oil. Soaps which have finest physical characteristics are mainly affected by the raw materials used. The main raw materials used for making soap is fat or oils obtained from plant or animal [4]. However, oils used in this research was virgin cooking palm oils. Virgin cooking palm oils used as the cooking oils to fry the food because of the properties of palm oils which is can stable enough to resist chemical changes when heated to the high temperature [5]. Furthermore, natural additives are commonly formulated into clean soaps to enhance the soap composition, efficiency, and consumer's sensory perception of the finished product. The physical characteristics such as the solubility and moisturizing capabilities of clean soap will increase with the degree of unsaturated fatty acids exist in the vegetable oils such as palm oils. Nevertheless, the double bonds present in unsaturated fatty acids are allowing the oxidation which can take place during saponification, curing, and storage. Oxidation of the double bonds in unsaturated fatty acids can cause shorter chain fatty acids, ketones, unpleasant odours, and discoloration of soap which can affects the quality, sensory perception, and shelf life of the final product [3].

Conventional soap usage has been well integrated in life for most of the people in the worldwide. By using the conventional soap, it contains numerous harmful chemicals and toxins which can lead a person to get sick eventually. Conventional soaps are made with sulfates which let the skin to dried out and starved for moisture. Instead of drying skin like sulfates, glycerin softens and moisturizes skin. Unfortunately, most commercial soap companies remove the glycerin from the production of soap. Regardless of how, there is no doubt that the problem of conventional soap is the ingredients itself that contains hazardous chemicals which can give the bad impact to the human health condition. Therefore,

the solution for this problem need to find a soap with harmless ingredients in order to cleanse body and also protect skin.

2. Materials and Methods

A cold process method is the most common used method compared to other methods. Cold process method is the combination of the oils and lye-water solution. The amount of lye required is mixed with water and left to cool for around 60 minutes. Then, the mixture of lye and water was added to the oils so the mixture can be blended until thickened. Thus, the mixture filled in the moulds and the process will complete in 18 to 24 hours and around 3 to 4 weeks to preserve the finished soaps [3] Some of the advantages of the cold process method are this method allows to customize every single ingredient to suit personal preferences because of saponification process can be controlled. In addition, the trace of cold process soap can be manipulated for a variety of techniques and designs which is thin trace can be used to make swirls, while thick trace creates soap frosting. Next, the disadvantage of the cold process method is this method involved handling with strong alkali such as sodium hydroxide (NaOH), thus it will be dangerous if not handle carefully.

2.1 Materials

Lye is known as highly consist of alkaline chemical that is commonly used for soap making process. The most known and most commonly used is sodium hydroxide (NaOH) which has a very high pH value. The type and purity of alkali used decides the hardness and solubility of the finished soap. Sodium hydroxide (NaOH) can produce hard and durable soaps [3]. Moreover, potassium hydroxide (KOH) can be alternative chemical for sodium hydroxide (NaOH), but it will produce a soft and liquid soap. Sodium hydroxide (NaOH) is a white crystalline odorless solid which absorbs moisture from the air and produce substantial amount of heat, which is enough to ignite combustible materials when dissolved in water or neutralized with acid.

Natural additives include free fatty acids, plant extracts and essential oils are being added in the soap making process. One of the important subclasses of additives used in the formulation and manufacturing of framed soap is the plant extracts. The use of plant extracts from a variety of plants as additives in soap production provides two significant functions which is care of the body and providing nutrients for healthy skin. Due to the composition of each plants extracts, these extracts can contribute different benefits to enhance the properties of soap [6].

2.2 Production of soap

This section will describe the cold process method involved to produce soap. The cold process method is the process of saponification reaction between oils and lye which is sodium hydroxide (NaOH) solution and eventually produce soap, water, and glycerin. The cold process is economically sustainable and environmentally friendly as there is no waste product produced. Some safety precaution has been taken before and during the soap making process. For safety purposes, face mask and gloves need to be used before starting the soap making process as there is a chemical substance which can irritate the skin. During the process of making soap, if the lye flakes make contact with skin, it is advised to rinse immediately with running tap water for 15 minutes and 20 minutes if the lye flakes make contact with the eye. To avoid undesirable things from happen, it is advisable to make the process in proper place such as places with good ventilation.

Table 1 below shows the production of soap with different stirring time and composition of additives in the soap making process. In this experiment, the two types of plant-based additives will be added which includes Cinnamon powder and Ginger powder. V stands virgin cooking oils while c stands for cinnamon additive and g stands for ginger additive. The stirring time includes of 5 minutes and 10 minutes while the value of additives is 5%,10%, and 15% of 200 gram of oil used.

Table 1: Production of soap with different stirring time and composition of additives

Sample Name	Stirring time (min)	Composition of additives	
		Value (%)	Type
V_{c0505}	5	5	Cinnamon
V_{c0510}		10	
V_{c0515}		15	
V_{c1005}	10	5	
V_{c1010}		10	
V_{c1015}		15	
V_{g0505}	5	5	Ginger
V_{g0510}		10	
V_{g0510}		15	
V_{g1005}	10	5	
V_{g1010}		10	
V_{g1015}		15	

2.3 Scratch resistance test

Scratch resistance test can be done by using pencil hardness test to determine the hardness of the soap. ASTM D3363 is a pencil hardness test method which is designed to evaluate the hardness of substances through use of pencil [7]. This method involves of evaluating the surface aesthetics of the soap by scratch it with a pencil of known hardness at an angle of 45 degree for approximately 10 to 12 mm. The process is repeated with a pencil that is lower on the hardness scale until the highest hardness scale to determine whether the soap will cut or not. The pencil of different thickness of lead has been chosen from 6H to 8B for soap to know the physical characteristics of the soap. Friction due to the movement of asperities on a coated material's surface in contact with the harder pencil lead material causes friction which has been shown in Figure 2 below.

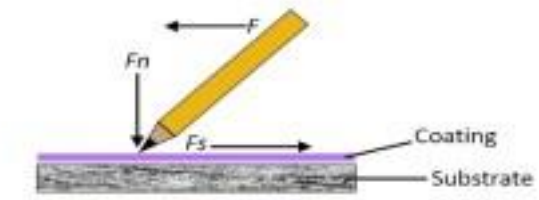

Figure 2: Position of pencil to scratch the surface [7]

This pencil hardness test method was conducted by using Staedtler Mars-Lumograph. Calibrated wood pencils of different hardness from 8B which is soft to 6H which is the hardest are supposed to be used from the same manufacturer. In addition, the difference in pencil hardness is determined by the amount of graphite, clay, and wax. The pencil with 6B has 85% amount of graphite, 10% clay and 5% wax while a mid-hardness pencil such as HB has 68% graphite, 27% clay and 5% wax [7].

2.4 pH test

The pH test is one of the tests has been done for the soap to identify the excess alkali can be presence in the soap. The excess alkali which is Sodium Hydroxide (NaOH) in the form of lye is very

hazardous to human skin and highly corrosive. Lye produces a strongly alkaline solution when dissolved in water which can cause a number of problems, including chemical burns if it comes into contact with the skin. It can also be highly flammable and could boil or splatter if large amounts of lye are dissolved. pH test also done to maintain the quality of the soap to be safely used for skin and also prove the handmade soap produced no longer caustic. Handmade soap is always alkaline which has a cleansing ability within the safe range of pH between 8 to 10. For pH value, more than 11 is considered too harsh for the skin and will cause irritations while a pH value below than 8 not possible for handmade soap which means no more cleansing power.

The initial step to perform pH test on a cold process soap is adding a bit of distilled water on the surface on the handmade soap. The surface that made contact with water will be rubbed until bubbles appears. Next, place the pH strip onto the bubbles and the strip will react immediately by changing its color based on the soap pH value. Consequently, this color change can be matched against a calibrated color chart to indicate the pH value of the handmade soaps with plant-based additives produced. Figure 3 below shows the pH strip used to determine the pH value of the handmade soap.

Figure 3: pH strips by Johnson test papers

2.5 Swelling test

Swelling test can be done to record the resistance of dissolvement in 4 different solution which is oil, vinegar, sugar, and salt. The resistance of dissolvement can be observed by measured the change in term of volume of the soap. The procedure of the swelling test starts by cutting the soap into 4 cube which have the similar volume. Then, the data is recorded by measured the volume of each cube every 2 days in the time span of 4 days. Compare the data obtained with the initial volume of the cube to achieve the resistance of dissolvement of soap in 4 different solutions. To determine the precise volume of the handmade soap, electronic digital caliper was used. The resistance of dissolvement of handmade soap in four different solution was determined by the percentage of increment of value of soap as shown Equation 1 below.

$$Percentage\ of\ increment\ of\ value\ of\ soap\ = \frac{Final\ Volume}{Initial\ Volume}\ x\ 100\ \%\quad \text{Eq. 1}$$

3. Results and Discussion

Several tests have been carried out to investigate the physical characteristics of handmade soap with plant-based additives by using Cinnamon powder and Ginger powder as plant-based additives. Total of 3 test was conducted and all the data was recorded, and the result was analyzed. Those tests are including Scratch Resistance test, pH test and Swelling test was carried out. The analyzed result for this study is started with physical characteristics of handmade soap with plant-based additives produced. This analysis is obtained by conducted Scratch Resistance test to determine the hardness of the handmade soap with plant-based additives. In addition, pH test was conducted to determine the pH value of the handmade soap. Next, the resistance of dissolvement of handmade soap produced when react in 4 different solutions including oil, salt, sugar, and vinegar was determined by conducting Swelling test.

3.1 Production of soap

A total of 12 sample has been prepared including 2 types of additives which are ginger powder and cinnamon powder as additives for the handmade soap. Figure 4 clearly shows the produced handmade soap with Cinnamon additives with 5 minutes stirring time. The color of the soap is dark chocolate due to the additive used. The handmade soap produced also has 3 different composition of additives which is 5%, 10% and 15%. Figure 4 below show the handmade soap with plant-based additives produced.

Figure 4: Handmade soap with plant-based additives

3.2 Scratch Resistance test

A total of 12 samples which is handmade soaps with plant-based additives was achieved 10 days of curing period before the pencil hardness test method was conducted. The aim of this test is to determine the hardness of the handmade soap with plant-based additives with different stirring time and composition of additives. The characteristics of different composition of additives and stirring time of handmade soaps was presented in the table 4.1. Data observed for pencil hardness test method is shown in Table 2 below.

Table 2: Pencil hardness test result

Pencil / Sample	6H	4H	2H	H	HB	B	2B	3B	4B	6B	7B	8B

V_{c0505}												
V_{c0510}												
V_{c0515}												
V_{c1005}												
V_{c1010}												
V_{c1015}												
V_{g0505}												
V_{g0510}												
V_{g0515}												
V_{g1005}												
V_{g1010}												
V_{g1015}												

Based on Table 2 above, the data can be observed that the higher composition of additives has the higher hardness of pencil which lead to the harder soap. The result attained also implies that the handmade soap with higher stirring time produced harder soaps with higher H number up to 6H. This is due to the higher stirring time can lead the soap to cure faster by using every possible excess water in the soap. This data also signifies that handmade soap with higher stirring time has lower percentage of abrasive wear which means by the process of hard material that will leave scratch on a softer material [7].

3.3 pH test

The result and analysis of the pH test have been seen from 12 samples which include different types of additives, the composition of additives and stirring time. According to [8], the pH value of handmade soaps in the range of 9 to 10. Furthermore, it can be observed from the pH test that was conducted, all the handmade soap has pH value ranges from 9 to 10. The pH value of the handmade soaps was clearly shown in Table 3 below.

Table 3: Result of the pH value for handmade soap

Sample Name	Stirring time, min	Composition of additives		
		Value, %	Type	pH value
V_{c0505}		5		10
V_{c0510}	5	10		9
V_{c0515}		15		9
V_{c1005}		5	Cinnamon	9
V_{c1010}	10	10	(pH 8)	9
V_{c1015}		15		9
V_{g0505}		5		10
V_{g0510}	5	10		10
V_{g0510}		15	Ginger	9
V_{g1005}	10	5	(pH 8)	9

V_{g1010}	10	9
V_{g1015}	15	9

The variation of the result of pH value between the handmade soaps in the Table 3 above mainly because of the difference in stirring time and composition of additives. Moreover, the result of pH value of handmade soaps also can be controlled based on the pH value of the additives itself. Therefore, this data can be observed that a higher stirring time can produce a better quality of soaps with a safe range of pH value compared to the lower stirring time. By comparing the composition of additives, thus it can be seen that higher composition of additives produces a high quality of soaps because the presence of excess lye in the soaps is minimal.

3.4 Swelling test

This section will provide result and analysis of the swelling test for handmade soap with plant-based additives. The width, length, and height of the cube of handmade soaps has been measured in order to determine the volume of the cube. By cutting the cube with the same width, length, and height of 2.5 cm and thus the volume of the cube has been achieved which is 15.625 cm^3. Therefore, all the handmade soaps have equal volume before immersed into each of the solutions. The result of the swelling test was observed every 2 days in the time span of 4 days. Table 4 and Table 5 below clearly shows the volume of handmade soap at Day 2 and Day 4

Table 4: Volume of soap at Day 2

Sample Name	Volume, cm^3			
	Oil	Vinegar	Salt	Sugar
V_{c0505}	15.625	29.791	15.625	20.797
V_{c0510}	15.625	35.937	15.625	21.952
V_{c0515}	15.625	39.304	15.625	22.426
V_{c1005}	15.625	41.064	15.625	21.952
V_{c1010}	15.625	42.875	15.625	25.154
V_{c1015}	15.625	54.872	15.625	31.256
V_{g0505}	15.625	21.952	15.625	19.683
V_{g0510}	15.625	28.373	15.625	20.797
V_{g0510}	15.625	31.256	15.625	23.149
V_{g1005}	15.625	34.328	15.625	23.888
V_{g1010}	15.625	39.304	15.625	25.672
V_{g1015}	15.625	47.046	15.625	29.791

Table 5: Volume of soap at Day 4

Sample Name	Volume, cm^3			
	Oil	Vinegar	Salt	Sugar
V_{c0505}	15.625	46.656	15.625	25.154
V_{c0510}	15.625	49.836	15.625	30.371
V_{c0515}	15.625	57.512	15.625	31.256
V_{c1005}	15.625	61.630	15.625	34.012
V_{c1010}	15.625	70.445	15.625	35.611
V_{c1015}	15.625	82.881	15.625	36.594
V_{g0505}	15.625	41.782	15.625	22.426
V_{g0510}	15.625	44.738	15.625	25.672
V_{g0510}	15.625	50.243	15.625	25.672
V_{g1005}	15.625	52.734	15.625	34.012

V_{g1010}	15.625	61.630	15.625	35.288
V_{g1015}	15.625	71.473	15.625	36.265

From this data, it can be analysed that handmade soap with Cinnamon and Ginger additives experienced swelling only in vinegar and sugar water solution and shows no change of volume of soap in oil and salt solution. This data indicates that the volume of the handmade soap in vinegar is higher compared to the sugar solution. The resistance of dissolvement for handmade soap for Cinnamon and Ginger additive in each of the solutions was shown in Figure 5 and Figure 6 below.

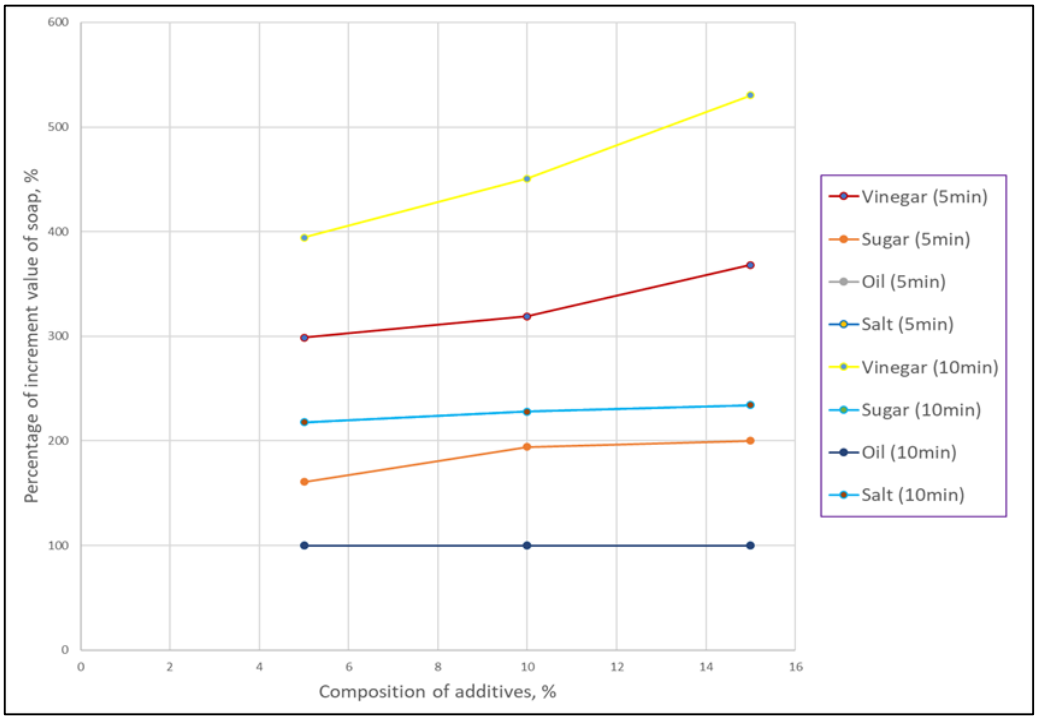

Figure 5: Resistance of dissolvement of handmade soap with Cinnamon additive

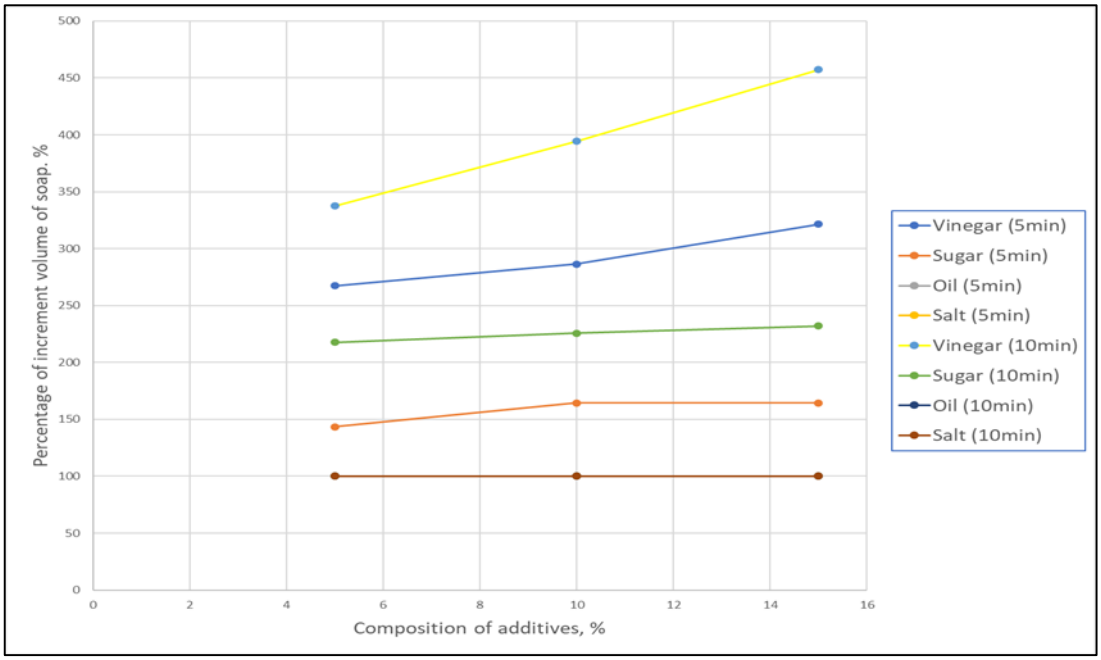

Figure 6: Resistance of dissolvement of handmade soap with Ginger additive

Figure 4.18 above shows the results between percentage of increment of value of soap and composition of additives for Cinnamon while Figure 4.19 shows the results between percentage of increment of value of soap and composition of additives for Ginger additive. The percentage of increment of volume of soap was obtained from the result of the swelling test at Day 4 which being compared to the initial volume of the soap. From these results, it can be observed that the higher stirring time and composition of additives, the higher the percentage of increment of volume of soap. The higher percentage of increment of volume of soap means that it has the lower resistance of dissolvement. Thus, it concludes that the resistance of dissolvement is also affected by the stirring time and composition of additives.

3.5 Preparation of brochures

The brochures produced consists complete procedures and figure in soap making process by using cold process method. Complete and accurate procedures along with figures is important to ensure that SME community can produce a handmade soap by own. The preparation of brochures can be produced by using online application such as Canva and other application.

Figure 7: Brochures produced

4. Conclusion

Cold process method was selected as the soap making process to produce handmade soap with plant-based additives. By using new palm cooking oils and plant based additives such as Cinnamon and Ginger additives, a total of 12 sample was produced. The result indicates that handmade soap can be produced by using virgin cooking oil and different types of herbs. The purpose of this study is to identify the physical characteristics of the soap which is made using virgin cooking oils and herbs additives. There are in total of three tests conducted to determine the physical characteristics of the soap. These include Scratch resistance test, pH test and Swelling test. The handmade soap with plant-based additives with higher stirring time and composition of additives produces a harder soaps. The soap has high cleansing power within the range of pH value 9 to 10 and shows resistance of dissolvement in oil and salt solution only. The study concludes that virgin cooking oils and plant-based additives have significant potential to produce a soap with best hardness, high cleansing power and has a safe range of pH value. The production of handmade soap with different types of herbs has a potentially enhance the physical characteristics of the soap.

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