Physicochemical Properties and Sensory Evaluation of Soap Prepared from *Elaeis guineensis* (Oil Palm) Fruits

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A thesis submitted in fulfilment of the requirement for the degree of Bachelor of Applied Science (Product Development Technology) with Honours

Faculty of Agro-Based Industry

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DECLARATION

I hereby declare that the work embodied in this report is the result of the original research and has not been submitted for a higher degree to any universities and institutions.

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I certify that the report of this final year project entitled "Physicochemical Properties and Sensory Evaluation of Soap Prepared from *Elaeis guineensis* (Oil Palm) Fruits" by Wan Nursyahira Izzanis Binti Megat Mahazer, matric number F15A0248 has been examined and all the correction recommended by examiners have been done for the degree of Bachelor of Applied Science (Product Development Technology) with Honours, Faculty of Agro-Based Industry, Universiti Malaysia Kelantan.

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LIST OF SYMBOLS AND ABBREVIATIONS

◦C	degree Celsius
◦F	degree Fahrenheit
L*	lightness
a*	redness
b*	yellowness
g	gram
ANOVA	Analysis of variance
CPO	Crude palm oil
RPO	Refined palm oil
PKO	Palm kernel oil
SOP	Standard operating procedures
FELDA	Federal Land Development Authority
MPOC	Malaysian Palm Oil Council
TPA	Texture profile analysis

PHYSICOCHEMICAL PROPERTIES AND SENSORY EVALUATION OF SOAP PREPARED FROM *ELAEIS GUINEENSIS* (OIL PALM) FRUITS

ABSTRACT

Global demand for soap is increasing rapidly especially in the cosmetic industry. Major productions of commercial soap usually contain a lot of preservative and additive that might cause harm to health. This study aims to determine the physicochemical properties and sensory evaluation of soap samples made from different ratio of crude palm oil (CPO) and also to determine the best formulation of CPO in soap preparation. This study use research design with five soap samples and three repetition and the data were analysed statistically using ANOVA followed by post hoc test. 5 soap samples were represent the ratio of CPO in the soap consist of 100%, 75%, 50%, 25% and 0%. The analysis of oil palm soaps was divided into two scopes which are physicochemical properties and sensory evaluation. For physicochemical properties, the pH of soap samples was ranged from 10.18 ± 0.071 to 10.48 ± 0.075 in vary ratio of CPO. The hardness score of the soap samples also varied in a different ratio, which were ranged from 788.89 ± 120.38 to 1083.56 ± 91.63. For colour analysis, the lightness (*L) of the soap increase as the ratio of CPO decreases. Meanwhile, the value for redness (a*) and yellowness (*b) of the soap are directly proportional to the ratio of CPO. Based on the sensory evaluation test with accordance of colour, aroma, texture and lathering attributes, most of the panellist preferred soap D, which contained 25% of CPO + 75% RPO as the best soap formulation.

Keywords: crude palm oil (CPO), refined palm oil (RPO), physicochemical properties, sensory evaluation.

SIFAT FIZIKOKIMIA DAN UJIAN PENILAIAN DERIA TERHADAP SABUN YANG DIHASILKAN DARIPADA BUAH KELAPA SAWIT (*ELAEIS GUINEENSIS*)

ABSTRAK

Permintaan global terhadap produk sabun semakin meningkat dengan pesatnya terutama dalam bidang kosmetik. Pengeluaran sabun yang komersial di pasaran biasanya mengandungi banyak bahan pengawet dan bahan tambahan yang mungkin menyebabkan kemudaratan kepada kesihatan. Kajian ini dilakukan untuk menentukan sifat fizikokimia dan ujian penilaian deria terhadap sampel sabun yang dihasilakn daripada nisbah minyak sawit mentah (CPO) yang berbeza dan juga untuk menentukan formula CPO mana yang terbaik untuk menghasilkan sabun. Kajian ini menggunakan reka bentuk penyelidikan dengan lima sampel sabun dan tiga pengulangan dan data yang diperolehi telah dianalisis secara statistik menggunakan ANOVA dan diikuti dengan ujian post hoc. 5 jenis sampel sabun dihasilkan daripada pelbagai nisbah CPO yang terdiri daripada 100%, 75%, 50%, 25% dan 0%. Analisis sabun kelapa sawit dibahagikan kepada dua skop iaitu sifat fizikokimia dan ujian penilaian deria. Bagi sifat fizikokimia, pH sampel sabun adalah terdiri daripada nilai 10.18 ± 0.071 hingga 10.48 ± 0.075 mengikut nisbah CPO yang berbeza. Skor kekerasan sampel sabun juga berbeza mengikut nisbah CPO yang berbeza, iaitu 788.89 ± 120.38 hingga 1083.56 ± 91.63. Untuk analisis warna, nilai cahaya (* L) untuk sample sabun meningkat apabila nisbah CPO yang digunakan sedikit. Sementara itu, nilai kemerahan (a *) dan kekuningan (* b) sabun adalah berkadar terus dengan nisbah CPO. Berdasarkan ujian penilaian deria, selepas mengambil kira ciri-ciri warna, aroma, tekstur dan pembuihan, kebanyakan panelis menggemari sabun D, yang mengandungi 25% CPO + 75% RPO sebagai formulasi sabun yang terbaik.

Kata kunci: minyak sawit mentah (CPO), minyak kelapa sawit (RPO), sifat fizikokimia dan ujian penilaian deria.

CHAPTER 1

INTRODUCTION

1.1 Research Background

Nowadays, the global demand for soap is increasing rapidly especially in the cosmetic industry. The Federal Food, Drug, and Cosmetic Act (FD&C Act) defines cosmetics by their intended use, as “articles intended to be rubbed, poured, sprinkled, or sprayed on, introduced into, or otherwise applied to the human body for cleansing, beautifying, promoting attractiveness or altering the appearance. Among products included in this definition are skin moisturizers, perfumes, lipstick, fingernail polishes, eye and facial make up preparations, cleansing shampoo, soap and deodorants, as well as any substance intended for use as a component of a cosmetic product ("Is It a Cosmetic, a Drug, or Both? (Or Is It Soap?)", 2012).

Soaps are cleaning agents that are usually made by reacting alkali such as sodium hydroxide (NaOH) and potassium hydroxide (KOH) with naturally occurring fat or fatty acids. The reaction produces sodium salts of these fatty acids, which improve the cleaning process with the addition of water. The combination able to lift away greasy stains from skin, hair, clothes and others. As a substance that has helped clean bodies as well as possessions, soap has been remarkably useful (James et al., 2007). Sodium hydroxide is usually being added into bar soap formulation, meanwhile, potassium hydroxide is used for liquid soap production.

Oil palm produces two types of oil which are crude palm oil (CPO) and palm kernel oil (PKO). CPO is extracted from fibrous mesocarp or the fleshy part of the fruit while PKO comes from the kernel at the fruit's core. CPO is a type of vegetable oils. It is cholesterol-free and semi-solid at room temperature. CPO is deep orange-red in colour due to the high content of natural carotenes. CPO is the rich source of carotenoid and vitamin E which offer natural stability against oxidative deterioration. Palm oil can be fractionated into liquid (olein) and solid (stearin) components ("Oil palm plantation", 2012). In the market, soaps are usually made from palm olein (refined palm oil). The fractionated process to make the palm olein causes some important nutrients in the palm oil is eliminated.

Due to this reason, soaps that are produced using palm olein has lack of palm oil originality properties in it, such as colour and aroma. The production of soap using CPO could give additional value in terms of colour and indigenous odour. In addition, the production of soap using CPO capable to give hard-bar properties with a stable lather, with long-lasting and resistant to melting.

1.2 Problem Statement

Nowadays, most available soap produced in the market is formulated using refined palm oil (RPO). However, the refining process causes discoloration and deodorization of the palm oil. Apart from that, palm oil that has been refined remove some antioxidant contents in the oil, such as α-carotene, β- carotene and many more.

Moreover, soap manufacturers tend to use preservative and additive in their product to maintain textural quality and shelf life of the product. However, some of the preservative and additive used might cause harm to human skin and health concern. Additionally, it also can cause skin allergic to those who are facing skin problems. Therefore, this study is made to produce soaps which are using a different ratio of CPO as the main ingredient to give value added to the product. Besides, the study also provides a standard operating procedure (SOP) to produce CPO and the soap.

1.3 Hypothesis

H_o: There is no significant difference in terms of physicochemical properties and sensory attributes of soap made from different ratio of CPO

H_a: There is significant difference in terms of physicochemical properties and sensory attributes of soap made from different ratio of CPO

1.4 Objectives

The objectives of this study are:

1. To extract and produce soaps from different ratio of CPO
2. To determine physicochemical properties and sensory attributes of soap prepared from CPO

1.5 Scope of Study

The study aims to prepare solid bar soap from different ratio of CPO. The quality of soap was analysed based on pH, texture and colour analysis. The sensory evaluation test was conducted using a hedonic scale to evaluate consumers' preference towards the palm oil-based soaps.

1.6 Significance of study

This research was conducted to introduce standard operating procedures (SOP) of palm oil crude extract originally from palm fruitlets. The SOP provided by the study could promote the production of handmade soap using palm oil extract to the small-scale processor. Apart from that, this research is also important as it will lead to a new kind of product which is safe, environmentally friendly and economic. Moreover, the research able to give contributions to the cosmetic industry to produce good quality soap. On the other hand, the methodology applied in the research also may enhance the experimental skill of the researcher.

CHAPTER 2

LITERATURE REVIEW

2.1 Soap

Soap is sodium or potassium salt of fatty acid produced by saponification reaction. According to Vivian et.al (2014), soap is defined as any water-soluble salt of those fatty acids which contain eight or more carbon atoms. Based on its chemical properties as an anionic agent or surfactant, soaps are produced for varieties of use ranging from washing, bathing, medication and many more. The cleansing action of soap is due to negative ions on the hydrocarbon chain attached to the carboxylic group of the fatty acids. The affinity of the hydrocarbon chain to oil and grease, while carboxylic group to water is the main reason soap is being used mostly with water for cleaning purposes (Zauro et al., 2016).

Soaps for cleaning are obtained by treating vegetable or animals fats with a strong alkaline solution through the saponification process. Fats and oils are composed of triglycerides which contain three molecules of fatty acids and a single molecule of glycerol. In the saponification process, the triglycerides are reacted with a strong alkali such as potassium or sodium hydroxide to produce glycerol and fatty acid salts. The salt of fatty acid is called soap (Vivian et al., 2014). Generally, sodium hydroxide (NaOH) is used for solid or bar soaps while potassium hydroxide (KOH) is used for liquid soaps. The equation below represents the typical saponification reaction.

$$C_3H_5(OOCR)_3 + 3KOH \longrightarrow 3KOOCR + C_3H_5(OH)_3$$

Fat Potassium hydroxide Soap Glycerol

Or

$$C_3H_5(OOCR)_3 + 3NaOH \longrightarrow NaOOCR + C_3H_5(OH)_3$$

Fat Potassium hydroxide Soap Glycerol

Where R represents the hydrocarbon chain or alkyl group.

The lathering and washing properties of soap are contributed by the used of fatty acids such as palmitic acid, stearic acid, lauric acid and oleic acid. Fats are solid esters of fatty acids and glycerine while oils are the liquid glycerol esters of fatty acid at room temperature.

There are a few types of soap such as opaque and transparent soaps. Opaque and transparent are made in two and three hours respectively. Opaque is made from the cold process while transparent soaps are made from ‘semi-boiled' process. In both processes, the fats and oils are pre-melted before being combined with base (Mabrouk, 2005). For "semi-boiled" process, heat is applied to speed up saponification process. The by-product glycerine is retained at the end of the process for both methods. The presence of glycerine is advantageous as humectant because it can prevent human skin from dehydrated.

2.1.1 Difference between Hot Process and Cold Process Soap

There are two ways to make solid bar soaps which are the cold and hot process. The difference between both of them is the use of external heat, the time it takes to saponify, curing time and finish of the soap. Cold process soaps use exothermic heat reaction that is created from the reaction between fixed oils (common oil include palm, coconut and olive) with an alkali (sodium hydroxide or lye). The result is a chemical process called saponification, where the composition of the oils change with the help of lye to create a bar soap (Bramble, 2012). No additional heat is used to facilitate the saponification process. Usually, saponification takes about 18- 24 hours to complete.

Meanwhile, for hot process soap, the external heat source is required to speed up saponification. The external heat source can be a crock pot, a double boiler or the oven. Saponification will be complete in approximately 2 hours. Next, for curing time, soaps made using cold process method take about three to four weeks to cure Curing time depends on the country where we live. If we live in a region with low humidity in the air, it takes only one to two weeks to cure. While for the hot process method, the curing time needs is one week only (La Shorida, 2015).

Cold process soaps have more smooth texture when compared to hot process soap. This is affected by when the additives are added in both soaps. For hot process soaps, the additives are added at the end of "cook" time while for cold process, the additives are added when the soap is still fluid and thus giving the finished soap a smoother texture. Typically, cold process soap has long shelf life depending on the ingredients use (Bramble, 2012).

2.2 The Oil Palm Tree

Elaeis guineensis and *Elaeis oleifera* are two species of oil palm tree. *Elaeis guineensis* is palm species which is native to Africa while *Elaeis oleifera* (less cultivated) is palm species which is native to South and Central America. Both species belong to Arecaceae family and widely cultivated for their oil which is used in cooking and in industry.

Elaeis guineensis was introduced to Malaysia in the early 1870s by the British as an ornamental plant (Awalludin et al., 2015). According to Malaysian Palm Oil Council (MPOB) in 1917, the first commercial planting took place in Tennamaran Estate in Selangor, laying the foundations for the vast oil palm plantations and the palm oil industry in Malaysia. In the early 1960s, the cultivation of oil palm increased at a fast pace under the government's agricultural diversification programme, which was introduced to reduce the country's economic dependence on rubber and tin.

Later, the government introduced land settlement schemes for planting oil palm as a way to eliminate poverty for the landless farmers and smallholder. The oil palm plantations in Malaysia are largely based on estate management system and smallholder scheme. Today, 4.49 million hectares of land in Malaysia is under oil palm cultivation, producing 17.73 million tonnes of palm oil and 2.13 tonnes of palm kernel oil. Malaysia is one of the largest producers and exporters of palm oil in the world, accounting for 11% of the world's oils and fats production and 27% of the export trade of oils and fats.

The oil palm trees that are planted in Malaysia usually from *tenera* variety, a hybrid between *dura* and *pisifera* as shown in in Figure 2.1. The *dura* variety has thick hull, thin pulp and produces a lower yield of oil while for *pisifera* variety, the characteristics are vice versa. The crossbreed between *dura* (male) and *pisifera* (female) will produce high oil yield with a thin hull and thick pulp (Silou et al., 2017). The *tenera* variety produces about 4 to 5 tonnes of crude palm oil (CPO) per hectare per year and about 1 tonne of palm kernels oil.

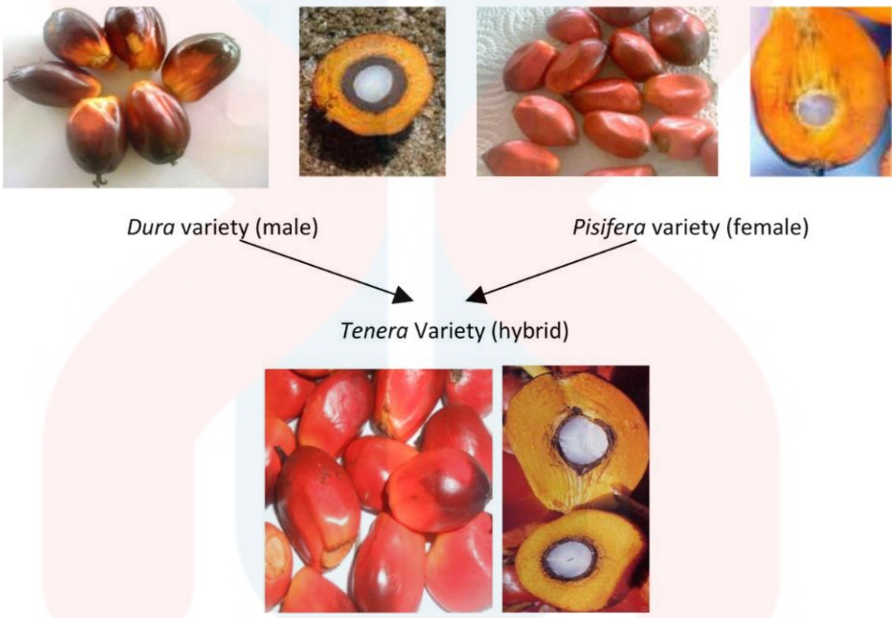

Figure 2.1: Palm oil nuts (varieties: *dura*, *pisifera* and *tenera*)

Source: Silou et al. (2017)

The oil palm keeps producing the fruit bunches until the end of its economic lifespan of between 25-30 years. This remarkable agronomic characteristic allows the oil palm to provide a consistent and uninterrupted supply of vegetable oils to meet ever-increasing global demand.

2.2.1 Structure of Oil Palm Tree

Elaeis guineensis which is grown largely in Malaysia oil palm plantations is a monoecious crop as it bears both male and female flowers on the same tree in an alternating cycle. In that way, it can minimize the chances of self-pollination. The oil palm trees is a single-stemmed plant which can reach a height up to 20-30 metre at maturity.

The oil palm leaves are pinnate or “feather-like” shape, arising from both sides of the frond. The length of the leaf can reach up to 5 m long. An oil palm tree begins to produce fruit after 3- 4 years of planting. The fruits will take about 5- 6 months to mature before can be harvested. The fruits are in bunches, comprising of the oily pericarp, shell and kernel which contain 45- 55% of edible oil (Awalludin et al., 2015)

Each tree produces compact bunches weighing between 10- 25 kilograms with 1000 to 3000 fruitlets per bunch as shown in Figure 2.2 and Figure 2.3. Each fruitlet is almost spherical or elongated in shape with dark purple, almost black and the colour turns to orange-red when it ripe. Each fruitlet consist of a hard kernel (seed) enclosed in a shell (endocarp) which is surrounded by a fleshy mesocarp as shown in Figure 2.4 (Awalludin et al., 2015). Lastly, oil palm tree grows well at a place that receives a fair amount of sunlight, hot climate, wet and humid tropic conditions with a high rainfall rate (2.0 mm of rain).

Figure 2.2: Fruit bunches on the oil palm tree

Figure 2.3: Palm fruit bunches

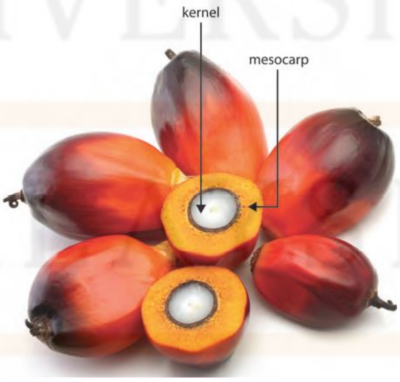

Figure 2.4: Palm fruitlets

2.2.2 Crude Palm Oil (CPO)

Oil palm produces two types of oil which are crude palm oil (CPO) and palm kernel oil (PKO). CPO is derived from fleshy mesocarp of palm fruitlets while PKO is extracted from the palm seed or kernel. Both are edible oils but differ in chemical compositions, physical properties and applications.

Each palm fruit produces about 90% of palm oil and 10% of palm kernel oil. The mesocarp comprises about 70- 80% by weight of the fruit and about 45- 50% of this mesocarp is oil. The rest of the fruit consist of the shell, kernel, moisture and other non-fatty fiber. The unripe fruits contain very little oil when compared to ripe fruits. Based on Awalludin et al. (2015), for every 10 tonnes of palm oil produced at the mill, 1 tonne of palm kernel oil is produced when the kernel is crushed.

Palm oil that is obtained from the fruits (mesocarp) is used in the making of soaps, cosmetics, candles, biofuels, and lubricating greases and in processing tinplate and coating iron plates. Moreover, palm kernel oil that is obtained from seed is used in the manufacturing of edible products such as margarine, ice-cream, chocolate confections, cookies and bread.

2.2.3 Composition of Palm Oil

CPO that is obtained from mesocarp of palm fruit contain glycerides and small quantities of non-glyceride components. Non-glyceride components consist of free fatty acids, trace metals, moisture and impurities, and minor components. The minor components in crude palm oil consist of carotenoids, tocopherols, tocotrienols, sterols, phospholipids, squalene, and triterpene and aliphatic hydrocarbons (Nagendran et al., 2000). The major components of interest are the carotenoids, tocopherols, and tocotrienols, sterols and squalene. Carotene and tocopherols are antioxidants and stabilize the oil against oxidation.

Malaysia crude palm oil contains a higher amount of natural carotenoids with 500 to 700 ppm. 50% of them is β-carotene while 37% is α- carotene. Carotenes are organic pigments that naturally occur in chromoplasts of plants and some other photosynthetic organism such as algae, some types of fungus and bacteria and any other living organism. In plants and algae, carotene is used to absorb light energy for use in photosynthesis. Besides, it also protects chlorophyll from photodamage (Mohd Fauzi and Sarmidi, 2011).

Next, carotene such as β-carotene is a precursor to vitamin A that is converted into vitamin A in vivo. Vitamin A is important for human vision, growth, cellular differentiation, morphogenesis and any other cellular and physiological functions. After that, carotenoids are the most important anti-cancer properties among other biological functions. It is able to decrease the toxic effects of reactive oxygen species (ROS) generated in different diseases such as aging, cancer and cardiovascular and neurodegenerative diseases (Basirnejad et al., 2017).

Other than that, carotenes play an important role in giving orange-red colour to crude palm oil. According to Mohd Fauzi and Sarmidi (2011), carotenoids also have been reported in some crude vegetable oil, but their levels are generally much lower, usually less than 100 ppm. CPO is considered the world's richest natural plant source of carotenoids. It has 15 times more retinol (provitamin A) equivalent than carrots and 300 times more than tomatoes.

Besides being rich in vitamin A, crude palm oil also contains a high amount of vitamin E that is present in the form of tocopherols and tocotrienols. The percentage of tocotrienols is larger compared tocopherols by 70%. Tocotrienols contain anticancer properties, hence it has the ability to protect and maintain heart condition from any disease (Mancini et al., 2015)

Furthermore, squalene that is present in crude palm oil also reported having an anti-carcinogenic activity that can prevent from lung, colon and skin cancer. In addition, squalene is a powerful antioxidant which can scavenge free radicals from the body and thus reduce free radical oxidative damage to the skin.

2.3 Palm Oil Processing

The technique used for processing oil palm fruits is varied with available technology use and this will influence the quality and yield of oil produced. The traditional process is simple, but tedious, inefficient and required much energy and labor. Usually, the knowledge and technology used to extract oil in a traditional way are passing from one generation to generation by induction. The technologies used to extract oil is vary depending on the processor knowledge, country of production, the scale of production (small, medium or large) and end use of palm oil product (food, soap or fuel) (Poku, 2002).

Three main processing technique used to extract palm oil which are the hand spindle press, the hydraulic press (commonly used by the small-scale processor) and the digester screw press (commonly used by medium to large scale processor). As stated by

Afoakwa and Sakyi-Dawson (2013), it shows that most of the medium and large-scale processor usually will use digester screw press as it is more efficient when compared to other two equipment used. However, the price of the equipment is quite expensive compared to hand spindle press and hydraulic press.

The extraction of palm oil from freshly harvested palm fruit bunch involves a few steps which are bunch reception, sterilization, bunch threshing, fruit digestion, pulp pressing, oil clarification and drying.

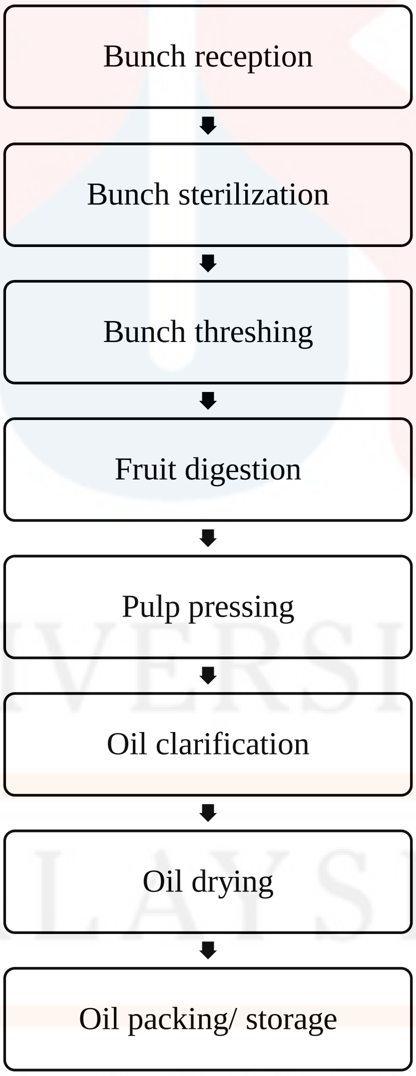

Figure 2.5: Flowchart of palm oil processing

Sources: Afoakwa and Sakyi-Dawson (2013)

2.3.1 Bunch Reception

Fresh fruit arrives from the plantations exist in a bunch or loose fruit. The fresh fruit is normally emptied into wooden boxes that are suitable for weighing so that, quantities of fruit arrived can be checked. Large installations use weighbridges to weigh palm fruits in the trucks.

Upon arrived at the mill, the quality standard of palm oil production will be determined. The quality of final palm oil is determined by a few factors such as genetics, age of the tree, agronomic, environmental, harvesting technique, handling and transport. The mill cannot improve the quality but can minimize or prevent it from further deterioration.

2.3.2 Threshing (Removal of Fruit from the Bunches)

Fruit stripping or loosening refers to the separation of fruits from the bunch and spikelets. Manual threshing is achieved by cutting the fruit-laden spikelets from the bunch stem with an axe or machete and then, remove the fruits from the spikelets by hand one by one (Poku, 2002). Although the process taking a lot of time, the fruits collected are clean and free from bruises.

For the small-scale and semi-mechanized process, fruits loosening are carried out by hitting the stored spikelets with a stick. The process seems faster than hand picking but large proportions of fruits are bruises and may be contaminated with dirt from the ground. After hitting, the spikelets are separated by winnowing with a tray. In a mechanized system (industrial), a rotating drum or fixed drum equipped with rotary beater bars detach the fruit from the bunch, leaving the spikelets on the stem. This process occurs immediately after sterilization (Afoakwa and Sakyi-Dawson, 2013).

2.3.3 Sterilization of Fruits

Sterilization or cooking is the use of high-temperature wet-heat treatment of loose fruit. The difference between cooking and sterilization is cooking normally uses hot water while sterilization uses pressurized steam. There are a few purposes of sterilization such as to deactivate lipolytic enzymes such as lipase in oil palm fruits. This is because the presence of lipase can cause hydrolysis of triglycerides or fat to produce free fatty acid (FFA). The free fatty acid is an undesirable chemical reaction that needs to be stop and removed. If the amount of free fatty acid in crude palm oil is higher, a lot of refining process is required to remove it. So, by using high temperature in the sterilization process, the enzyme can be deactivated and hydrolysis process will be stopped.

Next, sterilization help to soften the palm fruit and facilitate the removal or stripping of the fruitlet from the bunch. After that, fruit cooking help to weaken the pulp structure, softening it and make it easier to separate the fibrous material and its content during the digestion process. The high heat used during the treatment is sufficient to partially break up the oil-containing cells in the mesocarp and allow the oil to be released more easily. This readily improves the overall extraction efficiency and quality of the oil and kernels extracted (Poku, 2002).

2.3.4 Digestion of the Fruit

Digestion is the process of releasing the palm oil in the fruit through the rupture or breaking down the oil-bearing cells. Digestion of palm fruit is carried out in a digester. There are two types of digesters available in the market which are horizontal and vertical version. The vertical digester has been found to be more efficient than horizontal digester.

In small-scale processing, digestion is done either with foot-mashing or pounding in the mortar. The yield of palm oil produced is greatly influenced by the method of digestion. With an equal volume of fruits, a drum of fruits digested mechanically produce 50 litres of oil while manually produce not more than 25 litres (Afoakwa & Sakyi-Dawson, 2013).

2.3.5 Extracting the Palm Oil

There are two distinct methods of extracting oil from the digested material. One system uses mechanical presses and is called the ‘dry method'. The other system called the ‘wet' method that uses hot water to leach out the oil. In the ‘dry' stage, the objective of the extraction is to squeeze the oil out of a mixture of oil, moisture, fibre and nuts by applying mechanical pressure on the digested mash. This method is done by using digested screw press, hydraulic press and hand spindle press as shown in Figure 2.6, Figure 2.7 and Figure 2.8.

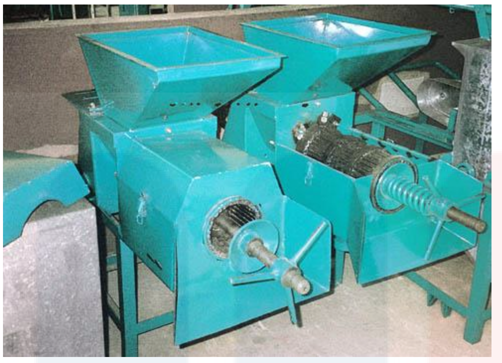

Figure 2.6: Motorised digested screw press

Figure 2.7: Hydraulic press

Figure 2.8: Hand spindle press (manual)

Studies by Afoakwa and Sakyi-Dawson (2013) revealed that the combined digested screw press is more efficient than the hydraulic press and then followed by hand spindle press. The oil yield of the hydraulic press systems is generally between 70% and 90% while the hand spindle press, the oil yield is between 60% and 80%. In Ghana, the use of hand spindle press is most common due to its low initial and maintenance cost. Other than that, the yield of oil produces also depending on the strength of the man who operates the systems.

2.3.6 Clarification and Drying Of Oil

Clarification is the last processing step in the production of palm oil. The purpose of clarification is to separate the oil from its entrained impurities. The fluid that is coming out from the press usually contained a mixture of palm oil, water, cell debris, fibrous materials and 'non- oily solids'. Due to the presence of 'non-oily solids', the mixture is very thick (viscous) and hot water is added to thin it. Water is added in a ratio of 3:1 (Poku, 2002). The dilution (addition of water) provides a barrier and cause the heavy solids to fall to the bottom of the container while the lighter oil droplets flow through the watery mixture to the top when heat is applied to break the emulsion.

In small-scale processing, clarification is not yet mechanized and the processor mostly prefers the manual method of boiling crude palm oil in lotus (drum). The oil is boiled between one to two hours depending on the quantity of oil that needs to be clarified. The oil is effectively clarified where there are no traces of water and dirt presence in the oil. Water presence in oil can cause hydrolysis of oil by increasing free fatty acid (FFA) and thus, reducing the quality of the oil.

2.3.7 Oil Storage

In industrial mills, the purified and dried oil is transferred into a tank for storage before sending from the mill. Since the rate of oxidation increases with the temperature, the suitable temperature to store the oil is around 50°C. However, for the small-scale processor, the dried oil is simply pack in used plastic drums which are blue or yellow in colour and then stored at ambient temperature.

2.3 Colour Analysis

Colour is an important quality attribute for any products which influences the consumer's preference. The colour measurement can be done using Chroma meter CR-400/ 401. Colorimetry quantifies colour by measuring three primary colour components of light which are seen by the human eye such as red, green and blue. In this principle, secondary and tertiary colours like yellow, orange are not individually quantified. Instruments using colorimetry principle are generally called chroma meters or colorimeter. They measure the colour much the same as the human eye.

Data output is in the form of L*, a* and b* values. Parameter L* represents lightness, a* represent redness and b* represent yellowness of the samples. The L*, a* and b* value have a positive and negative value that represents changing colour. The positive value for L*, a* and b* shown lightness, redness and yellowness. While, for the negative value of parameter L*, a* and b* indicates darkness, greenness and blue colour (Magdić et al., 2009).

2.4 Texture Profile Analysis (TPA)

The physical characteristic with the way on how the product feels to the touch being the critical factors in customer acceptance. The application of texture profile analysis (TPA) provides quantifiable, repeatable and accurate data on the physical properties of food, cosmetic, pharmaceutical and chemical products (Mare, 2018).

Texture test methods for cosmetics products are similar to those food types which have comparable physical structure. The cosmetic product exists in three forms which are solids, semi-solids and powder. Generally, for semi-solid such as creams, lotion and gels, the characteristic that will be evaluated are firmness, flow characteristic, consistency and stickiness. While, for solid products like lipstick and bar soaps, the parameters that will be observed are hardness and break resistance. Next, for powders products, the parameters that will be analysed are flow and spread, in associated with visual inspection for clumping.

There are various ranges of probes kit available for texture analysis test. The probe is used as the upper fixture, connected to the load cell and moves via the crosshead down and into the test sample. These accessories enable compression, extrusion, penetration and puncture test methods to be performed, by selection of the appropriate design. The selection of suitable probes is depending on the product to be tested. For bar soaps, the suitable probes use for texture analysis are small cylinders, needle and cones. These probes are used to penetrate into a solid sample's surface in order to test the product strength.

2.6 Sensory Evaluation

Sensory evaluation is used to measure, analyse and interpret characteristic of a product by evaluation of the properties which are detected by the sense of sight, smell, taste, touch and hearing. There are being used in many fields such as foods, cosmetics, pharmaceuticals and many more (Ismail and Ahmad, 2007). In the cosmetic industry, sensory evaluation data has been used as a part of a marketing decision. Besides, the data obtained also important in determining consumer's acceptance towards the product.

The component of sensorial analysis consists of three subsections, which are effective testing, affective testing and perception. Effective testing requires a trained panel for the sensory analysis. This is because the "objective facts" about the product, which would range from basic testing to descriptive profiling, needs to be achieved.

Next, affective testing is a sensorial analysis that is made by consumers. The data obtained from the consumers are subjective, based on their personal preference. The sensorial analysis required untrained personnel to do the testing. Lastly, for perception, the analysis involves the acceptance of the product to animal and human sensation based on the biochemical and physiological theories. The test analysis explains why certain characteristics are preferred over the other (V.Jog et al., 2012).

CHAPTER 3

MATERIALS AND METHOD

3.1 Materials, chemicals and equipment

3.1.1 Materials

Materials used in this research was oil palm fruits or known as *Elaeis guineensis* that was purchased from FELDA Palm Industries Sdn.Bhd- Kemahang, Tanah Merah, Kelantan. Next, cooking oil (Buruh brand) was bought from Pantai Timur Hypermarket Bukit Bunga.

3.1.2 Chemical

Chemicals used in this research was Sodium hydroxide that was purchased from Sigma- Aldrich (Malaysia).

3.1.3 Equipment

Equipment that were used in this research were hot plate (Thermo Scientific Cimarec, China), pH meter (Hanna inst. HI 208, Romania), digital balance (Kern PLE 200-3, Germany), Chroma meter CR-400/401 (Minolta, Japan), CT3 texture analyser (Brookfield Engineering Labs. Inc, USA), hand mixer, basin, cooking pot, gas stove, strainer, measuring cylinder, blue cap bottle, soap mold, spatula, knife, aluminium foil and gloves.

3.2 Methods

3.2.1 Extraction of crude palm oil (CPO)

The extraction of CPO has followed the in-house technique as described by Poku (2002) with some modification.

3.2.1.1 Collection of oil palm fruit (*Elaeis guineensis*)

Fresh palm fruit bunches were purchased from FELDA Kemahang, Tanah Merah, Kelantan. Palm fruitlets were detached from the bunch. A machete was used to cut fruit-laden spikelets from the bunch stem and the fruits were separated manually from the spikelets. After that, the fruitlets were cleaned under running tap water in order to remove dirt and undesired materials such as sand, stone and insect. Then, the fruitlets were weighed and the mass was recorded.

3.2.1.2 Cooking process

The fruitlets were immersed in hot water and cooked for one hour until they are soft. Heat treatment was applied to help in deactivation of lipolytic enzymes in oil palm fruits and make it easier to detach the pulp structure (mesocarp) from endocarp. Once the process completed, the cooked fruitlets were taken out from the boiler using a strainer and put in the basin.

3.2.1.3 Extraction of palm oil

A knife was used to strip the fruitlets to get the pulp (mesocarp). The pulp obtained was filled into a screw press machine. Then, the handler was rotated to expel or extract the oil physically out from the pulp. To increase extraction yield, the residual pulp from the first press is then mixed with water before it is pressed again. A basin was used to collect the extracted oil. The fluid coming out of the press is the mixture of palm oil, water, cell debris, fibrous materials and non-oily solids. Because of ‘non- oily solids' the mixture is very thick.

3.2.1.4 Clarification and drying of oil

Hot water was added in ratio 3:1 to the collected oil to thin it since the presence of ‘non-oily solids cause the mixture to become thick. Dilution causes heavy solids to settle down to the bottom of the basin while lighter oil droplets flow through the watery mixture to the top when heat is applied to break the emulsion. Next, the diluted mixture was passed through a screen to remove coarse fibre.

The screened mixture was boiled for 1 to 2 hour and left for a few minutes to let the palm oil, which is lighter than water to separate and rise to the top. The clear oil was decanted into a new container and reheated again for 10 minutes to remove excess water and dirt. The CPO obtained was decanted into blue cap bottle for storage. The oil was stored at room temperature and away from light until further use.

3.2.2 Preparation of soaps

The preparation of soaps has followed the formulation and method as described by Majestic Mountain Sage's (MMS) lye calculator with some modifications ("TheSage - Lye Calculator", 2018).

3.2.2.1 Make lye- water solution

6.7 g of sodium hydroxide (NaOH) pellets was diluted with 15 ml of distilled water. The mixture was stirred gently until it is fully dissolved. Set aside the solution for a few minutes to lower the temperature (100 ˚F to 125 ˚F).

3.2.2.2 Heat and melt soap making oils

50 g of CPO was weighed and slowly melted over medium-low heat. Keep stirring until all the solids were melted. Once the process completed, the pot was removed from the heat and allowed to cool down. If two types of oils were used, mix both of them together before heating.

3.2.2.3 Mixing process

Poured NaOH solution into the basin containing melted CPO. It was observed that the oil immediately turned to cloudy. The mixture was stirred vigorously for 15 minutes until becoming traces. Tracing makes the soap looks like a slightly thickened custard, not instant pudding but a cooked custard. During the process, it is observed that the bowl was becoming warmed due to the exothermic reaction between the vegetable oil (palm oil) and NaOH solution ("Saponification-The process of Making Soap (Procedure): Class 10: Chemistry: Amrita Online Lab", 2013).

3.2.2.4 Moulding the soap

Once tracing occurred, poured the raw soap into soap mold using a back and forth motion to spread the soap evenly. The spatula was used to smooth the uneven layer of the soap. A towel was laid around the soap mold to trap heat and facilitate the saponification process. Allowed soap to solidify at room temperature for 24 to 48 hours. Once it hardened, removed it from the mold. Placed the soap bars at good ventilation place for curing and drying process. This will allow the bar to firm and finish saponification. Cured the soap for 4 to 6 weeks before it was ready to be used.

Table 3.1: Formulation of soaps from different ratio of crude palm oil (CPO).

Soaps Sample	Crude palm oil (CPO)	Refined palm oil (RPO)
A	100%	0%
	Weight: 50 g	Weight: -
B	75%	25%
	Weight: 37.5 g	Weight: 12.5%
C	50%	50%
	Weight: 25 g	Weight: 25 g
D	25%	75%
	Weight: 12.5 g	Weight: 37.5 g
E	0%	100%
	Weight: -	Weight: 50 g

3.2.3 Physicochemical properties of soap

3.2.3.1 pH test

According to Dalen and Mamza, P.A, (2009), for the determination of pH, 10 g of soap shavings was weighed and dissolved in 100 ml distilled water. This was made 10% soap solution. The pH was determined using a pH meter (Hanna HI 208). The electrode of the pH meter was rinsed using distilled water before being inserted into the solution (Warra et al., 2011). The reading of pH was taken in triplicate for each sample.

3.2.3.2 Hardness test

The hardness of soap was tested using CT3 Texture analyzer (Brookfield Engineering Labs. Inc, USA) using TA39 cylinder 2mm D, 20 mm L probe. The test was repeated three times for each sample by pressing the tips of texture profile analyzer on the surface of the soap. The result shown on the screen was recorded. The texture profile analysis (TPA) was set based on the following parameters; pre- test speed 2.0 mm/s, test speed 10.0 mm/s, post- test speed 2.0 mm/s, target mood distance 10 mm and trigger load 5 g.

3.2.3.3 Colour Analysis

Chroma meter CR-400/401 (Minolta, Japan) was used to analyze the colour of the soap by putting it on the surface of the soap. The values shown on the screen in term of L* (lightness), a* (redness) and b* (yellowness) were recorded. The test was repeated three times for each sample to get an accurate result.

3.2.4 Sensory evaluation

The questionnaire has been distributed to UMK Jeli students and staff ages between 19-47 years old. The accessed attributes include the colour, texture, aroma, lathering and overall acceptance. 30 panels that involved in the sensory evaluation will access the degree of likeness based on the five attributes. The score range starting from 1 which is dislike very much to 5 which is like very much.

3.2.5 Statistical analysis

The experimental data were analyzed using one-way ANOVA and followed by Tukey post hoc test. The data were reported as means ± standard deviation. Statistical analysis was done using Statistical Packages for Social Science (SPSS) with version 20.0. From Tukey post hoc test, the significant difference at ($P \leq 0.05$) among means from triplicate samples was determined.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Physicochemical properties

The parameters that were analyzed under physicochemical properties are pH test, hardness and colour analysis of soap samples.

4.1.1 pH test

The pH of soaps sample was measured using pH meter to detect if there are any differences between each soaps sample. The pH scale measures how acidic or basic a substance is. The pH scales range from 0 to 14. The pH level ranging 7 is considered as neutral, pH above than 7 will consider as basic or alkaline and pH below 7 is acidic.

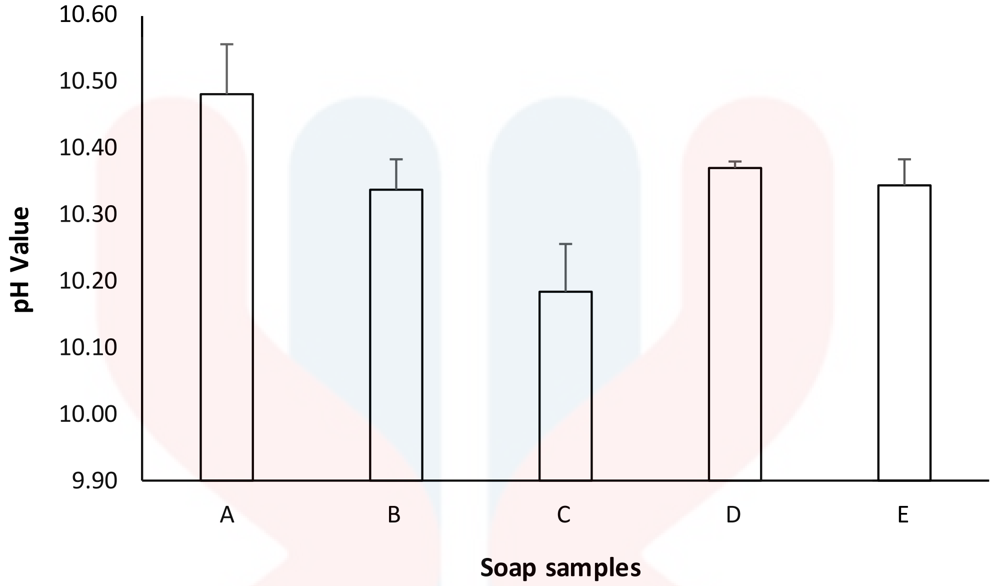

Figure 4.1: pH value of soap samples. A, 100% CPO; B, 75% CPO + 25% RPO; C, 50% CPO + 50% RPO; D, 25% CPO + 75% RPO; E, 100% RPO

Based on Figure 4.1, the pH value for each soap samples was ranged from 10.18 ± 0.071 to 10.48 ± 0.075. All the soaps were categorized as an alkali condition. Soap A (10.48 ± 0.08) which contained 100% of CPO had higher pH value, followed by soap D (10.37 ± 0.01), soap E (10.34 ± 0.04), soap B (10.34 ± 0.05) and soap C (10.18 ± 0.07).

Soap A which contained 100% of CPO had the highest pH value compared to others due to incomplete alkali hydrolysis resulting from the saponification process (Mak-Mensah and Firempong, 2011). This is because, during soap preparation, the addition of 100% CPO to the lye (sodium hydroxide) solution, makes the soap formulation to thicken in a few seconds and difficult to be stirred. Hence, the formulation could not be completely mixed together. However, all the soaps still considered as safe to be used since the pH level for all the samples were in the normal pH range for handmade soaps which were ranged from 9.00 to 10.0. This pH helps to gently clean the skin (Tarun et al., 2014).

Generally, handmade soaps were categorized as an alkali. This is because alkaline substance in soap help to neutralize the body's protective acid mantle that acts as a natural barrier against bacteria and viruses. Healthy skin has a pH around 5.4 to 5.9 (Mak-Mensah and Firempong, 2011). Determination of pH soap before being used is important because soap with too high or too low pH can causes irritation and drying to sensitive skin. Based on the ANOVA, the pH of soaps is significant with ($p < 0.05$). It showed that the pH of soap samples were significantly difference between each other.

4.1.2 Hardness (Texture profile analysis) (TPA))

Soap texture profile analysis (TPA) was carried out using CT3 texture analyzer in order to determine the hardness of soap bar. Hardness is an important attribute to soap as it is able to determine the shelf life. Good quality bar soap will have a longer shelf life.

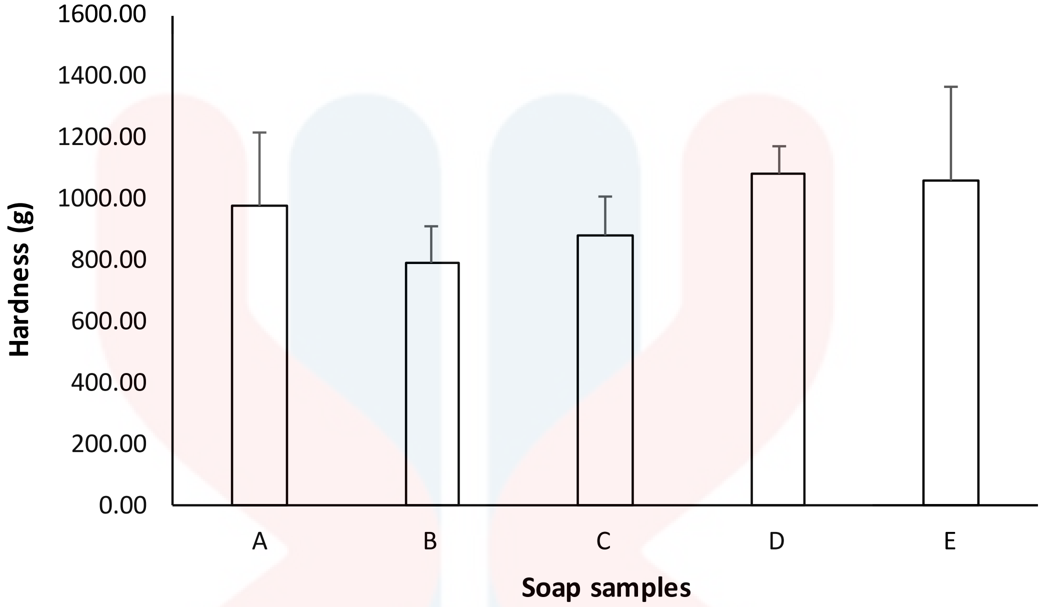

Figure 4.2: Hardness of soap samples A. 100% CPO; B, 75% CPO + 25% RPO; C, 50% CPO + 50% RPO; D, 25% CPO + 75% RPO; E, 100% RPO

Based on Figure 4.2, the result showed that the hardness score of soap samples was ranged from 788.89 ± 120.38 to 1083.56 ± 91.63. Soap D (1083.56 ± 91.63) which contained 25% of CPO had highest hardness value followed by soap E (1062.222 ± 304.88), soap A (975.22 ± 244.93), soap C (879.22 ±125.31) and soap B (788.89 ± 120.38).

According to the ANOVA, the hardness of soap is not significant with ($p > 0.05$). The hardness of soap was influenced by the type of oils used. In this study, both CPO and RPO used in soap formulation were extracted from the same source. Thus, the hardness of the soap sample were not significantly difference between each other.

Generally, the hardness of soap was influenced by a few factors such as the type of oils used in the soap formulation. The more soft oils (such as olive, sweet almond and canola) use in preparation of soap, the softer the bars will be. Moreover, it also requires more time to harden in the mold. Next, soaps that are made from hard oils (such as palm, coconut and beeswax) required a shorter time to harden. Next, usually after the soap hardened, it will be left for several weeks to cure before being used in order to allow excess water to evaporate. Curing creates a firmer bar that will last long longer.

Besides, the amount of superfat used in the making process also will influence the hardness of soap. Superfat is defined as remaining oil that does not turn into soap by sodium hydroxide (NaOH) lye. Extra oil will create a gentler bar, but it can also make the bar softer. In order to create a firmer bar and also gentle to skin, an average superfat use in soap recipe is about 1-7% of superfat. However, if the too much superfat use is, it will create more "free-floating" oils in the soap (Bramble, 2018).

4.1.3 Colour Analysis

The colour for each soaps sample was recorded by Chroma meter (Minolta, Japan) tool and the lightness (*L), redness (*a) and yellowness (*b) data were recorded. The data were recorded after two weeks of curing time. Result revealed that, the lightness(*L), redness (a*) and yellowness (*b) coordinate were ranged from 59.52 ± 0.45 to 65.39 ± 1.85, 1.23 ± 0.65 to 16.43 ± 1.61 and 18.94 ± 1.22 to 68.38 ± 1.89.

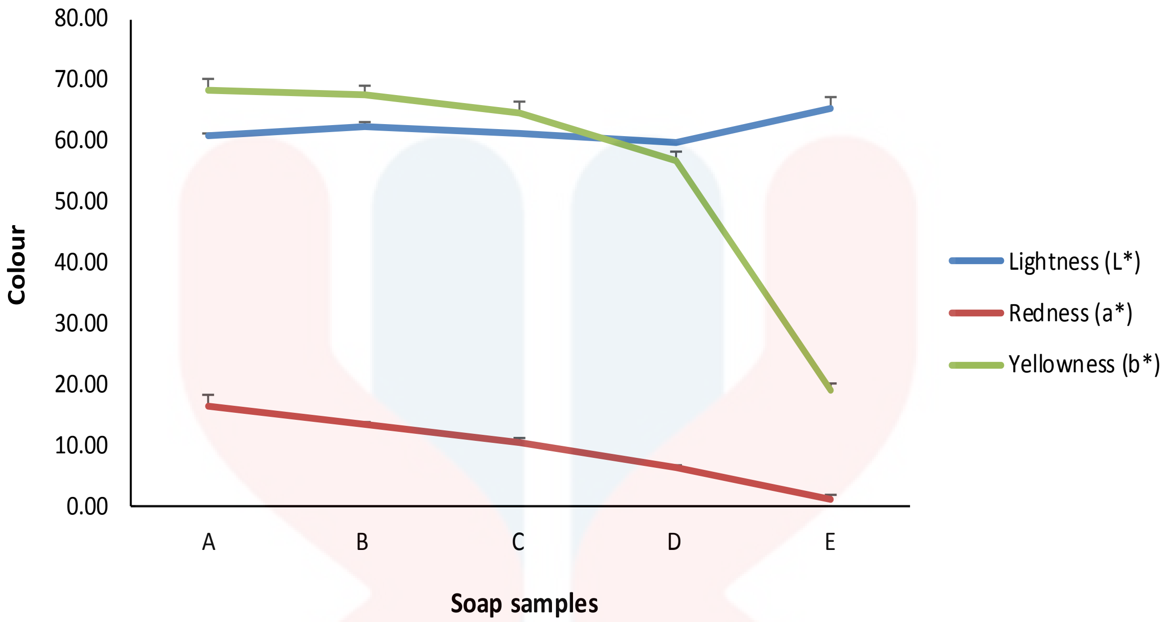

Figure 4.3: Colour L*, a*, b* of soap samples. A, 100% CPO; B, 75% CPO + 25% RPO; C, 50% CPO + 50% RPO; D, 25% CPO + 75% RPO; E, 100% RPO

Based on Figure 4.3, the lightness (L*) for all the soap samples were in positive value which categorized them as light in colour. Soap E (65.39 ± 1.85) which contained 100% of RPO showed highest lightness value followed by soap B (62.23 ± 0.79), soap C (61.30 ± 0.07), soap A (60.83 ± 0.48) and soap D (59.52 ± 0.45). Soap D showed the highest lightness value due to the presence of 100% of RPO. Palm oil that has been refined was bleached and deodorized (Gibon et al., 2007). Thus, the original deep orange-red in colour was reduced.

According to the ANOVA, the lightness (L*) value of soaps is significant with ($p < 0.05$). It showed that lightness (L*) of soap samples were significantly difference between each other. The lightness value of soap samples was affected by the amount of

CPO and RPO used in soap formulation. The higher the amount of RPO use, the higher the lightness value (L*) of oil palm soaps.

Next, for redness (a*), the data obtained showed positive value for all soap samples. However, the redness value for all soap samples was lower than lightness (L*) and yellowness (b*) value. Soap A (16.43 ± 1.61) which contained 100% of CPO showed highest redness (a*) value followed by soap B (13.37± 0.39), soap C (10.45 ± 0.53), soap D (6.15 ± 0.48) and soap E (1.23 ± 0.65). The colour of the soap was affected by the amount of CPO use. According to Nagendran et al. (2000), high contents of carotenoids, including β- carotene and lycopene contribute to the deep orange-red colour of CPO obtained. That is why soap A had higher redness (*b) value compared to other soaps. However, red colour cannot be seen with naked eyes since the yellow one is more dominant to the soaps.

According to the ANOVA, the redness (a*) of soaps is significant with ($p< 0.05$). It showed that redness (a*) of soap samples were significantly difference between each other. The redness of soaps was influenced by the amount of CPO used. The higher the amount of CPO used, the higher the redness value for oil palm soaps.

After that, for yellowness (b*), soap A (68.38 ± 1.89) which contained 100% of CPO showed highest yellowness (L*) value followed by soap B (67.43 ± 1.54), soap C (64.68 ± 1.75), soap D (56.69 ± 1.63) and soap E (18.94 ± 1.22). As the ratio of CPO to RPO is decreased, the yellowness value also will decrease. The yellow colour is more dominant to the soaps as it was influenced by the original colour of CPO itself. However, for soap E which contained 100% RPO, the colour obtained for the soap is white as no CPO was used during the making process. According to (Nagendran et.al (2000), RPO is palm oil that was refined to remove odours, flavours and impurities, as well as the deep orange-red colour. Refined, bleached and deodorized (RBD) palm is bland, odourless and light yellow in colour

According to the ANOVA, yellowness (b*) value of soaps is significant with ($p < 0.05$). It showed that the yellowness (b*) of soap samples were significantly difference between each other. Yellow is the dominant colour for soap A, soap B, soap C and soap D. However, the amount of yellowness were difference between each samples depending on the amount of CPO use during the making process.

4.2 Sensory Evaluation

30 untrained panellist were involved in the sensory evaluation test. They were given five soap samples that were made from different ratio of CPO. The accessed attributes include the colour, aroma, texture, lathering and overall acceptance. 30 untrained panellist that involved in the sensory evaluation will access the degree of likeness based on the five attributes. The score range starting from 1 which is dislike very much to 5 which is like very much.

4.2.1 Colour attribute

Colour is one of the most important image features because it contains the basic human vision. Colour significantly affects the consumer perception towards the product. For product commercialization, colour is important, especially in marketing. 90% of consumers admit that the colour and visual appearance are their primary reasons for purchasing a product.

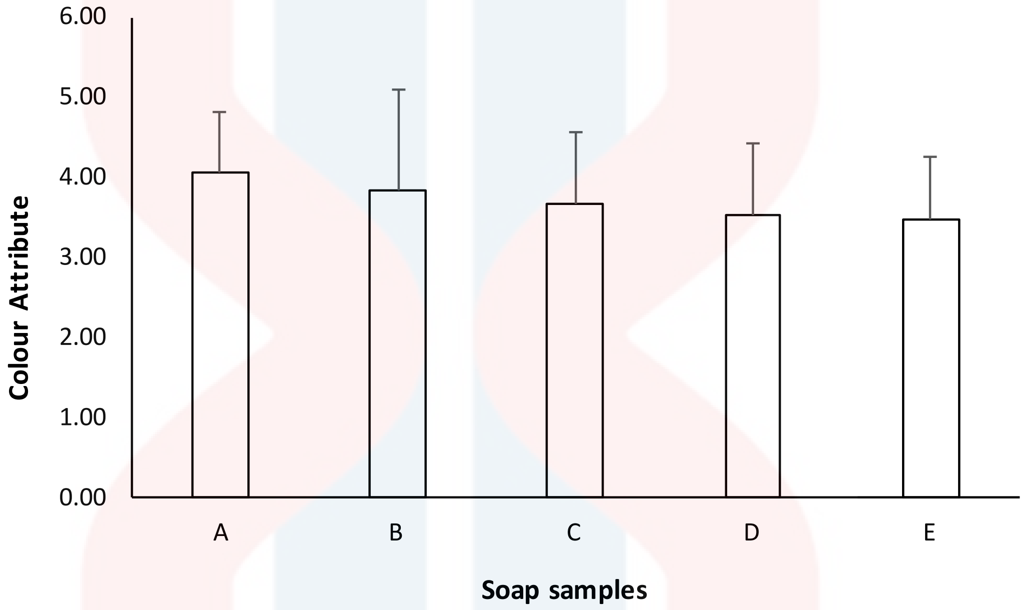

Figure 4.4: The sensory evaluation for colour attribute. A, 100% CPO; B, 75% CPO + 25% RPO; C, 50% CPO + 50% RPO; D, 25% CPO + 75% RPO; E, 100% RPO

Based on Figure 4.4, the average value for colour attribute was ranged from 3.47 ± 0.77 to 4.07 ± 0.74. The acceptability for colour attribute for soap A (4.07 ± 0.74) is highest followed by soap B (3.83 ± 1.26), soap C (3.67 ± 0.88), soap D (3.53 ± 0.90) and soap E (3.47 ± 0.77).

Most of the panels preferred to have soap A which contained 100% of CPO as it had a brighter yellow colour and more attractive. Colour in soap samples were influenced by the colour of CPO itself. As the amount of CPO used is higher, the brighter the yellow colour of soaps it is.

Soap E which contained 100% RPO was less preferred by the panels. Since there is no CPO used in soap formulation, the colour of the finished product is white and less attractive. According to the ANOVA, the colour attribute in sensory evaluation is not significant with ($p>0.05$). It showed that the colour attribute of soap samples were not significantly difference between each other.

4.2.2 Aroma attribute

Aroma is an important attribute that will attract customer to buy a product. Scent main role is to make the customer feel comfortable, happy and put them at ease so they will spend more time in the store, spend more money and ultimately make them more likely to return. Different people have different sensitivities to scent.

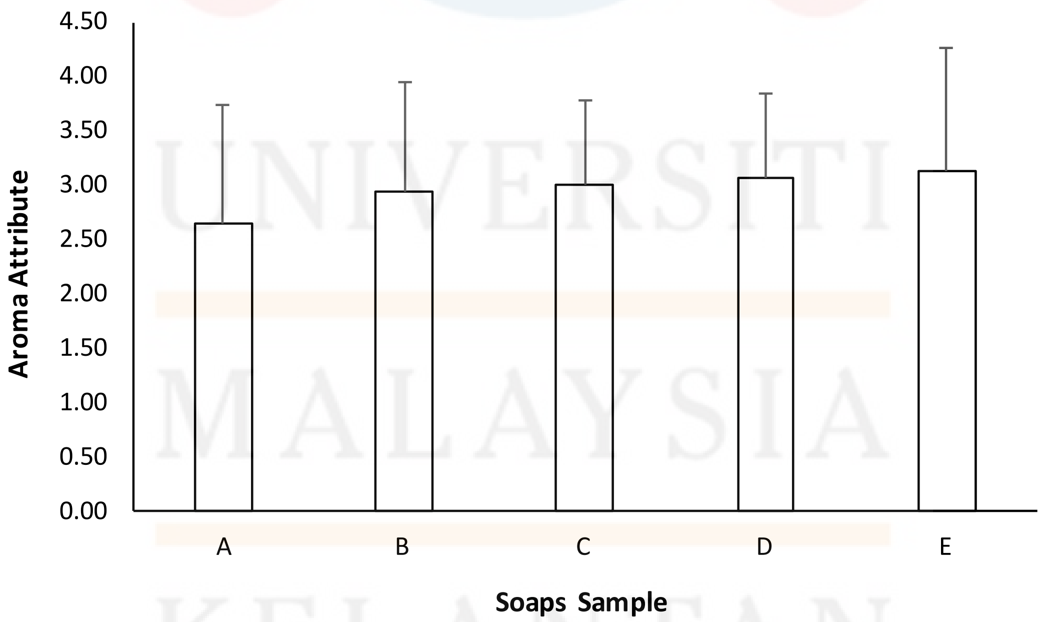

Figure 4.5: The sensory evaluation for aroma attribute. A, 100% CPO; B, 75% CPO + 25% RPO; C, 50% CPO + 50% RPO; D, 25% CPO + 75% RPO; E, 100% RPO

Based on Figure 4.5, the average value for aroma attribute was ranged from 2.63 ± 1.10 to 3.13 ± 1.14. The acceptability for aroma attributes for soap E (3.13 ± 1.14) which contained 0% of CPO is slightly higher compared to soap D (3.07 ± 0.78), soap C (3.00 ± 0.79), soap B (2.93 ± 1.01) and soap A (2.63 ± 1.10). Most of the panellist well-liked soap E more because it contained 100% RPO.

RPO is odourless when compared to CPO. Deep orange-red in colour of palm oil in its crude form is very strong tasting. It is very pungent and has a smell like overripe mushrooms (Nagendran et al., 2000). So, the higher the amount of CPO used in soap preparation, the more the pungent smell it is. Based on the ANOVA, the aroma attribute of soap sample is not significant with ($p>0.05$). It showed that the aroma attribute of soaps were not significantly difference between each other.

4.2.3 Texture attribute

The texture is referring as feel, appearance, or consistency of a surface or a substance. It can be perceived with the sense of touch. Barret et.al (2010) stated that the appearance of the product usually will determine whether a product is accepted or rejected. Appearance factors include the product size, shape, wholeness, pattern, the presence of gloss and consistency.

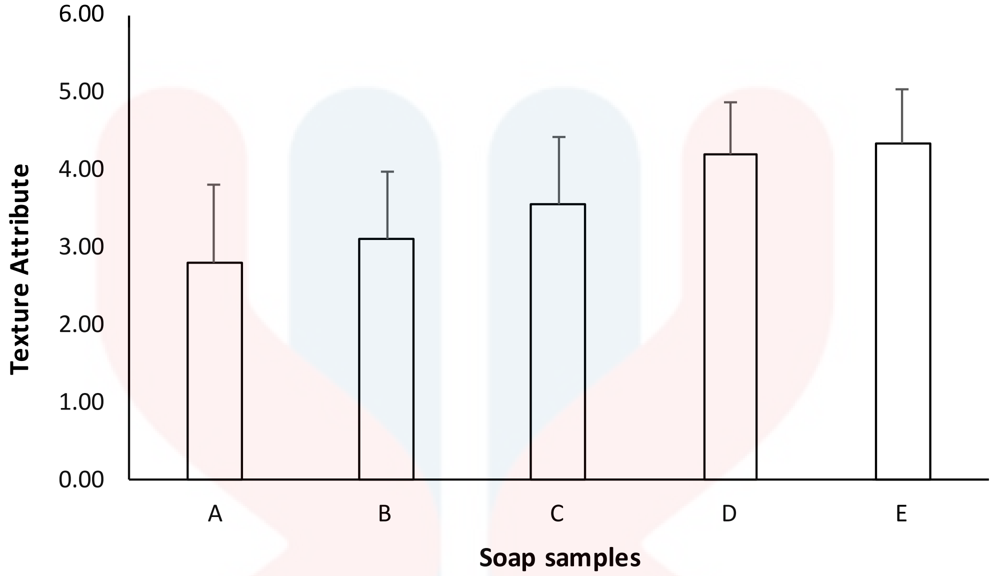

Figure 4.6: The sensory evaluation for texture attribute. A, 100% CPO; B, 75% CPO + 25% RPO; C, 50% CPO + 50% RPO; D, 25% CPO + 75% RPO; E, 100% RPO

Based on Figure 4.6, the average value for texture attribute was ranged from 2.80 ± 1.00 to 4.33 ± 0.71. Most of the respondents preferred soap E (4.33 ± 0.71) which contained 0% of CPO followed by soap D (4.20 ± 0.66), soap C (3.57 ± 0.86), soap B (3.10 ± 0.88) and soap A (2.80 ± 1.00)

Soap A is less preferred by the panels as the texture is rough and coarse compared to others. One of the factors that influenced the texture of soaps is the types of oil used in the soap recipe. Both of CPO and RPO are categorized as "hard oil". However, at room temperature, both of them appear in a different state. CPO appears as semi-solid while RPO appears as a liquid at room temperature. When the oils react with the lye solution, soap with a higher ratio of CPO will viscous faster and the condition of the trace formed was very thick. Trace reached once the lye and oils are saponified and the two will not separate (Atiku et al., 2014).

Soap A has rough and coarse texture because the trace formed is thick. Thick trace is the consistency of thick pudding and holds its shape when poured. However, it is difficult to pour and spread into the soap mold. For soap E, which contained 100% of RPO, the soap has soft and smooth texture since the trace formed is thin. Light trace refers to soap batter with no oil streaks. Thin trace is easy to pour and spread into the soap mold when compared to thick trace.

When referring to the ANOVA, the texture attribute of soaps is significant with ($p < 0.05$). It showed that the texture of soap samples were significantly difference between each other.

4.2.4 Lathering attribute

Soap is a combination of a number of ingredients. All soaps contain acids, which are actually fats or oils added to a base, and alkali products such as lye or potash. The combination of oils or fats with alkali products creates soap lather, which suspends dirt by creating greater surface tension in water, trapping dirt for easy removal through rinsing. Lathering differs from brand to brand in soap, because how soap lathers depend on what sort of oil it contains (Mishra, 2002). Other ingredients that were added to the soap formulation also affect the lathering process, but the main factor for good lather is the oil or fat used.

Soap that was used for personal skin care lathers in two ways. First, the soap will produce a foamy, fluffy lather. Secondly, the lather will be stable enough to pick up dirt well (Mak-Mensah and Firempong, 2011). Soaps that contain palm oil do not only produce hard bars of soap but also moisturize and lather well, making them very high-quality soap ingredients.

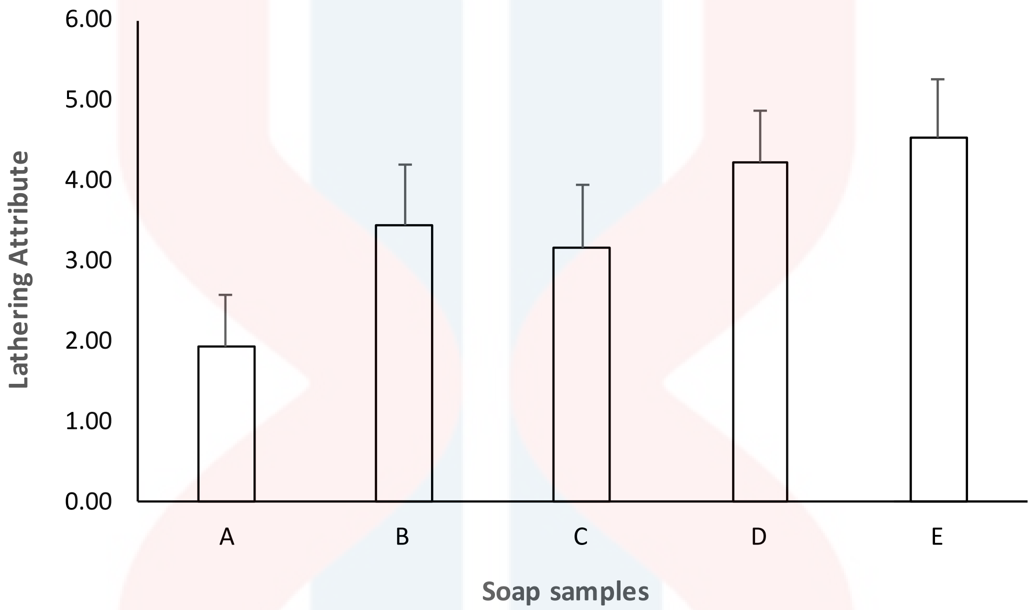

Figure 4.7: The sensory evaluation for lathering attribute. A, 100% CPO; B, 75% CPO + 25% RPO; C, 50% CPO + 50% RPO; D, 25% CPO + 75% RPO; E, 100% RPO

Based on Figure 4.7, the lathering attribute of soaps was ranged from 1.93 ± 0.64 to 4.53 ± 0.73. In terms of lathering, most of the respondents preferred soap E (4.53 ± 0.73) followed by soap D (4.23 ± 0.63), soap B (3.43 ± 0.77), soap C (3.17 ± 0.79) and soap A (1.93 ± 0.64)

Soap A produced less lather due to incomplete saponification which makes the lather formed feel a little bit oily and difficult to rinse off from the body. The ingredients in soap formulation were not mixed well as the trace formed was too sticky and hard to stir. However, for soap that was made with less ratio of CPO will produce a lot of foam and fluffy lather. It also easy to rinse with soft water. (Mishra, 2002)

According to the ANOVA, the lathering attribute of soaps is significant with ($p < 0.05$). It showed that the lathering attribute of soap samples were significantly difference between each other.

4.2.5 Overall acceptance

Generally, consumers tend to choose a soap based on colour, aroma, texture and lathering attributes. The characteristics of soaps that preferred by an individual are different between each other.

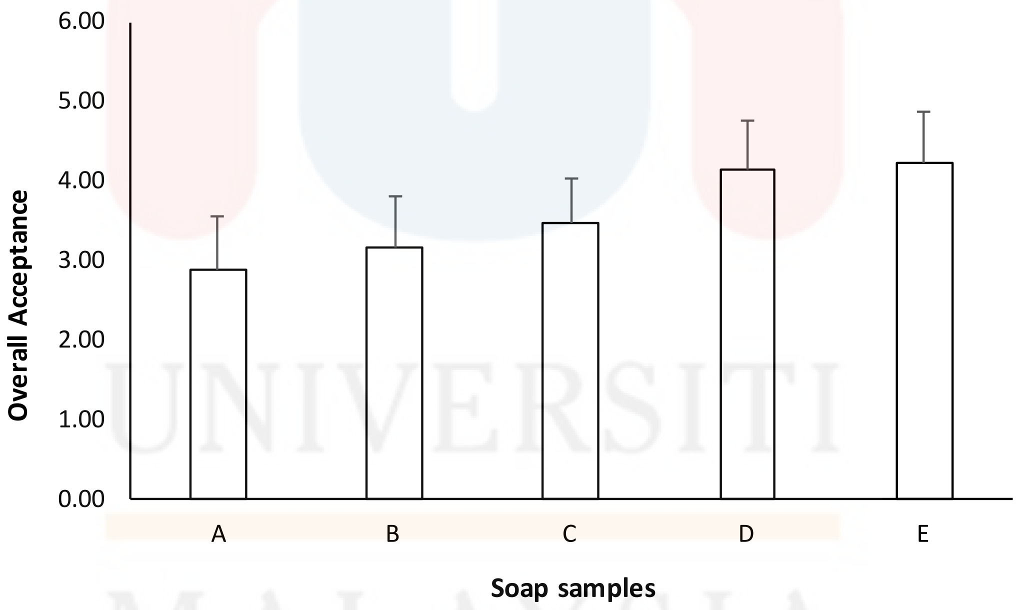

Figure 4.8: The overall acceptance of soap samples. A, 100% CPO; B, 75% CPO + 25% RPO; C, 50% CPO + 50% RPO; D, 25% CPO + 75% RPO; E, 100% RPO

Based on Figure 4.8, the average value for overall acceptance was ranged from 2.87 ± 0.68 to 4.23 ± 0.63. Soap E (4.23 ± 0.63) which contained 100% RPO was showed highest valued followed by soap D (4.13 ± 0.63), soap C (3.47 ± 0.57), soap B (3.17 ± 0.65) and soap A (2.87 ± 0.68).

However, there is slightly difference in mean for soap E and soap D. This can be shown that soap D that was made from 25% of CPO had same quality as commercial soap in the market (soap E) even though some modification and improvement are needed for certain attributes in order to make it viable in the market and meet customers demand.

Based on the ANOVA, for overall acceptance towards soap samples is significant with ($p < 0.05$). It showed that the overall acceptance of consumers towards the soap samples were significantly difference between each sample.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

Based on this study, the result showed soap that contained higher CPO is good in terms of colour and hardness. However, in terms of texture, soap that was with higher CPO appeared to be rougher. All the soaps prepared using the formulations in the study are safe to be used as the pH values are in the same range as commercial soap. For sensory evaluation, most of the respondents are preferring soap that contained lower CPO in accordance with the preference of colour, aroma, texture and lathering properties.

For recommendation, the essential oil can be added to soap has active ingredients to improve its functional properties. Moreover, the addition of fragrance also could give a value added to the product to attract consumers to use the soap. Apart from that, this soap also can be commercialized along with luffa sponge for bathing, exfoliating and cleaning purpose as both products contain naturally antimicrobial properties.

REFERENCES

Atiku, F. A., Fakai, I. M., Wara, A. A., Birnin-Yauri, A. U., & Musa, M. A. (2014). Production of Soap Using Locally Available Alkaline Extract from Millet Stalk: A Study on Physical and Chemical Properties of Soap. *International Journal of Advanced Research in Chemical Science*, *1*(7), 1–7. Retrieved from www.arcjournals.org

Awalludin, M. F., Sulaiman, O., Hashim, R., & Nadhari, W. N. A. W. (2015). An overview of the oil palm industry in Malaysia and its waste utilization through thermochemical conversion, specifically via liquefaction. *Renewable and Sustainable Energy Reviews*, *50*, 1469–1484. https://doi.org/10.1016/j.rser.2015.05.085

Basirnejad, M., Milani, A., & Bolhassani, A. (2017). Carotenoids and Cancer : Biological Functions, *1*(6), 11–20.

Bramble, B. (2012). Free Beginner's Guide to Soapmaking: Cold Process - Soap Queen. Retrieved from https://www.soapqueen.com/bath-and-body-tutorials/cold-process-soap/free-beginners-guide-to-soapmaking-cold-process/

Bramble, B. (2018) Why is My Cold Process Soap Soft?- Soap Queen. [online] Soap Queen. Available at: https://www.soapqueen.com/bath-and-body-tutorials/tips-and-tricks/cold-process-soap-soft/

Dalen, M. ., & P.A Mamza. (2009). Short Communication Report Some physicochemical properties of prepared metallic soap-dries of aluminium, copper and zinc. *Science World Journal*, *4*(3), 7–9.

Gibon, V., De Greyt, W., & Kellens, M. (2007). Palm oil refining. *European Journal Of Lipid Science And Technology*, *109*(4), 315-335. doi: 10.1002/ejlt.200600307).

Is It a Cosmetic, a Drug, or Both? (Or Is It Soap?). (2012). Retrieved from https://www.fda.gov/cosmetics/guidanceregulation/lawsregulations/ucm074201.html

Ismail, R., & Ahmad, S. (2007). Sensory evaluation for cosmetics and personal care products. *Star*.

James E., B., Fred, S., & Neil D., J. (2007). *Chemistry: Matter and Its Change* (5th ed.). Hoboken, NJ: Wiley.

La Shorida, T. (2015). The Difference between Hot Process and Cold Process Soaps. Retrieved from http://handmadesoapcoach.com/the-difference-between-hot-process-and-cold-process-soaps/

Mabrouk, S. T. (2005). Making Usable, Quality Opaque or Transparent Soap. *J. Chem. Educ.*, *82*(10), 1534–1537. https://doi.org/10.1021/ed082p1534

Magdić, D., Lukinac, J., Jokić, S., Čačić-Kenjerić, F., Bilić, M., & Velić, D. (2009). Impact analysis of different chemical pre-treatments on colour of apple discs during drying process. *Croatian Journal of Food Science and Technology*, *1*(1), 31–35. https://doi.org/https://doi.org/10.17508

Mak-Mensah*, E. E., & Firempong, C. K. (2011). Chemical characteristics of toilet soap prepared from neem (Azadirachta indica A. Juss) seed oil. *Pelagia Research Library Asian Journal of Plant Science and Research*, *1*(4), 1–7. https://doi.org/10.2337/dc05-1367

Mancini, A., Imperlini, E., Nigro, E., Montagnese, C., Daniele, A., Orrù, S., & Buono, P. (2015). Biological and nutritional properties of palm oil and palmitic acid: Effects on health. *Molecules*, *20*(9), 17339–17361. https://doi.org/10.3390/molecules200917339

Mishra, D. (2002). *Preparation of Soap Using Different Types of Oils and Exploring its Properties Submitted by Debesh Mishra Department of Chemical Engineering National Institute of Technology Under the guidance of Dr . Susmita Mishra*. *Journal of the American Oil Chemists' Society*. National Institue of Technologhy. https://doi.org/10.1021/acs.jchemed.5b00188

Mohd Fauzi, N. A., & Sarmidi, M. R. (2011). Extraction of Heat Treated Palm Oil and Their Stability on β-carotene During Storage. *Journal of Science and Technology*, *2*(1), 45–54. Retrieved from http://penerbit.uthm.edu.my/ojs/index.php/JST/article/view/234

Nagendran, B., Unnithan, U. R., Choo, Y. M., & Sundram, K. (2000). Characteristics of red palm oil, a carotene- and vitamin E-rich refined oil for food uses. *Food and Nutrition Bulletin*, *21*(2), 189–194. https://doi.org/10.1177/156482650002100213

Oil palm plantation. (2012). Retrieved from http://www.mpoc.org.my/The_Oil.aspx

Poku, K. (2002). *Small-scale palm oil processing in Africa*. Rome: Food and Agriculture Organization of the United Nations.

Saponification-The process of Making Soap (Procedure): Class 10: Chemistry: Amrita Online Lab. (2013). Retrieved from http://amrita.olabs.edu.in/?sub=73&brch=3&sim=119&cnt=2

Silou, T., Moussounda-Moukouari, R., Bikanga, R., Pamba-Boundena, H., Moussoungou, T., Mampouya, D., & Chalchat, J. C. (2017). Small-scale production in the Congo basin of low-acid carotene-rich red palm oil. *Oilseeds & Fats Crops and Lipids*, *24*(5), 1–13. https://doi.org/10.1051/ocl/2017017

Tarun, J., Susan, V., Susan, J., Suria, J & Criton, S. (2014). Evaluation of pH of bathing soaps and shampoos for skin and hair care. *Indian Journal of Dermatology*, 59 (5), 442. http://www.e-ijd.org/article.asp?issn=00195154;

TheSage - Lye Calculator. (2018). Retrieved from https://www.thesage.com/calcs/LyeCalc.html

V.Jog, S., Bagal, S. A., Chogale, M. M., & Palekar-Shanbhag, P. (2012). Sensorial analysis in cosmetics an overview. *Household and Personal Care Today*, *7(1)*(3), 23–24. Retrieved from http://www.teknoscienze.com/articles/hpc-today-sensorial-analysis-in-cosmetics-an-overview.aspx#.VtikPpyLSUk

Vivian, O. P., Nathan, O., Osano, A., Mesopirr, L., & Omwoyo, W. N. (2014). "Assessment of the PhyVivian, Onyango P, Oyaro Nathan, Aloys Osano, Linda Mesopirr, and Wesley Nyaigoti Omwoyo. 2014. "Vivian, Onyango P, Oyaro Nathan, Aloys O. *Journal of Applied Sciences*, *4*(July), 433–440. https://doi.org/10.1055/s-0032-1325286

Warra, A., Hassan, L., Gunu, S., & Jega, S. (2011). Cold- Process Synthesis and Properties of Soaps Prepared from Different Triacylglycerol Sources. *Nigerian Journal of Basic and Applied Sciences*, *18*(2), 315–321. https://doi.org/10.4314/njbas.v18i2.64350

Zauro, S. A., Abdullahi, M. T., Aliyu, A., Muhammad, A., Abubakar, I., & Sani, Y. M. (2016). Production and Analysis of Soap using Locally Available Raw-Materials. *Applied Chemistry*, *96*(7), 41479–41483. https://doi.org/10.1007/s12205-015-0717-1

APPENDIX A

Table A.1: One-way ANOVA for physicochemical properties of soap samples

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Texture	Between Groups	185182.268	4	46295.567	1.209	.366
	Within Groups	383061.685	10	38306.168		
	Total	568243.953	14			
pH	Between Groups	.135	4	.034	11.566	.001
	Within Groups	.029	10	.003		
	Total	.164	14			
Lightness	Between Groups	58.310	4	14.577	16.268	.000
	Within Groups	8.961	10	.896		
	Total	67.271	14			
Redness	Between Groups	430.678	4	107.670	146.174	.000
	Within Groups	7.366	10	.737		
	Total	438.044	14			
Yellowness	Between Groups	5190.700	4	1297.675	494.124	.000
	Within Groups	26.262	10	2.626		
	Total	5216.962	14			

Table A.2: Post Hoc Test (Tukey) for texture of soap samples

Texture

Tukey HSD[a]

Sample	N	Subset for alpha = 0.05 1
Soap B	3	788.8889
Soap C	3	879.2222
Soap A	3	975.2222
Soap E	3	1062.2222
Soap D	3	1083.5556
Sig.		.402

Table A.3: Post Hoc Test (Tukey) for pH of soap samples

pH

Tukey HSD[a]

Sample	N	Subset for alpha = 0.05	
		1	2
Soap C	3	10.1833	
Soap B	3		10.3367
Soap E	3		10.3433
Soap D	3		10.3700
Soap A	3		10.4800
Sig.		1.000	.053

Table A.4: Post Hoc Test (Tukey) for lightness (L*) of soap samples

Lightness

Tukey HSD[a]

Sample	N	Subset for alpha = 0.05		
		1	2	3
Soap D	3	59.5167		
Soap A	3	60.8333	60.8333	
Soap C	3	61.2967	61.2967	
Soap B	3		62.2300	
Soap E	3			65.3867
Sig.		.221	.420	1.000

Table A.5: Post Hoc Test (Tukey) for redness (a*) of soap samples

Redness

Tukey HSD[a]

Sample	N	Subset for alpha = 0.05				
		1	2	3	4	5
Soap E	3	1.2300				
Soap D	3		6.1533			
Soap C	3			10.4467		
Soap B	3				13.3733	
Soap A	3					16.4333
Sig.		1.000	1.000	1.000	1.000	1.000

Table A.6: Post Hoc Test (Tukey) for yellowness (b*) of soap samples

Yellowness

Tukey HSD[a]

Sample	N	Subset for alpha = 0.05		
		1	2	3
Soap E	3	18.9400		
Soap D	3		56.6933	
Soap C	3			64.6833
Soap B	3			67.4300
Soap A	3			68.3800
Sig.		1.000	1.000	.107

Table A.7: One-way ANOVA for sensory attributes of soap samples

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Colour	Between Groups	8.133	4	2.033	2.352	.057
	Within Groups	125.367	145	.865		
	Total	133.500	149			
Texture	Between Groups	53.667	4	13.417	19.390	.000
	Within Groups	100.333	145	.692		
	Total	154.000	149			
Aroma	Between Groups	4.507	4	1.127	1.182	.321
	Within Groups	138.167	145	.953		
	Total	142.673	149			
Lathering	Between Groups	125.027	4	31.257	61.054	.000
	Within Groups	74.233	145	.512		
	Total	199.260	149			
Overall_acceptance	Between Groups	42.760	4	10.690	26.756	.000
	Within Groups	57.933	145	.400		
	Total	100.693	149			

Table A.8: Post Hoc Test (Tukey) for colour attribute of soap samples

Colour

Tukey HSD[a]

Sample	N	Subset for alpha = 0.05	
		1	2
Soap A	30	3.40	
Soap B	30	3.53	3.53
Soap D	30	3.67	3.67
Soap E	30	3.83	3.83
Soap C	30		4.07
Sig.		.375	.178

Table A.9: Post Hoc Test (Tukey) for texture attribute of soap samples

Texture

Tukey HSD[a]

Sample	N	Subset for alpha = 0.05		
		1	2	3
Soap A	30	2.80		
Soap B	30	3.10	3.10	
Soap C	30		3.57	
Soap D	30			4.20
Soap E	30			4.33
Sig.		.631	.196	.972

Table A.10: Post Hoc Test (Tukey) for aroma attribute of soap samples

Aroma

Tukey HSD[a]

Sample	N	Subset for alpha = 0.05
		1
Soap A	30	2.63
Soap B	30	2.93
Soap C	30	3.00
Soap D	30	3.07
Soap E	30	3.13
Sig.		.279

Table A.11: Post Hoc Test (Tukey) for lathering attribute of soap samples

Lathering

Tukey HSD[a]

Sample	N	Subset for alpha = 0.05		
		1	2	3
Soap A	30	1.93		
Soap C	30		3.17	
Soap B	30		3.43	
Soap D	30			4.23
Soap E	30			4.53
Sig.		1.000	.601	.485

Table A.12: Post Hoc Test (Tukey) for overall acceptance of soap samples

Overall_acceptance

Tukey HSD[a]

Sample	N	Subset for alpha = 0.05		
		1	2	3
Soap A	30	2.87		
Soap B	30	3.17	3.17	
Soap C	30		3.47	
Soap D	30			4.13
Soap E	30			4.23
Sig.		.356	.356	.973

APPENDIX B

SENSORY EVALUATION FORM FOR PALM OIL SOAP (SAMPLE A/B/C/D/E)

Age:

Race:

Gender:

Directions:

You are given some samples for test attributes. Please state your degree of likeness based on the characteristics below at the mark provided. Circle which is appropriate.

1. Colour

1 2 3 4 5

Dislike very much — Neither like nor dislike — Like very much

2. Aroma

1 2 3 4 5

Dislike very much — Neither like nor dislike — Like very much

3. Texture

1 2 3 4 5

Dislike very much — Neither like nor dislike — Like very much

4. Lathering

1	2	3	4	5
Dislike very much		Neither like nor dislike		Like very much

5. Overall acceptance

1	2	3	4	5
Dislike very much		Neither like nor dislike		Like very much

APPENDIX C

Figure C.1: Sample collection

Figure C.2: Cooking palm fruitlets

Figure C.3: Stripping palm fruitlets

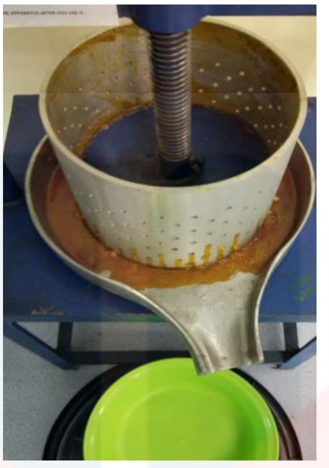

Figure C.4: Extraction of CPO

Figure C.5: CPO obtained

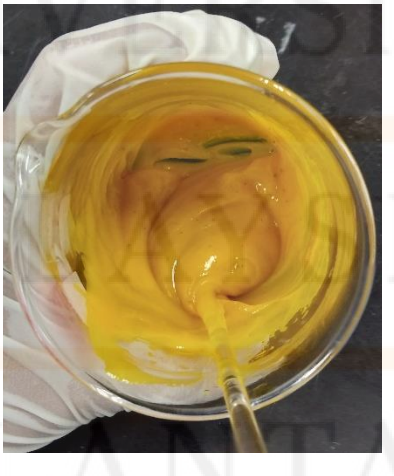

Figure C.6: Preparation of soap

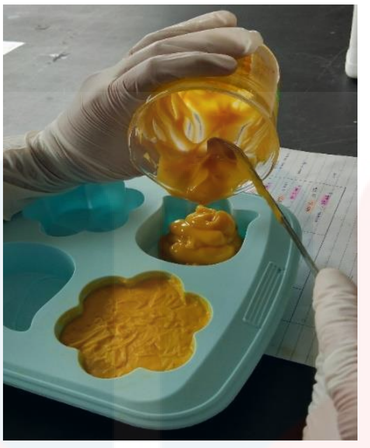

Figure C.7: Molding the soap

Figure C.8: Soap A, 100% CPO

Figure C.9: Soap B, 75% CPO + 25% RPO

Figure C.10: Soap C, 50% CPO + 50% RPO

Figure C.11: Soap D, 25% CPO + 75% RPO

Figure C.12: Soap E, 100% RPO