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Development Of Soap Formulation from Agarwood Essence Using Taguchi Method

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DECLARATION

I declare that this thesis entitled "Development of Soap Formulation from Agarwood Essence Using Taguchi Method" is the results of my own research except as cited in the references.

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Development Of Soap Formulation from Agarwood Essence Using Taguchi Method

ABSTRACT

This study was focuses on the development of an innovative bio soap formulation that combines the distinct uniqueness of agarwood through the Taguchi method approach. This approach is applied to optimize the formulation factors involving the exact concentration of agarwood, the type of base oil, and the percentage of additional ingredients in the soap formulation. The experiment was conducted by planning a structured experiment using the Taguchi Design of Experiment, and the data obtained was analysed to identify the optimal formulation combination that produced soap with the desired properties. This approach enables systematic factor analysis, reduces the need for repeated testing and leads to better efficiency in the soap formulation development process. The results from this analysis form the basis for an in-depth understanding of how different formulations affect the physical and chemical characteristics of soap, including pH, softness, and aroma. By using the Taguchi method, we can determine the key factors that have a significant impact on the quality of the soap produced. The use of Hedonic Tests was also held to evaluate appearance, texture, aroma, and colour, serving as an important indicator to measure the preferences and subjective perceptions of participants regarding soap formulations obtained from agarwood essences using the Taguchi method. The results of this study are expected to provide insightful guidance for the soap manufacturing industry to produce high quality products with special emphasis on the definite benefits of agarwood. In conclusion, this study brings an important contribution to the understanding of the development process of effective soap formulations, with the hope of producing a product that does not meet the basic needs of cleaning, but also offers an exclusive experience with unique additional benefits through the use of agarwood essence. The optimization of conditions through the Taguchi Method further ensures the production of soap formulations at their peak performance.

Pembangunan Formulasi Sabun daripada Pati Gaharu Menggunakan Kaedah Taguchi

ABSTRAK

Kajian ini memberi tumpuan kepada pembangunan formulasi sabun bio inovatif yang menggabungkan keunikan tersendiri gaharu melalui pendekatan sistem kaedah Taguchi. Pendekatan ini digunakan untuk mengoptimumkan faktor formulasi yang melibatkan kepekatan tepat gaharu, jenis minyak asas, dan peratusan bahan tambahan dalam formulasi sabun. Eksperimen dijalankan dengan merancang eksperimen berstruktur menggunakan Reka Bentuk Eksperimen Taguchi, dan data yang diperolehi dianalisis untuk mengenal pasti kombinasi rumusan optimum yang menghasilkan sabun dengan sifat yang dikehendaki. Pendekatan ini membolehkan analisis faktor sistematik, mengurangkan keperluan untuk ujian berulang dan membawa kepada kecekapan yang lebih baik dalam proses pembangunan formulasi sabun. Hasil daripada analisis ini membentuk asas untuk pemahaman yang mendalam tentang cara formulasi berbeza mempengaruhi ciri fizikal dan kimia sabun, termasuk pH, kelembutan dan aroma. Dengan menggunakan kaedah Taguchi, kita boleh menentukan faktor-faktor utama yang memberi kesan yang ketara terhadap kualiti sabun yang dihasilkan. Penggunaan Ujian Hedonik juga diadakan untuk menilai rupa, tekstur, aroma, dan warna, berfungsi sebagai penunjuk penting untuk mengukur keutamaan dan persepsi subjektif peserta mengenai formulasi sabun yang diperoleh daripada pati gaharu menggunakan Kaedah Taguchi. Hasil kajian ini diharapkan dapat memberi panduan yang bernas kepada industri pembuatan sabun untuk menghasilkan produk berkualiti tinggi dengan penekanan khusus terhadap faedah pasti kayu gaharu. Kesimpulannya, kajian ini membawa sumbangan penting kepada pemahaman proses pembangunan formulasi sabun yang berkesan, dengan harapan untuk menghasilkan produk yang tidak memenuhi keperluan asas pembersihan, tetapi juga menawarkan pengalaman eksklusif dengan faedah tambahan yang unik melalui penggunaan pati gaharu. Pengoptimuman keadaan melalui Kaedah Taguchi seterusnya memastikan penghasilan formulasi sabun pada prestasi puncaknya.

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LIST OF ABBREVIATIONS

NaOH	Sodium Hydroxide
DOE	Design of Experiments
S/N	Signal Ratios

LIST OF SYMBOLS

g	Gram
°C	Degree Celsius
RM	Ringgit Malaysia
>	Greater than
<	Less than
mm	Millimetre
°F	Fahrenheit
mL	Millilitre
%	Percentages

CHAPTER 1

INTRODUCTION

1.0 Background of Study

Soap is the sodium or potassium salt of a fatty acid that is formed during the saponification procedure. Every family uses soap on a daily basis. Soap's physicochemical qualities dictate its quality, and hence its effectiveness and cleaning properties. Soap is also the chemical product or combination of chemical compounds formed by the reaction of fatty acids or fatty glycerides with metal radicals (or organic bases). The number and composition of component fatty acids in the starting oil determine the quality of the soap. The use coconut oil and palm oil are used in soap making to see the effectiveness of the bar soap. Bar soap is a solid washing agent prepared from oil that has been saponified with lye (Maotsela et al. 2019). Soap clings to dirt and oil particles, making them simpler to wash away with water. Sweat and grime, when combined with the body's natural oils, can deposit on the skin and trigger bacterial development. This bar soap eliminates the greasy layer of the skin, allowing germs to be eliminated.

Agarwood, derived from the resinous portion of the non-timber Aquilaria tree, holds significant importance in both medicinal applications and the fragrance industry (Tan et al., 2019). Agarwood production is frequently linked to the deliberate wounding and fungal infection of Aquilaria trees. This one-of-a-kind technique includes stressing the trees, generally by physical harm, and allowing a specific form of fungal infection to take root. The Aquilaria tree responds to stress by releasing resin, which results in the creation of agarwood as a natural defense mechanism. This resinous material is important in many cultural rituals, traditional medicine, soap, therapeutic uses, and the fragrance industry because of its fragrant characteristics (Liu et al., 2017). Agarwood chemicals include 2-(2-phenylethyl)-4H-chromen-4-one derivatives, terpenoids (sesquiterpenes), flavonoids, and others. Agarwood resin's aromatic qualities and characteristics are modified by species and geographical distribution (Shivanand et al., 2022). Agarwood leaves can also be used to treat wrinkled skin. With this agarwood soap formulation, the soap will be natural aromatic and safe to use. The ratio of fatty acids determines the hardness, fragrance, cleaning, lathering, and moisturizing aspects of the soap (Félix et al., 2017).

The Taguchi method is one of the most effective experimental procedures for determining the lowest number of tests to be conducted within the allowable range of parameters and levels. The Taguchi method comprises three key stages: design of experiments (DOE), signal-to-noise (S/N) ratio analysis, and optimization. During the DOE stage, a series of experiments is meticulously planned to examine the impacts of different factors on process performance. These experiments are structured using orthogonal arrays, which are systematically organized test cases. This arrangement facilitates the thorough exploration of significant factors while minimizing the number of experiments needed. Orthogonal arrays ensure that all factors are tested at various levels, enhancing efficiency and effectiveness in identifying key variables (Meena et al., 2018).

1.1 Problem Statement

The problem statement associated are many large environmental impacts that the chemicals used in conventional soap production have, such as the use of artificial colors and scents. surfactants derived from petroleum, and preservatives derived from chemicals to aquatic life, soil biology, and our air quality, these substances may have adverse side effects (Wyborn, 2023). Therefore, by making bio soap this can reduce the negative impact on the environment.

Agarwood, known for its distinctive aromatic properties, has potential benefits for skin care, but the development of optimal soap formulations using the Taguchi Method poses challenges. Although the aromatic profile of agarwood is widely appreciated, its integration into soap formulations requires precision and optimization to effectively harness its potential. The challenge lies in achieving a harmonious balance between the desired fragrance, skin care properties, and overall soap quality. Conventional soap making processes may not take full advantage of the unique properties of agarwood essence, leading to variations in fragrance intensity, skin benefits and product consistency (Mohamed et al., 2010).

There are many soap makers who find it difficult to produce quality soap at low cost, resulting in low quality soap and excessive manufacturing expenses. Using a variety of oils (coconut oil and palm oil) of varying quality and price to make soap can help in the creation of high-quality soaps for bathing and general cleaning.

The Taguchi method, a well-established statistical technique, offers significant advantages in the context of soap formulation development. Unlike traditional trial and error methods, Taguchi's Design of Experiments (DOE) systematically explores multiple factors and their interactions to efficiently identify optimal conditions. By using the Taguchi approach can achieve not only optimized formulations but also cost reductions in the production process(Pundir et al., 2018). Taguchi's emphasis on consistency ensures that variations in raw materials or process parameters have minimal effect on the quality of the final soap. This method streamlines the experimental process, allowing to identify the main factors that influence the properties of the soap and the optimal level of each.

As a result, this experiment can overcome the challenges associated with finding the ideal balance between fragrance, and overall product quality. The efficiency and effectiveness of Taguchi DOE make it a valuable tool in soap formulation, providing a systematic and cost-effective approach to developing high-quality soaps. As highlighted by Taguchi's principle, this method contributes to minimizing variation, optimizing formulation, and ultimately improving the soap production process as a whole (Titu et al., 2018).

1.2 Expected Output

Overall, this research simultaneously examines the production of bioproducts by making bio soap with the optimal formulation of soap obtained from the Taguchi Method. With that, it will benefit many parties including eco-friendly of bioproduct. Since this study is focused on the bio use of products that have environmentally friendly properties. Environmentally friendly soap making employing renewable energy sources and green components. Essential oils, agarwood-based surfactants, and agarwood waste are among the biodegradable organic materials used in the creation of bio soap (Wyborn, 2023). In this research, a hedonic test that evaluates the appearance, texture, aroma and color serves as a questionnaire to evaluate the subjective choice and perception of participants towards soap formulations from different agarwood essences using the Taguchi method. The results of Hedonic Tests Questionnaire provide valuable insight into the overall acceptability and sensory properties of soaps, contributing to a comprehensive understanding of consumer preferences in relation to these key sensory dimensions. Therefore, it is hoped that this research can make the transition from conventional soap to environmentally friendly is a small but impactful decision that we as consumers can make to reduce our environmental impact. Finally, the optimal formulation of soap that formulated using the Taguchi method is developed and can be used safely.

1.3 Objective

The main aims of this study were to produce development of soap formulation from agarwood. to further illustrate and guide the study, the following objective was set:

1) To design the formulation of using Taguchi Method.

2) To study the physicochemical properties of the soap included pH, moisture content and aromatic.

3) To analyze the consumer satisfaction toward the developed product using a Hedonic Test Questionnaire.

1.4 Scope of study

Fat or oils derived from plants and animals are the primary raw materials used in the production of soap. Coconut oil and palm oil was employed in this study. Saponification of coconut oil and palm oil is simple. Lauric acid is the most abundant fatty acid in coconut oil and palm oil. Lauric acid is required for the production of soap. This is due to the saturated fatty acids in lauric acid, which can give great solubility and good foam qualities for soap formulations (Iriany et al., 2020). In addition to these oils, agarwood essential oil, known for its pharmacological properties such as anti-inflammatory effects, will be incorporated into the bio soap. Agarwood oil contains a variety of bioactive compounds, including flavonoids, terpenoids, chromones, phenolic acids, steroids, and alkanes, making it a key active component (Adam et al. 2017). In addition, the waste of agarwood will use in this soap is to make the texture of the soap into a scrub. It is because, scrubbing can remove of dry/ dead skin cells on the surface of the skin (Keshav et al. 2022).

The Taguchi Design of Experiment Method is used in this study. A computer simulation called MINITAB was used to conduct the experiment, and the ratio of signal to noise approach was used to analyze the results. The ideal factor level combination for the new product was discovered through the analysis of variance and main effect plots (Basu et al. 2014)**.**

1.5 Significant of study

In this study, agarwood soap is an anionic surfactant that is used with water to wash and clean with nutrients from agarwood. As mentioned, agarwood has a very high demand worldwide as a raw material including medicine and soap (Alam et al., 2015). One of the changes that affects us as consumers to reduce the impact on the environment is the production of bio soap using agarwood. Biodegradable components included in the eco soap formulation reduce waste production, energy consumption, bio soap making is also beneficial for the environment that ends up in landfills and promotes healthy skin in addition to generating large profits and contributing to economic empowerment.

This research is very significant in terms of information and the beneficial influence it may have on the community by educating them on the multiple applications of agarwood, including bar soap. Next, the Taguchi Method is used in this study to help researchers comprehend the notion of soap formulation creation, which may expand understanding in terms of specialized manufacturing. In this research, the use of hedonic tests, evaluating appearance, texture, aroma, and color, serves as an important questionnaire to measure the preferences and subjective perceptions of participants regarding soap formulations obtained from various agarwood essences using the Taguchi method. The results of hedonic testing offer valuable insights into the comprehensive acceptability and sensory characteristics of soaps, thereby enriching our understanding of consumer preferences in relation to these basic sensory dimensions. This study not only enhances knowledge of agarwood infused soap formulations but also contributes to the wider field of consumer behavior and product development, providing a basis for informed decision making in the soap industry. The study's findings will include recommendations that will one day boost soap production in the industry.

CHAPTER 2

LITERATURE REVIEW

2.1 Bio-soap development history

Soap is a typical skin washing product with an alkaline salts of fatty acid chemical makeup. Soap has been around for thousands of years, dating back to ancient Babylonia. The original soaps were greasy soaps with a disagreeable odor, which were created by heating animal fat with an alkali called "lye" derived from wood ash. Since then, soap has evolved, with different kinds and substances added to make it more aesthetically acceptable. Skin cleansers today are more complicated than the word "soap" suggests, incorporating not just surfactants but also skin conditioning ingredients (Sakkaravarthi, 2022).

The technique of skin cleaning has evolved through many thousand years, whether for personal cleanliness, religious ritual, or medicinal purposes. Bathing is the earliest responsible daily activity dating back to ancient Indians as stated in "grihya sutras." In ancient times, contaminants were scraped off with a bone or stone. Later cultures utilized soapwort plant ash suspension to wash their hands. Even the ancient Romans, who invented aqueduct systems and public baths, did not use soap for cleansing. Cleopatra was said to bathe with aromatic oils and white fine sand as an abrasive (Sheldrick, 2008).

The first evidence of soap production was discovered in Sumerian clay tablets dated from around 2000 B.C. The soap was prepared by boiling a lard and wood ash combination and was used to remove grease from wool before dying. According to the Ebers Papyrus, an Egyptian document, the ancient Egyptians bathed frequently and used a mixture of animal oil and ashes going back to 1550 B.C. The Phoenicians used tree ash and animal fat to make soap about 600 B.C. Soap was named after a Roman tale about Mount Sapo, where animals were slaughtered. Rain wiped away the animal fat and woody ashes that had formed soap on the slope. This substance was found by Roman women to be useful in cleaning garments (Sakkaravarthi, 2022). Pliny the Elder, a Roman scholar, reported in his book "Naturalis historia" from 77 A.D. that Gauls used tallow and ash soap to give their hair a reddish color. The Greek physician Galen (130-200 A.D.) was the first to write on the use of soap for personal cleanliness. Bathing traditions had diminished throughout Europe by the time Rome fell in 467 A.D. In the middle times, filth and poor living circumstances contributed to plague and the black death (Mukhopadhyay, 2011).

By the 7th century, soap production had become an art form in Spain, Italy, and France, where olive oil was utilized. Fragrances were eventually added to soap, and bathing, shampooing, and laundry soaps became available. By the 13th century, soap production in Britain had begun, resulting in the loss of significant tracts of British woods. As a result, soap was severely taxed and became a luxury item only the royals could afford for daily washing. Castile soap was created by Europeans using olive oil to create a pure white soap. It was named after the crown of Castile, where the soap was mass-produced. The show quickly gained popularity among Europe's royal houses. Meanwhile, a soap originated in West Africa, named "Dudu-Osun" made from the ash of locally harvested plants and peels which gave it a black color. Gladstone repealed the soap tariff and made it inexpensive by 1853. Nicolas Leblanc, a French scientist, created alkali soda ash by chemically converting sodium chloride in 1791. Because alkali was a vital component in soap, this discovery was a watershed moment in commercial soap production. When Louis Pasteur declared that proper personal cleanliness decreased the transmission of illnesses, the demand for soap surged. During World War II (1948), raw ingredients for soap manufacture were in low supply. German scientists discovered synthetic detergent as a result of this. This was a watershed moment in the history of the skin cleanser business since most modern cleansers were based on synthetic detergent (Syndet) systems (Ertel, 2000; Mukhopadhyay, 2011).

2.1.1 Bio-soap formulation

A soap is a chemical combination of fatty acids created through a process known as saponification. It is a procedure in which an oil (containing fatty acids) and water are combined. An alkaline material is combined. It functions as an anionic surfactant. The soap produced is utilized for a variety of reasons in our daily lives, including cleaning and washing. Soaps for medical use differ slightly from regular soap in that various medicinal substances are included into the base soap. This straightforward modification can be used to create or manufacture significant formulations with a variety of biological characteristics. Other ingredients are added to soap to give it different qualities (Mang & Dresel, 2007). The soap additions should contribute good character, color, and aroma to the finished soap. They should also have no effect on the soap's qualities. Various fatty acids, such as stearic and palmitic acid, are responsible for soap lathering and washing. Natural foaming agents have taken the place of synthetic agents like sodium lauryl sulphate. Natural antibacterials have taken the place of synthetic antibacterials. This substitution has resulted in a reduction in the related negative effects of synthetic soaps (Ribeiro et al. 2015; Shivanan et al. 2010).

People have employed medicinal plants as a means of treatment since antiquity. The leaves, stems, and roots of several medicinal plants have been utilized as natural treatments to cure a range of diseases (Ruckmani & Sankar, 2010). The introduction of natural ingredients into the preparation aids in the treatment of almost all skin disorders and issues due to their high health value, cost-effectiveness, availability, and compatibility (Saikia et al., 2006). The active chemicals that give these plants their medicinal effects are isolated and utilized topically as creams, soaps, oils, and ointments to treat skin disorders such as acne, eczema, wounds, and ringworm, as well as for aesthetic and anti-microbial purposes. Plants' therapeutic properties are employed in a variety of compositions for both medical and cosmetic reasons (Kareru et al., 2010).

The cold saponification procedure was used to create soap containing potentially active botanicals. Soap is a combination of numerous naturally occurring salts of fatty acids in the form of sodium or potassium (Warra et al., 2010). So, for the saponification reaction, coconut oil as a natural fat and alkali as a lye were utilized as follows: A beaker contains 150 mL of coconut oil and 150 cooking oil. 50 gram of alkali (NaOH) was dissolved in 25 ml of ethanol and distilled air in a separate beaker with steady stirring. The solution is then poured into the beaker holding the oil. The resultant mixture is maintained on a hot plate on a low heat with continual stirring until the oil/fat smell fades and the solution becomes homogenous. After filtering and obtaining, 10gm of agarwood extract was added. Some essential oils have been added and well blended up. The created homogeneous semi-solid slurry is put into the mold and allowed to harden at room temperature while physical changes are observed (Lessons, 2023).

2.1.2 Bio-soap analysis

2.1.2.1 pH

Utilizing a few conventional techniques, the physicochemical properties of soap were analyzed. pH, moisture content, texture and aromatic were the parameters that were measured. Normal healthy skin has a potential hydrogen (pH) range of 5.4-5.9 and a normal bacterial flora (Tarun et al., 2014). The use of high pH soap raises the pH of the skin, which increases the effects of dryness, irritation, and changes in bacterial flora. Soap typically used by the general public has a pH value that is outside of the pH range of the skin. As a result, it is expected that when suggesting soap to people, particularly those with sensitive and acne-prone skin, the pH factor will be considered, and that the manufacturer would evaluate the pH of the soap made by them, so that their product will be more skin-friendly (Tarun et al. 2014).

Total number of soap samples in the various pH range:

Table 2.1: Example of samples the skin pH range.

pH range	No. of soap samples in the pH range
5.01-6.00	2
6.01-7.00	0
7.01-8.00	2
8.01-9.00	1
9.01-10.00	53
10.01-11.00	6
Total samples	64

pH: Potential of hydrogen

Source: (Tarun et al. 2014)

Table 2.1 shows that the normal pH range for soap is 9.01-10.00, with 53 soap samples falling within this range, and 10.01-11.00, which includes 6 soap samples. This information is consistent with the findings in research conducted by Tarun, J., Susan, J., Suria, J., Susan, V. J., & Criton, S. (2014) in their study entitled "Evaluation of pH of Bathing Soaps and Shampoo for Skin and Hair Care" published in Indian Journal of Dermatology (Volume 59, Issue 5, pp. 442–444).

2.1.2.2 Texture

Solid soap must be firm in order to preserve its form. Coconut oil is a fat that is widely used in the production of hard soap. As the bentonite concentration of the soap grew, so did its hardness. Previously, the Optimal mixture experimental design was used to investigate the impact of various fatty acids and oils (cocoa butter, pure coconut oil, olive oil, palm oil) employed in the primary component of the soap formulation on final soap hardness. Their findings reveal that changes in the quantities of fatty acids and oils in soap have a significant impact on its hardness. They also discovered the influence of components on the physical qualities of cosmetics items like solid soap, which has a significant impact on the aesthetic and physical design look of soap. In this study, the hardness and visual performance of the best soap were achieved for soap containing 15 and 17.5 g of bentonite (Mokhtar et al., 2018)

2.1.2.3 Moisture

Manufacturing cold process soap (exothermic). This reaction could happen on its own and increase the system's entropy or randomness. They are identified by a decrease in empathy and a negative heat flow (heat is lost to the environment). When making soap, this method involves mixing natural oils (coconut, palm, olive, or butter), hydroxide, and water. The soap is typically permitted to solidify overnight (Anne et al, 2019). Typically, only 95% of the oils are turned into soap after this procedure; the remaining 5% of the oils stay in the soap to enhance its outstanding conditioning properties. The texture of the soap may then be very smooth or fine (Ahmad Warra et al., 2011).

2.1.2.4 Aromatic

For a fragrant smell and a fresh taste when washing hands or taking a bath, aroma is added to the soap. By using agarwood essential oil during the saponification reaction, the notion of scented soap has been extended to create antimicrobial soaps. Recently, hydroalcoholic extracts of the plants Curcuma longa L. Azadirachta indica A Juss, and Cassia tora L. were used to make anti-microbial soaps. The soap produced shows antibacterial efficacy and works well to treat Tinea corporis (Tabasiyya et al. 2022).

2.2 The Application of Agarwood Essence

Agarwood (also known as gaharu in South East Asia, oud in the Middle East, chen xiang in China, jinkoh in Japan, and agar in India) is a fragrant dark resinous heartwood of the Aquilaria species(Liu et al., 2017). The wounding and fungal infection of Aquilaria trees is often related with the production of agarwood. The resin is released by the trees as a defense response and deposited around the wounds over time, where the buildup of volatile substances finally produces agarwood (Subasinghe & Hettiarachchi, 2013). Other than that, agarwood is the resinous component of the non-woody Aquilaria tree, and it is a very important medicinal and fragrance commodity. To safeguard endangered Aquilaria species, large-scale Aquilaria tree planting has proven a sustainable means for Asian countries to get very valuable agarwood. Because only physiologically induced Aquilaria trees can produce agarwood, the agarwood business has long sought an effective induction technique.

Agarwood has long been utilized in medicinal fragrances, traditional medicine, religious rituals, and as an aromatic culinary component (Xuan et al., 2013). Some of the oldest documented applications of agarwood may be found in ancient literature, religious scriptures, and medicinal books. The term "aloes," which implies agarwood, was discovered in the Sanskrit poet, Kâlidâsa, who lived during the 4th and 5th centuries CE (Mohamed, 2016). Meanwhile, the use of agarwood in traditional Chinese medicine prescriptions from the same time period has been documented. It is used in Chinese medicine as a natural sedative, pain reliever, digestive aid, and carminative. Agarwood oil is the most effective natural cure for nourishing the skin from within. Agarwood oil has the potential to forage for free radicals in the system. Wrinkles, blemishes, and fine lines are all symptoms of aging.

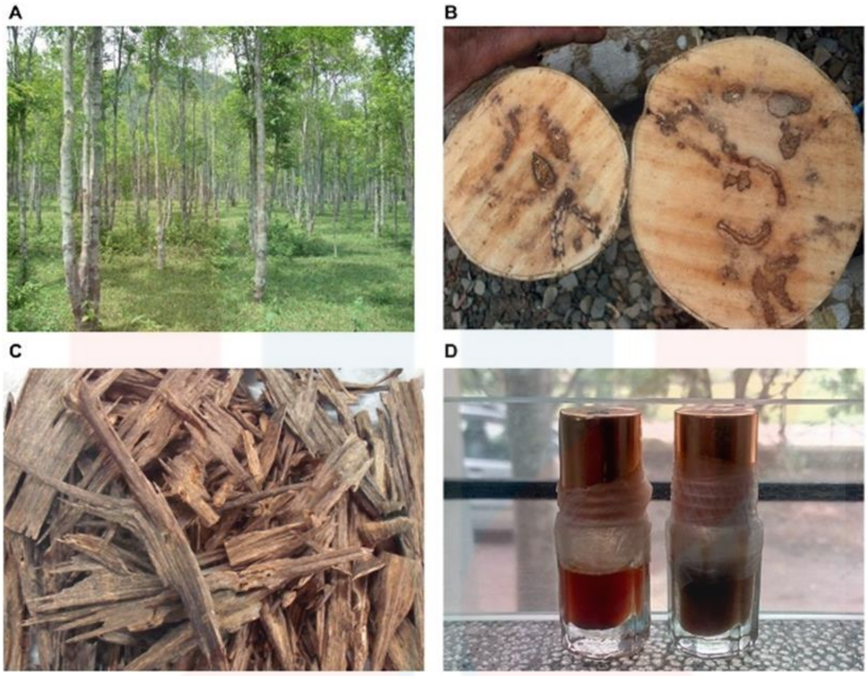

Figure 2.1: Agarwood and its product. (Naziz, et al. 2019)

A) Aquilaria trees grow at a plantation near Assam, India. **B)** Resin- impregnated stems are observed. **C)** Which, when chiseled and polished, disclose the resinous parts. **D)** The wood is distilled to make aromatic agarwood oils.

2.3 Taguchi Method

Taguchi's optimization approach is a one-of-a-kind and powerful optimization discipline that enables for optimization with a small number of tests. The Taguchi experimental design saves money, improves quality, and gives reliable design solutions. The Taguchi technique has the benefit over other approaches in that it can optimize several parameters at the same time and extract more quantitative information from fewer experimental trials. Taguchi techniques have been applied to optimize wastewater treatment in a variety of industries. have reported using the Taguchi approach to optimize treatment settings for metal-contaminated wastewater. Optimization of process parameters for color removal from textile dye effluents was also described (Engin et al., 2008). This strategy may also be used to create factorial experiments and analyze their results.

Product quality in the manufacturing business is determined by the combined impacts of many input factors that function solo or jointly, hence emphasis has been devoted to process capacity indices to transition from a single domain to a multivariate one. In the case of multivariable domains, the capacity to incorporate uncertainty during decision making becomes essential. The data was collected in linguistic form to derive its process capability, and the effect of each factor was determined using Design of Experiments (DOE) and analysis of variance technique (Taguchi) for improving the soap quality in terms of softness (Basu et al., 2014).

2.4 Hedonic Test

Tests of hedonic quality, especially the smell of the soap and the degree of foam formation, are included in the organoleptic tests. Meanwhile, the hedonic test revealed the overall opinion of the panelists about the soap product. Table 2.2 displays the results of an example analysis. The results of the evaluation show that the soap produced by each formulation has a lower fat smell without significant difference ($p>0.05$). As a result, it can be concluded that all soaps produced still have a slight smell of fat. The study also revealed that there was no significant variation in odor across all formulations ($p>0.05$). Furthermore, further quality tests revealed that the degree of foaming (ability to produce foam) of soaps made from all formulation modifications was not statistically different ($p>0.05$). The foaming ability score was determined between 2.61 and 3.09, with a quality of "moderate foaming." The hedonic test showed that the preference for the soap produced was quite good, with scores between 2.61-2.95, and there was no significant difference between any of the formulations ($p>0.05$). The results of the hedonic test showed that the panelists preferred soap with 6% kefir added (F4), although the difference was not statistically significant ($p>0.05$) (Marya et al. 2023).

Table 2.2: The Hedonic Test results from tallow-based soap from all formulations.

Parameter	0	2%	4%	6%	Value
Aroma	2.50	2.60	2.60	2.61	Less fat
Foam forming degree	2.61	2.66	2.85	3.09	Moderate foaming
Impression	2.61	2.85	2.90	2.95	Liked

Source: (Marya et al., 2023)

CHAPTER 3

MATERIALS AND METHODS

3.1 Materials

In this research, the materials that used is spent agarwood essence through online purchase and agarwood waste from woodworking workshop at Fakulti Sains Bumi Universiti Malaysia Kelantan. In addition, palm oil, coconut oil and essential oil are purchased at Pasar Pantai Timur, Tanah Merah. About 2g of agarwood essence were used for each bio soap, 40g to 60g of NaOH, 60mL of cooking oil for each biosoap, 5 drops of essential oil, 70mL to 90mL of water.

3.2 Chemical

The chemical used in this experiment is Sodium Hydroxide available at the Microbial Laboratory of Universiti Malaysia Kelantan (Fukushima, 2015).

3.3 Apparatus and equipment

The apparatus used in the research of agarwood soap production is a beaker (100 mL), a hand mixer, a silicone mold, a thermometer, safety glasses, a spatula, a pH indicator and pH paper, a hot plate, a mold, a magnetic stirrer, gloves, possibly an apron, and a filter cloth for filtration.

3.4 Methods

3.4.1 Design of Experiment

The formulation to produce this formulated soap, represented below according to the Taguchi Method, involved 36 experimental runs before implementation.

Table 3.1: Table of Taguchi Method

No	Dust	Oil	Water	NaOH
1	No	Palm	70	15
2	No	Palm	80	17
3	No	Palm	90	19
4	No	Coconut	70	15
5	No	Coconut	80	17
6	No	Coconut	90	19
7	No	Co + Pa	70	17
8	No	Co + Pa	80	19
9	No	Co + Pa	90	15
10	2g	Palm	70	19
11	2g	Palm	80	15
12	2g	Palm	90	17
13	2g	Coconut	70	17
14	2g	Coconut	80	19
15	2g	Coconut	90	15
16	2g	Co + Pa	70	19
17	2g	Co + Pa	80	15
18	2g	Co + Pa	90	17

3.4.2 Formulation of Soap Preparation

Soap formulation involves a combination of oil, NaOH, and water. Table 3.1 is a general outline of the soap making process from agarwood essence.

3.4.3 Mixing

The first step is to measure the appropriate quantity of oil and alkali. The oil is heated to a temperature of 120-130 ° F. Alkali (NaOH) is dissolved in water separately.

3.4.4 Saponification

Oil and alkaline solution are combined slowly while stirring continuously. This mixture is heated and maintained at the same temperature range.

3.4.5 Trace

As the mixture is stirred, it goes through a process called "trace." This is the point at which the oil and alkali have reacted sufficiently, and the mixture thickens to a consistency similar to pudding or custard. This is achieved through hand stirring or by using a wooden grinder.

3.4.6 Adding agarwood

On the trace, add 2mL of agarwood essential oil to the mixture. Stir well to ensure even distribution.

Add 2g agarwood waste to the mixture while stirring.

3.4.7 Drying of agarwood solid soap

Pour the soap solution into silicone mold. The bar soap was left dry in open space along one week. The temperature was optimized at ambient temperature.

3.4.8 Repeat

The step above will repeat with different formulation as shown in **Table 3.1**.

3.5 Assessment of the physicochemical properties of the soap.

This conventional approach is used to analyze the physicochemical characteristics of soap. pH, moisture content (dry matter) and1 foam are all measured values.

3.5.1 pH

In determining the pH, 2 g of soap is weighed and diluted in 10 mL of distilled water (Vivian et al., 2014). The measurements were done using the pH meter and pH paper for the accurate result.

3.5.2 Foam level and stability

1 gramme of soap was placed in a test tube containing 10 ml of distilled water and vortexed for 30 minutes. A ruler is used to measure the height of the created foam (initial foam height). After a few minutes, the height of the foam is measured again (high foam end) (Febriani et al., 2020).

$$\text{Foam Stability} = 100\% - \%\ \text{Foam Loss} \quad \text{Equation 3.1}$$

$$\%\ \text{Foam Loss} = \frac{(\text{High Initial Foam} - \text{High Final Foam})}{(\text{High Initial Foam}} \times 100\% \quad \text{Equation 3.2}$$

3.5.3 Determination of moisture content

In a weighted porcelain container, two grammes of the sample product were inserted. The sample was weighed using an analytical balance and placed in an aluminium foil container The sample was placed in a 101°C oven for 12 hours. The following equation is used to calculate moisture content (Bahari et al. 2021). The percentage of humidity is calculated using the following formula provided in the method

$$\text{Moisture Content} = \frac{\text{Difference in weight (g)}}{\text{Sample weight (g)}} \text{ x } 100\% \qquad \text{Equation 3.3}$$

3.6 Hedonic Test

The Hedonic Test. The hedonic test was used to compare levels of soap. The purpose of this test is to identify which formula was favoured by customers. The test criteria were look, colour, scent, skin irritation, and skin moisture. The preference test was conducted with 20 panellists chosen from Science Bioengineering and Technology students. The panellist preference level utilised had a score of 1-10 (Modified from Febriani et al., 2020).

Criteria:

1 = Extremely dislike it

2 = Very, very dislike

3 = Really don't like it

4 = Don't like it

5 = Rather not like

6 = Normal / Neutral

7 = Rather like it

8 = Like

9 = Really like it

10 = Extremely like it

Table 3.2: Table of Hedonic Test Questionnaire

Criteria	Dislike extremely	Very, very dislike	Really don't like it	Don't like it	Rather not like	Normal / Neutral	Rather like it	Like	Really like it	Extreme like it
Appear	1	2	3	4	5	6	7	8	9	10
Colour	1	2	3	4	5	6	7	8	9	10
Aroma	1	2	3	4	5	6	7	8	9	10
Texture	1	2	3	4	5	6	7	8	9	10

3.7 Test of antimicrobial

3.7.1 Type of study

It is laboratory research characterised by an examination of the antibacterial activity of 18 different soaps prepared using the Taguchi method.

3.7.2 Study location

The study was carried out in the Microbiology Laboratory Universiti Malaysia Kelantan (Jeli Campus).

3.7.3 Bar soap sample preparation (dilute)

18 glass test tubes and and distilled water were sterilized using an autoclave machine. Then 0.1g of bar soap was weighed and mixed with 10mL of distilled water that had been sterilized in a test tube. Leave for 24 hours while remaining in the laboratory incubator shaker at 35°C for 18 hours to mix (Balouiri et al., 2016).

3.7.4 Positive control setup

20g of ampicillin powder was weighed using a laboratory balance. Ampicillin was dissolved in 10mL distilled water that has been sterilized. Put the ampicillin powder that has been weighed into the distilled water. Ampicillin powder is mixed or rotated slowly in the solution to facilitate the dissolution of ampicillin. It takes some time for the powder to dissolve completely. reconstituted ampicillin solutions are stored in aliquots at the recommended temperature and conditions. Ampicillin solutions are stored at -20°C for long-term use.

3.7.5 Antimicrobial test

To grow E. coli, streak non-pathogenic E. coli strains on Nutrient agar plates and incubate for 24 hours at 37 °C to generate single colonies. Keep at 4 °C (Wolfe & Lantagne, 2017). One day before the start of the experiment, one colony was picked from the plate and inoculated with 10 mL of nutrient broth using an inoculation loop. Incubate overnight at 37 °C with shaking (shaker incubator).

The soap provided has been applied to antimicrobial screening with the agar well diffusion standard cup method. The organism used is E. coli. The sample was diluted with 10mL distilled water sterilized (Modified from Dr.A. et al., 2021). Then, Sterilized the nutrient agar. After that, marked the Petri dish for 4 sections (negative control, positive control, soap have dust of agarwood and soap no dust of agarwood). The antibacterial activity of the materials was tested using the agar dilution technique (Figure 3.1), and the minimum inhibitor concentration (MIC) was determined. The approach entails putting antimicrobial-saturated paper discs over a lawn of bacteria sown on the surface of an agar medium, incubating the plate overnight, and evaluating the presence or absence of an inhibitory zone surrounding the discs (Tenover, 2019). By using Plate Total Count Determination, the microbiological growth in agarwood soap may be evaluated. A petri dish and agar medium (such as nutritional agar) are used for this test. 18 samples of the soap surface were obtained after the agar plate had been prepared. With the use of a sterile cotton swab or swab, soap is administered to each chosen spot. After sampling, we will then inject by dabbing the smear on top of the agar media in the petri dish. Ensure that the sample is flat on the plate's surface. The next step is incubation. Put the petri dish in the incubator for microbial development, which should be set at 30–40°C (room temperature). Next is Observations. Regularly check the petri dish for any indications of microbial development, such as colonies or obvious agar changes. Since every bacterium has a unique appearance, this experiment will be performed three times until a particular species can be recognized. After incubation, examine the colonies on the agar to look for microbial development and get a sense of whether the soap is contaminated by microbes (Aryal, 2022).

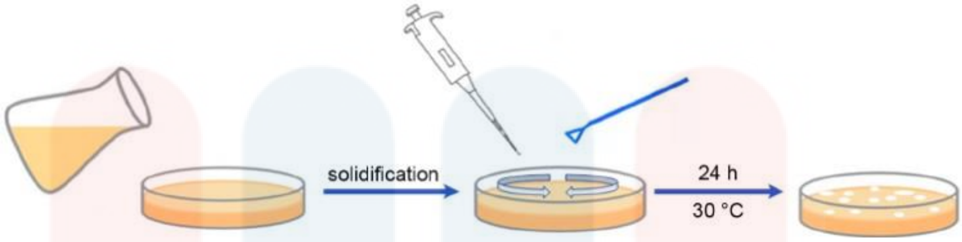

Figure 3.1: Process flow in agar dilution method

3.7.6 Diffusion method results analysis of antimicrobial

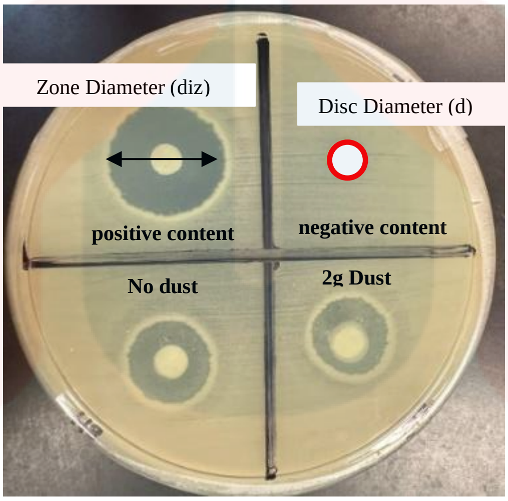

Figure 3.2: Picture of disk and clear zone for 4 sections

Figure 3.2 represented 4 section of result analysis of antimicrobial for positive content (antimicrobial), negative content (sterilized distilled water), sample no dust and sample have 2gram of dust.

A digital caliper/ruler are used to measure both the diameter of the inhibition zone (diz) and the disc diameter (d) as illustrated in Figure 4. Then, using the equation, calculate the normalized width of the clear zone and antimicrobial “halo” (nw_{halo}) sample and the antimicrobial of each disc (Martí et al., 2018).

Zone diameter (diz), disc diameter (d). Normal width "halo" sample and antimicrobial.

$$Nw_{halo} = \frac{\frac{diz-d}{2}}{d} \qquad \text{Equation 3.4}$$

Calculated the mean and standard deviation of the sample's antimicrobial "halo" width by considering three values of “nwhalo” determined for each sample.

CHAPTER 4

RESULTS AND DISCUSSION

This chapter describes the results obtained from using the methodology outlined in Chapter 3. It explores the analysis of both the Taguchi method and the Hedonic Test Questionnaire, each evaluated according to their respective specifications. This chapter is structured into five sections. The first part serves as an introduction, followed by the second segment, which requires statistical analysis and presentation of results from the Taguchi approach for each response variable. The third section provides a description and analysis of the results obtained from the Hedonic Test Questionnaire. The next section covers the validation of properties for each formulation. Finally, this chapter concludes with the presentation of regression analysis, which is a statistical technique that relates a dependent variable to one or more independent variables (explanatory).

4.1 Results

An exploration into the development of soap formulations from agarwood essence using the Taguchi method has provided a nuanced understanding of the complex interactions between formulation variables and their effect on soap properties. This section aims to unpack the main findings and their implications, offering a comprehensive analysis of the experimental results. The table 4.1 and chart in figure 4.1 show the rating of different soap formulations by the Taguchi Method.

Table 4.1: Table of Result Hedonic Test Questionnaire

	Hedonic					Properties				
No	Sample	Appear	Aroma	Texture	Colour	Foam (%)	Microbe (mm)	pH	Cost (RM)	Moisture (%)
1	1	7.85	8.20	8.35	8.90	73.33	8.33	12	1.56	37
2	2	7.20	7.95	7.80	7.70	75.00	9.67	12	1.60	35
3	3	6.55	6.95	5.65	6.70	80.00	14.00	9	1.64	25
4	4	8.50	7.70	8.90	8.95	12.50	14.33	12	1.56	38
5	5	8.05	7.10	8.45	8.45	3.70	9.33	13	1.60	43
6	6	7.75	7.15	8.30	8.20	20.00	9.33	14	1.64	45
7	7	6.75	5.85	6.20	7.15	72.00	9.00	8	1.54	24
8	8	6.05	5.70	7.00	6.90	90.91	6.83	8	1.58	25
9	9	8.15	7.35	7.85	7.90	61.54	8.00	13	1.50	45
10	10	5.60	6.25	6.60	6.30	38.46	10.00	12	2.04	38
11	11	7.90	8.20	8.25	7.50	32.00	10.33	13	1.96	41
12	12	6.55	7.10	7.05	7.55	100.00	10.33	12	2.00	0.8
13	13	6.95	6.10	6.25	7.20	4.00	11.33	13	2.00	30
14	14	5.65	6.05	6.60	7.00	33.33	7.67	13	2.04	34
15	15	7.90	7.45	8.40	7.15	6.67	9.00	12	1.96	43
16	16	7.15	7.30	6.95	7.30	66.67	11.00	12	1.98	37
17	17	8.55	7.95	7.85	7.20	75.00	12.00	12	1.90	45
18	18	8.65	7.30	7.65	8.25	40.00	8.67	14	1.94	35

In this investigation, the researcher plans to conduct a brief survey targeted at a specific group of students to ensure accuracy in addressing the four main sub-questions of the study. For this survey consisted of 20 individuals, selected exclusively from the population of male and female students in the Faculty of Bio-Engineering and Technology, all aged between 22 and 23 years. The instrument used for data collection was the Hedonic Test Questionnaire, chosen for its relevance in capturing nuanced responses to sensory experiences. This deliberate and focused approach, focusing on different demographics in the academic environment, is designed to produce accurate and thoughtful answers that are important for subsequent discussions (Bettiga et al., 2020).

Figure 4.1, 4.2, 4.3, 4.4, 4.5 and 4.6 are graphs plotted through Excel, providing a visual representation of the main aspects in the study of soap formulation from agarwood essence using the Taguchi Method. Figure 4.1 illustrates the development of hedonic output, showing the stages of development of the sensory properties of soap. On the other hand, Figure 4.2 offers a graphical representation of the simultaneous development of the properties of the foam according to equation 3.1, Figure 4.3 shows the microbe graph according to equation 3.3, Figure 4.4 is a graph showing pH, Figure 4.5 shows a cost graph and the last is Figure 4.6 which shows a graph moisture according to equation 3.2, all of which are detailed in Chapter 3. This graph provides a comprehensive overview of the soap formulation process. This graphical representation serves as a valuable tool for detailed inspection and analysis, assisting in the interpretation and discussion of experimental results.

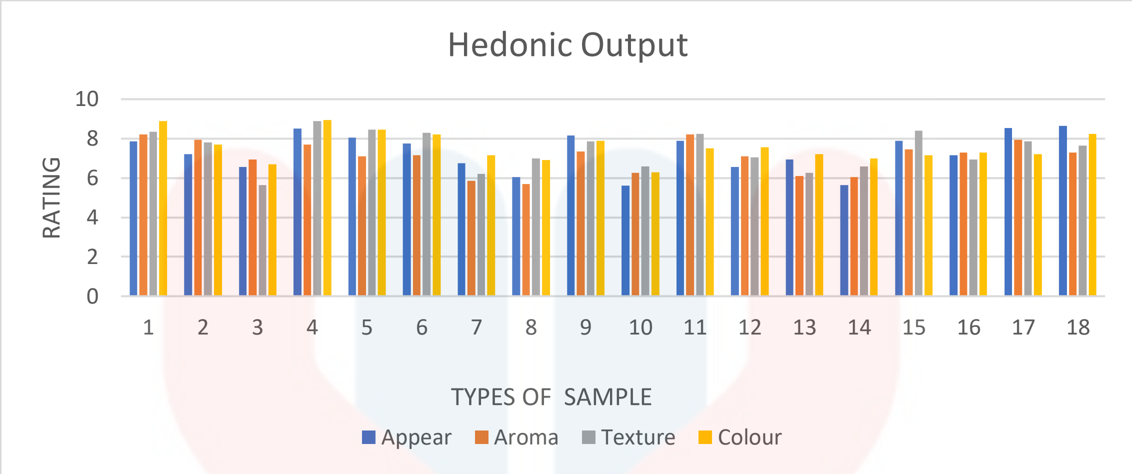

Figure 4.1: Charts illustrating the hedonic output development of soap formulation from agarwood essence using the Taguchi Method

The chart depicted in Figure 4.1 provides a visual overview of the hedonic evaluation results throughout the development phase of the soap formulation obtained from agarwood extract using the Taguchi Method. Each sub chart in Figure 4.1 corresponds to a different sensory aspect of the soap, including fragrance, texture, colour and overall appearance.

On the x-axis, the chart categorizes sample types alongside hedonic output dimensions such as appearance, aroma, texture and colour, while the y-axis reflects the corresponding Hedonic score. This score captures the subjective responses of participants, offering valuable insight into consumer preferences and satisfaction levels.

Analysing the results for appearance, Sample 18 appeared with the highest score of 8.65, while Sample 10 reached the lowest score of 5.60, visually represented by the blue bar in Figure 4.1. The next dimension is aroma, depicted by the orange bar, where Samples 1 and 11 obtained the highest score of 8.2, while Sample 8 recorded the lowest score of 5.7.

Turning to sensory texture, represented by the grey bars, sample 4 obtained the highest score at 8.9, while Sample 3 achieved the lowest score of 5.65. Finally, for colour,

This detailed chart contributes to a clearer understanding of how individual parameters affect the perceived sensory quality of a soap formulation. This graphical representation not only deepens the understanding of experimental results but also enriches the narrative surrounding soap formulation development, highlighting critical considerations in the pursuit of optimized products (Sharif et al., 2017).

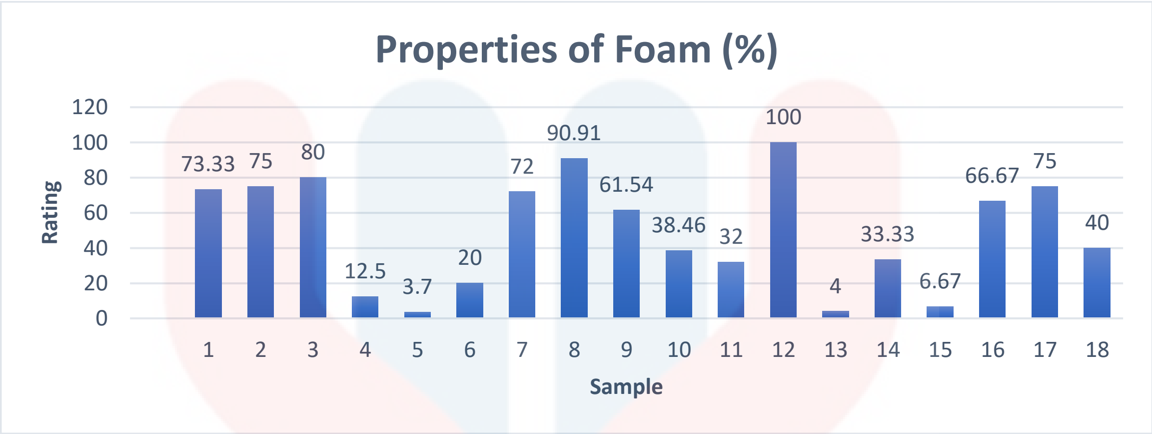

Figure 4.2: Charts illustrating the foam properties of soap formulation from agarwood essence using the Taguchi Method

The height of the foam in a soap product is not directly related to its cleaning effectiveness; rather, it plays an important role in consumer perception and aesthetic appeal. The foam height of soap products is affected by factors such as the presence of unsaturated compounds, including oil, as well as the composition and type of additives present in the water. In particular, soaps made from palm oil show the ability to produce a lot of foam, especially in water with high salt or alkaline levels. This phenomenon highlights the complex interaction of formulation components and environmental conditions in shaping the visual characteristics of soap foam (Fitriani, 2017). Notably, the analysed foam chart revealed that Sample 12, derived from palm oil, achieved the highest foam percentage at 100%, while Sample 5, derived from coconut oil, recorded the lowest at 3.7%. According to Ossai (2014), increasing the stability of the foam increases the detergency of the soap. based on past studies, 80% foam is the best for bar soap (Sukeksi et al., 2021).

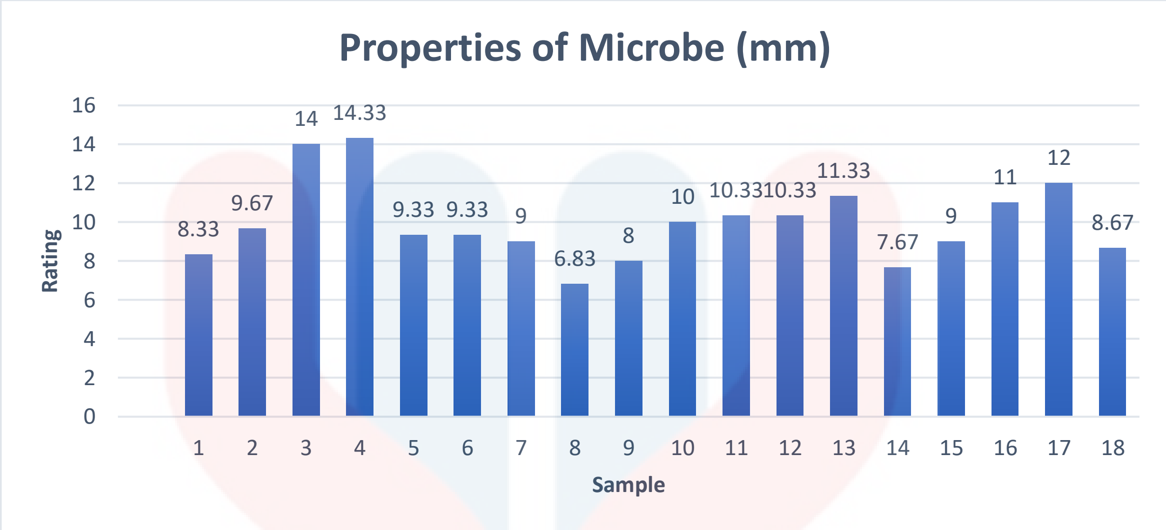

Figure 4.3: Charts illustrating the microbial properties of soap formulation from agarwood essence using the Taguchi Method

Antimicrobial efficacy in bar soap, especially against Escherichia coli (E. coli), is a critical aspect to ensure product effectiveness in promoting hygiene and reducing bacterial contamination. To achieve accurate and reliable results, test protocols often involve multiple cycles, usually run in triplicate and calculated using mean method. This approach increases the robustness of the study and provides a more comprehensive understanding of the antimicrobial capabilities of soaps (Chaudhari, 2016). %. In the microbial chart, Sample 4 exhibits the highest antimicrobial effectiveness at 14.33, contrasting with the lowest effectiveness found in Sample 8 at 6.83.

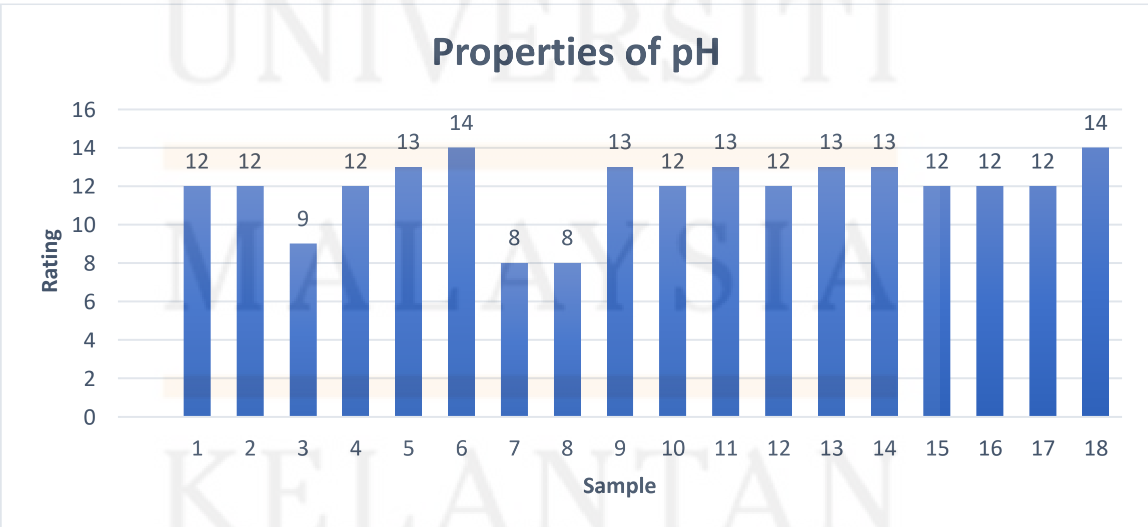

Figure 4.4: Charts illustrating the pH properties of soap formulation from agarwood essence using the Taguchi Method

The pH of the soap is affected by the ratio of sodium hydroxide to triglycerides, with a trend observed where a high ratio corresponds to an increase in pH level. This indicates that the proportion of sodium hydroxide to triglycerides plays an important role in determining the alkalinity of soap products. This relationship is important to understand, as variations in this ratio can directly affect the final pH of the soap formulation, thus affecting its overall characteristics and application potential (Tarun et al., 2014). In terms of pH in the charts, samples 6 and 18 exhibit the highest pH at 14, while Samples 7, 8, and 9 maintain optimal pH levels at 8 and 9. Samples 8, and 9 exhibit optimal pH levels, in line with industry standards and ensure that the soap remains within the recommended pH range of 8 to 9. This pH balance is important because it affects not only the chemical stability of the soap but also its compatibility with the skin, making it suitable for a variety of application (Sukeksi et al., 2021).

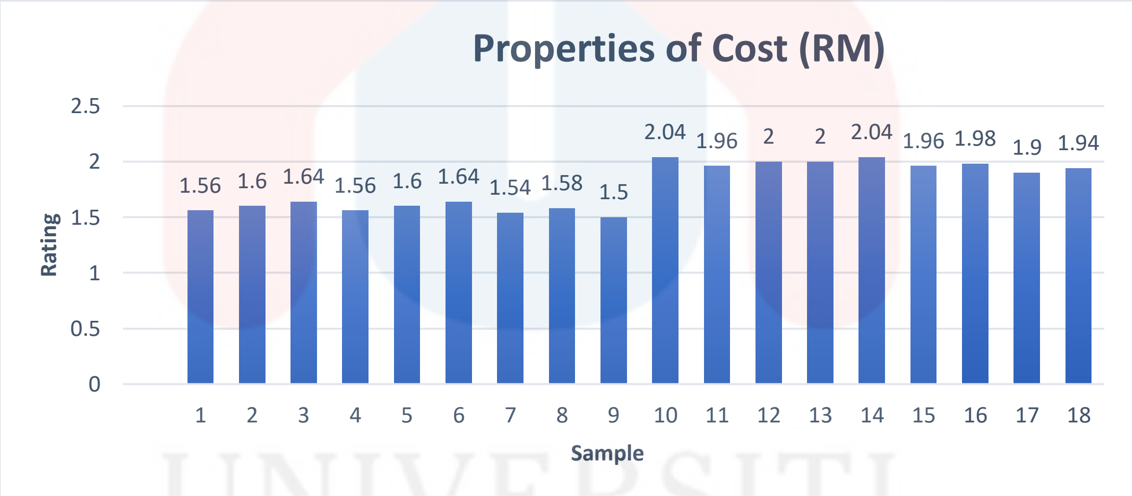

Figure 4.5: Charts illustrating the cost properties of soap formulation from agarwood essence using the Taguchi Method

The cost breakdown for agarwood bar soap includes several main components, namely the cost of oil, agarwood essence, and sodium hydroxide (NaOH). These components are fundamental to the soap formulation process and directly impact the overall production cost. The cost chart provides a detailed analysis, revealing that Samples 10 and 14 bear the highest production costs, amounting to RM2.04. This higher cost may be attributed to certain factors such as the type and quantity of materials used in this sample. On the other hand, Sample 9 stands out as the most cost-effective, with a production cost of RM1.50. Understanding these cost variations is important for effective financial management and decision making in the production of agarwood bar soap.

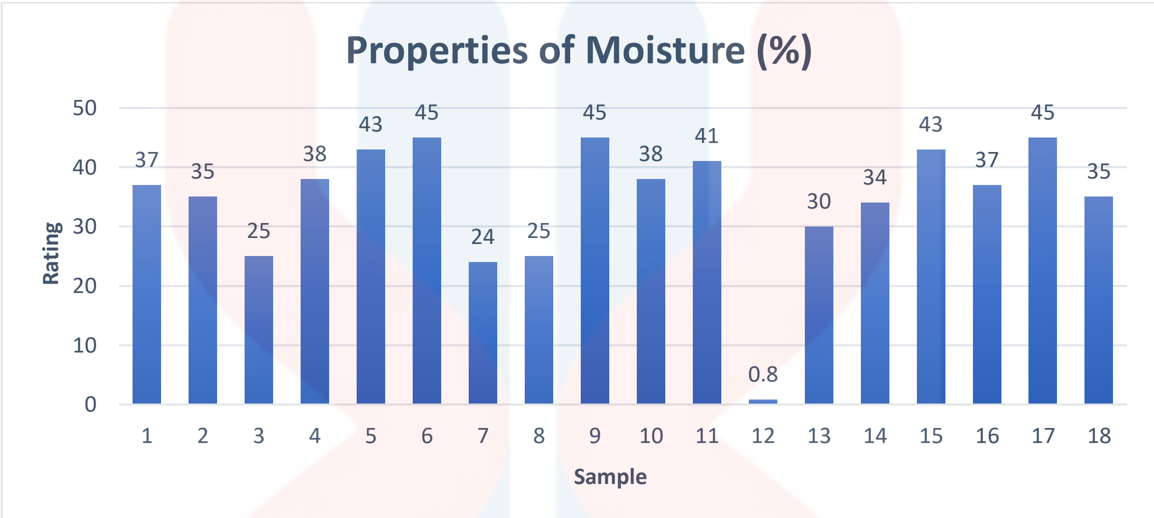

Figure 4.6: Charts illustrating the moisture properties of soap formulation from agarwood essence using the Taguchi Method

The moisture content is a crucial parameter in evaluating the shelf life of a product. Elevated levels of moisture in soap can result in an excess of water reacting with unsaponified fats, initiating a process known as the hydrolysis of soap during storage. This reaction leads to the formation of free fatty acids and glycerol, underscoring the significance of monitoring moisture content to prevent undesirable changes and maintain product stability over time (Vivian et al., 2014). According to the chart, Sample 17 is depicted with the highest moisture content at 45%, while Sample 12 exhibits the lowest at 0.8%.

This graphical analysis not only facilitates a detailed examination of experimental outcomes but also enriches the narrative of the soap formulation journey, providing crucial insights for achieving a well-balanced.

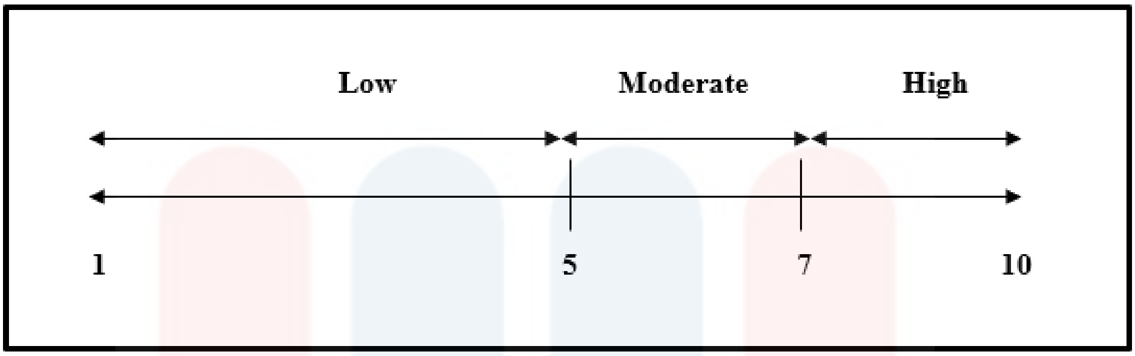

Figure 4.7: Rating Scale for each sample

Figure 4.7 shows rating of scale. Using a scale ranging from 1 to 10, our rating scale categorizes ratings into three levels: low, medium and high. Low ratings range from 1 to 5, medium ranges from 6 to 7 and high from 8 to 10. Analysis of the graph provided shows that Sample 1 received the highest rating, exceeding 8 in appearance, aroma, texture, and colour. On the other hand, Sample 10 received a lower rating due to its reduced value in aroma, texture and colour, resulting in an overall suboptimal rating. This tiered rating approach offers a nuanced understanding of each sample's performance across multiple attributes, facilitating comprehensive evaluation.

4.2 Taguchi Analysis

Reaction Bar soap yields were evaluated using Taguchi's Design of Experiments (DOE) application in Minitab19. According to the design outlined in methodology table 3.1, runs were executed, and their effects on the Signal-to-Noise (S/N) ratio, standard deviation and mean level were analysed through the software (Welvaert & Rosseel, 2013).

4.2.1 Hedonic Test (Appear, Aroma, Texture and Colour)

To determine the Signal-to-Noise (S/N) factor, the effect on the S/N ratio is calculated using a "bigger is better" approach. The result table for the S/N ratio of the solid soap product is provided in Table 4.2. The analysis revealed that certain factors contributed significantly to the variation in the S/N ratio. Figure 4.1 visually illustrates the effect of these factors on the signal-to-noise ratio, with a focus on maximizing solid soap yield. Table 4.2 furnishes a reaction table that facilitates the comparison of relative impact levels. The sorting is performed based on delta values, representing the difference between the highest and lowest means for each parameter. This delta value serves as a measure to assess and rank the impact of each parameter on the observed outcomes (Nia et al., 2019).

Response Table for Signal to Noise Ratios

Level	Dust	Oil	Aqua	NaOH
1	17.40	17.15	17.06	18.06
2	17.08	17.40	17.26	17.19
3		17.17	17.41	16.47
Delta	0.33	0.25	0.35	1.59
Rank	3	4	2	1

Larger is better

Table 4.2: Response table for Signal to Noise Ratios

Table 4.2 is presented outlining the Signal-to-Noise (S/N) ratio for different factor levels in the experimental design. The factors include Dust, Oil, Aqua and NaOH, each with three levels denoted as 1, 2, and 3. S/N Ratios are provided for each of these factor levels. The delta value represents the difference between the highest and lowest mean S/N ratio for each parameter. It serves as a measure of the variability in the S/N ratio across different factor levels. The NaOH delta value is the highest of 1.59 and the oil delta value is the lowest of 0.25. Next, the table includes a ranking column, where each factor is ranked based on its delta value. The factor with the highest delta value is ranked 1 (NaOH), showing its significant effect, while the factor with the lowest delta value (Oil) is ranked lower." Larger is better" emphasizes that, in this context, a higher S/N ratio is better. The objective of the experiment is to maximize the S/N ratio, and thus, factors with higher values contribute positively to the desired result. In summary, the table provides a systematic comparison of the effects of different levels of Dust, Oil, Aqua and NaOH on the S/N ratio. The delta and position values help identify which factors have a greater influence to achieve a larger and desirable S/N ratio.

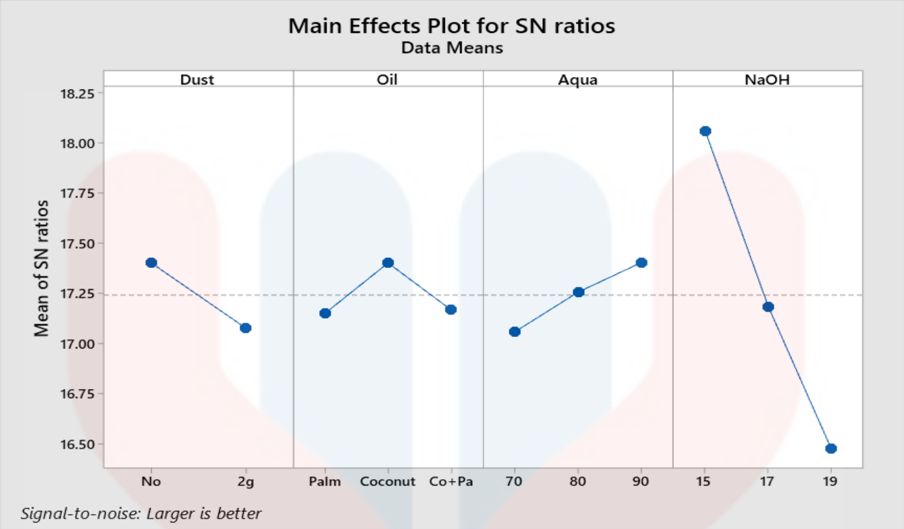

Figure 4.8: Main effects plot for SN ratios

As depicted in Figure 4.8, in situations where a larger value is preferable, the Signal-to-Noise (S/N) ratio indicates that the absence of dust is superior to the presence of 2g of dust. This conclusion is drawn from the observation that the S/N ratio is higher when there is no dust compared to the case with 2g of dust. In the main effects plot for the SN ratio concerning oil, coconut oil outperforms palm oil and the mixed oil combination of coconut and palm oil. Additionally, in relation to aqua, a quantity of 90mL is superior to both 70mL and 80mL. Furthermore, the NaOH quantity of 15g is preferable when compared to 17g and 19g.

Response Table for Means

Level	Dust	Oil	Aqua	NaOH
1	7.504	7.277	7.219	8.037
2	7.212	7.508	7.377	7.302
3		7.290	7.479	6.735
Delta	0.292	0.231	0.260	1.302
Rank	2	4	3	1

Table 4.3: Response Table for Means

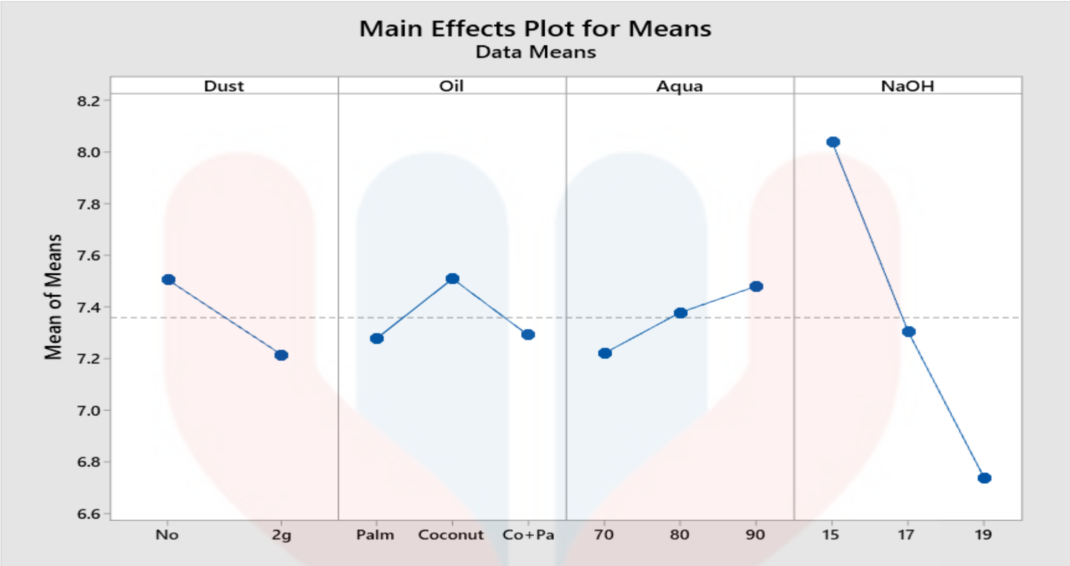

Figure 4.9: Main effects plot for means

Table 4.3 provided labelled Table of Responses for Means, presents the mean values for the different factor levels in the experimental design. While Figure 4.9 shows the main effects plot for means. The factors considered are Dust, Oil, Aqua and NaOH, each with three levels denoted as 1, 2, and 3. Mean values are calculated for each level of these factors. The delta value represents the difference between the highest and lowest mean values for each parameter. It shows the degree of variation in mean values across different factor levels. The table includes a ranking column, where each factor is ranked based on its delta value. The factor with the highest delta value (NaOH) is at position 1 n, showing a large effect, as evidenced in figure 4.9, NaOH is the most different compared to the others. While the factor with the lowest delta value (Oil) is in a lower position. Interpreting the table involves understanding how the mean values for Dust, Oil, Aqua and NaOH change across different levels. The delta and position values help in identifying factors that have a more significant influence on the overall mean response. In summary, this table provides valuable insight into the effect of various levels of Dust, Oil, Aqua and NaOH on mean values. Delta values and rankings help prioritize factors based on their contribution to achieving the desired mean response in experimental results.

4.2.2 Properties (Foam, Microbe, Cost)

In the exploration of the development of soap formulations from agarwood essence using the Taguchi Method, the main properties play an important role in determining the overall quality and effectiveness of the product. This discussion delves into three critical properties, namely Foam, Microbes, and Cost, which have been carefully evaluated as part of the experimental framework.

Response Table for Signal to Noise Ratios

Larger is better

Level	Dust	Oil	Aqua	NaOH
1	8.522	9.679	9.408	9.315
2	10.377	9.311	9.431	9.297
3		9.359	9.510	9.737
Delta	1.855	0.368	0.103	0.440
Rank	1	3	4	2

Table 4.4: Response for Signal Noise Ratios for properties (foam, microbe and cost)

Response in table 4.4 for Signal-to-Noise Ratios, specifically focusing on Foam, Microbial and Cost properties, provide valuable insight into the effect of different factor levels on the overall quality of soap formulations developed from agarwood essence using the Taguchi Method. The table, based on the "bigger is better" criteria, rates the soap's performance across various levels of Dust, Oil, Aqua and NaOH. In the context of Foam, the data illustrates that Level 2 for Dust (with a Signal-to-Noise Ratio of 10.377) produces the highest ratio, indicating superior foam characteristics. This insight, coupled with a delta value of 1.855, emphasizes the great impact of Dust on foam production, placing it as the most influential factor in achieving optimal foam properties.

For the Microbial trait, NaOH at Level 3 emerged as the most influential factor, obtaining the highest Signal-to-Noise Ratio of 9.737. A small delta value of 0.440 indicates that the effect on microbial efficacy is fairly consistent across NaOH levels. In terms of Cost, Oil at Level 3 shows the highest Signal-to-Noise Ratio of 9.510, implying superior cost. However, the delta value of 0.368 indicates a more moderate influence than Dust in the context of Foam.

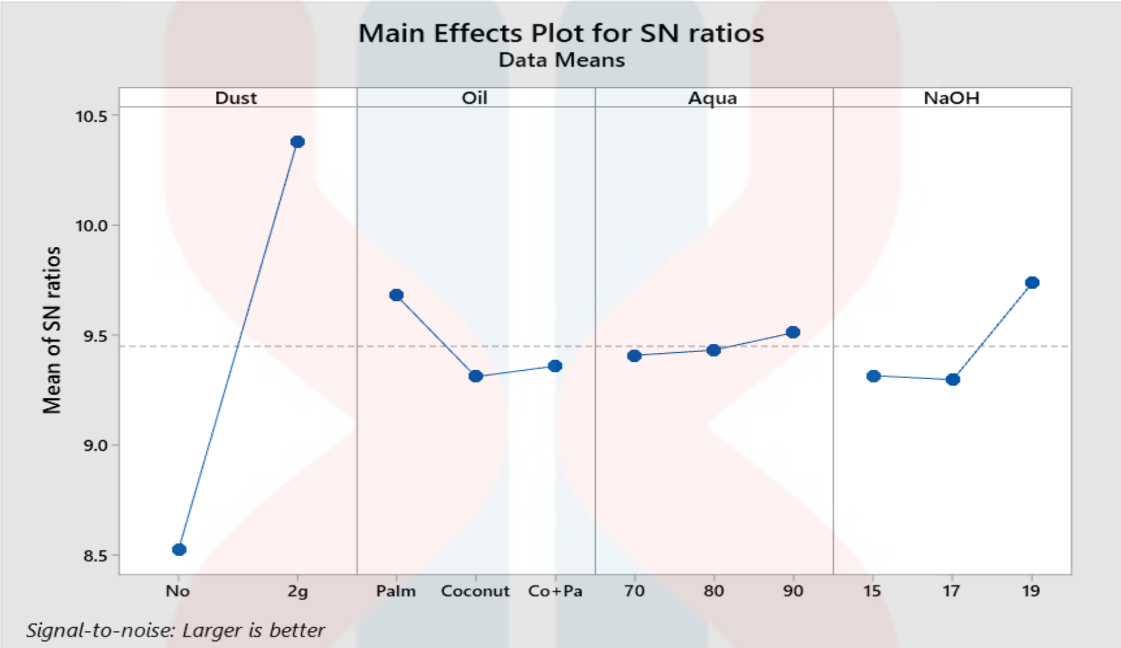

Figure 4.10 Main effects plot for SN ratios of properties (foam, microbial and cost)

The ranking column provides a brief perspective, showing that Dust is the most critical factor for optimizing Foam, followed by NaOH for the Microbial trait, Oil for Cost and Aqua being fourth in all three traits. Figure 4.8 shows the graph based on table 4.4.

Response Table for Means

Level	Dust	Oil	Aqua	NaOH
1	21.927	26.236	18.979	18.526
2	18.677	8.444	20.914	20.206
3		26.226	21.012	22.173
Delta	3.250	17.792	2.033	3.647
Rank	3	1	4	2

Table 4.5: Response table for means of properties (foam, microbe and cost)

Figure 4.11: Main effects plot for means of properties (foam, microbial and cost)

In the context of Foam, the data in table 4.5 shows that Oil at Level 2 dominates the highest mean value of 26.236, it is also shown in figure 4.11 which makes it the most influential factor in improving foam properties. The large delta value of 17.792 emphasizes the essential contribution of Oil to optimize the foam characteristics, ensuring its top position. For Microbial properties, NaOH at Level 2 appeared as the most influential factor, with a mean value of 26.226. A large delta value of 3.647 indicates a noteworthy impact, highlighting the role of NaOH in enhancing the effectiveness of soap microbes.

On the other hand, in evaluating the Cost property, Oil at Level 1 exhibits the highest mean value of 8.444, placing it as the most cost-effective factor. The large delta value of 17.792 underlines the significant influence of Oil in achieving cost heights. In the graph shown in figure 4.11, palm oil and coconut palm mixture are the highest. Aqua, while ranked fourth in all three properties, displays a noteworthy mean value in the Cost context (20.914 at Level 2), suggesting its potential role in influencing cost effectiveness despite its lower ranking in other properties.

4.3 Regression Analysis

Table 4.6: Table of Regression equation Hedonic Output

Continuous predictor	Responses	Regression Equation
• No Dust • Oil **(Palm)** • Aqua • NaOH	Appear	Appear = 12.86 - 0.165 Dust - 0.00569 Oil + 0.0229 Aqua - 0.421 NaOH
	Aroma	Aroma = 10.82 + 0.135 Dust + 0.01486 Oil + 0.0158 Aqua - 0.3104 NaOH
	Texture	Texture = 12.70 - 0.247 Dust - 0.00861 Oil + 0.0138 Aqua - 0.354 NaOH
	Color	Colour = 11.64 - 0.326 Dust - 0.00264 Oil - 0.0004 Aqua - 0.2167 NaOH
• No Dust • Oil **(Coconut)** • Aqua • NaOH	Appear	Appear=12.41 + 0.060 Dust + 0.01681 Oil + 0.0229 Aqua - 0.4208 NaOH
	Aroma	Aroma = 11.01 + 0.039 Dust + 0.00528 Oil + 0.0158 Aqua - 0.3104 NaOH
	Texture	Texture = 12.06 + 0.074 Dust + 0.02347 Oil + 0.0138 Aqua - 0.3542 NaOH
	Color	Colour = 11.26 - 0.135 Dust + 0.01653 Oil - 0.0004 Aqua - 0.2167 NaOH
• No Dust • Oil **(CoPalm)** • Aqua • NaOH	Appear	Appear = 12.97 - 0.219 Dust - 0.01111 Oil + 0.0229 Aqua - 0.4208 NaOH
	Aroma	Aroma = 11.52 - 0.215 Dust - 0.02014 Oil + 0.0158 Aqua - 0.3104 NaOH
	Texture	Texture = 12.83 - 0.310 Dust - 0.01486 Oil + 0.0138 Aqua - 0.354 NaOH
	Color	Colour = 11.87 - 0.439 Dust - 0.01389 Oil - 0.0004 Aqua - 0.2167 NaOH
	Appear	Appear=12.75 + 0.024 Dust - 0.01319 Oil + 0.0229 Aqua - 0.4208 NaOH

• Dust (2g Dust) • Oil **(Palm)** • Aqua • NaOH	Aroma	Aroma = 11.12 - 0.040 Dust + 0.00264 Oil + 0.0158 Aqua - 0.3104 NaOH
	Texture	Texture = 12.53 - 0.164 Dust + 0.00028 Oil + 0.0138 Aqua - 0.354 NaOH
	Color	Colour = 11.59 - 0.261 Dust - 0.00389 Oil - 0.0004 Aqua - 0.2167 NaOH
• Dust (2g Dust) • Oil **(Coconut)** • Aqua • NaOH	Appear	Appear= 12.75 - 0.014 Dust - 0.00944 Oil + 0.0229 Aqua - 0.4208 NaOH
	Aroma	Aroma =11.12 + 0.122 Dust - 0.01361 Oil + 0.0158 Aqua - 0.3104 NaOH
	Texture	Texture = 12.53 - 0.110 Dust - 0.00514 Oil + 0.0138 Aqua - 0.354 NaOH
	Color	Colour = 11.59 - 0.261 Dust - 0.00389 Oil - 0.0004 Aqua - 0.2167 NaOH
• Dust (2g Dust) • Oil **(CoPalm)** • Aqua • NaOH	Appear	Appear= 12.75 - 0.335 Dust + 0.02264 Oil + 0.0229 Aqua - 0.4208 NaOH
	Aroma	Aroma = 11.12 - 0.124 Dust + 0.01097 Oil + 0.0158 Aqua - 0.3104 NaOH
	Texture	Texture = 12.53 - 0.210 Dust + 0.00486 Oil + 0.0138 Aqua - 0.354 NaOH
	Color	Colour = 11.59 - 0.378 Dust + 0.00778 Oil - 0.0004 Aqua - 0.2167 NaOH

Table 4.6 provides a comprehensive summary of the regression equations derived from the Hedonic Test, which assesses the sensory attributes (Appear, Aroma, Texture, and Color) of soap formulations based on various formulation factors. Each set of regression equations corresponds to a specific combination of ingredients, including different oils (Palm, Coconut, and CoPalm), Aqua, Dust, and Sodium Hydroxide (NaOH).

For Appear, the regression equations highlight the impact of individual factors on the visual perception of the soap. Notably, Dust and Aqua exhibit negative coefficients, suggesting a decrease in the perceived appearance with higher concentrations of these components, while Oil and NaOH contribute positively.

Aroma, as assessed in the Hedonic Test, is influenced by Dust, Oil, Aqua, and NaOH. The regression equations indicate the varying effects of these factors on the aromatic qualities of the soap, with Dust and NaOH playing significant roles.

Texture is evaluated in relation to Dust, Oil, Aqua, and NaOH. The coefficients in the regression equations signify the respective contributions of these factors to the perceived texture of the soap. Notably, Dust and NaOH exhibit consistent negative impacts, suggesting a decrease in texture with higher concentrations.

Color, assessed in terms of the Hedonic Test, is influenced by Dust, Oil, Aqua, and NaOH. The regression equations illustrate the effects of these factors on the visual color perception of the soap. Dust and NaOH, in particular, show consistent negative impacts on color.

Overall, the regression equations provide a quantitative understanding of how each factor contributes to the sensory attributes evaluated in the Hedonic Test. This analysis aids in deciphering the intricate relationships between formulation components and the perceived qualities of the soap, guiding further refinement and optimization of the soap formulation process (Auddy et al., 2022).

Table 4.7: Table of Regression equation Properties Output

Continuous predictor	Responses	Regression Equation
• No Dust • Oil **(Palm)** • Aqua • NaOH	Foam	Foam = -32 + 0.29 Dust + 0.544 Oil + 0.344 Aqua + 2.85 NaOH
	Microbe	Microbe = 14.81 + 0.283 Dust + 0.0199 Oil - 0.0388 Aqua - 0.132 NaOH
	pH	pH = 12.25 + 0.611 Dust - 0.0056 Oil + 0.0417 Aqua - 0.250 NaOH
	Cost	Cost = 1.230 + 0.20500 Dust + 0.000500 Oil - 0.000000 Aqua + 0.02000 NaOH
	Moisture	Moisture = 75.3 - 1.46 Dust - 0.072 Oil - 0.085 Aqua - 1.88 NaOH
• No Dust • Oil **(Coconut)** • Aqua • NaOH	Foam	Foam = -0.4 - 15.72 Dust - 1.057 Oil + 0.344 Aqua + 2.85 NaOH
	Microbe	Microbe = 14.65 + 0.366 Dust + 0.0282 Oil - 0.0388 Aqua - 0.132 NaOH
	pH	pH = 11.25 + 1.111 Dust + 0.0444 Oil + 0.0417 Aqua - 0.250 NaOH
	Cost	Cost = 1.230 + 0.20500 Dust + 0.000500 Oil - 0.000000 Aqua + 0.02000 NaOH
	Moisture	Moisture = 70.5 + 0.96 Dust + 0.169 Oil - 0.085 Aqua - 1.88 NaOH
• No Dust • Oil **(CoPalm)** • Aqua • NaOH	Foam	Foam = -32 - 0.04 Dust + 0.512 Oil + 0.344 Aqua + 2.85 NaOH
	Microbe	Microbe = 16.18 - 0.397 Dust - 0.0481 Oil - 0.0388 Aqua - 0.132 NaOH
	pH	pH = 12.92 + 0.278 Dust - 0.0389 Oil + 0.0417 Aqua - 0.250 NaOH
	Cost	Cost = 1.2600 + 0.19000 Dust - 0.001000 Oil - 0.000000 Aqua + 0.02000 NaOH

	Moisture	Moisture = 75.8 - 1.71 Dust - 0.097 Oil - 0.085 Aqua - 1.88 NaOH
• Dust (2g Dust) • Oil **(Palm)** • Aqua • NaOH	Foam	Foam = -22 - 8.36 Dust + 0.320 Oil + 0.344 Aqua + 2.85 NaOH
	Microbe	Microbe = 15.21 + 0.038 Dust + 0.0046 Oil - 0.0388 Aqua - 0.132 NaOH
	pH	pH = 12.14 + 0.722 Dust - 0.0056 Oil + 0.0417 Aqua - 0.250 NaOH
	Cost	Cost = 1.240 + 0.19500 Dust + 0.000500 Oil - 0.000000 Aqua + 0.02000 NaOH
	Moisture	Moisture = 73.9 + 1.06 Dust - 0.179 Oil - 0.085 Aqua - 1.88 NaOH
• Dust (2g Dust) • Oil **(Coconut)** • Aqua • NaOH	Foam	Foam = -22 + 2.18 Dust - 0.734 Oil + 0.344 Aqua + 2.85 NaOH
	Microbe	Microbe = 15.21 + 0.260 Dust - 0.0176 Oil - 0.0388 Aqua - 0.132 NaOH
	pH	pH = 12.14 + 0.639 Dust + 0.0028 Oil + 0.0417 Aqua - 0.250 NaOH
	Cost	Cost = 1.240 + 0.19500 Dust + 0.000500 Oil - 0.000000 Aqua + 0.02000 NaOH
	Moisture	Moisture = 73.9 - 1.21 Dust + 0.048 Oil - 0.085 Aqua - 1.88 NaOH
• Dust (2g Dust) • Oil **(CoPalm)** • Aqua • NaOH	Foam	Moisture = 73.9 - 2.04 Dust + 0.131 Oil - 0.085 Aqua - 1.88 NaOH
	Microbe	Microbe = 15.21 - 0.046 Dust + 0.0130 Oil - 0.0388 Aqua - 0.132 NaOH
	pH	pH = 12.14 + 0.639 Dust + 0.0028 Oil + 0.0417 Aqua - 0.250 NaOH
	Cost	Cost = 1.2400 + 0.21000 Dust - 0.001000 Oil - 0.000000 Aqua + 0.02000 NaOH
	Moisture	Moisture = 73.9 - 2.04 Dust + 0.131 Oil - 0.085 Aqua - 1.88 NaOH

Table 4.7 presents regression equations relating various continuous predictors no dust, 2g of dust, Oil (Palm, Coconut, CoPalm), Aqua, and Sodium Hydroxide (NaOH)) to responses in terms of Foam, Microbe, pH, Cost, and Moisture properties of soap formulations. For instances with no Dust, the Foam property is positively influenced by Oil (Palm, Coconut, CoPalm) and NaOH, while negatively impacted by Aqua. Microbe property is affected by Dust and NaOH, with varying effects of other factors. The pH property is influenced by dust, aqua, and NaOH, where dust and aqua contribute positively, while NaOH has a negative impact. Cost is determined by dust, oil, aqua, and NaOH, with the coefficients specifying their respective contributions. Moisture property is influenced by dust, oil, aqua, and NaOH with specific coefficients indicating the impact of each factor. In cases involving 2g dust, similar patterns emerge, with dust having significant impacts on various properties, and the regression equations providing quantifiable insights into the relationships between formulation factors and soap properties. These equations serve as a valuable tool for understanding and optimizing soap formulations based on specific ingredient combinations (Zhi et al., 2018).

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In conclusion, the research carried out for the thesis "Development of Soap Formulations from Agarwood Using the Taguchi Method" has successfully achieved the set objectives, leading to valuable insights and important discoveries in the field of soap formulation. The application of the Taguchi Method has provided a systematic and efficient approach to optimize the soap formulation process, enabling the identification of the main factors affecting the quality of soap enriched with Agarwood extract.

Experimental results, analysed through the Signal-to-Noise (S/N) ratio, have contributed to a comprehensive understanding of the effects of various factors, including Dust, Oil, Aqua and NaOH, on soap formulation. Response tables for Mean and Signal-to-Noise (S/N) Ratios have facilitated the identification and ranking of influential factors, further contributing to the development of optimized soap formulations.

Additionally, the incorporation of a Hedonic Test Questionnaire has enriched the study by providing insightful feedback on consumer preferences and satisfaction with soaps infused with agarwood dust. A holistic approach, combining both quantitative and qualitative analysis, ensures a comprehensive evaluation of the soap formulation. Based on the output of the Hedonic Test Questionnaire, it is evident that samples 4 and 18 are in the highest position. Moreover, from a property perspective, sample 17 was identified as the best.

In principle, the successful development of a soap formulation from Aloe extract, guided by the Taguchi Method and supplemented with user feedback through the Hedonic Test Questionnaire, marks an important contribution to the field. The optimized formulation not only meets quality standards but also aligns with consumer preferences, reflecting potential commercial success in the soap industry. This research lays a solid foundation for further exploration and advancement in the use of agarwood essence in the development of personal care products.

5.2 Recommendation

After completing the study and research on "Development of Soap Formulation from Agarwood Essence Using the Taguchi Method," coupled with the integration of the Hedonic Test Questionnaire, some suggestions are proposed for the improvement and advancement of the research. One important suggestion involves Taguchi Parameter Filtering. To further improve the optimization of soap formulation, it is advisable to refine the parameters identified through the Taguchi Method. This requires the exploration of additional levels or combinations of factors, ensuring careful investigation of variables that have a significant influence on soap quality.

Furthermore, an important aspect of improvement is the Extended Sensory Assessment. Strengthening the Hedonic Test Questionnaire is important, involving a more detailed analysis of fragrance notes, textures and overall consumer satisfaction. This comprehensive approach promises to provide deeper insight into consumer preferences. Another recommendation worth noting is the Exploration of Variable Interactions. Investigating potential interactions between formulation variables identified during Taguchi's experiments can lead to more nuanced and effective soap formulations. Understanding the interplay of these variables is essential to optimizing the overall product.

For consumer demographic considerations, it is important to conduct a more targeted analysis of the Hedonic Test Questionnaire. Tailoring questions to specific age groups, cultural backgrounds or skin care preferences can reveal variations in preferences between diverse consumer segments. Additionally, a comprehensive Cost-Benefit Analysis is recommended. Assessing the economic feasibility of large-scale production and market price potential, while considering the delicate balance between quality and affordability, will provide valuable insights.

Finally, a continuous monitoring and adaptation approach is proposed. Adopting continuous monitoring for consumer feedback and staying in tune with market trends will enable regular updates to soap formulations based on emerging priorities, technological advances and sustainability standards. By implementing these recommendations, this study can go beyond its current scope, contributing to a more comprehensive and effective understanding of soap formulation from agarwood extract using the Taguchi Method.

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APPENDIX

SECTION A

Picture of bar soap from 18 formulations

Sample 1

Sample 2

Sample 3

Sample 4

Sample 5

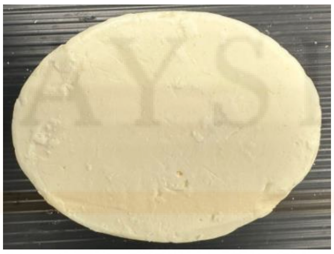
Sample 6

Sample 7

Sample 8

Sample 9

Sample 10



Sample 11

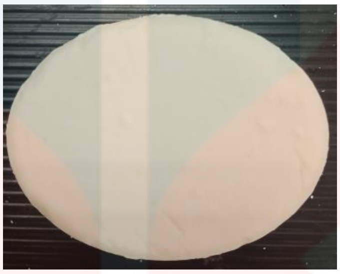
Sample 12

Sample 13

Sample 14

Sample 15

Sample 16

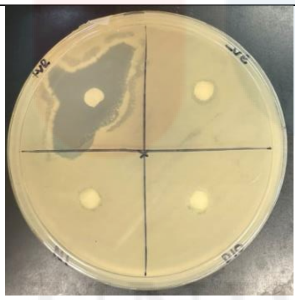


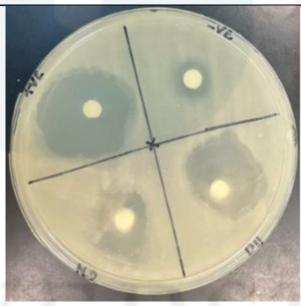
Sample 17

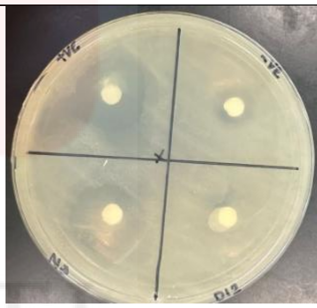
Sample 18

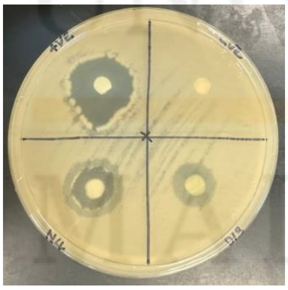
Picture or Antimicrobial Test

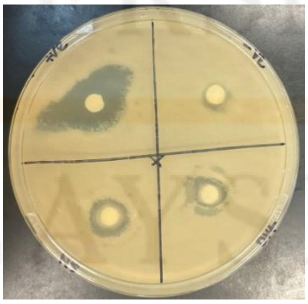
Batch 1

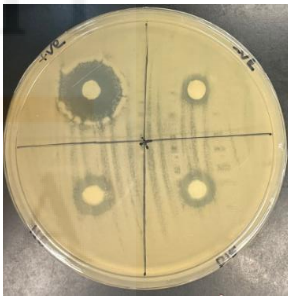


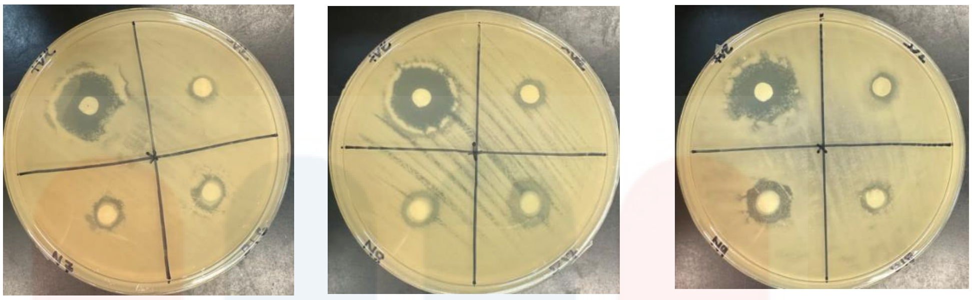












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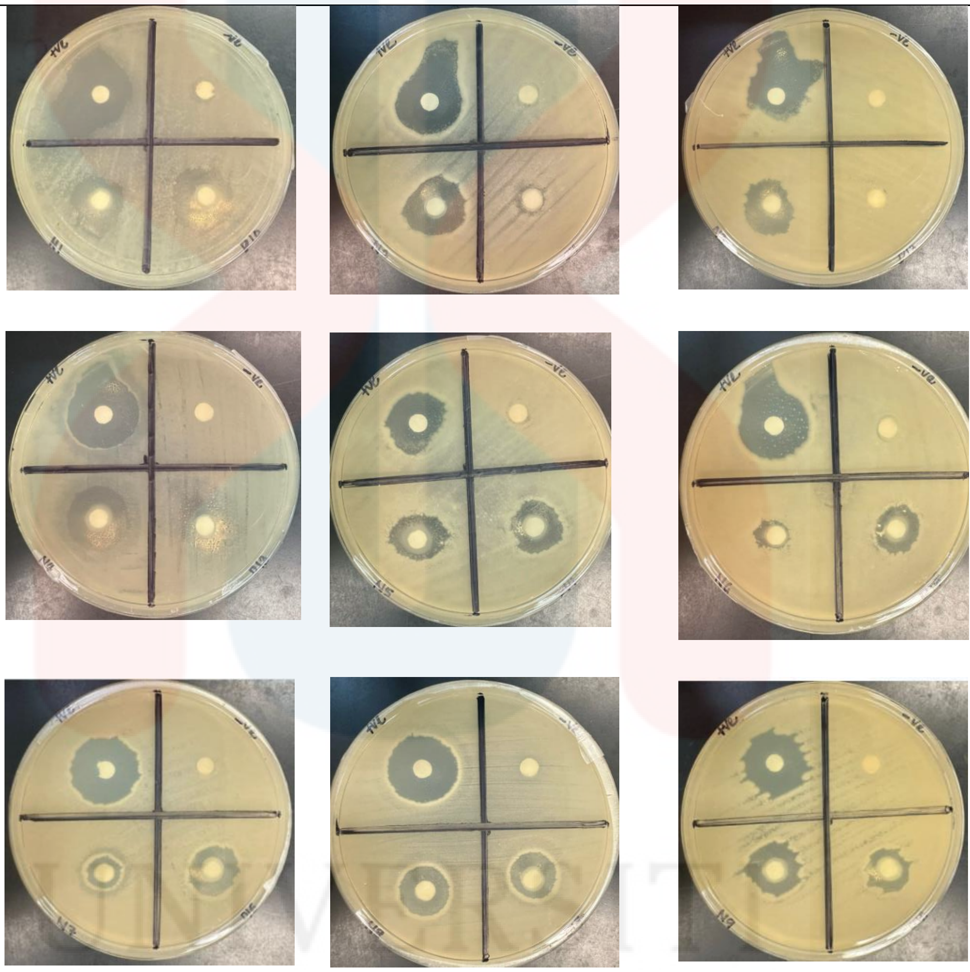

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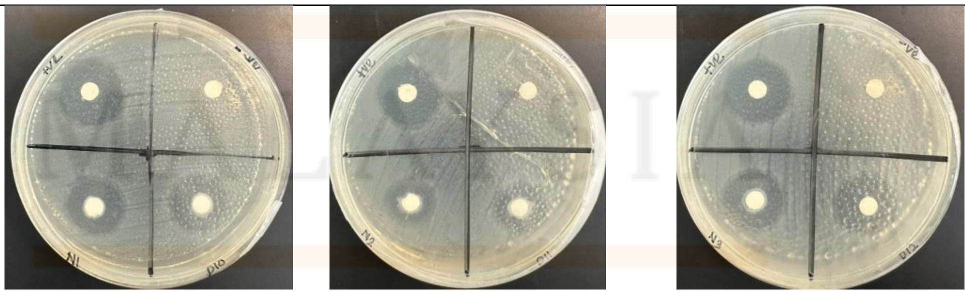

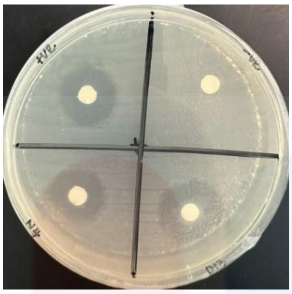 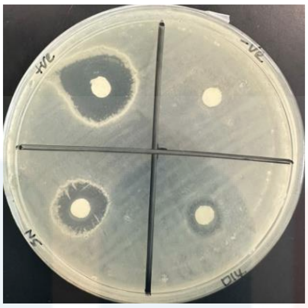 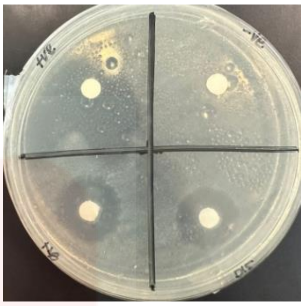

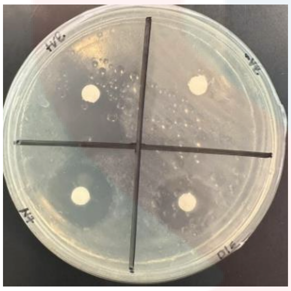 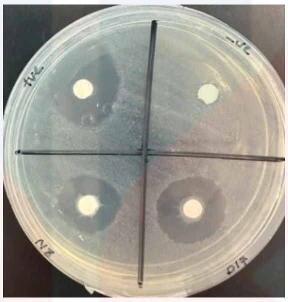 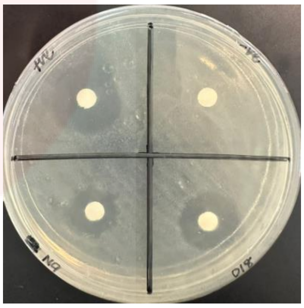

SECTION B

Table of Foam Stability

Sample	High Initial Foam (cm)	High Final Foam (cm)	Foam Stability (%)
1	1.5	1.1	73.33
2	2	1.5	75.00
3	2.5	2.0	80.00
4	4	0.5	12.50
5	2.7	0.1	3.70
6	4.5	0.9	20.00
7	2.5	1.8	72.00
8	5.5	5.0	90.91
9	1.3	0.8	61.54
10	1.3	0.8	38.46
11	2.5	0.8	32.00
12	1.7	1.7	100.00
13	2.5	0.1	4.00
14	4.5	1.5	33.33
15	1.5	0.1	6.67
16	1.2	0.8	66.67
17	2.0	1.5	75.00
18	2.5	1.0	40.00

Table of Moisture Content

Sample	Initial Weight of Soap (g)	Final Weight of Soap (g)	Moisture Content (%)
1	2.1831	1.3556	37
2	2.1418	1.3725	35
3	2.1990	1.6308	25
4	2.1292	1.3066	38
5	2.1898	1.2350	43
6	2.1805	1.987	45
7	2.1320	1.6054	24
8	2.1532	1.6149	25
9	2.1636	1.1890	45
10	2.1448	1.3089	38
11	2.1250	1.2376	41
12	2.1227	1.2100	0.8
13	2.1862	1.5203	30
14	2.1349	1.3894	34
15	2.1260	1.2034	43
16	2.1949	1.3738	37
17	2.1458	1.1717	45
18	2.1585	1.3936	35

Table of Antimicrobial Test

Sample without dust

No Sample	Diz	D	(Diz-D)/2	((Diz-D)/2)/d	In mm
1	0.7cm	0.5cm	0.1cm	0.2cm	2mm
	1.5cm	0.5cm	0.5cm	1.0cm	10mm
	1.8cm	0.5cm	0..65cm	1.3cm	13mm
2	1.5cm	0.5cm	0.5cm	1.0cm	10mm
	1.8cm	0.5cm	0.65cm	1.3cm	13mm
	1.1cm	0.5cm	0.3cm	0.6cm	6mm
3	2.0cm	0.5cm	0.75cm	1.5cm	15mm
	1.7cm	0.5cm	0.6cm	1.2cm	12mm
	2.0cm	0.5cm	0.75cm	1.5cm	15mm
4	2.0cm	0.5cm	0.75cm	1.5cm	15mm
	1.3cm	0.5cm	0.8cm	1.6cm	16mm
	1.7cm	0.5cm	0.6cm	1.2cm	12mm
5	1.2cm	0.5cm	0.35cm	0.7cm	7mm
	1.6cm	0.5cm	0.55cm	1.1cm	11mm
	1.5cm	0.5cm	0.5cm	1.0cm	10mm
6	1.5cm	0.5cm	0.5cm	1cm	10mm
	0.1cm	0.5cm	-0.2cm	0.4cm	4mm
	1.9cm	0.5cm	0.7cm	1.4cm	14mm
7	1.0cm	0.5cm	0.25cm	0.5cm	5mm
	1.0cm	0.5cm	0.25cm	0.5cm	5mm
	2.2cm	0.5cm	0.85cm	1.7cm	17mm
8	1.0cm	0.5cm	0.25cm	0.5cm	5mm

	1.5cm	0.5cm	0.5cm	0.25cm	2.5mm
	1.8cm	0.5cm	0.65cm	1.3cm	13mm
9	1.4cm	0.5cm	0.45cm	0.9cm	9mm
	1.0cm	0.5cm	0.25cm	0.5cm	5mm
	1.5cm	0.5cm	0.5cm	1.0cm	10mm

Sample with 2g of dust

No Sample	Diz	D	(Diz-D)/2	((Diz-D)/2)/d	In mm
10	0.5cm	0.5cm	0cm	0cm	0mm
	2.0cm	0.5cm	0.75cm	1.5cm	15mm
	2.0cm	0.5cm	0.75cm	1.5cm	15mm
11	2.5cm	0.5cm	1cm	2cm	20mm
	0.8cm	0.5cm	0.15cm	0.3cm	3mm
	1.3cm	0.5cm	0.4cm	0.8cm	8mm
12	1.5cm	0.5cm	0.5cm	1cm	10mm
	0cm	0.5cm	0.25cm	0.5cm	5mm
	2.1cm	0.5cm	0.8cm	1.6cm	16mm
13	1.5cm	0.5cm	0.5cm	1cm	10mm
	1.5cm	0.5cm	0.5cm	1cm	10mm
	1.9cm	0.5cm	0.7cm	1.4cm	14mm
14	1.3cm	0.5cm	0.4cm	0.8cm	8mm
	1.5cm	0.5cm	0.5cm	1cm	10mm
	1.0cm	0.5cm	0.25cm	0.5cm	5mm
15	1.0cm	0.5cm	0.25cm	0.5cm	5mm
	1.5cm	0.5cm	0.5cm	1cm	10mm

	1.7cm	0.5cm	0.6cm	1.2cm	12mm
16	1.2cm	0.5cm	0.35cm	0.7cm	7mm
	1.6cm	0.5cm	0.55cm	1.1cm	11mm
	2.0cm	0.5cm	0.75cm	1.5cm	15mm
17	1.3cm	0.5cm	0.4cm	0.8cm	8mm
	1.8cm	0.5cm	0.65cm	1.3cm	13mm
	2.0cm	0.5cm	0.75cm	1.5cm	15mm
18	0.1cm	0.5cm	0.2cm	0.4cm	4mm
	1.5cm	0.5cm	0.5cm	1cm	10mm
	1.7cm	0.5cm	0.6cm	1.2cm	12mm

SECTION C

Hedonic test questionnaire

Score sheet of **Hedonic Test** of cream formulation from Agarwood essence using **Taguchi Method**

You're presented with 18 samples of cream. Please evaluate the best cream product sample according to your personal preferences using sensory characteristics.

Name :

Age :

Gender : Female ( ) Male ( )

Occupation :

Code sample :

Cream characteristic : Appearance, Aroma, Texture, Color, Impression

Score value assigned:

1- Extremely dislike
2- Very dislike
3- Really dislike
4- Don't like
5- Rather not like
6- Normal/neutral
7- Rather like
8- Like
9- Really like
10- Extremely like

No	Sample	Hedonic				Properties		
		Appear	Aroma	Texture	Color	Microbe	pH	Cost
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								