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Development of cream formulation with Agarwood Essence using Taguchi Design of Experiment method

Nur Qurratuain binti Baharuddin
J20A0574

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DECLARATION

I declare that this thesis entitled "Development of Cream Formulation with Agarwood Essence using Taguchi Method" is the result of my research except as cited in the references.

Signature : ____________________________

Student's Name : NUR QURRATUAIN BINTI BAHARUDDIN

Date : ____________________________

Verified by:

Signature : ____________________________

Supervisor's Name : DR. AZFI ZAIDI MOHAMMAD SOFI@AZIZ

Stamp : ____________________________

Date : ____________________________

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Pembangunan formulasi krim dengan Pati Gaharu menggunakan kaedah Taguchi

ABSTRAK

Bahan utama dalam kajian ini ialah pati Gaharu. Pati gaharu ialah minyak berharga yang diekstrak daripada kayu inti resin pokok Aquilaria, dihargai kerana baunya yang kaya dan berkayu. Ia digunakan dalam minyak wangi, kemenyan dan perubatan tradisional untuk aroma kompleks dan faedah terapeutik yang dirasakan. Reka bentuk kaedah eksperimen Taguchi memfokuskan kepada pembangunan formulasi krim optimum untuk menyerlahkan kualiti tersendiri melalui penggunaan pati Gaharu yang digabungkan dengan kapur barus dengan menggunakan pendekatan kaedah Taguchi. Kaedah Taguchi digunakan untuk mengoptimumkan prestasi produk dengan mengenal pasti faktor gabungan optimumnya yang membawa kepada hasil yang diingini. Ini menunjukkan bahawa ia boleh menganalisis faktor-faktor yang mempengaruhi prestasi krim untuk menentukan formulasi optimum. Ia juga digunakan dalam mengukur hubungan antara isyarat (prestasi yang diingini) dan hingar (prestasi yang tidak diingini). Faktor yang paling mempengaruhi isyarat kepada bunyi adalah air. Dengan menggunakan proses berstruktur dan cekap untuk bereksperimen dengan perubahan reka bentuk, kaedah Taguchi mengenal pasti faktor paling berpengaruh yang mempengaruhi kualiti rupa, tekstur, aroma dan warna. Kemudian, ia diikuti dengan Ujian Hedonik. Ujian hedonik ialah kaedah penilaian deria yang digunakan untuk mengukur keutamaan atau penerimaan pengguna terhadap produk berdasarkan sifat derianya, seperti rasa, aroma, tekstur atau rupa. Ia melibatkan pembentangan sampel produk kepada peserta dan meminta mereka menilai kesukaan atau keutamaan mereka menggunakan skala, selalunya daripada tidak suka kepada sangat suka. Ujian ini membantu syarikat memahami pilihan pengguna dan membuat keputusan tentang pembangunan produk, perumusan semula atau strategi pemasaran. Ini membolehkan pengilang atau penyelidik mengoptimumkan proses atau reka bentuk produk, mencapai hasil yang konsisten dan berkualiti tinggi dengan pengurangan masa dan kos pembangunan. Dalam kajian ini, parameternya ialah jenis minyak asas, jenis lilin, kuantiti air yang digunakan, dan penggunaan kapur barus, pengawet, dan alkohol. Untuk kelembapan, jumlah yang diingini adalah antara 50 hingga 80, untuk kelikatan antara 3 hingga 15, dan untuk pH ialah 6. Berdasarkan ini formulasi yang baik jatuh pada Sampel 7. Ujian Hedonik juga menunjukkan bahawa sampel yang diingini ialah sampel 7. Faktor yang paling mempengaruhi krim adalah air diikuti oleh lilin. Kesimpulannya, hasil kajian ini adalah untuk membangunkan formulasi krim dengan pati Gaharu menggunakan kaedah Taguchi.

Development of cream formulation with Agarwood Essence using Taguchi method

ABSTRACT

The main ingredient in this study is Agarwood essence. Agarwood essence is a precious oil extracted from Aquilaria trees' resinous heartwood, prized for its rich, woody scent. It's used in perfumery, incense, and traditional medicine for its complex aroma and perceived therapeutic benefits. Taguchi's design of the experiment method focuses on the development of the optimal cream formulation to highlight its distinctive quality through the use of Agarwood essence combined with camphor by using Taguchi method. Taguchi method is applied to optimize the performance of a product by identifying its optimal combination factor that leads to a desirable outcome. This implies that it can analyze the factors influencing the cream's performance to determine the optimal formulation. It is also used in quantifying the relationship between the signal (desired performance) and the noise (undesired performance). The factor that most influences signal-to-noise is water. By using a structured, efficient process for experimenting with design changes, the Taguchi method identifies the most influential factors affecting the quality of appearance, texture, aroma, and colour. Then, it follows with the Hedonic Test. A hedonic test is a sensory evaluation method used to measure consumer preferences or acceptance of a product based on its sensory attributes, such as taste, aroma, texture, or appearance. It involves presenting participants with samples of the product and asking them to rate their liking or preference using a scale, often ranging from dislike to like very much. This test helps companies understand consumer preferences and make decisions about product development, reformulation, or marketing strategies. This enables manufacturers or researchers to optimize processes or product designs, achieving consistent, high-quality outcomes with reduced development time and costs. In this study, the parameters are the type of base oil, the type of wax, the quantity of water used, and the use of camphor, preservatives, and alcohol. For moisture, the desirable amount is between 50 to 80, for viscosity is between 3 to 15, and for pH is 6. Based on this the good formulation falls on Sample 7. The Hedonic test also shows that the desirable sample is sample 7. The factor that most affected the cream is water followed by wax. In conclusion, the outcome of this study is to develop a cream formulation with Agarwood essence using the Taguchi method.

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CHAPTER 1

1 INTRODUCTION

1.1 Background of the Study

Agarwood cream, sometimes referred to as oud or aloeswood, is a particular kind of scented cream that is widely prized for its distinctive and opulent perfume. The heartwood of some trees, primarily in Southeast Asia, produces the uncommon and valuable resin known as agarwood (Liu et al., 2017). When a certain type of mold infects a tree, resin is created. Over time, the infected wood develops a rich, nuanced fragrance that is highly valued in perfumery and aromatherapy (Ghani et al., 2004).

Agarwood resin is generally combined with other commercial natural substances to create agarwood cream. The scent is then enhanced by adding essential oils or other perfumes. The resulting creams are used for meditation, relaxation, and spiritual pursuits as they have a warm and woody perfume that is both exotic and seductive. However, agarwood creams are widely regarded as being well worth the cost due to their distinctive aroma and medicinal properties (López-Sampson & Page, 2018).

The ability of Agarwood is it has a distinct and alluring aroma that is highly prized in the perfume and fragrance industries (Le, 2018). It gives a variety of goods, including fragrances, incense, candles, and air fresheners, a deep, woodsy, and oriental aroma. Agarwood is well-liked by fans of smell because of its aroma, which is frequently characterized as warm, earthy, and sensual. Other than that, it has a therapeutic agent and is used in aromatherapy. Agarwood is well known for its therapeutic properties and is used in both aromatherapy and conventional medicine. Agarwood is thought to offer calming, sedating, and mood-lifting properties. It can lessen stress, encourage mental clarity, and foster a feeling of well-being. Due to its aromatic properties, agarwood is suitable for skin creams. The benefits of relaxing the body are one of its greatest advantages. It can clear out bad and destructive energy, lessen anxiety, improve mental performance, and even increase your level of awareness and alertness.

Other than that, Agarwood has calming and meditative properties that can aid in improving your mental clarity. Finally, agarwood also has a lot of health advantages. It has tonic, aphrodisiac, and diuretic properties. It can also be applied to treat epilepsy symptoms. Oud has been used for disease for millennia, including ailments of the respiratory system, fevers, abdominal pain, asthma, and even digestive issues (Worwood, 2016).

A semi-solid or thick liquid fluid that is frequently used in skin care, cooking, and other applications is referred to as cream. When discussing skincare, the term "cream" often refers to a category of cosmetics used to hydrate and nourish the skin. Cream is an emulsion of water and certain lipids, typically containing beeswax. Unlike vanishing cream, which is known as an oil-in-water emulsion because it appears to vanish when applied to the skin, cold cream is an emulsion of small amounts of water in a greater amount of oil. The term "cold cream" refers to the numbing sensation the cream left behind on the skin (Chauhan & Gupta, 2020).

A cream is a topical medication that is typically applied to the skin. Even cosmetic creams are based on pharmacy-developed procedures and unmedicated creams are widely utilized in a range of skin problems (dermatoses), creams may be regarded as pharmaceutical items. To determine how much topical cream is needed to cover various locations, the Fingertip unit idea may be useful. In a suitable base, one or more drug compounds are dissolved or dispersed in creams, which are semisolid dosage forms. Historically, this term has been used to describe semisolids with a fluid viscosity that are formulated as either water-in-oil (such as Cold Cream) or oil-in-water (such as fluocinolone Acetonide Cream) emulsions (Olejnik et al., 2012).

The Taguchi method is a statistical approach used for quality assurance, process optimization, and product design (Güldane, 2023). This method can be used to optimize the formulation and production parameters while making Agarwood cream to attain the required features and attributes in the finished product.

This method entails identifying and regulating variables that can affect the quality of the final product, including viscosity, colour, pH value, primary skin irritation test, visual appearance, stability studies, saponification value, acid value, and fragrance oil type. The Taguchi technique can assist in determining the ideal mixture of elements that yields the desired effect on skin and other features by methodically altering these parameters and analyzing the resulting quality characteristics of the cream (D. S. Karna & R. Sahai, 2012).

The Taguchi approach identifies the ideal mix of elements that produce the required quality features of the Agarwood cream while minimizing variation and improving consistency through a series of experimental designs and statistical analysis tools. Manufacturers can create a more effective and efficient production process, resulting in a higher quality product that fulfills client expectations, by using the Taguchi technique while creating cream from agarwood (D. S. Karna & R. Sahai, 2012).

1.2 Problem Statement

The problem associated with this study is how to avoid skin inflammatory problems and moisturize the skin at the same time. In this study, using Agarwood in the formulation of cream will help avoid the inflammatory problem since it provides anti-inflammatory effects. At the same time, it will help moisturize the skin. The skin is moisturized and kept hydrated by agarwood oil. When used topically, agarwood cream can deeply moisturize dry skin, leaving it supple, smooth, and silky. Agarwood cream can help maintain a healthy skin barrier by preventing moisture loss over time. Other than that, it can help skin healing. Agarwood essential oil has calming and restorative qualities. Cream made from agarwood can be used to calm and repair dry, irritated, or harmed skin. When the skin needs delicate care and nourishment due to problems like eczema, dermatitis, or sunburn, it is especially helpful.

Other than that, factorial design is used in producing an optimum formulation of cream, it will cause a lot of damage. One of the disadvantages is increased complexity. Factorial designs need concurrent examination of numerous elements, which can complicate both the design and analysis. To guarantee that these aspects and their interconnections are properly accounted for, meticulous planning and execution are necessary. Besides, larger sample numbers and greater resources, including time, materials, and staff, are frequently needed when doing a factorial design. Costs may rise as a result, particularly if the causes under investigation demand pricey machinery or specialized knowledge.

1.3 Expected Output

The expected output in this study is to produce a natural product. Due to the lack of harsh chemicals in this formulated cream, so significantly less waste and toxins are going down the drain. Organic beauty products are good for our skin, good for our internal health, and good for the earth (Gross & Kalra, 2002). Other than that, this formulated cream will have an optimum formulation since it follows the Taguchi method. With the use of the Taguchi method, it will improve the quality of the manufactured products (S. K. Karna & R. Sahai, 2012). The Taguchi technique makes use of statistical analysis to calculate how different design parameters affect the performance of the final product. This gives important insights into how changes to these parameters affect the functionality of the product, enabling designers to make well-informed choices and trade-offs throughout the design process.

1.4 Objective

1. To apply the Taguchi Design of Experiment method in cream formulation development.
2. To analyze the properties of cream including pH, moisture content, and viscosity.
3. To analyze consumer satisfaction towards the developed product using the Hedonic Test Questionnaire.

1.5 Scope of Study

In this study, agarwood will be used as an aromatic ingredient. The agarwood that was chosen is in the state of oil known as essential oil. This essential oil will be one of the ingredients that will be put in the formulated cream. The reason why agarwood is used instead of other ingredients is because it has a unique and luxurious fragrance. Agarwood has a distinct and complex aroma that is highly valued in perfumery and aromatherapy. The warm and woody scent of agarwood is considered exotic and sensual and is often associated with luxury and opulence. Besides, it gives astringent and anti-inflammatory qualities (Alamil et al., 2022). Agarwood is a rare and precious material that is difficult to obtain, making it an exclusive and high-end product. Creams made from agarwood are good for our skin as they help moisturize and keep the skin barrier at an optimum level. Other than that, Camphor also will be added to the cream to enhance the scent. The combination of these two ingredients will help increase the effect on the consumer. The procedure is carried out from natural source ingredients and added on with the essential oil of agarwood and Camphor.

Beeswax is also used in this cream as an emulsifying agent. Beeswax helps stabilize emulsions, which are mixtures of oil and water (Gao et al., 2021). Creams frequently contain substances that must be blended that are both oil- and water-based. As an emulsifying agent, beeswax keeps these components from separating and gives the cream a uniformly smooth texture.

This study will be based on the Taguchi method. Through the Taguchi method, it will test the effectiveness of all creme with different ratios. All of the cream will be put in a container and will be characterized through FTIR.

1.6 Significance of Study

Agarwood has been used for its therapeutic benefits in many forms throughout history. The benefits of agarwood cream, such as its capacity to ease skin disorders, lessen inflammation, or accelerate wound healing, can be validated by conducting studies on it. Due to its capacity to alleviate pain, and asthmatic symptoms, and stop vomiting, agarwood has been widely used for medical purposes since ancient times. In terms of inflammation, it has been discovered that the main component of agarwood, agarwood oil, has several bioactive substances that can control the molecular pathways of chronic inflammation, creating a wide range of pharmacological effects for treating different inflammatory illnesses (Alamil et al., 2022). Other than that, it aids in reducing the visibility of age spots and moisturizes skin, wrinkles, and scars.

However, Agarwood is slowly becoming an endangered species due to its demand in the market. Thus, the process of producing Agarwood cream will become costly since it is hard to find. Studies on agarwood cream can help develop sustainable methods of resource management. The burden on agarwood trees in the wild can be lessened by researching alternate agarwood supplies, cultivation techniques, or synthetic alternatives that approximate its qualities (Kakar A., 2022).

It also complies with eco-friendly products which can degrade. There are environmental benefits when employing biodegradable materials. In fundamental and applied research fields, the importance of biodegradable and biocompatible polymers is rising (Karne et al., 2023). Biodegradable products are designed to degrade upon disposal by the action of living organisms (Gross & Kalra, 2002). A substance's biodegradability refers to its capacity to be broken down into more basic, non-toxic components by bacteria, fungi, or other microorganisms.

CHAPTER 2

2 LITERATURE REVIEW

2.1 Bioproduct development

Nowadays, the majority of soaps seen in stores are devoid of glycerin and contain additional chemicals like triclosan and sodium lauryl sulfate. These two chemicals have both been shown to thin human skin and make it drier (Kim et al., 2015). As a result, those with allergies, endocrine disruption, antibiotic resistance, or acute or chronic toxicity should avoid using household soap since it contains triclosan and sodium lauryl ether sulfate (SLES), which can make their conditions worse. Such illnesses that society needs to deal with are caused by environmental pollution and skin exposure to sunshine (Abd Rahman et al., 2022). In this journal, the production of olive oil handmade soap was attempted with the presence of glycerin and sodium hydroxide via a cold saponification process. Other than that, Energy is a fundamental prerequisite for the growth of practically every facet of society worldwide (Fu et al., 2014). However, using conventional energy sources can result in several issues. First off, conventional energy (i.e., fossil fuel) is non-renewable and its overuse will result in a significant energy problem, which is currently a major issue for the entire globe. Second, using conventional fossil fuels can produce pollutants like carbon dioxide and other greenhouse gases, which contribute to global warming (Hoekman et al., 2018). As a result, bioenergy, a potent renewable fuel that can replace fossil fuels, has grown over the past few decades, particularly in North America and Europe, with the goals of addressing the rise in global population, ensuring energy security, and reducing global warming (Hoekman et al., 2018). Any plant material utilized to make bioenergy is referred to as a bioenergy crop. These plants can grow in poor soils and have a significant potential for energy production and biomass production. One of the promising agricultural possibilities is to grow bioenergy crops on damaged soils (Lemus & Lal, 2005).

The Green Revolution saw a dramatic increase in crop production thanks to the use of chemical fertilizers, but continued reliance on them for agricultural growth in the future would result in further soil quality loss, decreased fertility, potential water contamination, and an unsustainable burden on the agricultural system (Rajasekaran et al., 2012). The substance known as "biofertilizer" contains living microorganisms and is known to aid in seed germination and root system growth. When applied to seeds, plant surfaces, or soil, a biofertilizer—a substance containing live organisms such as bacteria, algae, and fungi—colonizes the rhizosphere and may aid in boosting the supply or availability of essential nutrients to the host plant. Biofertilizers have demonstrated considerable promise for fixing nitrogen, solubilizing phosphorus, and encouraging plant growth by creating chemicals that encourage development. Biofertilizer is a low-cost, renewable source of plant nutrients that is sustainable or environmentally beneficial (Kumar et al., 2017). Lastly, the production of biocomposite to replace polymer is getting popular. This is because it causes an organic compound deficit brought on by diminishing oil and gas resources and rising oil and gas prices. Global warming and environmental concerns over their destruction or cremation are further repercussions (Jamshidian et al., 2010). The search for materials that may overcome these difficulties and keep the necessary qualities for diverse uses was sparked by these worries. Biomaterials are thus utilized on a global scale since they support sustainability. As reinforcement materials, biocomposites frequently use renewable resources like plant fibers like jute, hemp, or bamboo. Biocomposites help to lessen reliance on non-renewable resources by utilizing these natural fibers as opposed to conventional synthetic fibers. When compared to traditional composite materials, they also have a lower carbon footprint (Nagalakshmaiah et al., 2019).

2.2 Cream development

2.2.1 History of cream

Galen, a physician in second-century Greece, is credited with developing cold cream. Beeswax, rose water, and either almond or olive oil were the main ingredients in the original recipe. Beeswax is the emulsifying component of successful creams. However, it is incredibly ineffective when compared to contemporary emulsifiers. Beeswax-only creams need a lot of mixing and can separate when left standing. Thus, a later addition of beeswax and modest amounts of borax was made. Beeswax's fatty acids are saponified by borax, resulting in a cream that is more stable thanks to the small amounts of soap that are produced (Sahu et al., 2016).

2.2.2 Modern cream invention

Modern creams almost universally use mineral oil in place of plant oils in addition to alcohol, glycerine, and lanolin. Jojoba oil started to be used often as a substitute for whale spermaceti in the 1970s (Sherrow, 2001). New applications for the product have been discovered throughout the ages, including "as a toilet requisite cold cream is used for softening and cooling the skin after sunburn, as a cleansing cream, to relieve the harshness of the skin, etc." The cleanser sold by Lush under the name Ultra Bland most closely resembles the original formula credited to Galen; the foundation of the cream is made from plant oils rather than mineral oils (Hammerton).

The goal of developing cream was to create a skincare product that could gently and effectively wash and moisturize the skin. Cream has a reputation for being extremely moisturizing (Purnamawati et al., 2017). Emollients, including mineral oil or petroleum jelly, which help to retain moisture and stop water loss from the skin, make up a large percentage of the product (Lodén, 2003). This makes it especially advantageous for people with dry skin.

2.2.3 Cream formulation

Cream is made by a mixture of water, beeswax, and rose petals. These were the main moisturizer components he used to create the cream (Sahu et al., 2016). Galen's cream was the common name for this skin lotion. Creams are used to remove temporary tattoos and cosmetics in addition to moisturizing the skin (Sahu et al., 2016). After applying the cream to the tattoo marks, a cotton ball is used to wipe them away. These creams are used to make children's face paint, too.

Nowadays, the formulation of cream starts with the heat of a borosilicate glass beaker with liquid paraffin and beeswax, mixture to 75 °C and keep it there (Oil phase). Borax and methylparaben should be dissolved in distilled water and heated in a separate beaker to 75 °C to produce a transparent aqueous phase solution. The heated oily phase will then gradually receive this watery phase (Ashara, 2013). After that, stir vigorously while adding measured amounts of aloe vera gel, neem extract, and tulsi extract. This will create a smooth cream. Then, as a scent, add a few drops of rose oil. Put this cream on the slab and, if necessary, add a few drops of distilled water. Then, mix the cream geometrically on the slab to give it a smooth texture and ensure that all the elements are thoroughly combined. Slab technique or extemporaneous cream preparation is the name of this technique (Navindgikar et al., 2020).

2.2.4 Cream analysis (pH, texture, moisture, and aromatic level)

The nature of the skin's surface was thought to be acidic (Schade & Marchionini, 1928). Previously, widely accepted papers claimed that the pH of the skin of an adult male's forearm ranges from 5.4 to 5.9 (Braun-Falco & Korting, 1986). More recent research has revealed that the skin's pH is much more acidic, and it is now generally acknowledged that the skin's pH fluctuates from 4.1 to 5.8 depending on the location of the body (Segger et al., 2008). Refer to Figure 2.1, there are certain exceptions that the pH ranges from 6.1 to 7.4 in specific physiological gaps (axillae, groin, toe interdigit, and anus) (Kleesz et al., 2011). These data were all achieved using flat glass electrodes and potentiometric techniques. Some writers assert that the actual skin pH may be closer to 6, with some more acidic microdomains, due to the measurement principle that only considers water-soluble components (Schmitt & Neubert, 2018).

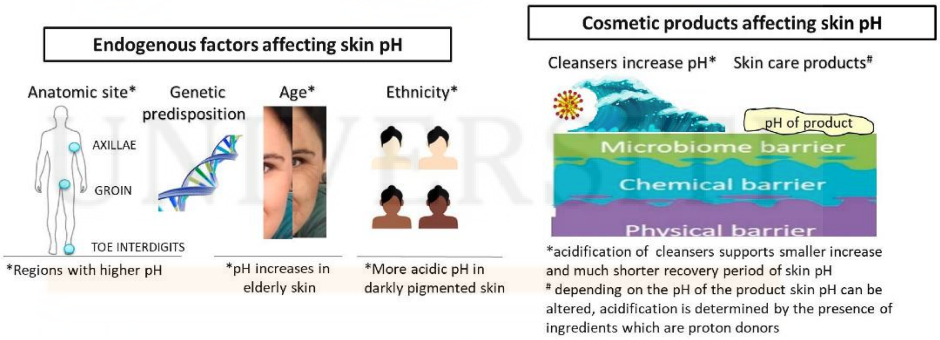

Figure 2.1: Endogenous and exogenous factors affecting skin pH

(source: (Lukić et al., 2021)

There is broad consensus that topical products should be acidified and have a pH between 4 and 6. However, more detailed instructions on appropriate product pH values and the choice of cosmetic ingredients that may cause acidification, as well as a deeper comprehension of the mechanisms underlying the process of skin acidification by topical products, would be helpful to formulators, dermatologists, and consumers (Lukić et al., 2021).

For the formulated cream texture, the majority of moisturizing creams are thick and provide the skin with significant hydration. They function by creating a shield of moisture that protects your skin from the elements and moisture loss, giving it time to repair and regenerate. Most creams work best on dry skin or skin that needs extra care after being exposed to harsh weather conditions like heat and snow (Shukla & Pandey, 2022).

Creams typically have a water content between 50% and 70%. The skin is given hydration and emollient characteristics thanks to this enhanced moisture content. It makes the cream spreadable and gives off a chilly sensation when applied. The creamier, thicker consistency of cold creams is also a result of the higher water content (Sonia et al., 2017).

Agarwood is made up of a vast range of substances, which give it its fragrant and therapeutic characteristics. The majority of the discovered compounds—more than 150 in total—are sesquiterpenoids, chromones, and volatile aromatic substances (Naziz et al., 2019). A thorough study of agarwood compounds has been provided, including a detailed list of the volatile and semi-volatile components derived from Aquilaria species, primarily *A. malaccensis, A. sinensis*, and *A. crassna. Agarofurans, cadinanes, eudesmanes* (and *selinanes*), *valencanes* (and *eremophilanes), guaianes, prezizanes, vetispiranes,* 2-(2-phenylethyl)-chromones, and other typical volatile aromatics like benzene, toluene, and naphthalene are among the most noticeable classes of chemicals (Naef, 2011).

2.3 The application/usage of Agarwood

The resinous component of wood called aquilaria is also referred to as agarwood, eaglewood, oudh, oud, kanankoh, kyara, jinkoh, and kalambak. The wood is a member of the Thymelaeaceae family taxonomically. According to reports, the Asean region is home to 19 different species of Aquilaria. Agarwood can be used in a variety of ways, such as essential oil, chips, flakes, and branches (Wetwitayaklung et al., 2013).

The use of agarwood oil has dramatically increased in Malaysia, according to numerous studies (Ismail et al., 2014). Accordingly, there are more agarwood plantations in this nation, and there is a growing demand for its oil on the global market (Ismail et al., 2014). Agarwood oil is made from the stem of the agarwood plant and is composed of concentrated volatile aromatic chemicals. Agarwood oil is generated for incense, fragrance, and traditional remedies, as several scholars have noted (Barden et al., 2000). Agarwood oil is sold all over the world and is in high demand, particularly in the United Arab Emirates, Saudi Arabia, China, and Japan. Depending on the grade, the agarwood oils are exchanged differently.

Numerous researchers have looked into the variations in agarwood oil's chemical composition (Pornpunyapat et al., 2011). The majority of them concurred that the main chemicals in agarwood oil were sesquiterpene components and their chromone derivative (Wetwitayaklung et al., 2013). Agarwood oil's high and low quality is determined by the component makeup (Ishihara et al., 1993). Agarwood oil quality has been classified by the Forest Research Institute Malaysia (FRIM) based on the physical characteristics of the wood, the burnt aroma's longevity, color, resin content, high fixative capabilities, and consumer perception (Ismail et al., 2014). For instance, the quality of the agarwood oil can be graded based on odor and appearance, with grades ranging from A to D (Ismail et al., 2014). A study conducted in Japan in the interim categorized the quality of agarwood oil as high, moderate, or low based on peak area percentages (or abundances) of chemical components. Wood oils that include α-guanine with a peak area smaller than 0.05% are categorized as high-quality oils, while oils that do not contain α-guanine are categorized as low-quality (Ishihara et al., 1993)

Traditional Arabian medicine frequently employs agarwood in aromatherapy to treat sedative, digestive, and neurological illnesses (Afzal et al., 2021). The beneficial pharmacological properties of agarwood oil, including its anti-inflammatory properties, can be attributed to the presence of a wide range of bioactive compounds, including flavonoids, terpenoids, chromones, phenolic acids, steroids, and alkanes, according to modern research. Agarwood oil is typically thought to be the main active component of agarwood (Taylor et al., 2004). Additionally, more and more fresh substances are being discovered in agarwood and isolated from it thanks to phytochemical research (Afzal et al., 2021).

Some bioproducts use agarwood as their ingredients. The most prevalent and well-liked bioproduct made from agarwood is agarwood essential oil, usually referred to as oud oil. It is widely used in aromatherapy, traditional medicine, and perfumery. It is extracted from the resinous heartwood of agarwood plants. Other than that, Agarwood is processed into chips and powder by either grinding or shredding the wood. These bioproducts are employed in a variety of settings, including the manufacture of incense, religious rituals, and as a fragrance or aromatic component in potpourri or air fresheners. There is also Agarwood Hydrosol. Agarwood Hydrosol is a by-product of the steam distillation method used to obtain agarwood essential oil. It is sometimes referred to as oud water or agarwood distillate. In contrast to essential oil, it has a softer scent and water-soluble components. Agarwood hydrosol is utilized in the creation of skincare products, as a facial mist, and as a foundation for perfumes. Lastly, incense that made from agarwood. Incense sticks, cones, or coils are frequently made from agarwood chips or powder. Agarwood incense is prized for its distinctive and alluring scent and is used in religious rituals, meditation exercises, or just to fill rooms with a pleasant fragrance.

2.4 Taguchi method

A statistical experimental design and optimization methodology called the Taguchi method was created by Dr. Genichi Taguchi and is utilized to raise the caliber and effectiveness of goods and procedures. It seeks to achieve robustness in the face of unpredictable factors and minimize variability. Numerous industries, including manufacturing, engineering, and research and development, frequently use the Taguchi approach. To manufacture high-quality goods at low development and manufacturing costs, robust design is an engineering methodology for obtaining product and process conditions that are minimally susceptible to the many causes of variation. An essential technique for resilient design is Taguchi's parameter design. It provides a straightforward and methodical approach to design optimization for cost, quality, and performance. A loss occurs when a critical quality attribute deviates from the desired value (Unal & Dean, 1990). The key to achieving high quality and lowering costs is to relentlessly pursue variability reduction from the target value in crucial quality attributes.

To examine the impact of numerous independent factors on a dependent variable, experimental investigations frequently employ the study design technique known as the factorial design. It entails methodically adjusting and combining the levels of two or more independent variables to investigate the impact of each variable on its own as well as the interactions between them and the dependent variable (Amraini et al., 2023). The reason why factorial design does not get selected in this project is because it will increase the complexity. The number of conditions in the design expands exponentially as the number of components and levels rises. As a result, there are more treatment combinations available, increasing the number of participants, resources, and time needed to complete the study. It might be difficult to manage and analyze data from a factorial design with several levels and components (Collins et al., 2009).

In health care, the core of Taguchi's methods is the quadratic loss function. It may be used to accurately model the loss to society from health care and is a potent motivation for a quality plan. Additionally, it provides a connection between price and variability. As a result, it can be combined with the functionality and specifications of medical application design. Signal-to-noise ratios can be used to gauge how closely a performance resembles the ideal. The goal of quality engineering operations can be to discover close to the optimum levels of factors and achieve zero quality by maximizing the signal-to-noise ratio (Taner & Antony, 2006).

Taguchi method also can be applied for an optimization strategy for the production of nano-hydroxyapatite powder using adsorbents from bovine bone that were mechanically activated to remove lead ions (Pb^{+2}). The Taguchi approach was used to construct the trials, taking into account four variables that could be controlled which are the ball milling time (A), the initial concentration of lead ions (B), the initial pH of the solution (C), and the dosage of the adsorbent (D) (Googerdchian et al., 2018). The Taguchi approach is renowned as a powerful design of experiment (DOE) technique that can support an optimized design configuration even when it is impossible to disregard the interactions between the governing variables. Utilizing DOE techniques results in cost reduction, quality improvement, and reliable design solutions (Zolfaghari et al., 2011).

Based on this research study, Acrylonitrile Butadiene Styrene (ABS) is the target material, and Taguchi is utilized to determine the best combination factor values for minimizing surface roughness in test materials using Fused Deposition Modelling (FDM). However, as a result of the adequate process parameters, the research community has paid less attention to the surface quality. This study seeks to fill that gap. In this work, the Design of Experiment (DOE) method is used to assess the effects of specific factors on the surface roughness of Ultimaker 2 + generated goods, including orientation, infill density, and nozzle diameter (Górski et al., 2013). To limit the number of tests and provide various combinations of these three elements and their levels at each experiment, Taguchi Orthogonal array was employed to construct the specimens (Nangare & Chavan, 2023).

2.5 Hedonic test

The hedonic test, often known as the consumer preference level test, is one of the crucial tests since it involves consumer participation. The test formulations will be created, and the panelists will be asked to comment on their texture, color, and odor. On a scale of 1 to 9 (with points 1 for very dislike, 2 for dislike, 3 for dislike, 4 for rather dislike, 5 for neutral, 6 for rather like,7 for like, 8 for really like, and 9 for very like), the consumer was asked to rate it.

This test is crucial for cosmetic purposes. A sensory analysis or hedonic test can be performed to evaluate the acquisition and continued usage of cosmetics concerning the sensation the consumer causes. It is vital to create formulations by pleasing sensory experiences for increased acceptability (Oliveira & Tescarollo, 2021). The visual appeal of cosmetics products is a crucial aspect in determining consumer preference (Yang & Chen, 2015). Additionally, the product's scent also exerts a major influence. For example, a 1% increase in essential oil in cream can change consumer preferences.

CHAPTER 3

3 MATERIALS AND METHODS

3.1 Materials

The materials used in this experiment are beeswax, paraffin wax, mineral oil, olive oil, palm oil, cetyl alcohol, preservative, Agarwood, and Camphor essential oil through online purchase from Shopee. Meanwhile, borax is available at the Microbial Laboratory of University Malaysia Kelantan

3.1.1 Design of Experiment

Table 3.1: Table of Taguchi method

Number	Camphor	Preservatives	Alcohol	Water	Oil	Wax
1	-	-	-	20ml	Mineral	8g Beeswax
2	-	-	1%	35ml	Palm	8g Paraffin wax
3	-	-	2%	55ml	Olive	4g Paraffin wax 4g Beeswax
4	-	1.5%	-	20ml	Palm	8g Paraffin wax
5	-	1.5%	1%	35ml	Olive	4g Paraffin wax 4g Beeswax
6	-	1.5%	2%	55ml	Mineral	8g Beeswax
7	-	2%	-	35ml	Mineral	4g Paraffin wax 4g Beeswax
8	-	2%	1%	55ml	Palm	8g Beeswax
9	-	2%	2%	20ml	Olive	8g Paraffin wax
10	2ml	-	-	55ml	Olive	8g Paraffin wax
11	2ml	-	1%	20ml	Mineral	4g Paraffin wax 4g Beeswax
12	2ml	-	2%	35ml	Palm	8g Beeswax
13	2ml	1.5%	-	35ml	Olive	8g Beeswax
14	2ml	1.5%	1%	55ml	Mineral	8g Paraffin wax
15	2ml	1.5%	2%	20ml	Palm	4g Paraffin wax 4g Beeswax
16	2ml	2%	-	55ml	Palm	4g Paraffin wax 4g Beeswax
17	2ml	2%	1%	20ml	Olive	8g Beeswax
18	2ml	2%	2%	35ml	Mineral	8g Paraffin wax

3.1.2 Preparation

Beeswax, Paraffin wax, Mineral oil, Palm oil, Olive oil, cetyl alcohol, preservative, borax, water, and essential oil (Agarwood and Camphor) were prepared.

3.1.3 Heating

8g of wax, 49 ml of oil, and cetyl alcohol was heated at 75℃. Next, 0.4g of borax, water, and preservatives were heated at 75℃ separately from the previous ingredient.

3.1.4 Combining

The first mixture was added to the second mixture slowly with continuous stirring until a thick stable emulsion was formed. Then, the essential oil was added when the temperature fell to 35℃. Lastly, the mixture was stirred again and stored in a suitable container.

3.1.5 Repeat

The step above was repeated with different formulations as shown in Table 3.1

3.2 Method for evaluation of cream

3.2.1 pH

1g of formulated cream was weighed. Then, the pH of the formulated cream was measured using pH paper (Sirsat et al., 2022).

3.2.2 Moisture content

0.5 grams of the sample was weighed using a digital weighing scale. Then it was placed into a Moisture content analyzer. After that, the reading was recorded in % Moisture Content (MC).

3.2.3 Viscosity

The viscosity of the formulation was determined by Vibro Viscometer. It recorded any value between 1~100 Pa.

3.2.4 Test for microbial growth

The designed cream was diluted using sterile distilled water then it was inoculated onto the nutrient agar media using a cotton swab, and a controlled was created using sterile distilled water. The plates were put in the incubator, where they would stay for 24 hours at 37°C. The plates were removed from the incubation period, and the microbial growth was compared with the control (Sirsat et al., 2022). The test was done in three batches and the best result was recorded.

3.2.5 Determination of texture, aromatic, and irritancy (Hedonic Test)

A questionnaire was given to the consumer and the response was analysed. The positive and negative feedback will be recorded. On a scale of 1 to 10 (with points 1 for extremely dislike, 2 for very dislike, 3 for dislike, 4 for don't like, 5 for rather not like, 6 for neutral,7 for rather like, 8 for like, 9 for really like, and 10 for extremely like), the consumer was asked to rate it.

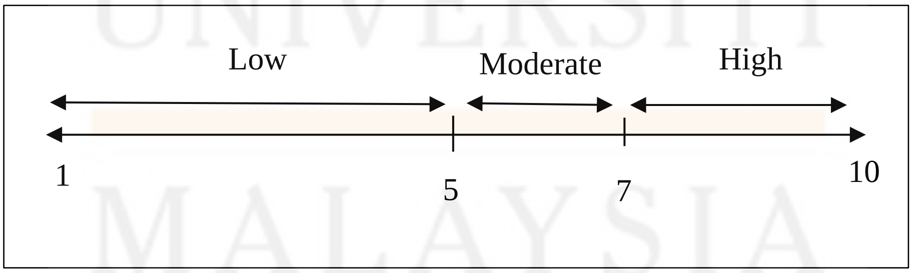

Figure 3.1: Rating scale of each sample

CHAPTER 4

4 RESULTS AND DISCUSSION

In the previous study, the cold cream underwent comprehensive analysis including determination of pH, primary skin irritation test, assessment of visual appearance, viscosity evaluation of spreadability, stability studies, rheological studies, examination of thermal behavior, determination of saponification value, and assessment of acid value. In this study, only the visual appearances that falls under Hedonic and properties like viscosity, moisture, ph and microb was evaluated (Katkale et al., 2022).

4.1 Results

An exploration into the development of cream formulation with Agarwood essence using the Taguchi method has provided a nuanced understanding of the complex interaction between formulation variables and their effect on cream properties. This section aims to analyze the main finding and their implication offering a good result presentation.

Table 4.1: Table of Hedonic output and properties observe

No	Sample	Hedonic				Properties				
		Appear	Aroma	Texture	Color	Viscosity (Pa.s)	Moisture (%MC)	Microbe	pH	Cost (RM)
1	Taguchi 1	5.7	5.3	5.6	7.3	15.8	12.01	No	8	6.5
2	Taguchi 2	5.3	5.4	5.0	4.8	4.92	30.83	No	8	5.5
3	Taguchi 3	3.4	3.6	3.2	5.0	18.3	37.48	No	8	9.0
4	Taguchi 4	3.8	4.6	4.4	4.4	2.83	13.18	No	8	6.1
5	Taguchi 5	5.1	5.7	5.4	6.6	16.5	20.91	No	8	9.6
6	Taguchi 6	3.9	4.3	3.4	4.5	12.7	23.52	No	8	8.3
7	Taguchi 7	6.9	7.3	7.6	7.8	12.5	2.79	No	7	7.1
8	Taguchi 8	5.9	5.8	6.5	7.3	18.0	39.60	Yes	8	6.7
9	Taguchi 9	7.6	4.7	6.1	6.6	4.71	21.11	No	7	9.6
10	Taguchi 10	3.6	4.1	4.2	5.2	0	34.34	No	8	9.5
11	Taguchi 11	6.4	6.2	7.5	7.4	9.63	42.48	No	8	11.5
12	Taguchi 12	6.8	5.6	5.7	6.1	34.7	15.88	No	8	11.7
13	Taguchi 13	6.8	6.5	6.1	6.0	9.32	25.80	No	8	14.6
14	Taguchi 14	3.8	3.7	3.7	4.3	0	40.70	No	8	12.1
15	Taguchi 15	7.0	6.2	7.1	7.0	13.1	5.51	No	8	12.3
16	Taguchi 16	6.5	5.9	6.2	5.8	2.01	39.75	No	8	11.5
17	Taguchi 17	6.4	6.7	6.1	6.3	44.4	46.67	No	8	15.0
18	Taguchi 18	3.5	5.7	4.3	5.1	0	81.27	No	8	12.5

4.1.1 Test for Microbial Growth

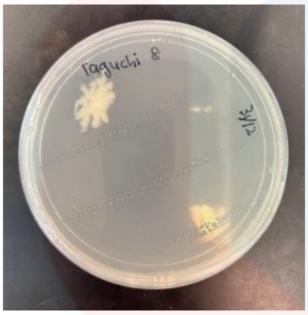	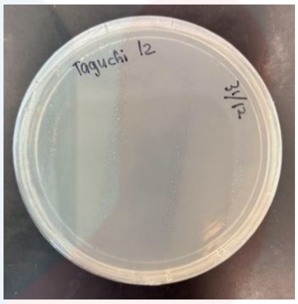
Sample 8 Negative	Sample 12 Positive

Figure 4.1: Negative and positive results of microbial test

Based on the table above, it's been observed that Sample 8 has shown the presence of a colony on the plates, indicating microbial contamination as shown in Figure 4.1. This finding is significant as it suggests that these particular cream formulations may have a relatively short shelf life and are susceptible to microbial growth, which can negatively impact their quality and safety.

4.1.2 Hedonic Test and Properties of Cream

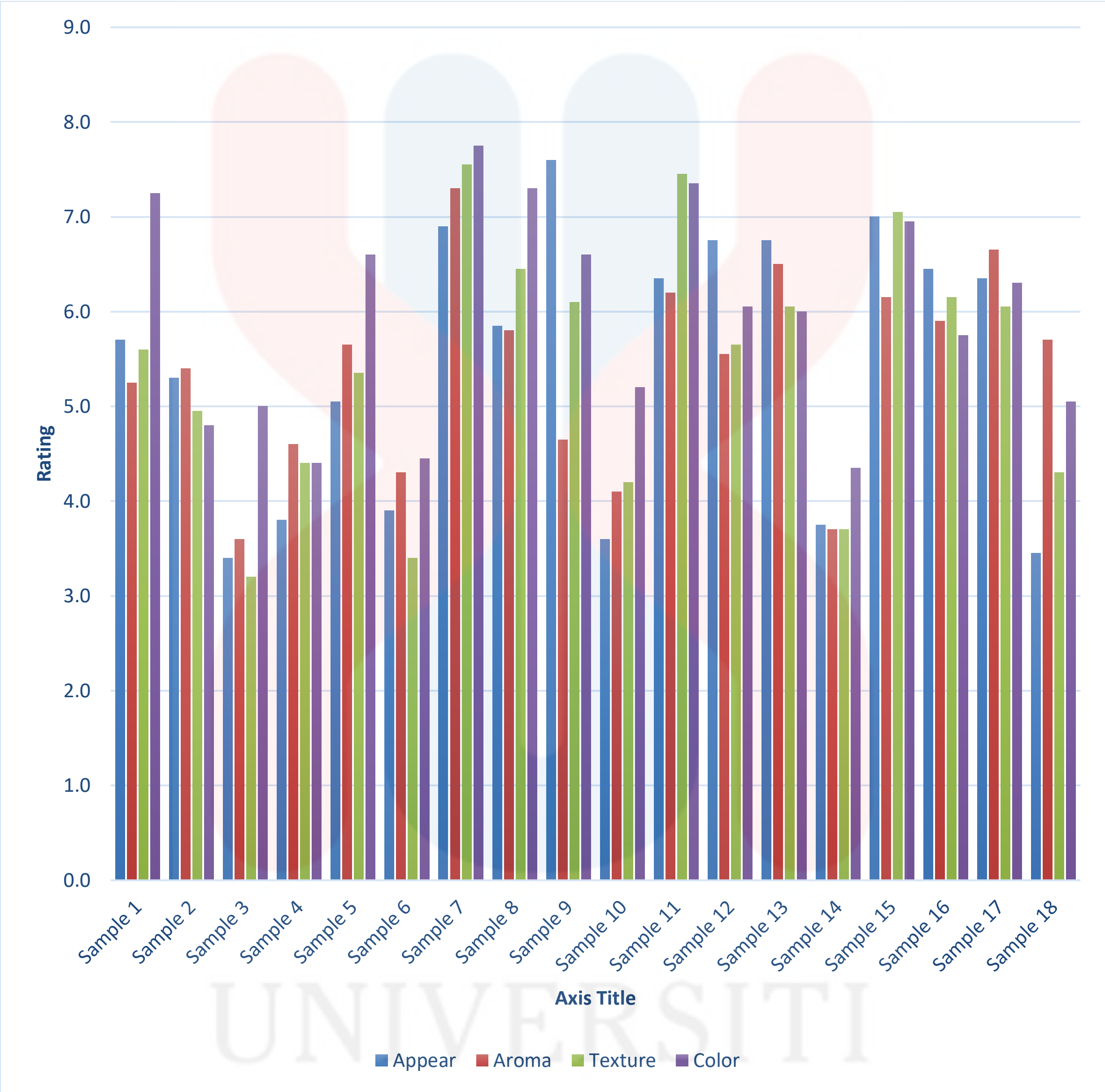

Figure 4.2: Bar graph for Hedonic output

The provided graph in Figure 4.2 represents data from this study focused on the development of cream formulations containing agarwood essence, with a particular emphasis on sensory evaluation. The table includes various sensory attributes such as appearance, aroma, texture, and color. Hedonic ratings are measures of overall liking, and the average ratings for each cream formulation are presented. Additionally, Table 4.1 displays the average ratings for appearance, aroma, texture, and color, all of which are essential factors in determining the cream's quality and acceptability. This sensory evaluation process aims to identify the cream formulation that is most preferred by respondents, the result from this evaluation helps in making decisions for further development or production. It provides valuable insights into which sensory attributes play a crucial role in the formulation's success, catering to the preferences of the target market.

In the dataset of this study, the sensory attributes of appearance, aroma, texture, and color were evaluated for various cream samples, labeled as Sample 1 to Sample 18. The highest rating for appearance was assigned to Sample 9, with a score of 7.6, indicating that it had the most visually appealing presentation. Conversely, the lowest appearance rating was given to Sample 3, receiving a score of 3.4. In terms of aroma, Sample 7 secured the highest rating at 7.3, while Sample 3 also received the lowest aroma rating of 3.6. For texture, once again, Sample 7 stood out with the highest rating of 7.6, while Sample 3, once more, had the lowest texture rating at 3.2. Lastly, in evaluating color, Sample 7 received the highest rating of 7.8, and Sample 14, received the lowest color rating, also at 4.3. These ratings provide valuable insights into the sensory characteristics of the cream formulations and highlight specific samples that performed exceptionally well or needed improvement in different sensory aspects.

Based on the Figure 4.3, the scale is consisting from 1 to 10. These scales have been grouped into three ratings which are low, moderate, and high. Low rating is from 1 to 5 while moderate rating is from 6 to 7 and high rating is from 8 to 10. Based on the graph in Figure 4.2 above shows that Sample 7 has the best rating since the value of aroma, texture, and color is above 7. Meanwhile, a bad rating is given to Sample 3 with low values of aroma, texture, and color.

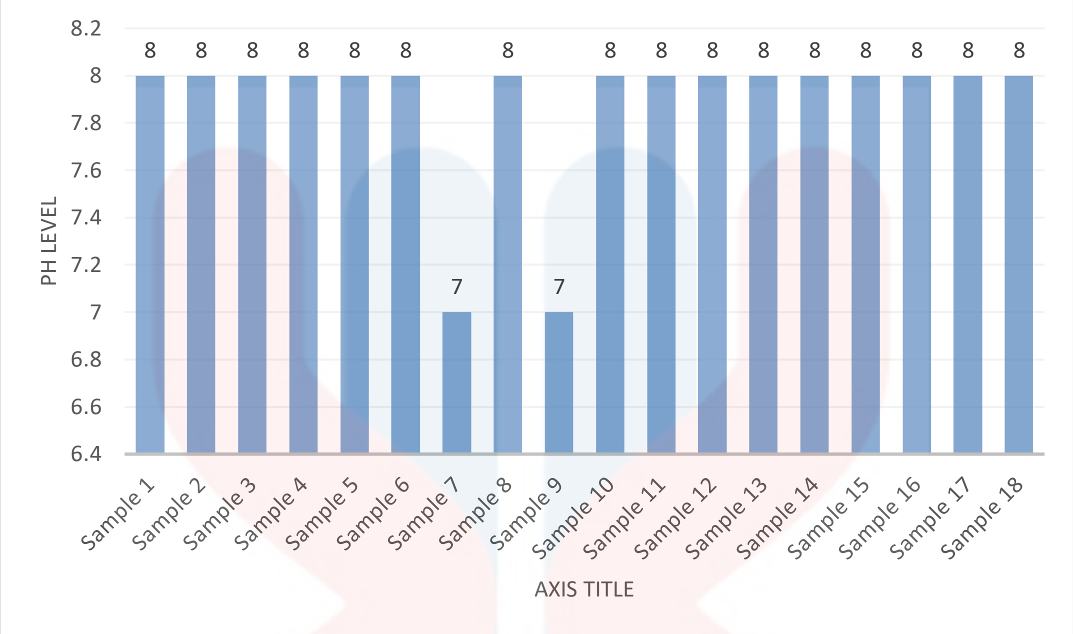

Figure 4.3: Bar graph for pH of each sample

The provided graph in Figure 4.4 contains data related to the pH levels of different samples, labeled as samples 1 to 18. In this dataset, pH serves as the parameter that is being measured. The pH values of all the samples range from 7 to 8. Most of the samples, specifically Sample 1 to Sample 10 and Sample 12 to Sample 18, have a pH level of 8. This suggests that these samples have a slightly alkaline pH, which may not be a desirable characteristic for developing a cream. However, for Sample 7 and Sample 9, they have a pH level of 7. This indicates a more neutral pH for this cream. The specific context and purpose are to determine whether a different type and quantity of ingredient could affect the alkalinity or acidity of the cream formulations with agarwood. In the context of cream formulations, pH is a critical factor that can significantly influence the product's performance and skin compatibility. Based on my research, the optimum pH level for cream is 6 and any level higher or lower also can be accepted. pH levels play a crucial role in determining the compatibility and stability of products, so these measurements are essential for quality control and formulation optimization in the development of cream products.

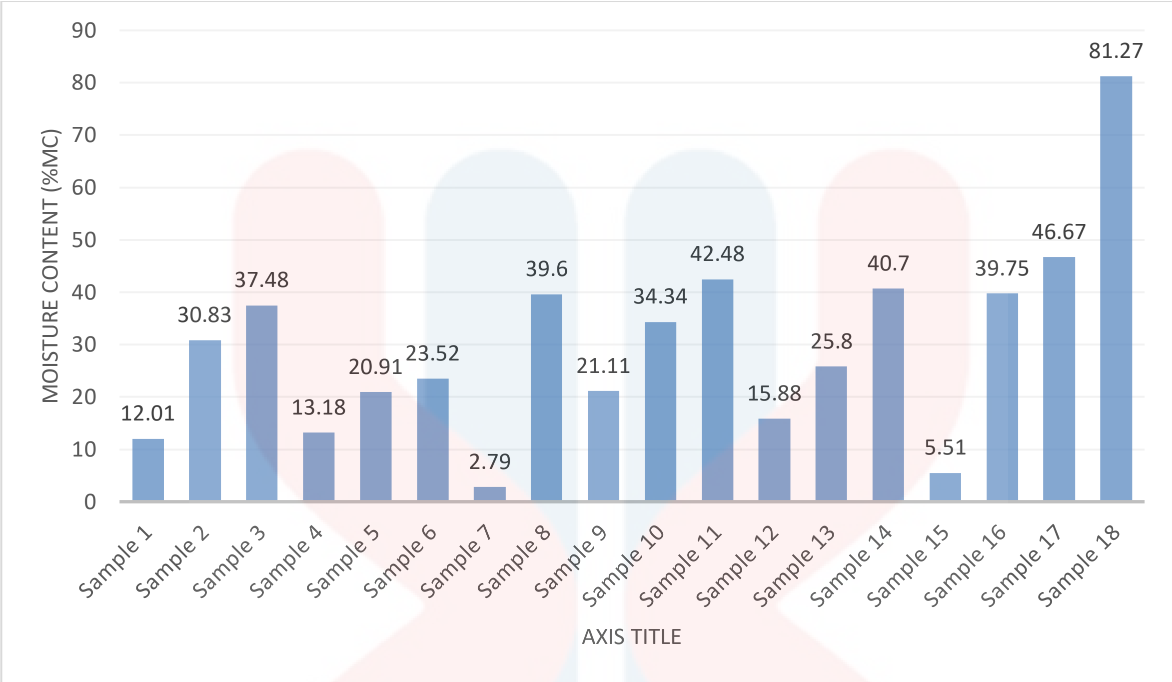

Figure 4.4: Bar graph for moisture content in %MC of each sample

The graph in Figure 4.5 shows the moisture content (%MC) of all of the cream samples, labeled as Sample 1 to Sample 18. Moisture content is a critical parameter in cream formulations, as it directly impacts the product's texture, stability, and overall quality. In the dataset, a significant variation in moisture content across the different cream samples was observed. The moisture content is expressed as a percentage, indicating the proportion of water present in each sample relative to its total weight. The lowest moisture content is found in Sample 7, which has a remarkably low %MC which is 2.79. This suggests that this particular cream sample contains very little water and is likely to have a relatively thick and dry consistency. This cream is in a balm texture thus it has the lowest moisture compared to the other. Such low moisture content may be desirable in certain formulations, such as heavy moisturizing creams or ointments.

Conversely, the highest moisture content is observed in Sample 18, with an %MC of 81.27. This indicates that Sample 18 contains a significant amount of water, making it a highly hydrating and potentially lighter-textured cream. Creams with high moisture content are often preferred for their ability to provide hydration to the skin. The remaining cream samples exhibit varying levels of moisture content, which can be attributed to differences in formulation and intended use. The specific moisture content chosen for a cream formulation depends on the product's purpose and the desired sensory characteristics. Creams with lower moisture content may be more occlusive and suitable for dry skin, while those with higher moisture content are often chosen for their hydrating properties, making them ideal for normal to oily skin types.

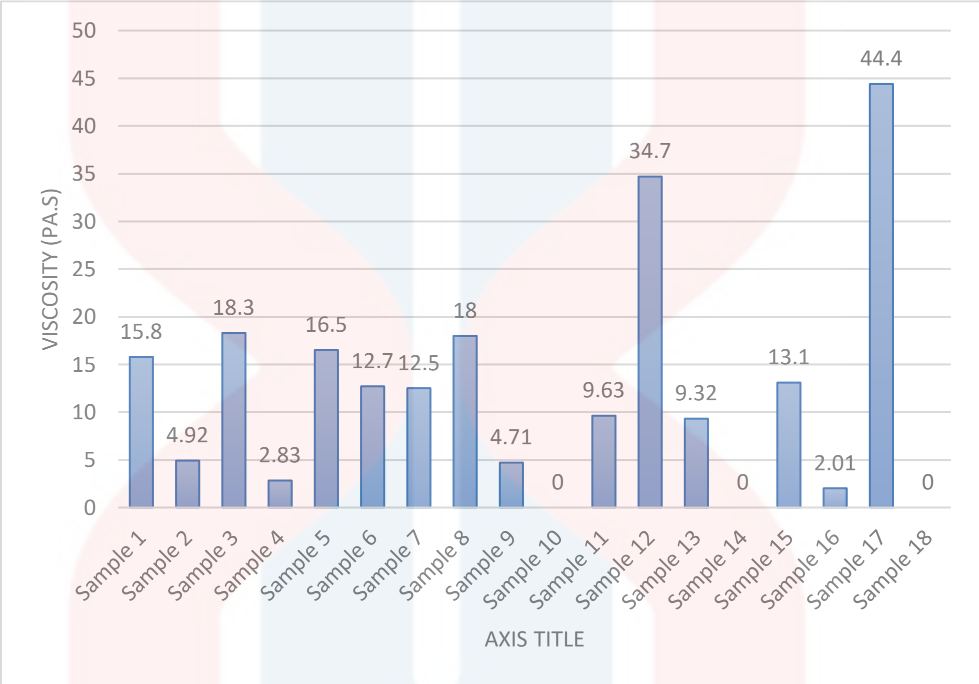

Figure 4.5: Bar graph for viscosity in pascal-second for each sample

The provided graph in Figure 4.6 presents the viscosity of various cream samples, measured in Pascal-seconds (Pa.s), which is a unit for dynamic viscosity. Viscosity is a crucial property in cream formulations as it directly influences the texture, flow, and application characteristics of the product.

In this dataset, there is a wide range of viscosity values across the different cream samples, labeled as Sample 1 to Sample 18. Viscosity is a measure of a fluid's resistance to flow, and higher values indicate thicker or more viscous creams, while lower values suggest thinner or less viscous ones. For instance, Sample 17 has the highest viscosity with a measurement of 44.4 Pa.s. This indicates that Sample 17 is exceptionally thick and resistant to flow, making it a highly viscous cream. Such creams may be suitable for specific applications, such as deep hydration or protective barrier creams.

On the other hand, several samples, including Sample 10, Sample 14, and Sample 18, have a viscosity measurement of 0 Pa.s. A viscosity of 0 indicates a complete absence of resistance to flow, suggesting that these creams are extremely fluid or watery. Such formulations are likely to be lightweight and easy to spread, making them suitable for products like lotions or serums. The remaining samples exhibit varying viscosity values, which can be attributed to differences in formulation and intended use. Creams with moderate viscosity values, such as Sample 1 or Sample 3, strike a balance between thickness and spreadability, offering a pleasant texture for general skincare applications.

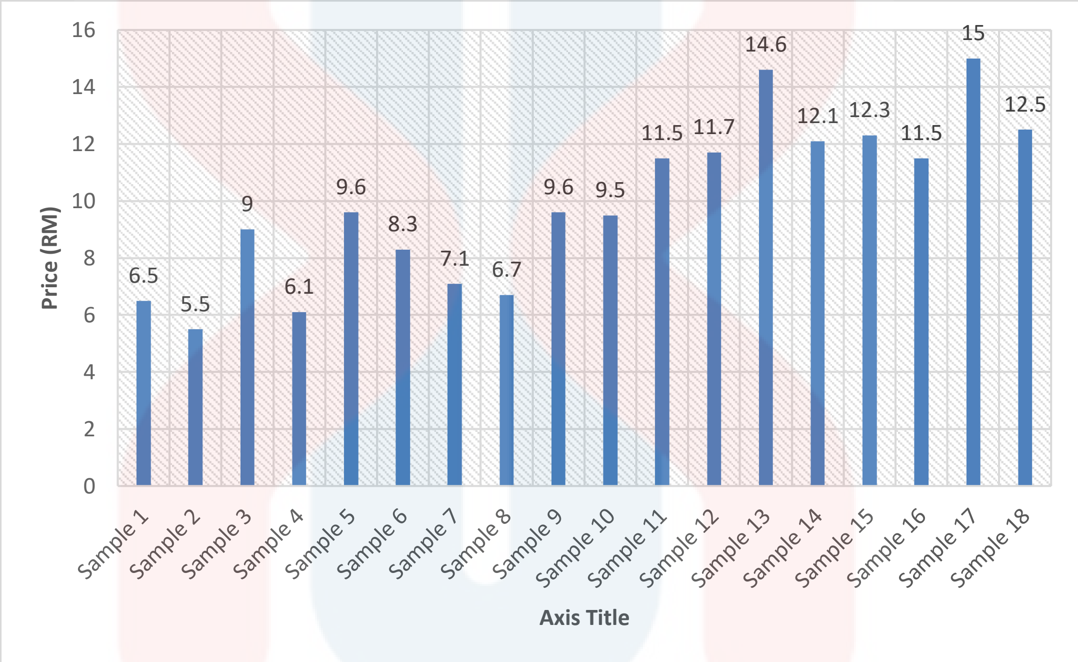

Figure 4.6: Bar graph for the price of each sample in Ringgit

The provided graph in Figure 4.7 represents the price of various cream samples, labeled as Sample 1 to Sample 18. The price reflects the cost of producing each cream formulation based on the price of its ingredients and production processes. Analyzing this data can provide insights into the cost differences among the cream samples, which can be essential for budgeting, pricing, and cost-effectiveness considerations in product development.

Based on this dataset in Figure 4.7, there is a wide range of prices for the different cream samples. Sample 3, with a price of RM 9, stands out as one of a bit more expensive formulation. This suggests that the ingredients used in Sample 3, or possibly the production processes involved, are relatively costly. Creams with a higher price point may contain premium or specialized ingredients, which can justify the increased cost. For this case, sample 3 used Olive oil as its emollient properties which is a little bit pricey.

Conversely, Sample 2 is one of the more affordable options, priced at RM 5.5. This indicates that Sample 2 may use more cost-effective ingredients or production methods, resulting in a lower price point. Such creams may be positioned as budget-friendly options for consumers. Several other samples, such as Sample 10, Sample 11, Sample 13, and Sample 17, have prices exceeding RM 10, suggesting that they are on the higher end of the price spectrum. These creams may offer a different benefit or feature premium ingredients which is it has camphor in its ingredient which can justify their higher cost.

Overall, understanding the cost of each cream based on ingredient prices is crucial for product development and pricing strategy decisions, as it allows manufacturers to align their pricing with market expectations and production costs while meeting consumer demands.

4.2 Taguchi Analysis

The analysis of cream formulation was evaluated using the Taguchi Design of Experiment (DOE) application in Minitab 19. According to the design outline in methodology table 3.1, analysis was executed and the effect on Signal Noise ratio (SN), standard deviation, and the mean level was analyzed through the software

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

Table 4.2: Respond Table for Signal-to-Noise Ratios

Response Table for Signal-to-Noise Ratios

Larger is better

Level	Camphor	Preservative	Alcohol	Water	Oil	Wax
1	14.32	14.19	14.87	15.43	14.28	15.11
2	14.81	13.96	14.89	15.12	15.07	13.19
3		15.54	13.92	13.14	14.34	15.39
Delta	0.49	1.58	0.97	2.30	0.78	2.19
Rank	6	3	4	1	5	2

Table 4.2 shows Signal to Noise Ratio for six ingredients (Camphor, Preservative, Alcohol, Water, Oil, Wax) across three levels, alongside their respective changes (Delta) and rankings based on improvement. The ranking system prioritizes the magnitude of Signal Noise Ratio improvement, with higher Delta values indicating better performance. Water is ranked first with the highest improvement, demonstrating a significant change in SNR with a Delta of 2.30. Despite the overall decrease in its Signal Noise Ratio from an initial 15.43 to a lower value, this large Delta underscores the system's preference for substantial fluctuation, valuing the magnitude of change most highly. Wax follows closely behind, ranked second with a Delta of 2.19. It shows a notable recovery in its Signal Noise Ratio, bouncing back to 15.39 after a drop, which highlights its ability to significantly improve across the levels. Preservative is in third place, with a Delta of 1.58, starting from 14.19 and climbing to a higher Signal-Noise Ratio of 15.54 after a slight decrease. This resilient performance indicates a robust recovery and improvement over time. Alcohol, with a Delta of 0.97, is ranked fourth. Its signal-noise ratio changes from 14.87 to 13.92, reflecting modest overall improvement amidst the fluctuations. Oil, showing a Delta of 0.78, is fifth in the rankings. Its signal-noise ratio moves from 14.28 to 14.34, indicating a slight but stable enhancement in its performance across the levels. Lastly, Camphor, with the smallest improvement and a Delta of 0.49, is ranked sixth showing the least improvement. Starting at 14.32 and moving to 14.81, Camphor demonstrates the least variability and improvement among the substances, with its SNR reflecting minimal change.

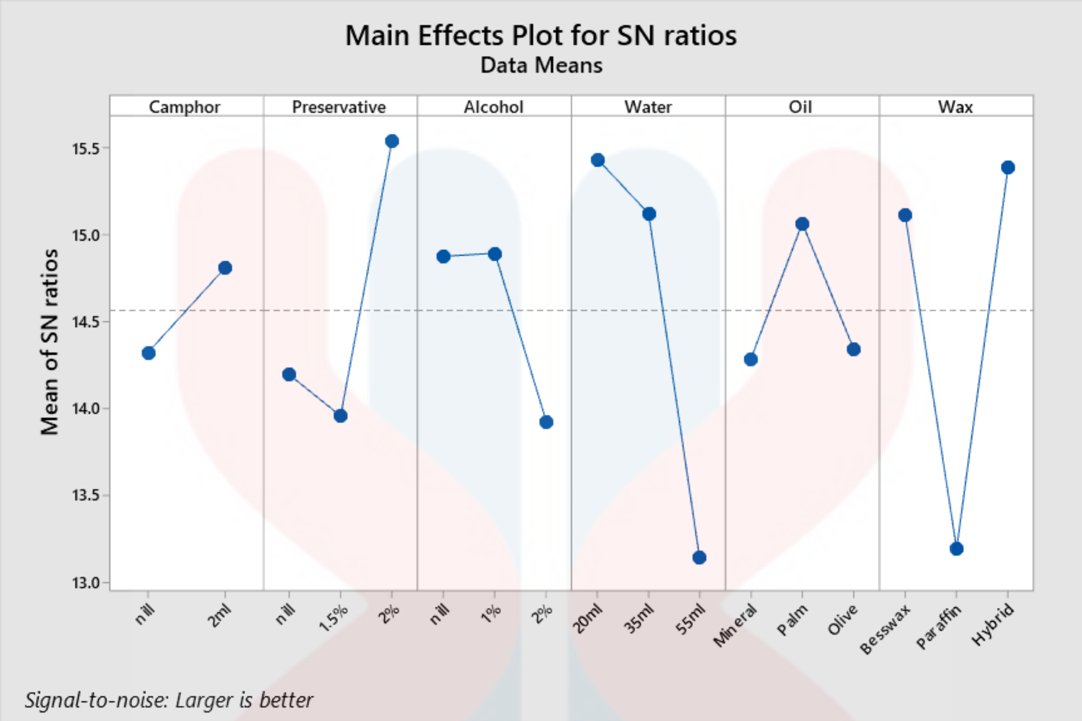

Figure 4.7: Taguchi result on main effects plot for SN ratios with response data in appearance, aroma, texture, and color

The Main Effects Plot for Signal Noise ratios displays the mean Signal Noise ratios for six ingredients—Camphor, Preservative, Alcohol, Water, Oil, and Wax—across different levels. Camphor's signal-noise ratio starts at approximately 14.3 at 0ml of camphor and slightly increases to 14.8 at 2ml of camphor. This shows that 2ml of camphor is preferable. The Preservative has an initial Signal Noise ratio of just under 14.2 at 0% of preservative, dips slightly below 14 at the 1.5% level, and then significantly jumps to above 15.5 at the 2% level. This shows that 2% of preservatives is preferable. Alcohol begins near 14.9 at 0%, holds steady at the 1% level, but then declines to around 13.9 at the 2% level. This shows that 0% and 1% are considered acceptable to create a good quality cream. Water starts with the highest signal-noise ratio of all, over 15.4 at 20ml, drops to about 15.1 at 35ml, and then sharply falls to around 13.1 at 55ml. This shows water is preferable at 20ml. Oil's Signal Noise ratio increases from around 14.3 in mineral oil to just over 15 in palm oil and then marginally decreases to 14.3 again in olive oil. This shows palm oil is the most preferable. Finally, Wax shows a considerable fluctuation, starting at 15.1 at beeswax, plummeting to about 13.2 at paraffin wax, and then recovering to nearly 15.4 at a hybrid of beeswax and paraffin wax. The graph reveals varying patterns of change for each substance, with Water showing the most dramatic overall change, despite a final decrease, and Camphor exhibiting the least variability in Signal Noise ratio. The plotted data suggests that while some substances, like Water and Wax, undergo significant swings in their SN ratios, others like Camphor and Oil display more stability across the levels tested.

Table 4.3: Response Table for Means

Response Table for Means

Level	Camphor	Preservative	Alcohol	Water	Oil	Wax
1	5.422	5.329	5.715	6.075	5.446	5.829
2	5.681	5.160	5.696	5.850	5.769	4.737
3		6.165	5.244	4.729	5.440	6.087
Delta	0.258	1.004	0.471	1.346	0.329	1.350
Rank	6	3	4	2	5	1

Table 4.3 shows the mean values for six ingredients across three levels, with the subsequent Delta indicating the change between the first and last recorded levels, and the Rank reflecting their comparative performance based on these changes. Wax leads the ranking with the highest positive Delta of 1.350, despite its mean dipping from 5.829 to 6.087, indicating a strong finish that renders it the most improved and thus most preferable substance. Water, while starting with the highest initial mean of 6.075, ends with a lower mean of 4.729, yet the substantial Delta of 1.346 secures it the second rank, reflecting a significant degree of change. Preservative follows with a third rank, having a Delta of 1.004, and shows a notable increase in its mean value from 5.329 to 6.165, marking a considerable improvement. Alcohol sees a moderate change with a Delta of 0.471, descending from 5.715 to 5.244, ranking it fourth. Oil has a slight Delta of 0.329, with a small decrease in mean from 5.446 to 5.440, making it the fifth in terms of preference. Lastly, Camphor shows the least change with the smallest Delta of 0.258, moving from 5.422 to 5.681, which places it at the bottom of the ranking. This Delta-based ranking system thus suggests that substances like Wax and Water, which demonstrate the greatest changes in mean values, even if those changes include declines are preferred over those with more stable or minor changes.

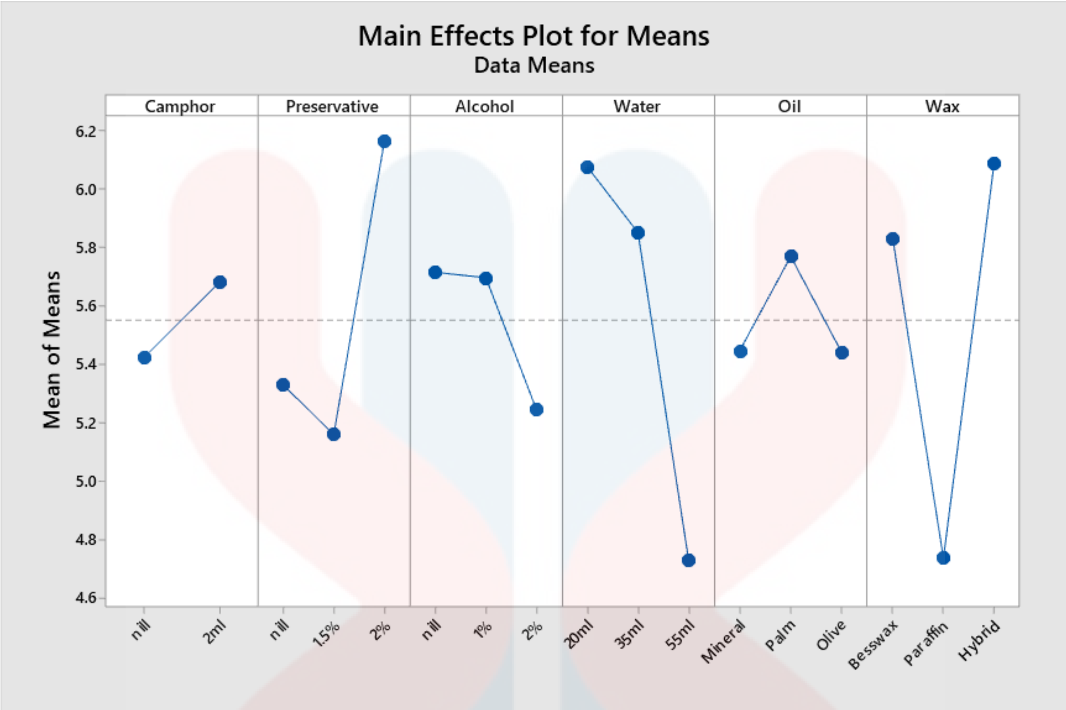

Figure 4.8: Taguchi result on main effects plot for means with response data in appearance, aroma, texture, and color

The main effects plot for means suggests that the level settings for the factors under study have variable impacts on the performance characteristics. For camphor, a rise from 5.4 at nil to 2ml at 5.7 seems to correlate with a general increase in the mean, indicating a potentially positive effect on the quality characteristic of interest. In the case of the preservative, there's a notable decrease when the level changes from 5.3 at nil to 5.1 at 1.5%, followed by a slight increase of 6.2 at 2%. This could suggest an optimal level around the lower concentration for the preservative or a non-linear effect. For alcohol, the stable value at 5.7 at nil and 1% followed by a decrease of 5.2 at 2%. This might indicate that the presence of alcohol at these concentrations negatively impacts the performance characteristic. The water content exhibits a clear downward trend with increasing volume from 20ml to 55ml, suggesting that water has a dilutive or negative effect on the characteristic being measured. Looking at the oils, mineral oil shows a relatively stable mean at 5.5 with a minor peak at Palm with 5.8, while both mineral and olive oils exhibit a considerable same trend. The mean is highest with palm oil and decreases with olive oil, indicating that the type of oil has a significant impact on the outcome. For wax, the plot shows dramatic variability. Paraffin has a less pronounced effect which is 4.7 on the mean compared to beeswax at 5.8 and hybrid at 6.2, which suggests a substantial negative impact. However, the Hybrid wax which stands for a combination of beeswax and paraffin wax shows the highest mean value, which implies a synergistic effect when different waxes are combined, or it might be a special formulation that outperforms the others significantly.

4.2.2 Properties

In the exploration of the development of cream formulations with Agarwood essence using Taguchi method, the main properties play an important role in determining the overall quality and effectiveness of the product. This discussion dive into the three properties which are Moisture content, Viscosity, and Microbe which have been carefully evaluated in this part.

Table 4.4: Response Table for Signal-to-Noise Ratios

Response Table for Signal-to-Noise Ratios

Larger is better

Level	Camphor	Preservative	Alcohol	Water	Oil	Wax
1	8.971	9.426	7.655	9.404	8.063	9.679
2	8.002	8.353	8.455	9.134	7.963	5.965
3		7.681	9.350	6.922	9.434	9.816
Delta	0.969	1.745	1.695	2.481	1.471	3.851
Rank	6	3	4	2	5	1

Table 4.4 shows Signal Noise Ratios for six different ingredients across three levels, with the aim being to achieve higher SNR values. The table includes the change in Signal to Noise Ratio, referred to as Delta, and a corresponding rank that assesses each ingredient's improvement over the levels. Wax stands out with the most considerable overall increase in Signal Noise Ratio, presenting a Delta of 3.851, moving from a Signal Noise Ratio of 9.679 down to 5.965 before a significant climb to 9.816. This substantial improvement places Wax as the first in the rank, indicating it as the most preferable choice in terms of signal-noise ratio improvement. Water is next, showing the second-highest Delta of 2.481. Starting with a Signal Noise Ratio of 9.404, it decreases slightly to 9.134 and then falls more sharply to 6.922. Despite this decrease, the large Delta signifies a high level of change, earning Water the second rank. Preservative follows with a third rank, having a Delta of 1.745. Its signal-noise ratio declines from 9.426 to 7.681, which, while a decrease, still reflects a notable change in performance.

Alcohol sees a close Delta to Preservative at 1.695, climbing from 7.655 to 9.350, and is ranked fourth, suggesting a robust improvement despite its lower starting point compared to others. Oil has a Delta of 1.471, with a small dip in Signal to Noise Ratio from 8.063 to 9.434, positioning it fifth in the ranking order. Camphor exhibits the least improvement, with a Delta of 0.969, dropping from 8.971 to 7.681, which ranks it last among the substances. Therefore, the Delta values indicate how much each ingredient's Signal Noise Ratio has changed over the levels, and the ranking reflects their relative improvement, with higher Delta values being preferable. Wax, with the highest Delta, is considered the best performer in terms of SNR improvement, despite the fluctuating values, while Camphor, with the smallest Delta, is deemed the least improved.

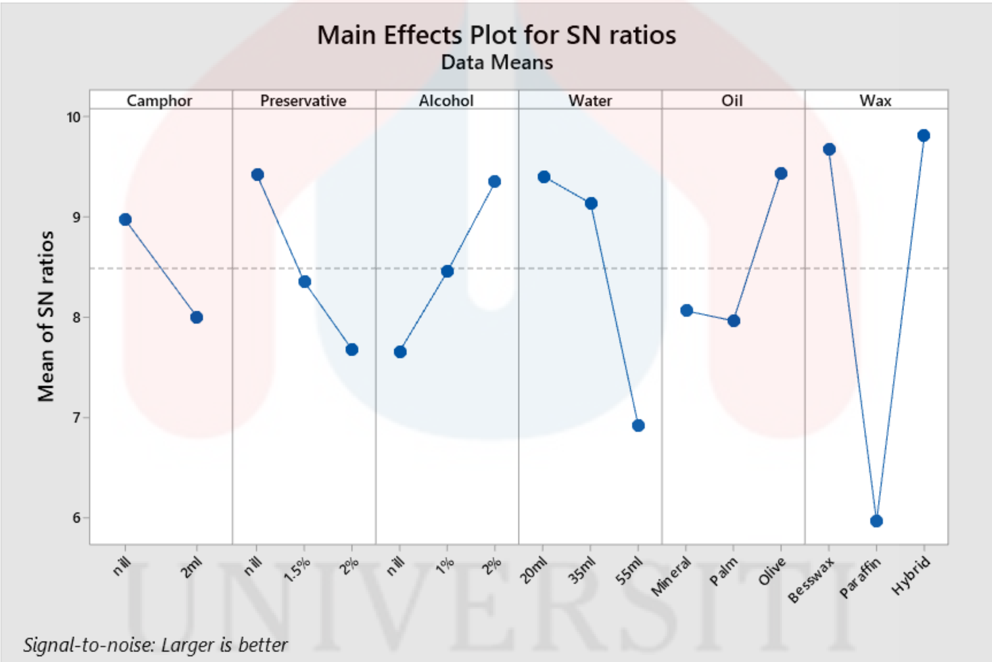

Figure 4.9: Taguchi result on main effects plot for SN ratios with response data in Moisture content, Viscosity, and Microbe

Camphor's signal-noise ratio starts around 9 at 0ml of camphor and decreases over the levels to just above 7 at 2ml of camphor, suggesting a decline in performance. Preservative begins above 9 at 0%, drop to approximately 8.5 at 1.5%, and then fall further to below 7.5 at 2%, which also indicates a downward trend. Alcohol's mean Signal Noise ratio begins just below 8 at 0%, rises to around 9 at 1%, and then rises to 9.2 at 2%. Water starts just below 10 at 20ml, decreases slightly to around 9 at 35ml, and then drops more significantly to just above 6 at 55ml, reflecting the largest overall decrease among the substances. Oil's Signal Noise ratio shows a drop from above 8 to just below 8 at mineral oil and palm oil and then a slight increase to above 9 at olive oil, displaying a dip before improving. Finally, Wax exhibits the most dramatic changes, starting near 10 at beeswax, plummeting to below 6 at paraffin wax, and then surging to just below 10 with the combination of beeswax and paraffin wax, which suggests a substantial recovery.

Table 4.5: Response Table for Means

Response Table for Means

Level	Camphor	Preservative	Alcohol	Water	Oil	Wax
1	11.99	14.97	10.13	13.47	14.86	17.19
2	17.28	10.89	18.15	14.91	12.79	13.77
3		18.04	15.63	15.52	16.25	12.94
Delta	5.29	7.15	8.02	2.05	3.46	4.25
Rank	3	2	1	6	5	4

The Response Table for Means in Table 4.5 reflects the changes in mean values for six ingredients over three levels, with a preference for higher values. Alcohol emerges as the standout performer, boasting the largest Delta of 8.02, escalating from a mean of 10.13 to 15.63, and thereby earning the first rank. Such a significant increase makes it the most preferable substance in terms of mean value enhancement. Preservative also displays a remarkable turnaround, despite an initial decline from 14.97 to 10.89, it recovers to reach 18.04, resulting in a Delta of 7.15 and a second-place rank. Camphor, too, shows a solid increase with a Delta of 5.29, climbing from 11.99 to 17.28, securing the third rank. In contrast, Wax, starting with the highest initial mean of 17.19 but falling to 13.77 and slightly rising to 12.94, achieves a Delta of 4.25 and a fourth rank, reflecting a less consistent performance. Oil, with a Delta of 3.46, fluctuates from 14.86 down to 12.79 and up again to 16.25, and is placed fifth in the ranking. Lastly, Water, with the smallest Delta of 2.05, shows a steady increase from 13.47 to 15.52, which, while positive, is modest compared to the others, thus Water is deemed the least preferable, positioned at rank six. Overall, the ranking illustrates a clear preference for substances that demonstrate significant increases in their mean values, indicative of their enhanced performance over the levels tested.

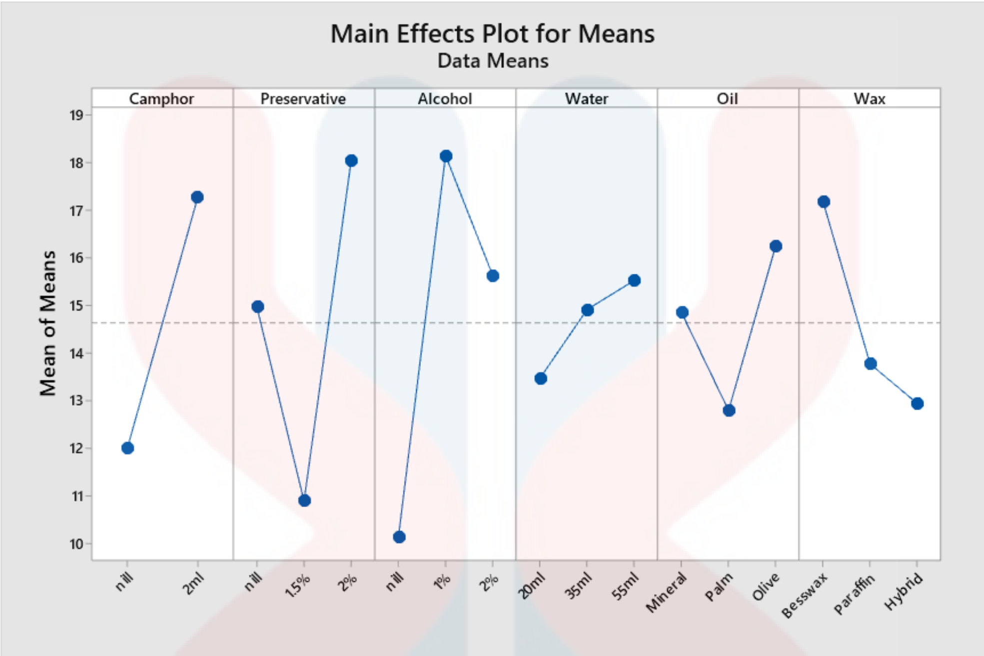

Figure 4.10: Taguchi result on main effects plot for means with response data in Moisture content, Viscosity, and Microbe

In the provided Taguchi design analysis, the properties of cream are moisture content, viscosity, and microbial testing are evaluated to understand the impact of various ingredients. The main effects plot for means and the plot for signal-to-noise (S/N) ratios inform us of how each ingredient influences these properties. The main effects plot for means indicates that camphor significantly enhances the desired properties at a concentration of 2ml with a value of 17.3. This suggests that camphor might be contributing to an optimal moisture balance, improving viscosity, or even possessing antimicrobial properties that benefit the cream's overall quality. Preservatives show a peak in the desired properties at 2% with a value of 18, but before that, it has a lower value of 1.5% at 11 as it indicates the concentration for preserving cream properties has negative side effects. Alcohol presents a complex interaction. Initially, it appears to enhance the properties at 1% with a value of 18 but then degrades them at 2% at 15.5. This could be due to alcohol's dual role as a solvent affecting viscosity and as an antimicrobial agent. Water, unexpectedly, slightly enhances these properties across all volumes, likely diluting the cream and affecting both moisture content and viscosity positively. The type of oil used exhibits diverse effects. Mineral oil maintains a neutral impact with a value of 15, while palm oil negatively influences the properties with a value of 12.5, and olive oil positively affects them at 16.5. Olive oil's beneficial effects may be due to its fatty acid composition, which could enhance moisture retention and contribute positively to the microbial stability of the cream. The wax components show the most significant variability. Paraffin wax drastically reduces the properties marginally, possibly due to its occlusive nature affecting moisture content and viscosity adversely. The hybrid wax, however, also leads to decreasing polar suggesting a synergistic effect of the combined waxes on the cream's moisture, viscosity, and microbial stability.

4.3 Regression

4.3.1 Hedonic output

Table 4.6: Table of Regression equation under Hedonic output

Continuous predictor	Responses	Regression equation
• Camphor • Preservative • Alcohol • Water	Appear	Appear = 6.73 + 0.164 Camphor + 0.331 Preservative – 0.092 Alcohol – 0.0476 Water
	Aroma	Aroma = 6.167 + 0.217 Camphor + 0.399 Preservative – 0.308 Alcohol – 0.0314 Water
	Texture	Texture = 6.883 + 0.200 Camphor + 0.328 Preservative – 0.354 Alcohol – 0.0461 Water
	Color	Color = 7.252 – 0.064 Camphor + 0.124 Preservative – 0.188 Alcohol – 0.0325 Water
• Camphor • Preservative • Alcohol • Mineral oil • Water	Appear	Appear = 6.95 + 0.164 Camphor + 0.331 Preservative – 0.092 Alcohol – 0.0133 Mineral - 0.0476 Water
	Aroma	Aroma = 6.157 + 0.217 Camphor + 0.399 Preservative – 0.308 Alcohol + 0.00060 Mineral - 0.0314 Water
	Texture	Texture = 6.93 + 0.200 Camphor + 0.328 Preservative – 0.354 Alcohol – 0.0027 Mineral - 0.0461 Water
	Color	Color = 7.211 – 0.064 Camphor + 0.124 Preservative – 0.188 Alcohol + 0.0025 Mineral - 0.0325 Water

• Camphor • Preservative • Alcohol • Olive oil • Water	Appear	Appear = 6.72 + 0.164 Camphor + 0.331 Preservative – 0.092 Alcohol + 0.0005 Olive - 0.0476 Water
	Aroma	Aroma = 6.265 + 0.217 Camphor + 0.399 Preservative – 0.308 Alcohol – 0.00604 Olive - 0.0314 Water
	Texture	Texture = 7.01 + 0.200 Camphor + 0.328 Preservative – 0.354 Alcohol – 0.0081 Olive - 0.0461 Water
	Color	Color = 7.253 – 0.064 Camphor + 0.124 Preservative – 0.188 Alcohol – 0.0001 Olive - 0.0325 Water
• Camphor • Preservative • Alcohol • Palm oil • Water	Appear	Appear = 6.52 + 0.164 Camphor + 0.331 Preservative – 0.092 Alcohol + 0.0128 Palm - 0.0476 Water
	Aroma	Aroma = 6.078 + 0.217 Camphor + 0.399 Preservative – 0.308 Alcohol + 0.00544 Palm - 0.0314 Water
	Texture	Texture = 6.71 + 0.200 Camphor + 0.328 Preservative – 0.354 Alcohol + 0.0108 Palm - 0.0461 Water
	Color	Color = 7.290 – 0.064 Camphor + 0.124 Preservative – 0.188 Alcohol – 0.0024 Palm - 0.0325 Water
• Camphor • Preservative • Alcohol • Beeswax	Appear	Appear = 6.08 + 0.164 Camphor + 0.331 Preservative – 0.092 Alcohol + 0.1625 Beeswax - 0.0476 Water
	Aroma	Aroma = 5.675 + 0.217 Camphor + 0.399 Preservative – 0.308 Alcohol + 0.1229 Beeswax - 0.0314 Water

• Water	Texture	Texture = 6.42 + 0.200 Camphor + 0.328 Preservative – 0.354 Alcohol + 0.1156 Beeswax - 0.0461 Water
	Color	Color = 6.672 – 0.064 Camphor + 0.124 Preservative – 0.188 Alcohol + 0.1448 Beeswax - 0.0325 Water
• Camphor • Preservative • Alcohol • Paraffin wax • Water	Appear	Appear = 7.38 + 0.164 Camphor + 0.331 Preservative – 0.092 Alcohol – 0.1625 Paraffin - 0.0476 Water
	Aroma	Aroma = 6.658 + 0.217 Camphor + 0.399 Preservative – 0.308 Alcohol – 0.1229 Paraffin - 0.0314 Water
	Texture	Texture = 7.35 + 0.200 Camphor + 0.328 Preservative – 0.354 Alcohol – 0.1156 Paraffin - 0.0461 Water
	Color	Color = 7.831 – 0.064 Camphor + 0.124 Preservative – 0.188 Alcohol – 0.1448 Paraffin - 0.0325 Water
• Camphor • Preservative • Alcohol • Hybrid • Water	Appear	Appear = 6.52 + 0.164 Camphor + 0.331 Preservative – 0.092 Alcohol + 0.0781 Hybrid - 0.0476 Water
	Aroma	Aroma = 5.961 + 0.217 Camphor + 0.399 Preservative – 0.308 Alcohol + 0.0771 Hybrid - 0.0314 Water
	Texture	Texture = 6.532 + 0.200 Camphor + 0.328 Preservative – 0.354 Alcohol + 0.1318 Hybrid - 0.0461 Water
	Color	Color = 6.945 – 0.064 Camphor + 0.124 Preservative – 0.188 Alcohol + 0.1151 Hybrid - 0.0325 Water

For Appearance, Camphor and Preservative consistently have a positive effect across all equations, improving the appearance by 0.164 and 0.331 units, respectively. Alcohol has a negative impact, decreasing appearance by 0.092 units, and Water slightly decreases it by 0.0476 units. The addition of oils or waxes alters this pattern slightly; for instance, Beeswax significantly improves appearance by 0.1625 units, while Paraffin wax has a substantial negative effect, decreasing appearance by the same amount.

Next is aroma. Aroma is positively influenced by Camphor and Preservative with every unit increase in Camphor, enhancing the aroma by 0.217 units, and Preservative by 0.399 units. Alcohol reduces the aroma quality by 0.308 units. Water has a minor negative effect, slightly decreasing the aroma by 0.0314 units. Beeswax has a notably positive effect on aroma by 0.1229 units, while Paraffin negatively impacts it by a similar magnitude.

Third, texture. The texture is improved by Camphor and Preservative by 0.200 and 0.328 units, respectively, but is worsened by Alcohol by 0.354 units. Water also slightly decreases texture quality by 0.0461 units. The effect of oils and waxes varies, with Beeswax enhancing texture by 0.1156 units and Paraffin wax reducing it by the same amount.

The effect of the predictors on Color shows that Preservative has a small positive effect, increasing the color quality by 0.124 units. In contrast, Camphor slightly decreases color quality by 0.064 units, and Alcohol has a more substantial negative effect, reducing it by 0.188 units. Water also decreases color quality by 0.0325 units. Beeswax and Paraffin wax, similar to their effects on texture and aroma, have opposite impacts on color, with Beeswax improving it by 0.1448 units and Paraffin decreasing it by the same amount.

In summary, Camphor and Preservatives are generally positive for hedonic qualities, with Preservatives being particularly beneficial for Aroma. Alcohol typically hurts these properties, and Water's effect is consistently slight but negative. The type of oil or wax used can significantly alter the hedonic outcomes, with Beeswax generally having a positive impact and Paraffin wax a negative one. These insights from the regression equations can guide cosmetic formulators in selecting and balancing ingredients to optimize the sensory attributes of their products.

4.3.2 Properties

Table 4.7: Table of Regression equation under Properties

Continuous predictor	Responses	Regression equation
• Camphor • Preservative • Alcohol • Water	pH	pH = 7.746 + 0.1111 Camphor - 0.1282 Preservative + 0.0000 Alcohol + 0.00495 Water
	Viscosity	Viscosity = 16.0 + 0.55 Camphor – 0.85 Preservative + 3.42 Alcohol – 0.180 Water
	Microbe	Microbe = 1.816 + 0.1111 Camphor – 0.0897 Preservative + 0.0833 Alcohol – 0.00045 Water
	Moisture	Moisture = 1.7 + 7.28 Camphor + 2.62 Preservative + 4.74 Alcohol + 0.352 Water
	Price	Price = 6.70 + 2.350 Camphor + 0.796 Preservative + 0.675 Alcohol - 0.0193 Water
• Camphor • Preservative • Alcohol • Mineral oil • Water	pH	pH = 7.773 + 0.1111 Camphor - 0.1282 Preservative - 0.0000 Alcohol - 0.00170 Mineral + 0.00495 Water
	Viscosity	Viscosity = 18.2 + 0.38 Camphor – 0.85 Preservative + 3.42 Alcohol – 0.115 Mineral - 0.190 Water
	Microbe	Microbe = 1.660 + 0.0000 Camphor + 0.064 Preservative + 0.000 Alcohol – 0.00170 Mineral + 0.00495 Water
	Moisture	Moisture Content = -0.4 + 7.28 Camphor + 2.62 Preservative + 4.74 Alcohol + 0.127 Mineral + 0.352 Water
	Price	Price = 6.85 + 2.350 Camphor + 0.796 Preservative + 0.675 Alcohol - 0.0087 Mineral - 0.0193 Water

	pH	pH = 7.773 + 0.1111 Camphor - 0.1282 Preservative - 0.0000 Alcohol - 0.00170 Olive + 0.00495 Water
	Viscosity	Viscosity = 14.7 + 0.38 Camphor – 0.85 Preservative + 3.42 Alcohol + 0.103 Olive - 0.190 Water
• Camphor • Preservative • Alcohol • Olive oil • Water	Microbe	Microbe = 1.660 + 0.0000 Camphor + 0.064 Preservative + 0.000 Alcohol – 0.00170 Olive + 0.00495 Water
	Moisture	Moisture Content = 1.0 + 7.28 Camphor + 2.62 Preservative + 4.74 Alcohol + 0.043 Olive + 0.352 Water
	Price	Price = 6.071 + 2.350 Camphor + 0.796 Preservative + 0.675 Alcohol + 0.0388 Olive - 0.0193 Water
	pH	pH = 7.690 + 0.1111 Camphor - 0.1282 Preservative - 0.0000 Alcohol + 0.00340 Palm + 0.00495 Water
	Viscosity	Viscosity = 16.1 + 0.38 Camphor – 0.85 Preservative + 3.42 Alcohol + 0.012 Palm – 0.190 Water
• Camphor • Preservative • Alcohol • Palm oil • Water	Microbe	Microbe = 1.577 + 0.0000 Camphor + 0.0641 Preservative + 0.000 Alcohol + 0.00340 Palm + 0.00495 Water
	Moisture	Moisture Content = 4.4 + 7.28 Camphor + 2.62 Preservative + 4.74 Alcohol - 0.169 Palm + 0.352 Water
	Price	Price = 7.20 + 2.350 Camphor + 0.796 Preservative + 0.675 Alcohol - 0.0301 Palm - 0.0193 Water
	pH	pH = 7.662 + 0.1111 Camphor - 0.1282 Preservative + 0.0000 Alcohol + 0.0208 Beeswax + 0.00495 Water

	Viscosity	Viscosity = 6.14 + 0.38 Camphor – 0.85 Preservative + 3.42 Alcohol + 2.551 Beeswax - 0.190 Water
• Camphor • Preservative • Alcohol • Beeswax • Water	Microbe	Microbe = 1.948 + 0.0000 Camphor + 0.0641 Preservative – 0.083 Alcohol – 0.0208 Beeswax + 0.00090 Water
	Moisture	Moisture Content = 6.5 + 7.28 Camphor + 2.62 Preservative + 4.74 Alcohol - 1.21 Beeswax + 0.352 Water
	Price	Price = 6.08 + 2.350 Camphor + 0.796 Preservative + 0.675 Alcohol + 0.1563 Beeswax - 0.0193 Water
	pH	pH = 7.829 + 0.1111 Camphor - 0.1282 Preservative + 0.0000 Alcohol - 0.0208 Paraffin + 0.00495 Water
	Viscosity	Viscosity = 26.55 + 0.38 Camphor – 0.85 Preservative + 3.42 Alcohol – 2.551 Paraffin - 0.190 Water
• Camphor • Preservative • Alcohol • Paraffin wax • Water	Microbe	Microbe = 1.781 + 0.0000 Camphor + 0.0641 Preservative – 0.083 Alcohol + 0.0208 Paraffin + 0.00090 Water
	Moisture	Moisture Content = -3.2 + 7.28 Camphor + 2.62 Preservative + 4.74 Alcohol + 1.21 Paraffin + 0.352 Water
	Price	Price = 7.33 + 2.350 Camphor + 0.796 Preservative + 0.675 Alcohol - 0.1563 Paraffin - 0.0193 Water
	pH	pH = 7.773 + 0.1111 Camphor - 0.1282 Preservative + 0.0000 Alcohol - 0.0104 Hybrid + 0.00495 Water
	Viscosity	Viscosity = 16.4 + 0.38 Camphor – 0.85 Preservative + 3.42 Alcohol – 0.034 Hybrid - 0.190 Water

• Camphor • Preservative • Alcohol • Hybrid • Water	Microbe	Microbe = 1.892 + 0.0000 Camphor + 0.064 Preservative – 0.083 Alcohol – 0.0104 Hybrid + 0.00090 Water
	Moisture	Moisture Content = 4.1 + 7.28 Camphor + 2.62 Preservative + 4.74 Alcohol - 0.91 Hybrid + 0.352 Water
	Price	Price = 6.60 + 2.350 Camphor + 0.796 Preservative + 0.675 Alcohol + 0.0406 Hybrid - 0.0193 Water

Table 4.6 shows a series of regression equations that model the relationship between a set of continuous predictors (Camphor, Preservative, Alcohol, various oils or waxes, and Water) and different responses (pH, Viscosity, Microbe count, Moisture content, and Price). Each predictor's coefficient represents its estimated effect on the response variable, holding all other variables constant.

For pH, the regression equation indicates that Camphor increases pH by 0.1111 units per unit increase in Camphor, whereas Preservative decreases it by 0.1282 units. Alcohol does not affect pH, while Water increases it by 0.00495 units. The coefficients for oils and waxes vary, with Mineral oil and Olive oil slightly reducing pH, Palm oil slightly increasing it, Beeswax significantly increasing it by 0.0208 units, Paraffin wax reducing it, and Hybrid oil slightly reducing it by 0.0104 units.

In the context of Viscosity, each unit increase in Camphor increases viscosity by 0.55 units, while Preservative decreases it by 0.85 units. Alcohol has a substantial positive effect, increasing viscosity by 3.42 units. Water reduces viscosity by 0.180 units. Different oils and waxes have diverse impacts: Mineral oil and Olive oil have a slight negative effect, Palm oil has a negligible positive effect, Beeswax significantly increases viscosity by 2.551 units, Paraffin significantly decreases it, and Hybrid oil has a slight negative effect.

For Microbe count, Camphor and Preservatives typically have a small positive effect, increasing microbe count by 0.1111 and 0.0641 units, respectively. Alcohol's effect varies, with no impact in most equations but a negative impact in some, especially when combined with Beeswax or Paraffin. Water consistently increases microbe count by 0.00495 units. The impact of oils and waxes is mixed, with some reducing and others increasing the microbe count.

Regarding Moisture content, Camphor has the most significant positive effect, increasing moisture by 7.28 units. Preservatives and Alcohol also increase moisture by 2.62 and 4.74 units, respectively. Water increases moisture by 0.352 units. The effect of oils and waxes on moisture content is variable, with most increasing it, except Beeswax and Paraffin, which decrease it.

Finally, for Price, Camphor adds 2.350 units to the price per unit increase. Preservatives and Alcohol increase the price by 0.796 and 0.675 units, respectively. Water decreases the price by 0.0193 units. The oils and waxes have varied impacts on price, with Mineral oil slightly decreasing it, Olive oil slightly increasing it, Palm oil decreasing it more noticeably, Beeswax increasing it by 0.1563 units, Paraffin decreasing it, and Hybrid oil having a negligible positive effect.

These coefficients give a clear indication of the direction and magnitude of each predictor's impact on the responses. In conclusion, for formulating a product that aims to increase its pH, Camphor and Water are needed in relatively high amounts but the amount of Preservative needs to be reduced. If the goal is to raise the viscosity, the amounts of Camphor need to be added, The same goes for Alcohol, and perhaps include Beeswax, while minimizing Preservatives and Water. The detailed coefficients provide a nuanced understanding of each ingredient's role, which can be critical for product formulation and achieving specific property targets.

CHAPTER 5

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The purpose of this thesis was to develop an optimal cream formulation incorporating Agarwood essence, utilizing the Taguchi method for design and analysis. The research objectives included applying the Taguchi method to streamline the formulation process and examining the cream's properties such as appearance, texture, aroma, and color. Consumer satisfaction was also assessed with the final product. This study aimed to blend scientific rigor with consumer preferences to create a high-quality, naturally derived cosmetic product.

The study's key findings highlighted the effective use of the Taguchi method in developing a premium cream with Agarwood essence. This method optimized the formulation process, ensuring a blend of ingredients that maximized quality and consumer appeal. The cream, characterized by its appealing texture, stability, and ideal moisture content, stood out in terms of both physical properties and user satisfaction. These results not only demonstrate the Taguchi method's applicability in cosmetic science but also showcase the potential of Agarwood essence as a key ingredient in skincare products. Furthermore, this study provided valuable insights into the interactions between various components, offering a template for future product development in the natural cosmetics sector. This work underscores the balance between scientific approach and consumer needs, paving the way for innovative, natural, and effective skincare solutions.

The best formulation based on this study is Sample 7. Based on previous study, the best moisture content is between 50 to 80, the best level of viscosity is 3 to 15 and the best pH is 6. Based on this finding, sample 7 is the most optimum. The implications of this study's findings extend significantly within the cosmetic science field, emphasizing the innovative integration of traditional and modern methodologies. The successful application of the Taguchi method in developing a cream with Agarwood essence represents a stride forward in precision and efficiency in cosmetic formulation. This approach could revolutionize product development strategies, fostering a more systematic and data-driven process in creating high-quality, consumer-focused products. This research could thus inspire a new wave of product innovation, blending ancient wisdom with modern science, and catalyzing a shift in industry paradigms towards more systematic data structure.

While this study made significant strides in cream formulation using Agarwood essence, it is not without limitations. One key limitation was the scope of variability in raw material quality, which might affect the reproducibility of the cream's properties. Additionally, long-term stability and efficacy studies were beyond the scope of this study, presenting avenues for future exploration. Future studies could expand on these findings by examining the long-term effects of the cream on skin health, exploring alternative natural essences, and potentially scaling up production for broader market testing.

In conclusion, this thesis marks a significant contribution to the field of cosmetic science, blending innovative methodology with ingredient exploration. The successful formulation of a cream with Agarwood essence using the Taguchi method not only demonstrates a novel approach to product development but also underscores the potential of a variety of ingredients in enhancing cosmetic products. This research bridges the gap between traditional cosmetic methods and modern scientific methods, offering a sustainable path for future cosmetic innovations

5.2 Recommendations

In light of the findings and experiences gained from this study, I recommend future research in cosmetic science, particularly with natural ingredients like Agarwood, to focus on diversifying natural essences and ingredients to explore their unique benefits and sustainability in cosmetic formulations. Emphasis should also be placed on advanced stability and efficacy studies to ensure product quality and effectiveness over time. Understanding consumer preferences through comprehensive studies is crucial for developing targeted and effective products. Adopting eco-friendly production techniques is vital in aligning with global sustainability trends and improving the cosmetic industry's ecological footprint. Exploring scalability and conducting market analyses will help understand the commercial viability of products developed using natural ingredients. Interdisciplinary collaboration across fields such as botany, chemistry, and dermatology is essential for enriching research and innovation. It's also important to stay updated on regulatory changes and ethical considerations in using natural resources, ensuring compliance and sustainability. Finally, integrating emerging technologies like artificial intelligence and big data analytics could optimize formulations and predict consumer trends, further advancing the natural cosmetics sector.

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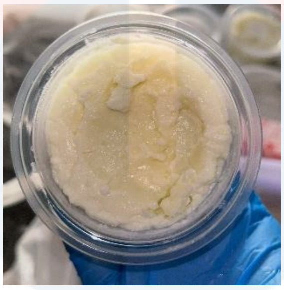
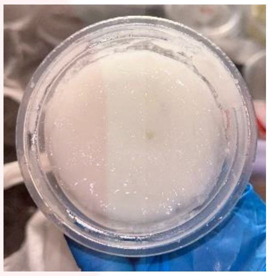
APPENDIX A

		
Sample 1	Sample 2	Sample 3
		
Sample 4	Sample 5	Sample 6
		
Sample 7	Sample 8	Sample 9

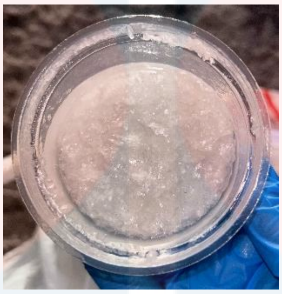
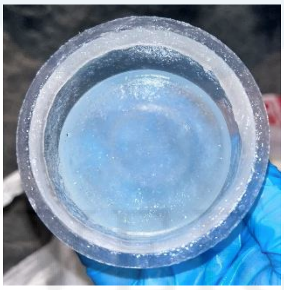
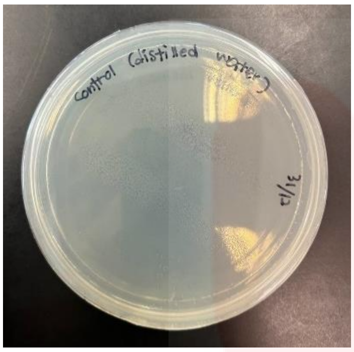
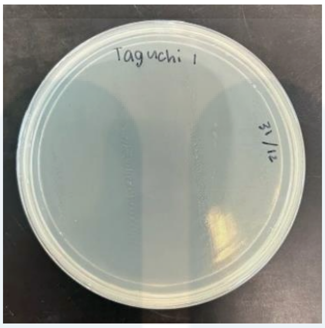
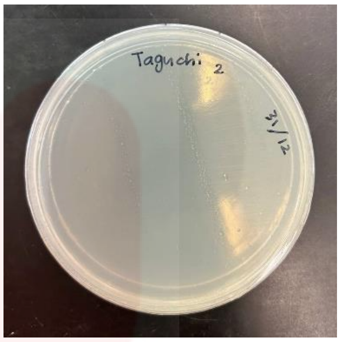
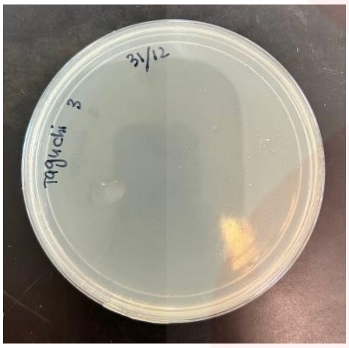
		
Sample 10	Sample 11	Sample 12
		
Sample 13	Sample 14	Sample 15
		
Sample 16	Sample 17	Sample 18

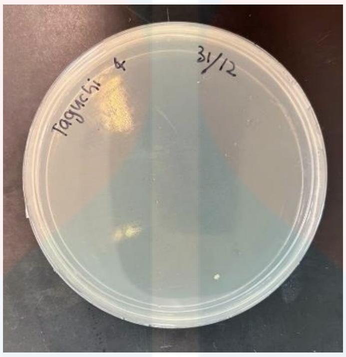
Figure 1. The list of cream sample

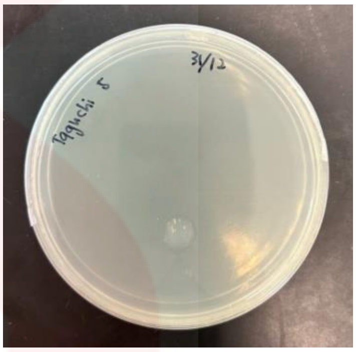

control (distilled water)
31/12

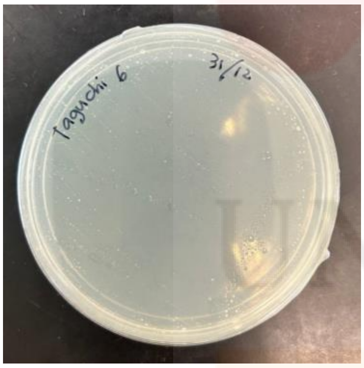

Taguchi 1
31/12

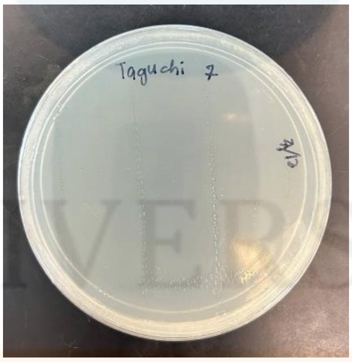

Taguchi 2
31/12


Taguchi 3
31/12

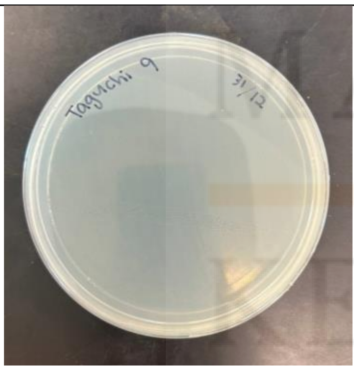

Taguchi 4
31/12

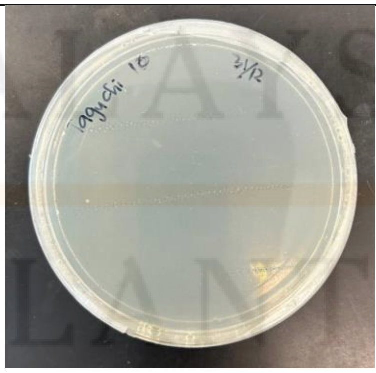

Taguchi 5
31/12

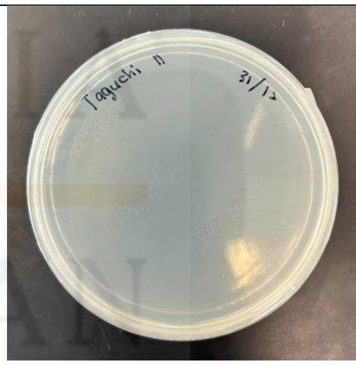

Taguchi 6
31/12


Taguchi 7


Taguchi 8
31/12


Taguchi 9
31/12


31/12


Taguchi 11

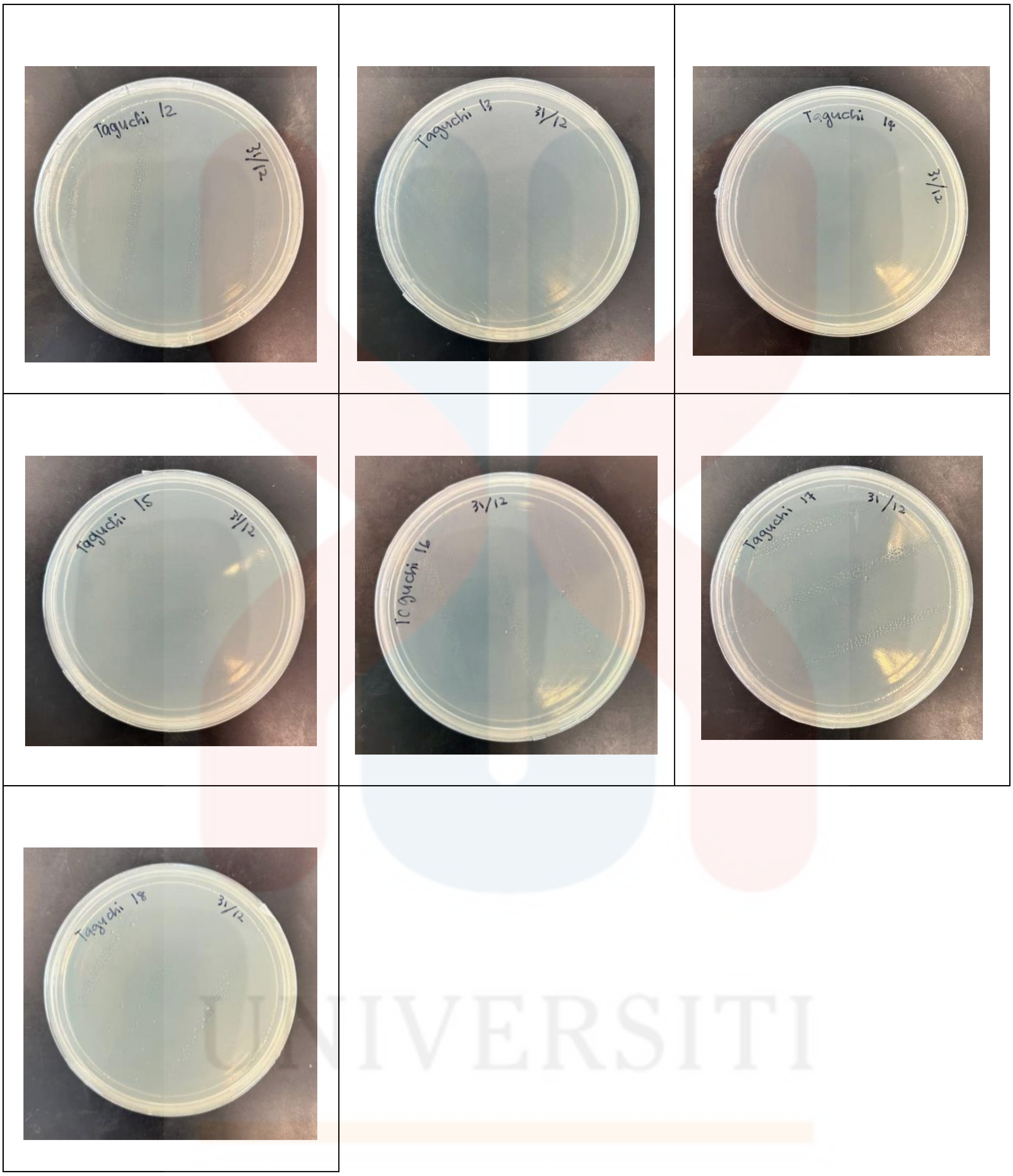


Figure 2. One of the batches from the microbial test

Figure 3. Advance moisture analyzer that used to calculate moisture content in cream

Figure 4. Vibro viscometer used to calculate viscosity of cream

APPENDIX B

Table 1. The pH of each cream on day 1 and day 14

Cream	Before	After 2 weeks
Taguchi 1	pH 8	pH 8
Taguchi 2	pH 9	pH 8
Taguchi 3	pH 8	pH 8
Taguchi 4	pH 7	pH 8
Taguchi 5	pH 8	pH 8
Taguchi 6	pH 8	pH 8
Taguchi 7	pH 6	pH 7
Taguchi 8	pH 8	pH 8
Taguchi 9	pH 7	pH 7
Taguchi 10	pH 8	pH 8
Taguchi 11	pH 8	pH 8
Taguchi 12	pH 8	pH 8
Taguchi 13	pH 7	pH 8
Taguchi 14	pH 8	pH 8
Taguchi 15	pH 8	pH 8
Taguchi 16	pH 7	pH 8
Taguchi 17	pH 7	pH 8
Taguchi 18	pH 6	pH 8

Table 2. The Moisture content of each cream and the time taken

Cream	% Of Moisture Content (%MC)	Time (min)
Taguchi 1	12.01	5.42
Taguchi 2	30.83	4.59
Taguchi 3	37.48	8.13
Taguchi 4	13.18	14.27
Taguchi 5	20.91	10.03
Taguchi 6	23.52	6.20
Taguchi 7	2.79	1.43
Taguchi 8	39.60	7.27
Taguchi 9	21.11	10.00
Taguchi 10	34.34	6.29
Taguchi 11	42.48	7.59
Taguchi 12	15.88	6.21
Taguchi 13	25.80	9.01
Taguchi 14	40.70	6.23
Taguchi 15	5.51	3.01
Taguchi 16	39.75	2.40
Taguchi 17	46.67	8.16
Taguchi 18	81.27	24.48

Table 3. The Viscosity of each cream and the temperature

Cream	Temperature (̊C)	Viscosity (Pa.s)
Taguchi 1	27.4	15.8
Taguchi 2	27.6	4.92
Taguchi 3	27.6	18.3
Taguchi 4	27.6	2.83
Taguchi 5	27.5	16.5
Taguchi 6	27.2	12.7
Taguchi 7	27.3	12.5
Taguchi 8	26.6	18.0
Taguchi 9	27.3	4.71
Taguchi 10	27.2	-
Taguchi 11	27.0	9.63
Taguchi 12	27.2	34.7
Taguchi 13	26.9	9.32
Taguchi 14	27.2	-
Taguchi 15	26.9	13.1
Taguchi 16	27.4	2.01
Taguchi 17	27.0	44.4
Taguchi 18	27.1	-

APPENDIX C

<u>Score sheet of **Hedonic Test** of cream formulation from Agarwood essence using **Taguchi Method**</u>

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								

Figure 5. Hedonic Test Questionnaire