Physico-chemical and Consumer Preference Analysis of Novel Herbal Soap Enriched with Aloe vera (*Aloe barbadensis*)

S. I. S. De Silva[1], B. E. A. U. Bulathgama[2], K. T. A. G. Somarathna[3], R.D.A.K. Ranasingha[4], K.H.T. Karunarathna[5], K.M.W. Rajawatta[6] and E.P.S. Chandana[7]

[1,2,3,4,5,6,7]*Department of Biosystems Technology, University of Ruhuna, Sri Lanka*

[1]ishankasewwandi1@gmail.com, [2]uthpalabulathgama@gmail.com, [3]arunodag@gmail.com, [4]araniranasinghe@gmail.com, [5]thissa@btec.ruh.ac.lk, [6]wathsala@btec.ruh.ac.lk, [7]epschandana@gmail.com

Abstract

Herbal soaps are popular products at a homemade scale worldwide, but innovative and commercialized local formulations are rare. Sri Lanka has a rich herbal diversity, and several plant extracts have been scientifically proven to show bioactivities such as anti-inflammatory, antibacterial, and antifungal properties. An instance of this is a herbal soap formulation that is useful for treating microbiological infections and regular use. The current study aimed to develop a novel herbal soap enriched with extracts of aloe vera (Aloe barbadensis), citronella oil (Cymbopogon nardus) and black tea (Camellia sinensis), evaluate the physico-chemical properties, and gauging consumer preference for the finished prototype while advancing the technology of the current saponification process. The soap base was produced by saponifying coconut oil with NaOH at 40°C, subsequently value added by incorporating 8% aloe vera gel, 4% citronella oil, and 4% black tea extract, and allowed to age for 72 hours at 32°C. The physico-chemical properties were determined as follows: density was 0.95 mg/ml, NaOH ratio was 4.16, free alkali content was 0.028% (0.007 mol/dm³), and Total Fatty Matter (TFM) was 79.6%. These metrics comply with the SLS 34:2009 standards and align with previous research findings, thereby classifying the product as Grade 1. Consumer assessment considered colour, aroma, texture, washing quality, and overall acceptability, revealing a brownish-golden hue, pleasant fragrance, a soft, consistent texture and gentle hand impact. Consumer preference was assessed across diverse socio-economic groups, revealing a high overall acceptability rating of 8.65 out of 10. The study advances soap technology, emphasizing compatibility with existing standards and consumer satisfaction.

Keywords: Herbal soap, Aloe vera, Tea, Total fatty matters, Saponification

I. INTRODUCTION

Soap is a commodity that is commonly used for hygienic practices such as washing and cleaning. The soap is generated through a process known as Saponification. In this process, triglycerides, free fatty acids (FFA), and fatty acid methyl esters react with an alkaline (NaOH or KOH) to produce soap (Bahl and Arun, 2017). There are several fatty acids that have been involved in the production of soap such as lauric acid, myristic acid, palmitic acid, stearic acid, and oleic acid (Arasaretnam and Venujah, 2019). In commercialization, colourants and fragrances are added to soap as value addition (Rahman and Paramita, 2021; Nchimbi, 2020).

Different scientific studies have proven that aloe vera gel can be used as a moisturizer for hydrating the skin due to its antiviral, antibacterial, and antioxidant properties (Mishra et al., 2023). Hence, the novel soap developed under this study was prepared with the incorporation of aloe gel. Moreover, the colour and fragrance of the novel soap were intended to be taken from natural ingredients. Citronella oil (*Cymbopogon* nardus) was used as the fragrance agent which imparts with addition of pleasant herbal smell to the developed soap and contributes to numerous actions such as antimicrobial, antioxidant, anticonvulsant and wound healing (Singh and Kumar, 2017) in addition to giving the fragrance for the developed aloe vera enriched soap. Hence, these properties have generated additional value for the developed soap further (Sharma et al., 2019).

Black tea (*Cameliia sinensis*) was imparted for the addition of natural colour which has been

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recognized as containing natural antioxidants such as catechin and has shown the antimicrobial, anticancer, and antifungal biological activities which generate more value to the developed soap product (LIczbiński, and Bukowska, 2022; Wang et al., 2022). Thus, when selecting the ingredients for the value addition, the aforementioned properties were considered (Pratama et al., 2021). This novel soap product was developed with enhancements to the technology of the existing saponification process to be easily adoptable in small and medium-scale enterprises. Nowadays, many novel herbal developments are carried out within the local university community, but the major drawback of these studies is the lack of commercial viability. In addressing this issue, the novel herbal soap enriched with aloe vera gel, citronella oil, and tea extract was assessed for compatible physico-chemical properties of a common soap product and acceptable consumer preference. In addition to the mere development of the product, in designing this study the concept of incorporation of aloe vera into several possible productions that could be carried out within the island is intended.

II. METHODOLOGY

A. Soap Production

Soap was made by saponification, filtering, and incorporation of herbs. For saponification, coconut oil and 20% NaOH were mixed and stirred in a beaker at 40°C for 40 minutes at 800 rpm, under controlled environmental conditions (23 ± 2^0C). As the next step, saturated sodium chloride (NaCl) was added into the soap base in an ice bath. The NaCl-soap mixture was filtered through a muslin cloth. Then, the filtered soap base was washed with ice-cold water and 0.05 M Citric acid respectively until the washouts gave a pH below 8. The resulting soap base was weighed and then melted in a 90 ^{0}C water bath until the desired melted texture. Then, the soap was enriched with the herbal incorporations and herbal formulations were taken according to a scientific design based on the trial-and-error method. The product optimization was done to the selected final formulation with regard to the organoleptic properties. Then, the herbal soap mixture was set to the moulding and the final product was obtained after 72 hours of holding time.

B. Physico-Chemical Characterization

The physico-chemical characterization comprised visual observations on product quality, including colour, texture, and aroma, alongside the mole ratio of coconut oil to NaOH (Rahman and Paramita, 2021), which were basically observed during its storing period and final stage of optimized soap at room temperature (32 ± 2 C^0).

Furthermore, density, pH, free alkali content (Betsy et al., 2013), and total fatty matter (TFM) (SLS 34:2009) were measured in triplicate to assess the formulation and quality of the novel herbal soap product.

C. Consumer Preference Evaluation

Consumer preference of the developed novel herbal soap was analyzed involving a 50-member consumer panel, recruited through careful screening from a pool of volunteers from the University staff to representing all defined social classes. In this consumer preference evaluation, the panelists were provided with a questionnaire and asked to rate the product regarding the attributes; colour, texture, odor, washing quality, and overall acceptability by using a ranking scale of 1 to 10, 10 being the highest value an attribute can obtain. Further, they were asked a few multiple-choice questions on their demographic details and preference perception.

D. Statistical Analysis

Data was analyzed using Microsoft Excel Professional plus 2016 and Minitab -17 statistical software to get the mean rank value and the standard deviation of each mean rank value for the consumer preference and each physico-chemical data regarding the newly developed herbal soap with the incorporation of aloe vera.

III. RESULTS AND DISCUSSION

As shown in Table 01, panelists have shown a higher preference, above the acceptable range in each attribute for the developed novel herbal soap. With the acceptance of 96% of consumer panelists, the developed herbal soap product has obtained overall consumer acceptability with 8.65/10 mean rank value. The panelists were specifically invited to represent a cross-section of the general public, encompassing a range of socio-economic backgrounds. Therefore, the received consumer preference score is comprehensive in defining the quality of the developed novel herbal soap.

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Table 01 : Mean rank values of the evaluation of consumer preferences

Consumer Preference (n=48)	Mean rank value (out of 10)
Color	8.06±0.96
Texture	8.27±1.25
Odor	9.98±0.94
Washing Quality	9.31±0.97
Overall acceptability	8.65±0.92

The final aloe vera incorporated herbal soap has given the observations as shown in Figure 01. It was brownish gold in colour and found to have a soft consistency. The citronella aroma existed after the solidification and the smell remained throughout the storing time at room temperature. In herbal value addition to the novel soap, aloe vera was used as the major value-adding ingredient, due to its antimicrobial activities, antioxidant activities, wound healing, moisturizing and beauty care properties.

The high antioxidant content of aloe vera slows down the ageing process of the skin while stimulating proper blood saturation via the vitamin and minerals present in aloe fillets. Also, due to its Additionally, though the citronella oil was used for the fragrance, and the tea extract was intended for imparting color, the antioxidants, flavonoids, and polyphenols compositions had enhanced the medicinal properties (antimicrobial, insecticidal, antioxidant, and dermatotoxicity activities) of the soap (Wany, et al., 2013; Sharma et al., 2019).

The weight of the prepared trial samples was between 7.6 ± 0.5 g. As shown in Table 02, the physico-chemical properties of the final sample, pH value was measured as 7.03 which represented the neutralized chemical nature. Although the resulting pH value is less than the standard value (pH 8.0 -10.0), the neutralized pH value represents that the developed herbal soap is ideal for the prevention of skin irritation due to the incorporation of aloe vera gel while advancing the soothing effect. Thus, it is suitable for body washing, and cleansing purposes further.

hydrating effect, aloe vera is beneficial in masking the dehydration that may be caused by the coconut oil-based soap. The most common oil used in soap production is coconut oil which is known to cause skin dryness evident in a wealth of previous studies (Ngan et al., 2020). Further, aloe gel has the ability to remove dead skin cells and has a good penetrating power, which aids in the transportation of healthy substances through the skin (Liang et al., 2021).

Figure 01 : Prototype of developed Aloe vera incorporated novel herbal soap

The density of the soap and the molar ratio between coconut oil and NaOH used in the saponification process were calculated as 0.95±0.006 g/mL, and 1:4.16 respectively. Those values were proved to be compatible compared to the previous study of Rahman and Paramita, (2021).

Table 02: Results of determined physicochemical properties of the final porotype

Physico-chemical Property	Amount	Reference values	Reference
pH	7.03±0.01	8.0 – 10.0	Das et al., 2024
Density (g /mL)	0.95±0.006	1.02	Rahman and Paramita, 2021

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Mole ratio (Coconut oil: NaOH)	1:4.16±0.006	1:5	Rahman and Paramita, 2021
Free caustic alkali content (Percent in mass)	0.028%±0.000	0.06% (max.)	SLS 34:2009
Total Fatty Matter (TFM) content	79.6% ±0.058	76.5 (min.)	SLS 34:2009

The free alkali content of the sample was given a value of 0.028% (0.007 moldm-3) with standard 0.1 moldm-3 HCl solution under the phenolphthalein indicator. The alkalis used to make soap are KOH (potassium hydroxide) and NaOH (sodium hydroxide). The most popular toilet soaps are sodium carboxylates. The fatty acids that are bound to glycerol in the precursor triglycerides play a crucial role in determining the molecular makeup of soap. Specifically, the proportion and type of these fatty acids determine the resulting sodium or potassium carboxylates formed during saponification, and this relationship governs the physicochemical properties of the soap (Moody et al., 2004).

Total Fatty Matter (TFM) content was 79.6% which is higher than the estimated TFM content of the previous study of Ahmed et al., (2021) (Ahmed et al., 2021). TFM value denotes one of the most important factors in terms of the quality of soap. According to the TFM value, the soap is graded into three categories such as grade 1 (above 76%), grade 2 (above 60%), and grade 3 (above 50%) (Betsy et al., 2013). Further, the TFM value is a metric for calculating how much fatty matter is present in soaps and the quality of the soap improves with a higher TFM content. High moisture concentrations in soap are caused by TFM%. Other elements that may affect the TFM value include the forms and amounts of fatty materials employed, as well as potential variations in the saponification process. Additionally, the resulting TFM value of the novel soap represents the lack of the presence of unreacted NaOH. Hence, the determined result of the TFM value of the prepared organic soap belongs to grade 1. That is associated with high quality, less hardness, and increased moisturizing properties of the soap (Betsy et al., 2013).

IV. CONCLUSION

The production of the aloe vera-enriched herbal soap, incorporating citronella as a fragrance agent and tea extract as a colouring agent, demonstrated compatible physico-chemical properties—such as pH, density, molar ratio between coconut oil and NaOH, free alkali content, and total fatty matter (TFM)—with commercial products. Additionally, the soap achieved favourable consumer acceptance, indicating a successful development at the laboratory scale.

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ABBREVIATIONS

Sodium hydroxide (NaOH), Potassium hydroxide (KOH), Sodium chloride (NaCl), Total fatty matter (TFM), Sri Lanka standard (SLS)