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Development of Bar Soap from Hemp Seed Oil Using the Saponification Method

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A B S T R A C T

This study developed a natural soap containing hemp seed oil and evaluated its physicochemical and consumer acceptance properties. Hemp seeds of the RPF3 variety from Chiang Rai, Thailand, were cold-pressed, yielding 19.95% oil. GC–FID identified 3 primarily polyunsaturated fatty acids; Omega-6 (57.75%), Omega-3 (16.60%), and Omega-9 (12.06%). HPLC detected 26.35mg/100g vitamin E (α-tocopherol). Two soap formulations were prepared: Formula A (coconut, palm, olive, and hemp seed oils) and Formula B (coconut, palm, olive oils only). The sodium hydroxide-based formula for bar soaps were produced by cold saponification and tested for pH, hardness, and foaming. Thirty volunteers participated in satisfaction surveys. Results showed cleansing, moisturizing effect, and natural composition as top purchase drivers. Eighty percent expressed interest, and 63.3% indicated purchase intention. Hemp seed oil soap showed significantly higher purchase intention than control ($t(29)=2.76$, $p=0.010$). Overall satisfaction also trended higher ($p=0.095$). Findings support hemp seed oil as a functional ingredient in natural soap with promising market potential.

Keywords: Hemp seed oil; Cold screw press; Natural soap; Saponification; Consumer acceptance

1. INTRODUCTION

Soap is one of the oldest cleansing agents known to humankind, with evidence of its use dating back more than 2,800 years. Throughout history, soap has served not only as a cleansing product but also as a means of preventing disease transmission and maintaining personal hygiene. In recent years, the global COVID-19 pandemic has underscored the critical role of soap in daily life, as frequent hand washing was recommended as one of the most effective preventive measures against viral transmission (Sakkaravarthi, 2022). However, prolonged use of synthetic soaps, which often contain harsh surfactants, fragrances, and chemical preservatives, can result in adverse effects such as skin dryness, irritation, and disruption of the natural skin barrier. These drawbacks have driven consumer interest toward natural alternatives that are gentler, safer, and more sustainable.Natural soap formulations typically rely on plant-based oils as the primary raw materials (Kanyama et al., 2025; Rupasinghe et al., 2020). These oils not only serve as cleansing agents through the saponification reaction but also provide valuable bioactive compounds that nourish the skin. Among plant-derived oils, hemp seed oil has attracted considerable attention due to its unique fatty acid composition, particularly the balanced ratio of Omega-6 to Omega-3 polyunsaturated fatty acids, and its high content of antioxidants such as tocopherols (Arango et al., 2024). Hemp (*Cannabis sativa* L. subsp. sativa) is widely recognized as a sustainable crop with low environmental impact, requiring minimal pesticide input while yielding fibers, seeds, and bioactive-rich oil. The cultivation of hemp has therefore become a subject of increasing interest for both agricultural and industrial purposes, particularly in the fields of nutrition, cosmetics, and pharmaceuticals (Izzo Luana et al., 2020; Sorrentino, 2021). Despite the growing popularity of hemp seed oil in cosmetic formulations, its application in solid bar soap remains underexplored. The cold process (CP) method of soap production is particularly suitable for incorporating hemp seed oil, as it preserves heat-sensitive bioactive compounds that might otherwise degrade under higher processing temperatures. The present study was designed to evaluate the potential of hemp seed oil as an ingredient in natural bar soap, focusing on oil extraction, characterization, soap production, physicochemical testing, and consumer acceptance (Hsu et al., 2021; Liu et al., 2021). This study aimed to: (i) extract hemp seed oil by Screw press extraction and analyze fatty acid composition and tocopherol; (ii) formulate and evaluate bar soaps with and without hemp seed oil; (iii) analysis of consumer satisfaction data for products.

2. Materials and Methods

2.1 Materials

Hemp seeds (*Cannabis sativa* L., RPF3 variety) were sourced from Chiang Rai, Thailand, and air-dried in the shade until the moisture content was reduced to below 10%. Prior to oil extraction, the seeds were roasted at 75 °C. In addition, coconut oil, palm oil, and olive oil (1 L each) were purchased from a local supermarket for use in soap formulation.

2.2 Chemicals

Sodium hydroxide (NaOH) and distilled water were purchased from World Chemical Group in Chiang Mai, Thailand.

2.3 Extraction methods

2.3.1 Screw press extraction

Hemp seed oil extraction was carried out using a single-screw SHANBEN model 304 extruder specifically designed for cold pressing. The unit was equipped with a 400 W motor operating at a maximum voltage of 220 V. The technical specifications of the extruder included a 20 cm screw length, a 2 cm pitch, an internal diameter of 1.20 cm, and a channel depth of 0.50 cm. The outer sleeve had an internal diameter of 2.5 cm and was fitted with a perforated outlet filter (2 mm in diameter) to facilitate efficient oil separation. To ensure uniform extraction, the screw rotation speed was maintained at 32 rpm. Dried hemp seeds were fed into the machine at a rate of 1 kg per batch, and the extraction temperature during pressing was controlled between 40–50 °C to preserve the oil's bioactive compounds. After extraction, the crude oil was filtered through filter paper to remove impurities. The clarified hemp seed oil was then transferred into plastic bottles and stored at 4 °C until further analysis.

2.3.2 Crude oil yield

The oil extracted by screw press extraction, was filtered through filter paper to remove the sediment. The extracted hemp seed oil was stored in a refrigerator for subsequent analysis of its physical and chemical properties.

Equation (1) expresses the percentage yield of extracted hemp oil as follows:

$$\%Yield = \frac{Weight\ of\ oil\ obtained\ (g)}{Weight\ of\ raw\ material\ (g)} X100 \qquad (1)$$

2.4 Analysis of fatty acid composition and tocopherol

2.4.1 Gas Chromatography–Flame Ionization Detector (GC-FID) Analysis of Fatty Acids

The fatty acid composition of hemp seed oil was determined using Gas Chromatography equipped with a Flame Ionization Detector (GC-FID). Prior to analysis, the oil samples were subjected to methyl esterification to obtain fatty acid methyl esters (FAMEs). The analysis was performed on an Agilent 6890N GC system (Agilent Technologies, USA) equipped with an HP-88 capillary column (100 m × 0.25 mm × 0.20 µm, Agilent Technologies, USA). The injector and detector temperatures were set at 250 °C, and the oven temperature was programmed from 120 °C (hold for 2 min) to 220 °C at a rate of
5 °C/min, with a final hold of 10 min. Nitrogen was used as the carrier gas at a flow rate of 1.0 mL/min. Fatty acids were identified by comparing their retention times with those of a standard mixture (Supelco 37 Component FAME Mix, Sigma-Aldrich, USA).

2.4.2 High-Performance Liquid Chromatography (HPLC) Analysis of Vitamin E

The vitamin E (α-tocopherol) content in hemp seed oil was analyzed using High-Performance Liquid Chromatography (HPLC). The analysis was conducted on an Agilent 1200 Series HPLC system (Agilent Technologies, USA) equipped with a fluorescence detector. A C18 reversed-phase column (250 mm × 4.6 mm, 5 µm; Agilent ZORBAX Eclipse Plus, USA) was used at 30 °C. The mobile phase consisted of methanol:water (97:3, v/v) with an isocratic flow rate of 1.0 mL/min, and the injection volume was 20 µL. Fluorescence detection was performed with excitation and emission wavelengths of 295 nm and 330 nm, respectively. Quantification was carried out using calibration curves constructed from α-tocopherol standards (Sigma-Aldrich, USA).

2.5 Soap Formulation

Two soap formulations were prepared in **Table 1**: Formula A contained hemp seed oil mixed together with coconut, olive, and palm oils, while Formula B contained the same mixed oils but without hemp seed oil. The required amount of sodium hydroxide (NaOH), as the alkali, was calculated based on the saponification values of each oil and dissolved in cool distilled water, then cooled to 35–40 °C. Oils were weighed, melted if solid, combined, and adjusted to the same temperature. The NaOH solution was slowly added to the oils while stirring, and mixing continued with a stick blender until trace was reached. The soaps were left to set for 24–48 hours, unmolded, cut into bars, and cured for 4–6 weeks at room temperature to complete saponification.

Table 1 - Formulation of soap Composition

Ingredient	Saponification values	Formula A	Formula B	Role
Hemp seed oil	0.137	150 g	-	Moisturizing, Anti-Inflammatory
Coconut oil	0.190	170 g	170 g	Moisturizing, Lathering agent
Palm oil	0.141	130 g	130 g	Hardness, Durability
Olive oil	0.134	350 g	500 g	Moisturizing, Emollient
Sodium hydroxide (NaOH)	-	118.0 ml	117.6 ml	Saponification agent
Distilled water	-	283.2 ml	282.0 ml	Solvent

2.6 Soap evaluation

The produced soaps were then tested for acidity-alkalinity (pH), hardness, and foaming ability using standard methods according to the previous reports (Anggraini et al., 2015; Febriani et al., 2020) with slight modifications. For pH determination, 1 g of grated soap was dissolved in 10 mL of distilled water, stirred until homogeneous, and the pH was measured using a pH indicator paper. Hardness was measured using a penetrometer by recording the penetration depth of the needle after 5 sec under a constant load. Measurements were taken at three points per sample, and the mean value was reported. Foaming ability and stability were tested using the vortex method. 1 g of grated soap was dissolved in 10 mL of distilled water, and vortexed for 30 sec, and the initial foam height (H_0) was recorded. After leaving to stand for 5 min, the foam height (H_5) was measured. Foam stability was calculated as $(H_5/H_0) \times 100\%$.

2.7 Analysis of consumer satisfaction data for products

Data from questionnaires were collected, categorized, and converted into quantitative variables for analysis. Statistical analysis was performed using the IBM SPSS statistics 23 program. Descriptive statistics (frequency, percentage, mean, and standard deviation) were used to summarize responses, and results were presented in tables and figures for comparison. Inferential statistics were applied to compare experimental groups, specifically using independent-samples t-tests. When differences were found, Duncan’s multiple range test was applied to evaluate group comparisons at a significance level of $p < 0.05$.

3. Results

3.1 Efficiency of hemp oil extraction by screw press extraction methods

This study investigated the efficiency of hemp oil extraction using screw press extraction methods (Rattana Muangrat & Apisada Kaikonjanat, 2025). The average oil yields from hemp seeds, presented in **Table 2**, ranged from 19.0 % to 20.5 %. The extraction of hemp seed oil using screw press extraction method yielded an average of 19.95 ± 0.43% (Mean ± SD) from ten independent trials (**Table 2**). Each trial used 1000 g of raw hemp seeds, producing an average oil weight of 199.5 g. These results demonstrate the consistency and efficiency of the cold-press method for extracting hemp seed oil from the RPF3 variety cultivated in Chiang Rai, Thailand.

Table 2- Percentage yield of oil from hemp seeds obtained by screw press extraction methods

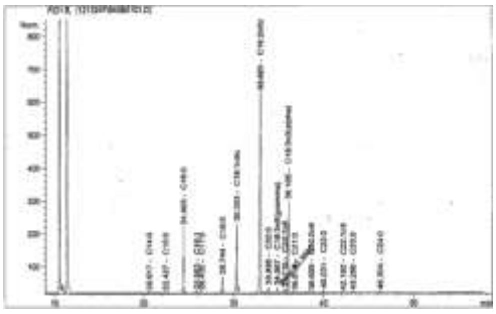
Trial	Raw material weight (g)	Oil weight obtained (g)	% yield (%)
1	1000	198	19.8
2	1000	200	20.0
3	1000	199	19.9
4	1000	203	20.3
5	1000	205	20.5
6	1000	190	19.0
7	1000	196	19.6
8	1000	201	20.1
9	1000	199	19.9

Trial	**Raw material weight (g)**	**Oil weight obtained (g)**	**% yield (%)**
10	1000	204	20.4
Average	**1000**	**199.5**	**19.95**

3.2 Fatty acid composition and tocopherol analysis

As shown in **Fig. 1(a)**, GC-FID analysis identified thirty fatty acids in the extracted hemp seed oil with 3 predominating peaks of polyunsaturated fatty acids. Linoleic acid (Omega-6) accounted for 57.75%, α-linolenic acid (Omega-3) for 16.60%, and oleic acid (Omega-9) for 12.06%, while saturated fatty acids were present in relatively lower amounts. The ω-6/ω-3 ratio was consistent with values considered beneficial for nutritional and dermatological applications. Furthermore in **Fig. 1 (b)**, HPLC analysis revealed a vitamin E content of 26.35 mg/100 g, with α-tocopherol as the dominant isomer (Arango et al., 2024). These results confirm that hemp seed oil is not only a rich source of essential fatty acids but also a natural reservoir of antioxidants, supporting its potential application in skincare and soap formulations.

(a)



(b)

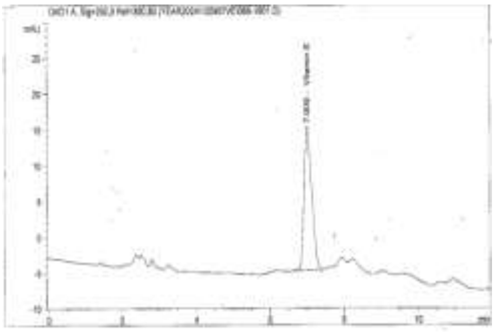


Fig. 1 - (a) Chromatogram showing the fatty acid analysis of hemp seed oil by GC-FID

(b) Chromatogram showing the analysis of vitamin E by HPLC

3.3 Soap Properties

Both formulations yielded stable bar soaps with acceptable structural integrity. The produced soaps were molded into square bars, as illustrated in **Fig. 2**.

(Formula A**)** **(**Formula B**)**

Fig. 2 - Characteristics of the soap mixed with hemp seed oil (Formula A) and the soap without hemp seed oil (Formula B)

As shown in **Fig. 2**, the characteristics of the natural soap differed between the formulations. Formula A, which incorporated hemp seed oil, exhibited a greenish-yellow coloration with a slightly coarse texture. In contrast, Formula B, which did not contain hemp seed oil, displayed a milky white appearance and a similarly coarse texture.

The physicochemical properties of the two soap formulations (Formula A and Formula B) were evaluated and summarized in **Table 3**, focusing on pH, hardness, foam formation, and foam stability.

Table 3 - Results of soap evaluation

Sr. No.	Parameters	Formula A	Formula B
1	pH	9	9
2	Hardness	30	30
3	Foam formation	71 ml	64 ml
4	Foam stability (%)	99.06 %	99.48 %

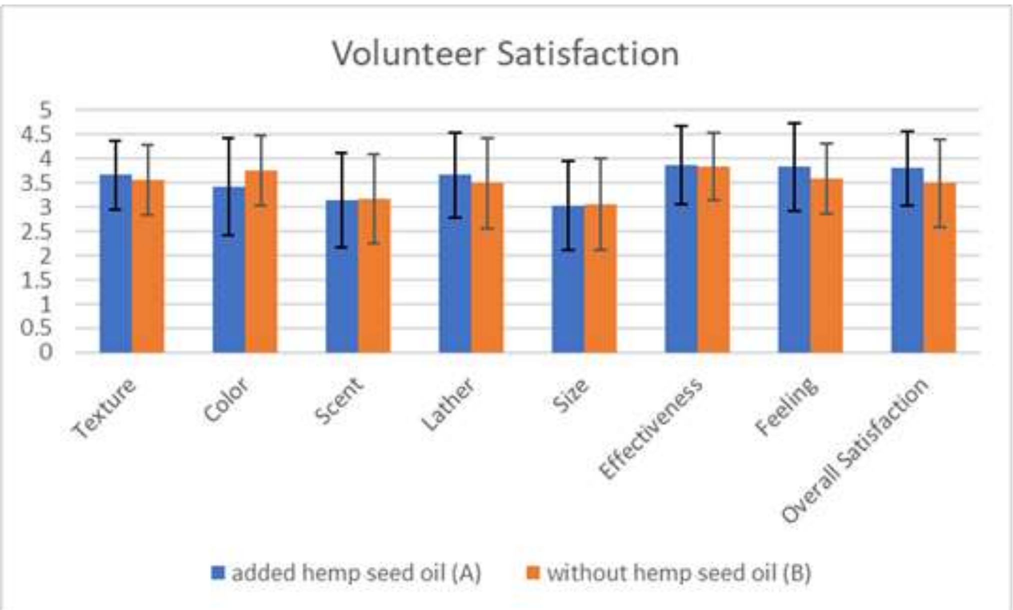
Table 3 presents the physicochemical properties of the two soap formulations (Formula A and Formula B), evaluated in terms of pH, hardness, foam formation, and foam stability. Both formulations exhibited the same pH value of 9, which falls within the alkaline range typical of bar soaps, indicating their suitability for effective cleansing. The hardness values of both formulations were identical (30), demonstrating comparable structural firmness and durability.

A slight difference was observed in foam formation, where Formula A produced a foam height of 71 mL, while Formula B produced 64 mL, suggesting that Formula A possessed a marginally higher foaming ability. Furthermore, the foam stability values were 99.06% for Formula A and 99.48% for Formula B, indicating that both formulations maintained exceptionally stable foam over time, with Formula B showing slightly greater foam retention.

3.4 Analysis of consumer satisfaction data for products

Among the 30 volunteers, most respondents were female (63.3%), aged 40–49 years (46.7%), held a bachelor's degree (63.3%), and were employed in the private sector (86.7%). Cleansing ability, moisturizing effect, and natural ingredients ranked highest. The evaluation indicated that both hemp seed oil soap (Formula A) and non-hemp seed oil soap (Formula B) achieved comparable average scores for texture, color, scent, and foaming ability. However, Formula A exhibited slightly higher ratings in cleansing performance and post-use skin sensation. Despite variations in individual responses, as reflected by the standard deviation (SD), the overall trend suggested that the incorporation of hemp seed oil had a positive influence on the quality of the soap, as assessed using a 5-point Likert scale.

Fig. 3 - Consumer acceptance of soap added with hemp seed oil compared with the soap without hemp seed oil.



From **Fig. 3,** both formulations showed no significant differences ($p > 0.05$) in texture, color, scent, foam quantity, and size. However, the hemp seed oil soap (Formula A) was rated significantly higher ($p < 0.05$) in cleansing performance and post-use skin sensation, suggesting that the addition of hemp seed oil positively enhanced product quality.

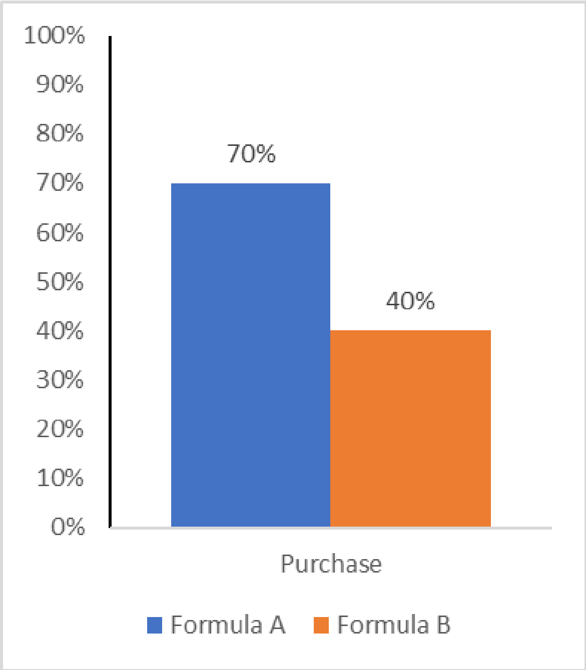


Fig. 4 –Comparison of purchase decision tendency between added hemp seed oil soap (Formula A) and without hemp seed oil soap (Formula B)

Fig. 4 shows the comparison of purchase intention between added hemp seed oil soap (Formula A) and without hemp seed oil soap (Formula B). The results indicate that 70% of participants expressed willingness to purchase the soap added hemp seed oil, whereas only 40% expressed willingness to purchase the soap without hemp seed oil, suggesting that the incorporation of hemp seed oil positively influenced consumer purchasing decisions. Significantly higher purchase intention was recorded for the soap added hemp seed oil (Formula A) vs. the soap without hemp seed oil (Formula B) ($t(29)=2.76$, $p=0.010$). Overall satisfaction trended higher for hemp seed oil soap ($p=0.095$).

Discussion

The present study demonstrated that cold-press extraction of hemp seed oil from the RPF3 variety yielded an average of 19.95 ± 0.43%, which is consistent with previously reported yields of hemp seed oil obtained under similar extraction conditions. The relatively stable yield indicates the efficiency of the cold screw press method and highlights its potential for sustainable oil production (Rattana Muangrat & Apisada Kaikonjanat, 2025).The GC-FID analysis confirmed that hemp seed oil is rich in polyunsaturated fatty acids, particularly linoleic acid (57.75%), α-linolenic acid (16.60%), and oleic acid (12.06%). This composition corresponds with literature emphasizing the importance of essential fatty acids in maintaining skin barrier function and providing anti-inflammatory effects. The ω-6/ω-3 ratio was within the favorable range for dermatological and nutritional applications, underscoring the functional potential of hemp oil as a skincare ingredient. Moreover, HPLC analysis revealed a vitamin E content of 26.35 mg/100 g, which supports the antioxidant capacity of the oil and its potential role in protecting skin from oxidative stress and premature aging (Arango et al., 2024; Izzo Luana et al., 2020; Şeker & Esen, 2021).Two soap formulations were prepared to evaluate the effect of hemp seed oil incorporation. Both sodium hydroxide-based formulas produced solid bar soaps with acceptable physicochemical properties, including pH, hardness, and foaming ability, comparable to standard natural soaps. However, consumer satisfaction evaluation revealed that the hemp seed oil soap (Formula A) was rated slightly higher than the non-hemp seed oil soap (Formula B) in cleansing performance and post-use skin sensation. Statistical analysis showed that purchase intention for hemp seed oil soap was significantly higher ($t(29) = 2.76$, $p = 0.010 < 0.05$), while overall satisfaction demonstrated a positive trend ($p = 0.095$). These findings suggest that hemp seed oil enhances the consumer-perceived quality of soap, particularly in aspects related to skin feel and market acceptance. Nevertheless, some limitations should be acknowledged. The study involved a relatively small sample size ($n = 30$) and focused exclusively on a single seed variety (RPF3). Thus, the generalizability of the results is constrained. Further research should expand the sample population, include multiple hemp seed varieties, and assess the long-term stability of hemp oil soap under storage conditions.

Conclusion

This study successfully developed a natural bar soap incorporating cold-pressed hemp seed oil. The oil exhibited favorable yields, high levels of essential fatty acids, and significant vitamin E content, confirming its bioactive potential for skincare applications. Comparative testing indicated that hemp seed oil soap possessed similar physicochemical properties to conventional herbal soaps but offered enhanced consumer satisfaction and purchase intention. These results highlight hemp seed oil as a sustainable and value-added ingredient for natural soap formulations. Future studies should broaden the scope by including diverse varieties, larger consumer panels, and extended stability testing to support commercialization and long-term application of hemp-based personal care products.

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