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An Ethical Study of Antioxidant Property of Snail "*Achatina Fulica*" via Heat Sonication Method for Moisturizing Lotion Stick

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Abstract

This study investigates the extraction and characterization of mucin from *Achatina fulica* for its potential use in cosmeceutical lotion sticks. The research aims to address the problem of dried skin during sunny days and the unethical practices in snail mucin extraction, which often fail to meet quality and safety standards. By using ethical heat and sonication methods, the study seeks to optimize mucin extraction. An optimization method generated by the Response Surface Methodology (RSM) was used to identify key factors such as temperature, light intensity, and extraction duration that influence mucin quality and yield. The optimized conditions were found to be 30°C, 410 light intensity, and 20 minutes extraction time. Biological testing of the lotion stick formulated with snail mucin and virgin coconut oil demonstrated enhanced antioxidant ability with increased mucin concentration. The findings support its use as a trending ingredient in skincare products, emphasizing both efficacy and ethical considerations in extraction practices.

1. Introduction

Dry skin, or xerosis, occurs when the skin loses moisture and becomes dehydrated. This condition can be caused by factors such as the environment, genetics, aging, and specific medical conditions. Dry skin can lead to additional issues like itchiness, cracking, and peeling, making it both painful and unsightly. Exposure to air can also cause dry skin to become infected due to bacteria and debris. Therefore, it is important to use a suitable lotion that can hydrate, moisturize, and protect the skin.

This study utilizes a new technology involving a sonicator water bath to extract snail mucin efficiently and humanely, ensuring no harm to the snails. Research shows that snail mucin contains bioactive substances beneficial for skin health. The study examines the biological properties of mucin in detail, focusing on its antioxidant capacity to understand how it protects the skin from free radicals. This study also explores the combination of snail mucin with virgin coconut oil, known for its hydrating, anti-inflammatory, and antimicrobial properties, to create innovative cosmeceutical products. Emphasizing ethical practices, this research aims to develop effective and ethical skincare products from natural sources, making a promising contribution to the field of cosmeceuticals.

The study aims to investigate the biological properties of snail mucin extracted from *Achatina fulica* and its combination with virgin coconut oil in cosmeceutical formulations. Key questions include optimizing the extraction process for snail mucin from *Achatina fulica* and evaluating its antioxidant properties.

2. Methodology

2.1 Sample preparation for snail *Achatina fulica*

Achatina Fulica were collected from the residential area in Pagoh Jaya, Pagoh, and the lake around University Tun Hussein Onn Malaysia (UTHM), Pagoh, for a total of 54 *Achatina Fulica* which typically weighed 5 ± 25 grammes on average, a saline solution with a concentration of 0.9% NaCl in 100 ml distilled water was used to wash and clean the snails The snails were kept in the container shown in Figure 1, following the method described by (3), and maintained at room temperature (27-28 °C) in a dark space..

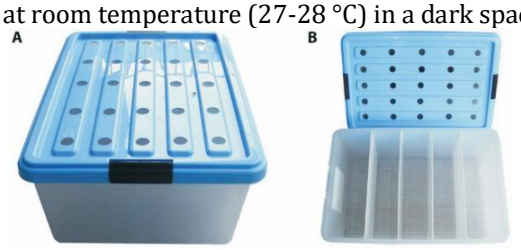

Fig. 1 *Container for snail (a) Outside view (b) Inside compartment view*

2.2 Designing of Expert (DOE) factors variable temperature, light reading and time duration for extraction heat & sonicated stimulation and conventional method.

All the factors considered were designed using Design of Expert (DOE) with State-ease software. The factor parameters for the extraction focused on temperature, light reading, and time duration, with units in Celsius (°C), lux, and minutes (min), respectively. Special attention was given to the ethical treatment of snails. High-temperature conditions that resulted in snail mortality were identified as unethical and are not recommended for future use. This study emphasizes the importance of humane practices in research.

Starting on the DOE using software State-ease, the temperature value as factor 1 were set at 25°C as the lowest, indicating water at room temperature, and 35°C as the highest, indicating warm water(4).The light reading as factor 2 was set at 20 lux as the lowest, indicating a dark area, and 800 lux as the highest, indicating the highest light reading with additional light supply(5). Lastly, the time duration as factor 3 was proposed at 15 minutes for the lowest and 25 minutes for the highest(6). The response of the experiment was the mucin weight collected and the concentration of the mucin *Achatina fulica*. Table 1 below shows the generated table including all the parameter that was mentioned.

Progress in Engineering Application and Technology Vol. 5 No. 2 (2024) p. 611-621

Table 1 : Design of Expert DOE generated table for the extraction snail mucin.

Stimulation					
	Factor			Response	
Run Test	Temperature (°C)	Light reading (Lux)	Time (min)	Mass (g)	Concentration (%v/v)
1	27	425	25		
2	27	425	15		
3	27	50	20		
4	27	800	20		
5	32	425	20		
6	32	800	15		
7	32	425	20		
8	32	50	15		
9	32	425	20		
10	32	425	20		
11	32	800	25		
12	32	425	20		
13	32	50	25		
14	37	425	25		
15	37	50	20		
16	37	800	20		
17	37	425	15		
Conventional method					
18	25	425	20		

2.3 Preparation according to factor Table 1 before extraction

The light setup involved adjusting the light passing through aluminum foil wrapped around the beaker. For the lowest light condition of 20 lux (dark), the beaker was entirely covered with aluminum foil. To achieve a moderate light condition of 425 lux (half dark), the foil was pierced with holes and wrapped around the beaker to allow minimal light inside. For the brightest condition of 800 lux, the beaker was exposed to room lighting without any foil. Actual light readings could vary during the experiment (7).

Temperature adjustments were made using a water bath sonicator. Two methods were used for mucin extraction from *Achatina fulica* snails , the conventional method, involving manual stimulation with a spatula, at temperature 25°C without activation of sonication.

2.4 Extraction of raw mucin *Achatina Fulica* sample

Based on the 54 snails that were gathered, 17 test runs with three snails each were conducted using method Heat & Sonicated Stimulation and single method for conventional method. Both methods were done in Sonicator waterbath the only differences between two methods are activation of sonication. The extraction procedures from (8,9) were changed into two new techniques that combined conventional stimulation with heat-and-sonicated stimulation. Extraction was done by following factor according to table 1 above and will be generated by Response Surface Methodology (RSM) with State-ease software for identifying optimised method.

The extraction process began by cleansing the snails with distilled water to remove debris. Then, they were placed in beakers under specific lighting conditions and sprayed with distilled water for increased humidity. Afterward, the snails were stimulated based on the chosen method.

For sound energy stimulation at 25°C, the snails were exposed to sound frequencies of 20-40 kHz to encourage gland secretion for mucin production. The mucin produced was then collected and measured for mass and Refractive Index according to the designated time duration. These steps were repeated for other temperatures, i.e., 30°C and 35°C.

For manual stimulation, the snails were initially stimulated for 1 minute before being placed into the beakers. The temperature of the water bath was adjusted to investigate the effect of temperature at 25°C. The produced mucin was collected and measured similarly.

2.5 Collection mucin *Achatina fulica* in mass to determine the optimised mucin extraction in scope of quantity.

To weigh the mucin extraction, the collected mucin from the beaker containing a snail was weighed using a weighing scale in the laboratory. The mucin from both stimulation methods was weighed for total net mucin using the formula Eqn. 1 below,

$$\Delta\ mucin\ (g) = ms_F - ms_i \quad \text{Eqn. 1}$$

$ms_F : mass\ snail\ final\ , ms_i : mass\ snail\ initial$

2.6 Concentration measurements from Refractive index to determine the optimized mucin extraction in scope of quality.

Data on mass and refractive index of the extracted mucin were collected and analyzed using RSM. This analysis helped identify the optimal conditions for mucin extraction. Further details on statistical tests and data interpretation are provided to ensure transparency and reproducibility. Firstly, a calibration curve of refractive index vs. dilution of the concentration of snail mucin, ranging from 0% to 100%, was created with diluted in 1ml of distilled water. This standard curve allows for the calculation of the concentration using the following formula Eqn. 2below,

$$\text{Concentration}\ \left(\%\frac{v}{v}\right) = \frac{\text{RI each on extraction method} - \text{RI of distilled water}}{Slope\ gradient\ from\ calibration\ curve} \quad \text{Eqn. 2}$$

Where RI indicated as Refractive index.

2.7 Replicated extraction method from the data gathered and evaluated by the (RSM) with purification and filtration.

The optimized sample contained the most mucin and was selected for replication. The scale of production was increased at a ratio of 7-folds from the original number of snails which is 3. The optimized mucin sample was filtered by passing through a phase of filtration on a 0.45-µm membrane filter (Millipore) using a vacuum pump to filter out impurities. To extract pure mucin, mucin from *Achatina fulica* was placed in a centrifuge at 3000 rpm for 15 minutes. The liquid supernatant was collected and stored in a freezer at a temperature of 4°C(10,11).

2.8 Antioxidant activity using DPPH.

A laboratory scale was used to weigh out 0.0049 grammes of crystalline DPPH powder, which was then combined with a 150 mL solution of methanol using a 0.025 g/DPPH to methanol ratio. In order to test samples of mucus from a single snail, 3 test tubes were made, each containing 3 mL of the DPPH solution (1 test tube for the control, 1 test tube for 20 µl of mucus sample, 1 test tube for 40 µl of mucus sample, and 1 test tube for 80 µl of mucus sample).

After adding mucus samples using a pipette and vortex mixer, all test tubes were covered with parafilm and given 30 minutes to allow the reductant reaction to take place. The material in each test tube was transferred into single-use cuvettes (with a wavelength range of 200 nm to 900 nm) after 30 minutes. A UV-vis spectrophotometer was used to measure the quantitative light absorbance of each cuvette (12). Formula scavenging activity was used following the Eqn. 3 below .

$$Scavenging\ activity\ (\%) = \frac{A_{sample} - A_{control}}{A_{control}} \times 100\% \quad \text{Eqn. 3}$$

where A_{sample} means absorption of samples at 595 nm wavelength; A_{blank} means absorption of blank at 595 nm wavelength; $A_{control}$ means absorption of control at 595 nm wavelength.

2.9 Formulation of lotion stick 25 ml base of mucin secretion from *Achatina fulica* with combination of Virgin Coconut Oil (VCO)

The ingredients listed on table 2 below were precisely weighed on a digital weight scale to create a 25 ml lotion stick. First, beeswax will be melted at temperature 60°C with the refinery coconut oil and cocoa butter using hot plate with continuous stirrer. Next, prepared the solution of the bioactive ingredient for the later mixing with the beeswax solution, snail mucin for LS1 and Cosrx for LS2 that was purified and mix with the rose essential oil and Virgin coconut oil (VCO). After the beeswax solution is well mixture in temperature 60°C, slowdown the heat temperature to 50°C for the addition of the bioactive ingredient and continuous stirrer for 30 minutes until it achieves homogenize. Lastly, prepare the lotion stick container as the molding shape for the lotion mixture until its cooldown for 4 hours (13,14). Lotion sticks 1 and lotion stick 2 will be tested performed

Progress in Engineering Application and Technology Vol. 5 No. 2 (2024) p. 611-621

following the procedure on 2.11, 2.12 and 2.13 to evaluate the performance of the concentration 3% of the snail mucin and Cosrx.

Table 2 *Formulation 25 ml lotion stick mucin Achatina fulica cooperate with Virgin Coconut Oil (VCO)*

Ingredient	Function	Concentration (%)	
		LS1	LS2
Virgin coconut oil (VCO)	Oil base	26	28
Refinery coconut oil	Oil base	28	28
Mucin *Achatina fulica*	Humectants and bioactive ingredient	3	-
Snail mucin Cosrx	Humectants and bioactive ingredient	-	3
Cocoa Butter	Oil base	17	8
Beeswax	Hardener	25	32
Rose Essential oil	Fragrances	1	1

3. Result and Discussion

3.1 Design of experiment

The results obtained highlight the need for more information to fully understand the implications of time as a factor. The impact of time on mass and refractive index fluctuations is unpredictable. For example, run 9 had a larger mass (3g) and concentration (0.5211 %v/v) compared to run 7, which had a lower mass (0.77g) and concentration (0.5117 %v/v). Due to the complexity of snails and the limited studies on mucin extraction timing, determining the exact production timing is challenging (15). More repetitions are essential to determine if time has statistically significant effects, considering variables like gender, diet, and mating season (16).

Temperature plays a vital role in snail mucin production. The results indicate that temperature significantly impacts mucin yield. At 25°C, 30°C, and 35°C, the average mucin collected was 1.083g, 1.96g, and 2.787g, respectively, with corresponding concentrations of 0.3708%v/v, 0.4882%v/v, and 0.6056%v/v. However, at 35°C, 12 out of 54 snails died, highlighting the need for ethical considerations. The average mucin yield increased with temperature, peaking at 35°C but resulting in significant snail mortality. Maintaining the temperature between 18°C and 30°C during extraction is crucial to ensure snails can produce mucin without harm. This range safeguards snail survival and promotes efficient mucin extraction for cosmetic or biopharmaceutical purposes (17). Higher temperatures stimulate *Achatina fulica* snails to produce more mucin, likely as a physiological response to prevent water loss and maintain hydration. The gel-like mucus acts as a barrier, trapping moisture on the snail's skin. However, temperatures above 35°C can be harmful, with a 22% mortality rate. The optimal range balances quantity and quality while minimizing mortality. Sonication may also enhance extraction, but more research is needed on the synergistic effects of temperature and sonication on *Achatina fulica* mucin production (18).

The data suggests that light exposure affects mucin production in snails. The average mucin mass was higher at 410 lux (2.29g) compared to 20 lux (1.26g) or 800 lux (1.8625g) (1). However, the highest mucin collection weights were 3g, 4.16g, and 3.32g for the 20 lux, 410 lux, and 800 lux categories, respectively. Furthermore, run 17 at 800 lux had a larger mass (3.32g) and concentration (0.9201 %v/v) compared to run 7 at 410 lux, which had a lower mass (0.77g) and concentration (0.5177 %v/v). It is well known that snails are photophobic, meaning they prefer low light conditions such as those found at night or on cloudy days (19). Snails can become stressed by intense or continuous light exposure, which might impact their physiological processes, such as secreting mucus. This may affect the quality of mucin by changing its composition or secretion (20).

The findings suggest that ethical extraction methods can produce high-quality mucin suitable for cosmeceuticals. Compared to conventional methods, the optimized conditions not only yield more mucin but also ensure the well-being of the snails. These results support the use of Achatina fulica mucin as a viable ingredient in skincare products, offering both efficacy and ethical integrity

3.1.1 Mass mucin collection as response 1

A high yield makes the extraction process cost-effective since it allows for the extraction of more mucin from a given number of snails. Increased yields are often linked with improved mucin purity and quality(21).Based on table 3 below shows the optimized data for each category of the factor, which is temperature. The classified temperature factors are 25°C, 30°C, and 35°C compared with the conventional method. Obviously on the table 4 below show the conventional were least in mass collected rather that optimize at each temperature classify for heat sonicated stimulation.

Table 4 Optimize table on Mass mucin collected response compared of the Stimulation Sonicator & waterbath and Conventional (without Stimulation).

Method			Stimulation Sonicator & waterbath			Conventional
Optimize Run			3	13	17	18
	Temperature	°C	25	30	35	30
Factor	Time	Min	20	20	20	20
	Light	lux	20	410	800	30
	Reading					
Response	Mass	g	1.3	1.97	3.32	0.14

Based on figure 2, the data were analyzed using RSM to find the ideal mass and time combination required light reading actual temperature. This information can be used to determine which factor has the biggest impact on the snail mucin mass collection. According to Fig.2(A), run 17 produced the highest amount of snail mucin (*Achatina fulica*) at 35°C after a 20-minute extraction period and 800 lux of light. When using a Sonicator water bath, this high temperature produced the greatest amount of mucin. But since the 12 snails did not survive the extraction for each run, this method is unethical and should not be used in the future.

Run 13 yielded the highest amount of snail mucin (*Achatina fulica*) at 30°C, 20 minutes of extraction time, and 410 lux of light, as shown in Fig.2(B). This temperature offers the required warmth when using an activated Sonicator water bath to produce mucin. The mucin yield at 30°C was slightly less than at 35°C, but the snails were still able to live, suggesting that 30°C is a more morally acceptable temperature for future research aimed at optimising mucin extraction.

The extraction of snail mucin (*Achatina fulica*) was optimised in run 3 at 25°C and 20 lux light reading for 20 minutes, as shown in Fig.2(C). The amount of mucin produced by this gentle method was 1.3g, which is less than the 1.97g and 3.32g produced at 30°C and 35°C, respectively. The snails were not as effectively stimulated by the low light and mild 25°C conditions. In comparison to the traditional method of collecting 0.14g of mucin, using a Sonicator for 20 minutes helped collect 1.3g of mucin, demonstrating that harsher conditions, such as higher temperatures, light, and vibration, are more effective for optimising mucin extraction. While the optimized conditions yielded significant mucin quantities, the study faced limitations, including variations in snail conditions that may affect reproducibility. Future research should investigate these variables to refine the extraction process further.

Progress in Engineering Application and Technology Vol. 5 No. 2 (2024) p. 611-621

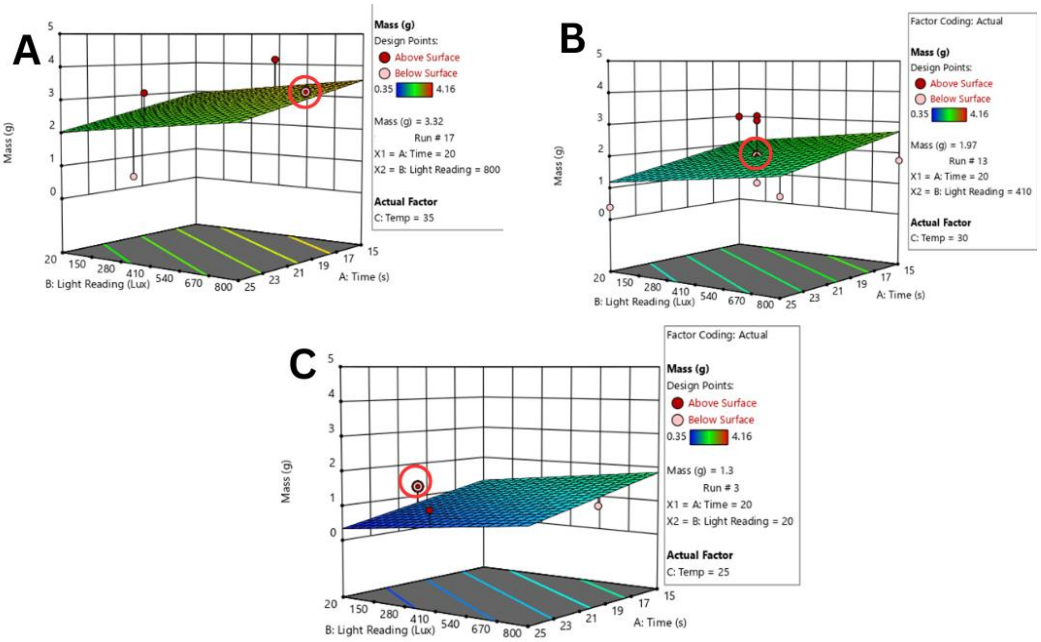

Fig.2*: Optimized mass collection on factor (A)Temperature 35°C (B) Temperature 30°C (C) Temperature*

3.1.2 Concentration of the snail mucin

On this section , the concentration of the snail mucin was evaluated regarding not only of its quantity but also the quality of the *Achatina fulica* mucin. From all the data from Table 5 below gathered the optimize factor for each temperature classify 25°C, 30°C, and 35°C compared with the conventional method , the concentration were identical since the Refractive index of the snail mucin *Achatina fulica* at 1.3 and its similarity to the water , snail mucin *Achatina fulica* consists largely of water, it's reasonable to expect that its refractive index would be similar to that of water. Water has a refractive index of around 1.3231 at room temperature as it already tested during the extraction. Therefore, the extraction technique used has a direct impact on the snail mucin *Achatina fulica* concentration as refractive index and concentration have a relationship. A solution's refractive index typically increases as the solute's concentration increases. The concentration of the active ingredient in snail mucin *Achatina fulica* increases as the concentration of snail mucin itself increases due to the direct relationship between the two factors. When the concentration of snail mucin *Achatina fulica* is higher, there is a greater amount of the active ingredient present(22). Obviously on the table 5 below show the conventional were least in concentration rather that optimize at each temperature classify for heat sonicated stimulation.

Table 5 Optimize table on concentration of mucin compared of the Stimulation Sonicator & waterbath and Conventional (without Stimulation).

Method			Stimulation Sonicator & waterbath			Conventional
Optimize Run			7	15	17	
Factor	Temperature	°C	25	30	35	30
	Time	Min	15	20	20	20
	Light Reading	lux	410	410	800	30
Response	Mass	g	0.5117	0.6995	0.9201	0.4647

Temperature plays a major role in snail mucin *Achatina fulica* concentration. Based on Fig.3(A), the highest concentration of 0.9201%v/v was recorded in run 17 (20 minutes, 800 lux), with an average concentration of 0.6455 %v/v across four runs at 35°C.Mucin concentration and amount are both increased in harsh environments. However, because 12 snails died during the extraction process, the high temperature of 35°C is regarded as unethical.

On Fig.3(B) at temperature 30°C, where data shows that snail mucin *Achatina fulica* can be extracted ethically. At 30°C, the average concentration over nine runs was 0.5373 %v/v, as shown in Figure 4.5. The maximum concentration in run 17, which lasted 20 minutes at 410 lux of light, was 0.6995 percent v/v. These data suggest that mucin concentration and mass collection are influenced by the harshness of the environment. While the concentration of mucin is lower at 30°C than it is at higher temperatures, this is

still an ethical and effective way to extract mucin.
When the temperature is set to 25°C, Fig.3(C) shows its optimised factor. At 35°C and 30°C, snail mucin *Achatina fulica* is still produced, but compared to temperature 25°C were less concentrated. The average concentration over the course of four runs was 0.3591% v/v. Run 7, which takes 15 minutes and 410 lux to complete, indicates that mucin secretion occurs early at lower temperatures. These circumstances suggest that snails can survive on ultrasonication and low temperature without the need for severe stimulation. As a result, this temperature produced the least amount of mucin and the least concentrated amount, indicating lower quality and fewer active ingredients.

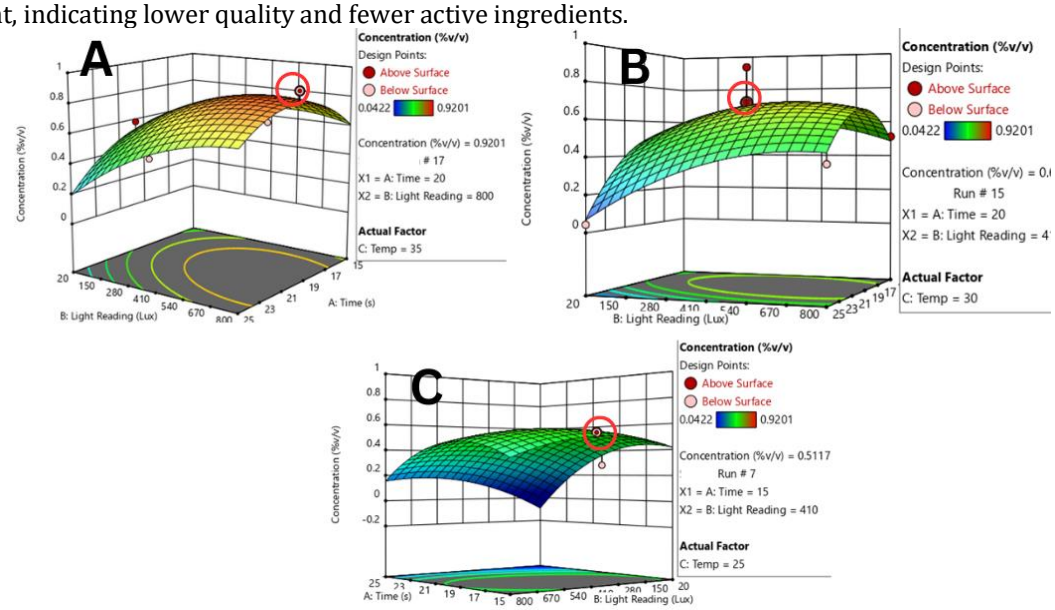

Fig.3*: Optimized concentration on factor (A)Temperature 35°C (B) Temperature 30°C (C) Temperature 25°C*

3.2 Antioxidant activity

The scavenging activity of snail mucin and the LS1 and LS2 samples was much higher than that of the blank sample, as shown in Table 6. The ability of a substance to neutralize free radicals, which can harm tissues and cells, is measured by its scavenging activity. Antioxidants aid in preventing this kind of damage.
Scavenging activity was at or above 30% in all samples (except the blank) in Table 6. Samples 4, 3, and LS1 had the highest activity, suggesting that LS1, LS2, and snail mucin all have antioxidant qualities. The antioxidant activity of snail mucin increased with its concentration. Sample 2 (50.87%), Sample 3 (75% mucin) 53.67%, Sample 4 (100% mucin) and Sample 1 (25% mucin) all showed 36.79%, 50.87%, and 60.19% of activity, respectively. The lotion sticks exhibited greater antioxidant activity than Samples 1 and 2, with LS1 at 62.28% and LS2 at 56.34%.

Table 6 *Scavenging Activity for the snail mucin Achatina fulica , LS1 and LS2*

Sample	Concentration mucin / lotion stick	Absolute Reading	Scavenging activity (%)
Blank	-	0.859	-
1	25%	0.543	36.79
2	50%	0.422	50.87
3	75%	0.398	53.67
4	100%	0.342	60.19
LS1	50%	0.456	62.28
LS2	50%	0.412	56.34

*Lotion Stick 1 (LS1) and Lotion Stick 2 (LS2).

Several bioactive compounds, particularly proteins, are responsible for the antioxidant qualities of *Achatina fulica* snail mucin. Snail slime contains antioxidant enzymes that help neutralize free radicals and reactive oxygen species (ROS), shielding cells from oxidative damage. These enzymes include glutathione peroxidase (GPX), catalase (CAT), and superoxide dismutase (SOD). Hydrogen peroxide is converted into

Progress in Engineering Application and Technology Vol. 5 No. 2 (2024) p. 611-621

oxygen and water by CAT, lipid hydroperoxides and free hydrogen peroxide are reduced to water by GPX, and superoxide radicals are broken down into oxygen and hydrogen peroxide by SOD. According to (24,25) these enzymes support the snail mucin's total antioxidant potential. *Achatina fulica* snail mucin contains polysaccharides that are also antioxidants. The dextran AFPS-IB from *Achatina fulica* exhibits significant reducing power and efficient DPPH• and O2-scavenging activity, according to a study by (26).
To summarize, the antioxidant characteristics of *Achatina fulica* snail mucin are attributed to proteins, polysaccharides, and enzymatic antioxidants. Together, these bioactive components scavenge free radicals, stop lipid peroxidation, shield cells from oxidative damage, and raise the snail mucin's overall antioxidant capacity.

3.3 Lotion Stick sensory evaluation.

The lotion stick formulations were made complying with Table 2's formulation. *Achatina fulica* snail mucus and virgin coconut oil (VCO) forms Lotion Stick 1 (LS1), which also contains 17% cocoa butter and 25% beeswax. Using a commercial product containing 96% snail mucin from Cosrx and VCO, 8% cocoa butter, and 32% beeswax, Lotion Stick 2 (LS2) is produced. The final lotion stick products are displayed in Fig.4 below.

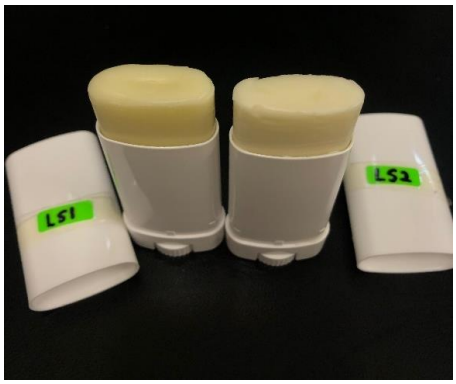

Fig.4 *Lotion Stick 1 (LS1) and Lotion Stick (LS2)*

To assess customer satisfaction with lotion sticks LS1 and LS2, a sensory evaluation was conducted at University Tun Hussein Onn Malaysia (UTHM) in Pagoh, involving 20 respondents. A hedonic scale ranging from 1 (extremely dislike) to 9 (like extremely) was used to rate the lotions on smell, color, oiliness, spreadability, smoothing, absorption, and overall acceptability. The average scores for each attribute are shown in Figure 5 below.
In all categories, LS1 outperformed LS2. The main difference between the two lotions is the amount of cocoa butter and beeswax. Cocoa butter gives a smooth, glossy texture, while beeswax acts as a hardener. Both lotions contained 3% rose oil for scent, but LS1 was preferred, likely due to the influence of cocoa butter. LS1's creamier, more appealing color was favored over LS2's plain white appearance.
LS1 was also preferred for its oiliness, spreadability, smoothing, and absorption. Its oily texture improved skin feel, smoothing, and spreadability, earning a smoothing score of 7.45 compared to LS2's 5.8. LS2's higher beeswax content negatively affected absorption, resulting in a rough texture. Overall, LS1 achieved higher satisfaction, with an acceptability score of 7.45 versus LS2's 5.95.

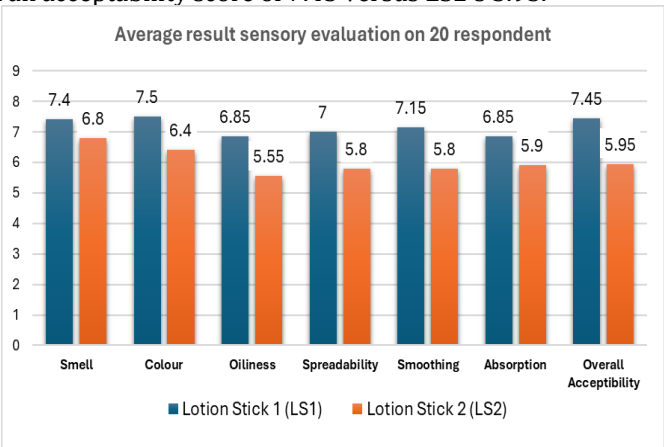

Fig.5 *Chart of average result sensory evaluation on 20 respondents.*

4. Conclusion

This study successfully met its objectives by extracting, characterizing, and applying mucin from *Achatina fulica* snails in lotion stick formulations. extraction methods, including heat and sonication, were used to avoid harming the snails. Extraction conditions were optimized using a RSM identfying, adjusting temperatures, light levels, and time durations. The optimized mucin was analyzed based on the mucin weight produced in mass and concentration of the mucin. The mucin's antioxidant was evaluated as its have biological properties was proved. A lotion stick with *Achatina fulica* mucin and Virgin Coconut Oil (VCO) was created and tested by 20 participants. Lotion Stick 1 (LS1), with more cocoa butter, was preferred over Lotion Stick 2 (LS2) in sensory tests. LS1 demonstrated better spreadability, smoothing, color, oiliness, smell, and overall acceptability. The mucin-infused lotion stick showed strong antioxidant activity, moisturizing, and antimicrobial qualities. In conclusion, *Achatina fulica* mucin can enhance the biological and sensory aspects of lotion sticks, making it a promising ingredient for cosmeceutical products.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Haziq Imran, Aliff Hisyam;* ***data collection:*** *Haziq Imran;* ***analysis and interpretation of results:*** *Haziq Imran, Aliff Hisyam, 'Aisyah Rehan;* ***draft manuscript preparation:*** *Haziq Imran, Aliff Hisyam.*

Appendix A: An Example

Authors including an appendix section should do so before the References section. Multiple appendices should all have headings in the style used above. They will automatically be ordered A, B, C etc.

References

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