American Journal of Microbiological Research, 2024, Vol. 12, No. 3, 51-62
Available online at http://pubs.sciepub.com/ajmr/12/3/3
Published by Science and Education Publishing
DOI:10.12691/ajmr-12-3-3

Development of Two Ointments from Corn (*Zea mays L.*) Silk and Rice (*Oryza sativa*) Hull: Their Phytochemical Compositions, Antibacterial Properties, and Sensory Profiles

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Received June 02, 2024; Revised July 04, 2024; Accepted July 11, 2024

Abstract Agricultural residues have been evident worldwide and can seriously threaten the environment after harvesting crops. This study aimed to develop two organic ointments from corn (*Zea mays L.*) silk (CS) and rice (*O. sativa*) hull (RH) liquid extracts. It quantitatively assessed the extracts' phytochemical compositions and antibacterial properties while the product's sensory profiles were also assessed in addition to commercial ointment (CO). The phytochemical activity was determined in terms of alkaloids, anthraquinones, coumarins, flavonoids, quinones, sterols, tannins, and terpenoids. Also, this study analyzed the zone of inhibition of the liquid extracts and positive control (amoxicillin) against gram-positive *Staphylococcus aureus* and gram-negative *Escherichia coli* bacteria. Meanwhile, the sensory evaluation of the three ointment products was done using a five-point Likert scale questionnaire on 30 healthcare workers within Malaybalay City, Bukidnon. The result of the phytochemical screening showed positive remarks in all five (5) trials on the tests of coumarins, quinones, sterols, tannins, and terpenoids but negative in alkaloids, anthraquinones, and flavonoids. Furthermore, antibacterial analysis showed a susceptible interpretation in the mean zone of inhibition of both extracts and positive control. CS extract has mean inhibition zones of 23.1 mm against *S. aureus* and 10.28 mm for *E. coli* bacteria, while RH extract inhibited 21.57 mm and 15.77 mm, respectively. In addition, the positive control also inhibited 21.33 mm and 16.34 mm. On the other hand, the sensory evaluation in terms of appearance, fragrance, and texture resulted in an overall mean and standard deviation (SD) of 4.48 (SD=0.11), 4.49 (SD=0.37), and 4.54 (SD=0.21) for products CS, RH, and COs, respectively. Thus, all products have a rating of ''very high acceptability (VHA)'' as the means are more significant than the 4.21 (mean > 4.21) rating for VHA interpretation. Moreover, the independent T-test showed a significant difference with p-values of 0.00, 0.03, and 0.03 between the two bacteria tested in CS, RH extracts, and positive control. Subsequently, the One-way ANOVA of the sensory evaluation yielded a p-value of 0.96, indicating no significant difference in the sensory evaluation of the three ointments as it was greater than 0.05 level of significance. These results comprehensively give knowledge about the samples that can be used in future research. To expand the knowledge about these samples, it is recommended that more research and tests be conducted to investigate their efficacy, improve the concentration and safety of the ointments, and achieve better results for commercial use.

Keywords: *Antibacterial, Corn (Zea mays L.) Silk, Kirby-Bauer technique, Ointments, Phytochemicals, Rice (Oryza sativa) Hull, Sensory evaluation*

Cite This Article: John Eljay O. Abdon, Justien P. Abaya, Nikkafeb P. Pepito, and Ian Jay P. Saldo, "Development of Two Ointments from Corn (*Zea mays L.*) Silk and Rice (*Oryza sativa*) Hull: Their Phytochemical Compositions, Antibacterial Properties, and Sensory Profiles." American Journal of Microbiological Research, vol. 12, no. 3 (2024): 51-62. doi: 10.12691/ajmr-12-3-3.

1. Introduction

Agricultural residue in the Philippines has been steadily increasing and is predicted to continue in the coming years [1]. The country's most common agricultural wastes are corn and rice. Corn, scientifically known as Zea mays L., is prevalent in Ukraine and the Philippines with its diverse varieties and adaptability to climates [2,3]. This adaptable plant belongs to the Poaceae family, which has multiple uses for energy, nourishment in biological activity, and medicinal properties, specifically its silk part [4]. On the other hand, RH belonging to the Poaceae family is grown mainly in India, where it occupies the most significant land area and produces the second-highest volume of any crop worldwide [5]. Its hull has substantial nutritional and therapeutic properties and is an essential diet for millions [6].

The Philippines consists of 13 million hectares, divided between food crops, non-food crops, and food grains used for agricultural purposes in this country. Z. mays L. is a major crop that generates large amounts of agricultural residue. It is estimated that the yearly production of grain maize is 4 million metric tons, while that of maize cobs is 0.96 million metric tons [7]. Also, the nation produces 15.2 million tons of rice (O. sativa), leaving behind 11.3 million tons of RH annually, which farmers need to avoid burning in the open following harvest for economic and environmental reasons. For that reason, there is a need to adopt proper approaches to reducing and reusing agricultural waste [8].

Generally, phytochemical screening facilitates the discovery of bioactive compounds used in producing valuable pharmaceuticals and identifying the constituents of plant extracts that predominate over others [9]. These phytochemicals in plants may lead to the discovery of antibacterial agents [10]. Accordingly, bacterial pathogens are among the most severe problems facing medicine today due to their capacity to acquire antibiotic resistance and their variety of colonization and invasion methods [11]. The worldwide problem of increasing antibiotic resistance threatens modern medicine and emphasizes the urgent need for innovative antibacterial treatments. [12] emphasize the severe clinical and financial impact caused by antibiotic resistance, and the global lack of antibiotics can cause a severe problem for millions. In addition to these concerns, customer demand for various products is increasing rapidly. Sensory or organoleptic aspects are essential in maintaining quality standards [13]. Determining which product elements affect consumers' preferences is crucial while considering variations in person-related factors. A more precise description of the sensory perceptions of the product can be obtained by combining this type of data with findings from instrumental measurements and sensory evaluation [14].

Furthermore, humans have used phytochemicals for medicinal purposes, as they help prevent various illnesses, such as bacteria pathogens. It led to the discovery of potent molecules crucial to preventing and treating pathogenic infections [15,16,17]. Highlighting the urgency, [18] stated that developing new classes of antibacterial drugs has the potential to combat the worldwide rise in resistance to reduce the high cost of healthcare and increase patient access to vital treatments. The creation of medicinal ointments can lessen the possibility that bacteria might grow resistant [19], addressing the rising demand for improved wound care amid the increasing incidence of antibiotic resistance [20]. Moreover, sensory properties of the product, such as appearance, fragrance, and texture, are crucial to uphold quality standards and guarantee economic success. It offers a more thorough comprehension of the essential characteristics affecting market success and customer satisfaction, often utilized with other strategies to maximize its potential [13,21]. It also provides input for any necessary improvements and aids in assessing the acceptance and quality of new products [22].

This study aimed to assess the medicinal properties of the liquid extracts of CS and RH, precisely their phytochemical and antibacterial properties. After that, this study developed medicinal ointments from the liquid extracts and subjected them to sensory evaluation, including the prepared CO delimited to appearance, fragrance, and texture only. This study was delimited to the physical features of the prepared ointments and not their efficacy, as the products were not authorized by the Food and Drug Administration (FDA) for safe use. By achieving these objectives, the findings of this study not only supported the benefits associated with the plant but also contributed vital scientific understanding that guided its safe and successful medicinal utilization.

2. Methods

2.1. Research Design

This study utilized quantitative research, specifically experimental design, and strives to develop medicinal ointments made from CS and RH ethanolic extracts. The dependent variables were the various chemicals, bacteria, and respondents. In contrast, the independent variables were the liquid CS, RH, and COs. By employing this research design, the researchers comprehensively understood samples on their medicinal ointment and sensory profile.

2.2. Entry Protocol

Authorization was obtained from different institutions, offices, authorities, and personnel to ensure the study was conducted ethically and professionally.

2.3. Locale of the Study

The collection of samples was conducted in P-2 Simaya, Malaybalay City, Bukidnon, and delivered to the Office of Forest and Welfare Research, Development, and Extension Center (FWRDEC), located in Region 10, Station Office, Sumpong, Malaybalay City, Bukidnon for final identification. Institutions such as San Isidro College, Malaybalay City, Bukidnon, and Central Mindanao University, Maramag, Bukidnon, were also involved in the study's processes, analyses, and formulations. Meanwhile, the locale for collecting CO and sensory evaluation was in Malaybalay City, Bukidnon, due to the availability of products and medical professionals. Moreover, the ingredients for the formulation of ointments were collected online because they were unavailable in the mentioned localities.

2.4. Sampling Procedure

This study utilized purposive sampling to select participants for sensory evaluation. The researchers carefully considered participant selection to ensure that the sample was representative of the population and that the data obtained were valid and reliable.

2.5. Participants of the Study

This study selected 30 medical professionals/other people working in medical facilities aged below and above 40 years old who were involved in the sensory evaluation and voluntarily took part in it. This method was adapted from [23], and a minimum sample size was recommended based on the Central Limit Theorem (CLT) in probability and statistics. Accordingly, healthcare workers advise on or apply preventive and curative measures, promote health to meet individuals' and populations' health needs and expectations, and improve population health outcomes [24]. Having them as participants in the sensory evaluation may help determine the acceptability of the medical ointments. Sensory evaluation will determine the quality and effectiveness of ointments [25].

2.6. Research Instrument

A close-ended survey questionnaire focused on the respondents' sensory perceptions of the sample products was used in this study. The researchers gathered structured survey questions based on readings, findings, and publications relevant to the current study. They connected them to the research questions as it was the typical and convenient technique for collecting data. Furthermore, for the sake of validity, copies of the structured questions for the survey were given to the Capstone teacher for corrections. After validation, the researchers used copies of the structured questions as a survey guide to ensure reliability. The questionnaire for the product evaluation was adapted from the study of [26], in which the data collection of this study utilized a five-point Likert Scale ranging from 5 - 1: 5 for Strongly Agree, 4 for Agree, 3 for Not Sure, 2 for Disagree, and 1 for Strongly Disagree [27].

Table 1. Scoring Procedure for the Participants' Perception of CS, RH, and COs

Mean Rage	Descriptor	Scale	Interpretation
4.20 – 5.00	Strongly Agree	5	Very High
3.40 – 4.19	Agree	4	High
2.60 – 3.39	Not Sure	3	Moderate
1.80 – 2.49	Disagree	2	Low
1.00 – 1.79	Strongly Disagree	1	Very Low

2.7. Collection and Identification of the Samples

The samples were collected manually in P-2 Simaya, Malaybalay City, Bukidnon, and were pre-identified by the researchers. The samples were then brought to the Forest and Welfare Research, Development, and Extension Center (FWRDEC) in Region 10, Station Office, Sumpong, Malaybalay City, Bukidnon, for final identification. The identification process was thorough, examining the macroscopic and microscopic attributes of the sample. Proper identification and classification of the samples were done in consultation with the experts in botany, ensuring that the samples were accurately identified.

2.8. Preparation of the Samples

The samples were rinsed and cleaned with distilled water to remove impurities for this study. The samples were then cut into small pieces using scissors, allowed to sun and air dry for 14 days, and reduced independently using a ceramic mortar, pestle, sieve, and high-speed electric blender. The measurement and drying procedures were repeated once the sample's mass plateaus were sufficiently brittle to be powdered and were carefully stored in airtight glass containers within an environment that was thermally controlled and protected from sunlight throughout this experiment [28].

2.9. Extraction Process

The extraction process was performed according to the method reported by [29] with minor modifications. Two (2) extraction processes were conducted for this study, specifically for CS and RH, using the maceration process. The 200 gm powdered samples were steeped in 98 % ethanol for 72 hours at a room temperature of 4°C, with a ratio of 1:10. The ethanolic-based extracts were filtered out using filter paper and stored in specimen bottles at a temperature of 4°C as suggested by a microbiologist. The ethanolic extracts were then used for the analyses of this study and were not exposed to any other extraction processes in support of [30,31,32,33,34]. Each liquid extract was stored at 50 mL for phytochemical screening. For antibacterial analysis, sample extracts were stored with volumes of 10 mL each and were taken to the College of Veterinary Medicine at Central Mindanao University for analysis. After the positive results, the extracts were used to develop the two organic ointments accordingly.

2.10. Preparation and Implementation of Phytochemical Screening

For this process, ethanolic extracts assessed the secondary metabolites in CS and RH. This means that two different tests were utilized for each metabolite. The materials, methods, and processes used in this study supported the study of [31,32,33].

Test for Alkaloids

Wagner test. A 1.5 mL of hydrochloric acid (HCl) was combined with 1.5 mL of the ethanolic extract, and then two (2) drops of Wagner reagent were added and shaken for 5 minutes. The reddish-brown color change and a precipitate indicated the presence of alkaloids.

Test for Anthraquinones

Two (2) drops of hydrochloric acid (HCl) were added to 1.5 mL of ethanolic extract and shaken for 5 minutes. The color change to red indicated the presence of anthraquinones.

Test for Coumarins

A 1.5 mL of ethanolic extract was added to 1.5 ml of sodium hydroxide (NaOH) and observed for 5 minutes. A color change to yellow indicated the presence of coumarins.

Test for Flavonoids

Five milliliters of dilute ammonia solution was added to 5 ml of extract, followed by conc. H2SO4. The appearance of yellow color indicates the presence of flavonoids.

Test for Quinones

1.5 mL of sulfuric acid was added to 1.5 mL of ethanolic extract for 5 minutes. The color change to red indicated the presence of quinones.

Test for Sterols

A 1.5 mL of ethanolic extract was mixed with 1.5 mL of chloroform and H2SO4 and stirred for 5 minutes. If the chloroform layer was seen to change to red color, and if the formation of the acetic layer showed fluorescent reddish-brown or yellow-green color, then the presence of sterols was confirmed.

Test for Tannins

Ferric chloride test. Two (2) ferric chloride solutions were added to 1.5 mL of ethanolic extract. The color change of the extract to greenish-blue or greenish-black indicated the presence of tannins.

Test for Terpenoids

Salkowski test. To 1.5 mL of ethanolic extract, 2 mL of chloroform was added, the samples were shaken for 5 minutes, and 1 mL of sulfuric acid was added. They were shaken manually, and the changes in each sample were observed. The color change to reddish-brown indicated the presence of terpenoids.

2.11. Preparation and Implementation of Antibacterial Analysis

The antibacterial experiment was performed according to the method reported by [34] with minor modifications. Bacteria *E. coli* and *S. aureus* are the most suitable bacteria for educational settings due to their known zone sizes [35]. The process of antibacterial analysis started by soaking filter paper discs in the extract for 24 hours and preparing a bacterial suspension of the desired bacterial isolate. Subsequently, a loopful of bacterial colonies was added to 9 mL of sterile distilled water, adjusting the turbidity of the bacterial suspension to a 0.5 McFarland standard. The bacterial suspension was also inoculated on Mueller-Hinton agar using the Kirby-Bauer technique. (A sterile swab was dipped into the bacterial suspension and streaked onto Mueller-Hinton agar, ensuring that the bacterial suspension covered all areas of the agar). Furthermore, the soaked filter paper disc was placed on the inoculated Mueller-Hinton Agar alongside the antibiotic disc as a positive control. Care was taken to ensure that each filter paper disc had enough space from the others to avoid overlapping inhibition zones. Additionally, the Mueller Hinton Agar plate was inoculated in an inverted position at 37°C for 24 hours, and the zone of inhibition for each antibiotic or filter paper disc was read and recorded.

2.12. Preparation and Development of Medicinal Ointments

In this study, two (2) ointments were individually developed from CS and RH. The ointment constituents were presented in Table 2 based on the measurements of [30]. During the ointment preparation, the ingredients were weighed and melted under boiling water, gently stirred for 5 minutes at 60° - 70°C until the wax fully melted. Then, the mixture was removed from the heat and settled for 30 seconds. The two (2) liquid extracts of CS and RH were added separately and gently stirred for 5 minutes until homogenous masses were formed. Afterward, the products were stored in an airtight container at a volume of 50 g and left to cool and solidify at room temperature [30,36].

Table 2. Formulations of Ointments on Both Corn (*Z. mays L.*) Silk and Rice (*O. sativa*) Hull Liquid Extracts

Category	Components	Amounts (g)
Active Ingredient	Liquid extract	1
Constituents (Base)	Olive oil	30
	Beeswax	10
Additives	Lavender oil	0.25
	Vitamin E oil	0.25

2.13. Preparation and Implementation of Sensory Evaluation

This study utilized the two developed ointments and CO for sensory evaluation regarding appearance, fragrance, and texture. The product's physical features were only evaluated as it still needed approval from the Food and Drug Administration (FDA) for safety. The CO was bought from a local drug store around Malaybalay City, Bukidnon. Informed consent was obtained from each participant before the survey, and the objectives and reasons for conducting the study were briefly explained. The survey commenced once permission was granted. After the survey concluded, audio files were converted to text-enabled analysis, which facilitated the identification of themes or patterns related to the study objectives. Verbatim transcription of audio and responses was also conducted.

2.14. Data Gathering Procedures

The data-gathering procedure for phytochemical screening included Wagner, Ferric chloride, and Salkowski tests. This analysis used various chemicals such as Wagner reagent, hydrochloric acid (HCl), sodium hydroxide (NaOH), sulfuric acid (H_2SO_4), chloroform, and ferric chloride solution. For antibacterial analysis, this study utilized disk diffusion using the Kirby-Bauer method in an antibacterial test as part of the data collection process. This process required filter paper, distilled water, Mueller-Hinton agar, and petri dishes. Meanwhile, the ointment was developed using the sample extracts, beeswax, olive oil, lavender oil, vitamin E oil, a container, pan, stirring rod, water, stove, and spoon. Also, this study utilized printed survey questionnaires and blue or black pens for the sensory evaluation.

2.15. Data Analysis Procedures

In phytochemical screening, Wagner, Ferric chloride, Salkowski tests, and analyses from other studies were used to determine the presence and absence of secondary metabolites. The data on the inhibition of the liquid extracts after incubation was also gathered for the antibacterial analysis. The zone of inhibition was measured using the Zone of Inhibition Testing, or Kirby Bauer's Test, and the Independent t-test, which helped this study measure the potential of the liquid extracts in preventing the growth of the chosen bacteria. The diameter was measured using a caliper on the underside of the petri dish. On the other hand, the sensory evaluation utilized structured survey questionnaires to obtain data regarding the product's appearance, fragrance, and texture.

2.16. Statistical Treatment

The data gathered from the test were carefully recorded, analyzed, and interpreted accordingly based on the statistical analysis results. The researchers in this study utilized descriptive statistics such as percentage, mean, and standard deviation. One-way ANOVA and Independent sample T-tests were also employed for antibacterial and sensory evaluations. Additionally, the p-value of < 0.05 was taken as a criterion for statistically significant differences in support of [37].

2.17. Ethical Considerations

The researchers handled the confidentiality of any sensitive information acquired, prioritized it and handled the data carefully to preserve its reliability and integrity. Strict security measures were implemented to protect the data from misuse or illegal access. Additionally, all possible conflicts of interest were declared and handled openly to respect the moral guidelines for conducting ethical research. Furthermore, the researchers prioritized every participant's health and safety throughout the study. Lastly, they communicated openly with all pertinent parties, including participants and the school administration.

2.18. Documentation

The researchers photographed the corn (*Z. mays L.*) and rice (*O. sativa*) samples from their natural environment. The photos were taken to document the plants' natural state. Additionally, photos were gathered before, during, and after the study for credibility and validity. These samples have been used for future reference and sharing information about the plant.

3. Results and Discussions

3.1. Phytochemical Analysis

Secondary metabolism is a precise regulator of plant growth and development, which serves as a reserve of essential phytochemicals and shields plants from various environmental constraints [38]. Plant defense against herbivory and other interspecies frequently depends heavily on secondary metabolites. Humans use secondary metabolites as medicines, flavorings, pigments, and recreational drugs. It also created safe and effective medicines as a single compound or combination [39]. Secondary metabolites give plants the ability to quickly recognize herbivore attacks and act rapidly in a pest and environment that is constantly changing.

Furthermore, beneficial natural substances are produced by a plant's secondary metabolism or metabolites. Plants respond to various environmental constraints, which affect plant growth and alter secondary metabolite production [40]. The results of the phytochemical screening of CS and RH liquid extracts were summarized, recorded, and evaluated in Table 3 below.

Table 3. Phytochemical screening of *Z. mays L.* Silk and *O. sativa* Hull Ethanolic Extracts

Extracts	Phytochemicals	Results	Indication
CS	*Alkaloids*	Yellow-green	-
	Anthraquinones	Green	-
	Coumarins	Yellow	+
	Flavonoids	Red	-
	Quinones	Red	+
	Sterols	Reddish-brown	+
	Tannins	Greenish-black	+
	Terpenoids	Reddish-brown	+
RH	*Alkaloids*	Yellow-green	-
	Anthraquinones	Green	-
	Coumarins	Yellow	+
	Flavonoids	Red	-
	Quinones	Red	+
	Sterols	Reddish-brown	+
	Tannins	Greenish-black	+
	Terpenoids	Reddish-brown	+

Legend
+ = Positive
- = Negative

The content showed comprehensive phytochemical screening results with five (5) trials for each phytochemical. The testing of coumarins, quinones, sterols, tannins, and terpenoids in the two extracts demonstrated positive remarks in all five (5) trials that exhibited a result of yellow, red, reddish-brown, greenish-black, and reddish-brown colors, respectively. This indicates that these secondary metabolites are present in CS and RH, which can be a good source of therapeutic drugs and can be used to develop medicinal products such as ointments. These metabolites are present in both extracts because they defend against harmful environmental agents such as pests, pathogens, and UV radiation. They also contribute to the plant's recovery capacity from injuries and diseases.

However, alkaloids, anthraquinones, and flavonoids showed a negative remark with yellow-green, green, and red results. This means that the liquid extracts indicate the absence of these metabolites. It could be due to the extraction method that certain phytochemicals may fail from the final extracts if they favor substances with different polarity or solubility. Also, these particular chemicals may not be present in the extract if the plant naturally has lower concentrations of these substances or if they are primarily located in portions of the plant that were not used.

Accordingly, CS is an excellent source of many bioactive compounds such as volatile oils, steroids, alkaloids, and natural antioxidants such as flavonoids and other phenolic compounds that benefit human health and minerals such as Ca, K, Mg, Mn, and Zn [41]. Additionally, [4] discovered that CS has phytochemical content in polar solvents, higher extraction yields, phenolic acids, flavonoids, ascorbic acid, and cardiac glycosides. [42,43,44] corroborated these findings, reporting high protein, ash, phenolic, and flavonoid content in CS powder, which contributes to its antioxidant activity.

On the other hand, the study by [45] showed that the *O. sativa* hull contains various bioactive components. Significant phytochemicals were found in the sample, including alkaloids (13.07 mg/100 g), phytate (8.93 mg/100 g), glycosides (7.92 mg/100 g), cardiac glycosides (6.57 mg/100 g), flavonoids (5.64 mg/100 g), oxalate (0.63 mg/100 g), carotenoid (0.05 mg/100 g), cyanogenic glycosides (0.05 mg/100 g), and steroids (0.03 mg/100 g). Also, [46] stated that RH exhibits bioactive compounds, specifically flavone glycosides and O-methylated anthocyanidin, which are significantly involved in antioxidant and anti-glioma activities.

3.2. Antibacterial Analysis

The global public health community has been increasingly concerned about antibacterial resistance, prompting the quest for substitute antimicrobial drugs [47,48]. The inhibitory zone diameter CS and RH liquid extracts and treatment on *E. coli*, *S. aureus*, and positive control were summarized, recorded, and measured in Table 4 below.

Table 4. Antibacterial Activity of Corn (*Z. mays L.*) Silk and Rice (*O. sativa*) Hull Ethanolic Extracts and Positive Control (Amoxicillin) Against Gram-positive *S. aureus* and Gram-negative *E. coli* Bacteria

Antibiotic/Extract	Bacteria/ Isolate	Mean zone of inhibition (mm)	Interpretation
CS	*S. aureus*	23.1	Susceptible
	E. coli	10.28	Susceptible
RH	*S. aureus*	21.57	Susceptible
	E. coli	15.77	Susceptible
Amoxicillin (+ control)	*S. aureus*	21.33	Susceptible
	E. coli	16.34	Susceptible

Criteria for Antibacterial Power [34,49]

Range	Antibacterial interpretation
10 - 20 mm	Susceptible
5 -10 mm	Intermediate
5 mm or less	Resistant

Table 4 comprehensively illustrates that both CS and RH liquid extracts, as well as the positive control (amoxicillin), successfully produced zones of inhibition on gram-positive (*S. aureus*) and gram-negative (*E. coli*) bacteria. CS liquid extract has a mean zone of inhibition of 23.1 mm against *S. aureus* and 10.28 mm for *E. coli*. In comparison, RH liquid extract inhibited a mean zone against *S. aureus* of 21.57 mm and 15.77 mm against *E. coli*. In addition, the positive control (amoxicillin) also exhibited a mean zone of inhibition from 21.33 mm against *S. aureus* and 16.34 mm against *E. coli*. The results suggest the potential of these extracts as antibacterial agents, particularly in the development of ointments, supported by their susceptibility to both bacterial strains according to the Kirby-Bauer Disk Diffusion Susceptibility Test Protocol [34,49]. This susceptibility may be attributed to the presence of secondary metabolites in the extracts and the influence of sample preparation on antibacterial activity, emphasizing the importance of understanding the size and weight of antibiotic molecules in determining zone size. Also, sample preparation influences the antibacterial activity of the liquid extract against the bacteria, corroborating the assertion that the zone size may be influenced by the size and weight of antibiotic molecules [50].

Similarly, the study stated that CS extracts showed variable degrees of the inhibitory zone by using the disc diffusion method against tested bacteria. The highest inhibition zone (13.17 and 12.27 mm) was observed in 10.0 mg/ml of ethanol and methanol, respectively [51]. In addition, the in-vitro study of [52] shows a double inhibition effect on *S. mutans* compared with amoxiclav and a significant inhibitory effect compared with commercial gargles.CS extracts were tested for antibacterial activity and showed higher significance than amoxi-clav and commercial gargle against *S. mutans* ($p < 0.05$). However, the results of this study were incongruent with the study of [53], which stated that CS ethanolic extracts have no antibacterial activity against bacterial species (*S. aureus*, *S. pneumonia*, *E. coli*, *P. aeruginosa*, *K. pneumonia*, and *S. pyogenes*).

Meanwhile, results of testing RH extract's antibacterial activity against strains of MRSA and MSSA at various concentrations demonstrated that the extract could stop the growth of bacteria strains, particularly *S. aureus*, at high concentrations—60, 70, and 80 times more concentrated than the concentration of the extraction that is typically found in nature [54]. Similarly, it has been discovered that RH liquid smoke powder inhibits the growth of *Salmonella*, *E. coli*, *S. aureus*, and *B. subtilis* bacteria. This is because the varieties of organic chemicals in RH liquid smoke, such as acetic acid, carbonyl, and phenolic compounds, may suppress certain typical food germs [55].

The potential of rice hull-based materials in antimicrobial applications was investigated by [56]. The former developed a composite sorbent with antimicrobial properties, while the latter produced carbon/silica composites containing silver that demonstrated significant antibacterial activity. Additionally, the antibacterial activity of Rice Hulls-Ag composites can be attributed to their potent bacterial adsorption capacity, which causes the ultrastructure of the bacterial membrane to become disorganized [57]. Moreover, the most effective antibacterial activity against *E. coli*, *K. pneumoniae*, *L. monocytogenes*, *B. subtilis*, and *P. mirabilis* was obtained by combining 10% methanol (MeOH) with dried samples of rice hull that were heated to 100°C for two hours [58].

Notably, the positive control displayed a more susceptible diameter against *S. aureus* than *E. coli*, suggesting that gram-positive bacteria were more likely to be eliminated than gram-negative bacteria due to their distinct structure, which contributes significantly to global morbidity and mortality [59]. Various illnesses, including those carried on by aerobic Gram-positive and Gram-negative bacteria, can be successfully treated with amoxicillin. This medication is generally well tolerated, and the most commonly reported side effects include skin rash and soreness at the injection site [60]. Additionally, it has been discovered that novel prodrugs of amoxicillin are effective against various bacterial strains [61].

The study of [86] showed that the four concentrations of *C. crepidioides* liquid extracts do not exhibit any antibacterial activity against the bacteria *E. coli* and *S. aureus*, suggesting that the bacteria are resistant to the treatment. Also, according to [87], all of the rind extract samples of *A. heterophyllus* had a diameter of 0 mm, indicating that the rind extracts of *Salmonella spp.* and *S. aureus* did not effectively stop their growth. Furthermore, it is stated by [88] that the leaves and root extracts formed from *T. pandacaqui* demonstrated inhibitory actions on bacterial strains of *P. aeruginosa* and *S. aureus*.

Table 5. Participant's Sensory Evaluation of The Developed CS, RH, and COs

Product Evaluation	*Z. mays L.* Silk Ointment		*O. sativa* Hull Ointment		Commercial Ointment	
	Mean & SD	Descriptive Rating	Mean & SD	Descriptive Rating	Mean & SD	Descriptive Rating
Appearance	4.93 ± 0.11	VHA	4.77 ± 0.15	VHA	4.73 ± 0.06	VHA
Fragrance	4.23 ± 0.06	VHA	4.33 ± 0.50	VHA	4.23 ± 0.25	VHA
Texture	4.27 ± 0.15	VHA	4.37 ± 0.42	VHA	4.67 ±0.32	VHA
Overall Mean	4.48 ± 0.11	VHA	4.49 ± 0.37	VHA	4.54 ± 0.21	VHA

Scoring Procedure of the Participants' Perception [27]

Mean Range	**Descriptors**	**Interpretations**
4.21 – 5.00	Strongly Agree	Very High Acceptability
3.41 – 4.20	Agree	High Acceptability
2.61 – 3.40	Neither Agree nor Disagree	Average Acceptability
1.81 – 2.60	Disagree	Low Acceptability
1.00 – 1.82	Strongly Disagree	Very Low Acceptability

3.3. Sensory Evaluation

Since the product's sensory qualities deteriorate before its microbiological quality, sensory evaluation is typically employed to estimate the food products' shelf life [62]. In the study of [63], the Sensory Division of the Institute of Food Technologists (IFT, 1981b) describes sensory evaluation as "A field of science utilized to stimulate, measure, evaluate, and comprehend responses to those features of foods and materials as the senses of sight, smell, taste, touch, and hearing sense them." Evaluating something as "good" or "bad" is not the goal of the review, unlike typical quality judging techniques that employ scorecards. Products with significantly varying sensory attributes but no flaws will receive the same quality score when standard procedures are followed, according to established methodologies [64]. The results of the sensory evaluation of the developed CS, RH, and COs were summarized, recorded, measured, and evaluated in Table 6 below.

The content presents the findings from the study's sensory evaluation of the three products, specifically CS, RH, and COs, where evaluators assessed the mean, standard deviation, and descriptive rating based on the ointments' appearance, fragrance, and texture. The evaluation of the products CS, RH, and COs have overall means and standard deviations (SD) of 4.48 (SD=0.11), 4.49 (SD=0.37), and 4.54 (SD=0.21), respectively, which are more significant than 4.21 (mean > 4.21) rating for VHA. This indicates that there is no difference across the product ratings, and it was perceived as VHA by the evaluators, implying that the three products were accepted in terms of appearance, fragrance, and texture. The result of this study may be due to the ingredients used for the development of the ointments and the bioactive compounds present in the active ingredients, beeswax, olive oil, lavender oil, and vitamin E oil, which makes the products accepted in terms of appearance, fragrance, and texture.

Table 6. Independent Sample T-test Results Between the Two Bacteria at Corn (*Z. mays L.*) Silk and Rice (*O. sativa*) Hull Liquid Extracts and Positive Control (Amoxicillin)

Antibiotic/Extract	Bacteria	Mean	Variance	SD	df	T-crit	P-value
CS	*S. aureus*	23.1	5.81	3.06	3	2.78	0.00
	E. coli	10.28	0.64	0.49			
RH	*S. aureus*	21.57	9.39	3.06	3	2.78	0.03
	E. coli	15.77	0.24	0.80			
+ control (Amoxicillin)	*S. aureus*	21.33	6.33	2.52	3	2.78	0.03
	E. coli	16.37	1.40	1.18			

Significant at 0.05 level

In another study, 50 respondents tested the solid Sumenep Kingdom cream product, and they were provided questionnaires with rating criteria based on the indicators of feeling (smoothness), ease of use (form, performance), and preferences (smell, color). According to the data, the indication of smoothness, shape, and performance impact on the acceptability of Sumenep Kingdom body scrub and scrub cream with a "like" base modified with anionic sodium lauryl sulfate is well-accepted [65]. Furthermore, [66] stated that cohesion, spreadability, and texture were among the sensory characteristics of triamcinolone acetonide ointments that varied depending on their physicochemical qualities. At the same time [67], samples containing 0.4% of the oils were the most favored in a sensory investigation of cosmetic formulations, including essential oils.

As to the findings of [89], meat that was preserved with plant-derived preservatives had an excellent quality rate of 2.88, standard deviation = 0.57, but meat preserved with commercial preservatives had a poor quality rate of 2.22, standard deviation = 0.54. Comparing plant-derived preservatives to commercial preservatives, the study's overall findings show that the former have considerably retained the meat's color, texture, and fragrance.

Moreover, since the study's participants were healthcare professionals and other employees of medical institutions, their focus on product cleanliness matched the commitment to upholding a hygienic atmosphere. Also, hygiene awareness may contribute to a positive sense of cleanliness and job performance among healthcare professionals [68]. Healthcare workers' attitudes are significantly influenced by their moderate knowledge regarding cleanliness and hand hygiene practices [69]. This suggests that each participant's sensory perception differs depending on their level of knowledge.

The study utilized independent sample T-tests to compare the efficacy of liquid extracts from CS, RH, and amoxicillin as a positive control against gram-positive (*S. aureus*) and gram-negative (*E. coli*) bacteria. Based on the table above, significant differences in the zone of inhibition were observed between the two bacteria tested in CS and RH liquid extracts, as well as in amoxicillin, with P-values below the 0.05 significance level. For the CS extract, the mean quality score was 23.1 (SD=3.06) for *S. aureus* and 10.28 (SD=0.49) for *E. coli*, with variances of 5.81 and 0.64, respectively. Similarly, the RH extract showed mean scores of 21.57 (SD=3.06) and 15.77 (SD=0.80), respectively, with variances of 9.36 and 0.34. Amoxicillin, on the other hand, demonstrated a mean score of 21.33 (SD=2.52) for *S. aureus* and 16.37 (SD=1.18) for *E. coli*, with variances of 6.33 and 1.40. All tests had a T-crit value of 2.78, 3 degrees of freedom, and yielded P-values of 0.00 for CS and 0.03 for both RH and amoxicillin, indicating statistical significance. This implies the rejection of the study's null hypotheses for having no significant difference between the two bacteria tested in CS, RH, liquid extracts, and amoxicillin.

The positive result of this study could be due to bioactive components present in both extracts, such as coumarins, quinones, sterols, tannins, and terpenoids, which give them antibacterial solid qualities as proven in the phytochemical screening. These substances have antibacterial qualities that support their ability to disrupt bacterial cellular processes, restrict growth, and show synergistic effects. This could also be attributed to several factors, such as efficiency during extraction, bacterial mechanisms, or penetrating bacterial cell walls.

E. coli and *S. aureus* emerged as the most researched multidrug-resistant strain. Their findings indicated that some plants could be developed as bacteriostatic agents against *E. coli* and *S. aureus* [70]. However, most of these studies remained in vitro, necessitating further applied research. Another study states that the ability of bacteria to become resistant to antibiotics was demonstrated by the finding of penicillin resistance by *S. aureus* in hospitalized patients just a few years after the antibiotic's introduction. Since the first documented cases, *E. coli* resistance to antibiotics has been steadily increasing [71]. As a result of its impact on human health, the [72] has included *E. coli* resistance, along with the other members of the *Enterobacteriaceae* family, on its list of the 12 families of bacteria that pose the greatest threat to human health.

In the study by [73], inhibitory action was observed across all tested UTI bacteria from the lowest concentration, with *P. mirabilis* displaying the highest zone of inhibition, followed by *K. pneumoniae*, *E. coli*, and *S. aureus*. Similarly, CS extracts were also found efficient against *E. coli*, *S. aureus*, and *P. mirabilis* by [74], while [75] demonstrated their effectiveness against *K. pneumoniae*. Meanwhile, [54] showed that RH extract enhances antibiotic effectiveness and prevents biofilm formation by *S. aureus*, especially methicillin-resistant strains. This was supported by [76,77], who respectively demonstrated the antibacterial properties of carbonized RH and composite sorbents. Additionally, [78] identified two antibacterial compounds in RH that are effective against various microorganisms. Moreover, amoxicillin's antibacterial activity was improved through various strategies, including encapsulation in PCL nanoparticles by [79] against *P. aeruginosa*, *P. mirabilis*, and *S. aureus*, synthesis of specific spectrum action compounds on *E. coli*, *B. subtilis*, and *S. aureus* [80], and development of innovative prodrugs by [61].

Table 7. One-Way ANOVA Result Between the Participant's Sensory Evaluation of The Developed CS, RH, and COs

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.01	2.00	0.00	0.04	0.96	5.14
Within Groups	0.58	6.00	0.10			
Total	0.58	8.00				

Significant level at 0.05

The analysis of variance yielded an F value of 0.04 and an F crit value of 5.14, indicating that F crit > F value. The p-value, on the other hand, has a value of 0.96, which was greater than the 0.05 level of significance ($p < 0.05$). This means that the null hypothesis was accepted for having no significant difference in the sensory evaluation of the developed RH, CS, and COs using a structured survey questionnaire. This also means that all products are qualified for VHA, as the evaluation did not show any significant difference in the perceptions of the evaluators, implying that all products have high physical characteristics.

The lack of significant difference in sensory evaluation scores between the three products could be attributed to several factors. Both CS and RH contain antibacterial properties, specifically *P. mirabilis*, *K. pneumoniae*, *E. coli*, *P. aeruginosa*, and *S. aureus*, with diverse compositions [73,79], which could significantly contribute to these results. Additionally, all products have the same ingredients, which serve as the bases for these ointments. These bases also exhibit antibacterial properties, specifically, *S. aureus*, *S. enterica*, *C. albicans*, *A. niger*, S. *epidermidis*, *E. coli*, and *Proteus spp.* on beeswax, which helped the product have essential properties that were accepted by evaluators [81,82].

In addition, these ointments have additives, namely lavender oil and vitamin E oil, which are responsible for the fragrance and vitamins of the products. [42] claims that aroma and product identification are closely related and frequently have a significant role in consumer preference and purchasing decisions. A product's perceived quality and visual appeal can be improved by its pleasant scent. Furthermore, the most prevalent protector in human skin is vitamin E oil, a moisturizer for the skin's appearance [83]. Thus, the results of the variance analysis could be attributed to these factors as they show the acceptability of the product.

Moreover, a polyherbal ointment was created by [84], and it was discovered that it exceeded standard values for several characteristics, indicating promise for natural products. Crisaborole ointment was shown to be well tolerated when evaluated for its acceptability on sensitive skin areas. This is also significant for individuals with inflammatory skin conditions [85].

4. Conclusions and Recommendations

4.1. Conclusions

Based on thorough analyses and further evaluation of the results and findings of the study, the following conclusions were made:

In regards to phytochemical screening, five (5) of the phytochemicals showed the presence of CS and RH liquid extracts, specifically, coumarins, quinones, sterols, tannins, and terpenoids with colors yellow, red, reddish-brown, greenish-black, and reddish-brown colors respectively. CS and RH extracts contain phytochemicals that offer numerous health benefits. These compounds may promote gut health and are antioxidant and anti-inflammatory. Terpenoids and tannins may also aid in digestion, while sterols can lower cholesterol levels, potentially benefiting cardiovascular health. These phytochemicals may be used in developing new medicinal products or therapeutic agents, offering additional health benefits beyond the essential nutrients. This could appeal to those seeking natural medicines or preventive healthcare options.

The lack of certain phytochemicals in the liquid extracts of CS and RH, specifically alkaloids, anthraquinones, and flavonoids, suggests that their bioactivity and therapeutic potential may be limited. The full spectrum of phytochemical variety in other plant sources might not be present in these extracts because of their unique bioactivities, which could create difficulties when creating products utilizing RH and CS extracts.

Meanwhile, in any of the three trials, the antibacterial analysis of CS and RH, liquid extracts, and positive control (amoxicillin) against the two tested bacterial strains was detectable. This was shown by the presence of zones of inhibition throughout the test samples. It demonstrates that the extracts successfully eliminate or prevent the spread of the mentioned pathogens, meaning that these extracts can be used as a pesticide agent and for the development of antibacterial drugs such as medicines and ointments. This has the potential to improve patient outcomes while altering the field of infectious disease management. This may lead to the conclusion that using organic extracts as antibacterial agents could support environmentally responsible and sustainable solutions across a range of industries, especially those that generate a lot of agricultural residues.

The sensory evaluation delimited to appearance, fragrance, and texture results showed that the formulated CS and RH ointments, as well as a commercial ointment, were interpreted as "VHA" because of their individual overall means score that was greater than 4.21 to be interpreted as VHA. Customers prefer lighter colors and a soothing fragrance, while commercial and formulated ointments emphasize cleanliness and public acceptance. The calming smell and creamy texture of these products also contribute to their appeal and success in sensory evaluation.

Moreover, the independent sample T-test showed a significant difference between the bacteria tested in CS and RH liquid extracts and the positive control (amoxicillin) with p-values of 0.00, 0.03, and 0.03, respectively. CS liquid extracts exhibited larger inhibition zones due to their higher concentration of *maysin*, a naturally occurring insecticidal compound with antibacterial qualities. Furthermore, despite not being as strong as the positive control (amoxicillin), an antibiotic already used to treat bacterial infection, the extracts still had antibacterial solid power.

Furthermore, the study found no significant difference in sensory evaluation between CS, RH, and COs, as the p-value is 0.96, which accepts the study's null hypothesis. They were similar in appearance, fragrance, and texture due to consistent means and standard deviation, producing consistent interpretations throughout evaluations. This could be due to their similar bacterial compositions, processes, and formulations, as well as their likened presence and absence of secondary metabolites. That being said, despite being created from agricultural waste, they still produced the same sensory evaluation among respondents.

4.2. Recommendations

The study recommends a comprehensive investigation of corn and rice plants to explore their potential as antibacterial agents. It suggests using various extraction processes to extract liquid, crude, and solid extracts for analyzing activities like hypertension, antidiabetic, antioxidants, and anti-inflammatory properties. Different solvents such as water, hexane, petroleum ether, diethyl ether, n-heptane, isopropanol, acetone, and Tween 20 are suggested for modifying concentration.

The study also suggests quantitative testing of both liquid extracts to determine the percentage of phytochemicals present and test these on other phytochemicals. Different methods for testing phytochemicals are also recommended to gain a broader understanding of plants' properties and capabilities.

Various methods for assessing plants' antibacterial activity are also suggested, including the MIC assay, MBC assay, time-kill assay, disk diffusion method, broth dilution method, agar dilution method, and E-test. The study should also consider using different gram-negative bacteria and gram-positive bacteria to determine their antibacterial capability.

Future researchers should ensure the safety of the ointments before testing sensory evaluation, not just limiting to appearance, fragrance, and texture across different concentrations. Testing physical physicochemical and biochemical properties associated with the research topic would also provide a more comprehensive understanding of the percentage of antibacterial properties of CS and RH.

Future researchers should consider alternative ingredients for the ointment formulation, such as utilizing not only the silk of corn and hull of rice but also exploring other parts of the plants. Also, using different ingredients such as sunflower wax, hard and soft paraffin, cetostearyl and acetoacetyl alcohol, menthol, camphor, salicylate, wool fat, and coconut oil is highly recommended.

ACKNOWLEDGMENTS

This study extends heartfelt gratitude to all contributors, especially the entire San Isidro College (SIC) and Central Mindanao University (CMU), for their crucial assistance in testing. We also profoundly thank our families for their financial support and unwavering encouragement and express our deepest gratitude to the Almighty for His divine guidance and blessings throughout this research journey.

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