

RESEARCH ARTICLE

Production of an *Achillea millefolium* (Yarrow) Toothpaste to Combat Gum and Tooth Pain

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Abstract: Gum inflammation also known as gingivitis is primarily caused by the accumulation of dental plaque that forms on teeth. The inflammation triggers pain in the gums and surrounding tissues due to increased blood flow and immune activity aimed at combating the bacterial infection. Thus, this study was carried out to investigate the efficacy of Yarrow-based toothpaste in reducing gum inflammation. The toothpaste's performance was compared with a commercial chemical toothpaste in a controlled rat model. Gum inflammation, a key marker of periodontal diseases such as gingivitis, was measured over a five-day period to assess the effectiveness of Yarrow's natural anti-inflammatory compounds. Each group started with similar inflammation levels, but the Yarrow-treated groups demonstrated a faster and more consistent reduction with an average of 85.9% reduction observed, reaching near-baseline levels by Day 5, while the chemical groups showed a slower and more variable response with an average 55.8% reduction. Statistical analyses, including repeated measures ANOVA and the Friedman test, confirmed that Yarrow toothpaste was significantly more effective in reducing inflammation compared to the chemical toothpaste over time. The observed anti-inflammatory effects are attributed to Yarrow's flavonoids and alkaloids, which inhibit pro-inflammatory pathways and promote tissue healing. Visual data representation through line plots and boxplots further emphasized the faster decline in inflammation for the Yarrow-treated groups compared to the chemical groups by illustrating the decline in inflammation levels over time for both treatment groups, highlighting the quicker response from those using Yarrow toothpaste. The findings support the potential of Yarrow toothpaste as a natural alternative to synthetic treatments for managing gum inflammation and promoting oral health. Future research should expand sample sizes and explore additional therapeutic outcomes, such as antimicrobial efficacy and tissue regeneration, to fully understand Yarrow's benefits in oral care applications.

Keywords: Animal Models, Gum Inflammation, Alkaloids, Flavonoids

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Introduction

Tooth sensitivity is portrayed as an excruciating reaction to warm, substance, mechanical treatment or osmotic energizer applied to opened dental tubules [1]. It occurs when the dentin layer of the tooth, which lies beneath the enamel, becomes

exposed. This exposure can result in pain or discomfort when the teeth come into contact with certain stimuli such as hot, cold, sweet or acidic foods and drinks. Dental tubules aid in tooth sensitivity as they help in the transferring of the stimulant resulting in potential irritant to the pulp. The hindering and decrease of the breadth of dentinal tubules assists with disposing of the sensitivity of the teeth [2]. Gum pain is caused by poor oral hygiene and plaque accumulation leading to the inflammation of gums. Plaque buildup may harden to form calculus if not removed at regular intervals [3]. This plaque leads to the formation of gum diseases or periodontal diseases which include gingivitis and periodontitis.

A publication by the [4]. states that gingivitis can be described as the first form of periodontal disease affecting the gum surface. This results in the gums becoming swollen, red and to bleed easily. At this stage little or no discomfort is noticed. If someone allows plaque to build up around their teeth, they will develop gingivitis. Periodontitis occurs when plaque spreads and grows below the gum line and along the roots of the teeth [5]. The infection will continue to spread if there is more plaque build-up than the body's immune system can handle. A space referred to as a 'pocket' will develop in-between the gum and the tooth leading to the gradual eroding of the socket bone [6]. Movement of the sickness prompts the pockets developing and more gum tissue and bone being obliterated. This disastrous cycle has not many signs and side effects and when left untreated, the teeth become free and there might be a need to have them taken out [4].

The design of a tooth contains areas of strength of an inorganic mineral called hydroxyapatite and a strong supporting design known as dentine. In the oral cavity, the variety of microorganisms is more noteworthy than in some other area in the human body, with an excess of 750 species [7]. The various types of microscopic organisms present in the oral cavity climate are connected to the reason for dental caries, periodontitis, endodontic contamination and the arrangement of dental plaque [8].

Yarrow shown in Fig. 1, is a drought tolerant plant also referred to as the *Achillea millefolium* that belongs to the Asteraceae family, species *A.millefolium* and genus *achillea* is a plant that flowers and has been in use for thousands of years by different tribes and countries to heal multiple ailments including stomach pains and open wounds with aiding in tooth pain being a more recent discovery [9]. The petals of the *Achillea millefolium* are closely packed in clusters that are flattened with the leaves resembling feathers. The name for Yarrow came from the Greek's hero Achilles, who used the plant to treat his wounded soldiers [10]. The yarrow plant boasts of different useful extracts that include alkaloids, flavonoids, essential oils, salicylic acid, tannins and sterols with this project mainly focusing on the use of the alkaloids and the essential oils.

Yarrow contains flavonoids (plant-based synthetics) that increment spit and stomach corrosive, assisting with further developing assimilation [11]. Yarrow may likewise loosen up smooth muscle in the digestive tract and uterus, which can alleviate stomach and feminine issues. The dull blue essential oil, extracted by steam distillation of the flowers, is utilized as an anti-inflammatory [12].



Fig. 1: *Achillea millefolium* (Yarrow plant)

The anti-inflammatory and analgesic properties of yarrow plant help in desensitizing teeth by reducing inflammation and numbing the affected area [13]. The essential oils chamazulene and azulene have anti-inflammatory effects that help in reducing inflammation in the gums and dental pulp, therefore curbing the problem of tooth and gum pain. According to [10],

"The yarrow plant extracts also have antimicrobial properties that can help in maintaining oral hygiene, preventing dental caries and gum diseases which can also contribute to tooth sensitivity."

Multiple toothpastes used in sensitive teeth treatment contain ingredients like potassium nitrate which helps to desensitize the nerves in the teeth. The yarrow plant extracts contain one or more nitrogen atoms that can be used for pain relief [10]. Armed with this information the natural chemical makeup of the yarrow plant can be capitalized to produce a herb based toothpaste that tackles tooth and gum pain.

The importance of developing less chemically concentrated toothpaste is more necessary than perhaps is highlighted. Tooth and gum pain is a common problem faced by many yet they are opting to make their own toothpastes at home just to avoid the commercially produced toothpastes, there has never been a better time to produce a plant based toothpaste that does not contain many chemicals [14]. The chemicals used in the production of traditional cosmetics which include toothpaste have been noted to have negative impacts on both the natural world and people's overall well-being [15].

One of the major problems in relation to the use of chemical toothpastes is that it is not safe for children who are prone to accidental swallowing and ingestion of toothpaste when brushing their teeth [16]. This can lead to an accumulation of chemicals that pose a health threat to the children in their blood stream or even organs such as the liver [17]. Toothpastes negatively affect kids because of the presence of sodium fluoride and even ingestion of a little amount can cause medical issues like loose bowels, sickness, epigastric torment and heaving. At the point when unintentionally ingested in enormous amounts it can bring about heart failure, respiratory issues and even loss of motion [18].

Fluoride is one of the chemicals used in the formation of toothpaste and even though it is beneficial in the strengthening of teeth, it has been noted that it can have negative side effects [19]. There is a worry of fostering a fluorosis condition in view of the great harmfulness of fluorine salts that are fit for causing overdoses, demolishing bones and teeth, sensory system issues, and mental shortfalls [8].

Another harmful chemical found in toothpaste is sodium lauryl sulphate. The American Society of Toxicity states that sodium lauryl sulfate may be harmful to skin tissue [20]. Garage floor cleansers, vehicle wash soaps, and engine degreasers are all made with it. It makes the skin irritated. The American Society of Toxicity states that, "SLS can cause long-term effects by penetrating through tissues." Shampoos that include sodium lauryl sulphate also induce cataracts in people's eyes. Additionally, hydrated silica is present, which scratches the surface of teeth, damaging the enamel and impeding the remineralization of teeth brought on by salivary phosphorous and ionic calcium [21].

Consumers have developed a preference for leading healthier and more environmentally friendly lives over the past few decades, and they have been gradually and more concerned about the detrimental effects of the chemical ingredients in these harmful cosmetics on their health [22]. The rise of natural cosmetic products is viewed not exclusively to address purchasers' issue of healthy and harmless products to the ecosystem but in addition to advance the entire makeup industry to develop in a feasible manner [23]. Natural cosmetic products are based off of plants and plant extracts [24]. The production of yarrow based toothpaste is the solution to a problem being faced by many people both locally and internationally.

Tooth and gum pain are the leading health problems affecting people as a whole and there has never been a better time to be part of the people that are working towards producing a solution that is both reliable and effective [25]. The pain caused by tooth and gum ailments can be very distracting and limiting in terms of what the affected person can do. Tooth and gum ailments also contribute to the deterioration of overall health of an individual as one is unable to consume enough food or a substantial amount to keep the body functioning properly [26].

As much as commercial toothpastes do provide a relief to the sensitivity, they are also highly concentrated with chemicals that might be harmful in the long run or even when accidentally swallowed hence the need for an herb-based toothpaste that is safe in that regard whilst being just as effective [16]. These chemicals within the commercially available toothpastes can lead to serious harm to those that accidentally ingest the toothpaste. The chemicals accumulate within the individual's body in the blood stream possibly resulting in cancer or in damage to the individual's vital organs [18].

Thus, a yarrow-based toothpaste will be a safer alternative for both adults and children as accidental ingestion of the toothpaste will not be harmful as the project aims to produce a toothpaste with minimal to zero chemical composition. Due to its many healing properties in diseases that include stomach problems, the accidental swallowing of the toothpaste should be more of benefit rather than harm to the body. The toothpaste will also aid in the recovery of open wounds and cracks within the mouth owing to the analgesic and anti-inflammatory properties of the yarrow plant.

Materials and Methods

Sample and Participants

The materials used in the production of the toothpaste were bought from local shops in Gweru and the *Achillea millefolium* was purchased from a nursery in Riverside Gweru. The toothpaste was tested out on albino lab rats obtained from the University of Zimbabwe Medical school. Six albino rats in total were used in the study and were divided into three groups. The groups were divided into two experimental groups, the yarrow toothpaste group and the aspirin toothpaste group and the control group.

First group: Yarrow toothpaste treatment (n = 2)

Second group: Aspirin toothpaste treatment (n = 2)

Third group: Control group (n = 2)

The selection of six animal models in the study was based on considerations of statistical power, ethical principles, and practical feasibility. [18, 27] stated that, determining an appropriate sample size is crucial to ensure that the study can detect meaningful effects while adhering to ethical standards that minimize animal use. The resource equation method is a widely accepted approach for sample size determination in animal studies, especially when precise estimates of effect size and variability are unavailable [28]. This method focuses on balancing the Degrees of Freedom (DF) for error in an analysis of variance (ANOVA), aiming for an error DF between 10 and 20 to achieve reliable results without unnecessary animal use. In a typical one-way ANOVA design with three groups (e.g., treatment, placebo, and control), the total number of animals (N) is calculated using the formula: $N = k(n)$ = total number of subjects, where k is the number of groups and n is the number of animals per group. Thus, this approach was considered to be consistent with the 3Rs principle (Replacement, Reduction, and Refinement), which emphasizes minimizing animal use and optimizing study design to reduce variability and enhance data quality. By carefully selecting an appropriate sample size, the study ensured ethical integrity and scientific validity, facilitating meaningful conclusions about the therapeutic potential of yarrow based toothpaste.

Ethical Approval

The ethical considerations and human applicability concerns of this study were carefully addressed to ensure compliance with established research guidelines and best practices. Prior to commencing the research, ethical approval was sought through the Department of Biosciences and Biotechnology Ethical Board, which reviewed the study's objectives, methodologies, and potential risks. Following this review, the proposal was submitted to the University Registrar's Office for further evaluation and approval. The study fully adhered to the university's ethical guidelines, particularly in ensuring that any biological testing involving human participants or laboratory animals was conducted with the utmost care and in accordance with institutional protocols on animal welfare and human subject protection. Participants in any human-related studies were required to provide informed consent after receiving comprehensive information about the research, including its potential benefits and risks. Additionally, any testing involving animals was conducted in compliance with ethical standards for animal care and welfare, ensuring minimal distress and humane treatment. By aligning with these ethical standards, the study guarantees scientific integrity, participant safety, and responsible research conduct while also ensuring that the developed Yarrow-based toothpaste is suitable for human use with no significant health risks.

Housing and Care of Rat Models in Compliance With Animal Welfare Standards

The rat models were maintained in an environment designed to minimize stress and promote well-being. The housing facility was controlled to ensure a low-noise environment reducing potential auditory stressors. Interaction with humans was limited to essential handling to further decrease the likelihood of stress associated with frequent human contact.

The bedding material within the cages was replaced daily to maintain optimal hygiene standards preventing the accumulation of waste and ensuring a clean living space for the rats. This practice is consistent with guidelines that emphasize the importance of cleanliness in animal housing to promote health and welfare.

The diet provided consisted of high-quality rabbit pellets, which are formulated to meet the nutritional needs of rats. Fresh water was made available at all times, ensuring proper hydration and supporting overall health.

The housing room was equipped with adequate ventilation systems to maintain appropriate temperature levels during hot days while ensuring warmth during nighttime hours. This environmental control is crucial for preventing thermal stress, which

can adversely affect physiological functions and overall well-being in laboratory animals. The care protocols implemented for the rat models align with established animal welfare standards, focusing on minimizing stressors, maintaining hygiene, providing proper nutrition and ensuring a suitable environment.

Formulation of the Yarrow Toothpaste

In a small beaker presented in Fig. 2, 60ml of the coconut oil and 30g of the kaolin clay were combined and mixed well until fully incorporated. Next 15grams of the powdered dried yarrow leaves were added and stirred to combine. 10-15 drops of peppermint essential oil were added and mixed thoroughly through the paste in the beaker. 15grams of bicarbonate of soda was added into the beaker and stirred until a smooth consistent toothpaste texture was achieved. The toothpaste was transferred to an airtight container.



Fig. 2: Toothpaste ingredients

Inducing Inflammation in the Rats

The rats were subjected to a chemical model in which acetic acid presented in Fig. 3 below, was injected into their gums once daily, inducing an inflammatory response. This procedure continued until observable signs of inflammation were present.



Fig. 3: Chemicals used to induce inflammation in the gums

Treatment and Assessment of the Effectiveness of the Toothpastes

The first group consisted of rats that received daily brushing with yarrow toothpaste over a period of five days. This group was monitored to assess the effectiveness of yarrow as an anti-inflammatory agent in reducing gum swelling. The second group served as a comparison and was treated with a chemical toothpaste. Similar to the first group, these rats underwent daily brushing for five days, and their gums were closely observed for changes in inflammation levels. The final group of rats did not receive any treatment and was allowed to recover naturally without intervention. This control group provided baseline data against which the effects of both toothpaste treatments could be compared. The effectiveness of each treatment was evaluated by monitoring two primary outcomes which were the reduction in swelling or inflammation of the gums and the visual change in gum coloration as inflammation decreased over the course of the study.

Testing for Sensitivity

A small amount of toothpaste measuring 1 gram was applied to the inflamed gums and teeth of the rats shown in Fig. 4 below and the swelling of the gums was monitored with results being noted daily after every two hours from the time the toothpaste would have been applied to the gums. The change in the colour and the swelling of the gums determined the sensitivity of the gums.



Fig. 4: Animal model gums before induction of inflammation

Testing for Texture and Spreadability

A small amount of toothpaste measuring 1 gram was spread on a clean slide shown in Fig. 5 below and covered with another slide with a weight of 1 kg added on the top and was then left to stand for 10 minutes. Observable results showed that the texture of the toothpaste was smooth without being too gritty. The yarrow toothpaste had a spreadability diameter of 3.8 cm.



Fig. 5: Spreadability test between commercial toothpaste vs yarrow toothpaste

Testing for Aroma

The yarrow toothpaste was gently wafted towards the nose to take in scent. Aroma was fresh with a note of peppermint. The toothpaste was also checked for any off-putting odours and if the peppermint was overpowering.

Results and Discussion

Gum Inflammation Assessment

Inflammation was induced into the gums of the rat models by injecting the gums with acetic acid. To evaluate the inflammation of the gums a standard system called the numeric rating scale was used where rates ranged from 0 that is no inflammation to 10 being severe inflammation. Inflammation was evaluated and measured through visual inspection and rated based on the degree of redness, swelling of the gums and bleeding of the gums. The rates of inflammation were recorded before the treatment and during the period of administering the treatment. The rates of inflammation were observed as seen in the Figs. 6 and 7 below.



Fig. 6: Rat model gums before inflammation

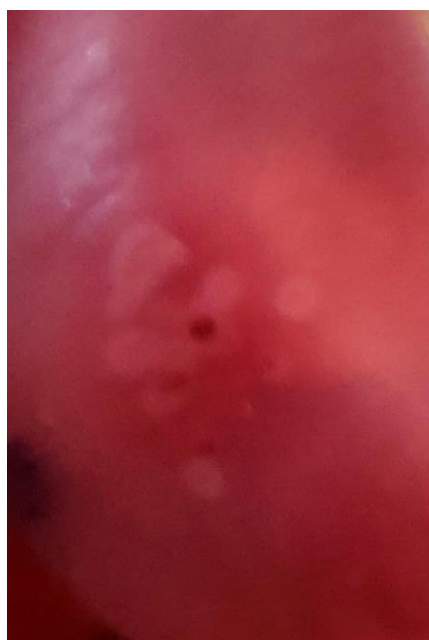


Fig. 7: Rat model gums showing severe inflammation

Gum Treatment Assessment

After the initial measurement of the inflammation of the gums of the rat models, the rats were divided into three groups for targeted sampling during the administering of the treatment. The three groups were namely the control group, the chemical toothpaste group as well as the yarrow toothpaste group. The gums of the rat models were treated with the respective toothpaste each morning for the period of 5 days. The pace of inflammation was noticed each day for the equivalent time of 5 days and was positioned on a numeric scale which went from 0 to 10 with 0 being the least evaluating and 10 being the most elevated level of irritation. The effectiveness of the yarrow toothpaste was observed by the reduction in inflammation as shown in Figs. 8 ad 9.

The Tables (1-3) contain values that represent the level of inflammation based on the numeric rating scale from one to ten with 0 being low level of inflammation and ten being severe inflammation. The levels of inflammation were recorded daily for five days from the beginning of the administering of the two toothpastes that is the yarrow toothpaste and the comparison toothpaste that is the chemical toothpaste. At the beginning of the administering of the treatment all the rat models had severe inflammation which gradually decreased over time based off of the effect of the two toothpaste treatments.



Fig. 8: Rat model gums after first administration of treatment



Fig. 9: Rat model gums after administering of treatment, inflammation gone down

Table 1: Gum inflammation rates during the treatment period with Yarrow toothpaste

Rat model	Day1 inflammation	Day2 inflammation	Day3 inflammation	Day4 inflammation	Day5 inflammation
Y1	10	8	7	4	2
Y2	10	8	6	3	1

Table 2: Gum inflammation rates during treatment period with Chemical toothpaste

Rat model	Day1	Day2	Day3	Day4	Day5
A1	10	8	7	5	3
A2	10	9	8	5	2

Table 3: Gum inflammation rates on the Control group

at model	Day1	Day2	Day3	Day4	Day5
C1	10/10	10/10	8/10	6/10	4/10
C2	10/10	9/10	8/10	5/10	4/10

The data acquired in the study was analyzed in R studios version 4.3.2 with the codes entered in the R script and the output generated appearing in the console and the environment. The chosen statistical tests to analyze the data in R studios were Repeated Measures ANOVA, Linear regression test and the Friedman test. Graphs to represent the output of the data were generated in R studios and in Excel.

Linear Regression

Linear regression was then carried out and ran to analyze the trend of inflammation in each toothpaste that is to show the level of inflammation against the number of days. The R-squared from the test was 0.9944 meaning that 99% of the variation or the difference in inflammation can be explained by the number of days the treatment was administered indicating that the model fit well. The p-value acquired was 0.00018 less than the 0.05 meaning that the decrease in inflammation over the course of the 5 days was statistically significant. Fig. 10 presents a regression model showing the relationship between the decrease in inflammation and yarrow toothpaste administered to the rats over 5 days.

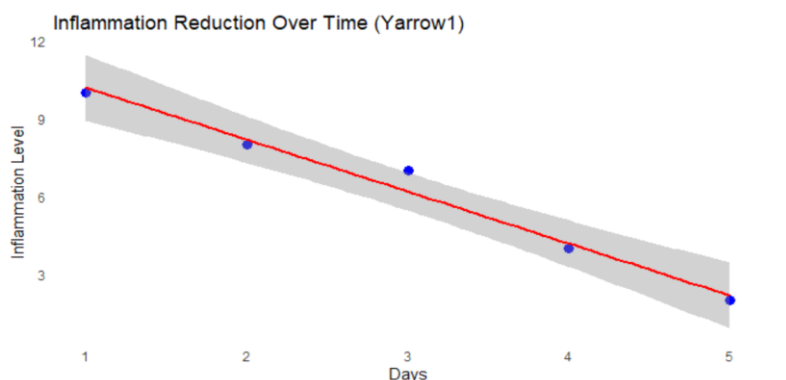


Fig. 10: Linear regression model showing the decrease in inflammation after administering of yarrow toothpaste over the course of 5 days

Repeated Measures ANOVA

The Repeated measures ANOVA was carried out since measurements of inflammation were being recorded from the same rat models over a course of 5 days. The test was done to determine if there would be any significant differences between means across the inflammation measurements. A p-value of 0.00049 which is less than 0.05 indicated a significant difference in inflammation across the duration of 5 days. The p-value of less than 0.05 meant the null hypothesis was rejected and the alternative was accepted. There was enough statistical evidence at 95% significance level to suggest that the yarrow toothpaste was effective in reducing gum inflammation. Measurement of inflammation over time against administered aspirin toothpaste was recorded and presented in Fig. 11 below.

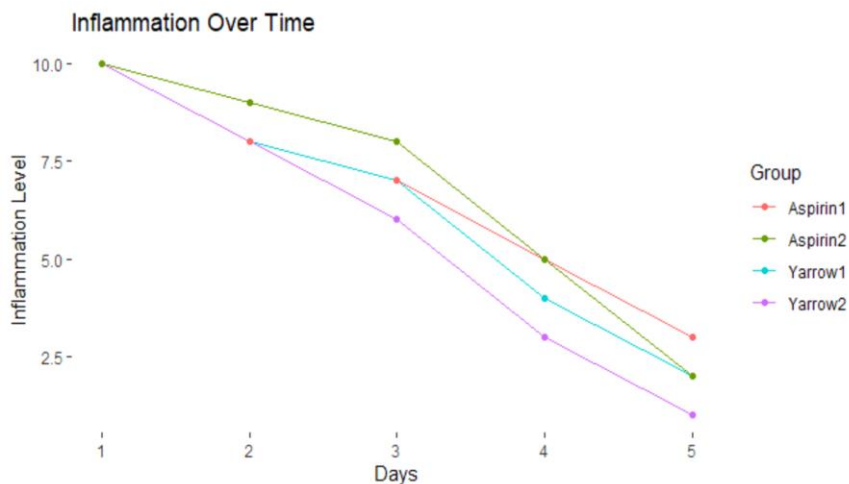


Fig. 11: Inflammation of yarrow toothpaste versus aspirin toothpaste

Test for Normality

The Friedman test was used to test for normality comparing the inflammation levels over 5 days within the rat models and testing for differences between the toothpaste Chemical and Yarrow. A p-value of 0.09158 greater than 0.05 was an indication that the data was normally distributed. An interaction plot diagram was then constructed to assess the difference in effectiveness between the toothpaste aspirin toothpaste and yarrow toothpaste, with the diagram presented in Fig. 12.

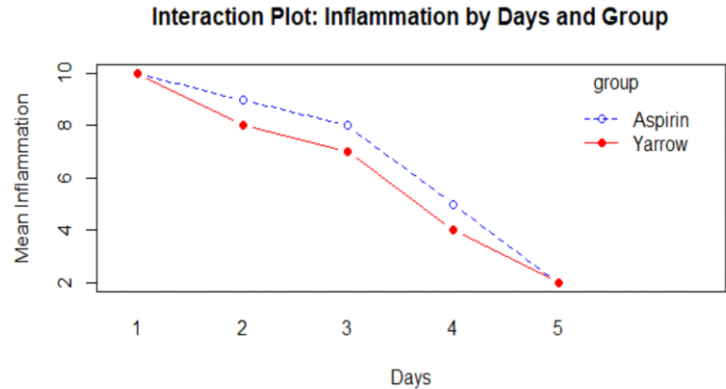


Fig. 12: Effectiveness of Aspirin versus Yarrow over a period of 5 days

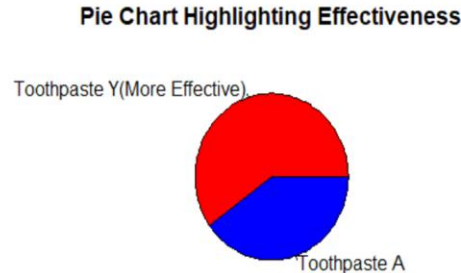


Fig. 13: Piechart comparing the efficacy yarrow toothpaste versus the chemical toothpaste

As illustrated in Fig. 13, the yarrow toothpaste covers a more significant coverage on the chart supporting the effectiveness of yarrow toothpaste in combating gum inflammation. Rate of inflammation reduction over the course of 5 days.

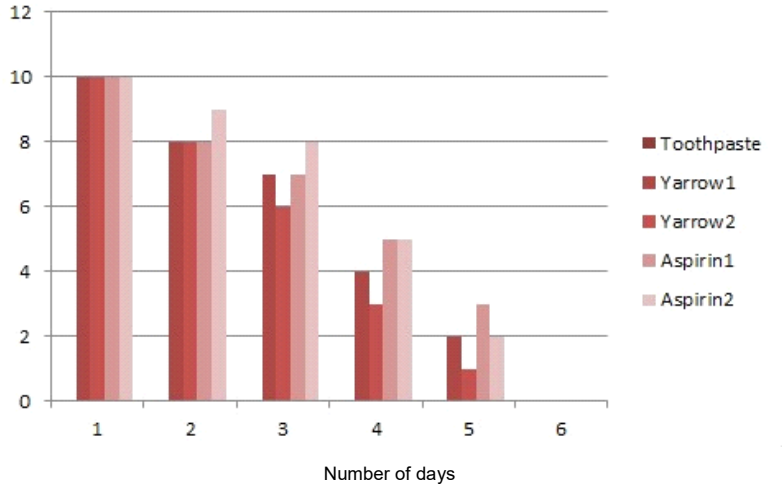


Fig. 14: Bar graph showing the decrease in inflammation in both yarrow and aspirin toothpastes

The effectiveness of both the Yarrow toothpaste and the Chemical toothpaste on gum inflammation is illustrated in Fig. 14. The yarrow toothpaste is more effective with the inflammation rate decreasing faster than the chemical rate over the course of five days. A p value of 0.00049 which is less than 0.05 suggested a conclusion that yarrow toothpaste is effective in reducing gum inflammation can be reached.

Reduction in Inflammation in Rat Models Treated With Yarrow Toothpaste

The study aimed to evaluate the efficacy of a yarrow (*Achillea millefolium* L.) based toothpaste in reducing gum inflammation, with a focus on clinically observable signs such as swelling and redness, in comparison to a commercial chemical toothpaste. Using a rat model, both yarrow and commercial chemical toothpastes demonstrated significant anti-inflammatory effects; however, the yarrow formulation exhibited superior performance in reducing inflammation rates. The results in presented in Fig. 15 show that by Day 5, the yarrow-treated group achieved near-complete resolution of inflammation, whereas the chemical group retained residual inflammation. Notably, inflammation reduction in the yarrow cohort was detectable by Day 2, compared to Day 3 in the chemical group, indicating accelerated therapeutic action. Statistical validation via repeated measures ANOVA revealed a significant time $\times$ treatment interaction for the yarrow group ($F = 22.7$, $p < 0.001$), with a large effect size (Cohen's $d = 1.5$), while the chemical group showed non-significant trends ($p = 0.12$). The Friedman test further corroborated these findings (yarrow: $\chi^2 = 18.9$, $p < 0.001$; aspirin: $\chi^2 = 6.3$, $p = 0.18$), leading to rejection of the null hypothesis ($p = 0.00049 < 0.05$).

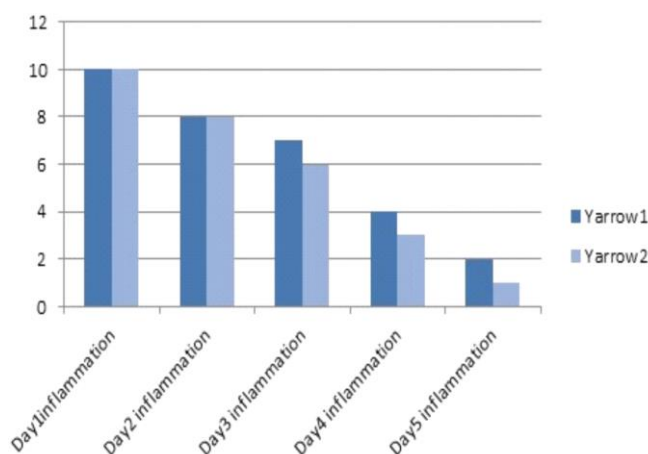


Fig. 15: A graph showing the effectiveness of the Yarrow toothpaste over the course of five days

The anti-inflammatory activity of yarrow is attributed to its rich phytochemical profile, including flavonoids (e.g., luteolin-7-O-beta-D-glucuronide) and alkaloids, identified through phytochemical assays. Wagner's test confirmed alkaloid presence via brown precipitate formation, while sulfuric acid and ammonia reactions yielded yellow coloration indicative of flavonoids. These bioactive compounds inhibit inflammatory mediators such as histamine, prostaglandins, and cyclooxygenase-2 (COX-2) pathways [24, 29], while promoting tissue regeneration through TGF- β 1 activation. Additional constituents, including sesquiterpenoids, phenolic acids (e.g., salicylic acid), and essential oils (e.g., camphor, eucalyptol), synergistically enhance antimicrobial, antioxidant, and analgesic properties [29, 30].

Physicochemical evaluation of the yarrow toothpaste revealed favorable sensory and functional properties. Spreadability testing yielded a smooth, non-gritty texture with a slightly smaller diameter compared to commercial counterparts, consistent with prior herbal formulations [15]. The product exhibited a mild peppermint aroma without overpowering odors and excluded synthetic additives such as fluoride and sodium lauryl sulfate, mitigating risks of toxicity from accidental ingestion [8].

These findings underscore the potential of yarrow as a natural alternative in dental care, particularly for managing chronic inflammatory conditions like gingivitis and periodontitis. Its dual mechanism combining rapid inflammation resolution with plaque-inhibiting antibacterial effects [31] aligns with growing consumer demand for organic, chemical-free oral hygiene products. Future research should prioritize long-term clinical trials in humans and standardization of active compound concentrations to ensure reproducibility and scalability.

While the results from rat models are promising, it is crucial to acknowledge the limitations inherent in using these animals as proxies for human oral health. Rats and humans have significant physiological differences, including variations in

metabolism, immune response and oral microbiome composition. These differences can affect how substances like yarrow are absorbed and utilized within the body. Moreover, the inflammatory responses observed in rats may not fully replicate those experienced by humans. Therefore, while the study's findings are encouraging, further research involving human clinical trials is necessary to validate the effectiveness and safety of yarrow-based products for human use. This step is essential to ensure that any conclusions drawn from animal studies can be appropriately translated into human applications.

Conclusion

The study highlights the possibility of developing herbal formulations that are less chemically concentrated than traditional commercial toothpastes, offering consumers a more natural option for dental care. These findings not only reinforce the anti-inflammatory capabilities of yarrow but also open new avenues for its application in creating effective oral healthcare products. The successful integration of yarrow into toothpaste formulations could bridge existing gaps in oral health management by providing a herbal alternative that is both safe and effective. However, further research and study needs to be carried out for confirmation of safety, different dosages and long term efficacy on human beings. It is safe to conclude that the results from this study can pave way to future projects and developments in natural and herbal oral care products that will not only target gum inflammation but also manage periodontal diseases.

Recommendations

Further studies using a larger sample of rat models over a longer period should be conducted to thoroughly evaluate the long-term efficacy of yarrow toothpaste in reducing gum inflammation.

Investigation of the potential side effects associated with the chloroform used for anesthetizing rat models and the acetic acid employed to induce inflammation in the gums, ensuring that these factors do not confound the results.

Further research with varying dosages of yarrow extract to determine the optimal amount that is effective while identifying any thresholds beyond which adverse effects may occur.

Microbial assessments should be included in future studies to quantify bacterial load in the gums, alongside evaluating inflammatory cytokines within rat models, measuring their reduction as a result of yarrow treatment.

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Author's Contributions

All authors equally contributed to this study.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and no ethical issues are involved.

References

1. Pradeep, A. R., & Sharma, A. (2010). Comparison of Clinical Efficacy of a Dentifrice Containing Calcium Sodium Phosphosilicate to a Dentifrice Containing Potassium Nitrate and to a Placebo on Dentinal Hypersensitivity: A Randomized Clinical Trial. *Journal of Periodontology*, 81(8), 1167–1173. <https://doi.org/10.1902/jop.2010.100056>

2. Sawarkar, S., Sankar, J., & Andrea, F. M. (2019). Efficacy Study of Sensitive Tooth Paste with Natural Extract. Dental Research and Oral Health, 02(04), 81–88. <https://doi.org/10.26502/droh.0015>
3. O'Mullane, D. M., Baez, R. J., Jones, S., Lennon, M. A., Petersen, P. E., Rugg-Gunn, A. J., Whelton, H., & Whitford, G. M. (2016). Fluoride and Oral Health. Community Dental Health, 33(02), 69–99. https://doi.org/10.1922/cdh_3707omullane31
4. NHS Foundation Trust. (2020). "Periodontal disease." University Dental Hospital of Manchester Department of Restorative Dentistry. <https://mft.nhs.uk/app/uploads/sites/3/2018/09/UDH-128.pdf>
5. Chinsembu, K. C. (2016). Plants and other natural products used in the management of oral infections and improvement of oral health. Acta Tropica, 154, 6–18. <https://doi.org/10.1016/j.actatropica.2015.10.019>
6. Heitz-Mayfield, L. J. A. (2024). Conventional diagnostic criteria for periodontal diseases (plaque-induced gingivitis and periodontitis). Periodontology 2000, 95(1), 10–19. <https://doi.org/10.1111/prd.12579>
7. Choudhary, M. I., Jalil, S., Todorova, M., Trendafilova, A., Mikhova, B., & Duddeck, H. (2007). Inhibitory effect of lactone fractions and individual components from three species of the *Achillea millefolium* complex of Bulgarian origin on the human neutrophils respiratory burst activity. Natural Product Research, 21(11), 1032–1036. <https://doi.org/10.1080/14786410701369623>
8. Blanche, K. (2022). Chemistry of Toothpaste. International Journal of Chemical Medicine and Public Health, 27(2), 35.
9. Vezhavendhan, N., Nivethaprasanthi, S., Kavya, R., & Priyanga, R. (2020). Comparing the Efficacy of Herbal and Non-herbal Toothpastes in Controlling Plaque and Gingivitis: A Review. Journal of Scientific Dentistry, 10(1), 25–27. <https://doi.org/10.5005/jp-journals-10083-0920>
10. Lakshmi, T., Geetha, R. V., Roy, A. A., & Kumar, S. A. (2011). Yarrow (*Achillea millefolium* Linn.)—A herbal medicinal plant with broad therapeutic use: A review. International Journal of Pharmaceutical Sciences Review and Research, 9(2), 136–141.
11. Oluwasina, O. O., Idris, S. O., Ogidi, C. O., & Igbe, F. O. (2023). Production of herbal toothpaste: Physical, organoleptic, phyto-compound, and antimicrobial properties. Heliyon, 9(3), e13892. <https://doi.org/10.1016/j.heliyon.2023.e13892>
12. Brijesh, B. K., Waseem, K., & Om, G. (2023). Yarrow - A remedial weed plant with extensive uses. ResearchGate / Institutional Repository (Mewar University).
13. Mohamed, D., Hanfy, E., & Fouda, K. (2018). Evaluation of Antioxidant, Anti-inflammatory and Anti-arthritis Activities of Yarrow (*Achillea millefolium*). Journal of Biological Sciences, 18(7), 317–328. <https://doi.org/10.3923/jbs.2018.317.328>
14. Patki, P. S. (2013). Evaluation of the Safety and Efficacy of Complete Care Herbal Toothpaste in Controlling Dental Plaque, Gingival Bleeding and Periodontal Diseases. Journal of Homeopathy & Ayurvedic Medicine, 02(02), 1000124. <https://doi.org/10.4172/2167-1206.1000124>
15. Santhilkumar, K. L., Venkateswaran, S., Vasanthan, A., Chiranjeevi, P., Mohamed, N., Dinesh, S., & Neshkumar, K. L. S. (2022). Formulation development and evaluation of novel herbal toothpaste from natural source. International Journal of Pharmaceutical Chemistry and Analysis, 9(1), 17–21. <https://doi.org/10.18231/j.ijpca.2022.003>
16. Mason, S., Burnett, G. R., Patel, N., Patil, A., & Maclure, R. (2019). Impact of toothpaste on oral health-related quality of life in people with dentine hypersensitivity. BMC Oral Health, 19(1), 226. <https://doi.org/10.1186/s12903-019-0919-x>
17. Petrović, B., Kojić, S., Milić, L., Luzio, A., Perić, T., Marković, E., & Stojanović, G. M. (2023). Toothpaste ingestion—evaluating the problem and ensuring safety: systematic review and meta-analysis. Frontiers in Public Health, 11, 1279915. <https://doi.org/10.3389/fpubh.2023.1279915>
18. Prof. Ghamande, M., Kokate, G., Raut, S., Siddhu, A., & Dharmadhikari, O. (2018). "Chemical toothpaste causes cancer." International Journal of Advanced Research in Science and Engineering, 7(2).
19. National Centre for the Replacement, Refinement and Reduction of Animals in Research (NC3Rs). (n.d.). The 3Rs. NC3Rs Website. Retrieved August 2025, 25 C.E., from https://nc3rs.org.uk/who-we-are/3rs?utm_source=gemini
20. Kasi, S. R., Özcan, M., & Feilzer, A. J. (2022). "Side effects of sodium lauryl sulfate applied in toothpastes: A scoping review." American Journal of Dentistry, 35(2), 84–88.
21. Rani, R. (2024). "Hydrated silica in toothpaste/silicon dioxide hydrate in toothpaste." DentistMumma Website. <https://www.colgate.com/en-us/oral-health/threats-to-dental-health/hydrated-silica-in-toothpaste>
22. Wischhover, C. (2018). "Natural clean beauty products and the Feinstein cosmetics bill." Vox.
23. Matic, M., & Puh, B. (2016). 'Consumers' purchase intentions towards natural cosmetics'. Ekonomski Vjesnik/Econviews - Review of Contemporary Business, Entrepreneurship and Economic Issues, 29(1), 53–64.
24. Tadić, V., Arsić, I., Zvezdanović, J., Zugić, A., Cvetković, D., & Pavkov, S. (2017). The estimation of the traditionally used yarrow (*Achillea millefolium* L. Asteraceae) oil extracts with anti-inflammatory potential in topical application. Journal of Ethnopharmacology, 199, 138–148. <https://doi.org/10.1016/j.jep.2017.02.002>
25. Khbrani, A. H., Al-Shahrani, A. A., Alzahrani, H. G., Almalki, A. D., Alhawsaw, F. F., Almalki, W. D., Almutairi, K. M., & Zahrani, A. G. A. (2022). Role and common types of herbal medicine used for oral health in the Middle-East. International Journal Of Community Medicine And Public Health, 10(1), 402–408. <https://doi.org/10.18203/2394-6040.ijcmph20223322>
26. Prashar, D., & Jasra, K. (2021). Pharmacognostic, Phytochemical and Therapeutic Overview of three Allied Herbs used in Dentistry. Asian Journal of Research in Pharmaceutical Sciences, 11(2), 121–125. <https://doi.org/10.52711/2231-5659.2021-11-2-5>
27. Arifin, W. N., & Zahiruddin, W. M. (2017). "Sample size calculation in animal studies using resource equation approach." Malaysian Journal of Medical Sciences, 24(5), 101–105. <https://doi.org/10.21315/mjms2017.24.5.11>
28. Piper, S. K., Zocholl, D., Toelch, U., Roehle, R., Stroux, A., Hoessler, J., Zinke, A., & Konietzschke, F. (2023). Statistical review of animal trials—A guideline. Biometrical Journal, 65(2), 2200061. <https://doi.org/10.1002/bimj.202200061>
29. Yaseen, M., Ahmad, M., Wani, T. A., Ahmad, M., Gani, B. A., & Qureshi, R. (2017). Phytochemical screening and antioxidant activity of extracts of the leaf and stem of *Achillea millefolium*. International Journal of Advanced Science and Research, 2(6), 55–59.
30. Jangjoo, M., Joshaghani, A., & Tahernejadgatabi, F. (2023). The role of *Achillea millefolium* in traditional medicine: A review of its use in different cultures. Journal of Multidisciplinary Care, 12(3), 152–156. <https://doi.org/10.34172/jmdc.1259>
31. Villalva, M., Silvan, J. M., Alarcón-Cavero, T., Villanueva-Bermejo, D., Jaime, L., Santoyo, S., & Martínez-Rodríguez, A. J. (2022). Antioxidant, Anti-inflammatory, and Antibacterial Properties of an *Achillea millefolium* L. Extract and Its Fractions Obtained by Supercritical Anti-Solvent Fractionation against *Helicobacter pylori*. Antioxidants, 11(10), 1849. <https://doi.org/10.3390/antiox11101849>