Processing of an underutilized fruit crop sumac berry from the north-eastern region of India: A Review

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Abstract. Sumac, a native wild fruit crop with over 250 varieties, grows 12-25 feet in sub-tropical to tropical climates with well-drained soil, creamy white blooms, and waxy-coated seeds. *Rhus chinensis* Mill. is a promising natural medicine with health benefits, anti-cancer, anti-inflammatory, antimicrobial, antiviral, and anti-diarrheal properties. Its methanolic extract has reduced kidney stone risk, suppresses bone resorption, and inhibits HIV-1 activity. Evidence suggests that *R. chinensis* contains flavonoids, phenolics, and triterpenoids because of its excellent nutritional profile, and distinctive tangy flavor, *Rhus chinensis* has enormous potential as a niche fruit crop. *Rhus chinensis* Mill. fruits are notably rich in carbohydrates (15.49 ± 1.60%), ascorbic acid (840.45 ± 86.44 μg/g), and minerals like potassium and phosphorus. While the fruit pulp is naturally acidic, processing it into tablets and candies reduces its acidity by 3.70% and 3.68%, enhancing its palatability and potential health benefits. Sumac processing typically adheres to traditional methods, with the berries sun-dried for approximately one week. Additionally, dried fruits, jams, juices, and tea can be made from *Rhus chinensis*. Some difficulties are raising customer awareness, conquering ignorance about cultivation, and adjusting its flavor to Western palates. Breeding programs, post-harvest technology, marketing, and sustainable farming methods are needed to overcome these obstacles.

Keywords: Nutritional; Pharmacological properties; *Rhus chinensis* Mill. Sumac; Underutilized fruit crop; Value addition.

1. Introduction

Sumac is an underutilized indigenous wild fruit crop, which is highly acidic and found in the northeastern regions, for instance, Manipur [1], South Assam, Arunachal Pradesh, and West Bengal [2]. With more than 250 species, the Rhus genus is mainly distributed in warm temperate to tropical areas with full light and well-drained soil that is either acidic or alkaline, “*Rhus chinensis* Mill.” (synonym: *Rhus semialata* Murray/ *Rhus javanica*) is the species belonging to the family Anacardiaceae [1,3] generally known as Chinese sumac [4]. Chinese gall, or nutgall tree, where it is popularly called “Heimang” in Manipur [5]. A sumac tree is a small tree or shrub [4] that grows to a height of 12 to 25 feet, Young shoot, and fruit parts are used and the fruiting season is Dec-April [6], it is known for its creamy white blossoms and waxy-coated seeds. When fully ripe, an individual fruit weighs approximately 16.23 ± 2.66 mg and has a distinct sharp acid taste, it is either orange or red [1]. Sakhr & El Khatib’s et al. (2020) [7] identified malic acid as the sour taste in sumac from *Rhus coriaria* fruit, along with β-caryophyllene, cembrene, and caryophyllene oxide.

2. Anatomical features, and Cultivation techniques

*Rhus chinensis*, a deciduous tree, blooms in summer and matures by October [1,8]. Its leaf rachis exhibits distinct winging along the petiole, displaying a yellowish-white hue, while leaflets ranging from 7 to 13 feature dentate-crenate margins. Female inflorescences generally exceed 25 cm, while their male counterparts measure 30– 40 cm. Anthers and filaments measure either 2 mm or 0.7 mm [9].

*Rhus chinensis* flourishes in diverse environments, including sunny slopes, hill sides, forests, stream sides, and roadsides. Propagation techniques that encompass seed planting, rooting, and softwood cutting [10] ageing seeds for over a year may enhance germination rates in Assam rural communities that combine non-timber forest plants with crops growing *R. chinensis* in villages across upper Assam [8,11,12].

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3. Medicinal importance and Pharmacological properties of *R. chinensis* Mill.

*R. chinensis* emerges as a promising source of natural medicines with diverse applications, research is pivotal for unlocking its full therapeutic perspective and evolving novel safe, and effective for various diseases.

Recent scientific research has been done on *R. chinensis* Mill. has shown assuring health benefits, anti-cancer, anti-inflammatory, antimicrobial, antiviral, and antidiarrheal qualities among other advantageous attributes [1,14,15,16].

A study was done at North-Eastern Hill University (NEHU), Shillong where antiarrhoeal activity of the methanolic extract of *Rhus javanica* ripened fruit (MERJ) in Swiss albino mice. The study indicates *R. javanica* ripe fruit extract has the potential as an antidiarrheal agent, potentially reducing fluid secretion, relaxing intestinal muscles, and combating inflammation [17]. On the other hand, a study conducted by Heirangkhongjam et al. (2021) [18], the study reveals that *R. chinensis* Fruit Pulp (RCFP) organic acid effectively prevents urinary stones, supporting the traditional claim that *R. chinensis* fruit inhibits calcium oxalate (CaOx) crystallization (can result in kidney stones of the most prevalent kind) in vitro. *Rhus chinensis* extracts, particularly (*Rhus chinensis*) RC-1, exhibit anti-HIV-1 properties, effectively suppressing syncytium and HIV-1 p24 antigen production, making them a potential medicinal herb for HIV-1 chemotherapy [19].

Zheng et al. (2022) [20] discovered that the *R. chinensis*. Mill. fruit extract efficiently suppressed the formation of osteoclasts in raw2647 cells among the 14 identified compounds citric acid quercetin myricetin-3-o-galactoside and quercetin-3-o-rhamnoside were identified as potential main active components responsible for inhibiting Osteoclastogenesis (break down bone tissue) these findings indicate the potential of *R. chinensis* fruit extract as a naturally occurring consumable substance. The outcomes of these studies imply that the fruit of *R. chinensis* displays significant medicinal and pharmacological attributes, supported by the research results.

4. Nutritional importance

According to recent methodical research, biologically active chemicals found in *R. chinensis*, such as flavonoids, phenolic, and triterpenoids, have been shown to provide a range of health advantages, including antibacterial, hepatoprotective, anti-inflammatory potential [4].

A comparative study evaluated by Kossah et al. (2009) [21] on the chemical composition of Chinese and Syrian sumac fruits shows significant differences. Chinese sumac had higher ash, protein, fat, and fibre content, while Syrian sumac fruit had more vitamins and essential amino acids. Both species had higher concentrations of organic acids and malic acid, showing they have potential as food ingredients or additives.

A study on the nutritional composition of sumac fruits was conducted on the fresh fruit and found that the 1.80% total ash content, moisture of 10.60 %, crude energy was 147.8 kcal/100g, and acidity of 4.60%. Dried sumac fruits have moisture at 2.43%, [7,22,23].

Nutritional analysis of *R. chinensis* fruits shows seeds with the highest fiber at 25.97%, surpassing pulp, whole fruit, tablets, and candy. The pulp has the highest acidity at 19.94%. Furthermore, food formulations such as tablets (3.70%) and candy (3.68%), derived from *R. chinensis* fruits, demonstrate lowered acidity levels, rendering them promising candidates for promotion as medically valuable products, as discussed in [3,8].
Table 1. Nutritional profiling of Sumac fruit

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Nutritional profiling</th>
<th>Contents</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Macronutrient:</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Protein contents (%)</td>
<td>3.94</td>
<td>[1]</td>
</tr>
<tr>
<td></td>
<td>Carbohydrate:</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Total carbohydrate content (%)</td>
<td>15.49 ± 1.60</td>
<td>[24]</td>
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<tr>
<td></td>
<td>Crude fat or oil (%)</td>
<td>19.68 ± 0.68–20.27 ± 1.33</td>
<td></td>
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<tr>
<td>2.</td>
<td>Micronutrient:</td>
<td></td>
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<td></td>
<td>Vitamin:</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Ascorbic acid (Vit.C) (μg/g)</td>
<td>840.45 ± 86.44</td>
<td>[24]</td>
</tr>
<tr>
<td></td>
<td>Vitamin -A (μg/g)</td>
<td>210.44 ± 5.12</td>
<td>[24]</td>
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<tr>
<td>3.</td>
<td>Mineral:</td>
<td></td>
<td></td>
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<td></td>
<td>Macrominerals:(mg/100g dry weight)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Potassium (K)</td>
<td>452 ± 11</td>
<td>[8,26]</td>
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<tr>
<td></td>
<td>Microminerals:(mg/100g dry weight)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Phosphorous (P)</td>
<td>276 ± 6.56</td>
<td>[8,26]</td>
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<tr>
<td>4.</td>
<td>Phytochemicals: (mg/g dry weight)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>total phenolic content (TPC) (mg GAE/g)</td>
<td>123.52±1.29</td>
<td>[27]</td>
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<tr>
<td></td>
<td>Folin-Ciocalteu Method</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total flavonoid content (mg QE/g)</td>
<td>62.41±1.2</td>
<td>[28]</td>
</tr>
<tr>
<td>5.</td>
<td>Individual Polyphenol Content (mg/100 g):</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gallic acid HPLC analysis</td>
<td>823.34</td>
<td>[8,29]</td>
</tr>
<tr>
<td>6.</td>
<td>Total Antioxidant Capacity (TAC):</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FRAP assay (mM)</td>
<td>4.89±0.68</td>
<td>[30]</td>
</tr>
</tbody>
</table>

7. Organic acid:

<table>
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<tr>
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<th>144,519.7 ± 9 ± 21,651.25</th>
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<tr>
<td>Malic acid (μg/g)</td>
<td>[20]</td>
</tr>
<tr>
<td>Citric acid (μg/g)</td>
<td>135,452.7 ± 8 ± 16,530.37</td>
</tr>
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<td></td>
<td>[20]</td>
</tr>
</tbody>
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8. Other Bioactive Compounds:

<table>
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<tr>
<th></th>
<th>3791.02 ± 490.83</th>
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<tbody>
<tr>
<td>Gallic acid (μg/g)</td>
<td>[20]</td>
</tr>
<tr>
<td>Quercetin-3-O-rhamnoside (quercetin) (μg/g)</td>
<td>3592.77 ± 463.06</td>
</tr>
<tr>
<td></td>
<td>[20]</td>
</tr>
</tbody>
</table>

5. Sumac processing and value-addition

5.1. Processing: *Rhus chinensis* Mill. fruits contain abundant bioactive compounds with diverse potential uses nonetheless it is essential to employ suitable processing methods to extract and safeguard these valuable substances below is an overview of the standard procedures typically employed for processing:

- Harvesting
- Drying traditional method
- sun drying (7 days)
- Cleaning & Sorting
- Extraction
- Purification
- Packaging & storing
- Formulation
- Marketing

![Fig.2. Production stages of sumac.](https://doi.org/10.1051/bioconf/202411002004)
R. chinensis fruits are harvested upon achieving maturity and undergo thorough cleaning to uphold sanitation and quality standards. Consequently, they are subjected to drying processes aimed at minimizing moisture content and mitigating spoilage risks. Following drying, the fruits are pulverized or crushed to form a fine powder or paste, facilitating the efficient extraction of bioactive compounds. The resulting extract is then utilized in the formulation of various products, including capsules, tablets, liquid extracts, and topical formulations. The final products are meticulously packaged and stored.

5.2 Value-Addition:

Chinese Sumac offers a wealth of potential for developing valuable products beyond its traditional uses as a spice and herbal remedy. Its unique composition, rich in antioxidants, vitamins, and other bioactive compounds, opens doors to diverse and innovative product possibilities. Here’s a glimpse into some exciting value-added products derived from Rhus spp.:

According to Khoshkharam et al. (2022) [4], sumac tea is rich in vitamin D and is effective in treating colds, flu, asthma, shortness of breath, diarrhoea, cough, sore throat, and infections. Shimray et al., (2021) [5] conducted a study formulating tea using Rhus chinensis (heimang), such as Rhus chinensis, cinnamon, ginger, tea leaves, and sugar and salt for taste, which will eventually improve the product's quality and provide more benefits for health.

Source: (medicinal plants.co.in/heimang)
Figure 3: Sumac tea

Sumac berry tea, also known as Heimang tea in Manipur, is already available in the market, with startups like Dweller Teas, founded by Elizabeth Yamben, leading the way in promoting this unique local beverage.

Figure 4: Sumac berry tea (Heimang Tea)

A study on sumac gummy candy using pomegranate juice, sumac powder, and other ingredients was carried out by Jamir et al. (2023) [31]. Results indicate that the fruit pulp possess high flavonoid, polyphenol, and antioxidant activity, pointing to R. chinensis fruit as a possible functional food ingredient. The study by Heirangkhongjam et al. (2019) [18] explored the nutritional qualities and physicochemical characteristics of R. chinensis candy and tablet. The tablets were made with dry pulp powder, jaggery, chilli, garlic, black pepper, salt, sugar, and guar gum. The study found high fiber, fat, pulp, and total acidity content it revealed that the pulp of whole fruit, tablet, and candy had the highest total fiber-seed, fat-seed, and acidity content, respectively.

Fig.5: value-added product of Rhus chinensis Mill.
 a). Sumac candy b). tablet

Source: [22]

Dried berries from the Rhus chinensis Mill. plant yield sumac, a valued red spice known for its tangy, citrus-like aroma and flavor. It is celebrated in Middle Eastern culinary traditions for its ability to enhance savory dishes. Additionally, sumac shows potential for health promotion due to its abundant antioxidant phenolics.

In the Sikkim Himalayas, the Nepali community utilizes the juice extracted from R. chinensis fruits, known as bhakmilo-ko-chuk, as a
vital ingredient in traditional recipes consumed at home and marketed locally [33].

6. Future thrust

The future of the Rhus chinensis fruit crop presents a tapestry of opportunities woven with challenges. Despite its long history of medicinal and culinary uses, this unique fruit with its sweet and tangy taste remains largely unknown commercially. However, several factors hint at its potential to emerge as a niche fruit crop with intriguing possibilities.

6.1 Growing consumer demand for exotic fruits

Culinary curiosity, health conscience, and the desire for novel experiences drive a growing global appetite for unusual and tasty fruits. Due to its unique flavor profile and vivid red clusters, Rhus chinensis has the potential to capitalize on this trend by providing an appealing substitute for conventional fruits.

6.2 Rich nutritional profile and potential health benefits

According to studies, Rhus chinensis is a good source of antioxidants vitamin C, and other bioactive substances further investigation into its possible anti-inflammatory anti-diabetic, and antimicrobial qualities may increase its appeal as a functional food.

6.3 Adaptability and Resilience

The potential for future exploration and innovation spans multiple disciplines regarding Rhus chinensis. Utilizing the distinctive traits of this adaptable plant species presents promising avenues for addressing critical environmental issues, enhancing agricultural methodologies, and promoting advancements in human health and wellness.

6.4 Potential for diverse value-added products

Growers’ revenues are increased, and new markets are opened by the versatility of sumac fruits in processing dried fruits, tea, jams, and juices.

6.5 Focus on Research and Development

To properly comprehend the bioactive substances in sumac fruits their modes of action and possible health advantages extensive research is essential. Government agencies, academic institutions, and nutraceutical and pharmaceutical corporations will need to work together on this. Clinical trials are essential to validate the efficacy and safety of sumac fruit-based products before widespread adoption. Companies should invest in well-designed trials that adhere to international standards.

6.6 Government initiative in promotion of this crop

6.6.1 Research funding: Encourage academic and business research partnerships to expand scientific knowledge and create sumac-based products with validated health claims.

6.6.2 Enhance infrastructure: To maximize the Sumac value chain, make investments in the construction of infrastructure for facilities for storage, processing, and cultivation.

6.6.3 Regulations and standardization: To guarantee consumer confidence and safety, establish unambiguous and uniform quality requirements for Sumac products.

6.6.4 Promoting awareness: Increasing consciousness Collaborate with businesses and academic organizations to inform customers about the culinary applications and possible health advantages of sumac fruits.

6.6.5 Cooperation with other countries: Facilitate research collaboration and knowledge sharing with other countries cultivating or studying sumac fruits.

6.7 Challenges and obstacles

Notwithstanding its promise, the sector confronts problems such as adjusting to Western preferences, inadequate commercial infrastructure, and a shortage of information regarding cultivation.

6.8 Outlook: The future of Rhus chinensis as a viable commercial crop hinges on overcoming these challenges through:

6.8.1 Breeding programs: Developing cultivars with improved sweetness, yield, and disease resistance.
6.8.2 Post-harvest Technologies: Refining processing techniques to optimize flavor and shelf life.

6.8.3 Marketing and education: Raising consumer awareness about the fruit's unique qualities and safe consumption practices.

6.8.4 Sustainable cultivation practices: Developing efficient production methods that minimize environmental impact.

7. Constraints

7.1 Limited Availability of High-Quality Plant Material

Wild populations pose challenges in obtaining consistent samples due to geographical dispersion and varying cultivation practices, necessitating the implementation of standardized protocols and quality control measures.

7.2 Incomplete Understanding of Phytochemical Variability

Research on plant material source and diversity often lacks proper description, making comparing and evaluating findings challenging. Standardized procedures are needed for precision and repeatability.

8. Conclusion

R. chinensis Mill. is a crop that holds great potential for use in functional foods and medicines. However, due to its wild origins and lack of standardized research methods, the crop's variability in plant material poses challenges. To fully realize the crop's potential, these challenges must be addressed by establishing consistent cultivation practices and scientific protocols.

9. Acknowledgement

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10. Conflict of Interest

There is no conflict of interest.

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