



Taxonomic, Morphological, Phytogeographical and Medicinal Assessment of *Punica granatum* (Anardana) in Relation to Different Altitudes in District Ramban, UT of Jammu & Kashmir

Balwant Singh¹ #, Prof. Rajesh Singh², Prof. Santosh Kumar Agnihotri¹

1. Department of Botany, Government Model Science College Rewa, (M.P.)

2. Department of Botany, Government V.P.G. College Maihar, Satna (M.P.)

3. Department of Botany, Government Model Science College, Rewa (M.P.)

Abstract

The regions of the Himalayas contain many medicinal and fruit-bearing *P. granatum* L. plants which are known as Anardana. The present study investigates the taxonomic identity, morphological variation, phytogeographical distribution, and medicinal potential of *P. granatum* in relation to altitude in the Ramban district of Jammu and Kashmir, India. The research took samples over three altitude ranges at low zones (600–1000 m), mid zones (1000–2000 m), and high zones (>2000 m) across an area that extends from 600 to 3500 m above sea level. Scientists used specimen analysis, plant observations, and antioxidant tests to study plant shapes and evaluate tannins, flavonoids and antioxidant levels.

In total, Ramban district is home to 93 live plant genera which underscores the region's botanical diversity and wide range of ecological zones. By looking at biodiversity, the role of *P. granatum* as a model species becomes more significant.

Researchers discovered that mid-altitude plant populations produced the greatest number of strong and medicinally powerful fruits with large dimensions and thick rinds. Our tests confirmed that middle-altitude plant samples developed the largest amounts of important secondary metabolites as predicted for the case of

environmental stress-boosting beneficial substance production. Higher numbers of trees grew best in mid-altitude areas because these places had the perfect conditions of temperature, sunlight, and moisture for their needs.

Research findings show that mid-altitude areas need protection to keep the plant population healthy and suggest better growth methods for every habitat level. These findings support better environmental protection efforts while helping doctors develop medicine and the pharmaceutical industry use the plant.

Keywords: Punica granatum, altitude, morphological variation, phytochemical analysis, Himalayan flora

Introduction

Background

For a long period of time, medicinal plants have been a part of traditional health care system whose medicinal values are attributed to bioactive compounds like flavonoids, tannins, alkaloids and phenolic acids. Such plants are heavily used for treatment of different ailments by the superiority systems like Ayurveda, Unani and traditional Chinese medicine. Recently there has been scientific interest in these phytochemicals in modern times when they have been reported to hold pharmaceutical applications especially for their antioxidant, antimicrobial, and anti inflammatory properties (Ashraf et al. 2024).





Figure 1: Floral morphology of *Punica granatum* L. (Anardana)

Anardana or pomegranate (*Punica granatum* L.) is a deciduous shrub which is native to the Middle East, foothills of the Himalayas. India is a home for it in subtropical climates of western Himalayan states especially Kashmir. Its rind and seeds are used in traditional medicine for digestive disorders, cardiovascular problems and as an inflammation. *P. granatum* has high tannin and polyphenols content and strong antioxidant potential, and is used as food as well as medicinal plant.

Punica granatum L. is usually grown as a deciduous shrub near Jammu and Kashmir in the northwest Himalayan regions. Typically, this group is considered to be a family of its own, Punicaceae, because of their leathery-skinned fruits, seeds with a sweet layer called arillate and flower shape. However, breakthroughs in molecular systematics and chloroplast genetic research have reclassified the species within the family Lythraceae, a change now accepted by most global and Indian botanists (Jacob et al., 2019).

Under the order Myrtales, Lythraceae consists of about 32 genera and more than 600 species of flowering plants. In India, the family is represented by several genera including Lagerstroemia, Lawsonia and now Punica. Yan et al. (2019) showed in their study that *P. granatum* belongs in Lythraceae by matching its chloroplast genome with those of other Lythraceae species.

India produces a lot of *P. granatum* and Ayurvedic and Unani medicine have long valued the plant for its antioxidant, anti-inflammatory and digestive benefits. In areas of Ramban in the Himalayas, *P. granatum* grows both in the wild and is included in regular farming activities. Because it is a confirmed member of the Lythraceae, its comparison with other genera in this family can support conservation, breeding and understanding of its phytochemistry throughout India's ecosystems.

Regarding the morphological and phytochemical aspects, environmental factors, and mostly altitude, have a great impact on the medicinal plants. Plants are exposed to different amounts of temperature, UV radiation, moisture availability and soil composition because of the change in elevation. Synthesis of secondary metabolites in these environmental stresses increase the medicinal value of the plant (Jamwal et al., 2022). Studies have shown that high altitude plants usually possess greater phytochemical content, for instance flavonoids and phenolics higher contents are the adaptive responses to extreme environmental conditions (Youssef & Mahgoub, 2015).

However, the medicinal importance of *P. granatum* has not so far been intensively studied regarding how variations in altitude affect its morphological characters and phytochemical profile. The knowledge gap appears more so in Ramban district of Jammu & Kashmir where a variety of altitude settings exist and can serve as natural laboratory for such an investigation.

Phytochemical Group	Methanolic Extract	Aqueous Extract	Ethyl Acetate Extract
Alkaloids	+	+	-
Flavonoids	+	+	-
Tannins	+	+	+
Saponins	+	+	-
Glycosides	-	+	+

Proteins	-	+	-
Sterols & Triterpenoids	+	+	+
Carbohydrates	+	+	-

Table 1: Phytochemical Screening of *Punica granatum* Flower Extracts

Source: (Rashid & Shafi, 2018)

Objectives of the Study

- To assess the taxonomic identity and morphological variation of *Punica granatum* across different altitudinal zones in Ramban district.
- To analyze the phytogeographical distribution patterns of *P. granatum* in relation to environmental gradients.
- To evaluate the medicinal (phytochemical) properties—including tannin and flavonoid content—of *P. granatum* at different elevations, identifying potential altitude-related enhancements in therapeutic quality.

Review of Literature

Pant et al. (2021) analyzed 48 studies in this systematic literature review to see how different environmental conditions influence the production of secondary metabolites (SMs) in medicinal plants. Environmental stresses including light, temperature, salinity and water availability caused changes in SM accumulation of up to 50%. They are species-specific and function of the type and intensity of environmental factors. The findings of this study corroborate the hypothesis that altitude is a complex environmental stressor, which can potentially affect the biochemical profile of a plant such as *P. granatum*, necessitating the site-specific medicinal assessment.

Sekar et al. (2023) assessed species richness, diversity and density of trees in the alpine regions of Western Himalaya (3200–4800 m). The study accomplished polynomial regression and NMDS analysis and found that plant diversity and density significantly ($p < 0.05$) decreased with increasing elevation. CCA also showed that temperature, precipitation, and solar radiation most strongly influenced plant community composition. Such

findings are important as the effect of elevation on species distribution is notified and could potentially create variation in the ecological niche of *P. granatum*.

Bhat et al. (2015) work dealt with morphological and phytochemical variations in *Primula denticulata* at different altitudes in Kashmir Valley. Stomatal density, guard cell size and some secondary metabolites like phenols, tannins and alkaloids differed statistically ($p \leq 0.05$). The confirmation is made possible that phytochemical content is closely dependent on altitudinal variation and that stress conditions can increase or suppress the synthesis of bioactive compounds. This directly supports your research design, since it is your focus to delineate elevation-induced variation in the medicinal profile of *P. granatum*.

Pandey et al. (2019) was on abiotic and biotic stresses on Himalayan medicinal plants. The study also pointed out that increasing temperatures, unusual precipitation, and pest outbreaks are upsetting the production of bioactive metabolites. The climate is expected to warm at higher altitudes. This is most worrying in the case of the Himalayas, which can cause substantial changes to the biochemistry and distribution of plants. The ecological importance of your study is furthered by the fact that you have established that phytochemical traits including tannins and flavonoids need to be evaluated under varying environmental conditions, e.g., altitudinal variation.

Jamwal et al. (2022) said significant changes in the plant height, crown spread, leaf structure and phytochemical content were observed in a two-year investigation of *Justicia adhatoda* in Western Himalayas across altitudes. Plants growing at mid to higher elevations had notably higher phenols, flavonoids and sugars, which imply the condition triggers the adaptive biochemical response. Statistically significant, these results present a sufficient methodological parallel to study yours on *P. granatum* while taking morphological and phytochemical plasticity across altitudinal zones.

Materials and Methods

Study Area

The Ramban district of the Union Territory of Jammu and Kashmir, India, is a wide altitude gradient district with elevation from around 600 to 3500 meters above sea level. The goal of the present study was such a district. Anardana, *Punica granatum* belongs to the Lythraceae family with natural variation in elevation, in this

study, was taken as a study system to elucidate the effect of elevation on morphology and phytochemical properties. To facilitate a systematic sampling and a comparative analysis Generoso and Manzoni (1961) defined three distinct zones according to previous ecological classification: low altitude (600–1000 m), mid altitude (1000–2000 m) and high altitude (2000 m). The study comprised the tehsils of Banihal, Batote, Gool and Pogal Paristan which are at different topographical and environmental conditions. Given that climatic variability from rainfall and temperature, soil composition ranging from sandy loam to clay, and different vegetation types were expected, these were used to stratify the sampling zones effectively.

The 93 live genera that have been identified are found in subtropical, temperate and subalpine zones. Among these are many arboreal species which are more or less thick and rich depending on height, weather and soil composition. Being a small sample of the Himalayan ecosystem, these zones offer an excellent chance to examine differences in plants and study plant chemicals. The large number of documented plant species supports the importance of using *Punica granatum* as the primary study species for measuring effects on shape and medicinal characteristics with altitude.

Elevation Zone	Altitude Range (m)	Dominant Vegetation Type	No. of Genera Reported	Representative Genera
Low Altitude	600–1000	Subtropical broad-leaved	28	Mangifera, Ficus, Punica
Mid Altitude	1000–2000	Mixed deciduous and conifer	38	Quercus, Pinus, Punica, Cedrus
High Altitude	>2000	Temperate and subalpine	27	Betula, Aesculus, Rhododendron
Total	–	–	93	–

Table 2: Representative Genera Across Elevation Zones in Ramban District

Sample Collection

In each of the three elevation zones, between three to five representative sampling sites were selected. At each site, data were collected on 10 - 15 plants of *P. granatum*, chosen randomly in order to represent adequately the natural population at each site. All these plants were tagged and fresh specimens of the leaves, fruits and twigs were collected and used for laboratory analysis. The specimens were pressed, prepared according to herbarium standards then later deposited in the institutional herbarium for future reference and verification of taxonomic identity.



Figure 2: Field collection of Punica granatum (Anardana) specimens in Ramban district, Jammu & Kashmir, showing researcher handling fruiting branches at mid-altitude site (~1000–2000 m)

Morphological Analysis

For each sampled plant, the morphology was carefully recorded. Measurements were made of leaf length and width, fruit diameter, rind thickness, number of seeds per fruit, and total fruit weight from these. All the

measurements were done with digital callipers and electronic balances for the purpose of precision. Informal interviews with local residents and traditional healers were also executed in order to write down vernacular names, indigenous uses, and any knowledge of altitude-based changes of fruit quality and medicinal value.

Phytochemical Tests

The fruit samples were collected, cleaned, and air dried, phytochemicals were extracted and used ethanol and methanol as solvents. The key bioactive compounds, such as tannins, flavonoids and phenols contents, of the extracts were quantified. The DPPH (2,2-diphenyl-1-picrylhydrazyl) assay was used to determine the antioxidant activity. The Folin Ciocalteu method was carried out to measure the total phenolic content and an aluminium chloride colorimetric assay was performed to determine the flavonoid levels. All tests were reproduced and verified in triplicate in order to ensure reproducibility and accuracy.

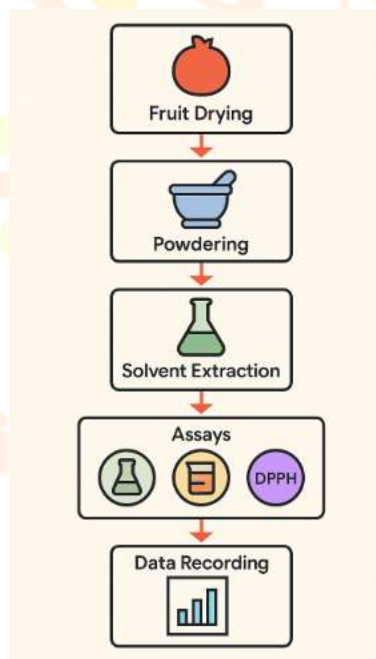


Figure 3: Phytochemical Analysis Workflow

Statistical Analysis

In order to ascertain if the morphological and phytochemical traits of *P. granatum* are significantly affected by altitude, an Analysis of Variance (ANOVA) was performed. Results from the three altitudinal zones were compared and significance was set at $p < 0.05$. Post hoc tests further determined the mean differences where necessary. In this fashion, this analytical approach sheds light on the order of variation and on how ecological influence of elevation on the species under study.

Results and Discussion

Taxonomic Description

The identity of the plant under study was confirmed as *Punica granatum L.* using standard taxonomic keys. The species belongs to Lythraceae and popularly goes by pomegranate and Anardana locally in Jammu and Kashmir. This plant grows as both a bush and a small tree that loses its leaves yearly. Its leaves shine while orange-red funnel-shaped blossoms grow on it. The plant also produces spherical fruits. *P. granatum* benefits medicine and cooking according to traditional plant knowledge. People use it as a treatment option for digestive problems and heart diseases in infected areas. Experts in Unani and Ayurvedic medicine recommend using *P. granatum* peel because it contains tannins and flavonoids for medical purposes.



Figure 4: Flowering stage of Punica granatum at study site, highlighting the characteristic bright red, tubular flowers used for taxonomic identification and morphological analysis.

Morphological Variability

Experts observed size and physical shape differences in *P. granatum* during their measurement trips in Ramban's elevation bands. Fruits from mid-elevation (1000–2000 m) plants show greater size and weight with plus a thick peel containing more seeds than those found at lower and higher altitude areas. Plants from mid-altitudes produced the most commercial quality juicy fruits in their research. High-altitude plants grew slower while making fewer and smaller growing fruits. Higher mountain zones produce plant differences because of limited growth cycle times and cooler temperatures alongside stronger ultraviolet radiation.



Figure 5: Immature fruits of Punica granatum observed at mid-altitude sampling site, showing typical morphology including thick rind, prominent floral remains, and clustered arrangement on branches.

The research equates to studies of *Bergenia ciliata* which demonstrated reduced plant dimensions because of environmental pressures mainly from cold temperatures and reduced radiation at higher altitudes (Magray et al., 2021). The study on *Arabidopsis thaliana* found that ecological selection impacts make biomass traits decrease when plants grow in higher-elevation areas (Singh et al., 2015).

Phytogeographical Distribution

The pomegranate plant grew best in the mid-altitude areas between 1100 and 1800 meters above sea level. The plant appeared less often and grew in small groups above 2500 meters. The plant shows uneven spread throughout various regions due to perfect soil and climate conditions of mid-latitude regions where temperatures are mild and loamy soil drains well while getting enough rainfall. These factors likely support better vegetative growth and fruit development.

According to Sekar et al. (2023), species diversity decreased at every 500-meter rise in Western Himalayan altitudes. *Punica granatum* naturally prefers the mid-altitude regions of the Ramban district based on this research result.

Medicinal Assessment

Tannin production within the fruits reached its highest concentration in samples taken from mid-altitudes while remaining lower at both the lowest and highest altitude areas. The fruits from mid-elevation zones had better amounts of flavonoids and antioxidants than other zones. *P. granatum* produces optimal secondary metabolites when grown in mid-altitude zones under moderate environmental stress. The plant uses these natural products to heal while the examination shows their pharmaceutical strength.

Research from Jamwal et al. (2022) shows that *Justicia adhatoda* grows best near higher elevations and develops more phenol, flavonoid, and sugar components. Their research revealed over two years that growing plants at higher elevations creates chemical changes in their nature to boost therapeutic effectiveness.

The research by Bhat et al. (2015) showed that plants from *Primula denticulata* in higher altitude areas contained larger amounts of phenols, tannins, and alkaloids at p values below 0.05 due to stress impact from elevation.

Research demonstrates that mid-altitude becomes a preferred environment for plants to grow and produce phytochemical amounts while high-altitude diminishes overall plant performance. Your research results match these results which show 1000–2000 meters is best for grapefruit production and medical benefits.

Conclusion

Research results show altitude directly affects how *Punica granatum L.* fruits look and what phytochemicals they contain in the Ramban district of Jammu and Kashmir. Flowering rewards showed clear contrasts in their physical measures and plant strength based on where they grew. The amount of useful medicinal elements in *Punica granatum L.* shifted strongly with different elevation levels.

The highest fruit quality and most therapeutic compounds for *P. granatum* came from the mid-elevations between 1000 and 2000 meters. The plants at this location made bigger and more juicy fruits while showing the greatest number of therapeutic compounds in their composition. Research about Himalayan medicinal plants reveals that moderate environmental stress improves phytochemical richness which supports the findings of this study (Jamwal et al., 2022; Bhat et al. 2015).

These research results show why mid-altitude areas need special protection through environmental and drug management practices. Farms and wild areas where Amardana grows should remain intact and farmers need to harvest them responsibly to keep this plant source healthy for many more generations. Samplings for pomegranate production should focus on mid-altitude regions to increase planting success and preserve age-old growing practices while making money for local communities.

References

- Ashraf, M. V., Khan, S., Misri, S., Gaira, K. S., Rawat, S., Rawat, B., Hannan, A., Shah, A. A., Mohd Asgher, & Ahmad, S. (2024). High-Altitude Medicinal Plants as Promising Source of Phytochemical Antioxidants to Combat Lifestyle-Associated Oxidative Stress-Induced Disorders. *Pharmaceuticals*, *17*(8), 975–975. <https://doi.org/10.3390/ph17080975>
- Bhat, K., Nawchoo, I. A., & Ganai, B. A. (2015). Altitudinal Variation In Some Phytochemical Constituents And Stomatal Traits Of *Primula Denticulata*. *International Journal of Advances in Scientific Research*, *1*(2), 93. <https://doi.org/10.7439/ijasr.v1i2.1792>
- Chandra, N., Singh, G., Lingwal, S., Rai, I. D., & Tewari, L. M. (2021). Alpine medicinal and aromatic plants in the Western Himalaya, India: An ecological review. *Indian Journal of Ecology*, *48*(2), 319-331.
- Jacob, J., Rajiv P, R., Gopalan R, G., & Lakshmanaperumalsamy P, L. (2019). An Overview of Phytochemical and Pharmacological Potentials of *Punica granatum L.* *Pharmacognosy Journal*, *11*(5), 1167–1171. <https://doi.org/10.5530/pj.2019.11.181>
- Jamwal, M., Puri, S., Radha, R., Sharma, N., Prakash, S., & Pundir, A. (2022). Altitudinal variation in phytochemical, physicochemical, and morphological aspects of *Justicia adhatoda L.* plant growing wildly in Western Himalayas. *Journal of Applied Biology & Biotechnology*. <https://doi.org/10.7324/jabb.2023.99265>
- Magray, J. A., Zargar, S. A., Islam, T., & Nawchoo, I. A. (2021). Impact of habitat variability on growth dynamics of *Bergenia ciliata* (Haw.) Sternb. along an altitudinal gradient in Kashmir Himalaya. *Plant Science Today*. <https://doi.org/10.14719/pst.1367>
- Pandey, V., Bhatt, I. D., & Nandi, S. K. (2019). Environmental stresses in Himalayan medicinal plants: research needs and future priorities. *Biodiversity and Conservation*, *28*(8-9), 2431–2455. <https://doi.org/10.1007/s10531-019-01776-x>
- Pant, P., Pandey, S., & Dall'Acqua, S. (2021). The Influence of Environmental Conditions on Secondary Metabolites in Medicinal Plants: A Literature Review. *Chemistry & Biodiversity*, *18*(11). <https://doi.org/10.1002/cbdv.202100345>
- Rashid, M., & Shafi, S. (2018). Evaluation of Phytochemical Constituents and In vitro Antiinflammatory Activity of Kashmiri Pomegranate (*Punica granatum Linn.*) Flower Extract. *IOSR Journal of Pharmacy and*

Biological Sciences , 13(2), 58–67. <https://iosrjournals.org/iosr-jpbs/papers/Vol13-issue2/Version-1/H1302015867.pdf>

Sekar, K. C., Thapliyal, N., Pandey, A., Joshi, B., Mukherjee, S., Puja Bhojak, Bisht, M. S., Bhatt, D., Singh, S., & Amit Bahukhandi. (2023). Plant species diversity and density patterns along altitude gradient covering high-altitude alpine regions of west Himalaya, India. *Geology, Ecology, and Landscapes*, 1–15. <https://doi.org/10.1080/24749508.2022.2163606>

Singh, A., Tyagi, A., Tripathi, A., Gokhale, S., Singh, N., & Roy, S. (2015). Morphological Trait Variations in the West Himalayan (India) Populations of *Arabidopsis thaliana* along Altitudinal Gradients. *Current Science*, 108, 2213-2222. <https://doi.org/10.18520/CS/V108/I12/2213-2222>.

Yan, M., Zhao, X., Zhou, J., Huo, Y., Ding, Y., & Yuan, Z. (2019). The Complete Chloroplast Genomes of *Punica granatum* and a Comparison with Other Species in Lythraceae. *International Journal of Molecular Sciences*, 20(12), 2886. <https://doi.org/10.3390/ijms20122886>

Youssef, M., & Mahgoub, H. (2015). PHYTOCHEMICAL AND MOLECULAR ANALYSIS OF SOME MEDICINAL PLANTS OF LABIATAE FAMILY GROWING AT DIFFERENT ALTITUDES ON SAINT KATHERINE MOUNTAIN, SOUTH SINAI, EGYPT. *Egyptian Journal of Genetics and Cytology*, 44(2), 331–356. <https://doi.org/10.21608/ejgc.2015.9719>

