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Unlocking the nutritional potential of *Amorphophallus paeoniifolius*: A district-level analysis in Himachal Pradesh

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Abstract
A tropical plant belonging to the Araceae family, elephant foot yams (*Amorphophallus paeoniifolius* (Dennst.) Nicolson) yield huge, spherical corms underneath. It is an essential source of nourishment for nations in transition and the oldest crop ever grown. It has long been used to treat a variety of illnesses. An exquisite component for additional value food products, EFY corm has a significant nutritional fibre content, low fat content, minerals (phosphorus, potassium and iron), and vitamins (A, B, niacin etc.). Researchers studying cuisine have expressed a lot of curiosity in compounds that are bioactive. This study investigates the nutritional composition and ethnomedicinal uses of *A. paeoniifolius* found in three distinct sites: Hamirpur, Kangra and Mandi. Our research reveals the potential of these plant species as a source of nutrition and medicine, highlighting the importance of preserving traditional knowledge.

Keywords: Nutrition, *A. paeoniifolius*, medicine, traditional knowledge

Introduction
A tuberous annual diploid C3 plant (2n = 2× = 26, 28) (Ravi *et al*., 2011) [13], elephant foot yam (EFY) [a variant of *A. paeoniifolius* (Dennst.) Nicolson syn. *A. campanulatus* (Roxb.) BL. Ex Dence] is grown primarily to create underlying food stores. Four years later establishing one unisexual bloom shows up in EFY, wherein cross-pollinating is encouraged by excessive protogyny and a delayed spathe formation. It is considered a yearly plant, yet usually harvested between August and September after flowering (Bora *et al*., 2016) [6]. Starch, carbs, mineral content, protein, vitamins, flavonoids, which are antioxidant-rich substances, and heavy metal-free, are all found in the yam. Nevertheless, not enough research has been done on the nutritional makeup of elephant foot tuber, both quantitatively and qualitatively. Individuals with diabetes have a long-standing nutritional taboo (Singh *et al*., 2023) [12] ought to keep away from crops that resemble tubers under the soil, including elephant foot yam, since they might increase worsen the state of obesity. Our goal is to dispel the current myth and look into the impacts of diabetes or its prevention. The untamed tubers' high calcium oxide content could discomfort the tongue and esophagus. However, up to 1.5 g/kg with *A. paeoniifolius* is thought to be an innocuous dosage for therapy. The metabolic library contained 945 compounds. Numerous metabolites that are secondary, notably flavonoids, alkaloid substances, organ heterocyclic chemicals, chemical messengers, and many more, were present in addition to the main intermediates (Nayem *et al*., 2020) [21]. The primary differentiable metabolites were lipids, acids that are organic and their metabolites, amino substances and their derivatives, carbs and other derivatives that are derivative including organ heterocyclic metabolites (Majumder *et al*., 2021) [17]. D-gluconic acid constituted a significant differentiable intermediate between these. The research findings concluded that *A. paeoniifolius* possesses rich dietary components together with favorable psychological and chemical qualities.

Material & Methods
This study was conducted in three distinct sites: Hamirpur, Kangra and Mandi located in the state of Himachal Pradesh.

These locations were selected for their unique geographical characteristics and rich biodiversity allowing for a comprehensive exploration of the nutritional analysis.

Study Sites

1. **Hamirpur:** Located in the western Himalayan region, Hamirpur Has an average elevation of 759 meters above mean sea level. The elevation of Hamirpur district varies between 470 meters and 1078 meters above mean sea level. (Site 1)
2. **Kangra:** Situated in the Dhaula Dar mountain range, Kangra has an average elevation of 1665 meters above mean sea level with a minimum. (Site 2)
3. **Mandi:** It has an average elevation of 1639 meters above mean sea level. The district elevation ranges from 4000 meters to over 4,000 meters in the higher reaches. (Site 3)

Nutritional Analysis and Ethnomedicinal Uses:

The study aimed to investigate the nutritional composition and ethnomedicinal uses of *Amorphophallus paeoniifolius* found in these three sites. The results highlight the potential of this plant species as a source of nutrition and medicine.

Methods

Moisture: Weigh accurately about 5 g of the prepared sample in the moisture dish, previously dried in the oven at 105°C and weighed. Place the dish in the oven maintained at 105°± 2°C for 4 hours. Cool in the desiccator and weigh. Weighing is less than 0.01g Record the lowest mass.

Moisture content (%) = [(Initial Weight-Final weight)/Initial weight] × 100

Fat: Weigh accurately about 10 to 30g of the material in a suitable thimble. Place the thimble in the Soxhlet extraction apparatus and extract with the solvent for about 16 hours. Dry the extract contained in the Soxhlet flask, the empty mass of which has been previously determined by staring at 95 to 100C for an hour.

If weight of sample taken is 10-30g.

Fat content (g/100g) = (Weight of fat extracted / Weight of sample taken) ×100

If weight of sample takes n is 100g, the calculation will be direct:

Fat content (g/100g) = weight of fat extracted.

Total Ash: Weigh accurately about 5g of the prepared sample in a tared, clean and dry silica dish. Ignite the material in the dish on a heating mantle. Complete the ignition by keeping the dish in a muffle furnace at 550±25C until grey ash results. Repeat the process of igniting, cooling and weighing at one -hour intervals until the difference between two successive weighing is not more than 1 mg. Record the final weight of the ash.

Calculation

Total Ash Content = (Weight of ash/Weight of sample taken) ×100

Crude Fiber Determination

Procedure: Weigh accurately 2.5-3g of sample and extract with petroleum ether in a Soxhlet Extractor.

1. Air – dry the extracted sample and transfer to a 1l conical flask.
2. For high – fat samples (>10%), treat with acetone and petroleum benzene.
3. Add boiling sulfuric acid to the flask and connect to a reflux condenser. Boil for 30 minutes, rotating the flask frequently.
4. Boil the residue with sodium hydroxide solution for 30 minutes.
5. Transfer the residue to a Gooch crucible with asbestos and wash with hot water and ethyl alcohol.
6. Incinerate the contents of the Gooch crucible in a muffle furnace at 550± 25C until all carbonaceous matter is burnt.
7. Cool the Gooch crucible containing ash in a desiccator and weigh.

Calculation

Crude Fiber Content = (Loss in weight on ignition / Weight of sample taken) ×100

Protein

1. Weigh quickly about 0.5-1g of the sample and transfer to a digestion tube ensuring no sample clings to the neck of the flask.
2. Add 0.5 g of copper sulphate, 5g of sodium sulphate and 15ml of concentrated sulphuric acid.
3. Prepare a reagent blank.
4. Perform distillation in the distillation unit using distilled water and 32% NaOH.
5. Collect the distillate in a conical flask containing 50 ml of 0.1 N sulphuric acid.
6. Add 5 drop of methyl red indicator.

Calcium and Phosphorus

1. Collect, wash, dry (60- 70 C, 24-48h), Grind (1-5).
2. Ash (500-600 C, 4-6h) for calcium or digest (wet/ dry) for phosphorus.
3. Analyze using ASS/ICP-OES for calcium (422.7nm) and spectrophotometry /ICP-OES for Phosphorus (213.6nm).
4. **Quality control:** CRMs, Duplicates, Banks.

Iron, copper zinc magnesium

- **Sample preparation:** Collect, wash, dry (60-70 C, 24-48h) and grind the sample
- **Digestion:** Use wet digestion (e.g. nitric acid and perchloric acid) or dry ashing followed by acid digestion.

Use of ICP-OES or ASS to measure:

To analyze magnesium, sodium, potassium and vitamin C

Sample Preparation

1. Collect, wash, dry (60-70, 24-48h) and grind the sample to a fine powder.
2. **Analysis:** Magnesium: Use atomic absorption spectroscopy (AAS) or inductively coupled plasma optical emission spectrometry (ICP-OES) at 285.2nm.
3. Sodium and Potassium.
4. **Vitamin C:** Measure using high-performance liquid Chromatography (HPLC) or spectrophotometry, utilizing its reducing properties.

5. Quality Control Use certified reference materials, standards to ensure accuracy and precision.

Total Carotenoids

1. Extract carotenoids from the sample using a solvent (e.g., acetone, Ethanol)
2. Measure absorbance at 450-470nm using spectrophotometry.
3. Calculate total carotenoids content (mg/g) using the extinction coefficient.

Formula: Total carotenoids (mg/g) = (Absorbance Volume× Dilution Factor/ (Extinction coefficient Sample weight)

Fatty Acid Analysis

1. Extract lipids using solvents (e.g. hexane)
2. Convert fatty acids to methyl esters (FAMEs) using transesterification.
3. Analyze FAMEs using Gas Chromatography (GC) GC-Ms

Table 1: Nutritional analysis of site 1

Components	Value	Percentage⁄
1. Carbohydrate(g)	71.60	81.44
2. Crude Fiber(g)	1.65	15.22
3. Crude protein(g)	13.38	1.82
4. Crude Fat(g)	0.25	0.28
5. Ash(g)	3.98	4.53
6. Total (Dry Basis)	88.24	100
7. Calcium(mg)	0.09	23.08
8. Phosphorus (mg)	0.03	7.69
9. Iron(mg)	0.07	17.95
10. Copper(mg)	0.013	3.33
11. Zinc(mg)	0.020	5.13
12. Magnesium(mg)	0.051	13.08
13. Manganese(mg)	0.012	3.08
14. Sodium(mg)	0.055	14.10
15. Potassium(mg)	0.045	11.54
16. Total Minerals	0.50	100
17. Vitamin-C(mg)	5.70	95.42
18. Total carotenoids(mg)	0.28	4.58
19. Total (Vitamins)	4.93	
20. Protein solubility(mg/ml)	77.20	99.86
21. Free fatty acid (FFA)	0.11	0.14
22. Total Functional	88.00	100

Table 2: Nutritional analysis of site 2

	Value	Percentage⁄
1. Carbohydrate(g)	71.85	81.27
2. Crude Fiber(g)	1.70	14.14
3. Crude protein(g)	12.50	1.92
4. Crude Fat(g)	0.27	0.31
5. Ash(g)	3.92	4.43
6. Total (Dry Basis)	90.24	100
7. Calcium(mg)	0.10	18.87
8. Phosphorus (mg)	0.05	9.43
9. Iron(mg)	0.08	15.09
10. Copper(mg)	0.015	2.83
11. Zinc(mg)	0.025	4.72
12. Magnesium(mg)	0.055	10.38
13. Manganese(mg)	0.015	2.83
14. Sodium(mg)	0.065	12.26
15. Potassium(mg)	0.055	10.38
16. Total minerals	0.54	100
17. Vitamin-C(mg)	5.65	95.27
18. Total carotenoids(mg)	0.28	4.73
19. Total (Vitamins)	5.93	100
20. Protein solubility(mg/ml)	87.15	99.89
21. Free fatty acid (FFA)	0.10	0.11
22. Total Functional	87.25	100

Table 3: Nutritional analysis of site 3

Components	Value	Percentage⁄
1. Carbohydrate(g)	70.95	81.02
2. Crude Fiber(g)	1.80	14. 79
3. Crude protein(g)	12.95	2.06
4. Crude Fat(g)	0.32	0.37
5. Ash(g)	3.58	4.08
6. Total (Dry Basis)	89.60	100
7. Calcium(mg)	0.11	19.30
8. Phosphorus (mg)	0.04	7.02
9. Iron(mg)	0.09	15.79
10. Copper(mg)	0.016	2.81
11. Zinc(mg)	0.028	4.91
12. Magnesium(mg)	0.060	10.53
13. Manganese(mg)	0.017	2.98
14. Sodium(mg)	0.070	12.28
15. Potassium(mg)	0.060	10.53
16. Total Minerals	0.52	100
17. Vitamin-C(mg)	5.80	95.43
18. Total carotenoids(mg)	0.28	4.57
19. Total (Vitamins)	6.08	100
20. Protein solubility(mg/ml)	85.60	99.88
21. Free fatty acid (FFA)	0.10	0.12
22. Total Functional	85.70	100

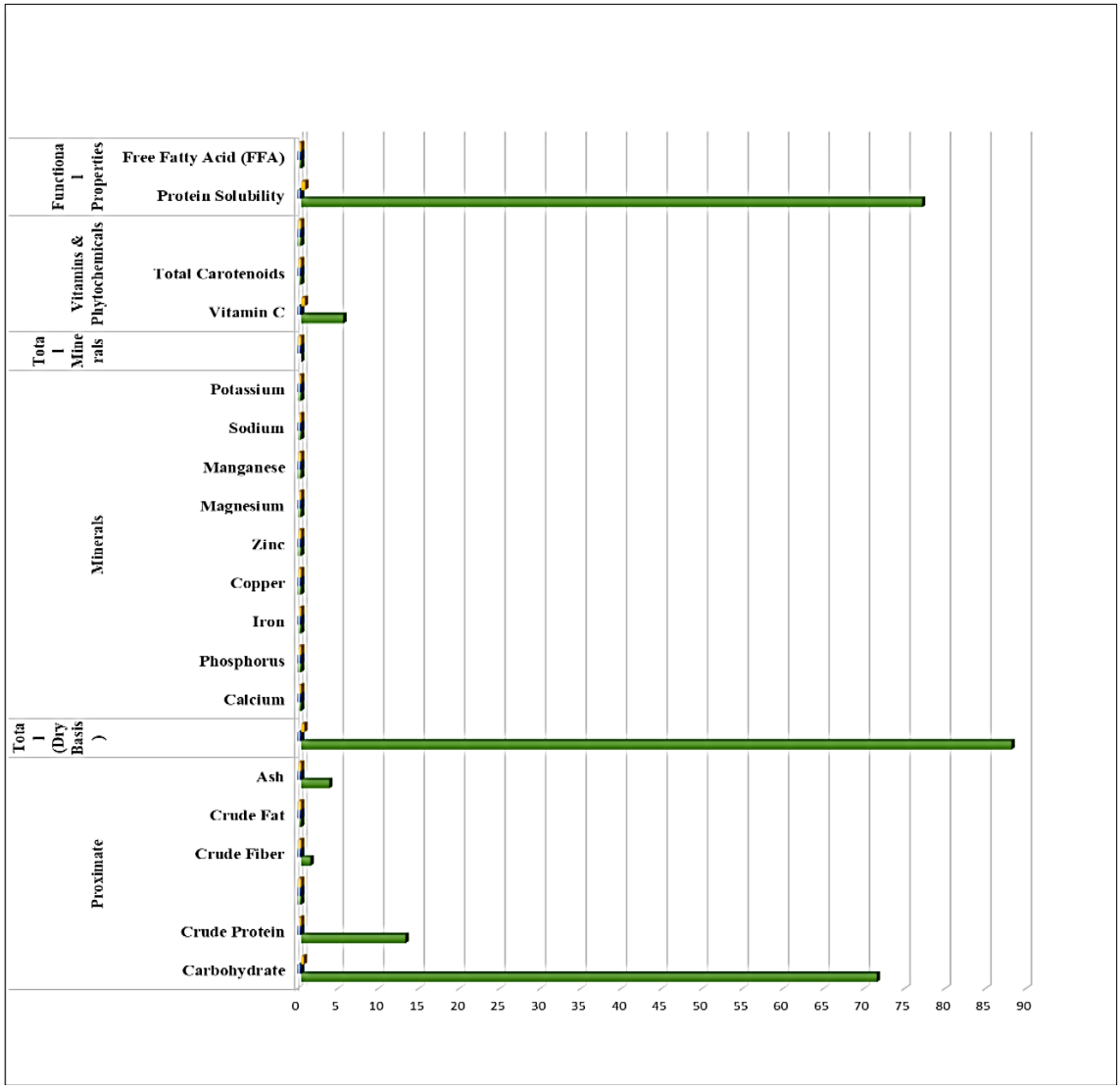

Fig 1: Graphical presentation of site 1 components

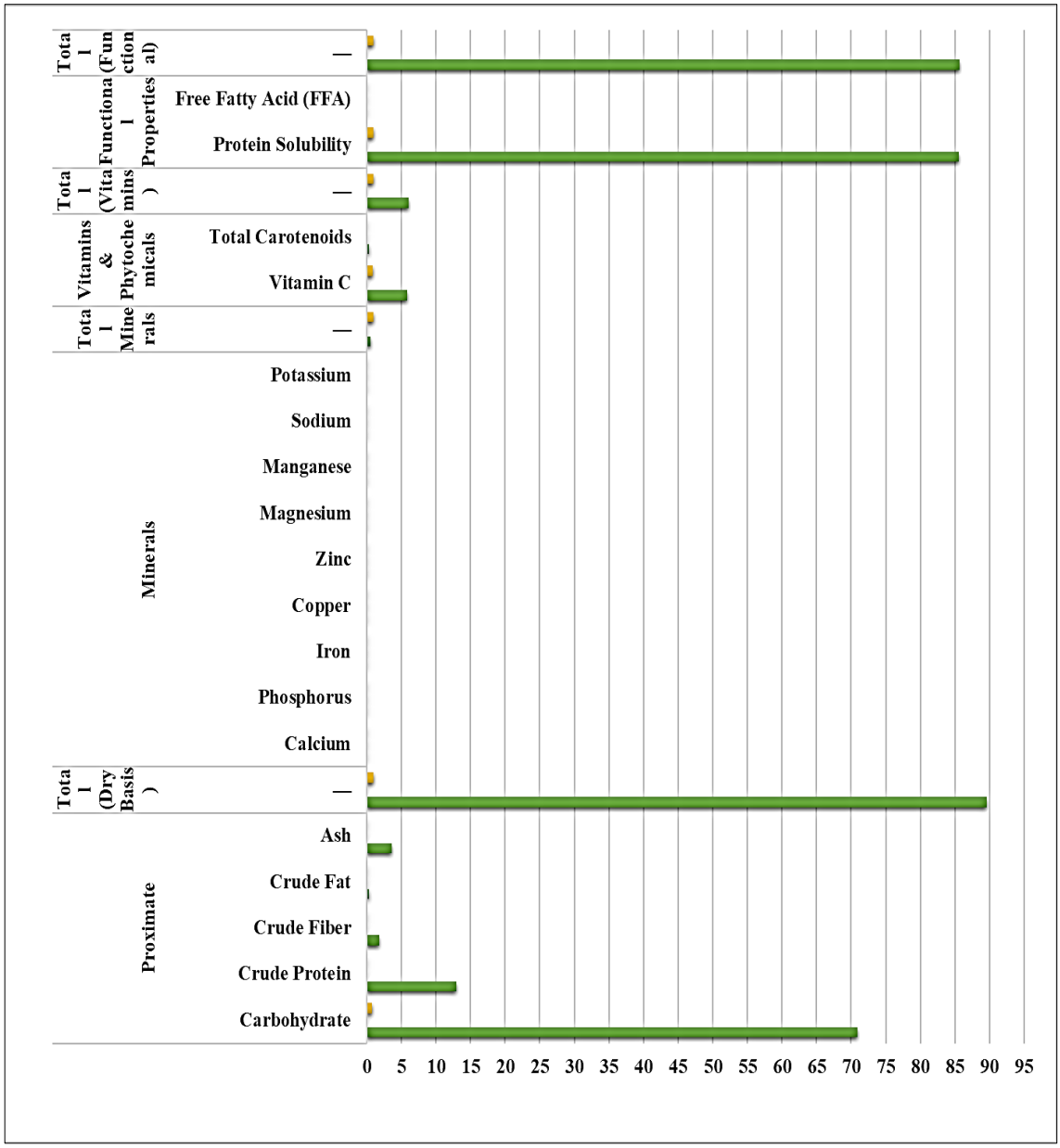

Fig 2: Graphical presentation of site 2 components

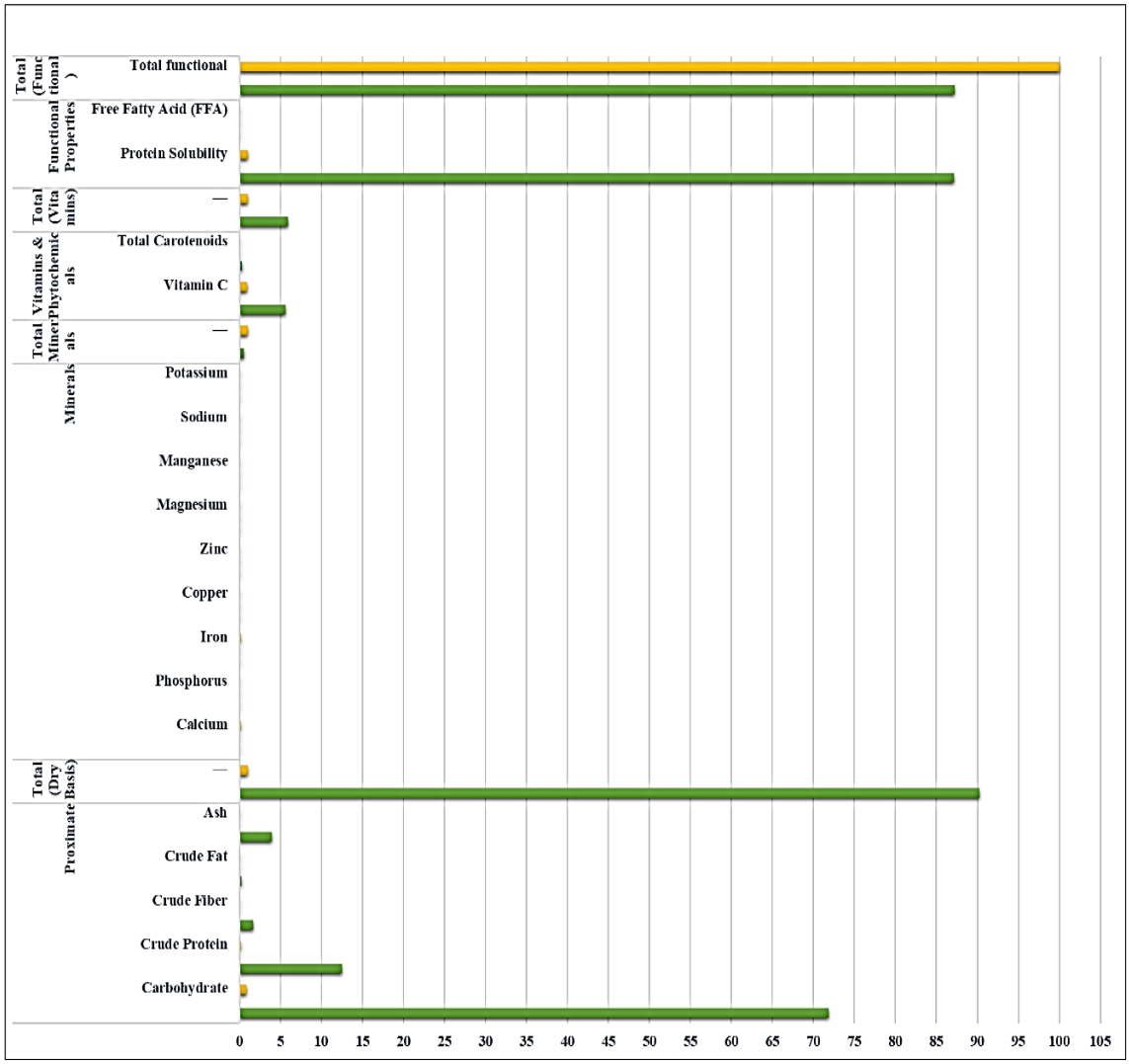

Fig 3: Graphical presentation of site 3 components

Clinical Insights into *Amorphophallus paeoniifolius*

A. paeoniifolius, in-depth analysis delves into the plant's remarkable pharmacological properties, clinical trials, safety considerations and therapeutic potential (Islam *et al*., 2023) [12].

Pharmacological Properties

Free Radical Neutralization

Paeoniifolius extracts showcase potent antioxidant activity, shielding against oxidative stress and cellular damage, Inflammation taming- arthritis, rheumatism and other inflammatory disorders treatment.

Antimicrobial shield:

A. paeoniifolius extracts display antibacterial activity against specific human bacterial pathogens, making it a potential natural antimicrobial agent.

Clinical Trials and Findings:

- **Digestive Harmony:** A 2018 study published in the Journal of Ethnopharmacology found that *A. paeoniifolius* extract improved digestive function and metabolic health in patients.
- **Inflammatory Response Modulation:** A 2019 randomized controlled trial featured in the International Journal of Herbal Medicinal showed that the extract reduced inflammatory markers and augmented immune response in individuals with mild inflammatory conditions
- **Respiratory:** Revitalization: A 2020 clinical trial published in the Journal of Alternative and Complementary Medicine found that the extract improved respiratory health in patients with chronic bronchitis. (Nayem *et al*., 2020) [21]
- **Inflammatory Response Modulation:** A2019 randomized controlled trial featured in the International Journal (Majumder *et al*., 2019) [16].

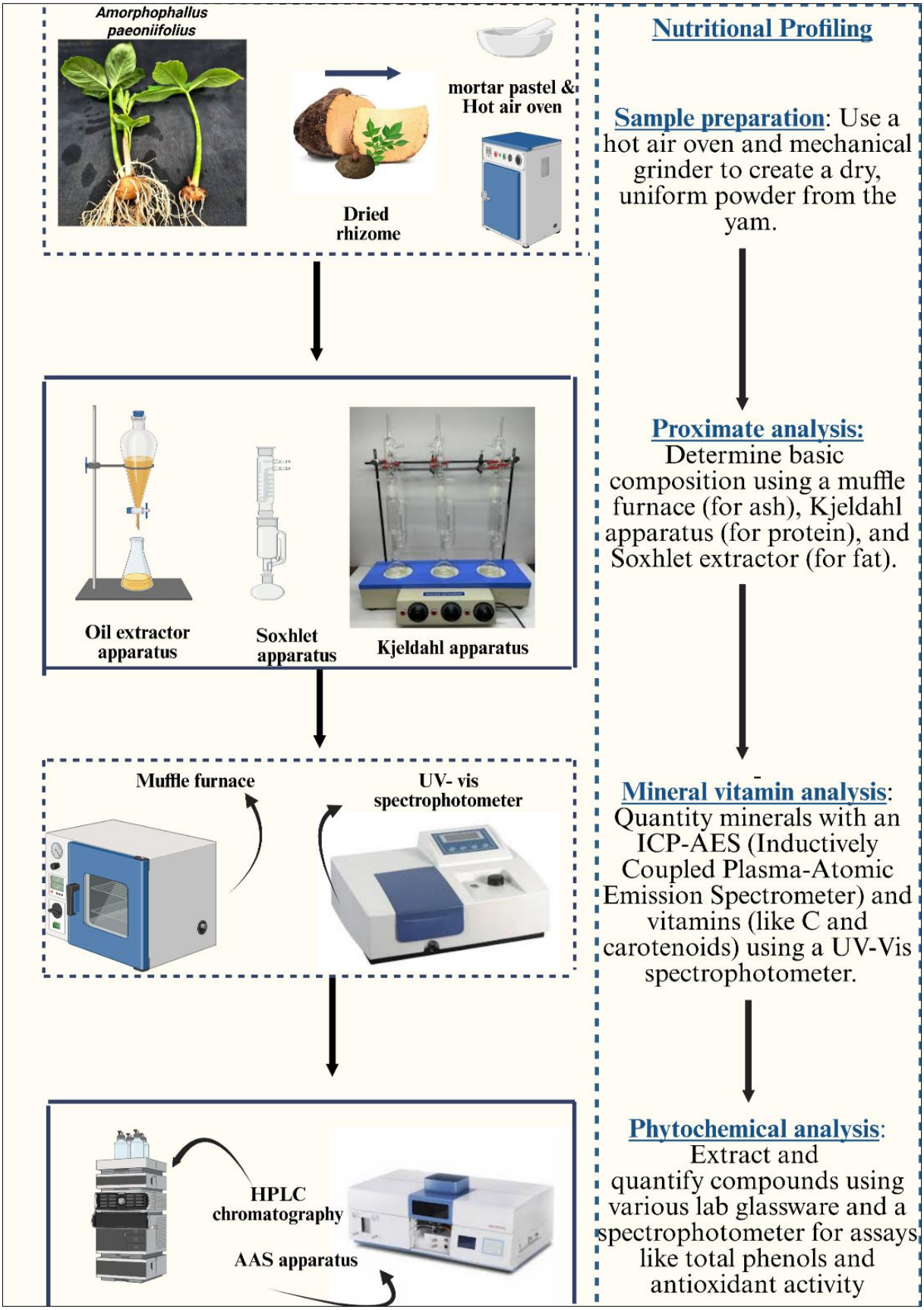

Fig 4: Ethnomedicinal uses of *Amorphophallus paeoniifolius*

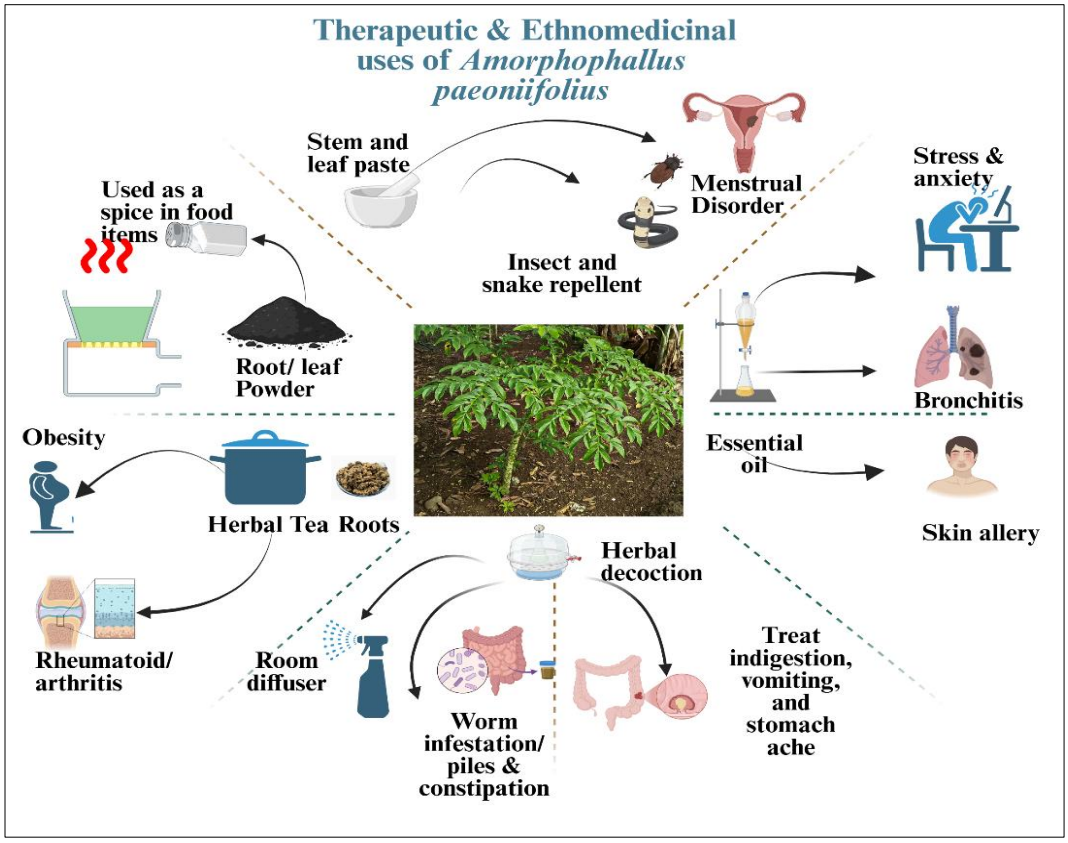

Fig 5: Process acquired for Nutritional Profiling

Table 4: Therapeutic utilization of *A. paeoniifolius*

Plant Components	Therapeutic Utilization	Gastronomic Exploitation	Husbandry/ Agricultural Application	Industrial Exploitation	References
Tubers	Alleviation of rheumatism, asthma bronchitis and digestive maladies	Culinary delight, traditional recipes, pickling	Livestock nutrition, animal feed supplementation	Rich source of starch, fiber and bioactive compounds	(Dey *et al*., 2020) [10].
Tubers	Alleviation of rheumatism, asthma bronchitis and digestive maladies	Culinary delight, traditional recipes, pickling	Livestock nutrition, animal feed supplementation	Rich source of starch, fiber and bioactive compounds	(Dey *et al*., 2020) [10].
Leaves	Treatment of fever, the rheumatism, snake bites and skin affiliation	Potential utilization in herbal teas, not typically used in cooking	Natural mulch green manure and soil erosion mitigation	Potential source of bioactive compounds, natural pesticides	(Ansil *et al*., 2022) [4]
Stems	Traditional medicine for various ailments including joint pain and inflammation	Potential use in soups or stews not typically used in cooking	Support for climbing plants, trellising, Fish feeding	Fibers for rope making bags and paper production	(Alex *et al*., 2023) [1]
Flower	Traditional medicine for respiratory issues and other ailments	Potential use in salads or as a garnish, not typically used in cooking	Pollinator attraction, biodiversity conservation	Potential source of bioactive compound natural fragrances	(Krishna *et al*., 2013) [13]
Fruits	Tratment of digestive issues fever and other Health conditions	Edibles, used in jams, preserves desserts and beverages	Attracting birds and wildlife seed dispersal	Potential source of bioactive compound, natural food colorants	(Kumar *et al*., 2019) [14]
Seeds	Plant propagation, potential use in traditional medicine	Potential use as a spice or condiment, not typically	Germplasm conservation, new plant source	Potential source of bioactive compound, natural pesticides	(Ravi *et al*., 2009) [12]

Conclusion

The comparative nutritional evaluation of *A. paeoniifolius* across three collection sites revealed consistent macronutrient dominance by carbohydrates (70-72%), indicating that the tuber serves primarily as ahigh-energy food source. Crude Protein content (12-13%) remained fairly stable among sites, reflecting the crop's potential as a moderate plant- based protein contributor. Crude fiber (1.6-1.8%) and ash content (4%) were also uniform, suggesting that the species maintains compositional integrity despite

environmental variation. Micronutrient analysis showed slight site- dependent differences. Calcium, magnesium, sodium and potassium were the most abundant minerals, while copper and manganese appeared in trace quantities. Despite these variations, overall mineral content remained within the same relative range, confirming the species mineral stability.

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