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AMORPHOPHALLUS PAEONIIFOLIUS (ARACEAE): A NUTRACEUTICAL FOR FOOD DISORDERS, NOVEL BACTERIAL & VIRAL INFECTIONS

Jugajyoti Swain[1], Rajkumari Supriya Devi[2], Sanjeet Kumar[2]✉, Lorena Lana Camelo Antunes[3]✉, Susanta K Biswal[4] & Padan Kumar Jena[1]

[1]Department of Botany, Ravenshaw University, Cuttack, India
[2]Biodiversity and Conservation Lab., Ambika Prasad Research Foundation, Odihsa, India.
[3]Biological Sciences Institute, Botanical Department, Federal University of Goiás, Goiânia, Goiás-74001-970, Brazil.
[4]School of Applied Sciences, Centurion University of Technology and Management, Odisha, India.
✉*sanjeet.biotech@gmail.com*

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ABSTRACT

Amorphophallus paeoniifolius is a very common tuber plant having diverse secondary metabolites and palatability levels. Keeping the problems of food shortage & novel infectious diseases throughout the world, an attempt has been made through fieldworks during 2009 to 2020 to gather the information on its ethnobotany, bioactive compounds from lab work and pharmacological properties from secondary sources to make it future nutraceutical against food disorders & novel microbial diseases. The tuber is used as food and medicines, it is rich with primary & secondary metabolites and its extracts are used to treat various infectious diseases. The compounds present in the species have potential to make novel drugs against present health problems throughout the world. The present study highlights the importance of wild tuberous plants in mitigation of food shortage, food disorders, anti-microbial resistance, novel bacterial & viral diseases like MDR-TB and COVID-19.

1.Introduction

Foods and medicines are the prime needs of human beings since primitive. The primitive human get these needs from wild. Land is limited and the population of world is increasing at alarming rate with modern life styles and anthropogenic activities leading food problems, disorders, anti-microbial resistance & novel microbial diseases. Hence, now we need nutraceuical from wild. Among the wild sources and contemporary health issues throughout the world, *Amorphophallus paeoniifolius* (Dennst.) Nicolson is right choice to study for getting future nutraceutical and pharmaceuticals against food problems & novel infectious diseases like COVID-19.

The genus *Amorphophallus* is among the most striking of all plants including the largest flower structures of the entire world flora. It is a perennial underground corm which grows mostly in semi-shady areas (Anuradha & Neeraj, 2014). *Amorphophallus paeoniifolius* stands out in the genera by their importance on local die in many regions of Asia and also their common use in medicine (Dey et al., 2016a). It was originated in India and later distributed to other regions of the world by human. The local short-distance dispersal is mostly by birds by feeding on its berries and dropping the seeds. Beetles are also known for cross-pollination in this species. The highly nutritive values as food and efficient neutraceutical for various ailments and other uses have placed the species in a special position for researchers to explore more and more. It is known to be frequently traded commercially in India (Santosa et al., 2017).

It is therefore cultivated not only as food but also as feed for animals. It prefers shady areas and hence makes a potential crop for intercropping which can be grown under the tree canopy. Such measures will encourage feed for animals such as cows and pigs and overcome feed shortage (Santosa et al., 2017; Koni et al., 2017).

Farmers have harvested the leaf petiole for use as a disinfectant for fish ponds. *Amorphophallus paeoniifolius* stands in a perfect position for an alternative source of peroxidase with excellent stability. This is because peroxidase has been using for various purposes such as wastewater treatment, biotechnological, biomedical and other applications but the high cost of commercially available horseradish peroxidase (HRP) is restricting its application (Singh et al., 2017).

Keeping the nutraceutical & pharmaceutical potentials (Table 1) and emerging of novel viral diseases in last two decades, some research has been done at selected regions of India (Sikkim Himalayas, Indo-Burma Biodiversity Hotspots, Eastern Ghats, Western Ghats, Coastal parts of India and Chotanagpur plateau) for collection of food & medicinal values followed by collection of corm (Coastal areas of Puri district of Odisha, India) for estimation of primary and secondary metabolites using standard methods (Kumar et al., 2017; Sadashivam & Manickam, 2010) and collection of pharmacological values from secondary sources.

Table 1. Etnomedicinal use(s) of *Amorphophallus paeoniifolius* in study areas

Parts used	Mode(s)	Target ailment	Collection site(s)
Corm	Dried powdered of corm with warm water	Jaundice	Jharkhand state
Corm	Boiled	Dysentery & Body pain	Odisha state
Shoots	Juice	Sinusitis	Odisha state
Corm	As vegetables	Gastritis & to Purifies the blood	Manipur state
Corm	Dried roots	Piles & Dysentery	Odisha state
Corm	Fresh roots	Stimulant & Expectorant	Odisha state
Leaves & Stem	Juice	Ulcers	Kerala state

2.Methodology

The study was developed in six locations from different parts of India (Sikkim Himalayas, Indo-Burma Biodiversity hotspots, Eastern Ghats, Western Ghats, Coastal part of India & Chotanagpur). The plant experiment was identified by usual methodology in taxonomy and using morphological characteristics (Haines 1925). The methodological framework for the ethno-botanical study were as per the standard techniques of exploration and germplasm collection (Hawkes 1980; Christan and Brigitte 2004), qualitative and quantitative ethno-biological approaches in the field, interviews, elicitation methods, data collection and further authentication (Martin 1995; Cotton 1996). The standard participatory rural appraisal method (Cunningham 2001; Gerique 2006) was adopted for sampling and data collection to incorporate the indigenous knowledge.

3.Results and discussions

3.1.Botanical description & distribution of family Araceae

Araceae is one of the most diverse family of monocots, has a cosmopolitan distribution and is represented by 125 genera and around 3750 species (Nauheimer et al., 2012). The species can be found in a wide variety of habitats and has many kinds of life forms from geophytes, climbing, epiphytes, terrestrial to rare aquatics (Mayo et al., 1998). The stems are usually glabrous and slightly succulent; its tissues often form latex tubes or raphides. The leaf ranges from simple and entire to compound and highly divided and may be basal or form an aerial stem. The Araceae family has a unique form of inflorescence forming a spadix with bisexual or unisexual or sometimes sterile, which then gets subtended by a spathe. Membranous sheaths are usually present at the base of the petiole or peduncle. Flowers vary from small to minute, crowded on a simple fleshy spadix with a green or colored spathe. Spadix often produced beyond the flowers. Fruits are usually baccate, free, or confluent. Seeds usually embedded in mucilaginous pulp. In recent times this family is one of the horticulturally important plants (Saxena & Brahman, 1996).

3.2.Chacracterization and description of the genus *Amorphophallus*

Amorphophallus is a diverse genus of Araceae family, with approximately 200 species (Jaleel et al., 2011). The maturation period of different species of *Amorphophallus* sometimes varies in terms of years. Most species are seasonal and show a period of activity and dormancy sometimes for decades and in few cases even centuries (Stewart & Wilbert, 2011). The plant produces a single inflorescence followed by a solitary leaf. The inflorescence consists of a bract known as spathe which envelops the spike-like organ known as a spadix. The flowers are highly reduced and found at the base of the spadix. After the growing season, the plant dies back to a large underground corm. On successful pollination, the flower can be as tall as 2 m. Some species emit an odour of rotting flesh. Moreover, some people regard its inflorescence as bizarre. The solitary leaf resembles a small tree with hundreds of leaflets from its leaf blade (Stewart & Wilbert, 2011; Dey et al. 2012).

Very stout herb; tuber dark brown, depressed hemispherical, rough with several nodes with seasonal rhizomatous buds; Leaf broad, 3-partite, the lateral segments bifurcate, pinnatifid with oblong lobes lobes or leaflets, acuminate, rachises winged, leaflets ovate to lanceolate; peduncle much shorter than spathe, elongating when fruiting, peduncle surface is similar with petiole both in wild and cultivated species, turns brownish green-brown when fruit is ripening; spathe with a campanulate tube, suddenly widening into an irregular spreading and strongly undulate, pale green to brown with pale green-whitish green spot outside, glossy dark brown to dark red-purple inside; spadix stout, longer than spathe; inflorescence produces very unpleasant odour; infructecens cylindric (Saxena & Brahman, 1996).

3.3.Diversity and distribution of *Amorphophallus*

Hetterscheid & Ittenbach (1996) reported 200 species of *Amorphophallus* distributed all over the world. Ittenbach & Lobin (1997) reported six new species and two new subspecies of the same genus. Although Boyce & Croat (2011) anticipated a total species of 219 of the same genus. It is distribution range from areas near the coastal line to an altitude of 900 m above sea level. They are more adapted to areas with shady and low light intensities which suit best in humid tropical areas. Such adaptability is quite suited to cultivate it under a forest tree canopy. This can enhance the availability of feed for animals (Santosa et al., 2017).

The genus is distributed in the paleotropics mainly confined to the Tropical and Sub-tropical regions of Asia and Africa with maximum diversity found in the Southeast Asia with about 70% of the total estimated species. *Amorphophallus* also shows maximum morphological diversity out of the total aroid

genera (Hetterscheid & Ittenbach, 1996). The genetic diversity is relatively high among the Indian, Thai, and Indonesian species (Santosa et al., 2017).

Amorphophallus paeoniifolius is widely found cultivated in Indonesia and other Asian countries (Santosa et al. 2017). This species is also widely cultivated in India, Sri Lanka, China, Malaysia, Thailand, Philippines and Africa (Behera et al., 2014). Reports on the *A. paeoniifolius* documented that it was originated in India and later extended its distribution to other parts of the world (Hetterscheid & Ittenbach, 1996; Devi et al., 2013).

3.4.Ethnobotanical values of *A. paeoniifolius*

3.4.1.Traditional food systems

During 2009 to 2020, the third author (Dr. Sanjeet Kumar) have visited different regions of India for documentation of ethnobotanical values and documentation of floral wealth of India and found that all parts of *A. paeoniifolius* is used as food through different traditional food practices by different tribal & rural communities. It was observed that tuber or corm of *A. paeoniifolius* is soaked overnight in water and used as vegetables by the Santhal tribal community of Giridih district of and Kuswaha community of Hazaribagh district of Jharkhand state whereas the Ho community of Mayurbhanj district, Juang community of Kendujhar district, Santhal community of Dhenkanal district and fishing community of Mahanadi river areas of Odisha state use the tubers after boiling. The local community of Manipur state use the leaves as vegetables and tribal community of Kerala state use the plant parts as vegetables after sundried. *Amorphophallus paeoniifolius* is known for its starchy nutritive food and is widely used in many countries including India, Malaysia, Indonesia, Philipines, etc. It is gaining importance as a cash crop with high export potential. It is a delicacy in many parts of India (Dey et al., 2012). It is widely used in ayurvedic preparations and pickles (Das et al., 2009). It is one of the traditional recipes in Bohag Bihu in Assam (Barnali and Zaman, 2013). It is rich in vitamin A, Vitamin B-6, fiber, and certain key minerals which makes the right choice as a vegetable with high nutritive value. The high fibre content makes it a good ingredient to promote weight loss and lower cholesterol levels (Rajlakshmi et al., 2001; Singh et al., 2016).

3.4.2.Folk medicines

A. paeoniifolius are also used to cure many diseases and disorders. It was noted that tribal communities of Giridih district of Jharkhand state use the corms against jaundice whereas dried corms are used against stomach problems by the tribal communities of Odisha state (Table 2).

Table 2. Medicinal properties in correlation to the phytochemical compounds

Bioactive compounds	Group of Compound	Solvent of Extraction	Target activity	Sources
Tetradecene, 1-pentadecanol, hexadecenoic acid		Methanol	Anti-oxidant activity	Basu et al. (2013)
Ambylone	Triterpenoid	Petroleum ether	Antibacterial activity	Khan et al. (2008)
3,5-diacetyltambulin	Flavonoid	Chloroform	Antifungal activity	Khan et al. (2007); Khan et al. (2008)
Quercetin	Flavonoid	Ethanol	Antitumour activity	Ansil et al. (2014)
β - sitosterol	Betulinic acid	Methanol	Against inflammation	Dey et al. (2016)

Quercetin	Flavonoid	Methanol	Hepatoprotective activity	Sharstry et al. (2010)
β - sitosterol	Betulinic acid	Petroleum ether	Antiosteoporetic activity	Sanaye et al. (2018)
Lupeol, Quercetin & Glucomannan	Not Clear	Not Clear	Prevents ulcerative colitis and Inflammatory bowel disease	Lee et al. (2012); Lee at al. (2016); Suwannaporn et al. (2013)
Flavonoids		Acetone and Phenol	Antidiabetic activity	Arva et al. (2013)
Flavonoids, Alkaloids & Steroids		Methanol	Antihelmenthic activity	Dey et al. (2017b)
Tannins, Flavonoids, Saponins & Polyphenol		Ethanol	Antidiarrheal activity	Wright et al. (2005); Polambo et al. (2006); Perez et al. (2005)
Ethanol			Anti-oxidant activity	Basu et al. (2013)
Petroleum ether & Ethanol			Cytotoxicity	Behera et al. (2014); Dey et al. (2016)
Methanol & Chloroform			Anticancer	Ansil et al. (2014); Jagathese et al. (2010)
Aqueous			Analgesic	Hemalatha et al. (2019)
Petroleum ether			Anticonvulsant activity	De et al. (2012)

Traditionally tuber roots are considered to be carminative, restorative and possess blood purifier properties and have been using for treatment of abdominal disorders, tumours, enlargement of spleen and asthma. It is also reported to possess tonic and appetizer properties (Dey et al., 2012). The dried roots are used for the treatment of piles and dysentery while the fresh roots act as stimulant and expectorant (Singh et al., 2016). The leaf and stem juice are used to get relief from ulcers. Tribal people like Kurichia, Adiya, Kuruma at Wayand of Kerala state uses the concoction of the dried powder of the corm and curd to treat jaundice and piles (Devi et al., 2013). The boiled corm is used in the treatment of dysentery and rheumatism, and its apical shoots are used to cure sinusitis (Husain, 1992; Barnali and Zaman, 2013). It is also reported to be used for the treatment of elephantiasis, inflammations, haemorrhoids, bronchitis, anorexia, antihelminthic, CNS depressant, hepatopathy, spleenopathy, fatigue and anemia (Nair, 1993; Dey et al., 2012). Apart from its uses to serve the needs of human consumption and medicines, it is used to feed cows or pigs

during the dry season. Besides, it is also used as a disinfectant in fishponds (Khan et al., 2009). Kurichia and Adiya tribes in Kerala used the dried, powdered corm with curd and hot water to treat jaundice (Prasad et al., 2013).

3.5.Nutraceutical values of *A. paeoniifolius*

3.5.1.Nutraceutical potential

The corm of *A. paenoiifolius* is collected from Bhubaneswar-Konark road of Puri district of Odisha state. After collection the corm was washed and kept for estimation of primary & secondary metabolites. Carbohydrate, starch, fibber, protein and lipid was estimated using standard methods of Sadashivum & Manickam (2018), Total phenol (Ainsworth & Gillespic, 2007), tannin (Kumar et al., 2017) & total oxalate (Nguyen & Savage, 2013) is estimated. The results revealed that corm has highest content of starch followed by carbohydrate, fiber, protein, lipid, total phenol, total tannin and total oxalate (Figure 1). The richness of primary metabolites indicates that it will be good future food and from it, food derivatives might be manufactured using value addition of *A. paenoiifolius*. It will be helpful to reduce food problems worldwide. The presence of phenolic compounds indicates that it might be used as an option food to improve immunity and act as an antioxidant agents (Lin et al., 2016; Ding et al., 2018) which will be helpful as a preventive food against infectious diseases.

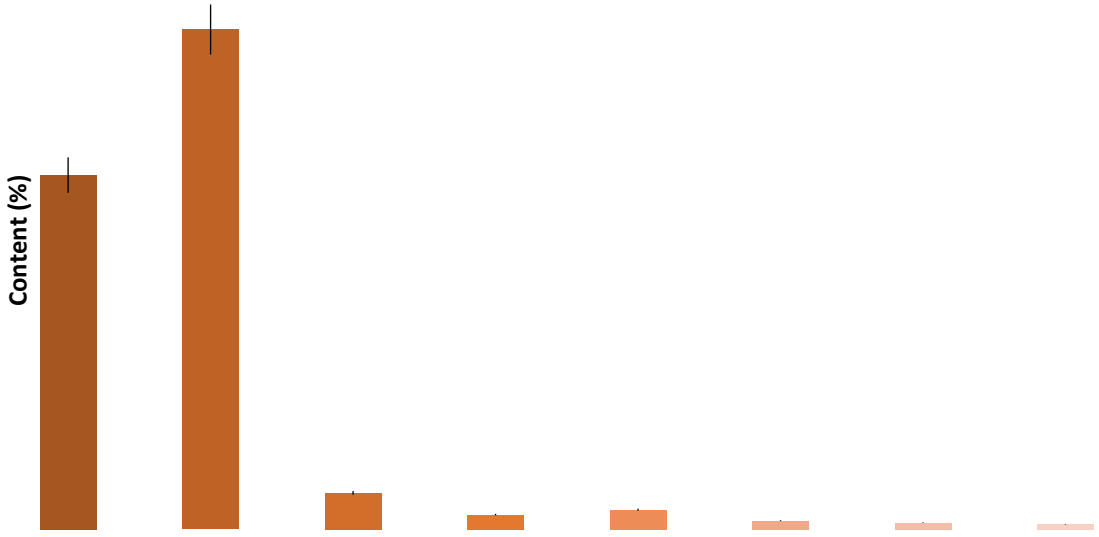


Figure 1. Nutraceutical potential of *A. paeoniifolius*

3.5.2.Anti-nutritional properties

In addition to the beneficial nutritive and medicinal values, *A. paeoniifolius* has anti nutritional or toxic properties which make it less commonly used as a vegetable. The freshly cut form of it shows the presence of oxalates owing to the acrid property. Acridity is the itching or burning sensation in the skin, followed by swelling (Kumar et al., 2017). Oxalates are reported to chelate minerals such as Iron, Zinc, Calcium, and Magnesium, making it unavailable to the body. Higher consumption of oxalate could also be fatal. A minimum amount of oxalate ingestion to make it fatal is 40-50 mg in an adult human. However, experimental data have shown that this toxic property can be negated by boiling for 10 minutes. Reports have been found that sun drying can also reduce the oxalate content. This process can reduce the oxalate at a safe level and also can restore other nutritional properties (Iwuoha & Kalu, 1995; Kumar et al., 2017). Tannins can form complexes with metal ions, proteins, and polysaccharides. In

Amorphophallus, tannins are reported to form complexes with proteins, and so it subsequently effect the growth rate of animals. It is reported to inhibit the growth of fibre degrading bacteria in the digestive tract of ruminants. These lead to less efficiency as feed. However, it can be overcome by fermentation as fermentation can decrease the tannin content to a safer level. Hydrogen cyanide is present in the form of cyanogen glucosides. The concentration of it varies depending upon the variety and its environmental conditions. A high level of Hydrogen cyanide can damage the central nervous system in animals, including humans. The content of hydrogen cyanide can be reduced by drying, soaking, and fermentation. Another such compound is phytate present in the same. Phytic acid affects the metabolic processes of the intestine in animals as it chelates metal ions such as phosphorous and zinc ions making it unavailable to the body. The phytate content can, however, be reduced by increasing the heating or by sun-drying (Koni et al., 2017). Oxidative browning occurs when the tissue is damaged in the corms of *A. paeoniifolius.* Tissue damaged during food processing has resulted in the loss of nutritional properties as well as commercial and economic values. Such oxidative browning is caused by a polyphenol oxidase, a copper-containing compound. This enzyme is reported to be not sensitive to temperature, and high temperature is required to inactivate the said enzyme. However, it can be inactivated with the combination of pH below 5 or above 7, high temperature, L ascorbic acid, and chloride effectively.

3.5.3.Effect on cholesterol

Amorphophallus paeoniifolius, in combination with *Vigna radiata*, has shown to maintain the cholesterol levels. Elevation of Low-Density Lipoprotein (LDL), also known as bad cholesterol, has contributed to the risk of Coronary heart diseases. Benil and his co-workers have shown a good synergistic effect of combination of *V.radiata* and *A. paeoniifolius* in lowering the LDL *i.e.,* bad cholesterol and increase in the HDL (High-density lipoprotein) *i.e.,* good cholesterol levels by providing omega-3 fatty acids. This was compared to a standard drug Cholestyramine which makes a very efficient nutraceutical for treating such diseases (Singh et al., 2016; Benil et al., 2017).

3.6.Bioactive compounds & Pharmacological values of *A. paeoniifolius*

3.6.1.Secondary metabolites

Amorphophallus paeoniifolius is also known as Elephant foot yam and popular for its rich content of secondary metabolites like such as glycosides, flavonoids, alkaloids, phenolic compounds, tannins and minerals like potassium, phosphorous, calcium, iron, ascorbic acid, and β-carotene. Such a rich source of metabolites could meet the daily leading requirement of the body (Misra et al., 2001; Singh et al., 2016; Dey et al., 2017b). Studies with regard to extraction with different solvents, phytochemical test along with Thin Layer Chromatography (TLC), Column Chromatography and High Performance Thin Layer Chromatography (HPTLC) have shown the presence of various bioactive compounds including as mentioned alone (De et al., 2010; Firdouse & Alam, 2011; Natraj et al., 2011; Jayaraman et al., 2010). Significant reports are based on the methanolic extract of *A. paeoniifolius.* The methanolic extract of it showed a significant content of flavonoid, alkaloids, steroids, and phenolic compounds. TLC of the methanol extract of it showed 7 bands with different R_f values which indicate the diversity of bioactive compounds in it (Ferdouse et al. 2011). It gives the better understanding for the related reports on gastroprotective activity in albino rats, antihelminthic activity against *Pheretima posthuma*, analgesic activity, antioxidant activity, anti-inflammatory activity and antimicrobial activity using methanol extracts of *A. paeoniifolius* (Nataraj et al., 2009a; Natraj et al., 2009b; Nataraj et al., 2011; Dey et al., 2010; Ansil et al., 2011; Das et al., 2009). The ethanol extract also showed anti-diarrheal activity; petroleum ether extract showed CNS

depressant activity which could be responsible for the analgesic activity. The methanol extract and chloroform extract both showed the antibacterial activity which reflects the presence of phenolic compounds in plant parts of *A. paeoniifolius* (Chibane et al., 2019).

3.6.2.Antimicrobial activity

There are lots of work has done on the antimicrobial activity of corm. The documentation revealed its anti-microbial potential. The ethanol and methanol extract of the tuber of *A. peoniifolius* shows antibacterial activity against gram positive bacteria like *Bacilus subtilis, B. cereus, B. thuringiensis, Staphylococcus aureus, Streptococcus β-haemolyticus,* and gram negative bacteria like *Escherichia coli, Shigella dysenteriae, S. sonnei, S. flexneri, Pseudomonas aeruginosa* and *Salmonella typhi* using disc diffusion method. It also shows good antifungal activity against *Candida albicans* but least on *Aspergillus niger, A. flavus* and *Rhizopus aryzae*. Reports have also been demonstrated that chloroform and petroleum ether show more effective antimicrobial activity. In general methanol extract of the said tuber showed maximum inhibition for most of the bacterial strains. However, ethyl acetate extract of the said tuber has also been reported to inhibit *B. subtilis* as well as *S. aureus*. The triterpenoid compound ambylone extracted from petroleum ether and flavonoid compound 3,5-diacetyltambulin from chloroform have also been suggested to be responsible for its antibacterial and antifungal property (Khan et al., 2007; Khan et al., 2008; Dey et al., 2016a; Dey et al., 2017b; Kadali et al., 2016; Muthukumaran et al., 2016). The above mentioned activity show the broad spectrum on its anti-microbial potential against future novel microbial diseases.

3.6.3.Antioxidant activity

Oxidative stress in the body leads to an increase in the level of enzymes that generate and release free radicals and disruption of electron transport chain leading to complications such as neurodegenerative diseases, damage in biomolecule such as lipids, proteins, and DNA, cancer, vision loss, etc. Polyunsaturated fatty acids of the cell membrane are prone to react with the Reactive Oxygen Species (ROS), causing damage to the cell (Schieber & Chandel, 2014). The antioxidant activity of tuber of *A. paeoniifolius* in different solvents such as aqueous, methanol, ethanol, ethyl acetate all elucidated and noticeable positive activity. A defence mechanism to relief the oxidative stress include SOD (superoxide dismutase), CAT (catalase), GP_x (glutathione peroxidase) and other phytochemicals such as phenolic acids, flavonoids, ascorbic acid, tocopherols, uric acid, tannins, lycopene, glutathione, etc. The enzymes present in *A. paeoniifolius* have been reported to serve as potential antioxidants (Hamid et al., 2010; Sanjay et al., 2009). Reports showed that DPPH (Diphenyl picryl hydrazyl) radical scavenging activity, Hydroxyl radical scavenging activity depicted maximum solvent extract activity in ethanol extract while phosphor molybdenum assay had shown maximum antioxidant activity with methanol extract of the said tuber. The methanol extract of *A. paeoniifolius* has been known to prevent the elevation of serum AST (serum glutamic-oxaloacetic transaminase), ALT (serum glutamic pyruvic transaminase), LDH (lactate dehydrogenase) enzyme levels that are responsible for releasing free radicals in the body (Singh & Wadhwa, 2014). Analysis of methanol extract of the said tuber demonstrated the presence of tetradecene, 1-pentadecanol, hexadecanoic acid, which showed a relative antioxidant activity (Basu et al., 2013). The above reports revealed the antioxidant potentials of the corm of *A. paeoniifolius*.

3.6.7.Antitumor activity

In the proliferation of uncontrolled growth of cells, the mechanism of apoptosis is generally targeted. The decrease in (GP_x), superoxide dismutase and catalase enzymes as a form of oxidative stress created by a carcinogen in liver and kidney. The ethanol extract of *A. paeoniifolius* tuber showed significant antitumor activity against DMBA (7,12-dimethyl benz anthracene) induced

mammary tumour rats. Flavonoids are known to possess antitumor activity in cell proliferation and angiogenesis. The flavonoid in ethanol extract of the said tuber was found to be 8.8g/100g and was reported to be equivalent to quercetin. Treatment with the said tuber extract could increase the mentioned enzyme levels towards normal. On the other hand, methanol extract and sub-methanol extract of chloroform of *A. paeoniifolius* tuber have also been demonstrated inhibition of growth against human liver cancer cell lines, PLC/PRF/5 in a dose-dependent manner. This apoptosis-inducing potential was determined by DAPI staining, annexin V-FITC staining, and JC-1 staining. Cytotoxicity assay method in-vitro has been used to check the chemotherapeutic activities. Antioxidant activity and cell toxicity can be contributed to the antitumor activity of the plant (Ansil et al., 2014; Jagathese et al., 2010; Florento et al., 2012).

3.6.8.Analgesic activity

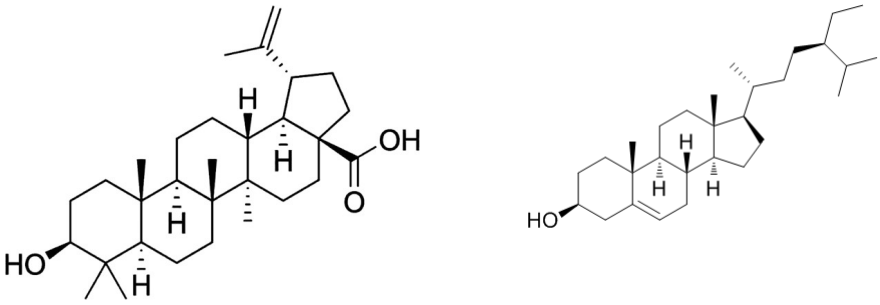
Analgesics are common pain killers given to relieve pain in the body. They include non-prescribed drugs such as paracetamol, non-steroidal anti-inflammatory drugs (NSAIDS) like aspirin and opoid drugs such as morphine. NSAIDS inhibit cyclooxygenases COX-1 and COX-2 enzyme and thereby disrupting the production of prostaglandins to decrease pain, lower fever, and reduce inflammation (Ricciotti & Geraid, 2011). Antidepressant work by blocking the monoamine uptake while anticonvulsants act by blocking the sodium channels or by increasing the extracellular levels of inhibitory transmitter GABA (Gamma-Aminobutyric acid). Several important centrally acting drugs target the GABA, a receptors like benzodiazepines. The methanol extract of tuber of *A. paeoniifolius* showed good analgesic activity given in a dose-dependent manner with a maximum 500 mg/kg of body weight shown in experiments by Dey and his co-workers (Dey et al., 2016b). The experiment had been carried out in two different methods viz. acetic acid writhing response method and tail flick method in mice. The extract of *A. paeoniifolius* was compared to the diclofenac sodium as standard to observe the increasing analgesic activity. In addition to this, the aqueous extract of the said tuber extract also exhibited analgesic activity due to peripheral and central inhibition of prostaglandin synthesis. Earlier studies revealed that petroleum extract of the above said tuber showed central depressant as well as a muscle relaxant (Angayarkanni et al., 2007; Dey et al., 2016b; Hemalatha & Sathiya, 2019).

3.6.9.Anti-diabetic activity

Although Sugars such as glucose, galactose and rhamnose, and carbohydrates are identified from the elephant foot yam tuber, members of *Amorphophallus* genus have been traditionally used to control diabetes. Acetone extract of the tuber given at 0.1% and 0.25% in the diet of steptozotocin induced diabetic rats showed an improved condition in urine output, urine sugar, fasting blood sugar, and glomerular filtration rate. Reports have shown that phenols and flavonoids play a major role in the anti-diabetic activity. They scavenge free radicals and prevent the secondary complications of diabetes. Flavonoids are also reportedly known to generate beta cells of pancrease and to stimulate insulin secretion (Arva et al., 2013; Soares et al., 2017). Now-a-days diabetic is very common and people face to select the food. In this case, it might be an optional food for them.

3.6.10.Gastroprotective activity

Methanol and aqueous extract of the tuber of *A. paeoniifolius* have been demonstrated to prevent or control inflammation and damage in colon of induced ulcer in rats.



Betulinic acid β-sitosterol

Figure 2. Bioactive compounds available in *A. paeoniifolius*

Reports demonstrated the pre-treatment with extracts of the said tuber for ulcerative colitis in acetic acid-induced ulcerative colitis in Wistar rats turned out to be quite beneficial for mucosal damage, inflammation and oxidative damage (Dey et al., 2017a). The tuber extracts were also shown to exhibit gastrokinetic activity which correlates with the correction of gastrointestinal disturbances (Dey et al., 2017a). Earlier studies found out that β-sitosterol and betulinic acid (Figure 2) are key constituents for the anticolitic activity. It has also been demonstrated that betulinic acid exhibited anticolitic activity on 2,4,6-trinitrobenzenesulfonic acid-induced ulcerative colitis in rats through inhibitory influence on inflammatory mediators and antioxidant activity (Sener et al., 2013). β-sitosterol, on the other hand, exhibited anticolitic activity on the above mention rat through inhibition of proinflammatory cytokines and cyclooxygenase (COX-2). Other compounds like lupeol, quercetin, and glucomannan in the tuber extract also showed preventive effect on ulcerative colitis and inflammatory bowel diseases (Lee et al., 2012; Lee et al., 2016; Suwannaporn et al., 2013).

3.6.11.Hepatoprotective activity

Methanol, ethyl alcohol and aqueous extracts of the tuber of *A. paeoniifolius* have shown to exhibit hepatoprotective activity against induced liver damage in rats through paracetamol and carbon tetrachloride. Liver damage is characterised by the increase in the serum hepatic enzymes levels of sGOT, sGPT, sALP, and sB. Pre-treatment with the above extracts considerably reduced the said hepatic enzymes levels comparable to the commercial drugs such as Silymarin and Liv 52. Methanol extract demonstrated a better activity as compared to the aqueous extract. Reports also suggested that flavonoids and steroids may play a key role in the hepatoprotective activity. Quercetin, a flavonoid compound has reportedly screened for the same activity. This study supports the previous findings, but more bioactive compounds need to clarify the exact mechanism of its activity (Hurkadale et al., 2012; Singh & Wadhwa, 2014; Benil et al., 2017; Dey et al., 2016a; Sharstry et al., 2010; Sanjay et al., 2009).

3.6.12.Anti-osteoporetic activity

Osteoporosis, a common health problem is more prone to women after menopause. The reason for it is the decreased level of estrogen and bone density with aging in the body. The petroleum ether extract of *A. paeoniifolius* has been shown to treat the osteoporetic activity. The petroleum extract of the said tuber showed the presence of β-Sitosterol, which shows a similar structure as that of estrogen. Since the structure of β-Sitosterol mimics estrogen, the petroleum ether extract can effectively be an alternative to hormone replacement therapy. The experiment on ovariectomised rats has shown positive results. This phytoestrogen has been proven scientifically and can be an excellent way to include in the diet to reduce such health issues (Sanaye & Bohra, 2018; Joy et al., 2016; Li et al., 2013).

3.6.13.Anti-helmintic activity

Parasitic worm infection has affected over 2 billion all over the world infecting mostly the gastrointestinal tract in animals including man causing deprivation of food, injury to organs and secreting toxins in the body. The principle treatment of parasitic worms involves the disturbance in the integrity of the parasites, co-ordination of the neuromuscles and protective mechanism against host immunity leading to starvation, expulsion, or digestion of the parasite. In the search for reverse pharmacology in controlling helminths, *A. paeoniifolius* has been one of the sources to control such parasites. An experiment illustrated that the methanol extract of the above said tuber showed significant antihelmintic activity against *Pheretima posthuma* collected from soil and *Tubifex tubifex* collected from aquarium in a dose-dependent manner comparable to the standard drug piperazine citrate. As for the mechanism of piperazine is to paralysed the parasite by blocking the neuromuscular transmission and later expel the paralysed parasites by peristalsis but the exact bioactive compound responsible the antihelmintic activity is yet to discover. Moreover, methanol extracts of the said tuber have been demonstrated many times to the presence of flavonoids, alkaloids, and steroids (Dey et al., 2017b).

3.6.14.Anti-diarrheal activity

Diarrhoea, characterised by the excessive loss of fluids and electrolytes from the body leading to dehydration, abdominal cramps, frequent loose, watery stools, fever, etc. is common in man and other animals due to various infections (Anigilaje, 2018). Active phytochemical components of various parts such as flavonoids, terpenoids, steroids, alkaloids and phenolic compounds that are demonstrated to have antibacterial activity are correlated to the antidiarrheal activity (Wright et al., 2005). The ethanol extract of leaves of *A. paeoniifolius* was reportedly exhibited to reduce the severity of diarrhoea in castor oil induced diarrhoea in swiss albino rats. The above said extract when given in 100,200 and 400 mg/Kg significantly reduced the frequency of diarrhoeic faeces in a statistically significant manner ($p<0.05$) (Purwal et al., 2011). Prostaglandins are known to induce intestinal mucosal secretion accompanied by stomach cramp thereby enhancing diarrhoea (Hawkey and Rampton, 1985). On the other hand tannins and flavonoids are suggested to have antidiarrheal activity causing to retain colonic water and electrolytic re-absorption (Palombo, 2006). Flavonoids in association with saponins are reported to inhibit the prostaglandins, motility and hydrolytic secretions (Perez et al., 2005). It has also been illustrated that the combined effect of polyphenols and tannins work in a synergistic way to decrease the intestinal secretion and promote water balance in the body (Dubreuil et al., 2013).

3.6.15.Anti-convulsant activity

Epilepsy is a neurological disorder which is associated with signs of abnormal brain activity, periods or seizures of unusual behaviour and loss of awareness. The main cause of seizure development is caused by the imbalance between the excitory and inhibitory neurotransmission in the brain. Drugs for epilepsy are also known as anticonvulsant drugs. Plant-based anticonvulsant activity has also been reported from petroleum ether extract of *A. paeoniifolius.* The said extract demonstrated an effective anticonvulsant activity in doses of 200, 300 and 400 mg/Kg on isoniazid induced mice which are comparable to the standard drug diazepam (De et al., 2012). It was also put forth that the petroleum ether extract of the said tuber also exhibited central nervous system depressants in a statistically significant way ($P<0.05$). It induced sedation and a decrease in the locomotor activity in mice. The 1500 mg/Kg doses have also been illustrated as a safety dose (Das et al., 2009).

3.6.16.Cytotoxicity

To analyse the cytotoxicity test is very important for a wild species to make them a strong pharmaceutical agent. Many reports are documented regarding the cytotoxicity of A. paeoniifolius. Petroleum ether and ethanol extracts of *A. paeoniifolius* tuber showed

significant antiproliferative activity against Hep-2 cells. Although methanol extract of the said tuber is also reportedly found to reduce the growth rate of MCF-7 cell lines, which is associated with the antiproliferative properties. IC_{50} of the extract of *A. paeoniifolius* in <100µg/ml on the cell line is potentially cytotoxic. This confirmation of cell cytotoxicity is supported by another cytotoxicity experiment that was determined against brine shrimp nauplii which showed a positive result (Behera et al., 2014; Dey et al., 2016a). The above experimental reports make *A. paeoniifolius* a preventive food against cancer.

3.6.17.Antiviral agents against coronavirus

Severe acute respiratory syndrome coronavirus emerged in early 2003 to cause a very severe respiratory syndrome caused by corona virus and in 2019, a type of corona virus again come from Bat in China and within some days became pandemic known as COVID-19 (Li et al., 2020). Wholeworld fighting with COVID-19 and searching new medication to mitigate the infections and pre & post preventive drugs from plant wealth. Luo et al. (2007) documented that plant species of family Araceae have anti-viral activity whereas Rajbhandari et al. (2009) reported the anti-viral activity of plant (*Arisaema flavum*) belongs to Araceae family against Human influenza virus (A/WSN33; H1N1) & herpes Simplex virus type 1 (HSV-1). Indrasetiwan et al. (2019) showed the antiviral activity of Araceae (*Anthurium plowmanii*) against Hepatitis B virus. Hence, all the pervious works indicate that *A. paeoniifolius* might be useful against COVID-19 as a nutraceutical. Another evident is presence of lectin in *A. paeoniifolius.* Lectin, a carbohydrate-binding protein used to regulate virus receptor binding activity. Keyaerts et al. (2007) reported that plant lectins are potent inhibitors of coronavirus by interfering with two targets in the viral replica cycle, and Fei et al. (2003) and Mondal et al. (2012) reported presence of lectins in *A. konjac* and *A. paeoniifolius*. Hence, *A. paeoniifolius* might be used as preventive food against COVID-19 (Figure 3) and their isolated bioactive compounds might be playing a vital role to mitigate the infections of this pandemic viral disease as a wild nutraceutical.

4.Conclusions

Considering the valuable properties in terms of health and nutrition, feed, enzymes for industrial purpose and medicines contributed by the secondary metabolites of *A. paeoniifolius,* we should rethink going back to plant-based nutraceutical or reverse pharmacology in other term. With the increasing use of chemicals as food, food additives, disinfectants, medicine, processed products and lifestyle that are endlessly depending on chemicals has become a threat not only to man but also to other living beings on earth. The question that is arising with the safety of GMO (Genetically Modified Food) food products or unknown side effects with the altered genes for mass production, or the attempts with chemical-based medicines to control diseases are working in a different way arising multi drug resistance bacteria or new diseases. Therefore phytochemical compounds that are already available and not been commercially available in plants need to be explored more and make commercially available throughout the world. This practice will not only prevent many of the diseases without side effects but also create a sense to conserve them. *A. paeoniifolius* being rich in nutrients and secondary metabolites that can treat for various ailments (Figure 4). As from literature and information collected during the fieldworks, we conclude that the mentioned plant as nutraceutical to mitigate the food problems & food disorders. There is need for advance scientific research in gene level on removing factors responsible for acrid properties of plant parts to make it more palatable keeping remain the other metabolites. Therefore, priority might be given for attaining food self-sufficiency through proper utilization of plant parts of *A. paeoniifolius.* For developing nutraceutical and isolation of active compound(s) against microbial infections & coronavirus, rapid bioactivity should do against pathogens. The number of techniques might be

used to regulate the production of desired active metabolites like lectin via gene expression, over expression, addition of precursors,elicitation, bioreactor scaling and metabolic engineering etc against novel dirorders and infectious diseases like COVID-19.

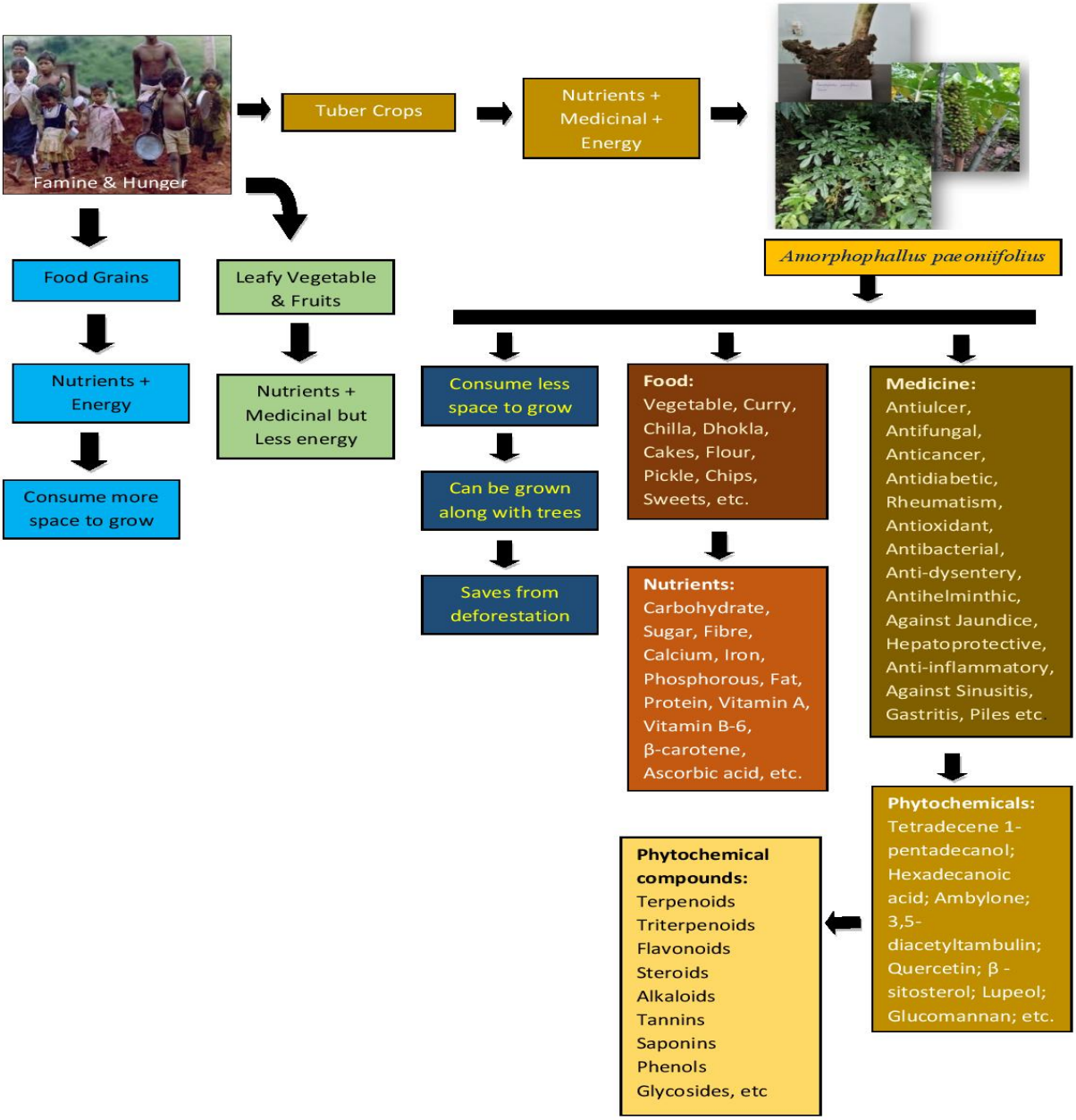


Figure 3. Nutraceutical & pharmaceutical importance of *A. paeoniifolius*

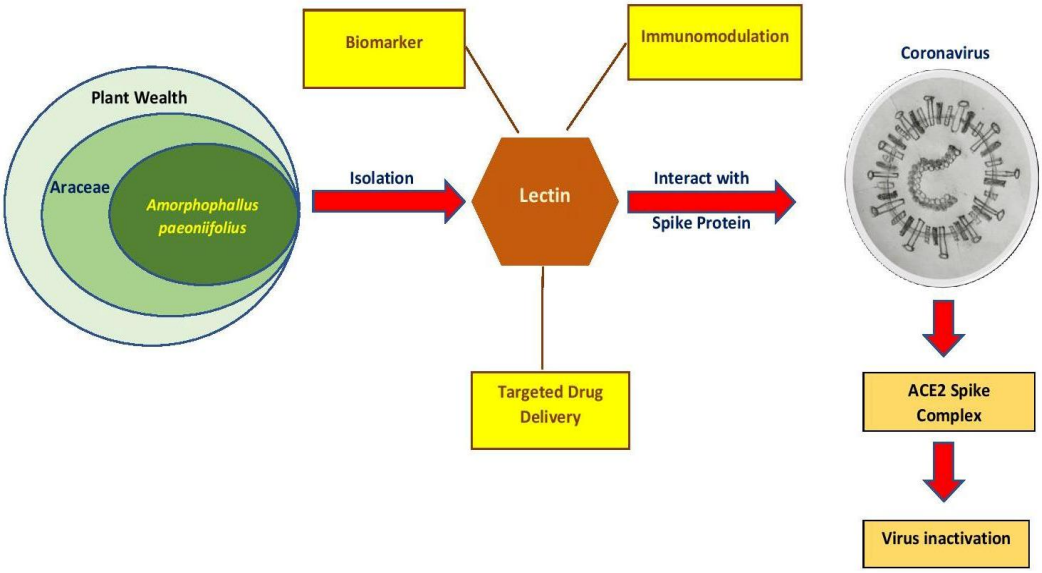


Figure 4. Future aspects of Araceae family including *A. paeoniifolius* against COVID-19 as a nutraceutical agent

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