

Cyperus rotundus, a substitute for *Aconitum heterophyllum*: Studies on the Ayurvedic concept of Abhava Pratinidhi Dravya (drug substitution)

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ABSTRACT

In the absence of a desired first choice medicinal herb, classical Ayurveda recommends use of a functionally similar substitute. Post 16th century Ayurvedic texts and lexicons give specific examples of possible substitutes. Here we report a preliminary study of one such Ayurvedic substitution pair: *Musta* (*Cyperus rotundus* L., Cyperaceae), a common weed, for the rare Himalayan species, *Ativisha* (*Aconitum heterophyllum* Wall. ex Royle; Ranunculaceae). The study's strategy was to use modern phytochemical and pharmacological methods to test the two herbs for biochemical and metabolic similarities and differences, and literary studies to compare their Ayurvedic properties, a novel trans-disciplinary approach. No previous scientific paper has compared the two herbs' bioactivities or chemical profiles. Despite being taxonomically unrelated, the first choice, but relatively unavailable (Abhava) plant, *A. heterophyllum*, and its substitute (Pratinidhi) *C. rotundus*, are not only similar in Ayurvedic pharmacology (Dravyaguna) profile, but also in phytochemical and anti-diarrheal properties. These observations indicate that Ayurveda may attach more importance to pharmacological properties of raw drugs than to their botanical classification. Further research into the nature of raw drugs named could open up new areas of medicinal plant classification, linking chemistry and bioactivity. Understanding the logic behind the Ayurvedic concept of *Abhava Pratinidhi Dravya* (drug substitution) could lead to new methods of identifying legitimate drug alternatives, and help solve industry's problems of crude drug shortage.

Key words: Abhava Pratinidhi Dravya, Ayurveda, anti-diarrheal, drug substitution.

INTRODUCTION

Natural sources of medicinal plants are often unable to meet demand for popular herbal products. Populations of many species have limited distribution in their natural habitats, requiring conservation strategies for protection.^[1] Unavailability of such medicinal plants has led to arbitrary substitution and adulteration in the raw drug market.^[2] Even for some of the top-traded drugs such as Asoka (*Saraca asoca* Roxb.), there appear to be substitutes in today's market.^[1] Ayurvedic texts from the 16th century and later, name several pairs of substitutes (Abhava Pratinidhi Dravya) for preferred plants, if unavailable (Abhava).

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For example, for *Plumbago zeylandica* L. (Chitraka) of the Plumbaginaceae family, they name *Baliospermum montanum* Willd^[3] (Danthi), belonging to an entirely different family (Euphorbiaceae). While the concept of substitute use is mentioned as early as Charaka Samhita,^[4] Bhavaprakasha Nighantu^[5] and Bhaishajya Ratnavali^[6] name plant pairs. Drug unavailability may have pertained to specific regions and not necessarily across the country.

Even a cursory glance at the list of Abhava Pratinidhi Dravya mentioned in classical Ayurveda texts excites scientific curiosity concerning the Ayurvedic principles behind selection of substitute drug. In this paper we report both Ayurvedic and preliminary phytochemical and pharmacological investigation of one pair of Abhava Pratinidhi Dravya viz., *Ativisha* (*Aconitum heterophyllum* Wall. ex Royle; Ranunculaceae) [Figure 1] and *Musta* (*Cyperus rotundus* L.; Cyperaceae) [Figure 2]. *Aconitum heterophyllum* is a high value (Rs. 4000/kg), endangered Himalayan species with an estimated annual demand of over 400 MT.^[1] It is traditionally used to cure fevers and diarrhea.^[7-9] The suggested substitute, *C. rotundus* is a weed, used to treat similar conditions.^[8,9]



Figure 1: Ativisha (*Aconitum heterophyllum* Wall. Ex Royle.)

Topics like the one discussed here have evolved within the epistemological framework of Indian Systems of Medicine, whose principles, science and practice are different from those of Western biomedicine. Understanding them therefore requires trans-disciplinary approaches,^[10] using scientific tools that can provide meaningful insights.

MATERIALS AND METHODS

A strategy was structured through brainstorming sessions involving expert Ayurvedic theoreticians and practitioners as well as modern scientists.

Listing Abhava Pratinidhi Dravya

A list of Abhava Pratinidhi Dravya was drawn up from the 16 to 19th century Ayurveda texts, Bhavaprakasha Nighantu,^[5] Yogaratnakara^[3] and Bhaishajya Ratnavali.^[6] Due to striking dissimilarities in both taxonomy and trade value, *A. heterophyllum* and *C. rotundus* were selected for comparison at three different levels: Dravyaguna (Ayurvedic pharmacology), chemical profiles (using phytochemical screening and chromatographic fingerprinting) and pharmacology (comparative anti-diarrheal effects in mice models).

Plant material

Field samples of *A. heterophyllum* and *C. rotundus* were collected and authenticated by an authorized field botanist and Ayurvedic practitioner at FRLHT, Bangalore. Voucher specimens were deposited with the Herbarium and Raw Drug Repository (FRLHT, Bangalore, India). The Herbarium voucher specimen and Raw Drug accession numbers of *A. heterophyllum* were FRLH 46188 and L/06/11/10, while those of *C. rotundus* were FRLH 34337 and L/05/06/050, respectively.

Dravyaguna studies

Ayurvedic pharmacological parameters (Rasapanchaka) on Ativisha and Musta were compiled from Charaka Samhita,^[4]



Figure 2: Musta (*Cyperus rotundus* L.)

Susruta Samhita,^[11] Astanga Hridaya,^[12] Yogaratnakara^[3] and Bhaishajya Ratnavali,^[6] and from lexicons like Bhavaprakasha,^[5] Dhanvantari,^[13] Raja^[14] and Kaiyadeva Nighantu.^[15] Contemporary understanding was also considered from the works of authors like Sastry^[8] and Sharma.^[9] Information about similarities and differences based on Ayurvedic pharmacognosy, pharmacology (Dravyaguna) and Pancha Mahabhuta (five basic elements) dominance was analysed in terms of their Rasa (taste), Guna (properties), Virya (potency) and Vipaka (taste after digestion).^[16]

Qualitative phytochemical evaluation

Methanolic extracts (5 g/25 mL) of the tubers of *A. heterophyllum* and *C. rotundus* were screened to identify the presence or absence of phytochemical groups.^[17]

Chromatographic fingerprinting

Chemical fingerprints of *A. heterophyllum* and *C. rotundus* were compared under identical High Pressure Liquid Chromatography (HPLC) conditions. Two grams of air-dried *A. heterophyllum* and *C. rotundus* root were powdered and refluxed with methanol at 60°C for 1 h over a water bath. The extract was filtered and concentrated under reduced pressure in a rotary evaporator. Concentrated extract (30 mL) was used for HPLC analysis in a Shimadzu (Japan) system with a Rheodyne 20 μ l injector, dual pump (LC-10ATVP), UV-Visible detector (SPD 10AVP) and a CLASS-VP6 software for separation and analysis. Stationary and mobile phases were Lichrocart C18 (250 \times 4.6 mm; 5 μ m particle size) column, and a gradient system of Water (Pump A) and Methanol (Pump B). Pump B starting concentration (10%) was raised to 100% in 45 min and maintained for a further 10 min. The column was equilibrated with initial solvent ratio for an hour and pumped at a rate of 1.0 mL/min for 55 min at 254 nm.

Pharmacological studies

Maximum Tolerated Dose (MTD) of dried methanolic

crude extracts of *A. heterophyllum* for Swiss Albino mice was determined to be successive doses of 550 and 2000 mg/kg body weight in accordance with OECD 425 guidelines for tests of acute oral toxicity.^[18] Animal experimentation was conducted at Al-Ameen College of Pharmacy, Bangalore. Drug performance was compared on anti-diarrheal activity, a clinical indication, for which Ativisha (*Aconitum heterophyllum*) is well known in Ayurveda. Approximately 10 mg/kg b.w. dried methanolic crude extracts of the two drugs were tested in a Castor oil-induced (0.1 mL/animal) diarrheal model on Swiss Albino mice.^[19] Diarrhea severity was assessed by comparing total numbers of diarrheal feces excreted during recording periods for four groups of six mice. After 30 min, controls were fed 0.05% Sodium carboxy methyl cellulose suspended in distilled water, the second group received the reference drug Loperamide (3 mg/kg; p.o.). Test groups were orally fed 10 mg/kg b.w. of crude dried methanolic extracts (suspended in fresh 0.05% Sodium CMC) of *A. heterophyllum* and *C. rotundus*. Total number of diarrheal feces excreted over a 4-h period was scored. Standard deviations and *P* values were calculated using ANOVA.

RESULTS

The exercise of compilation of Abhava and Abhava Pratinidhi Dravya from 16th to 19th century Ayurveda texts drew a list of 46 pairs [Table 1], most of them being unrelated taxonomically. The logic of selection of substitutes, parts and details of usage were not mentioned in any of the referred texts.

An analysis of the texts summarized in Table 2 indicated that the Dravyaguna qualities of the two herbs i.e., Rasa (taste), Guna (properties), Vipaka (state of taste after digestion) and Karma (actions) were very similar, while Virya (potency) alone was dissimilar; Musta being Sheeta Virya (cold potency) and Ativisha, Ushna Virya (hot potency). Both drugs were predominantly made up of Agni (fire), Vayu (air) and Akasha (space), as determined by Mahabhuta (basic elements) analysis of their Rasa, Guna, Virya and Vipaka. Musta, however, also seemed to possess Prithvi (earth) and Jala (water) Mahabhuthas. The *Grahi* (absorbing water content) action of both herbs is said to be useful in treating different kinds of diarrhea, curing fevers, liver, spleen, urinary tract diseases and diabetic conditions. Both are useful in treating Kaphaja Twak Rogas (Kapha skin diseases) [Table 2]. *Cyperus rotundus* is also used by current day Ayurvedic practitioners to treat cases of fungal infestation, erysipelas or herpes, itches and burning sensation, and Ativisha as a Deepana-pachana (to increase digestion), Shothahara (anti-inflammatory), Arshoghna (anti-hemorrhoidal) and Kasahara (anti-tussive) drug. Musta is not necessarily the drug of choice for these conditions, instead it is used to alleviate Pitta dosha and

cure Daha (burning sensation), Trishna (thirst) and Aruchi (tastelessness).

Toxicity studies revealed that while there was no observable toxic effect at doses less than 2000 mg/kg b.w., at that level, extracts of both plants led to symptoms such as convulsions, tremors, tachycardia, increased respiration rate, highly restricted motility and low alertness up to 8 h after administration. While alertness was restored after 8 h, reversal of other responses was only observed 48 h after drug administration. Recovery from these acute toxic symptoms was faster in the case of Musta than Ativisha. However, no mortality was observed at tested doses of either extract.

Bio-equivalence on castor oil induced diarrhea showed that at 10 mg/kg b.w., both drugs possessed good anti-diarrheal activity, *A. heterophyllum* being more effective, inhibiting 53% diarrheal activity compared to 46% of that of *C. rotundus* [Table 3]; activities comparable to that of Loperamide, a synthetic piperidine (65% at 3 mg/kg b.w.), especially considering the herbal extracts were crude, as opposed to Loperamide's chemical purity. Increasing dose of test extracts should improve activity.

Screening to qualitatively identify presence or absence of groups of phytochemicals revealed that tubers of both plants contained alkaloids, glycosides, saponins, phytosterols, flavonoids and tannins i.e., despite their taxonomic differences, no qualitative difference could be observed in their overall chemical composition [Table 4]. Superimposed HPLC profiles of *A. heterophyllum* and *C. rotundus* bore a striking resemblance in terms of peak profiles and fingerprints, except that the former possessed two more peaks at retention times of 11.8 and 29.6 min. Moreover, common peaks were significantly larger in Ativisha than Musta, indicating higher phytoconstituent concentrations [Figure 3].

DISCUSSION

At least 46 substitutes for 44 herbs are mentioned as Abhava Pratinidhi Dravya in the texts named [Table 1]. Bhava Mishra suggests substitutes for all eight of the Ashtavarga group of herbs.^[5] It was observed that, even though some substitutions like Musta for Ativisha are actually in practice today, many, like substituting Dhataki for Yashtimadhu were new to the practitioners [Table 1], also that the texts unfortunately do not detail parts, form or condition of the substitute to be used, nor the logic behind such substitutions.

Despite their taxonomic and morphological dissimilarities,

Table 1: List of Abhava Pratinidhi dravyas

Drug	Botanical names	Substitute	Botanical names
Chithraka ^[3,6]	<i>Plumbago zeylandica</i> L.	Danthi or Apamarga Kshara	<i>Baliospermum montanum</i> wild., or alkaline preparation of <i>Achyranthes aspera</i> L.
Dhanvayasa ^[3,6]	<i>Fagonia cretica</i> L.	Duralabha	<i>Alhagi pseudalhagi</i> Desv.
Tagara ^[3,6]	<i>Valeriana wallichii</i> DC.	Kusta	<i>Saussurea lappa</i> Clarke.
Murva ^[3,6]	<i>Marsdenia tenacissima</i> (Roxb.)	Jinghini	<i>Lannea coromandelica</i> (Houtt).
Ahimsra ^[3,6]	<i>Capparis sepiaria</i> (L.)	Manakanda	<i>Alocasia indica</i> (Lour.)
Lakshmana ^[3,6]	<i>Solanum xanthocarpum</i> Schrad.	Nilakanta shikha	<i>Celosia cristata</i> L.
Bakula ^[3,6]	<i>Mimops elengi</i> L.	Kamala	<i>Nelumbo nucifera</i> (Gaertn.)
Neelothpala ^[3,6]	<i>Nymphaea stellata</i> Willd.	Kumuda	<i>Nymphaea alba</i> L.
Kamala ^[3,6]	<i>Nelumbo nucifera</i> (Gaertn.)	Seeds of Kamala (Kamalaksha)	Seeds of <i>Nelumbo nucifera</i> (Gaertn.)
Bakula bark ^[3]	<i>Mimops elengi</i> L.	Babbula bark	<i>Acacia arabica</i> Willd.
Jathipathra ^[3,6]	Aril of <i>Myristica fragrans</i> Houtt.	Lavanga or Jathiphala	<i>Syzygium aomaticum</i> L. or fruits of <i>Myristica fragrans</i> Houtt.
Pushkara mula ^[3,6]	<i>Inula racemosa</i> Hook. f.	Kusta or Eranda mula	<i>Saussurea lappa</i> C.B. Clark or root of <i>Ricinus communis</i> L.
Sthouneyaka ^[3]	<i>Taxus baccata</i> L.	Kusta	<i>Saussurea lappa</i> C.B. Clark
Chavya and Gajapipali ^[3]	<i>Piper chaba</i> Hunter and <i>Scindapus officinalis</i> Schott.	Pippali mula	Root of <i>Piper longum</i> L.
Somaraji ^[3]	<i>Psoralea corylifolia</i> L.	Prapunnata phala/ bija	Fruit/seeds of <i>Cassia tora</i> L.
Daruharidra ^[3,6]	<i>Berberis aristata</i> Hook. f.	Haridra	<i>Curcuma longa</i> L.
Bharangi ^[3,6]	<i>Clerodendrum serratum</i> L.	Talisa Patra or Kantakari	<i>Abies webbiana</i> Lindl. or <i>Solanum xanthocarpum</i> Schrad.
Yastimadhu ^[3,6]	<i>Glycyrrhiza glabra</i> L.	Dhathaki	<i>Woodfordia fruticosa</i> L.
Amlavethasa ^[3,6]	<i>Garcinia pedunculata</i> Roxb.	Chukra	<i>Garcinia indica</i> Choisy.
Chukra ^[3]	<i>Garcinia indica</i> Choisy.	Sarva Jambiradi rasa	Juice of Citrus fruits.
Draksha ^[3,6]	<i>Vitis vinifera</i> L.	Kashmari Phala	Fruits of <i>Gmelina arborea</i> Roxb.
Kashmariphala ^[3]	Fruits of <i>Gmelina arborea</i> Roxb.	Madhuka pushpa	<i>Madhuca indica</i> Gmel. flowers
Nakha ^[3,6]	<i>Ziziphus mauritiana</i> Lam.	Lavanga Kusuma	Flower of <i>Syzygium aomaticum</i> L.
Kankola ^[3,6]	<i>Piper cubeba</i> L.f.	Jathi Pushpa	<i>Jasminum grandiflorum</i> L.
Haritaki ^[3]	<i>Terminalia chebula</i> Retz.	Karkata Shringi	<i>Pistacia chinensis</i> Bunge.
Karpura ^[3,6]	<i>Cinnamomum camphora</i> L.	Sugandha musthaka	<i>Cyperus rotundus</i> L.
Karpura ^[3,6]	<i>Cinnamomum camphora</i> L.	Granthiparna	<i>Leonotis nepetaefolia</i> R. Br.
Dadima ^[3,6]	<i>Punica granatum</i> L.	Vrikshamla	<i>Garcinia indica</i> Choisy.
Kumkuma Kesara ^[3,6]	<i>Crocus sativus</i> L.	Kusumbha Pushpa	Flower of <i>Carthamus tinctorius</i> L.
Chandana ^[3,6]	<i>Santalum album</i> L.	Karpura	<i>Cinnamomum camphora</i> L.
Rakthachandana ^[3,6]	<i>Pterocarpus santalinus</i> L.	Ushira	<i>Vetiveria zizanioides</i> (L.)
Ativisha ^[3,6]	<i>Aconitum heterophyllum</i> Wall. ex Royle	Musta	<i>Cyperus rotundus</i> L.
Musta and Athivisha ^[3]	<i>Cyperus rotundus</i> L. and <i>Aconitum heterophyllum</i> Wall. Ex. Royle	Harithaki	<i>Terminalia chebula</i> Retz.
Nagapushpa ^[3]	<i>Mesua ferrea</i> L.	Padmakesara	<i>Nelumbo nucifera</i> (Gaertn.)
Ballathaka ^[3]	<i>Semecarpus anacardium</i> L.	Nadi bhallataka	<i>Semecarpus travancorica</i> L.
Ballathaka ^[3,6]	<i>Semecarpus anacardium</i> L.	Chithramula	Root of <i>Plumbago zeylanica</i> L.
Meda-Mahameda ^[3,5]	Varieties of <i>Polygonatum cirrhifolium</i> Royle.	Shathavari	<i>Asparagus racemosus</i> Willd.
Jeevaka-Rushabhaka ^[3,5]	<i>Microstylis muscifera</i> Ridl. - <i>Microstylis wallichii</i> Lindl.	Vidarikanda	<i>Pueraria tuberosa</i> DC.
Kakoli-Kshirakakoli ^[3,5]	<i>Lilium polyphyllum</i> Don. - <i>Fritillaria roylei</i> Hook.	Ashvagandha	<i>Withania somnifera</i> L.
Rudhi-Vrudhi ^[3]	Varieties of <i>Habenaria intermedia</i> Don.	Varihikanda	<i>Dioscorea bulbifera</i> L.
Ikshu ^[3]	<i>Saccharum officinarum</i> L.	Nala	<i>Arundo donax</i> L.
Kusha ^[3]	<i>Desmostachya bipinnata</i> Don.	Kasha	<i>Saccharum spontaneum</i> L.
Tulasi ^[3]	<i>Ocimum sanctum</i> L.	Nirgundi	<i>Vitex negundo</i> L.
Kutherika ^[3,6]	<i>Ocimum basilicum</i> L.	Gramya tulasi	<i>Ocimum sanctum</i> L.
Swetha Punarnava ^[3,6]	White variety of <i>Boerhavia diffusa</i> L.	Rakha punarnava	Red variety of <i>Boerhavia diffusa</i> L.
Rasna ^[3,6]	<i>Pluchea lanceolata</i> C.B. Clarke	Kolanjana	Willd.

Table 2: Summary of properties and actions (Rasapanchakas) of Ativisha and Musta

Properties	Ativisha	Musta	Similarities
Rasa (taste)	Katu ^[5] (pungent), Tikta ^[5] (bitter)	Katu ^[5,14] (pungent), Tikta ^[5,14] (bitter), Kashaya ^[5,14] (astringent)	Katu (pungent), Tikta (bitter)
Guna (property)	Laghu ^[5] (light), Ruksha ^[8] (dry)	Laghu ^[9] (light), Ruksha ^[9] (dry)	Laghu (light), Ruksha (dry)
Virya (potency)	Ushna ^[5] (hot)	Sita ^[14] (cold)	
Vipaka (taste after digestion)	Katu ^[5] (pungent)	Katu ^[8] (pungent)	Katu (pungent)
Karma (actions)	Kapha-Pittahara ^[5,14] (reduces Kapha-pitta), Dipana ^[15] (increases digestive fire), Pachana ^[15] (digests undigested material), Grahi ^[4,14] (absorbing), Shotahara ^[3] (antiinflammatory), Vishaghna ^[14] (anti poisonous), Krimihara ^[6] (anthelmintic), Arshoghna ^[6] (anti hemorrhoid), Jwarahara ^[5] (anti pyretic), Kasahara ^[12] (anti-tussive), Atisaraghna ^[14] (anti-diarrheal)	Kapha-Pittahara ^[5,14] (reduces Kapha-pitta), Dipana ^[14] (increases digestive fire), Pachana ^[14] (digests undigested material), Grahi ^[14] (absorbing), Jwarahara ^[4,5,14] (anti-pyretic), Kandu ^[13] (anti itching), Atisaraghna ^[13] (anti-diarrheal)	Kapha-Pittahara (reduces Kapha-pitta), Pachana (digests undigested material), Grahi (absorbing), Jwarahara (anti-pyretic), Atisaraghna (anti diarrheal)
Indications	Atisara ^[3,6] (diarrhea), Jwara ^[3,4,6] (fevers), Shotha (inflammations), Krimiroga ^[15] (helminthiasis), Visha ^[14] (poisoning), Vami ^[12] (vomiting), Ajeerna ^[4,6] (indigestion)	Jwara ^[4,5,12,14] (fevers), Atisara ^[13] (diarrhea), Shotha ^[3,4] (inflammations), Trishna ^[13] (thirst), Aruchi ^[15] (tastelessness), Krimiroga ^[5] (helminthiasis), Ajeerna ^[3,4] (indigestion)	Jwara (fevers), Shotha (inflammations), Atisara (diarrhea), Ajeerna (indigestion), Krimiroga (helminthiasis)
Mahabhuta dominance	Agni (fire), Vayu (air), Akasha (space)	Agni (fire), Vayu (air), Akasha (space), Prithvi (earth), Jala (water)	Agni (fire), Vayu (air), Akasha (space)
Part used	Tuberous root ^[2,8,9]	Tuberous root ^[2,8,9]	Tuberous root

Table 3: Anti-diarrheal activity of crude methanolic extracts of *Aconitum heterophyllum* and *Cyperus rotundus* in wistar albino mice using Castor oil induced model

Group	Dose/drug	Mean number of diarrheal feces in 4h ± SEM	Percentage inhibition of diarrhea
Control	0.05% Sodium CMC water	3.583 ± 0.35	-
Positive control (Loperamide)	3 mg/kg body wt.	1.25 ± 0.34**	65.11
<i>Aconitum heterophyllum</i>	10 mg/kg body wt.	1.67 ± 0.33*	53.47
<i>Cyperus rotundus</i>	10 mg/kg body wt.	1.92 ± 0.14*	46.49

n = 6; **P < 0.001 as compared with control; *P < 0.01 as compared with control (ANOVA)

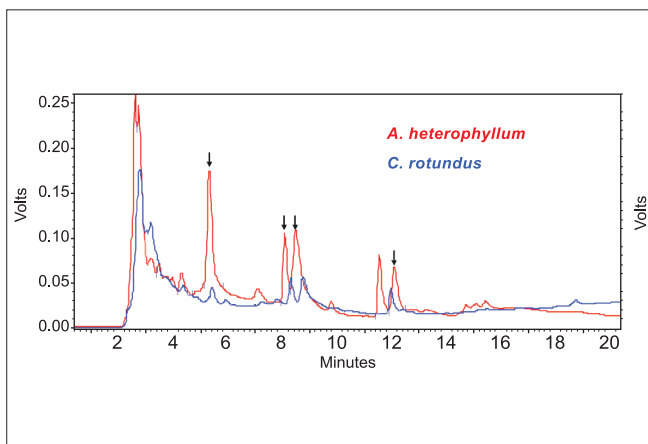


Figure 3: HPLC profiles of methanol extracts of *Aconitum heterophyllum* Wall. Ex Royle. and *Cyperus rotundus* L.

Table 4: Qualitative chemical screening of *Aconitum heterophyllum* and *Cyperus rotundus*

Phytoconstituents	Tests	<i>Aconitum heterophyllum</i>	<i>Cyperus rotundus</i>
Alkaloids	Mayer's test	+	+
	Dragendorff's test	+	+
	Wagner's test	+	+
	Hager's test	+	+
Anthraquinone glycosides	Bortrager's test	+	+
Cardiac glycosides	Legal's test	+	+
Saponins	Foam test	+	+
	Froth test	+	+
Phytosterols	Liebermann	+	+
	Burchard's test		
Flavonoids	Lead acetate test	+	+
Tannins	Lead acetate test	+	+
	Gelatin test	+	+

Ayurvedic profiles of the chosen pair of herbs were found to be very similar, including the *Atisaraghna* (anti-diarrheal) property, as stated in Ayurvedic Materia Medica. Furthermore, the animal studies confirmed that both drugs were bio-equivalent in this pharmacological activity. Substitution for that condition is therefore supported.

What is both interesting and surprising to a modern scientist is the similarity of the phytochemical and HPLC profiles of the two drugs. Several previous scientific characterizations have been made of the two herbs individually, but no exploration of possible similarities in their chemistry and action has been made. The majority of phytochemical

reports on *A. heterophyllum* tubers has focused on alkaloid isolation and characterization,^[20] whereas *C. rotundus* reports concern sesquiterpene essential oils.^[21]

In contrast to Ayurvedic *Dravya* (material) analysis, phytochemical and pharmacological techniques generally cannot provide insight into entire plant metabolites and functions. For want of objective protocols to assess *Rasapanchaka* (Ayurvedic quality parameters), we resorted to modern reductionist techniques like HPLC. Observed correlations in HPLC profiles, though not conclusive, do reflect similarities in polarity and conjugation, raising the question of their significance when comparing drugs.

Ayurveda states that Rasa (taste) of a drug has a bearing on its pharmacological action (Karma).^[4] Other modern authors have drawn attention to the Ayurvedic concept of use of Rasa for drug identification, drug action, selection of alternate drugs and new drug discovery.^[22,23] There have also been attempts by biochemists to relate pharmacological activities of different molecules based on their taste.^[24] Ativisha and Musta both have Katu (pungent) and Tikta (bitter) Rasa suggesting their possible similar use for conditions like indigestion, diarrhea, fever etc.

The dissimilarity in the Virya (potency) of Ativisha (Ushna) as against Musta (Sita) is important to note. Ativisha would be useful in Kaphaja Atisara (diarrhea with dominance of Kapha Dosha),^[3,6] while Musta in Pittaja Atisara (diarrhea with dominance of Pitta Dosha).^[3,6]

To select a substitute for a drug would therefore require an understanding of the Guna-Karma (Properties and actions) of the drugs. A substitute is always that; 'a substitute', meaning there may be some Guna-Karmas that are absent in it when compared to the original drug. However the substitute could be used in selected conditions. How to select a substitute according to Ayurveda is not clear today and requires further research. Yogaratnakara indicates that if Rasa, Virya, Vipaka etc. of one drug are similar to those of another, then it may be selected as a substitute.^[3]

CONCLUSION

To understand Ayurvedic principles and science more deeply, adopting strategies that transcend epistemological and cultural barriers may be helpful. Here remarkable results ensued from both Ayurvedic and scientific perspectives. In general, in integrative Ayurvedic studies, what may seem obvious from one perspective can translate into unusual or remarkable circumstances when seen from the other perspective. In the present study of two herbs said to have similar actions, the modern

biochemical perspective still regards close similarities in spectra of groups of metabolites as a noteworthy result. The fact that many centuries previously Ayurveda had already identified the two as having sufficiently similar pharmacological properties to be used as substitutes is all the more remarkable.

Botanical classification may be central to herbalism and quality control, but techniques to evaluate medicinal uses are more relevant to treatment. Modern scientific chemotaxonomy classifies plants with similar chemicals. However, this too may not be sufficient to study plants for the purpose of Ayurvedic drug formulation.

Our work raises the question whether studies like this should not consider broad groups of chemicals rather than individual compounds to begin with. Use of metabolomic tools^[25] such as NMR, GC-MS and LC-MS integrated with sophisticated bioinformatics and bioassays would help understand the exact nature of observed similarities and dissimilarities. Software like Chrompare (www.chrompare.com) would help in analysis of chemical data points.^[26]

Even though the current study is preliminary, and inconclusive, it provides a new perspective that should be applied to study drug substitutes. That could lead to a solution to raw drug unavailability.

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