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THE PHYTOCHEMICALS AT EACH MATURITY STAGES OF *TERMINALIA CHEBULA* RETZ AND A BASIS FOR SCIENTIFIC VALIDATION OF INDIAN TRADITIONAL SEASONAL REGIMEN - A MARKER VIEW

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ABSTRACT Research on *Terminalia chebula* fruits (TCFs) suggest the size and area to be definitive markers based on positive correlation with tannin alone. Negative correlations exist between roundedness and tannin. There are markers other than Tannin in TCFs. So, challenges reside in the selection of TCFs for pharmaceutical purpose amidst 7 Indian geographical types and each with 6 stages of maturity (MS). The Phytochemical quantity is susceptible to higher variation interfering with the compliance to standardisation parameters. So this review aim to: Identify and correlate phytochemicals with the seasonal MS all over India and provide common correlative table to find the MS in a view not to miss regional phytochemical analytical results, preclinical and clinical data, done to ascertain scientifically the Indian traditional claims regarding the uses, since exact MS data is lacking in scientific papers; Correlate with seasonal regimen; Order the 7 marker compounds based on the MS of TCFs.

KEYWORDS : *Terminalia chebula* fruits, Indian traditional claims, marker compounds.

INTRODUCTION:

Terminalia chebula 1, 2 fruit (TCF) used in Indian systems of medicines, grows wild in under nutritious soil under drought conditions. TCF is a kayakalpa herbal drug. The quality of a drug is assessed by the compliance of the collected / market drug with the microscopic and macroscopic characters, identity, purity and strength of phytochemicals included under standardization parameters in pharmacopoeias. Indian traditional medicines use only three TCFs based on maturity and are available in the market. There are around 133 natural products isolated from TCFs. The susceptibility of phytochemical changes of TCFs is at very higher rates influenced by temperature, light, moisture, air drying and edaphic carbon. This accounts for the high tree to tree variation. Within tree variations may be due to tannin increase by unwanted animal/ human disturbances to the fruit. This is reflected on the 6 MS of the fruit during the 6 seasons[3]. Such variations interfere in standardization of TCFs. The nutritious TC seeds may grow at any time from November'15 to January'15 naturally and yield fruits starting from the 3rd year and yield healthy fruits from 10 years of age up to 70 years. The autumn flowering TCFs have 6-7 months (maximum up to 9 months in closely related spp) fruiting period. Since India is a land of rich biodiversity, the reproductive period varies widely. So the present review is conducted with the following objectives; Identify and correlate phytochemicals with the seasonal MS all over India and managed to provide common correlative table to find the maturity of TCFs inspite of the above variations since any one of the data is lacking in recent scientific papers; Specific tastes accumulate in specific fruit parts and 6 different vehicles are prescribed in classical texts for intake. The study also correlates this concept with the seasonal MS of TCFs which form the basis to scientifically validate the traditional claims regarding the vehicles; Order the 7 marker compounds based on the MS of TCFs[6]. This study uses reproductive data as per FAO[5] which coincide with the data of Vindhya Range.

MATERIALS AND METHODS

Table 1: Common identification of maturity of TCFs based on size and colour

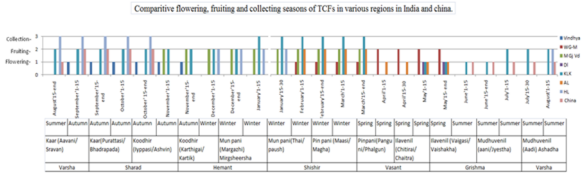
S No	Traditional Size	Metric Size	Colour	Size as per Research publications	Stage of Maturity
1	Cumin seed	4 to 6 mm Length[1]			Young
2	Barley corn	0.85cm Length		Small[7]	Adolescence
3	Raisin	1.5 -2.5 cm long and 0.5-1.5 cm wide [8]	Green	1.5-1.8 Medium[7]	Adult Hood
4	Chini fruit	0.6-1.5 cm in diameter	Greenish yellow	1.9 -2.5 Big immature[7] less wrinkled, less furrowed. tanneries and preparations of colours[9]	Fertilization stage
5	Asfer (Boy, Yellow dinar)[10, 11]	2.9cm	Very nearly mature		Conception (Fertile seed)
6	Kabul	Longest, maximum size	Fully matured fruit		Senescence (Fruit) or Birth time/dispersal (seed)

Table 2: Comparitive flowering, fruiting and collecting seasons of TCFs in various regions in India and china.

Season & Month	Calender months	Vindhya	Western Ghats, Maharashtra	Vadodara Gujarat	Delhi	Kolkatta	Arunachal pradesh	Himachal pradesh	China
Summer Autumn	August'15-September'15	Fl				Fr		C	Fl Fr
Autumn	September'15-October'15	Fl				Fr		C	Fr
Autumn	October' 15-November'15	Fl		Fr		Fr		C FrC	Fr
Autumn Winter	November'15-December'15	Fl		Fr		Fr		FrC	
Winter	December'15-January'15	Fl		Fr		Fr C		Fr	
Winter	January'15-February'15		Fl	Fr		C	Fr2yr	Fr	
Winter Spring	February'15-March'15		Fl	Fr		C	Fr2yr		
Spring	March'15- April'15	Fl	Fr	Fr		C	Fr2yr Fl1yr		
Spring	April'15- May'15		Fr		Fl	Fl	Fl1yr		
Spring Summer	May'15- June'15	Fr			Fl Fl & Fr	Fl	Fl1yr		Fl
Summer	June'15- July'15				Fl & Fr	Fl Fr			Fl
Summer	July'15- August'15				Fl	Fr Fr		Fr	Fl

*Fl- Flowering, Fr- Fruiting, C-Collection

Chart-1: Representation of published reproductive seasons Indian regional TCFs[11-27]



*The Indian pharmacopoeias and Chinese blogs included the August month as the flowering end period of TCs with actual duration of flowering being 4 months. Research publications indicate two fruiting seasons of Terminalia sps namely during dry season and after rainfall. FAO recommends TC fruiting from January~March. If so, for a general minimum 6-7 months fruiting period with 2-3 months of natural mature fall of fruits, January indicate the ripe stage which implies the inclusion of autumn flowering. Early fruiting in the context of collection during calender months (January), this flowering period stands first. Also to include the closely related species & for future comparison the common vindhyan data is preferred.

Table 3: Seasonal dependence of maturity of TCFs and corresponding variations of phytochemicals with the seasonal regimen[28, 29]

Seasonal Months in Siddha & Ayurveda	Season	Duration in Months	Maturity of TCF	Research update of Phytochemical	Vehicle
Aavani/ Sravan	Sum Aut	Aug'15- Sep' 15	V. Mature ripe fruits (mature seeds-C) & Fl start	Ethyl gallate Chebulic acids, Gallic acid, Less tannin & Ellagic acid, High anthraquinones & Methyl quercetin flavanoids	Saindha lavana (Rock salt)
Purattasi/ Bhadrapada	Aut	Sep' 15- Oct' 15	Nearly mature Ripe fruits (mature seeds-C) & Fl		Saindha lavana
Iyppasi/ Ashvin	Aut	Oct'15- Nov' 15	VI. Fully mature Ripe fruits		Sugar
Karthigai/ Kartik	Aut Win	Nov'15-Dec'15	Fully mature ripe & Fl (BT)		Sugar
Margazhi/ Mirgsheersha	Win	Dec'15- Jan'15	Some ripe & Fl / I.Young Fr (without seed)	High Tannin & Ellagic acid & Chebulagic acids (in seeds). No quinone and Methyl quercetin flavanoids in traces, presence of mellotic acid, *p*-coumaric and varallic acids	Dry ginger
Thai/ paush	Win	Jan'15- Feb'15	Young Fr (without seed)		Dry ginger
Maasi/ Magha	Win Spr	Feb'15- Mar'15	II.Adl (seeds form)		Piper longum
Panguni/ Phalgun	Spr	Mar'15- Apr'15	Adl (seeds form)		Piper longum
Chitirai/ Chaitra	Spr	Apr'15- May'15	III. AH (young seed) (Unripe)	Moderate Tannin & Ellagic acid, Moderate quinone & Methyl quercetin flavanoids, presence of mellotic acid, p-coumaric and varallic acids. Ferulic and caffeic acids may be present or absent	Honey
Vaigasi/ Vaishakha	Spr Sum	May'15- Jun'15	AH (young seed) (unripe)		Honey
Aani/ Jyestha	Sum	Jun'15- Jul'15	IV. FS (Start ripening)		Jaggery
Aadi Ashadha	Sum	Jul'15- Aug'15	FS (Ripening)		Jaggery

All Season and months are abbreviated to first three alphabets similar to January - Jan.

C Conception
BT Birth time
Adl Adolescence
AH Adult Hood
FS Fertilization stage

*In kerala, seedless fruit of the same species (Khare, 2003), is accepted as haritaki[30]

TABLE 4 Accumulation of tastes in the seasonal maturity stages of TC Fruit parts- A correlation of Indian traditional concept

Month	Maturity of TCF	Taste	Fruit part
Dec'15-Feb'15	I. Young Fruit	Sweet	Kernel
Feb'15-Apr'15	II. Adolescence	Bitter	Petiole, Rachis
Apr'15-Jun'15	III. Adult Hood	Astringent	Pulp
Jun'15-Aug'15	IV. Fertilization stage	Pungent	Outer Skin
Aug'15-Oct'15	V. Nearly mature ripe fruits	Sour	Vein (bulky portion)
Oct'15-Dec'15	VI. Fully mature Ripe fruits (Birth Time) & Flowering		

Kottai- generally denotes seed coat but as per research updates for TCFs coincides with the Pulp. TCFs are often termed (vernacular) as seeds (pulp), Narambu- vernacular term denote the vein of a leaf, nerve & fibre.

Table 5: Initial rearrangement of general Marker compounds young to matured TCFs

S No	Marker compounds- young to matured TCFs
1	Gallic Acid
2	Ellagic Acid
3	Chebulagic Acid
4	Chebulinic Acid
5	Methyl Gallate
6	Ethyl Gallate

DISCUSSION:

Table 1 & 2 describe the identity of 6 MS and highlight the existence of an earlier circular order in the geographical flowering pattern of TC trees observed as: West, equatorial west, south west, central longtitudinal (Delhi & Kolkatta), north east and north west (approximation to a minimum of 3 three months before fruiting) respectively. During the maturation of the tree, the amount of tannin decrease and the acidity (Chebulic and gallic acid)of the fruits increase[33]. Volatile ethylene release after being fed by animals followed by the synthesis of tannins within 30 minutes, is observed in the rest of Acacia leaves. Ripener ethylene controls astringency with in fruits[34]. The Phytochemicals present in the extractions are found absent in the fresh ripe fruits. The dried fruits significantly reduced: diabetic fasting serum glucose than the fresh fruits; serum cholesterol levels in 16% and 14% respectively[35]. Traditionally the astringency reduces the sweet sugar. The same principle is observed within fruits (see Table 4). As beetle boring and dryness affect considerably, reflection is in the thermolabile constituents at all stages. They are assembled as per research updates in table 3. Gallic acid and its metabolites (major being 4-O-Methyl gallic acid) on dry distillation get converted to pyrogallol type (white) of tannins. The pyrogallols on hydrolysis yield chebulic acid (in mature ripe TCFs, Table 3) and d-galloyl glucose[36]. Non Hydrolysable Tannins (condensed type) are phlobatannins or proanthocyanidins (flavonoid pigments) that are polymerized or decomposed into red coloured substances called phlobaphenes , are in all three stages of the fruit [9]. They are insoluble in water and indicate the typical brownish-red colour of many plants and drugs[37]. So based on the contribution to the colour, the phlobabenes can be assumed to be less in first three immature stages. On dry distillation they yield catechol (for assessment). The high ellagic acids (EAs found in the young TCF show gradual decrease that in mature full ripe fruits they are found only in traces. The ellagic acids derived from ellagitannins are susceptible to thermohydrolytic cleavage and form thermolabile chebulagic acid (CLG). So when the temperature increase, transformation in to intermediate compounds favour gallic acid and chebulin formations i.e., emergence of the intermediate ferulic acids decrease the ellagic acid content further. Anthraquinones and Sennosides[38]associated with maturity: Anthraquinones C14H8O2 are (9, 10-Anthraquinone/anthracene- 9, 10-diones/ Benzopyrans/ Carbaldehydes) aromatics derived also from phthalic anhydride: yellow - green crystals soluble in acetone. But Sennosides-A (SAs) are C42H38O20. Yellow-brown powder with a slight odor and taste. M.W: 862.746 g/mol. Solubility in acetone not mentioned. The difference is to signify that though both compounds are cathartic in nature they are different. SAs contain anthraquinone glycosides. But the colour difference between AQs and SAs in particular from yellow-green to yellow-brown crystals indicate that one might be a derivative of another under high temperatures and light or exposure to air. Correlation of colour with the increase in the molecular weight from lower 208 to higher 862 g/mol levels prove that the additions of AQs may happen during maturation (unripe to ripe stages or during drying). Presence of most of the compounds in this stage (medium sized fruits) gave maximum and presented with less residue on sieving[7]. This implies that the insoluble fibre to be present in less quantity. And contribution to the maximum yield is from the moderate presence of most of the phytochemicals in these stages (III & IV).

Confirmation of quantitative presence of chlorogenic acids especially ferulic acid in TCFs of young seeded stage III and full ripe stage IV (summer months) can be analysed to include in formulations indicated to reduce pitha to extract the best benefit. The Forest Research Institute, Dehradun, India identifies the second,

third and sixth MS to be suitable for medicinal use and the fourth and fifth for tanning. This implies that vehicles for IV and V MS of TCFs be more strictly adhered if used for medicinal purpose. Correlating Table 4 with Table 3, objectives 2 & 3 can be met. TCF Markers during MS are ordered in Table 5.

CONCLUSION:

This discussion on the marker compounds may be useful for analysing the various TCFs based on maturity in future, as the correct harvesting time influence the quality of produce.

REFERENCES:

1. Anonymous (1989), Ayurvedic pharmacopoeia of India, MoHFW, Goverment of India. New Delhi, Part-I, I.
2. http://nischennai.org/uploaded/pdf/THE%20SIDDHA%20PHARMACOPOEIA%20OF%20INDIA.pdf
3. Anonymous, The Wealth of India raw materials, (1998), vol. X New Delhi, India Y.R. Chadha (Chief Editor) CSIR, 173
4. Talwar, S., & Bhatnagar, A. K. (2005) Pollination biology of Terminalia chebula. Acta Biologica Cracoviensia. Series Botanica. Supplement, 47 (1).
5. http://www.fao.org/docrep/x5334e/x5334e04.htm
6. Anil D. Mahajan, Nandini R. Pai, (2014)Development and Validation of HPLC Method for Quantification of Phytoconstituents in Haritaki Churna, Vol.3, No.1, pp 329-336, Jan-Mar 2011. & Chander, J., & Chauhan, S. K. (2014). Current status of management of harar (Terminalia chebula Retz.) in Shiwalik hills. J Krishi Vigyan, 3(1), 13-17.
7. Gandhi, A. J. (2017). Industrial approach of process validation of Bharjana (frying) process WSR to Eranda Bhrishta Haritaki: An experimental observation. International Journal of Green Pharmacy (IJGP), 10 (04).
8. Ghrairi F, Lahouar L, Brahmi F, Ferchichi A, Achour L, Said S (2013). Physicochemical composition of different varieties of raisins (Vitis vinifera L.) from Tunisia. Industrial crops and products May 1; 43: 73-77.
9. Denni, M., Sandhya, M., & Ramesh, S. (2012). An investigation to variation in constituents in the fruits of Terminalia Chebula Retz. at different maturity stages, International Journal of Pharma and Bio Sciences 3(1):416-419.
10. https://nametranslate.com/searchNames.php?name=Asfer
11. https://en.numista.com/catalogue/pieces1206.html
12. Bhagat, R. B., Chambhare, M., Mate, S., Dudhale, A., & Zaware, B. N. (2016). Prospective wild edible fruit plants from part of northern Western Ghats (NWG), Mulshi (MS), India. Journal of Medicinal Plants, 4(1), 15-19.
13. Ingle, P., & Dhabe, A. (1832). Anatomical investigation of Terminalia chebula Retz. Hist, 2(659).
14. Bag, A., Bhattacharyya, S. K., & Chattopadhyay, R. R. (2013). The development of Terminalia chebula Retz.(Combretaceae) in clinical research. Asian Pacific journal of tropical biomedicine, 3(3), 244.
15. https://books.google.com
16. Guleria, S. H. I. K. H. A., Dev, K. A. M. A. L., & Khosla, P. K. (2016). Comparative analysis of phytochemicals and antioxidant activities of fruit and leaves of Terminalia chebula from Himachal Pradesh. IJBPAS, 5(6), 1195-1206.
17. http://shodhganga.inflibnet.ac.in/bitstream/10603/167098/12/12_ chapter% 207.pdf
18. Nanda, A., Suresh, H. S., & Krishnamurthy, Y. L. (2014). Phenology of a tropical dry deciduous forest of Bhadra wildlife sanctuary, southern India. Ecological processes, 3(1), 1.
19. Gupta, B. N. 1994. India. In Non-wood forest products in Asia. Rome, Food and Agriculture Organization of the United Nations.
20. Singh, K. P., & Kushwaha, C. P. (2005). Diversity of flowering and fruiting phenology of trees in a tropical deciduous forest in India. Annals of Botany, 97(2), 265-276.
21. Baliga, M. S., Meera, S., Mathai, B., Rai, M. P., Pawar, V., & Palatty, P. L. (2012). Scientific validation of the ethnomedicinal properties of the Ayurvedic drug Triphala: a review. Chinese journal of integrative medicine, 18(12), 946-954.
22. Khan, M. U., Khalilullah, H. A. B. I. B. U. L. L. A. H., Akhtar, J. A. W. E. D., & Elhasan, G. O. (2015). Terminalia chebula: an ephemeral glance. Int J Pharm Pharmac Sci, 7(2), 40-43.
23. Ratha, K. K., & Joshi, G. C. (2013). Haritaki (Chebulic myrobalan) and its varieties. Ayu, 34(3), 331.
24. Sharma, K., Thakur, S., Sharma, S., & Sharma, S. D. (2012). A new record on flowering in Harar (Terminalia chebula Retz.) seedling. American Journal of Plant Sciences, 3(05), 693.
25. Ram, T. S., Srinivasulu, B., & Narayana, A. (2015). PRAGMATIC USAGE OF HARITAKI (TERMINALIA CHEBULA RETZ): AN AYURVEDIC PERSPECTIVE VIS-Ã€-VIS CURRENT PRACTICE. International Journal of Ayurveda and Pharma Research, 1(3).
26. http://www.chineseherbshealing.com/terminalia-chebula/ & Li K, Diao Y, Zhang H, Wang S, Zhang Z, Yu B, Huang S, Yang H. Tannin extracts from immature fruits of Terminalia chebula Fructus Retz. promote cutaneous wound healing in rats. BMC Complementary and Alternative Medicine. 2011 Dec;11 (1):86.
27. C. Anjaneyulu and Charu Chandra Giri (2018), Biochemical characterization of somatic embryogenesis and genetic transformation studies in Terminalia chebula Retz.: An immensely valuable medicinal tree, Annals of Phytomedicine 7 (1): 38-51.
28. HL Sharma K, Thakur S, Sharma S, Sharma SD (2012). A new record on flowering in Harar (Terminalia chebula Retz.) seedling. American Journal of Plant Sciences. May 30;3 (05):693.
29. DT. Ms. Asmita, Screening Of Phytoconstituents And In-Vitro Anti-Diabetic And AntiInflammatory, Journal of Medicinal Chemistry and Drug Discovery Activity Of Fruits Of Terminalia Chebula, 03, (03), January 2017, 229-237 30-31
30. Ran Vijai K. S. Maurya, Neeraj Kumar, International Journal of Pharmaceutical & Biological Archives 2016; 7 (2): 1 – 8.
31. Murugesa mudhaliyar, Siddha material medica, Part-1, Published by the Department of Indian Medicine and Homeopathy, Chennai-106.
32. Khare, 2003 Muhammad, S., Khan, B. A., Akhtar, N., Mahmood, T., Rasul, A., Hussain, I., ... & Badshah, A. (2012). The morphology, extractions, chemical constituents and uses of Terminalia chebula: A review. Journal of Medicinal Plants Research, 6(33), 4772-4775.
33. The Wealth of India raw materials, 1998, vol. X New Delhi, India Y.R. Chadha (Chief Editor) CSIR.
34. Heldt, H. W., & Heldt, F. (2005). Phenylpropanoids comprise a multitude of plant secondary metabolites and cell wall components. Plant Biochemistry (3rd eds). Elsevier Academic, New York, 448.
35. Akhand, R. N., Ahmed, S., Bhowmik, A., & Rokeya, B. (2013). Sub-chronic oral administration of the ethanolic extracts of dried Terminalia chebula mature fruits in streptozotocin (STZ)-induced type 2 diabetes mellitus (T2DM) model of Long-Evans (LE) rats improve glycemic, lipidemic and anti-oxidative status. Journal of Applied Pharmaceutical Science, 3(5), 27.
36. Muhammad, S., Khan, B. A., Akhtar, N., Mahmood, T., Rasul, A., Hussain, I., ... & Badshah, A. (2012). The morphology, extractions, chemical constituents and uses of Terminalia chebula: A review. Journal of Medicinal Plants Research, 6(33), 4772-4775.
37. R. Ramasubramania Raja, M. Sreenivasulu (2016) DRUGS CONTAINING TANNINS-AN OVERVIEW, Indo American Journal of Pharmaceutical Research, 6 (05), 2231-6876
38. https://pubchem.ncbi.nlm.nih.gov