Tapping the potential of arid fruit genetic resources for nutritional security

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ABSTRACT

India is considerably rich in biological diversity of arid fruits such as ber (*Ziziphus mauritiana*), aonla (*Emblica officinalis*), bael (*Aegle marmelos*), pomegranate (*Punica granatum*), jamun (*Syzygium cuminii*), karonda (*Carissa carandas*) phalsa (*Grewia subinaequalis*), wood apple (*Feronia limonia*), custard apple (*Annona squamosa*), fig (*Ficus carica*), tamarind (*Tamarindus indica*), mulberry (*Morus sp.*), lasoda (*Cordia myxa*) etc. The most of them are not commercially grown but provides significant source of livelihood support for many rural communities. These fruit species are immensely productive by surviving harsh arid agro-climatic conditions such as high and low temperature, erratic rainfalls, frequent drought, soils with low nutrients and water holding capacity and require low inputs. Arid fruit crops provide micronutrients (minerals and vitamins) along with macro nutrients with high biological utilization efficiency. These fruits are rich in phyto-chemicals such as anthocyanins, carotenoids, phenols and flavonoids, which provides protection against reactive oxygen species and act as health promoter. Arid fruit production is dependent upon the improvement of diverse genetic resources to obtain uniform, high quality products and to adapt those products to arid environmental constraints and market demands. Untapped genetic resources of arid fruits offer unique potential to develop high yielding varieties with improved quality and high nutritional value. Thus, their systematic exploration, improvement and utilization can provide nutritional and livelihood security to the inhabitants.

Key words: Arid fruits, genetic diversity, improved varieties and nutritional security

Introduction

India is an important centre of diversity of many arid fruit crops like ber, bael, aonla, jamun, wood apple, custard apple, tamarind, karonda, phalsa, mulberry, fig, ker, lasora, pilu, mahua, khirni, Indian dates and chironji. Some arid fruit crops such as ber, aonla, pomegranate and date palm are exploited commercially owing to development of improved cultivars with high yield and improved quality with adaptability to varied agro-climatic conditions while most of the other fruit crops remain unexploited due lack of systematic exploration, evaluation, characterization and further use in improvement programme with development region specific technologies. In recent past, a significant progress made in some underutilized arid fruit crops such as bael, jamun and custard apple by developing superior cultivars and apposite technologies. Some arid fruit crops could have originated in more than one region in the world, evolving either simultaneously or at different times. Wild germplasm contribute a significant source of food in addition to cultivated crop species in tribal and rural areas. The untapped genetic resources in arid fruit crops and their targeted or trait specific varietal development and potentialities for diversified cropping system under arid climate could be an advantage for arid horticulture.

The tribal inhabitants of India were traditionally reliant on non-timber forest products and favoured local fruit species like tamarind, aonla, ber, etc. for their livelihoods (Diengngan *et al.*, 2015). Wild fruit species in Central Asia are under threat owing to deforestation, overgrazing and urbanization. The fruits are used unsustainably by local people which leads to genetic erosion. Additionally, the best-quality fruits are collected for better marketing opportunities which leave only inferior quality germplasm which are not immediately marketable. Consequently, it results in loss of wild fruit species, and reduction of intra-specific

variability in forests and reserves (Turdieva *et al*., 2012).There is also need for development appropriate technologies for creation of favourable micro-climate by minimizing the adverse effect of abiotic and biotic stresses in defined sub-zones of arid region for their promotion.

The nutritional value of aonla is numerous and is recommended as part of the daily diet. The fruit is the richest source of vitamin C and as an anti-oxidant, it prevents premature ageing. Aonla stimulate the isolated group of cells that secrete the hormone insulin. Thus it reduces blood sugar in diabetic patient (Iyer *et al*., 2009). Ber fruit contains high amount of vitamin C (85-95 mg/ 100 g) and rich source of vitamin A and B complex. Karonda fruits are rich in iron and have good amount of vitamin C. They also contain protein, carbohydrates, fat, fibre and calcium. Fig fruits are highly nutritious and possess protein, calcium, iron, vitamin A and thiamine at varying concentrations (Kaur *et al*., 2018).

The indigenous arid fruit genetic resources has been enriching by introduction of germplasm/species from other countries. These introduced germplasm/species also diversified in India due to segregation over time and space, and diversity in climate and breeding approaches. The introduction of genetic material from other parts of world has also resulted in accumulation and diversification of enormous genetic variability in arid fruits. In the past, explorers, visitors and traders contributed significantly towards enriching the genetic-diversity of arid fruit crops. Presently under semi-arid tribal and rural areas, a large number of indigenous fruit species such as jamun, custard apple, lasora, tamarind, mahua, khirni, wood apple, karonda, jharber, ker, phalsa and Indian dates have great genetic diversity and can be prioritized for improvement and region specific promotion. The indigenous fruit species have tremendous economical significance and nutritional value. These may also encouraged in rural and tribal dominating zones for diversified rainfed cropping system. Therefore, systematic collection, characterization, conservation and evaluation are the pre-requisite for potential utilization genetic resources.

Present status of arid fruits genetic resources

In India, organized germplasm collection, conservation and utilization of arid fruit crop work was initiated in 1978 through All India Coordinated Research Project on Arid Zone Fruits (AICRP on AZF) and its implementation was collaborative with crop specific ICAR institutes and SAU's located in different agro-climatic zones. Initially, emphasis was given on ber, aonla, bael, pomegranate and date palm by different crop specific AICRP-AZF centres and NBPGR centres with regional and national perspective. To promote profitable indigenous unexploited fruit crops in hot arid and semi-arid climate, systematic germplasm augmentation, conservation, characterization, evaluation and improvement programmes were formulated and implemented and it was mainly emphasized on ber, pomegranate, aonla, date palm, bael, custard apple and lasora through AICRP-AZF, SAU's and CIAH, Bikaner. Like-wise, for semi-arid fruit crops such as jamun, custard apple, tamarind, karonda, khirni, wood apple, chironji, mahua and phalsa was prioritized and attended at CIAH regional station CHES, Godhra (Gujarat) and later on some more crops like jamun, custard apple and tamarind were brought under the umbrella of AICRP-AZF. The intensive survey, germplasm collection and augmentation programme resulted to the development of *ex-situ* field repository of arid fruits such as ber (177), pomegranate (101), date palm (65), bael (33), aonla (15), lasora (17), mulberry (15), phalsa (05), ker (05), and others minor arid fruit crops (55) at CIAH, Bikaner. Similarly, semi arid fruit crops germplasm such as bael (210), jamun (68), tamarind (25), custard apple (15), karonda (40), wood apple (39), mahua (30), chironji (30), khirni (30), bael (120), phalsa (25) and Manila tamarind (25) are being maintained at CIAH regional station, CHES, Godhara and being utilized for improvement programmes under semi-arid climatic conditions (Saroj *et al*., 2017). Under AICRP on AZF, large number of germplasm of arid fruits crops like ber (600), pomegranate (475), date palm (125), aonla (150), bael (250), custard apple (50) and fig (35) are collected and conserved at different centre's field gene bank for further improvement through breeding programmes (Anonymous, 2015 and 2019).

Improvement of arid fruits genetic resources

Earlier, most of the crops like pomegranate, ber, aonla and bael were grown in a small area and date palm was newly introduced under AICRP on Arid Zone Fruits. With the development in the project more number of crop were brought under the umbrella of AICRP on arid Zone fruits like jamun, tamarind, lasora, custard apple, fig etc. ICAR institutes and State Agricultural Universities have enormously increased the production of quality planting material of improved varieties. As result of this a total of 1.45 lakh hectare was under arid fruits with 14.5 lakh metric tonnes in early nineties which have grown recently to 5.0 lakh hectare with 57 lakh metric tonnes production, respectively (Anonymous, 2017). The technologies developed led to increase in fruits production of pomegranate nearly fifty times, ber and aonla by three times and date palm by five times. This has improved the income and nutritional security of the people of arid region. Since most of the fruits are grown on wastelands/marginal lands and has potential to increase area, production and value addition, therefore, these fruits are upcoming crops which will nourish ever growing population of the country.

The genetic resource of different arid fruits were evaluated under different agro-climatic condition of arid region and found that potential for quality production varies with germplasm and region under apposite production technologies. In case of ber, cultivar Gola has been found to be suitable for very dry areas, Kaithali for slightly higher rainfall areas and Umran for moderate arid and semi-arid areas. Pomegranate variety Bhagwa have been reported as the most promising for Maharashtra, Andhra Pradesh, Karnataka and Gujarat and also performing well in Rajasthan, while Jalore Seedless found good for Rajasthan. Aonla varieties NA-7, Chakaiya, Kanchan and NA-6 have been found most promising uniformly all over the region. Date palm varieties Halawy, Barhee and Medjool are reported to be most suitable for date growing regions. Custard apple varieties Island Gem, Bullocks Heart and Mammoth are reported as suitable in Karnataka, Andhra Pradesh and Maharashtra for situations of minimum irrigation availability. Fig varieties Conadria, Poona Fig and Dianna are reported as suitable for fig growing areas of Maharastra. Similarly, date palm varieties Halawy and Barhee are reported as most suitable for desert, variety Medjool for making dry dates (*chhuhara*) and varieties Zahidi and Halawy for soft dates (pind khajoor). Mundra centre has collected very high yielding, good quality clones from wild date palm groves of Kachchh area, which were supposedly developed by Middle East settlers a few centuries ago. In custard apple, variety Balanagar is suitable under very low rainfall situation (Anantapur) and Selection A.S.1 under moderate rainfall situation (Aruppukottai). NDUAT, Faizabad has selected two promising lines of bael *i.e.* NB 5 and NB 9, which possess salinity tolerance.

In arid fruits, most of varieties are developed through selection. In these crops, there is need to select the drought tolerant cultivars for rain fed production. ICAR-CIAH, Bikaner has developed varieties of arid and semi arid horticultural crops (Table 1) by selection and hybridization to improve quality production which are adaptable to harsh climatic condition hot arid and semi regions. Similarly, large number of varies developed/recommended though AICRP on Arid Zone Fruits (Table 2) which revolutionized the scenario of arid fruit production in the country.

Table 1. Varieties of arid and semi arid fruits developed by ICAR-CIAH, Bikaner

Fruits/perennials	Variety released
Ber	Thar Sevika, Thar Bhubhraj and Thar Malti
Aonla	Goma Aishwarya
Bael	Goma Yashi, Thar Divya, Thar Neelkanth
Jamun	Goma Priyanka, Thar Kranti
Pomegranate	Goma Khatta
Tamarind	Goma Prateek
Mulberry	Thar Lohit and Thar Harit
Phalsa	Thar Pragati
Khirni	Thar Rituraj

Karonda	Thar Kamal
Chironji	Thar Priya
Mahua	Thar Madhu
Lasoda	Thar Bold
Wood apple	Thar Gaurav

(Source: Saroj *et al*., 2017)

Table 2. Varieties of fruit crops identified under AICRP on Arid Zone Fruits

Centre name	Crop	Variety
Rahuri	Pomegranate	Mridula, Phule Arakta, Bhagwa and Super Bhagwa
	Custard apple	Phule Janaki
	Fig	Dianna, Poona Fig
Bengaluru	Pomegranate	Ruby, Amlidana (for Anardana)
	Custard apple	Arka Sahan
Aruppukottai	Custard apple	APK (Ca)-1
Faizabad	Ber	Narendra Ber Selection-1 and 2
	Aonla	NA-6, NA-7, NA-10
	Bael	NB-4, NB-5, NB-9
Lucknow	Jamun	CISH J-1, CISH J-2
	Bael	CISH B-1, CISH B-2
Anantapur	Red Tamarind	Anantharudhira
Jobner	Lasora	Karan Lasora

[Source: Sharma and Sharma (2016); Anonymous, 2015; Anonymous, 2019]

Large number of traits specific germplasm have been collected through systematic explorations over the years at CIAH, Bikaner and its regional station at CHES, Godhra and conserved at field gene bank. After evaluation, characterization and improvement large number of elite germplasm released as varieties which are having adaptability to harsh arid environment, tolerance to abiotic stresses like drought, high and low temperature with improved fruit and processing quality. Special attributes of some improved varieties of arid fruits are presented in Table 3.

Table 3. Characteristics of improved varieties of arid fruits developed at CIAH, Bikaner

Crop	Variety	Characters
Ber	Goma Kirti	It is high yielding late maturing variety. Fruit yield potential at 5 year age is 35.60 kg per tree. It has better keeping quality.
	Thar Sevika	Developed by the hybridization from a cross Seb x Katha and it is an early maturing variety. Average fruit yield is 30-32 kg/tree.
	Thar Bhubhraj	A selection from local material of Bhusavar area of Bharatpur district of Rajasthan having an average yield potential of 30-36 kg/tree. The fruits are sweet and TSS content 22-23 per cent.
	Thar Malti	It is late maturing, fruit greenish-yellow colored & oval shape, fruit yield 65-70 kg/plant; TSS 18.6 °Brix, acidity 0.46 %, vitamin C 126.7 mg/100g, total antioxidant activity 13.1µM TE/g, tolerant to low temperatures. It is suitable for table and processing purposes.
Bael	Goma Yashi	Plant dwarf, fruit quality excellent with weight of 1.25 kg/ fruit. Fruit are ovate in shape and greenish yellow. Flesh straw colour and fruit shell weight 180g. Number of locules is cross section/fruit is 17.

	Thar Divya	Plant vigorous, semi-spreading, very less spines and comparatively earliest in maturity (second fortnight of Feb.), precocious bearer. Fruit weight 1.51 kg, pulp 70.50 %, TSS pulp 37°Brix, acidity 0.30 per cent and vitamin C 19.80 mg/100g pulp and yield/plant is 85.20 kg. Suitable for table and processing purpose (powder and RTS).
	Thar Neelkanth	Fruit ripening start from 3rd week of April. Yield 70-75 kg per plant, fruit weight 1.50 kg, TSS (pulp) 41.20 °Brix, acidity 0.29 per cent and vitamin C 23.40 mg/100 g pulp, shelf life of mature fruit 10 days. It is highly suitable for powder, candy, murabba, and RTS.
Aonla	Goma Aishwarya	Goma Aishwarya is a high yielding selection. It is an early variety with drought tolerance character. The average yield potential is 105 kg/tree. Suitable for semi arid conditions.
Pome-granate	Goma Khatta	The variety is developed for Anardana purpose. Yield potential is 6.59 kg/plant and anardana yield is 1.18 kg/plant. Seeds medium hard, juice 46 %, TSS 14.5°Brix and acidity 7.3 per cent.
Jamun	Goma Priyanka	It is semi-dwarf, spreading type, precocious bearer and suitable for high density planting. It ripens during May and recorded 43.80 kg fruit yield /plant, 19.86 g fruit weight, 85.06 % pulp, 16.80° Brix TSS, 0.38 % acidity, 12.10 % total sugar, 45.44 mg/100 g vitamin C content. (Singh *et al*., 2005b)
	Thar Kranti	It is dwarf, semi-spreading with fruit yield 65.00 kg/plant. Fruit oblong, deep purple with off white flesh colour, fruit weight 20.10g, pulp weight 17.20 g, pulp 85.57 %, TSS 17.10 °Brix, acidity 0.40 %, total sugar 12.50 %, vitamin C, 48.45 mg/100g. It is early ripening (last week of May) and drought tolerant.
Tamarind	Goma Prateek	It is early bearing, spreading growth habit, regular bearer, semi dwarf and starts flowering in fourth year. Fruit yield 58.50kg/plant, pod weight 26.70 g, 16.70 cm pod length, 50.50 % pulp, 14.06 % acidity, 71.00°Brix TSS, 55.81 % total sugar, 17.53 mg/100g vitamin C, 3.29g/100g protein. Fruit shape is slightly curved with reddish pulp, suitable for processing.
Chiraunji	Thar Priya	Plant dwarf, with semi-spreading growth habit, precocious bearer and suitable for high density planting. It recorded 23.90 °Brix TSS, 1.24 % acidity, 13.06 % total sugar, 48.70 mg/100g vitamin C and 31.36 % kernel protein. Fruit yield is 11.90 kg yield/plant with 1.15 g fruit weight. It is suitable for table and processing.
Mahua	Thar Madhu	Plant height 4.40 m, semi spreading growth habit, and thick trunk with dense foliage. Fresh flowers are very rich in TSS and vitamin C. Starts bearing in 5th year. It bears fruits in clusters. (Singh *et al*., 2005a)
Khirni	Thar Rituraj	It is comparatively dwarf, semi-spreading and precocious bearer. It recorded 24.73°Brix TSS, 0.32 % acidity, 17.80 per cent total sugar, 28.33 mg/100g vitamin C. Fruit yield 10-16 kg/plant with 5.20 g fruit weight. It is suitable for table and processing purpose due to high pulp and sugar content.
Karonda	Thar	Comparatively dwarf with plant height 1.77 m with semi-spreading growth habit. Flowering start, in 3rd year, regular bearer, ripens in

	Kamal	the month of June and recorded 4.97 g average fruit weight, 93.64 % pulp and 9.54°Brix TSS, 0.64 % acidity, 30.41 mg/100g vitamin C. Fruit yield 13.00 kg/plant. It is suitable for processing purpose.
Mul-berry	Thar Lohit	It is frost and high temperature tolerant. Yield 12.4 to 26.5 kg per plant. It starts bearing in 3rd year. Fruit width 9.13-9.90 mm and length 5.62-7.0 cm. TSS 20.8°Brix, acidity 1.6 %, Vitamin C 11.2 mg/100g total antioxidant activity 6.81µM TE/g. It is nutraceutically-rich fruit and suitable for table and processing purpose.
	Thar Harit	Fruit yield 32.6 kg per plant with fruit weight 3.76g, TSS 31.5 °Brix, acidity 0.42 %, vitamin C 23.7 mg/100g, 0.84 mg/g FW and total antioxidant activity 4.30 µM TE/g, tolerant to low and high temperatures. Suitable for both table and processing purposes.
Phalsa	Thar Pragati	Plant height 2.20 m, spreading growth habit, dense foliage and drooping branches. Fruit ripens in during 2nd week of April and yield 3-4 kg/plant. Fruit weight 2.1 g, pulp weight 1.9g, pulp 90.4%, fruit shape round, fruit colour deep purple, TSS 20.12 °Brix, acidity 3.12 per cent, total sugar 12.42 %, vitamin C 19.12 mg/100g.
Lasoda	Thar Bold	It is prolific bearer, bold fruit in cluster, yield tender fruit 1.5 to 2.0 q /tree/year. The tender fruit are suitable for making vegetable, pickles, and for dehydration purpose. It is suitable for block plantation and also as a component of agro-forestry system in arid region.

(Source: Saroj *et al.*, 2017)

Improvement strategies for arid fruits

To tap the potential of arid fruit genetic resources, there is need for intensive germplasm utilization in improvement programmes for development of good number of high yielding varieties suited to the different agro-climatic zones of the country. Breeding strategies varies with crop, agro-climatic condition and as per consumer preference (Table 6). Recently, due to increased awareness regarding nutraceutically and healthy food, the demand of varieties with novel colour and improved nutritional status has increased.

Table 6. Major thrust area for improvement of genetic resources of arid fruit crops.

Fruit Crop	Thrust area
Ber	• Development of tolerant/resistance to fruit fly/borer • Breeding for quality improvement (seed pulp ratio etc.) • Developing suitable rootstocks for dwarfing tree canopy
Pomegranate	• Red rind colour, sweet dark red, bold aril and soft seeds • Resistance fruit cracking • Resistance/tolerance to bacterial blight and wilt
Date palm	• Selection of male and female indigenous elite clones • Development of rain tolerant cultivars
Aonla	• Development of varieties having resistance to rust • High vitamin C content and coloured varieties • Frost tolerance cultivars • Dwarf canopy

Bael	• Dwarf growth habit and thorn less • Improvement fruit quality (size, colour, seed:pulp ratio, flavour)
Custard apple	• Breeding for improvement quality characteristics (seed: pulp ratio) • Rootstocks selection for dwarfing and tree canopy management • Enhancement of shelf life
Fig	• Breeding and selection of varieties suitable for dehydration • Resistant to rust and nematode • Selection of rootstock for tree canopy management

Conclusion

The diverse genetic resource is essential for crop improvement for development varieties and value added / trait specific genotypes. Arid fruit genetic resources are rich in vitamins, minerals, phytochemicals and good processing qualities and have high market demand. There are abundant untapped genetic resources for diversification and productivity enhancement of arid fruit crops. Therefore, to exploit the well-known genetic resources of arid fruits, special attention on conservation and use of crop specific variability is required. Systematic long-term breeding approaches on specific crops should be encouraged at high priority for developing better genotypes involving wider adaptability, tolerance to biotic and abiotic stresses, processing quality and ultimately their commercialization with region specific approaches. Indian sub-continent is one of the rich centres of diversity for number of arid fruit crops and need to be exploited commercially for nutritional security and sustainable production. The development of trait specific and value added genotype should be the utmost priority for development of arid fruit crops for particular region. Development of nutritionally rich bio-fortified varieties of arid fruits crops and promotion of nutritionally rich traditional fruits can help in increasing the bioavailability of specific nutrients for nutritional security and health benefits of inhabitants.

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