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Adaptation and significance of indigenous Indian arid dry land fruit: Aonla

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Abstract
Fruits are rich sources of energy and nutrients particularly minerals-Ca, P, Fe vitamins (vitamin B, C, Folic acid, and Carotenoids). Phytochemicals (anthocyanins, carotenoids, phenols and flavonoids) as well as dietary fibres play an important role in malnutrition alleviation. Fruits have healingproperties for treating disorders like scurvy, night blindness, stomach disorders, ulcers Anaemia, skin conditions, diabetes, haemorrhages etc. The traditional indigenous arid fruits, Aonla, Ber, Karonda, Phalsa, Jamun, Bael, Wood apple etc. are rich sources of nutrition and are considered as phytomedicines. A variety of value added products can be prepared out of them. Aonla an oldest Indian fruits, considered as "Wonder fruit for health" because of its unique qualities. Aonla is common abundant fruit of India. Fruit is highly valued in preparation of indigenous Ayurveda and Unani medicines. Fruits are rich source of vitamin 'C' (600 mg per 100 grams). The richness of fruit is taken into account, such as high antioxidants, calories particularly electrolytes, dietary fibre, and more recently, phytochemicals. Aonla fruits are used to prepare RTS beverage, candy, powder, pickle, preserve, juice, shreds, dried powder etc. (Deka *et al*., 2001). Dehydrated Amla powder and Amla candy showed high antioxidant activity (77.75%) and Vitamin C (298.3 mg/100 gm) respectively.

Keywords: Adaptation, Amla, Aonla, arid, fruit products, indigenous

Introduction
AONLA or Indian gooseberry (*Emblica officinalis*) is an indigenous fruit to Indian subcontinent. Aonla is also called as Amla, Amalki, Shriphala, Sheetaphala, Dhatri, Avala and Nelli. India is the centre of origin for many tropical and sub-tropical fruit tree species. The local inhabitants of Western Ghats, Maharashtra, Gujarat, Rajasthan and North Eastern States of India were traditionally reliant on local fruit species like Aonla, Tamarind, Ber, Chironji, Custard apple etc. (Singh *et al.*, 2023) [17] for food, medicine and livelihood.

Aonla is positioned as a significant Indian fruit, in view of its outstanding hardy nature, suitability to various waste lands, high productivity/unit area (20t/ha), nutritive and therapeutic value. Amla, a little fruit offers a wealth of health advantages. Vitamin C, antioxidants, and other elements that support general health are abundant in it. Aonla fruit contains number of polyphenolic substances such as tannic acid, gallic acids, phloroglucinol, pyrogallol, catechol, trigalloylglucose, terchebin, corilogin and ellagic acid (Kalra, C.L. (1988) [6]. In recent years, aonla fruits are processed into different value added products such as jam, jelly, syrup, sauce, chutney, preserve, candy, osmo-air dried aonla slices, pills, pickle, shreds and supari (Rakesh *et al*., 2004) [13]. There is great scope of processed products rather than fresh aonla. Low cost of the production, high nutritive value and long shelf-life. Reflecting their adaptation to a wide range of edapho-climatic conditions of our country under rainfed conditions crops like Aonla, are grown without much difficulty (Chundawat, 1990) [3].

Fig 1: Amla

Climate and soil Adaptability of Aonla in Arid dry lands

Climatic variations of India is feasible for production of many fruits and vegetables. The Indian arid zone covers 12% of country's total geographical area in states Rajasthan, Gujarat, Punjab, Haryana, Maharashtra, Karnataka, parts of Telangana and Andhra Pradesh.

India ranks first in the world in area and production of Aonla crop. Wide distribution, ability to survive in temperature extremes, drought and various kinds of wastelands, reflects its adaptation to range of edaphoclimatic conditions. Aonla prefers dry subtropical climate. A mature Aonla tree can tolerate freezing as well as high temperature of 46 °C. Warm temperature seems conducive for the initiation of floral buds. Ample humidity is essential for initiation of fruit growth of dormant fruitlets during July-August. Heavy frost during winter is not conducive to its cultivation. Dry spells result in heavy dropping and delay in initiation of fruit growth. Since aonla is a hardy plant, it can be successfully grown in variable soil conditions. The deep root system, reduced foliage, dormancy of fertilized fruitlets (April-June) makes Aonla an ideal plant for arid and semi-arid conditions. Aonla can be cultivated in marginal soils slightly acidic to saline/sodic (pH 6.5-9.5) conditions. This has been adopted very well in the semi-arid regions of Gujarat and Maharashtra. Its intensive plantation is being done in the salt-affected areas of Uttar Pradesh. Aonla is being successfully grown in areas of extremes of climates like Gujarat. Location is characterized by hot semiarid climate, uneven and erratic rainfall confined to three months (July-September). Mean precipitation is about 750 mm, average 29 rainy days. The mean summer temperature is 32.9 ºC while the mean winter temperature is 21.3 ºC indicating that the area falls under hyperthermic soil regime. The mean annual maximum and minimum temperatures vary from 42-44 ºC to 6-9 ºC during May and January respectively. The average highest monthly evaporation rate (11.8 mm/ day) is recorded in May and lowest in September (1.3 mm/day) during the experimentation. The soil is clay to clay loam, soil depth ranges from 0.75-1.0 meter, derived from mixed alluvial basalts, quartzite, granite, and having layers of limestone just below the soil depth.

Aonla can florish in dry sub-tropical climate. Though it is classified as a subtropical fruit, its being successfully cultivated in rainfed semi-arid condition as well as tropical arid. The naturally growing plants can be seen on hills up to 1800 msl (Pathak 2003) [10]. Mature aonla tree can tolerate freezing as well as high temperature of 48 °C, but the plants are susceptible to frost in winter and sometimes heavy damage occurs owing to frost in hot arid ecosystem of western part of Rajasthan (Pathak *et al*. 2006) [12]. Warm temperature seems conducive for initiation flower buds, whereas ample humidity is essential for renew growth of dormant fruitlets during July-August. Abrupt changes in temperature during flowering and fruit set adversely affect the fruiting of Aonla. Dry spells result in heavy fruit dropping and delay in initiation of fruit growth (Pathak *et al*. 2006) [12]. Since aonla is very hardy plant, it can be grown in light as well as heavy soil. The deep root system, reduced foliage, dormancy of fertilized fruitlets (April-June), coincidence of fruit growth and development with moisture availability period make aonla an ideal plant for arid and semi-arid regions. Aonla can be grown in marginal degraded lands. It can be grown in acidic to saline/ sodic (pH up to 9.5, ESP-35 and ECe-6-9 ds/m) soils (Pathak and Pathak, 2001) [11].

In India, now it is grown near sea coast of South India as well as the foothills of North India. Warm temperature seems conducive for initiation of flower buds, whereas ample humidity is essential for resuming growth of dormant fruitlets during July-August (Pathak 2003) [10]. Since aonla is very hardy plant, it can be grown in light as well as heavy soil with good drainage. The deep root system, reduced foliage, dormancy of fertilized fruitlets (April-June), coincidence of fruit growth and development with moisture availability period make aonla an ideal plant for arid and semi-arid regions. Aonla can be grown in marginal degraded lands. It can be grown in acidic to saline/ sodic (pH up to 9.5, ESP-35 and ECe-6-9 ds/m) soils (Pathak and Pathak 2001) [11]. Heavy soils with high water table and areas of heavy frost during winter season are limitations for its cultivation.

Aonla based cropping system

Aonla based agri-horticultural system has immense potential to utilize and conserve rainfed area for betterment of poor farmers. Perennial component (aonla) being a deep rooted and deciduous tree has a wide range of adaptability to grow in any type of soil and is considered a high tolerant potential fruit species suited to grow under salt-affected and wasteland/ravine lands with the little investments and higher economic return. The results indicated that the aonla + bottle gourd combination performed better in the terms of productivity/ha and net economic return. This combination is being practiced by the aonla growers of Gujarat. (Singh *et al*., 2020) [18] Crop diversification studies revealed that Aonla based multi -storey-cropping systems found to be sustainable and remunerative under arid ecosystem. In a potential Aonla based multi-storey system Brinjal (*Solanum melongena*) given an average net returns of Rs 56,000/ha per ha. Other compatible Aonla based combinations identified are Aonla- Beal- Karonda- Moth bean -Mustard and Aonla- Drumstick Senna -Mothbean -Cumin giving optimum retures per unit area. (The ICAR-CIAH: An Overview,).

Crop diversification: Growing of cucurbitaceous vegetable crops such as bottlegourd, spongegourd, bittergourd, cucumber and pumpkin can be grown successfully in association with plantation under rainfed condition of Gujarat. Economic analysis of aonla based cropping system revealed that the maximum net return of ` 147312.80/and 1000525.00/' may be obtained from aonla + bottlegourd and aonla + pumpkin respectively, under rainfed conditions of semi-arid ecosystem reported that the aonla + okra had given net returns of72505/ha without any adverse effect on aonla crop. Different intercrops such as okra, bottlegourd, cauliflower, coriander, gladiolous and marigold can be grown in association with aonla plantation (Krishna *et al*. 2018) [7]. Among the fruit crops, guava and karonda can be used

successfully as filler crops in aonla orchard (Pathak *et al*. 2006) [12]. Inter-cropping of cucurbits in aonla is economically viable under rainfed semi-arid ecosystem. Among the different cucurbits (bottle gourd, pumpkin, bitter gourd, sponge gourd and cucumber), aonla + bottle gourd fetches highest net return to the tune of Rs. 1,47,312/ha with the B: C ratio of 4.44. (The ICAR-CIAH: An Overview, 2018).

The vast land resources available in arid and semi-arid regions of country offer great deal of opportunities for cultivation.Aonla has incredible potential for diversified product preparations, contribute to socioeconomic upliftment and Indian economy as well and therefore, needs popularization.

Fig 2: Aonla based intercropping fetches more under dryland conditions

Nutritional and therapeutic significance

Trifla and Chavanprash are well-known indigenous medicines in Ayurvedic system, prepared using Aonla fruits. Besides fruits, leaves, bark and even seeds are being used for various purposes. Dried fruits have been reported to be useful in haemorrhages, diarrhoea, dysentery, anaemia, jaundice, dyspepsia and cough. Fruit is also used to prepare aonla powder, which is superior to synthetic vitamin C in treating deficiencies.

The pulp of fresh fruit contains 200-900 mg/100 g of vitamin C and as dehydrated aonla pulp retains as much as 1,699.09 mg/100 g of vitamin C on dry weight basis. Aonla is mentioned in Charaka Samhita for medicines for increasing age, reducing fever, curing cough and eliminating leprosy. Similarly, in the Sushruta Samhita, Amla has been described as a subpartisan medicine, which means that Amla is the medicine that helps in removing the faults of the body through feces (Vishal Vijayvargiya 2021) [22]. In Ayurveda, aonla has been extensively used, both as an edible (tonic) plant for its therapeutic potentials and fruit has been used in Ayurveda as a potent Rasayana (rejuvenator). It contains phytochemicals including fixed oils, phosphatides, essential oils, tannins, minerals, vitamins, amino acids, fatty acids, glycosides, etc. Various pharmaceutical potentials of Aonla have been reported previously including antimicrobial, antioxidant, anti-inflammatory, analgesic, antipyretic, adaptogenic, hepatoprotective, antitumor and antiulcerogenic, immunomodulatory activities (A K SINGH *et al.,* 2019) [20]. Different extract of aonla results show the presence of ascorbic acid, tannins and polyphenolic constituents and phytoconstituents are reported to have antioxidant efficacies against several free radicals such as 1,1-Diphenyl-2-picrylhydrazyl radical (DPPH) free radicals, superoxide, nitric oxide, iron reduction, 5, 5-dimethyl-1-pyrroline-N-oxide etc. Phytochemicals of aonlaare also reported as good metal ion chelatorthey as they can prevent the oxidative cascades (Scartezzini *et al*., 2006) [15]. The nutraceutical and therapeutic values of fruit include great health and vitality (Pathak 2003) [10]. Aonla is utilized commercially in processing cosmetic industries for making ayurvedic medicines such as chawanprash, trifala, syrup, diabetic powder, aonla powder in for shampoo, hair oil, dyes etc. (Pathak *et al*. 2006) [12].

Suitable varieties for arid areas

Improved varieties developed and recommended for higher production in Arid regions by Central Institute of Arid Horticulture are NA6, NA7 (Neelam), Krishna, Kanchan, Chakaiya, BSR1, BSR2, Balwant and Lakshmi-52. Goma Aishwariya, a selection from large population is an early drought tolerant variety and prolific bearer yielding 105 kg/tree. Anand 1, Anand 2 and Anand 3 have been selected as promising strains in Gujarat.Popular varieties of Aonla since decades are Banarasi, Francis (Hathijhool) and Chakaiya having limitations. Banarasi, shy-bearer, prone to heavy fruitdrop and poor shelf life. Francis is prone to fruit necrosis whereas Chakaiya fruits are smaller in size, fibrous and alternate bearer. Other promising varieties identified and released for commercial cultivation are Kanchan (NA 4), a seedling selection from Chakaiya, which is heavy (7.7 female flowers/branchlet) and regular bearer with medium-sized fruits. Having higher fibre content. It ispreferred by industries for pulp extraction and manufacturing of various products.NA-6, NA-7, Chakaiya etc. are found to be necrosis resistant (Pathak *et al*. 2006) [12] suggested for commercial cultivation. NA6 prolific and heavy-bearer (10.8 female flowers/branchlet). Where as NA 7(Neelam) precocious, prolific and regular-bearer (9.7 female flowers/branchlet) and most suitable for rainfed cultivation in semi arids. NA-6 and NA-7 gave excellent performance with respect to plant structure fruiting behaviour and fruit quality. Anand-1 and Anand-2 mature by last week of November under semi-arid ecosystem of Gujarat. Suitable varieties for South India are Banarasi, NA 7, Krishna, Kanchan, Chakaiya, BSR 1. Genotype named BSR-1 showed higher yield potential (43.05 t/ha) was recommended for commercial cultivation under irrigated and rainfed conditions of Tamil Nadu (Singh *et al*., 2019) [20].

Varieties which have low fiber content and higher pulp percentage highly suitable for the best quality jam preparation (Pareek *et al*., 2011) [9]. Big fruited variety NA-5 (Krishna). NA-9, seedling selection from Banarasi suitable for preserve and candy making. NA-7 (Neelum) a seedling selection of Francis is ideal for commercial cultivation which is devoid of fruit necrosis unlike Francis.

Singh *et al*., 2004 [12] reported that the NA-6 variety found better attributes for processing of various value added products of economic importance and Chakaiya suitable for beverages (nectar, squash and syrup) and jams.

Production Management of crop: Aonla has long been raised

through seeds and inarching. Budding is an ideal method It can be successfully propagated through Inarching and patch/modified ring budding in North India during mid-May to September with 60-100% success. Propagation of aonla in polybag, polytube, "root trainer" or in-situ orchards needs to be standardized and commercialized. Grafted or budded Aonla plants are planted 7-10 m apart during July-August or February in Pits of 1 mt^3 size are dug 2 months prior to planting. In aonla orchards, ber, guava and lemon are ideal filler plants planted in the centre of each square of aonla plants. Hedge-row planting is also being tried keeping line-to-line distance of 8x4 m. Under adverse soil conditions, seedlings are grown directly in the field pits in - situ budding is performed subsequently. 2 varieties in suitable combination need to be planted alternate rows as self-incompatibility problem is evident in Aonla varieties. Modified central leader system of training with 2 or 4 scaffold branches with wide crotch angle, in the opposite directions be encouraged in early years. Regular pruning of a bearing aonla tree is not required. As per growth habit, shedding of all determinate shoots encourages new growth in coming season. However, dead, infested, broken, weak or overlapping branches should be removed regularly. No irrigation is required during rainy and winter season. However, irrigation at 15-20 days interval is desirable in dry summer particularly during early years of orchard establishment under wasteland conditions. Irrigation should be avoided during flowering (mid-March-mid-April) period. Basin system of irrigation is well-suited for aonla. Drip irrigation has shown promising response with a water saving of 40-45%. Live mulch or with organic wastes is very effective tool for reviving sodic and ravinous areas. Mulching with organic wastes over a number of years shall be helpful in improving the organic-matter content, infiltration rate, and restricting the upward movement of soluble salts and thus escaping their toxicity menace in salt -affected soils. Necrosis is a physiological disorder. Francis variety is highly susceptible followed Banarasi. Spraying 0.6% borax thrice in September - October can help control internal necrosis caused by boron deficiency.

Value added products from Aonla

NA 6 is ideal for preserve and candy, owing to low fibre content. The Aonla fruit is available from October to January and is quite perishable by nature. The postharvest losses in aonla vary from 30% to 40% due to its perishable nature, which reduces the market value. Economic life the variety Francis, NA-7 and Banarasi is up to 5 days only at ambient temperature whereas Chakaiya and Anand-2 is 7 days after harvesting. As its storability after harvesting is also limited due to its high perishable nature. Fruits has great potential in processed forms, which can have great demand in national as well as international market. Furthermore, because of extreme acidic, sour and astringency of fruit, customers dislike consuming it in its fresh form. Fruit is less palatable to eat directly, hence, it can be consumed in processed form. Aonla is used in the Indian indigenous medicines of Ayurveda *viz*. Trifla and Chavanprash. Value addition through processing would be the effective tool for economic utilization of increased production of Aonla in the future. Processing not only reduces the postharvest losses but also provides higher returns to the growers. USDA defines value addition as a change in the physical state or form of the product. Selling the products at the lowest market value just to survive economically is not sustainable. It can lead to stress on the land as well as on the farmer. Value-added practices are key to future of sustainable farming (Nidhi Dalal *et al*., 2019) [5]. There are numerous products that can be prepared from dry aonla fruits such as dried whole fruit, flakes, slices, supari, shreds and powder. Blanching in hot water or with potassium metabisulfite before drying prevents enzymatic browning and improves the color and texture of the shreds. Solar drying is cheaper, whereas hot air oven- drying is a more convenient method of removing moisture from the product (Aditya Shukla, 2021) [1]. Fruits are commonly used for making preserve (murabbas), pickles, candy and jam.

Aonla Murabba/ Preserve is a very common traditional Amla productin India.Aonla murabba beneficial for purifying blood, reducing the cholesterol level and refining eyesight (Ranote and Singh, 2006) [14]. Fruit or its pieces impregnated with heavy sugar syrup till it becomes tender and transparent is known as preserve. The variety Krishna ranked first in all attributes in Murabba preparation followed by Chakiya.

Fig 3: Murabba

Aonla Jam is a concentrated fruit product of thick consistency rich in characteristic fruit flavour. Varieties havinghigh pulp to seed ratio, high pectin, low in fibre content suitable for best quality jam preparation (Pareek *et al*., 2011) [9].

Aonla Pickle prepared by adding oils, spices etc. and leave it for few days. Small sized fruits generally preferred, which are not suitable for preparation of preserves and other confectionary items, may be utilized for pickle making. Brining is important in pickling to improve texture and to remove astringency of the fruit.

Aonla chutney prepared by cooking fruit segments after elimination of seeds and adding spices. The product is hot, sweet, smooth, spicy, mellow, flavoured and appetizing which can be stored not more than a week.

Aonla Sauce and ketchup have same ingredients of chutney but takes more time to cook. Aonla sauce have high storage period above 9 months (Ranote and Singh, 2006) [14] and lasts long.

Aonla Candy is prepared by soaking the fruit slices for 24 hours in Sugar syrup of 75 ^{o}Brix and shade dried.

Fig 4: Aonla Candy

Aonla based mouth freshener (Amla supari) available in the market having limitation i.e. losses in vitamin C and other nutrientswhile processing. It can be replaced by better substitutealternate chewing product like dehydrated aonla pulp since it retains Vitamin C, Dehydrated aonla pulp of 'Desi' and 'Banarsi' cultivars by mixing carboxymethyl cellulose, gums, arecanut, cardamom, sugar and milk powder at different proportions as a substitute for pan masala, tobacco and gutka.

Aonla fruits used to prepare ready-to-serve beverage candy, powder, pickle, preserve, juice, shreds, dried powder etc. (Deka *et al*., 2001) [4]. Powder is made as paste and applied as face mask and hair mask. Fresh aonla juice contained 120.95 mg/100 ml of ascorbic acid with acidity of 2.336% and low pH of 1.97. Amla juice is a preferred to consume since it deliver a concentrated amount of the fruit's benefits. Aonla Squash is prepared by blending aonla juice with other juices *viz*., ginger, roselle, pineapple and lime. Aonla ready-to-serve (RTS) fruit beverages are well relished by all age groups of the society. It can help to reduce high cholesterol levels in our blood. Functional beverages are drinks that have been enhanced with added ingredients to provide specific health benefits and disease preventing property beyond general nutrition. Aonla juice blending lemon juice and /or ginger juice were utilized at various combinations with sugar or artificial sweeteners. Aonla shreds are prepared by solar drying after treatment with salt. Similarly, oil less pickle of aonla was prepared with 10-15% salt. Fruits can be stored as such in brine solution up to 75 days. Very nutritious, delicious and digestive Aonla Pills, are prepared by drying pulp groundalong with cumin, ginger and salt which is rich source of vitamin C. Amla paste can also be prepared used as balm to apply to the inflamed area for pain relieving. Amla Pachak is a traditional Ayurvedic digestive aid is made from a combination of amla, ajwain, jeera, black salt, and other aromatic natural herbs. It has a sweet, sour, tangy taste known to improve digestion, appetite, brain health, boost immunity.

Fig 5: Amla pachak

Fig 6: Amla Lemon Mint Candy

Other useful products of Aonla includes toffee, laddu, sherbet, liquor, aonla powder, functional indigenous ayurvedic products such as Chawanprash, Trifla syrup etc. Fruit is being intensely used by cosmetic industries blending in shampoo, hair oil, dyes, etc.

Fig 7: Aonla stall having 64 diverse products

Conclusion

The Indigenous Aonla is a significant fruit for nutritional security and therapeutic values. It thrives well in climate extremes and all kinds of wastelands giving abundant produce with little upkeep. There is great scope for processed products at low cost, high nutritive value and long shelf-life.

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