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Barbados cherry: Agriculture, breeding, utilization and role in nutritional and economical security-A review

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ABSTRACT

Barbados cherry is a wild under-utilized fruit crop grown mainly in the regions with tropical humid climate. Being a good source of vitamins, minerals, antioxidants, phenolic acids, especially the Vitamin C (richest source) it can protect from free radicals and cures cancer, kwashiorkor, marasmus, night blindness, hypertension, liver problems and hidden hungers which are threatening the modern world. Being a good source of pectin a number of processed products are prepared from it like syrup, juices, candy, murabbas, pickles and also for baby food preparation. By preparing these products rural people and housewives can earn a good income round the year. Besides, if small scale processing unit can be setup in collaboration with some NGOs', then it enhances much more employment and improves the socio-economic status of the rural people. Therefore, this paper reviews the overall agronomic, breeding, crop utilization practices with its role in nutritional and economical security.

Key words: Barbados cherry, Breeding, Cultivation, Economical security, Value addition.

The economy of India is agriculture based, known for possessing its own rich and diverse knowledge about cultivation practices (Nishant and Upadhyay, 2016). The Indian agricultural sector has undergone tremendous transformation over the years from a state of severe food crisis to self sufficiency in food grain production (Priscilla *et al*., 2017). Barbados cherry also known as Acerola or West Indian cherry (*Malpighia emarginata* D.C.) belongs to the member of Malpighiaceae family. Previously, the plant was known by the synonyms *Malpighia glabra* L. and *Malpighia punicifolia* L., but recently taxonomic work has resulted in the acceptance its current scientific name as *Malpighia emarginata* D.C. (Carrington and King, 2002). It is native to West Indies and distributed in the southern parts of North and South America, through Central America. Further it was distributed to tropical and subtropical parts of India. It performs well in tropical humid climate of India. The Barbados cherry is not a true cherry, the escape of name mainly due to similarities with the main cherry fruit. The fruit juice of acerola is used for fortifying the vitamin C content of other fruit juices. The ascorbic acid content of the fruit measured in a range of 1.5% to 3.5% by fresh weight of fruit. A 180 ml of this fresh fruit juice with a potentiality of 35mg/ml ascorbic acid can similar as much as vitamin C content of 14 liters orange juice (Johnson, 2003). Due to highest vitamin C content (4515 mg/100 g of edible portion) of acerola fruits it can easily meets the daily requirements of an adults (28-70 mg/person). It is a low branching and bushy shrub grown as ornamental up to a height of 2-3.5 m. It can be trained in to single or multiple trunks and pruned in to a desired shape. Initially the leaves are dark green but become light when mature with obviate to lanceolate in shape. Because of shallow root system plants are toppled easily by wind but recovered very soon. Barks are slightly rough and greyish brown in colour. Flowers are sessile, light pinkish-white in colour with five petals and appear almost throughout the year except some winter months. Fruits are round to obviate (3-15 g in weight with 1-3 cm in diameter), having cherry like 3 lobes and mature about 3-4 weeks after flowering. It arise separately or sometimes in cluster from leaf axil. They are initially light greenish white, then yellowish-orange to ultimately deep glossy cherry red colour at maturity. The fruit varies in size from about 1/2 to 1 inch in diameter, and weighs from 2 to 10 grams (approximately 0.1 to 0.4 ounce). Regardless of the size of the fruit, the three winged seeds (botanically, pyre nous carpels) are large in comparison to the flesh, but because of their light and pithy nature, they constitute only about 20 percent of the weight. Fruits having very delicate skin with juicy, mostly acidic or blending of sugar and acid in taste (depending upon the genetic type), with no distinct or pronounced flavor. Some think the flavour of thoroughly ripe acerola and the fresh,

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raw juice made from it resembles that of tart strawberries. Although commonly called a cherry, the odour and flavour of cooked acerola are more like that of tart apples or crab apples than cherries. Malic acid, the only organic acid (other than ascorbic acid) which acerola contains, is also the principal acid in apples (Miller *et al*., 1961). Besides huge amount of vitamin C, it also contains several phenolic compound, pectolytic enzymes, carotenoids with a small amount of Vitamin B. Its high antioxidant content helps in prevention of age-related diseases, such as hypertension and cancer (Hwang *et al*., 2002). Although the crop has not gained any popularity among the farmers due to lack of awareness of its nutritional value, agronomic practices and standard method preparation of several value added products. Farmers need proper information to eradicate mis-concepts, to raise their level of knowledge and eventually to help in their decision making process (Sadat and Chakraborty, 2017). However, information about its overall agronomic practices, importance and utilization is meager. This review paper includes the overview of its nutritional significance, cultural requirements, breeding programmes, production and productivity, value addition with importance in food security in modern world.

Different species: The genus *Malpighia* is one of the 55 genera in the family Malpighiaceae and it contains about 45 species of shrubs or small trees (Janick and Pauli, 2008). According to Ledin (1956), only *M. glabra* and *M. mexicana* have large edible fruits. *M. emarginata* is also known to be cultivated due to its sweet and juicy fruits, which are very rich in vitamin C (Johnson, 2003). *M. coccigera* L. and *M. urens* L. are also cultivated in South-East Asia (Orwa *et al*., 2009). While *M. punicifolia* is present as far north as Florida and Texas.

Other species are given below:

1.*Malpighia aquifoliah*.
2.*Malpighia cauliflora* Proctor & Vivaldi (Jamaica)
3.*Malpighia coccigera* L. - Singapore holly (Caribbean)
4.*Malpighia cubensis* Kunth - *palo bronco de hojapequeha* (Cuba)
5.*Malpighia emarginata* D. C. - Barbados cherry, acerola, *Malpighia fucata* Ker Gawl. (Puerto Rico)
6.*Malpighia glabra* L.
7.*Malpighia harrisii* Small (Jamaica)
8.*Malpighia mexicana* A. Juss.
9.*Malpighia obtusifolia* Proctor (Jamaica)
10.*Malpighia polytricha* A. Juss.
11.*Malpighia proctorii* Vivaldi (Jamaica)
12.*Malpighia setosa* Spreng. - bristly stinging bush (The Bahamas, Hispaniola, Puerto Rico)
13.*Malpighia suberosa* Small
14.*Malpighia urens* L. - cowhage (Caribbean)

Biochemical importance of fruit and its utilization: Acerola is one of the most nutritious under-utilized fruit crop with several medicinal value. The proximate composition of ripe fruit (based on 100 g edible portion) includes- energy 32 kcal, moisture 91.41%; protein 0.40 g, total lipid 0.30 g, ash 0.20 g, carbohydrate 7.69 g, total dietary fibre 1.1 g. Among several mineral contents- phosphorus 11 mg, calcium 12 mg, magnesium 18 mg, iron 0.20 mg, sodium 7 mg, zinc 0.1 mg, copper 0.086 mg and selenium 0.60 µg. Mature ripe fruits also contain a number of important vitamins which include- thiamine 0.020 mg), riboflavin 0.060 mg, niacin 0.400 mg, pantothenic acid 0.309 mg, vitamin B-6 0.009 mg, folate food 14 µg and vitamin A 767 µg (Freitas *et al*., 2006). It contains a good source of provitamin A, which about as much as tomatoes (Miller *et al*., 1961). Besides this, most important composition of the fruit is vitamin C content, varies from 3097-4515 (mg/100 g of edible part) which is much higher than other source of vitamin C likes- Aonla (600-700 mg/100 g), Guava (200-300 mg/100 g), citrus (50-100 mg/100 g), Jamun (290 mg/100 g) etc. Asenjo and Guzman (1946) of Puerto Rico were the first to point out the unusually large amount of ascorbic acid in this fruit and to prove by isolating the substance that it was pure I-ascorbic acid. Therefore, there is a great scope in blending of fruit juice with the juice of other fruits which having low vitamin C content. The recovery of fruit juice, pulp and seed is 36.11%, 82.56% and 17.44%, respectively with 5.44°Brix total soluble solids and 1.18 % acidity in ripe fruit (Singh and Medhi, 2003). Being a good source of pectin a number of processed products are prepared from it likes syrup, juices (concentrated, integral, lyophilised), candy, murabbas, pickles, ice-cream, gelatine, soft drinks, nectar, puree, jelly, gum, fruit conserve, nutraceutics, yogurts and sodas. Its juice helps in prevent the darkening of banana sliced for fruit cups or salads. They are also used for making of baby food and recipe items as source of vitamin C. A concentrate prepared from this fruits is very helpful for liver, gall bladder, blood circulation and in case of viral hepatitis. It is also one of three ingredients in a proprietary herbal medicine for allergic rhinitis and herpes (Corren *et al*., 2008; Sandra *et al*., 2009).

Climatic and soil requirements: It is basically grown under tropical and subtropical humid climates. A temperature of 26°C is optimum for its successful cultivation. It prefers penetration of sufficient amount of sunlight for better fruiting. This fruit production is hampered under shady condition. Besides, it can also survive at a temperature closed to 0°C or lower (Neto and Soares, 1994). A mature plant can bear a briefly exposure to -2.22°C, while young plants are killed if exposed even for a considerable period of time to a temperature below -1.11°C. Its smaller and shallow root system allows the plant to be grown as intercrop with other crops. Though the plant does not possess any soil specificity but performs well in sandy or sandy-loam to clay, limestone and others heavy type soil as it drains well. An average soil with a complete mixture of both clay and sand is optimal for

its better performance since they hold more humidity. However, water-logging condition is very detrimental to the crop. A soil pH of 6.5-7.5 is ideal, as acidic soil do not encourage vigorous growth of the plant. It produces well when annual rainfall distribution is in between 1200-1600 mm. Besides, heavy rainfall ranging from 1000-3000 mm can be tolerated by these plants. They possess a sufficient drought tolerant capacity also. Irrigation can be used for regulation of flowering cycles as under well irrigated condition it can produce up to 1-5 flowering peaks in a year.

Propagation and intercultural operation: Barbados cherry is usually propagated by seeds. But the viability of seeds is very poor. However, high variability was found in fruits, when propagated by seeds (Cavalcanti *et al*., 2007). Therefore, to achieve true to the type genotypes several asexual means of propagation also practiced *viz*. - cutting, layering, grafting and other standard methods. Among them, the former is currently favoured as easiest method. Hard wood cutting of cherry plants treated with 1500 ppm IBA results prolific rooting with good survival rate. In case of grafting, among several rootstocks, *Byrsonima crassifolia*. found superior for better vigour of the plant (Cooper, 1971). *In-vitro* cultivation of this cherry through micro-propagation has been also reported with satisfying results (Melo *et al*., 1999). Plant needs a balanced fertilized schedule with FYM 10-15 kg/pit; nitrogen 35 g/plant; phosphorus 15 g/plant and potassium 30 g/plant at the time of planting. During second year, doses of NPK and FYM should be doubled and apply before the onset of monsoon. As, the plants bears normally on current season flashes, pruning is essential for emergence of new growth but it should be done after harvesting of the crop specially during October to November. There are no such serious pest diseases are recorded except few minor insect like mealy bug and aphid.

BREEDING AND CROP IMPROVEMENT

Taxonomical classification: Kingdom- Plantae: Plants
Subkingdom- Tracheobionta: Vascular plants
Superdivision- Spermatophyta: Seed plants
Division- Magnoliophyta: Flowering plants
Class- Magnoliopsida: Dicotyledons
Subclass: Rosidae
Order: Polygalales
Family: Malpighiaceae
Genus: *Malpighia*
Species: *glabra*

Centre of diversity: Barbados cherry is native to American tropics including the lesser Antilles from St. Croix to Trinidad, also Curacao and Margarita and neighboring northern South America as far south as Brazil (Janick and Paull, 2008). Today, it has become naturalized in Cuba, Jamaica and Puerto Rico after cultivation over a period of times and is commonly grown as dooryards crop in the Bahamas, Bermuda and to some extent in Central and South America. The plants are spreading all over the world, however, its maximum distribution was noticed in Central America and the West Indies (Morton, 1987).

Objectives of crop improvements:
i..To develop high ascorbic acid content varieties. ii.To develop high yielding varieties. iii. To reduce acidity of fruits. iv.To develop varieties resistant and tolerant to nematodes likes root-knot nematodes (*Meloidogyne incognita* var. *acrita*) and burrowing nematodes (*Radopholus similis*) which are the major responsible factors for decline of its production. v. To develop varieties resistant to insects such as fruit fly (*Anastrepha suspence*), aphid (*Aphis spiraecola*), fruit worm (*Anthonomus florus*), Hesperid caterpillar (*Ephyriade sacras*).

Cytogenetics: A very little information is available regarding chromosome number of this species. Most of the species of the genus *Malpighia* are diploids, i.e. 2n= 20. The chromosome of Barbados cherry are small about 1.71 to 2.56 μm and metacentric except chromosome 2 which was classified as sub-meta-centric (Mondil *et al*., 2010).

Inheritance pattern: No attempt has been carried out to study the inheritance pattern and genetics of the commercial traits of the crop.

Problem in breeding: Very little work has been carried out in Barbados cherry, however certain behaviours of the plants may cause hindrance in breeding programmes such as bisexual flowers, self-and cross incompatibility and low seed content. In addition, fruit setting are also affected by seasons in this crop. Absence of rain may cause little or no fruits during the seasons.

FLORAL BIOLOGY

Flowering: Flowers usually appear after periods of rainfall or irrigation, thus flowering may occur any time during the year depending on local rainfall and climate pattern. Flowering may last a year-round (Anonymous, 2014). Flowering and fruit set occur almost continuously from April through November in Florida, and fruits mature in approximately 30 days.

Flowers: Flowers are borne in sessile or short-peduncle axillary cymes in cluster of 3 - 5 flowers on new terminal and on lateral spurs. Flowers are bisexual, 1 - 2 cm in diameter. There are five pink or lavender, and fringed petals. Flowers consist of calyx with 6-10 large sessile glands, 5 petals, fringed, slender-clawed or spoon-shaped, 10 stamens and filaments united below (Orwa *et al*., 2009).

Anthesis, dehiscence of anthers, stigma receptivity: Flower anthesis and anther dehiscence occurred early in the morning, with 98% of flowers starting to open between 4.00 and 5.00 h and only 1% of them opening between 5.00 and 8.00 h. Anther dehiscence started at 6.00 h and continued throughout the day, with most (72%) occurring between 7.00 and 10.00 h. Flowers lasted only one day. Stigmas were

already receptive at 6.00 h when anthers started to dehisce to release fresh pollen (Freitas *et al*., 1999).

Pollination: The main agents for pollination in Barbados cherry are bees. This was evidence by a significantly increase in fruit-set through maintenance of bee hives in Florida. In Hawaii, the pollination taking place through wind and insects is very little, and the inadequate population of insects resulted in often production of seedless fruits (Morton, 1987). The flowers of the members of the family Malphighiaceae have oil glands which are collected by certain species of the Anthophoridae family, such as Centris. Centris is known to be one of the most important groups of pollinators of Tropical America. The main species of Centris group observed in flowers of Barbados cherry are *Centris dirrhoda* (Raw, 1979), *Centris fuscata, C. aenea* and *C. sponsa* (Melo *et al*., 1997) and *Centris flavifrons* (Magalhaes and Oliveira, 1998). The population of the species varies with location, for example, *Centris aenea* was the most abundant (42.6%) in Bahia (Castro, 1998), while, *Centris* (Hemisiella) *tarsata* was the most abundant (71.4%) visitor of flowers in the semi-arid ecosystem of Caatinga. The self- and cross-incompatibiliy in Barbados cherry have been reported (Orwa *et al*., 2009).

In addition to pollinators, seasons of fruiting also affecting fruit setting in Barbados cherry. In Florida, the Bahamas, Puerto Rico and Hawaii there may be a spring crop which ripened in May, followed by small crops off and on until December. However, when there is no rain in the season then there will be no fruits until December and then followed by a heavy crop. While in Zanzibar, the fruiting season is during the months of December and January. The fruit set can be increased through application of growth regulators such IBA (100 ppm) and PCA (50 ppm). The duration between flowering and fruit maturity is about 22 days.

Crop improvement methods: There has been a great interest generated among the horticulturist and food industrialists to commercialize the crop following discovery of high ascorbic acid content in the fruits of Barbados cherry (Asenjo and Guzman, 1946). In Hawaii the first commercial orchard was established in 1956 which composed largely of unselected seedlings and inferior clones. For crop improvement purpose, different breeding methods like Introduction, Selection, Hybridization and mutation breeding could be utilized. There was a wide variation among the seedling population for characters such as fruit and ascorbic acid content (Jackson and Pennock, 1958; Ledin, 1956). And to feed the infant industry of Barbados cherry, a selection, and testing program was initiated and continued (Nakasone *et al*., 1968). So far only clonal selection has been attempted which led to the released of several varieties.

Varieties: The varieties of Barbados cherry are grouped as sweet and sour varieties based on ascorbic acid content. The ascorbic acid content of sour type was higher than that of sweet type. In addition, sour type is more preferred for processing such as juices and purees (Nakasone *et al*., 1968).

Sweet Varieties:

Manoa Sweet: This is a high yielder variety, a, selection made from B-17 seedlings. Trees are upright, spreading, open type of growth, vigorous, produce multiple leaders and attain a height about 15 feet. Fruits are orange red when fully ripe, sweet and good flavoured. (Nakasone *et al*., 1968).

Tropical Ruby: A good yielder variety selected from B-17 seedlings. Trees growth resembles Manoa Sweet with multiple leader production and requiring certain amount of training to obtain single trunk tree. It grows up to a height of about 15 feet without pruning. Fruit characteristics are similar to those of other sweet varieties type.

Queen: It is a selection from B-17 seedlings. Trees growth habit is upright, spreading, and open. Trees can be trained to a single trunk with minimum afford compared to other sweet varieties. Fruits are resembles to those of other sweet varieties.

Sour Varieties:

J.H. Beaumont: 3B-21 was christened as J.H. Beaumont after the late Dr. John H. Beaumont. It was a clone obtained from seeds. It a compact, low, densely branch growth habit and can easily be trained to a single trunk tree. Both fruit and ascorbic acid production are good. Fruits are large with orange-red colour when fully ripe.

C.F. Rehnborg: This is a high yielding cultivar named after Mr. Carl F. Rehnborg. It was derived from the Miami seeds germinated in Hawaii. Trees have a compact, densely branch growth type and can be easily trained to a single trunk tree. Fruits are large, orange - red colour, turning dark red when fully ripe with low ascorbic acid content.

F. Haley: This cultivar was named after the late Mr. Frederick Haley, the first person to introduce the acerola into Hawaii in large quantities for commercial purposes. It was also derived from Miami seeds. Trees can be easily maintained to a single stem and it has an upright growth habits with branches are mostly of short laterals and are not so spreading. Fruits are medium sized, turning purplish-red when on full maturity. This variety has a wide adaptability especially in the drier areas.

Red Jumbo: It is a selection made from the Miami seedlings. Trees are of single stem with compact growth and well branches, dense foliage and low growing habits. Flowering period extended to January and February and fruit setting percentage and bearing is very high indicating prolific flowering. Fruits are large (9.3 g/fruit), attractive colour turning cherry red to purplish-red upon full maturity.

Florida Sweet: This cultivar was evolved through selection in Florida. Trees are upright growth habit, large fruits, thick

peel, apple-like, semi-sweet flavor, and high yield (Morton, 1987).

In Puerto Rica, the first promising selections identified were 'A-l' and 'B-17' based on fruit size, yield and vitamin C content. Another variety identified was 'B-15' which was superior over 'A-l' and 'B-17' for ascorbic acid content and yield.

Maturation aspects: This fruit presents fast metabolic activity and its maturation occurs rapidly; there is no need to use any activator to get the cherry ready to consume. On the other hand, when commercialized in ambient conditions, it requires fast transportation or the use of refrigerated containers to retard its respiration and metabolism partially (Netto *et al*., 1996). This feature may make the trade of the fruit to distant areas difficult. After the cropping, metabolic reactions continue in the fruit and the physiological process is maintained for a considerable time. In Barbados cherry, as well as in other tropical fruits, a series of alterations occurs during the process of maturation, ripening and senescence, the main ones being the degradation of chlorophyll, the presence of carotenoids, decrease in acidity, increase in reducing sugars and mainly the acute decrease in ascorbic acid during these stages.

Harvesting and yield: When the time comes to do the fruit harvest, there is a great concern about the correct time, frequency, procedures and forms of storage. The fruits can be harvested after 3rd year of planting. But, it takes 7-8 years to come into full bearing stage. The productivity of the plant increases up to 15-20 years and after that it may be stabilized or reduced, though, the plant continues the yield almost 40 years. The harvesting of the fruit has divided into different stages, varying from mature green up to deep red fully ripe mature depending upon the utility of the fruits. It should be harvested at green stages for pickle purpose; at green mature stage for murabba preserve; and for candy, syrup, concentrated juice, wine preparation it needs to pluck at deep red ripe stage. Fruit need to be cropped 2-3 times in a week or daily, according to the productivity of the plant, in order to prevent the losses by falling on the ground. The shelf life of Barbados cherry is very poor, it deteriorates rapidly after removing from the plant. Changes in sensory attributes starts within 4 hour of harvest and fermentation will starts within 3-4 days. Therefore, it is necessary to avoid any physical injury during harvest and better to store in cool places or in refrigerator to avoid the mould growth. A well managed tree yielding about 1.5-2.0 kg fruits / plant and 4-5 kg fruits / plant at 3 years and 5th years after planting. Plants grown in dry areas in irrigated fields presented production between 2.01 and 27.11 kg per tree in four crops a year.

Nutritional and economical food security: The tribal people are severely malnourished along with multiple nutrient-deficiency disorders due to ignorance about importance of fruits and vegetables in their diets. The tribal areas are full of biodiversity having natural vegetation which is not harnessed fully. Due to which a wide gap is formed between health and optimal use of natural sources of nutrients, i.e., underutilized crops. Barbados cherry is one of such underutilized fruit crop having many advantages like easier to grow and hardy in nature, producing a crop even under adverse soil and climatic conditions. So, exploitation of this crop can become a solution to the social problem of health and nutrition insecurity, poverty, and unemployment. The consumption of cherry fruit can provide nutrition to the poor and needy tribals by meeting the nutrient requirements of vulnerable groups. Besides, being a rich of source of carbohydrates, proteins, energy, vitamins-C (highest among the fruits), A, B-6, thiamine, riboflavin, niacin, pantothenic acid, and minerals (Ca, Mg, P, Fe, Zn, Cu, selenium) and dietary fiber. These nutritional and anti-oxidant properties of the fruit prevent and cure various serious diseases like cancer, kwashiorkor, marasmus, night blindness, anemia, diabetes, hypertension, liver problems and hidden hungers which are threatened the modern world. Besides, having high pectin content of the fruit make it enable for preparation of number of value added or processed products, like- jam, jelly, murabba, pickles, candy etc. Therefore, the crop is potential to give economic security to tribals by giving employment and by fetching good returns from their sale in raw form as well as such value-added products. Apart from this, the cherry fruit has also used in commercial scale. Barbados cherry is the richest source of vitamin C, which is used in the preservation of dry and frozen fruits as an antioxidant. If used along with citric acid, it is effective in the prevention of the oxidation process that occurs during the dehydration and freezing of many fruits such as papayas, pears, apples, passion fruits and pineapples (Araujo and Minami, 1994). Besides, a large number of value added products can be prepared from the raw fruits, fruits residues after juice extraction or mixing with other fruits *viz*. Frozen Acerola, Hot-pressed Acerola Juice, Cold-pressed acerola juice, Frozen acerola juice, Bottled acerola juice, fortify other fruit juices (Passion fruit juice, pineapple juice, apple juice, grape juice, pear and apricot nectar, and some other fruit juices and necta) with acerola juice, Acerola Spread, Acerola Sauce, Acerola mint jelly, Frozen acerola and passion fruit topping, Acerola gelatin dessert, Ginger ale salad with acerola, Baked bananas with acerola juice, Acerola milk shake, Acerola sherbet etc (Miller *et al*., 1961). So, if proper training can be given with proper recepies and procedures of these value-added products to the rural housewives from any Departmental, research institute, university level or KVKs, then it would be a good alternative source of income to them (housewives from rural or marginal area) by fetching these products year the round.

CONCLUSION

Health benefits, value addition, market access, and education about propagation and cultivation of Barbados cherry are very much effective on proper utilization of the fruit in both regions for food and nutrition security. The global production of this fruit is very low as compared to other fruit crops. Efforts are needed to enhance its cultivation and production potential through crop improvement and participatory technology development with all the stake holders. It is very important to popularize the crop within suitable location in various part of the world. There is a need to develop and refine technology for higher productivity of the crop. There is also need for careful planning to avoid deterioration of antioxidant activity particularly during the immature green and green stages. As the crop is a potential source of Vitamin C and pectin, it can be successfully utilize in soft drinks and liqueurs preparation industry. Due to the existence of a great market for derivates of fresh fruits in the foreign market especially in Northern hemisphere, exportation of Barbados cherry is a potential alternative source of income in agricultural businesses. For exportation, a lot of work force is require specially in the steps of fruit harvesting and classification, thus occupying an important position among the fruits commercially exploited. As this fruit crop is perennial in nature and having almost year round production, it not only requires a lot of work force but it also provides small farms with continuous income throughout the year. Besides, exploration of strategies through scientific research for value addition and market access by small-scale fruit processing units through community cooperatives are an important contribution to curbing the challenge of food and nutrition security for households and individuals.

REFERENCES

Anonymous. (2014). *Malpighia punicifolia*. Trade winds fruit, http://www.tradewindsfruit.com/ content/acerola.htm. accessed on 28/ 10/2014.

Araújo, P.S.R., and Minami, K. (1994). Acerola. Fundação Cargill, Brazil. p. 81.

Asenjo, C.F., and Guzman, A.R.F. (1946). The high ascorbic acid content of the West Indian Cherry. *Science*, **103:** 219.

Carrington, C.M.S. and King, R.A.G. (2002). Fruit development and ripening in Barbados cherry, *Malpighia emarginata* D.C. *Scientia Horticulturae*, **92:** 1–7.

Castro, M.S. (1998). Diversidade de abelhasnaflor da aceroleira (*Malphighia punicifolia*). Anais do 4° Congresso Brasileiro de Ecologia, Brazil.

Cavalcante, I.H.L., Beckmann, M.Z., Martins, A.B.G., and Campos, M.C.C. (2007). Preliminary selection of acerola genotypes in Brazil. *Fruits*, **62:** 27–34.

Cooper, F. (1971). The acerola comes to California loaded with vitamin C. CRFG Yearbook. pp. 2-8.

Corren, J., Lemay, M., Lin, Y. and Rozga, L., Randolph, R.K. (2008). Clinical and biochemical effects of a combination botanical product (Clear Guard TM) for allergy: a pilot randomized double-blind placebo-controlled trial. *Nutrition Journal*, **7:** 20.

Freitas, B.M., Alves, J.E., Brandao, G.F., and Araujo, Z.B. (1999). Pollination requirements of West Indian cherry (*Malpighia emarginata*) and its putative pollinators, Centris bees, in NE Brazil . *Journal of Agricultural Science, Cambridge*, **133**: 303 -311.

Freitas, C.A.S., Maia, G.A., Costa, J.M.C., Figueiredo, R.W., and Sousa, P.H.M. (2006). Acerola: produção, composição, aspectos nutricionais e produtos. *Revista Brasileira de. Agrociênc.(Pelotas)*, **12:** 395–400.

Hwang, J., Hodis, H.N. and Sevanian, A. (2002). Soy and alfalfa extracts become potent low-density lipoprotein antioxidants in the presence of acerola cherry extracts. *Journal of Agricultural and Food Chemistry*, **49**: 308–314.

Jackson, G.C. and Pennock, W. (1958). Fruit and vitamin C production of five-and six- year- old acerola trees. Univ. *Puerto Rico Journal of Agriculture*, **42**: 196-205..

Janick, J. and Paull, R.E. (2008). Malphigia. In: The Encyclopedia of Fruit & Nuts. CABI. p. 462.

Johnson, P.D. (2003). Plants in Human Health and Nutrition Policy, Simopoulos, A. P. and Gopalan, C. Karger Publishers. pp. 63-74.

Ledin, B. (1956). A comparison of three clones of Barbados cherry and the importance of improved selections for commercial plantings. *Proceedings of the Florida State Horticultural Society*, **69:** 293-297.

Magalhaes, L.M.F. and Oliveira, D. (1998). Abelhasvisitantes da (*Malphighia punicifolia L.*) em Terra-Alta/PA, Amazonia. Encontrosobrc Abelhas Ribeirao Preto, Brazil.

Melo, N.F., Okasaki, W.Y., Leite, C.B. and Fári, M. (1999). Establishment of in-vitro culture of Barbados cherry (*Malpighia emarginata* D.C.). *Ciênciae Agrotechnologia*, **23**: 102–107.

Miller, C.D., Wenkam, N.S. and Fitting, O. (1961).Acerola-Nutritive value and home use. Hawaii Agricultural Experiment Station, University of Hawaii, Circular 59. pp. 1-18.

Mondin, M., de Oliveira, C.A., and Vieira, M.L.C. (2010). Karyotype characterization of *Malphigia emarginata* (Malphigiaceae). *Revista Brasileira de Fruticultura*, **32**: 369-374.

Morton, J. (1987). Fruits of warm climates, [Julia F. Morton (ed.)]. Miami. p. 204-207.

Nakasone, H.Y., Yamane, G.M. and Miyashita, R.K. (1968). Selection, evaluation, and naming of Acerola (*Malpighia glabra* L.) cultivars. Honolulu. p. 19.

Nishant, N. and Upadhyay, R. (2016). Presence of pesticide residue in vegetable crops: A review. *Agricultural Reviews*, **37**: 173-185.

Neto, L.G. and Soares, J.M. (1994). Acerola paraexportação: aspectos técnicos da produção. Brazil. p. 13.

Netto A.G., Ardito E.F.G., Garcia E.E.C., Bleinroth E.W., Freire F.C.O. and Menezes J.B., (1996). Acerola paraexportação: procedimentos de colheita e pós-colheita. Brazil.

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R. and Simons, A. (2009). Agroforestry Database: a tree reference and selection guide version 4.0. http://www.worldagroforestry.org/af/ treedb/.

Priscilla, L., Balakrishnan, A., Lalrinsangpuii., and Chauhan, A.K. (2017). A Study on the performance of agricultural sector in India. *Indian Journal of Agricultural Research*, **51**: 282-286.

Raw, A. (1979). *Centris dirrhoda* (Anthophoridae), the bee visiting West Indian Cherry flowers (*Malphighia punicifolia*). *Revue of Biology in Tropics*, **27:** 283-285.

Sadat, A., and Chakraborty, K. (2017). Farmers' knowledge, perceptions and practices in jute insect pest management and cultural strategy in the upper Gangetic plains of West Bengal, India. *Indian Journal of Agricultural Research*, **51**: 320-326.

Sandra, A.A., José Carlos, R.V., Iguatemy, L.B., and Khalil, N.M. (2009). Antioxidant activity, ascorbic acid and total phenol of exotic fruits occurring in Brazil. *International Journal of Food Sciences and Nutrition*, **60:** 439–448.

Singh, D.R. and Medhi,. R.P. (2003). West Indian cherry cultivation in Andaman. Director of CZARI (Publishers), Port Blair.