Averrhoa carambola, a monograph

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INTRODUCTION

Averrhoa carambola, a member of the Oxiladacea family is a fruit distinguished for its unique and attractive star shape, therefore gaining a high demand in the international market, even though it is a low risk specie. The fruit, with an undetermined origin, has traveled through various regions and gained multiple names according to its shape and sweetness such as, starfruit or sweet belimbing. *Averrhoa carambola* is a small and slow-growing tree cultivated in tropical and subtropical regions for its fruit and the medicinal uses of it. The following chapters will further develop essential characteristics of *Averrhoa carambola*, such as the ecological and biological properties, as well as how it is cultivated and merchandised.

Chapter 1 focuses on the ecological characteristics of the fruit, such as where in the world did it originated, the ideal altitude, climate and soil for it to grow. The second chapter, centralizes on its biology, stating how the plant reproduces and how tree and its components grow according to its surroundings. The next chapter discusses how both the tree and the fruit are managed including its propagation process, how it should be stored and maintained to avoid complications. The final chapter states both the flavor of the fruit and the properties related to it, as well as the various uses of *Averrhoa carambola*.

Image 1, *Averrhoa carambola* fruit and foliage, (Forest & Kim Starr, 2009)

1 ECOLOGY

1.1 AFFINITIES

Averrhoa carambola is part of the Oxiladacea family; its genus is the *Averrhoa*, which of approximately a dozen species, two are planted for the production of their fruit. These are the *Averrhoa carambola* and the *Averrhoa bilimbi.*

1.2 ORIGIN

Averrhoa carambola has an unknown origin, but it is believed to have emerged in Southeast Asia in either Malaysia, Indonesia or in southern China, considered a domesticated fruit that isn't found in the wild (Othman, 2004). Another possibility of its origin is the Americas, as the fruit was reported to be present during trades made in the Philippines with products from South America during the Spanish colonial period (Merrill, 1904) ;(Quisumbing, 1951). Julia Morton claims that the *Averrhoa carambola* was introduced in Florida, United States from a variety of seeds brought from Hawaii (Morton, 1987).

1.3 PRESENT DISTRIBUTION

Averrhoa carambola is primarily produced in Southeast Asia, India being the primarily exporter to European markets (CBI Ministry of Foreign Affairs, 2016). On the other hand, *Averrhoa carambola* is consider as one of the minor fruits of production in Florida, United States with an approximate area of production of 16 hectares and a maximum production of 47.2 metric tons in 1983. Consequently, due to the high production on South East Asia and a high importation to Florida, the *Averrhoa carambola* production is estimated to increase to about 450 metric tons (Knight & Crane, 2002). Malaysia is also considered to be one of the major contributors to its production and commerce. "*The four major export market for Malaysia's star fruit are Netherlands, France, Germany and Singapore"* (Othman, 2004), Figure 1.1 displays the

exportation amount in Malaysia from 1995 to 2001. Figure 1.2 represents the present distribution of *Averrhoa carambola*, based on multiple reports of various references of where it has been introduced and continued its production.

Year	Export Quantity (MT)	Export Amount (RM)
1995	13,778.08	21,964,665
1996	12,544.00	24,976,954
1997	7,597.42	24,202,730
1998	6,454.51	26,721,808
1999	6,599.52	28,125,069
2000	6,213.18	27,751,899
2001	9,182.29	31,561,325

Figure 1.1, *Averrhoa carambola* exportation from Malaysia, (Statistics Department, Malaysia, 2001)

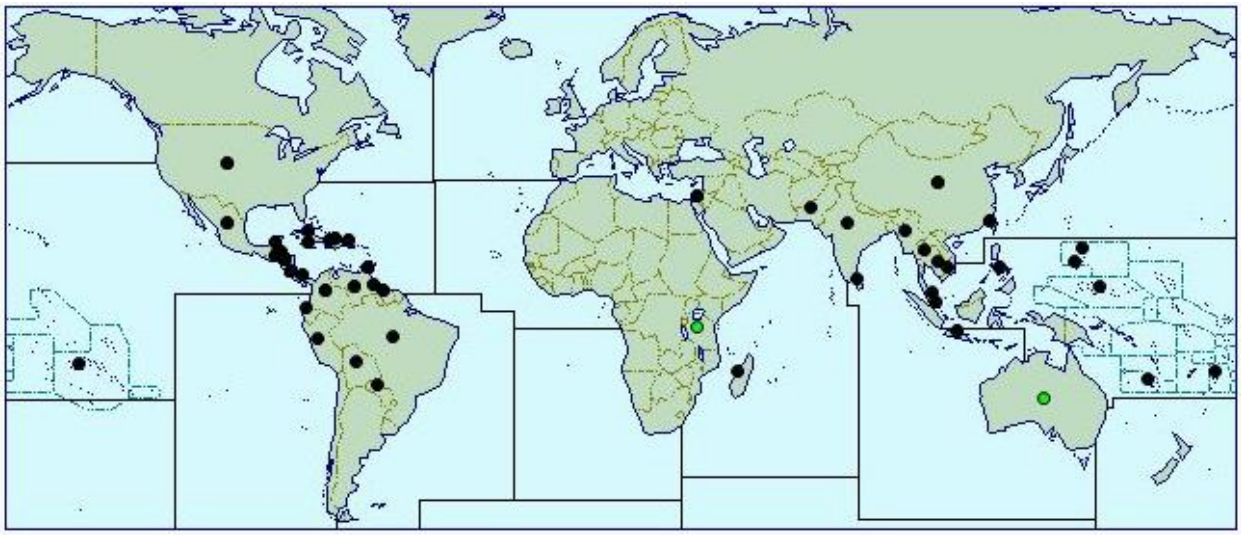

Figure 1.2, Present global distribution of the *Averrhoa carambola*, (CABI, 2017)

1.4 ENVIRONMENTAL FACTORS IN DISTRIBUTION

1.4.1 Elevation

Averrhoa carambola tend to grow at low elevations in an altitude range between 0 meters to 1500 meters. In Nicaragua it usually grows between 0 and 100 meters (Flora of Nicaragua, 2015), in Peru approximately at 500 meters (Peru Checklist, 2015), in Colombia it has been reported to grow between 0 and 500 meters and 1000 to 1500 meters (Vascular Plants of Antioquia, 2015) and in Bolivia at a range from 0 to 1000 meters (Bolivia Checklist, 2015).

1.4.2 Climate

Averrhoa carambola can grow in subtropical and tropical environments and it is able to tolerate freezing temperatures as low as -2.78º C (Morton, 1987). The *Averrhoa carambola* usually has a broader climate range than the rest of the plants in its genus. It usually grows in dry weather, hot humid environments and wetter climates (FAO EcoCrop, 2015). An appropriate amount of rainfall for *Averrhoa carambola* is between 1500 and 3000 millimeters per year. Exposure to dry and hot winds can damage and eventually kill the tree, while if exposed to cold winds of approximately 10ºC and a speed higher than 80 kilometers per hour will cause defoliation that requires months for the tree to recover (Janick & Paull, 2008).

1.4.3 Temperature Regimes

The optimal temperature at which *Averrhoa carambola* grows is between 21ºC and 32ºC. If the temperature is below 15ºC growth and flower opening will cease. Newly developed shoots are damaged at 0ºC and start to die below this temperature. Adult trees have more tolerance to these temperatures, but have the possibility of dying if exposed a temperature of -4ºC for more than a day (Janick & Paull, 2008).

1.5 GEOLOGY AND SOILS

Averrhoa carambola is capable of growing in various types of soils, such as sand, clay loam and very rocky soils. However, in areas where water ponds for twelve hours or more it is inapt. The soil in which it must grow can have a pH range of 5.5 to 6.5, and a few soils with a pH of 7.7 allow growth. It grows well in dry areas and is tolerant to droughts (Janick & Paull, 2008). *Averrhoa carambola* can grow in many types of soils, however, it requires good management, such as an irrigation system and the use of fertilizer (Othman, 2004).

2 BIOLOGY

2.1 CHROMOSOME COMPLEMENT

The chromosome number for the *Averrhoa carambola* is 2n = 2x = 22 or 24 (Ray, 2002)

2.2 LIFE CYCLE AND PHENOLOGY

2.2.1 Life cycle

Averrhoa carambola has a life span of approximately twenty-five to fifty years. Its tree takes approximately ten to twenty years to reach its full maturity and its full height, which is between 5 and 12 meters. The fertilization of the tree is dependent on the soil it grows. On soil with low fertility, fertilizer should be applied every two or three months, until the tree is well established. Afterwards, if the tree is in deep soil, it should be fertilized once or twice a year, and if it is in shallow soil three or more (Facciolo, 1990).

2.2.2 Phenology

Averrhoa carambola grows in a humid tropical environment, its phonological stages were determined with the trees grown in south Florida. The trees demonstrate an absence of growth during the months of February and March, due to their unfavorable weather conditions, such as low temperatures, strong winds and increased solar radiation due to the absence of cloud cover. Therefore, the tree conditions deteriorate during the winter season (Marler, 1994).

2.2.3 Deciduosness

The leaf production of the *Averrhoa carambola* begins to decline during October, but still produce fruits that are harvested during the months of December and January. As winter begins, the canopies consist of multiple aging leaves, many months old. Leaves begin to fall during the months of February and March (Marler, 1994). The leaves of the *Averrhoa carambola* have an

oval shape and grow between fifteen and twenty-five centimeters in length, and about 4.5 centimeters in width (Das Gupta & Chakraborty, 2013).

2.2.4 Flowering and fruiting

Averrhoa carambola trees flower in abundant proportions. Panicles (clusters of flowers), are formed along long, thin shoots (the upward growth after germination where leaves grow), on the canopy edge. The small shoots are usually weak and measure less than fifteen centimeters. Buds (Contains an undeveloped leaf or flower) mostly grow on the older branches (Salakpetch, Turner & Dell, 1990). The flower of *Averrhoa carambola* has a small size and has a purple color, which grow in the trunk, the branches and the twigs. It contains five sepals, five stamens and five petals. On the other hand, the fruit has an oval shape with 5 angles that give the fruit a star shape. When the fruit grows it is green colored at the beginning, and gains a yellow and orange color when it is ripe (Othman, 2004).

2.3 REPRODUCTIVE BIOLOGY

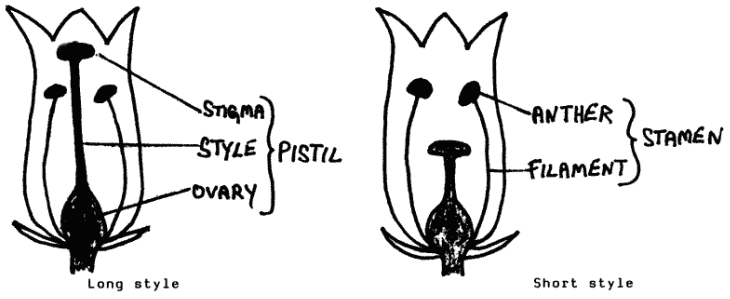

Figure 2.1, Flower Styles in *Averrhoa carambola,* (The Archives of the Rare Fruit Council of Australia, 1992)

2.3.1 Sexuality

The *Averrhoa carambola* is dioecious, meaning it has its male and female organs in different individuals. In other words, it requires a male and a female starfruit tree in order to reproduce a new tree (Watson *et al*, 1988).

2.3.2 Anthesis

The anthesis of the *Averrhoa carambola* is variable according to temperature. During summer, the flowering and fruit development takes about ten to twelve weeks, and during autumn it takes between twelve to sixteen weeks. The *averrhoa carambola* flower has usually five stamens, united at the base and a five-lobed compound pistil. The style is in two forms, short and long. The short-style (the stigmas located below the stamens) cultivars are generally self-incompatible and require pollination from long-style (stigmas above the stamens) types. Long-style types are self-fertile (Watson *et al*, 1988).

2.3.3 Pollination and potential pollinators

The pollination of the *Averrhoa carambola* isn't air born, it is pollinated by insects. These insects are mainly honey bees and *Diptera* species, which are mainly attracted to the sweet nectar of the starfruit and the bright colors of the flowers (Sedgley & Griffin, 1989).

3 PROPAGATION AND MANAGEMENT

3.1 NURSERY PROPAGATION

3.1.1 Propagation from seed

Averrhoa carambola fruit can contain between none to twelve brown, and usually flat seeds of about 5 millimeters in length. The seeds lose their usefulness after being removed from the fruit and can be propagated from the seed (Das Gupta & Chakraborty, 2013). For *Averrhoa carambola* to be propagated through its seed, the seed must be plump and fully grown. In damp peat moss the seed will propagate in approximately one week during summer and around two and three weeks during winter. The *Averrhoa carambola* seeds are very tender and require very good care (Maxwell, 1984).

3.1.1.1 Sowing and the germination process

The germination process for the *Averrhoa carambola* is a complicated process as when the seedlings begin to grow they tend to grow very tall with minimum branching for support, causing it to fall. For sowing its surroundings must be moist and warm. The seed must be covered in about 0.25 inches of soil. For it to grow in the best conditions, the *averrhoa carambola* seed must have access to sunlight, and an early use of fertilizers at about a year later. The germination process takes between a week and a month based on its conditions.

3.1.1.2 Storage

The *Averrhoa carambola* is arranged in a basket with the fruit covered in a wrapper which is insect proof and avoids insect infestation. The wrappers also protect the fruits for getting bruises. The fruits are kept and transported in cold storages so they are refrigerated, in order to avoid insects and loss of quality by lack of refrigeration (Othman, 2004). On the other hand, a study was conducted based on the effects of the different conditions of the storability of two different

types of carambola fruit, Fwang Tung and Arkin. The fruits were stored in cardboard boxes in which half of the fruits were wrapped in polyethylene bags and the other half was covered in absorptive paper. All of the boxes were kept at either 40ºC, 45ºC, 50ºC or 70ºC. The study concluded that the fruits kept at 50ºC had optimal conditions for the first week, while kept at 45ºC had adequate results for up to six weeks (Kenney & Paul, 1986).

3.2 VEGETATIVE PROPAGATION

3.2.1 Grafting

Averrhoa carambola trees can use side-veneer grafting using mature wood into the *averrhoa carambola* seedlings and is most useful for mass production. For more mature trees farmers often utilize bark grafting. Grafted trees fruit in approximately ten months from the moment they were planted out (Crane, 2007).

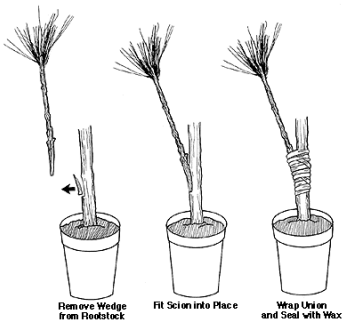

Figure 3.1, Side-Veneer Grafting, (Bilderback, 2014)

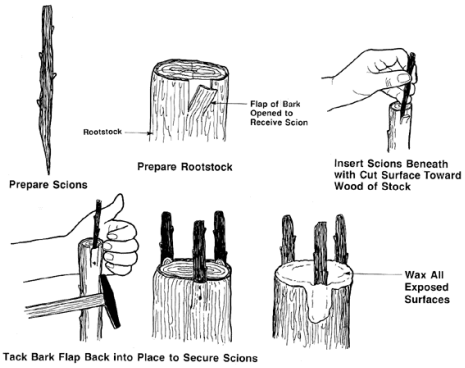

Figure 3.2, Bark Grafting, (Bilderback, 2014)

3.2.2 Cuttings

For propagation, grafting is a more preferable and common choice for *Averrhoa carambola* as cutting is not a very useful method for many tropical fruits as by this method the plant is most likely to develop weaker roots (Crane, 2007).

3.3 PLANTING

A*verrhoa carambola* tree must be planted in a location with good access to sunlight, as well as a location that provides protection to strong winds. *Averrhoa carambola* must be planted in either tropical or subtropical climates (Morton, 1987).

3.4 MANAGEMENT

3.4.1 Fruiting

The fruiting management for the *Averrhoa carambola* include regular watering, as rainy seasons in its ecological locations provide the rest needed. The soil required needs good drainage, and composed of good organic matter. The tree must be fertilized between four to five times a year with either liquid or granular fertilizer (Edison & Ford Winter Estates, 2011).

3.4.2 Pest and disease control

The main pests that affect the *Averrhoa carambola* are diaprepes weevil and red banded thrips. Approximately thirty percent of *Averrhoa carambola* crop growers state that they face crop damage due to insects. In response, insecticide and miticide are most commonly used to control such pests. On the other hand, many diseases are related to fungi and algae. Common diseases are anthracnose, which include: leave infection that turns them brown, fruit is invaded by fungus and its flowers die; as well as decline, which include the loss of tree liveliness, leaf drop, and root deterioration. To control such diseases, treatments such as fungicide and copper are common (Crane, 2007)

Figure 3.,3 Diaprepes Weevil, (Mayer, 2001)

Figure 3.4, Red Banded Thrips, (Hill, 1975)

4 EMERGING PRODUCTS, POTENTIAL MARKETS

4.1 FLAVOR IN AVERRHOA CARAMBOLA

The *Averrhoa carambola* is divided in two types, each with its unique flavor. The smaller fruit has a rich, and sour flavor, due to its high content of oxalic acid. On the other hand, the larger fruit has a sweet and mild flavor due to its low content of oxalic acid. Figure 4.1 demonstrates the food value and Figure 4.2 the amino acid content of the fruit (Morton, 1987). The fruit is characterized by having high contents of antioxidants and vitamin C. However, it also has low contents of sugar, sodium and acid (CBI Ministry of Foreign Affairs, 2016).

Food Value Per 100 g of Edible Portion*	
Calories	35.7
Moisture	89.0-91.0 g
Protein	0.38 g
Fat	0.08 g
Carbohydrates	9.38 g
Fiber	0.80-0.90 g
Ash	0.26-0.40 g
Calcium	4.4-6.O mg
Phosphorus	15.5-21.0 mg
Iron	0.32-1.65 mg
Carotene	0.003-0.552 mg
Thiamine	0.03-0.038 mg
Riboflavin	0.019-0.03 mg
Niacin	0.294-0.38 mg
Ascorbic Acid*	26.0-53.1 mg

Figure 4.1, Food Value of *Averrhoa carambola* fruit, (Morton, 1987)

Tryptophan	3.0 mg
Methionine	2 mg
Lysine	26 mg

Figure 4.2, Amino acid content of *Averrhoa carambola* fruit, (Morton, 1987)

4.2 FOOD ITEMS BASED ON PULP, SKIN AND JUICE

The *Averrhoa carambola* is commonly consumed as a fresh fruit or juice, as a refreshing beverage to drink. On the other hand, in the Philippines the juice is utilized as a seasoning for food. In Hawaii, the juice is mixed with gelatin, sugar and lemon juice to make sherbets. The fruit is also used to make jelly, sweets and concentrates. Malay culture use the fruit to produce tarts, jam or boil it to make syrup. The Javanese culture use the flowers as an ingredient in their salads. In Jamaica, when the fruit is in its best conditions it is dried (Thulaja, 2016) (Morton, 1987).

4.3 MEDICINAL USES

The *Averrhoa carambola* has multiple medical uses. On the first hand, on traditional Malay culture, the leaves are crushed in order to treat chickenpox, dermatophytosis (ringworm) and in some occasions headaches. By a process called decoction, where the flavor or essence of the fruit is extracted through boiling, vomiting can be treated by decocting the leaves. On the other hand, Asian countries such as China and India, the roots are decocted to treat poisoning in the human body. The juice of the *Averrhoa carambola* is utilized to cool the body temperature of patients suffering of fever (Thulaja, 2016).

4.4 WOOD USES

The wood of the *Averrhoa carambola* tree is white and becomes red as it ages. The wood also has a dense structure and a medium-hard texture. Thanks to this properties, the wood of the *Averrhoa carambola* tree is often used in building furniture and used for construction (Morton, 1987).

4.5 OTHER USES

Due to the acidic properties of the *Averrhoa carambola*, its juice can be utilized to clean and polish metallic surfaces, as it dissolves rust and tarnish. On the other hand, the juice can also bleach rust stains from white clothing. (Thulaja, 2016) (Morton, 1987)

Glossary

Anthesis - The period or act of expansion in flowers, especially the maturing of the stamens.

Buds - A small axillary or terminal protuberance on a plant, containing rudimentary foliage (leaf bud) the rudimentary inflorescence (flower bud) or both (mixed bud)

Canopy - Branches and foliage of a tree above ground or water.

Deciduousness - Shedding the leaves annually, as certain trees and shrubs.

Defoliation - To destroy or cause widespread loss of leaves in (an area of jungle, forest, etc.), as by using chemical sprays or incendiary bombs, in order to deprive enemy troops or guerrilla forces of concealment.

Genus - The usual major subdivision of a family or subfamily in the classification of organisms, usually consisting of more than one species.

Germination - To develop into a plant or individual, as a seed, spore, or bulb.

Grafting - The act of placing a portion of one plant (bud or scion) into or on a stem, root, or branch of another (stock) in such a way that a union will be formed and the partners will continue to grow.

Irrigation System - To supply (land or crops) with water by means of pipes, sprinklers, ditches, or streams.

Panicles - Any loose, diversely branching flower cluster.

Phenology - The science dealing with the influence of climate on the recurrence of such annual phenomena of animal and plant life as budding and bird migrations.

Pistil - The ovule-bearing or seed-bearing female organ of a flower, consisting when complete of ovary, style, and stigma.

Propagation - the ovule-bearing or seed-bearing female organ of a flower, consisting when complete of ovary, style, and stigma.

Sepal - One of the individual leaves or parts of the calyx of a flower.

Shoots - The aerial portions of a plant, including stem, branches, and leaves and also, new immature growth on a plant.

Sowing - To scatter (seed) over land, earth, etc., for growth; plant.

Stamen - The pollen-bearing organ of a flower, consisting of the filament and the anther.

Works Cited

Bilderback, T., Bir, R. E., & Ranney, T. G. (2014, June 30). Grafting and Budding Nursery Crop Plants. Retrieved from https://content.ces.ncsu.edu/grafting-and-budding-nursery-crop-plants

Bolivia Checklist, 2015. Catalogue of the Vascular Plants of Bolivia, Tropicos website. St. Louis, MO, USA: Missouri Botanical Garden. http://tropicos.org/Project/BC

CABI. Averrhoa carambola (carambola). (2015, March 17). Retrieved from http://www.cabi.org/isc/datasheet/8082

Campbell C.A, 1989. *Storage and Handling of carambola*. Proc. Interam. Soc. Trop. Hort. 33. 79-82

CBI Product Fact Sheet: Fresh Exotic Tropical Fruit in the European Market. (2016). CBI Ministry Of Foreign Affairs. Retrieved from https://www.cbi.eu/market-information/fresh-fruit-vegetables/exotic-tropical-fruit/europe/

Crane, J.H. 2007. *Carambola growing in the Florida Home Landscape*. Horticultural Sciences document HS12. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida.

Das Gusta, P., & Chakraborty, P. (2013). Averrhoa carambola: An updated review. International Journal of Pharma Research & Review. Retrieved from https://www.researchgate.net/publication/289630352

Facciolo, Stephen. *Cornucopia: a source Book of Edible Plants*. Kampong Publications, 1990. p. 39.

Flora of Nicaragua, 2015. Flora of Nicaragua, Tropicos website. St. Louis, MO, USA: Missouri Botanical Garden. http://tropicos.org/Project/FN

Hill, D. (1975) Agricultural Insect Pests of the Tropics and their Control. Cambridge Press, London. 516pp.

Janick, J., & Paull, R. (2008). *Encyclopedia of Fruits and Nuts*. CABI.

Kenney, P., & Hull, L. 1986. Effects of storage condition on carambola quality. *Proceedings of the Florida State Horticultural Society* 99: 222-224

Knight, R.J., & Crane J.H. 2002. The 'Arkin' carambola in Florida. *Proceedings of the Florida State Horticultural Society* 115:92-93

Marler, T.E., B. Schaffer and J.H. Crane. 1994. Developmental light level affects, growth, morphology, and leaf physiology of young carambola trees. J. Amer. Soc. Hort. Sci. 119: 711-718.

Maxwell, Lewis S. and Betty M. Maxwell. *Florida Fruit, rev.ed*. Lewis S. Maxwell, 1984. p. 19.

Mayer RT, Hunter WB, Lapointe SL, McKenzie CL, Shatters R, Shapiro J, Doostdar H, Weathersbee AA. *Diaprepes root weevil: recent advances at the U.S. Horticultural Research Laboratory*, Ft. Pierce. Part I. Citrus & Vegetable. 2001. July: 9-12.

Morton, J. 1987. Carambola. p. 125-128. In: *Fruits of warm climates*. Julia F. Morton, Miami, FL.

Peru Checklist, 2015. The Catalogue of the Flowering Plants and Gymnosperms of Peru. St. Louis, Missouri, USA: Missouri Botanical Garden. http://www.tropicos.org/Project/PEC

Othman, A. B. (2004). *Technical Document for Market Access On Star fruit (carambola).*

Quisumbing, E. 1951. Medicinal Plants of the Philippines. Department of Agricultural and Natural Resources Bulletin. No. 16.

Ray, P. K. (2002). In: *Breeding Tropical and Subtropical Fruits* (p. 307). Springer Verlag.

Salakpetch, S., D.W. Turner and B. Dell. 1990. *Flowering in carambola (Averrhoa carambola)*. Acta Hortic. 275: 123-129.

Sedgley M, Griffin AR. 1989. *Sexual Reproduction of Tree Crops*. Academic Press. London.

Thulaja, N. R. (2016). Starfruit. National Library Board - Singapore. Retrieved from http://eresources.nlb.gov.sg/infopedia/articles/SIP_173_2005-01-06.html

Watson, B.J., George, A.P., Nissen, R.J. & Brown, B.I. (1988) Queensland Agricultural Journal