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Nurturing Health and Sustainability through Coconut Innovations

In this edition, we delve into the realms of health and sustainability within the coconut sector, exploring compelling advancements that go beyond the ordinary. Addressing challenges in coconut production, a breakthrough has emerged from the Philippine Coconut Authority (PCA). Researchers unveil a synthetic coconut variety generated through classical breeding methods supported by SSR markers. Despite debates surrounding the technology, this synthetic variety proves pivotal, offering a solution to the substantial investment required for hybrid seed production. The protocol opens avenues for the assessment and accreditation of coconut plantations, ensuring a robust supply of high-quality planting materials for accelerated planting and replanting programs.

Increasing coconut production is crucial to meet the global demand for coconut products, including coconut sugar. The development of coconut sugar in Indonesia represents a significant exploration into the potential economic and public health benefits derived from this specific product extracted from coconut sap. In recent years, there has been a growing interest in the production of coconut sugar as a viable alternative sweetener, driven by its perceived health benefits and sustainable characteristics. The demand for coconut sugar in the US market has progressively increased, indicating a rising consumer interest in this specific coconut-derived product. These trends underscore the potential for market expansion and the need for sustained production to meet the growing consumer demand for coconut sugar. Thailand and Indonesia are major exporters of this product. From an economic perspective, the processing of coconut sugar provides a potential source of income for farmers and local communities. The demand for healthier and ethically sourced sweeteners has presented an opportunity for coconut-producing regions like Indonesia to diversify their agricultural activities and generate revenue.

The production of coconut products to meet local and global demand has been challenged by pests and diseases. The emergence of invasive whiteflies on coconut palms in India poses a significant challenge to coconut cultivation, prompting the exploration of management strategies, with a particular focus on eco-friendly approaches such as the use of biocontrol agents. Invasive whiteflies have the potential to transmit diseases and reduce overall plant health. Recognizing the ecological sensitivity and the potential harm associated with conventional chemical pesticides, the emphasis in India has shifted toward more sustainable and environmentally friendly methods to manage this pest. The eco-friendly approach to managing invasive whiteflies not only aims to reduce the environmental impact of pest control measures but also aligns with broader principles of sustainable agriculture. By promoting the use of biocontrol agents, the strategy seeks to maintain a balance in the ecosystem, minimizing the disruption caused by invasive pests while avoiding the negative consequences associated with the overuse of chemical pesticides.

As we navigate the intricacies of coconut innovation, from the sweet allure of coconut sugar to eco-friendly pest management and synthetic variety breakthroughs, we envision a future where health and sustainability intertwine seamlessly. May this edition spark curiosity, inspire action, and pave the way for a sweeter, more sustainable coconut sector.

DR. JELFINA C. ALOUW
Executive Director
Editor-in-Chief

Coconut Sugar Product Development in Indonesia as Potential Source of Income and Public Health Support

Steivie Karouw[1], Linda Trivana[1], Hengky Novarianto[2], Budi Santosa[2] and Syafaruddin[3]

Coconut has been in existence for millions of years in almost all tropical countries, and the people of the tropical world use a eulogistic epithet "Tree of Life" for coconut palms (Chinnamma et al., 2019), because it provides a large number of products that can be used to support the local economy such as almost all the necessities of life-food, drink, oil, medicine, fiber, timber, thatch, mats, fuel, and domestic utensils (Chan and Elevitch, 2006). Neera is an alternative in the array of value-added products besides the tree which holds the potential to revitalize the prospects of coconut farmers. Neera is obtained by tapping the unopened spadix of the coconut flowers (Borse et al., 2007). Neera contains sugar and the fresh neera is sweet, oyster-white, and translucent, with a nearly neutral pH (Borse et al., 2007). Harvesting of neera from the spadix of the selection of healthy palms without disturbing the physiology of the tree by pests and diseases.

Recently, coconut plants that are generally tapped are Tall coconut varieties, coconut that has a high stem, so it is very risky for the safety of the tapping personnel. To solve the problem, Dwarf coconut varieties as sources of neera are used, because their flowering is faster, and the stem is shorter and slower to grow compared to Tall varieties. Indonesian Palmae Crops Research Institute (IPCRI), Indonesian Agency for Agricultural Research and Development, Ministry of Agriculture has a collection of Dwarf coconut varieties and four of them have been released as superior dwarf coconut varieties are Salak Green Dwarf (SGD), Raja Dwarf (RBD), Nias Yellow Dwarf (NYD), and Bali Yellow Dwarf (BYD). Dwarf coconut varieties were evaluated for neera production and proven to be very suitable to be used as a source of sap.

Fresh neera is the raw material for coconut sugar processing to jaggery, granular palm sugar, and

coconut syrup. The fresh neera/ coconut sap is rich in carbohydrates with sucrose as its main constituent. It is well known that the coconut sap ferments very quickly thus producing alcohol in it. The fermented sap smells obnoxiously thus making it unacceptable as a beverage for consumption. Hence, there is a need to preserve the coconut sap without affecting its nutritional quality (Ramalakshmi et al., 2004). To prevent sap damage, it can be done by adding sap preservative to the sap container before it is used to tap the sap. Two types of sap preservatives are commonly used by farmers, namely natural and synthetic sap preservatives (Karseno and Yanto, 2019). Natural sap preservatives are more recommended to use by farmers because consumers perceive naturalness as a beneficial characteristic of food items.

Coconut sugar is very popular as a natural sweetener in some developed countries like Europe, America, Japan, and Australia because has low GI value suggesting that it can be a better source of healthier sugar. Coconut sugar has a lower glycemic index (GI) compared to cane sugar. Coconut sugar was reported to have a GI value of 35 while the sugar from palm sugar and sugarcane has GI values of 42 and 58-82, respectively. Coconut sugar (in 100 g) contains moisture 0.06%, protein 432 mg, minerals 5.24 mg, carbohydrate 11.0 mg, calcium 18.9 mg, phosphorous 1.9 mg, iron 5.2 mg (Ghosh et al., 2018).

Based on the advantages of coconut sugar and the potential of available raw materials, coconut sugar is one of the alternative coconut products that has the potential to be developed. This paper will describe the potential of coconut as a raw material for coconut sugar and its development opportunities which are expected to provide information for coconut farmers, observers, and business actors in Indonesia.

POTENTIAL OF NEERA

Coconut sap (neera) is obtained by tapping bunches of flowers that have not been opened from varieties of coconut type, namely Tall and Dwarf coconut (Matana et al., 2022). The physical and chemical composition of freshly collected coconut blossom "sap" or "nectar" indicates that it is naturally rich in potassium, magnesium, zinc, and iron and is a natural source of 12 of the essential vitamin B complex and vitamin C and has a neutral pH (Gosh et al., 2018). Neera yields also vary with variety. Tall coconut yields more neera than Dwarf coconut, but Tall coconut varieties have a high stem and it is extensively grown by farmers. Neera is the sweet honey-colored, unfermented sap tapped from the immature inflorescence of coconut. Fresh neera is rich in carbohydrates, vitamins, volatile acids, phenolic compounds, and minerals (micro and macro minerals). It contains 16 kinds of amino acids and is also a good source of natural sugar (Sharma and Meghwal, 2021). The proximate composition of neera is shown in Table 1. The most significant characteristic of neera is its low Glycemic Index (GI) 35, an indicator of the extent of sugar absorbed into the blood. Foods with GI less than 55 are classified as low GI foods. Neera and its value-added products are the latest additions that hold the potential to revitalize the prospects of coconut farmers and source of employment opportunities (Gosh et al., 2018). Neera is a raw material for the industry of coconut sugar, both brown sugar and granulated sugar.

Table 1. Proximate composition of neera

Component	Range
Total solids (g/100 ml)	15.2-19.7
pH	7.0-7.4
Total sugars (g/100 ml)	10.8-14.50
Total reducing sugar (g/100 ml)	0.439-0.647
Ash (g/100 ml)	0.11-0.41
Ascorbic acid (g/100 ml)	0.016-0.030
Carbohydrate (g/100 g)	15.000
Protein (g/100 g)	0.23-0.32
Phenolics (mg)	4.80-5.40
Antioxidant activity (mMTE)	0.299-0.355

Source: Sharma and Meghwal (2021)

Currently, the problem faced in sugar production is limited or lack of labor for tapping neera. This is due to many people falling from trees when tapping coconut sap, because of the height of the tapped tree. This condition did not follow with the addition of labors. Young labors are not interested in neera tapping. Dwarf coconut varieties can be selected considering its short advantage. Dwarf coconut varieties have a short stem, only 10 meters when 30 years old, slower to grow compared to Tall varieties (Novarianto et al., 1997). Tapping sap from Dwarf coconut varieties can be done by women because it does not need to be climbed and can be done using stairs.

Indonesian Palmae Crops Research Institute (IPCRI) has a collection of Dwarf coconut varieties that have potential as a source of neera. Four superior Dwarf coconuts were released, namely Bali Yellow Dwarf (BYD), Nias Yellow Dwarf (NYD), Salak Green Dwarf (SGD), and Raja Dwarf (RBD) and three other coconut accessions (Tebing Tinggi Dwarf (TTD), Jombang Green Dwarf (JGD) and Orange Sagerat Dwarf (OSD) were evaluated for neera yield. The evaluation was carried out on plants collected at the Mapanget Experimental Garden and the Paniki Experimental Garden, North Sulawesi. Production from four superior Dwarf coconut varieties is shown in Table 2 and neera production from seven Dwarf coconut varieties is shown in Table 3.

Table 2. Production Potential of 4 Varieties of Genjah Unggul coconut

Description	NYD	BYD	RBD	SGD
Harvest age (years)	3	3	3	2
Fruit/ha/year	18,700	17,500	18,700	20,500
Copra/ha/year (ton)	2.5	2.5	2.5	2.8

Source: Anonymous (2014)

Table 3. Neera production of Dwarf coconut varieties

Dwarf Coconuts	Average neera production (ml/days)	Tapping duration (days)
TTD	2172,38	19,00
BYD	1689,34	17,33
NYD	1333,52	17,00
JGD	1261,48	12,50
OSD	954,16	13,00
SGD	855,78	14,00
RBD	829,78	15,00

Source: Mashud and Matana (2014)

Table 1 showed Salak Green Dwarf (SGD) has the advantage of fruit production compared to other Dwarf coconuts (NYD, BYD, and RBD), namely faster fruiting and a higher number of fruits. The fruit production does not correlate with neera production, this is proven by data in Table 2. Salak Green Dwarf (SGD) neera yield was almost the same as RBD, but the neera yield from these two Dwarf coconuts are a little more than BYD and NYD. The Tebing Tinggi Dwarf (TTD) yielded higher neera than the others. Based on these data, TTD, BYD and NYD could be recommended to develop coconut cultivation with the desired product coconut sugar. Salak Green Dwarf (SGD) is more suitable to be used for the development of granulated coconut, while BYD can be used both as granulated coconut and as a source of sap.

TAPPING AND COCONUT NEERA PROCESSING

Selection of palm, inflorescence, and efficiency of the tappers are the main important factors for better neera production. Hebbar et al. (2015) reported that coconut trees can be tapped at an early age as soon as they attain yield stability. Generally, healthy trees which bear more fruits tend to yield more sap.

Tapping is done in unopened inflorescence. The immature inflorescence that is about to burst is the ideal stage at which neera tapping is done (Ghosh et al., 2018).

Tapping Neera

A healthy garden with an adequate irrigation facility is chosen for tapping and the unopened coconut flowers must be free from pest attacks and diseases. The immature inflorescence that is about to burst is the ideal stage at which neera tapping is done. The development of female flowers inside the Spathe (about 60 cm) causes swelling at the base, which is an indication of an appropriate stage for tapping. The inflorescence selected for tapping is first tied around with a strong coir or plastic rope to prevent it from bursting. The spadix is then trained by a gentle uniform beating using a mallet and hand massaged (using the palms) all over twice a day in the morning and the evening for a week. After 4-5 days of stroking 7-10 cm tip is sliced off and in a week's time sap starts oozing out from the cut end. It takes 12-15 days for the sap to exude from the inflorescence tip. When the sap starts flowing, a container is placed under the dripping spadix. Tapping is done usually for six months only. A coconut palm can yield an average of 1.5-3 liters of neera per day, which may go even up to 4.5 liters per day based on the health of the palm and management of the garden (Muralidharan and Deepthi, 2013; Ramaswamy and Ramaswamy, 2017).

A farmer extracting neera from the pots, by Prabalika M. Borah (Source: The Hindu)

Jnanadevan (2013) highlighted that the growing conditions of the palm and its vigor plays an important role in neera production. Continuous tapping of coconut inflorescence does not affect the palm. Neera yields differ with palm variety, palm vigor, and season (Hebbar et al., 2015). The sap flow is closely associated with the leaves, and water content, suggesting an influence on sap flow by the internal water condition of the trees. The neera yield decreases strongly after the relative water content of the leaves decline. Low rainfall, particularly when the soil water reserves were low, and palms suffered from water stress affect neera yield. As the flow of neera decreases with increasing transpiration, high temperature and low relative humidity have similar effects. Neera yields were not significantly correlated with photosynthetically active radiation. Sap production is relatively high at night, due to reduced transpiration and increased sap pressure. Tall coconuts yield much more neera than dwarf palms. A good tall palm may yield about two liters per day and hybrids even more. Sap yield is influenced by both genotype and environment; it varies from day to day, season to season, spadix to spadix and tree to tree. The sap yield is also influenced by the skill of the tappers (Gosh et al., 2018). Gosh et al. (2018) reported that the production of neera mostly depends upon the following points like the efficiency of the tapper, stage of selection of inflorescence, type of massage, season, and variety etc.

Collecting coconut sap to make sugar which is used in sweets and desserts (Source: Alamy Stock Photo)

The flow of neera dwindles when the spadix is damaged by rats, insects, caterpillars/worms etc., and when the spathe covering the inflorescence is removed partially or totally after it has cracked open (Gosh et al., 2018). Besides that, the coconut sap ferments very quickly, to prevent sap fermentation after slicing, the fresh cut may be brushed with the anti-ferment solution, or some anti-ferment solution may be put in the container. The most effective harvesting cycle is twice a day. More harvests are not profitable with the additional work and fewer harvesters involve the risk of breaking the spathe under the excessive weight of the container, and they may also provoke other problems such as sap fermentation and drying of cuts.

Neera Preservative

Neera coconut is the sweet honey-colored, unfermented sap tapped from the immature inflorescence of coconut. The fresh coconut sap from the cut inflorescence has 13.51-14.77% of sucrose and pH 6.17-6.41 (Mashud dan Matana, 2014). Since neera is a rich source of nutrients it is highly prone to fermentation both by enzymatic and microbial action. Fresh sap when left exposed to the atmosphere undergoes initial lactic acid fermentation, middle alcoholic fermentation, and final acetic fermentation consequent on the action of microorganisms. The sap gets fermented, it becomes acidic, the pH reduces, and neera becomes cloudy like milk and foamy (Karouw dan Lay, 2006). Parameters can be measured directly containing sucrose with a hand refractometer and pH using a pH-meter or indicator pH universal. Neera without preservation has a sucrose level and pH tends to decrease with longer storage time. Changes in the pH and the sucrose level occur due to microbial activity in the sap. The main microbe in sap is yeast which is dominated by Saccharomyces cerevisiae (Borse et al., 2007).

To prevent sap damage, preservatives are added to the sap container before it is used to tap the sap. There are two types of sap preservatives that are commonly used by farmers, namely natural and synthetic sap preservatives (Karseno and Yanto, 2019). The synthetic sap preservatives are namely sodium benzoate, sodium metabisulfite, and calcium hydroxide (whiting). While natural preservatives are namely mangosteen rind, coconut fiber (Rindengan et al., 2002), same fruit, mara leaf, and ginggihiang leaf (Barri et al., 2015).

Neera is collected under very hygienic conditions to prevent the entry of any foreign particles (Sharma and Meghwal, 2021). Neera is collected into a sterilized container and the preservative is added into the container to prevent fermentation of fresh sap. Neera has innate auto-fermentation properties due to the presence of sugar, microorganisms like yeast, bacteria, microbial, and enzymatic odorants as the major contributors to the toddy aroma (Sharma and Meghwal, 2021). The selected spadix for tapping is being sprayed or washed with distilled water from the base to the top for cleaning and by tissue paper-washed surface is being wiped to make it dry. The tip of the spadix is being sliced off with the help of a sterile knife (Sharma and Meghwal, 2021). Sterilization of the knife with boiling water is done before the tapping process. Combination treatment, namely hygienic conditions (sterilized container and knife) and the addition of whiting can maintain the quality of palm sap up to 8 hours after tapping, namely pH 5.7-6.8 and sucrose content of 13.1-14.9% (Lay et al., 2004). In the palm sap that was not treated with preservatives after 8 hours, the pH becames 3.88 and 11.0% sucrose content, compared to the initial pH and sucrosecontent of 5.47 and 12.0%, respectively (Lay et al., 2004).

Degradation of Neera

Fresh sap is a rich source of asparagine and glutamine. It is a very rich source of amino acids. Amino acids are the building block of protein. It contains in total of 17 amino acids which helps in maintaining proper acid/alkaline balance (neutral pH) (Sharma and Meghwal, 2021). Due to the presence of yeast in neera autolysis of yeast occurs. This leads to a reduction in amino acids of neera and it is observed on the first day of extraction due to the production of microorganisms and its innate auto-fermentation property, and gradually as the day passes concentration of amino acids is further reduced due to the degradation of protein content of neera (Sharma and Meghwal, 2021).

Fresh sap contains 15% sucrose, due to fermentation sucrose is converted into ethanol. At the time of natural fermentation physical and chemical changes occur. Gradually specific gravity drops down. Along with specific gravity pH also decreases parallelly. These changes occur due to the dominant lactic acid fermentation phase which favors or provides a more suitable pH for increased invertase activity. The reduction of the pH by the lactic acid production probably enhanced the growth and invertase activity of the yeasts, which enhance ethanol production. For acetic acid bacteria production, ethanol produced by the yeasts acts as the raw material (Atputharajah et al., 1986).

So many microorganisms especially a large number of aerobic mesophils feed on palm sap due to the sugar content of fresh sap. At the time of tapping, fermentation, and storage of palm sap, lactic acid bacteria, yeasts, and acetic acid bacteria are widely found in sap (Nwachukwu et al., 2006; Ogbulie et al., 2007). Amoa-Awua et al. (2007) observed that

immediately after tapping the multiplication of yeasts dominated by *S. Cerevisiae*. Quality change in fresh neera occurs due to the presence of different types of microorganisms at the time of natural fermentation. *L. mesenteriodes* acidified the sap after the first day of tapping and on the third day, the alcoholic concentration of fresh sap increased due to an increment in the population of *Acetobacter* and *Gluconobacter* species of acetic acid bacteria. The growth of microorganisms varies as influenced by palm sap, storage, season, and geographical location (Sharma and Meghwal, 2021).

Freshly harvested neera contains around 4.8±0.9% reducing sugar. Predominantly most of the reducing sugars are produced from hydrolysis of sucrose. Glucose and fructose are formed due to the decomposition of sucrose by the action of the invertase enzyme. In the fermentation of palm sap, Lactic acid bacteria (LAB) and yeasts play a major role. Fresh sap contains 15% sucrose, due to fermentation sucrose gets converted into ethanol. At the time of natural fermentation physical and chemical changes occur. Gradually specific gravity drops down. Along with specific gravity pH also

decreases parallelly. These changes occur due to the dominant lactic acid fermentation phase which favors a production of more suitable pH for increased invertase activity. The invertase enzyme plays a very crucial role in the breakdown of sugars into its monosaccharide form (Sharma and Meghwal, 2021). The reduction of the pH by lactic acid production probably enhanced the growth and invertase activity of the yeasts, which enhance ethanol production. For acetic acid bacteria production, ethanol produced by the yeasts act as the raw material (Atputharajah et al., 1986; Sharma and Meghwal, 2021).

Processing of Neera for Coconut Sugar Production

Coconut sugar is also known as coconut palm sugar, coco sugar, or coco sap sugar (Hebbar et al., 2013). Coconut sugar is obtained by boiling freshly harvested neera in a moderate heat to evaporate the water at 115 degrees Celsius. Coconut sugar is one of the best natural sweeteners. It is completely natural coming directly from the inflorescence of coconut and there are no added chemicals. Coconut sugar is truly a healthier substitute for artificial sweeteners which are toxic to one's health as well as a better alternative to other natural sugarcane-based sweeteners such as refined white sugar, brown sugar, molasses, and others (Hebbar et al., 2013).

Coconut sugar has high mineral content. It is a rich source of potassium, magnesium, zinc, and iron. Coconut sugar also contains all essential amino acids required for protein synthesis and is rich in B complex vitamins like B1, B2, B3, and B6. When compared to brown sugar (prepared from sugar cane molasses), coconut sugar has twice the iron, four times the magnesium, and over 10 times the amount of zinc (Hebbar et al., 2013; 2020; 2022).

Fresh neera is processed to produce palm sugar like molded coconut sugar and granular coconut sugar. The processing of molded coconut sugar is almost the same as crystal coconut sugar, but the difference is the final stage of processing of thick sap. The molded coconut sugar results from sticky brown sugar poured down into the mold, while the granular coconut sugar result from the continuous stirring of thick sap. The continuous stirring to avoid charring forms of sugar granules and cool at room temperature to get the sugar (14 to 15% recoveries). While cooling, it is stirred continuously to break the lumps. The sugar obtained is sieved to gel uniform particle size and to produce a quality product (Gosh et al., 2018).

The process of sugar is neera as the main material must have an acidity (pH) ≥6.0. The collected neera was then filtered by sheet cloth and poured into a large pan. Afterward, neera was cooked for 4-5 hours at a temperature of about 110-120°C to a high concentration of brown sugar that was indicated by a very viscous appearance. As boiling proceeds, the froth and foam coming up to the surface is removed using a perforated ladle. The juice is stirred at intervals to facilitate mixing and rapid evaporation. When the juice thickens, the fire is judiciously controlled to prevent it from caramelizing. Correct strike temperature is judged by patting a small quality of the thickened mass in water and rolling it into a ball shape. If the ball forms into a hard one, the strike is over, and the mass is poured into molds. Afterward, the hot sticky brown sugar was poured down into a mold made of bamboo, wood, or coconut shell. To facilitate easy removal of the blocks from the molds, the molds are either moistened with water or besmeared with fresh sweet oil before putting the thick mass into them

(Swamy, 2013). The sugar will cool down and harden after 1 hour and be ready for packaging. Traditional sugar processing produces sugar with brown color because of browning and Maillard reaction. High temperature and long heat treatment on the open pan evaporator favored the browning and Maillard reaction.

The initial process of granular coconut sugar is practically the same as that of molded coconut sugar. In this case also, the sap is collected, filtered, and boiled. The viscous and thick hot sap is cooled to get granular sugar. Further concentration with continuous stirring to avoid charring forms of sugar granules and cool at room temperature for 10-15 minutes to get sugar (14 to 15% recoveries). At this stage, the liquid will change into crystal form, and it is immediately cooled. While cooling, it is stirred continuously to break the lumps. The granular coconut sugar obtained is sieved with 20 wire-mesh to get uniform particle size and packed.

FUNCTIONAL PROPERTIES OF NEERA

Neera is rich in vitamin A, B complexes, and vitamin C. These vitamins have antioxidant properties and neutral pH, which makes neera a natural detoxifying drink. Neera has a cooling effect that cools the body. Antioxidants help in scavenging free radicals, and delay aging and other diseases also. Free radicals are one of the reasons for cancer. Antioxidants delays aging, keeping skin healthy for a longer time. Neera has a very low glycemic index (35), and it's diabetic-friendly. Neera is low in calories and plenty of minerals are present which is a good option for people looking for weight loss. Neera by-products is also a healthy option for diabetic patients. Neera also contains a high amount of potassium which helps in the reduction of blood pressure and high in calcium, which helps in mineralization and also prevents osteoporosis by preventing loss of bone. Help in improving bone density. Vitamin C, vitamin K, and iron on neera help in preventing anemia. Vitamin C helps in iron absorption in the body. Help in increasing hemoglobin level, which in turn helps in the binding of oxygen and other essential nutrients in red blood cells (RBC) (Sharma and Meghwal, 2021).

DEVELOPMENT OPPORTUNITIES

Frequent fluctuation and fall in the price of coconut and the severity of many pests and diseases results in coconut farming being a non-profitable enterprise. The need to revive the coconut sector has therefore become imperative and ways and means for a revival is on the agenda of all stakeholders and policymakers. Developing and popularizing more value-added products from coconut has been brought out as a viable strategy for regaining the lost glory of coconut. Neera is the latest addition in the array of value-added products which holds the potential to revitalize the prospects of coconut farmers. Neera is a potential product with many health-benefiting properties. Coconut cultivating countries all over the world are making use of this potential to make various value-added products from neera. Some rationale needed to develop neera as a potential value-added product namely to prove that neera can also earn better returns as compared to nuts, to create employment opportunities for the rural youths, to make coconut cultivation profitable, to provide natural healthy sugar to all including diabetic patients, to aware the consumers about the positive effects of neera as an ideal sweetener (Gosh et al., 2018).

The production of coconut sugar from unfermented sap is profitable in farm activity and is encouraged in many coconut-growing countries for local consumption as well as for export marketing (Thampan, 2013). In Indonesia, the farmers are encouraged to leave up to 30% of the palms in plantations for sugar production. Tapping and sugar production also augment on-farm employment. Currently, coconut sugar entrepreneurs are carried out by small and medium-scale industries (IKM) which are managed by the community, but the concentration is more centered on the island of Java. The coconut sugar process is still with traditionally produced, most of its production on a household scale and does not use modern technology. The product has a low quality because synthetic preservatives used to tap the sap. These can not be sold in the global market like Europe and America as they require to have organic certification.

The production of Sweet Tree organic coconut sugar has the single highest potential for lifting these farmers into a better life while creating a net benefit to their surrounding environment and consumers perceive naturalness as a beneficial characteristic of food items. Based on these facts, the efforts that can be made are:

1. Preparing Human Resources (HR) who have competence through production technology training to improve the process, production techniques training for product diversification (molded coconut sugar, crystal coconut sugar, crystal coconut sugar+ginger) and training on good manufacturing processing (GMP).
2. Applying appropriate technology to support productivity such as providing machine assistance and processing equipment, providing subsidies for the purchase of machines/ equipment at a price (machine restructuring/ equipment) and assistance and training to operate machinery/equipment (Junaidi, 2015).

The sugar industry development model that has been successfully carried out in several coconut sugar centers such as in Banyumas, Central Java Province, Kulon Progo Regency, Jogjakarta Province, and Lebak Regency, Banten Province has the potential to be applied or duplicated in coconut producing areas (Muhartoyo and Nair, 2016; Lay and Karouw, 2006).

The processing units and forum for farmer groups are required for effective control of development products of coconut sugar. In the sugar processing industry in Hariang, Banten, Banyumas and Kulon Progo, granular coconut sugar processing is carried out on the farmer groups scale. The granular coconut sugar processing was carried out in two stages, namely processing stage (tapping, collecting, and boiling sap into rough granular coconut sugar) carried out by members of farmer groups/cooperative members and the second stage includes drying, sifting and packaging by cooperatives (Lay and Karouw, 2006). Processing by cooperatives can produce coconut sugar with a more uniform quality, especially water content and grain size. The cooperative then plays a role in product marketing.

The positive impacts of processing and marketing coconut sugar products by involving cooperatives as managers are: 1) the burden on farmers in processing is reduced because there is no need to carry out the drying, sieving and packing processes as well as marketing, 2) farmers as members of the cooperative receive additional income from the sale of granular coconut sugar and 3) farmers receive

the remaining operating income from the profits received by the cooperative (Lay and Karouw, 2006).

Coconut sugar has led to the establishment of cooperative partnerships between village-level producers and local government units to enhance and support the reinvigoration of the coconut industry in the country (Deepthi, 2013). Cooperative partnership working through farmer communities together with technology application and adoption by local communities, was a powerful factor in developing the farmer groups' self-confidence to deal with pressing issues in production, processing, and marketing.

Coconut sugar production now has a niche market and presently is in high demand locally and globally as more and more of its health benefits are discovered by the scientific community. In the market, coconut sugar is available in 2 forms: molded and granular coconut sugar. The product has increased demand in the domestic and international markets. It is a good substitute for commercial sweeteners available on the market. With healthy nutrient-rich products like Neera and palm sugar, developing and establishing a market space, both in the domestic and export market offers immense potential. The global demand for low-calorie reduced sugar and sugar-free products is increasing day by day with the increasing health

awareness in the food market. Promotion of neera and its downstream product like coconut sugar as nutritious health has been identified as an important marketing strategy for ensuring remunerative prices to coconut farmers (Gosh et al., 2018).

Coconut rejuvenation using dwarf coconut varieties is one solution that can be taken, because its flowering is faster, the stem is shorter and slower to grow compared to Tall varieties, so they are easy to tap. The application of appropriate tapping, preservation techniques and hygienic processing are important things that must be considered to produce quality coconut sugar. The small processing industry model that has been successfully carried out in several coconut sugar center areas can be a pilot model to be developed in coconut-producing areas in Indonesia.

CONCLUSION

Sugar is one commodity that is quite strategic and plays an important role in the agricultural sector for the national economy. It is a very important product since it is used both in the daily needs of the household scale and for industrial needs. Neera is an alternative in the array of value-added products besides nuts which holds the potential to revitalize the prospects of coconut farmers. Neera is the raw material for many value-added products such as molded sugar, granular coconut sugar and liquid sugar. Coconut sugar has the potential as an alternative sugar resource instead of sugarcane. Coconut sugar obtained from fresh neera and natural sap preservatives are more recommended to use by farmers because consumers perceive naturalness as a beneficial characteristic of food items. The dwarf coconut varieties are recommended for sources of neera, because its flowering is faster, and the stem is shorter and slower to grow compared to Tall varieties. The small industry model of coconut sugar processing that has been successfully carried out in several coconut sugar center areas such as in Banyumas Regency, Central Java, Kulon Progo Regency, Jogjakarta, and Lebak Regency, Banten can be a pilot model to be developed in coconut producing areas in Indonesia.

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REFERENCES

Anonymous. (2014). *Kelapa Genjah Unggul*. Poster, Indonesian Palm Crops Research Institute.

Atputharajah, J. D., Widanapathirana, S., & Samarajeewa, U. (1986). Microbiology and biochemistry of natural fermentation of coconut palm sap. *Food Microbiology, 3*(4), 273-280.

Barri, N. L., Lay, A., Meldy, L. A. H., Arie, A. L., Jeanette, K., Yulianus, R. M., & Engelbert, M. (2015). Petunjuk Teknis Budi Daya Tanaman Kelapa Dalam. *Manado: Indonesian Palm Crops Research Institute*.

Borse, B. B., Rao, L. J. M., Ramalakshmi, K., & Raghavan, B. (2007). Chemical composition of volatiles from coconut sap (neera) and effect of processing. *Food chemistry, 101*(3), 877-880.

Ghosh, D. K., Bandyopadhyay, A., Das, S., Hebbar, K. B., & Biswas, B. (2018). Coconut sap (Neera)-untapped opportunity of spinoff gains in West Bengal, India. *International Journal of Current Microbiology and Applied Sciences, 7*(9), 1883-1897.

Hebbar, K. B., Mathew, A. C., Arivalagan, M., Samsudeen, K., & Thomas, G. V. (2013). Value added products from Neera. *Indian Coconut Journal, 56*(4), 28-33.

Jnanadevan, R. (2014). Neera tapping for making coconut the most profitable horticultural crop for future. *Indian Coconut Journal, 57*(8), 6-8.

Junaidi. (2015). Kebijakan pengembangan industri kecil menengah (IKM) gula kelapa dan aren di Indonesia. In *National Workshop on Coconut and Palm Sugar Development, Purwokerto 17-18 December 2015*.

Karouw, S., & Lay, A. (2006). Nira aren dan teknik pengendalian produk olahan. *Buletin Palma* (31), 116-125.

Yanto, T. (2019, March). The type and distribution of sap preservatives used by farmers in Kebasen District, Banyumas Regency, Indonesia. In *IOP Conference Series: Earth and Environmental Science* (Vol. 250, No. 1, p. 012031). IOP Publishing.

Lay, A., Barlina, R., Hutapea, R. T. P., Karouw, S., & Pasang, P. M. (2004). Teknik pengawetan nira aren untuk pengolahan gula semut skala industri pedesaan. *Annual Report: Indonesian Palm Crops Research Institute, Manado*.

Lay, A., & Karouw, S. (2006). Agroindustry of Granular Brown Sugar by Hariang Model in Banten Province. *Buletin Palma, 127*, 126-136.

Lay, A., & Heliyanto, B. (2011). Prospek agro-industri aren (Arenga pinnata). *Jurnal Perspektif, 10*(1), 1-10.

Matana, Y. R., Rindengan, B., Novarianto, H., Tulalo, M., Manaroinsong, E., & Kumaunang, J. (2022). The effect of fertilizer to production of neera dwarf coconut. In *IOP Conference Series: Earth and Environmental Science* (Vol. 974, No. 1, p. 012093). IOP Publishing.

Muhartoyo, & Nair, D. (2016). Banyumas Regency-the biggest coconut sugar production in Indonesia. *Cocoinfo International, 23*(1), 9-11.

Muralidharan, K., & Deepthi, N. S. (2013). Coconut Neera, The hidden uexplored treasure. *Indian Coconut Journal 7*(4), 4.

Mashud, N., & Matana, Y. (2014). Produktivitas nira beberapa aksesi kelapa Genjah. *Buletin Palma 15*(2), 110-114.

Novarianto, H., Miftahorrachman, & Kumaunang, J. (1997). Peluang bisnis pengembangan benih unggul kelapa. In *Proceeding of National Coconut Business Meeting, Manado 6-8 January* 1997, pp 86-108.

Ramaswamy, P., & Ramaswamy, L. (2017). Organoleptic acceptability, selected nutrient content and physicochemical characteristics of coconut neera on storage. *Journal of Food Science and Engineering, 7*(4), 192-201.

Swamy, G. S. (2013). Coconut neera production and processing in Karnataka. *Indian Coconut Journal*, 31-33.

Sharma, A., & Meghwal, M. (2021). An update on uses, benefits, and potential application of neera. *Journal of Nutrition and Food Processing, 4*(8), 1-18.

Thampan, P. K. (2013). Production of neera and coconut sugar deserves encouragement. *Indian Coconut Journal*, 11-14.

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Emerging Invasive Whiteflies (Hemiptera: Aleyrodidae) on Coconut and Their Management Strategies in India

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Coconut, *Cocos nucifera* L. (Arecaceae) is an important plantation crop grown mainly in the tropical and subtropical regions of the world. Millions of people depend on this directly or indirectly for their livelihood. India is one of the leaders in coconut farming and stands as the third largest coconut-producing country in the world. Coconut is grown in a large area of more than 21 lakh hectares in more than 15 states and union territories in India with an annual production of 21,500 million tonnes nuts. Among the coconut-producing states, Tamil Nadu, Kerala, Karnataka and Andhra Pradesh are the leading coconut-producing states which account for more than 90% of the total coconut produced in the country. Productivity increased to 11516 fruits/ hectare from 2017 to 2018 compared to 10122 fruits in 2013 and 2014. India has been exporting coconut oil to Malaysia, Indonesia and Sri Lanka and dry coconut in large quantities to the U.S. and European countries.

The coconut palm is attacked by several insect pests all around the year and more than 900 species of pests are associated with cultivated and wild coconut. Coconut Eriophid mite, *Aceria guerreronis* (Eriophyidae: Acari), rhinoceros beetle, *Oryctes rhinoceros* (Coleoptera: Scarabaieidae), red palm weevil, *Rhynchophorus ferrugineus* (Coleoptera: Curculionidae), black-headed caterpillar, *Opisina arenosella* (Lepidoptera: Oecophoridae) and white-grub, *Leucopholis coneophora* (Coleoptera: Scarabaieidae) are considered as the major pests of coconut. While the two whiteflies *viz.*, areca nut whitefly, *Aleurocanthus arecae* (Hemiptera: Aleyrodidae) and spiraling whitefly, *Aleurodicus dispersus* recorded on coconut in India are considered as minor pests (Josephrajkumar et al., 2012).

Biological invasions are of great concern as they have a pronounced impact on the native ecosystem, biodiversity and the economy. The enormous increase in the volume, diversity and swiftness of movement of plant products throughout the world has led to a proliferation and dissemination of invasive species, particularly ones closely associated with plants, such as scales and whiteflies (Wosula et al., 2018). Most alien species of whiteflies are accidentally introduced with their host plant and regularly dispersed among countries as a consequence of plant trade. The smaller whiteflies with their cryptic nature and immature stages are attached to the host plant. Due to these characteristics, they are one of the most commonly transported and most successful arthropod groups invading new geographical areas. Moreover, exotic whitefly pests can multiply in large proportions in a short time, exhibit high phenotypic plasticity, and have a strong potential to compete with native species and cause damage to economically important crop plants.

In India, 469 whitefly species belonging to 71 genera are known to feed on many agricultural, horticultural and forestry crop plants which include eight invasive species. The rugose spiraling whitefly (RSW), *Aleurodicus rugioperculatus* in 2016; Bondar's nesting whitefly (BNW), in 2018; nesting whitefly (NW), *P. minei* in 2018 and palm infesting whitefly, *Aleurotrachelus atratus* in 2019 invaded coconut agroecosystem.

Nymphs and adults of these invasive species feed aggressively on leaf sap and excrete copious amounts of sticky honeydew on which black sooty mold develops, while reducing respiration and photosynthesis leading to drying, drooping, premature leaf drop and fruit set may be reduced. These invasive have the potential to spread and reproduce throughout the year with multiple and overlapping generations which resulted in an outbreak situation in many locations in India. Hybrid and dwarf coconut varieties *viz.*, Chowghat orange dwarf, Malayan orange dwarf and Ganga bondam are most severely affected. These invasive species have now become major pests of coconut, warranting control measures to avoid crop losses. The introduction of invasive species, identification, distribution, symptoms of damage, associated natural enemies and management strategies with special reference to biological control are briefed in details.

MATERIALS OF RESEARCH

Systematic and continuous surveys were conducted in coconut-growing states of India from February 2015 to September 2022 to investigate the spatial range, patterns of co-occurrence, intensity of infestation of invasive whiteflies and their natural enemies on coconut. The frequency of the surveys at each site varied from 01- 26 trips across the study areas.

Spatial range

To study the distribution of these invasive at least 05-10 locations in each district and 5-12 districts in each state were chosen for sampling. Pest occurrence on coconut was recorded in each location and their damage was categorized into different grades by visual observation on all the active/live life stages.

Further, infested leaves with puparium were collected in paper envelopes as described by Dubey and David (2012) and adult whiteflies in 90% ethanol along with relevant collection data for further identification and documentation. Whitefly species confirmation based on morphological characteristics was achieved by preparing permanent mounts of the puparium.

The generic classification was done following the key of Sundararaj et al. (2020) and species confirmation by matching with the original and additional descriptions of respective species (Russell, 1965; Peracchi, 1971; Martin, 1978; Iaccarino, 1990; Martin, 2004; & Wosula et al., 2018).

Molecular characterization of the partial mitochondrial cytochrome c oxidase I (COI) (658bp) gene was done using adult whiteflies after they were morphologically identified. Genomic DNA extraction from individual adult whiteflies using DNAase Qiagen kit method based on the manufacturer's protocol. Polymerase chain reaction amplification of the 5′ terminus of the COI gene was carried out following the standard protocol which involves the cocktail of a reaction, using universal primers LCO 1490 5′-GGTCAACAAATCATAAAGATATTGG-3′ and HCO 2198 5′-TAAACTTCAGGGTGACCAAAAAATCA-3′ (Folmer et al., 1994) manufactured by Bioserves, Hyderabad. The quality of the amplicons was checked using agarose gel electrophoresis and the amplified products were sequenced by Chromous Biotech, Bangalore.

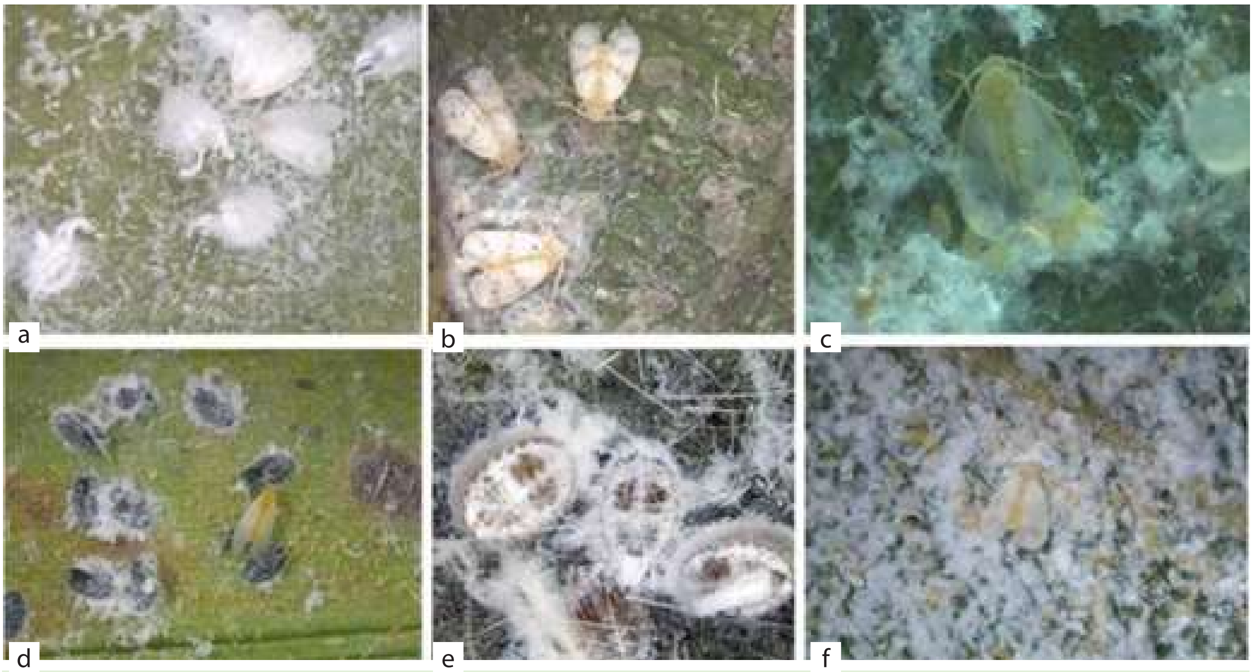

Figure 1. Life stages of invasive whiteflies attacking coconut in India: (a) Spiraling whitefly, (b) Bondars nesting whitefly, (c) Rugose spiraling whitefly, (d) Palm infesting whitefly, (e) RSW nymphs, (f) Nesting whitefly

Patterns of co-occurrence

To study the coexistence of these invasive species with other insect species in coconut, observations were made on the insect communities and dominant species at each location wherever coexistence was noticed. Spatial and temporal variations of co-occurring species were also recorded during the surveys to study the pattern of coexistence. Species dominance was calculated based on the presence and number of individual of life stages of different insects in each colony.

Natural enemies

Part of the collection of host plant leaves/parts infested with immature stages and puparium were placed in a rearing jar (21x10 cm) for the emergence of parasitoids. The emerging parasitoids were collected using an aspirator and preserved in vials containing 70% ethanol for further identification. Identification of natural enemies was confirmed by morphological means. Assessment of parasitism (%) was determined based on the number of puparium parasitized versus un-parasitized pupae on the host leaves.

Nature and intensity of damage

The intensity of damage was assessed on randomly selected five leaf/plant and five locations at each study area on economically important host plants. An assessment of their population level was carried out using the following qualitative scale i.e Low=(less than 10 live egg spirals or adults/ leaflet), medium=(11-20 live egg spirals or adults/ leaflet) and severe=(more than 20 live egg spirals or adults/leaflet).

RESULTS AND DISCUSSION

Species confirmation

The identity of the whitefly species was confirmed by the senior author based on the morphological characteristics of the puparia (4th instar nymph) and comparing them with the original and additional descriptions of respective species (Figure 1). Further, the partial mitochondrial cytochrome c oxidase I (COI) gene of 658bp size was amplified and sequenced. The sequences were submitted to GenBank under accession numbers MK472717, MF449463, MT422352, MK421974, MT422351, KY223606 and ON881119 for the following five invasive whiteflies and their parasitoids *viz.*, *Aleurodicus dispersus*, *Aleurodicus rugioperculatus*, *Paraleyrodes bondari*, *Paraleyrodes minei*, *Aleurotrachalus atratus*, *Encarsia guadeloupae* and *E. cubensis*, respectively. The COI sequences showed a 98-100% match with species reported elsewhere and submitted in National Center for Biotechnology Information database.

Distribution

I. ***Aleurodicus dispersus:*** This was the first invasive whitefly recorded in India. It was first reported in the Western Ghats of south India and is now distributed throughout the country including the Andaman, Nicobar and Lakshadweep islands on several host plants including coconut.

II. ***Aleurodicus rugioperculatus*:** Incidence of RSW was recorded on coconut and many other crop plants in 2016 at Coimbatore, Tamil Nadu (Sundararaj and Selvaraj, 2017). Subsequently, it has spread to different districts of Karnataka, Kerala, Andhra Pradesh, Goa, Assam and West Bengal (Selvaraj et al., 2017). It was recently observed in Lakshadweep islands, coastal districts of Maharashtra, Gujarat, Telangana, Odisha, Chhattisgarh and a few districts of Meghalaya.

III. ***Paraleyrodes bondari***: It was first reported in India on coconut palms in Kerala in 2018 (Josephrajkumar et al., 2019), Karnataka and the Andaman and Nicobar Islands (Vidya et al., 2019). Recently, its occurrence was noticed in the Lakshadweep islands and different districts of Tamil Nadu, Andhra Pradesh, Assam, Odisha, Maharashtra and West Bengal.

IV. ***Paraleyrodes minei:*** In India, it was reported on coconut in Kerala in 2018 (Sujithra et al., 2019) and in the Andaman and Nicobar Islands (Dubey, 2019). Subsequently, this species rapidly spread to different districts of Karnataka and Tamil Nadu.

V. *Aleurotrachelus atratus*: This species was recorded in India on coconut and an ornamental palm in the Mandya district of Karnataka in 2019 (Selvaraj et al., 2019), and subsequently spread to Tamil Nadu and Kerala.

The current rapid geographical expansion of these invasive species is likely due to favorable weather factors and the availability of host plants. Likewise, global climate change might have played a major role in the introduction and establishment of invasive species to new environments with a potentially devastating impact on coconut agroecosystems.

Nature and intensity of damage

Most of the nymphal and adult abound in the abaxial surface of leaflets causing direct damage by sucking the plant sap. Adults excrete prodigious quantities of honeydew, which in turn completely darkens the adaxial surface of the leaves and (Figure 2) also on the understory crops with the development of sooty mold. In heavily infested areas, the waxy flocculent material produced by nymphs and adults is a nuisance to human beings.

Figure 2. Rugose spiraling whitefly with severe sooty mold

Co-occurrence

Around four exotic whiteflies have been reported to attack coconut in India in rapid succession in addition to spiraling whitefly. All these whitefly species are highly polyphagous and have a host preference towards many economically important palm plants. It was observed that *Aleurodicus rugioperculatus* co-exist with *Aleurotrachalus atratus*, *P. bondari*, *A. dispersus* and *P. minei* on coconut (Figure 3).

Infestations of *A. atratus* and *A. rugioperculatus* along with *Aleurocanthus arecae* are native whitefly species that were commonly observed on coconut. The synchrony of coexistence and mutual survival of these competing insect species could be due to the marked time partitioning of the resource use among the species except that they are demographically nearly equivalent and need detailed study.

Such co-occurrence has been observed among these invasive species, in which one species occupies the breeding and feeding niche of another species under optimum weather parameters and attempts to displace one or more of its competitors gradually which leads to temporal variation. Further, this mutual survival of more than one species indicates

Figure 3. Co-existence of invasive whiteflies in coconut

deferring its existing pest management options in various crop plants.

Natural enemies of the invasive whiteflies

Two parasitoids, *Encarsia guadeloupae* and *E. dispersa* (Hymenoptera: Aphelinidae) colonized on *A. dispersus* and *A. rugioperculatus* (Mani, 2010; Selvaraj et al., 2016; & Selvaraj et al., 2017). *E. guadeloupae* was the dominant parasitoid which parasitized 62-95% and 56-82% of *A. dispersus* and *A. rugioperculatus*, respectively. *E. dispersa* parasitized 28-92% and 5-10% of *A. dispersus* and *A. rugioperculatus*, respectively. Natural parasitism of a parasitoid, *E. cubensis* on *A. atratus* ranged from 46-68% on coconut (Figure 4).

Predators such as *Apertochrysa* (*Pseudomallada*) *astur* (Neuroptera: Chrysopidae), *Jauravia pallidula*, *Cheilomenes sexmaculata* (Coleoptera: Coccinellidae) and *Cybocephalus indicus* (Coleoptera: Nitidulidae) were also observed feeding on these invasive whiteflies (Selvaraj et al., 2017). In addition, entomopathogenic fungi, *Isaria fumosorosea* (Hypocreales: Cordycipitaceae) (Figure 5) was found effective against all the life stages of *A. rugioperculatus* (Sumalatha et al., 2020) and nymphs and adults of BNW, NW and palm infesting whitefly (PIW). *Isaria fumosorosea* was highly pathogenic to the egg and early nymphal instar stage with a 91% mortality in these stages and up to 80% mortality in the late nymphal instar stages of RSW under laboratory conditions. The overall reduction in RSW population was 72.20- 75.83% recorded with *I. fumosorosea* (ICAR-NBAIR Pfu-5) under field conditions.

Augmentation strategies for parasitoids

Since natural enemies, particularly *E. guadeloupae* and *E. cubensis* were found to suppress the population of RSW and PIW effectively; farmers and other stakeholders were advised to redistribute/reintroduce the parasitoids whether absent or found in inadequate numbers by strategically placing the field-collected parasitized nymphs to infested vegetation (Figure 6). A plastic container (35 cm height x 25 cm width) with wire mesh (50-60 microns) is a strategy to advocate the redistribution of adult parasitoids and augment its population in the field.

Conservation strategies for parasitoids

Biological control is the implementation of farm practices that maintain and enhance the reproduction, survival, and efficacy of natural enemies of pests. One strategy to conserve endemic natural enemies is to enhance habitat diversity through the provision of semi-natural vegetation in coconut agroecosystems.

Figure 4. Natural enemies of the invasive whiteflies

During the initial stage of infestation, few farmers resorted to spraying chemical pesticides to control these invasive whitefly species. However, their efforts were in vain due to pest resurgence. Subsequently, growers advocated a pesticide holiday for the management of invasive whiteflies. In gardens where chemical pesticides were not applied, the population of the parasitoids multiplied rapidly and natural parasitism increased phenomenally thus preventing severe outbreaks. Therefore, frequent monitoring of the pest occurrence was done to conserve the natural enemies.

Banana and *Canna indica* (Figure 7) were found to be harboring the maximum population of *E. guadeloupae* in the field as well as in net-house conditions. The growers were advised to plant intercrops or border crops for conservation and augmentation. These banker plants support the natural enemies in their reproduction and therefore maintenance of their populations.

Isaria fumosorosea-a promising bioagent

Isaria fumosorosea (ICAR-NBAIR Pfu-5) was identified as a promising fungal entomopathogenic strain for the management of invasive whiteflies infesting coconut. This fungus was found to be very effective with longer shelf life, persistence, host-specific to the target insects and has self-multiplicative capacity under natural favorable conditions. Once applied, they can grow exponentially on the insect surface resulting in the death of target insects. Based on laboratory bioassays and multi-locational field evaluation, *I. fumosorosea* was found effective in killing all the life stages of the pests in Andhra Pradesh, Karnataka, Kerala and Tamil Nadu. The eggs and early nymphal instar mortality was up to 91% and the late nymphal instars and pupal mortality was up to 80%, respectively. Mass production technology for this fungus has been standardized using solid-state fermentation (broken rice grains)

Figure 5. Infection of Isaria fumosorosea on different stages of invasive whiteflies: (a-d) Rugose spiraling whitefly; (e) Palm infesting whitefly; (f) Nesting whiteflies

Figure 6. Redistribution techniques for parasitoids

and liquid-state fermentation technologies (Sabouraud dextrose yeast extract broth & Potato dextrose broth media).

The use of biological control was clearly evident in the pest-affected coconut agroecosystems six months after the innundative release of parasitoids. The released parasitoids successfully established and regulated the invasive pest population. The pest population was reduced (less than 10 live colony/leaflet) substantially. Further, the self-perpetuating parasitoids prevented the spread of infestation. The joint efforts of the various organizations weaned and prevented the farmers from using hazardous insecticides.

However, there is a dearth of information on studies conducted on the actual yield loss in terms of nut yield/palm. On the other hand, the chemical intervention cost i.e. a minimum of two sprays of chemical insecticide where compared with two releases of parasitoid and two sprays of *Isaria fumosorosea*. Economic analysis on the impact of biological control revealed about Rs 9500/ha crop protection cost and 900 ml of pesticides/ha being saved.

CONCLUSION

Invasive whiteflies pose a challenge to the Indian economy as biologists and the public widely

Figure 7. Various conservation strategies for parasitoids

increasingly recognize the damage caused by an invasive introduced species. Introduced species can achieve major pest status when they are accidentally introduced to new locations and are separated from their natural enemy complexes. Further, the invasive process from the initial introduction through establishment and spread under extreme climatic conditions and the ongoing dispersal of an exotic species is one of the most striking biological outcomes of global climatic changes.

Coconut is an important crop grown mainly in the tropical and subtropical regions of the world. Host preference of these invasive whiteflies towards coconut from the source country leads to a quicker establishment of these host plants in the newly introduced regions. Post-incursion management mostly through timely implementation of classical biocontrol programme using potential natural enemies by importation. Fortunately, most of such invasions, especially those of hemipteran species of the suborder Sternorrhyncha, which includes whiteflies, scale insects, aphids, psyllids and some smaller families are amenable for classical biological control.

An effective biological control programme has been implemented for *A. rugioperculatus* and *A. dispersus* by mitigating their adverse impacts on agriculture saving millions of rupees. Moreover, it is imperative that accurate and timely identification of these species for further studies on their bioecology, population dynamics on different environments and development of an integrated pest management can be carried out. At present, control strategies rely heavily on the augmentation and conservation of parasitoids, *Encarsia guadeloupae*, *E. cubensis*, foliar application of, *I. fumosorosea* and periodic release of predator, *Apertochrysa astur*. These biocontrol agents are more effective in suppressing the RSW when implemented in an integrative approach. These control strategies provide only short term control of pests and need repeated release and application to reduce the pest population. *I. fumosorosea* may be successfully integrated with the augmentation and conservation of *E. guadeloupae* to achieve long-term pest suppression of this notorious pest of coconut. *Isaria fumosorosea* is also considerably effective against other invasive whitefly species like nesting and palm-infesting whiteflies.

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REFERENCES

Dubey, A. K. (2019). Paraleyrodes minei Iaccarino (Hemiptera: Aleyrodidae)- a new invasive pest threat to Andaman and Nicobar Islands, India. *Phytoparasitica, 47*(5), 659–662.

Folmer, O., Black, M., Hoeh, W., Lutz, R., & Vrijenhoek, A. R. (1994). DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. *Molecular marine biology and biotechnology, 3*(5):294-299.

Josephrajkumar, A., Mohan, C., Babu, M., Krishna, A., Krishnakumar, V., Hegde, V., & Chowdappa, P. (2019). First record of the invasive Bondar's nesting whitefly, Paraleyrodes bondari Peracchi on coconut from India. *Phytoparasitica, 47*(3), 333-339.

Iaccarino, F. M. (1990). Descrizione di Paraleyrodes minei n. sp.(Homoptera: Aleyrodidae), nuovo aleirodide degli agrumi in Siria. *Bolletino del laboratorio di entomologia agraria Filippo Sylvestri, 46,* 131-149.

Mani, M. (2010). Origin, introduction, distribution and management of the invasive spiralling whitefly Aleurodicus dispersus Russell in India. *Karnataka Journal of Agricultural Sciences, 23*(1), 59-75.

Martin, J. H. (1987). An identification guide to common whitefly pest species of the world (Homopt Aleyrodidae). *International Journal of Pest Management, 33*(4), 298-322.

Mohan, C., Josephrajkumar, A., Babu, M., Krishna, A., Prathibha, P. S., Krishnakumar, V., & Hegde, V. (2019). Non-native neotropical nesting whitefly, Paraleyrodes minei Iaccarino on coconut palms in India and its co-existence with Bondar's nesting whitefly, Paraleyrodes bondari Peracchi. *Current Science, 117*(3), 515-519.

Peracchi, A. L. (1971). Dois aleirodideos pragas do Citrus no Brazil (Homoptera, Aleyrodidae). *Archivos do Museu Nacional. Rio de Janeiro, 54*, 145-151.

Russell, L. M. (1965). A new species of Aleurodicus Douglas and two close relatives (Homoptera: Aleyrodidae). *The Florida Entomologist, 48*(1), 47-55.

Selvaraj, K., Gupta, A., Venkatesan, T., Jalali, S. K., Sundararaj, R., & Ballal, C. R. (2017). First record of invasive rugose spiraling whitefly Aleurodicus rugioperculatus Martin (Hemiptera: Aleyrodidae) along with parasitoids in Karnataka. *Journal of Biological Control, 31*(2), 74-78.

Selvaraj, K., Sundararaj, R., & Sumalatha, B. V. (2019). Invasion of the palm infesting whitefly, Aleurotrachelus atratus Hempel (Hemiptera: Aleyrodidae) in the Oriental region. *Phytoparasitica, 47*, 327-332.

Selvaraj, K., Sundararaj, R., Venkatesan, T., Ballal, C. R., Jalali, S. K., Gupta, A., & Mrudula, H. K. (2016). Potential natural enemies of the invasive rugose spiraling whitefly, Aleurodicus rugioperculatus Martin in India. *Journal of Biological Control*, 236-239.

Sujithra, M., Prathibha, V. H. R., Vinayaka, H., & Poorani, J. (2019). Occurrence of nesting whitefly Paraleyrodes minei Iaccarino (Hemiptera: Aleyrodidae) in India. *Indian Journal of entomology, 81*(3), 507-510.

Sumalatha, B. V., Selvaraj, K., Poornesha, B., & Ramanujam, B. (2020). Pathogenicity of entomopathogenic fungus Isaria fumosorosea on rugose spiralling whitefly Aleurodicus rugioperculatus and its effect on parasitoid Encarsia guadeloupae. *Biocontrol Science and Technology, 30*(10), 1150-1161.

Sundararaj, R., & Selvaraj, K. (2017). Invasion of rugose spiraling whitefly, Aleurodicus rugioperculatus Martin (Hemiptera: Aleyrodidae): a potential threat to coconut in India. *Phytoparasitica, 45*, 71-74.

Sundararaj R., Selvaraj K., Vimala D., & Venkatesan, T. (2020). Whiteflies (Hemiptera: Aleyrodidae) of India. In S. Ramani, P. Mohanraj, & H. M. Yeshwanth (Eds.), *Indian Insects: Diversity and Science* (pp. 103-120). UK: CRC press, Taylor & Francis Group.

Vidya, C. V., Sundararaj, R., Dubey, A. K., Bhaskar, H., Chellappan, M., & Henna, M. K. (2019). Invasion and establishment of Bondar's nesting whitefly, Paraleyrodes bondari Peracchi (Hemiptera: Aleyrodidae) in Indian mainland and Andaman and Nicobar Islands. *Entomon, 44*(2), 149-154.

Wosula, E. N., Evans, G. A., Issa, K. A., & Legg, J. P. (2018). Two new invasive whiteflies (Hemiptera: Aleyrodidae) to Tanzania. *African Entomology, 26*(1), 259-264.

Accelerated Development of Coconut Synthetic Variety
Using Classical Breeding Methods and Microsatellite Marker Technology

Ramon L. Rivera[1], Ernesto E. Emmanuel[2] and Susan M. Rivera[3]

The use of seeds from any high yielding planting materials is a traditional practice among coconut farmers. This practice although wise and practical sometimes leads to disastrous results when applied to seeds from F_1 hybrids and worse if it involves taking them from dwarf x tall (d x t) single crosses. Unknown to many farmers, d x t hybrids inherit the self-pollinating trait of the dwarf parent. In a plantation of d x t palms, open pollination among these palms produces inbred seeds with higher frequency. This mating process leads to inbreeding depression, which is expressed in lower yields and general decline in the vigor of the succeeding generations.

Farmers who tried planting d x t hybrids during the last 20 years have mixed opinions about their choice of planting materials. In general, most Filipino farmers prefer high yielding planting materials with medium to large size nuts. They disdain small seeded ones because they had been used to the traditional commercial variety, which naturally bear medium to large nuts. Moreover, farm labor costs involved from nut harvesting to copra processing are paid on a per nut basis.

Many locally bred hybrids perform 3 to 4 times better than the traditional varieties due to their more efficient nutrient utilization. They are early bearing, "short" stature, and therefore, easy to harvest. Due to greater adaptability, they also have the desirable trait of superior recovery after a period of stress. They make up for lost yield in a short period of time; hence they have become the popular choice in agricultural development. Unfortunately, the use of hybrids requires big investment on seed production which cash-strapped governments like the Philippines can ill afford to sustain.

The development of open-pollinated varieties (OPVs) offers greater advantages because farmers can use the seeds of the original plantation over succeeding generations, again and again. The fundamental aim is to produce a population of palms having a high degree of balanced heterozygosity (Banzon and Velasco, 1982). This breeding scheme is considered by many coconut breeders impossible to do due to the perennial nature of coconut. Based on the breeding procedure for a synthetic variety, a modified breeding method was developed by PCA for coconut. Notwithstanding the limitations of possible inbreeding, and the difficulties of identifying the superior genotype (e.g. heterozygotes) during/after open-pollination, the development of synthetic varieties could be a more cost effective means of plant propagation for coconut since it would ensure the deployment and use of superior planting materials with durable stability and yield. Using a 15-year data, Rivera et al. (2008) presented a comprehensive report on the status and prospects of the development of coconut synthetic variety, in particular the development and performance of the t x t base populations (Syn_0) compared to the parental populations, including the initial application of microsatellites or simple sequence repeats (SSRs) marker technology.

Advances in DNA technology show that SSR markers for coconut could discern between phenotypically similar varieties and/or plant types with heterozygous genotypes even at the nursery stage (Rivera et al., 1999). The application of this robust DNA technology is facilitating the current efforts on the development of OPVs in particular the PCA-Syn Var 001 from 14 variety hybrids (Rivera et al., 2008).

Optimum utilization of molecular marker technology could make significant impact on the methods of assessment of the genetic structure of coconut populations as well as in locating desirable genes in breeding materials. With such applications, important phases in the conventional breeding protocol such as in case of development of coconut OPVs through the synthetic variety approach, and the identification of heterozygous individuals possessing desirable traits can be accelerated. Moreover, the identification and use of linked markers could facilitate the selection and higher probability of obtaining desired genotypes. These techniques, once properly developed and utilized, could pave the way for coconut breeders to optimize genetic improvement methods.

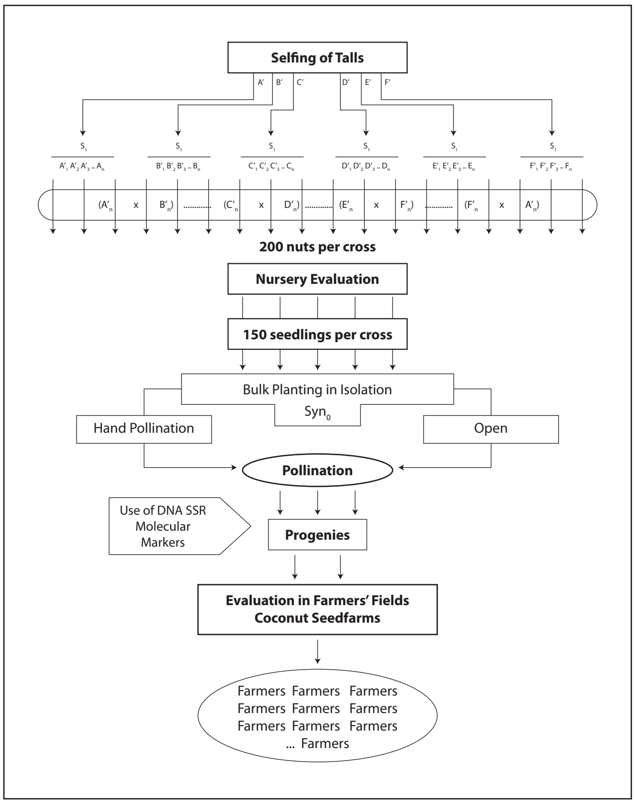


Figure 1. PCA SYN VAR 001 Synthetic Breeding Scheme

This research work aims not only provide information on the genetic structure of the resultant populations from the PCA SYN VAR foundation parents with that of the DNA patterns of the inter-crossed t x t F_1 hybrids, but also more importantly apply the DNA molecular marker technology to complement the classical breeding methods in identifying and selecting superior materials at the earliest time possible, i.e. seedling stage, for the establishment of coconut seedfarms. The application of DNA marker technologies could accelerate the establishment of coconut seedfarms using PCA Synthetic Variety, and provide the necessary genetic diversity in future coconut stands. Using the same technology, a protocol could be developed and utilized in the assessment and accreditation of coconut plantations for possible sources of high quality planting materials for accelerated planting/ replanting program.

MATERIALS AND METHODS

Experimental Materials

The experimental materials used in the study came from the PCA Syn Var experiment established in 1992 in Block 22 at the PCA-Zamboanga Research Center.

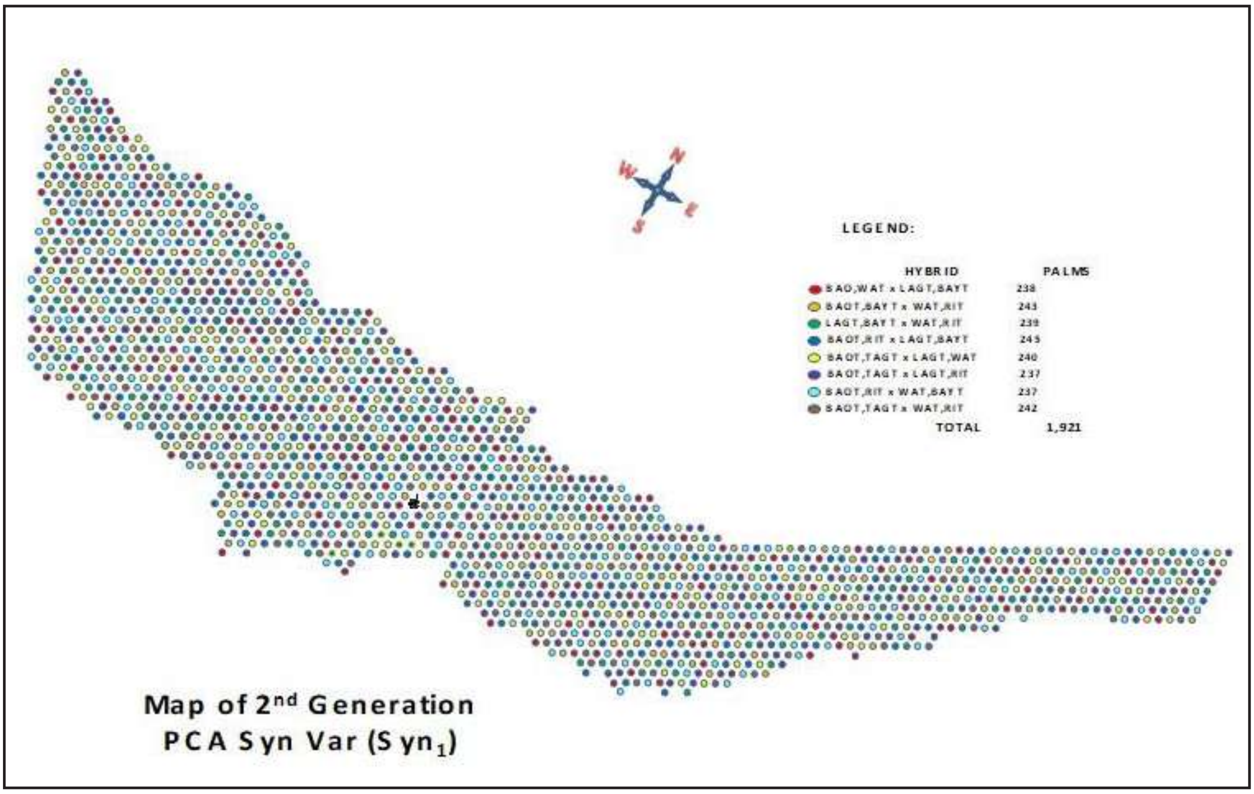


Figure 2. Coconut Seedfarm of the 2nd Generation Breeding Lines of PCA Syn Var (Syn_1)

The synthetic variety breeding scheme for the development of PCA coconut synthetic variety including the application of DNA molecular marker technology as research tool to accelerate its development were utilized (Figure 1). After the bulk planting of the t x t F_1 hybrids in isolation, it is followed by hybridization program consisting of controlled hand pollination (CHP) technique as described by Baliñgasa and Santos (1978), Santos et al. (1996); and 2) assisted pollination (AP) technique as described by Santos et al. (1996 and 1997).

The identification of the parental populations from t x t single crosses of PCA Syn Var base populations (Syn_0) was done following the predicted yield equation for synthetic varieties as described by Eberhart et al. (1967), and as shown:

$$\mathbf{Y^r_{co} = \tilde{Y}_c - (\tilde{Y}_c - \tilde{Y}_v)/n}$$

Where:

Y^r_{co} = predicted mean yield of composites obtained from random mating

$\tilde{Y}_c$ = the average of all possible inter-varietal crosses among n parental populations

$\tilde{Y}_v$ = the mean of **n** parental populations

Using the 10-year yield data of the Syn_0, predicted copra and nut yields of all double cross combinations were computed, and ranked. The eight (8) double crosses found with the highest predicted yields are as follows: 1) BAOT,WAT x LAGT,BAYT; 2) BAOT,BAYT x WAT,RIT; 3) LAGT,BAYT x WAT,RIT; 4) BAOT,RIT x LAGT,BAYT; 5) BAOT,TAGT x LAGT,WAT; 6) BAOT,TAGT x LAGT,RIT; 7) BAOT,RIT x WAT,BAYT; and 8) BAOT,TAGT x WAT,RIT. To produce these eight 2nd generation breeding lines (Syn_1), the following parental lines were utilized: 1) Female parent - BAOT x TAGT, BAOT x RIT, LAGT x BAYT, BAOT x BAYT, BAOT x WAT, and 2) Male parent - WAT x RIT, WAT x BAYT, LAGT x BAYT, LAGT x RIT, LAGT x WAT.

For each female parent population, 40 palms were selected to serve as mother palms. Crossing plan was prepared to ensure that hybridization activities are synchronized. For the hybridization program, the targets were as follows: (1) 4,800 seednuts (at 5 nuts produced/spathe), e.g. 40 palms/cross x 8 crosses x 3 spathes/palm; and (2) 240 or more seedlings raised per cross for the field planting of around 12 hectares. Coconut pollen collections for the hybridization works (AP and CHP) were done following the standard protocols. The distance and system of planting used were 8.5 meters, triangular.

Table 1. Coconut pollen utilized for the hybridization activities

Pollen Source	Mother Palms	AP Activities		CHP Activities	
		No. of Spathe Pollinated (no)	Amount of Pollen Utilized (g)	No. of Spathe Pollinated (no)	Amount of Pollen Utilized (g)
WAT x BAYT	BAOT x RIT	43	215	43	64.5
LAGT x BAYT	BAOT x RIT	51	255	67	100.5
LAGT x RIT	BAOT x TAGT	33	165	37	55.5
LAGT x WAT	BAOT x TAGT	42	210	42	63
WAT x RIT	BAOT x TAGT	30	150	62	93
WAT x RIT	LAGT x BAYT	44	220	75	112.5
WAT x RIT	BAOT x BAYT	41	205	78	117
LAGT x BAYT	BAOT x WAT	40	200	75	112.5
TOTAL		**324**	**1,620.00**	**479**	**718.5**

Establishment of the Coconut Seedfarm

Harvesting of pollinated seednuts followed the standard protocol described by Santos et al. (1996) wherein each seednut was carefully labeled with its pedigree followed by seasoning and sowing of seednuts in nursery beds.

Nursery Operations and Cultural Management Procedures

The harvesting, nursery operations, field planting and other cultural management for coconut followed the Manual on Standardized Research Techniques in Coconut Breeding (Santos et al., 1996).

Selection of Site

The chosen site inside the PCA-Zamboanga Research Center is a contiguous flat to gently rolling terrain, with good soil and within suitable class of coconut growing areas as described by Magat in 1978.

Application of Molecular Marker Technology in the Assessment of the Breeding Populations

The DNA microsatellite (SSR) marker protocols followed the procedures described by Rivera et al. (1999) with some modifications on the methods of DNA extraction, and Poly-Acrylamide Gel Electrophoresis (PAGE).

Plant Materials

Leaf samples from the ten palms each of the six (6) parental palms, and ten t x t single crosses (Syn_0), and ten seedlings each of the eight (8) 2nd generation breeding lines (Syn_1) were utilized in the genotype diversity and molecular profile assessment.

PCR Assay for Single Locus Profiles and Separation of Amplified DNA Fragments

The genetic profiles and diversity of the 6 parental populations, the 8 t x t F_1 base populations (Syn_0) and generated breeding lines (Syn_1) were assessed using four SSR primers (CNZ 18, CNZ 21, CNZ 51 and CN2A4).

Data Analysis

Microsatellite loci were scored individually, and the different alleles were screened and recorded for each parent population and breeding lines. Two different inter-sample similarity matrices were constructed (1) based on shared alleles using the simple matching coefficient calculated at each locus separately, and then the mean across loci were taken; and (2) each allele was treated for every locus as a separate band, and the Jaccard coefficient was used as the measure of similarity

Table 2. Status of coconut planting materials from pollination works

Hybrids	Assisted Pollination Technique (AP)			Controlled Hand Pollination Technique (CHP)		
	Nuts Sown (No.)	Nuts Germinated (No.)	Seedlings Polybagged (No.)	Nuts Sown (No.)	Nuts Germinated (No.)	Seedlings Polybagged (No.)
BAOT,WAT x LAGT,BAYT	1,970	1,119	500	515	400	387
BAOT,BAYT x WAT,RIT	1,827	1,206	500	369	302	296
LAGT,BAYT x WAT,RIT	1,872	1,240	507	470	395	250
BAOT,RIT x LAGT,BAYT	1,985	1,359	500	181	170	163
BAOT,TAGT x LAGT,WAT	1,613	1,146	529	129	118	114
BAOT,TAGT x LAGT,RIT	1,619	1,092	528	126	116	112
BAOT,RIT x WAT,BAYT	1,931	1,402	500	127	105	93
BAOT,TAGT x WAT,RIT	1,577	1,116	522	130	122	119
TOTAL	**14,394**	**9,680**	**4,086**	**2,047**	**1,728**	**1,534**

analogous to the manner in which RAPD and AFLPs are scored. Cluster analysis was performed on the similarity matrix using the unweighted pair group method with arithmetic averages (UPGMA), and the resultant dendograms were constructed. The similarity matrices were put into a principal coordinate analysis (PCO), and the scores for the resultant first three components were plotted pair-wise. Genetic diversity ($D = 1-\Sigma \boldsymbol{p}_i^2$) values were calculated according to Nei (1973). Data on the number of polymorphic loci, allelic richness, % heterozygosity and the kind alleles present were recorded.

RESULTS AND DISCUSSION

Hybrid Seednut Production Using the Classical Breeding Methods

Pollen Collection and Processing

Coconut pollen utilized in the hybridization works amounted to 1,620 g for the AP and 718.5 g for the CHP techniques (Table 1).

Coconut pollen collection and processing started on the early part of 2006 while the mother palms are being prepared for CHP and AP operations. For the AP activities, the coconut pollen were collected and processed in bulk. On the other hand, for the CHP operation the coconut pollen used were those from the targeted source palms, collected and processed individually from each palm.

Production of Seednuts and Seedlings from the Hand Pollination

From the harvested pollinated nuts, 14,394 and 2,047 nuts from AP and CHP techniques, respectively, were sown in nursery beds (Table 2). AP and CHP activities commenced on August 2006 with AP operations ending on September 2007 while CHP activities were completed on June 2008. Harvesting of pollinated seednuts commenced one year after hand pollination. Out of the 9,680 germinated AP seednuts, 4,086 were selected for polybag nursery operations while 1,534 seedlings were polybagged from 1,728 CHP nuts. The produced pollinated seednuts are more than enough to cover the establishment of one coconut seed farm consisting of 2nd generation (Syn_1) of breeding lines of the Syn Var population at the PCA-Zamboanga Research Center.

The rest of the pollinated seednuts were utilized for the establishment of coconut seedfarms in the PCA Research and Regional Centers, and identified farm sites in strategic coconut growing provinces of the country. The results of such activities are covered by another report.

Coconut Seedfarm Establishment at PCA-ZRC

A total area of 20 hectares was cleared in the northern side of the original Syn Var area near the Sax River inside the PCA-ZRC for the establishment of coconut seedfarm. Field planting was done from October 2008 to March 2009 consisting of 1,921 progeny seedlings produced from CHP (702

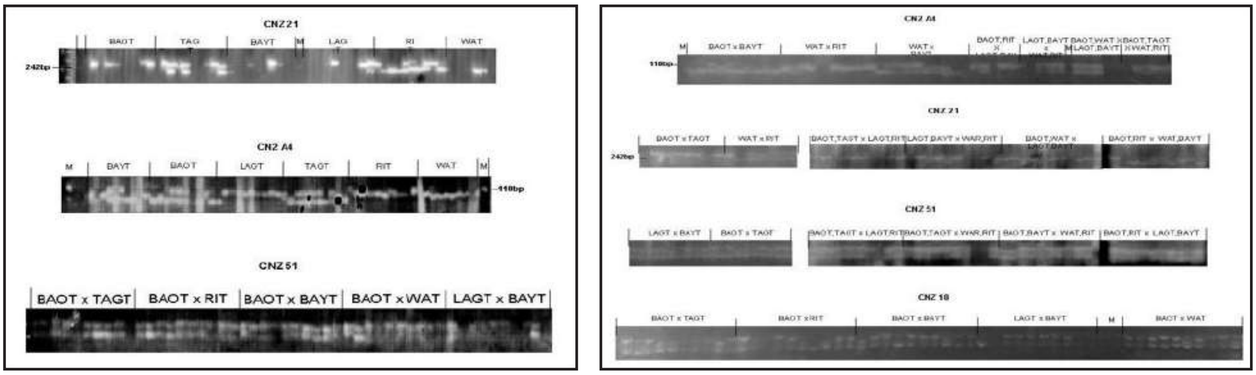


Figure 3. Banding patterns of the four SSR markers (CNZ 18, CNZ 21, CNZ 51 and CN2A4) used on the coconut parental and breeding lines

Table 3. Total number of AP & CHP seedlings planted

HYBRID	TOTAL	AP	CHP	AREA (ha)
BAOT,TAGT x LAGT,RIT	237	151	86	1.48
BAOT,TAGT x LAGT,WAT	240	152	89	1.51
BAOT,WAT x LAGT,BAYT	238	152	86	1.49
BAOT,TAGT x WAT,RIT	242	153	89	1.51
LAGT,BAYT x WAT,RIT	239	151	87	1.49
BAOT,RIT x LAGT,BAYT	245	152	93	1.53
BAOT,RIT x WAT,BAYT	237	154	83	1.48
BAOT,BAYT x WAT,RIT	243	154	89	1.52
TOTAL	**1,921**	**1,219**	**702**	**12.01**

seedlings) and AP (1,219 seedlings) covering an effective area of 12 hectares (Table 3 & Figure 2).

The vegetative data of the field planted seedlings i.e. girth size, plant height and number of leaves produced, of the Syn_1 breeding populations are likewise gathered and recorded which form part of another report. Standard cultural management procedures for coconut plantation are followed. Rubber trees are planted around the perimeter of the seedfarm to serve as natural barriers.

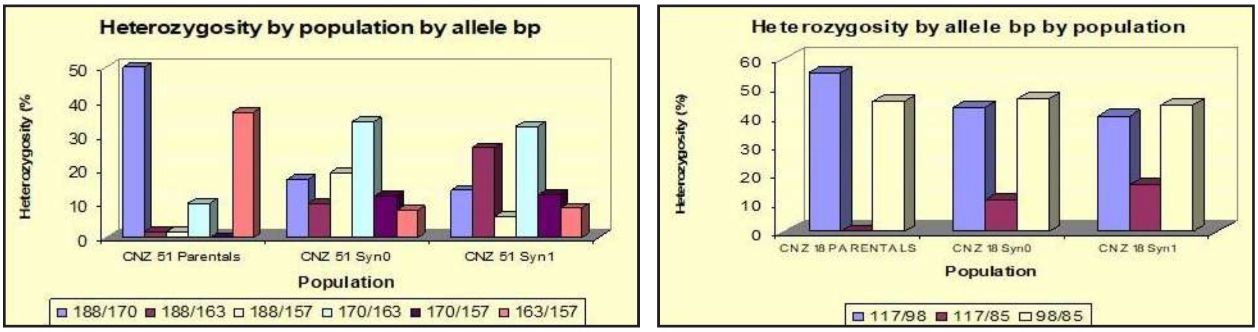
Application of SSR Marker Technology

Four coconut SSR primers, CNZ 18, CNZ 21, CNZ 51 and CN2A4 (Figure 3) were utilized in the assessment of allelic diversity and/or molecular profiles, and levels of heterozygosity of the three generations of breeding populations. Results (Table 4 and Figures 4 and 5) point toward the genetic improvement of the advance breeding populations as indicated by reduced levels of homozygosity, higher percentages of heterozygosity, as well as high and sustained levels of genetic diversity.

Genetic diversity values of the breeding populations are very high (0.92) when all the four microsatellite markers are employed. Comparable levels of genetic diversity were likewise obtained when DNA markers are utilized singly (Table 4). These levels were sustained in the advance breeding stages basically due the diverse tall coconut populations used as parent materials and the efficient breeding schemes employed.

DNA markers CNZ 51 and CNZ 18 detected six and three alleles, respectively (Figure 4). All alleles detected are in heterozygous state from the parents up to the advance breeding lines. In both makers, the evenness in the distribution of alleles is more pronounced in the advance breeding generations. Similarly, DNA markers CNZ 21 and CN2A4 found 3 and 4 alleles, respectively (Figure 5). Unlike markers CNZ 51 and CNZ 18, the detected alleles this time are in homozygous and heterozygous states. At the parental stage, levels of homozygote alleles are higher (with 85% for marker CNZ 21 and 83% for marker CN2A4) than the advanced breeding lines (Syn_0 and Syn_1). Homozygosity levels went down from 85% (parentals) to 45% (Syn_0), then to 40% (Syn_1) for marker CNZ 21. Conversely, their heterozygosity levels increased from 15% (parentals) to 60% (Syn_1). For DNA marker CN2A4, there was an abrupt decrease of homozygosity level from 83% to 5% from parents to Syn_0 then homozygote alleles level-off to 19% at Syn_1. At this breeding generation, heterozygosity level is 81%. Allelic richness is very visible while allelic evenness is more evident in the advance breeding stages.

The genetic improvement of the advance breeding populations is quite impressive as shown by the



a) CNZ 51; 6 Alleles; 157 to 188 bp

b) CNZ 18; 3 Alleles; 85 to 117 bp

Figure 4. Heterozygosity levels of the parents and breeding lines using CNZ 51 and CNZ 18 SSR primers

Table 4. Genetic diversity of the breeding populations and lines using the four SSR molecular markers

Population	Genetic Diversity (D)				
	CNZ 21	CNZ 18	CNZ 51	CN2A4	All Primers
Controlled Hand Pollination					
Parents	0.658	0.624	0.744	0.704	0.921
Syn_0	0.595	0.648	0.744	0.707	0.918
Syn_1	0.625	0.656	0.734	0.725	0.921
Assisted Pollination					
Parents	0.658	0.624	0.744	0.704	0.921
Syn_0	0.606	0.653	0.746	0.708	0.920
Syn_1	0.603	0.650	0.732	0.742	0.920

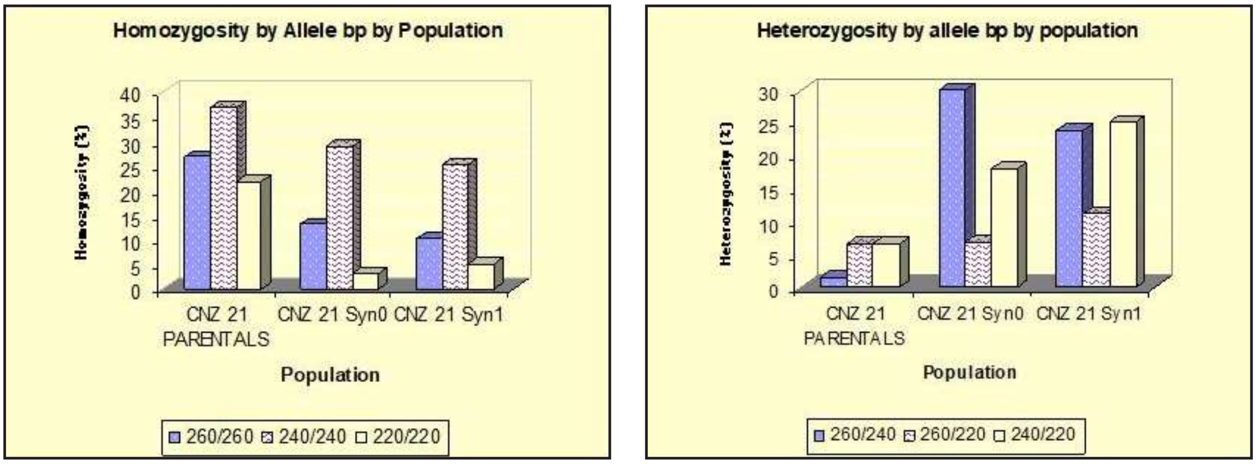
similarity matrices of the parentals, and the advance breeding lines (Figure 6). The Jaccard Distance and PCA Matrices indicated more groupings in the advance breeding generatiaons compared to the parentals indicating greater diversity or genetic variation in the breeding lines developed.

Allelic diversity analysis and molecular profiling require a certain minimum number of markers. The ideal number of markers for analysis should be at least two for each chromosome of the crop being studied, i.e. at least 32 markers for coconut (n = 16). The number of test materials should also be increased to an optimum level for higher confidence level in the results (Carcallas, 2001).

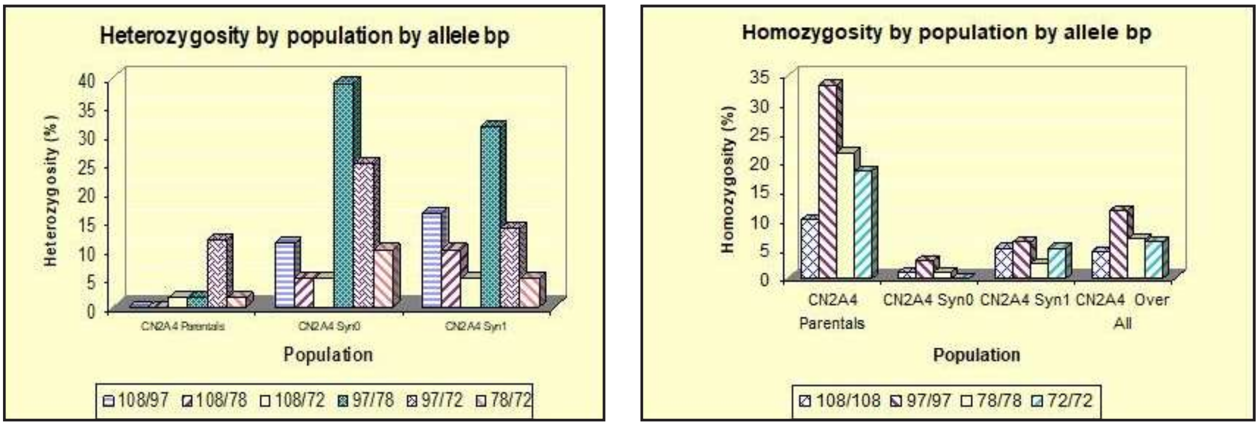
The abovementioned concerns could still be well addressed by the researchers since more polymorphic and discriminant SSR markers are available for use at the PCA-ZRC Molecular Genetics Laboratory. Likewise, the test palms of the parental and advance breeding lines are available as living collections, hence could easily be sampled for broader molecular profiling and genotype analyses.

The current results generated from the four SSR markers however, provided clear and positive indications that a population of palms with a high degree of balanced heterozygosity as suggested by Banzon and Velasco (1982) could be achieved. Moreover, development of a breeding scheme that would allow these populations to mate at random and to maintain high degree of heterozygosity and heterosis from generation to generation is possible. This breeding scheme is considered by many coconut breeders impossible to do due to the perennial nature of coconut. The PCA developed synthetic variety breeding scheme is a very cost effective means of plant propagation for coconut since it would ensure the deployment and use of superior planting materials with durable stability and yield based on the yield performance of Syn_0 (Rivera et al., 2008), and the indicative heterozygosity and genetic diversity of the Syn_1 breeding lines as shown by the current data from the application SSR marker technology.

The use of SSR markers in evaluating the breeding value of the genetic materials at seedling stage augurs well in the current efforts to accelerate the development of the PCA Synthetic Variety. While the development of the coconut synthetic variety was originally conceived to be totally dependent on the coconut breeder's unique instinct on individual



a) CNZ 21; 3 Alleles; 220 to 260 bp



b) CN2A4; 4 Alleles; 72 to 108 bp

Figure 5. Zygosity levels of the parents and breeding lines using CNZ 21 and CN2A4 SSR primers

palm selection, the SSR marker technology could very well facilitate the efficient genetic assessment of the breeder's breeding populations. This robust technology complements well with the classical breeding methods being used in coconut varietal development program of PCA.

SUMMARY AND CONCLUSION

To accelerate the development of the PCA Synthetic Variety using the classical breeding methods, SSR marker technology was applied in assessing the allelic diversity, genetic/molecular profile, and levels of heterozygosity of breeding lines in relation to their parental populations. In particular, the SSR marker technology was applied in the genetic assessment of the 2nd generation (Syn_1) breeding lines of PCA Syn Var produced using classical breeding methods from high yielding t x t F_1 base populations (Syn_0). The bottom line is to establish a coconut seedfarm comprising of 2nd generation (Syn_1) superior breeding lines of PCA Synthetic Variety coconut variety.

Using the classical breeding methods, the 2nd generation (Syn_1) of breeding lines of the PCA coconut synthetic variety from superior/high yielding lines of t x t F_1 base populations (Syn_0) was bred and/or developed. These breeding materials were genetically assessed using four SSR markers, and were found to possess superior genetic values based on their levels of heterozygosity, genetic diversity, allelic richness, evenness of allelic distribution, and sustained genetic diversity. A coconut seedfarm consisting of 1,921 double crosses produced from both controlled hand pollination (702 seedlings) and assisted pollination (1,219 seedlings) covering an effective area of 12 hectares was established at the PCA-Zamboanga Research Center. This coconut seedfarm is expected to produce high quality seednuts of breeding populations that could be instrumental in the establishment of coconut seedfarms in strategic coconut growing provinces of the country.

While the Syn Var project was originally conceived to be totally dependent on the coconut breeder's unique instinct for individual palm selection, the

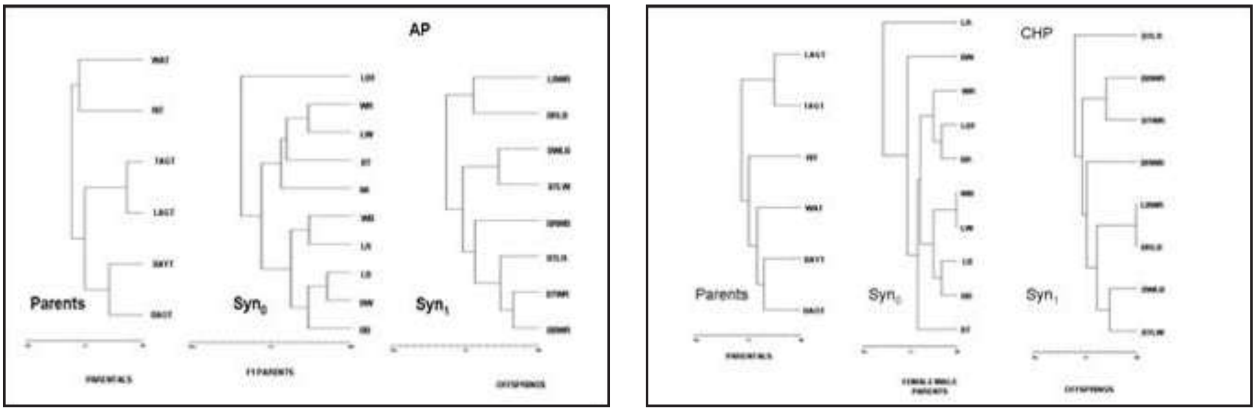


Figure 6. (AP): Dendogram of Jaccard Distance Matrix, and (CHP): dendogram of Principal Component Analysis of the Parents and Breeding Lines

application of the application of DNA molecular marker technology like SSR provides for fast and efficient assessment of breeder's breeding populations as well as generates information on the level of genetic diversity of existing stands of coconut in farmer's fields. When this robust technology is fully operationalize, the breeders will have the opportunity to quickly frame up an effective way of mass-producing the seeds for eventual multiplication of the relevant genotypes for coconut growing communities. This unique breeding research undertaking for coconut offers greater opportunities for all farmers not only in the Philippines but to all coconut growing countries in the world.

IMPLICATIONS AND RECOMMENDATIONS

The purposeful development of a coconut synthetic variety could lead to more permanent genetic gains over many generations and could achieve greater adaptability and stability in performance due to a wide genetic base. Likewise, seeds of the coconut synthetic variety are produced under natural conditions and constantly exposed to natural selection. Coconut farmers may use the seeds from synthetic variety directly from a second crop and expect better yields in the process. Over the years, establishment of coconut seedfarms could sustain immense commercial hectarage over time and even in places where areas are too small to support a coconut hybrid industry.

The abovementioned advantages of the synthetic variety approach in coconut breeding are masked by the fact that a coconut synthetic variety is very difficult breed and even considered impossible by some coconut breeders due to its perennial nature. The research efforts done so far by the PCA breeders in Zamboanga have proven that a COCONUT SYNTHETIC VARIETY could be achieved through the combination of classical breeding methods and the application of robust molecular marker technology.

To take advantage of this "first of its kind in the world" coconut synthetic variety, the following are recommended:

1. To develop a robust and working DNA molecular marker protocols, like SSR or combinations of available DNA molecular markers for coconut, for genetic assessment to fully complement the classical breeding methods in the development of the synthetic breeding populations, and to further accelerate the coconut varietal development in the country;
2. To use the current breeding materials developed from the synthetic variety approach in the establishment of productive coconut seedfarms in strategic coconut growing provinces of the country;
3. To further assess the potential of the coconut synthetic variety for emerging and high value products and uses.

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REFERENCES

Akuba, R. H. 2002. Breeding and population genetics studies on coconut (Cocos nucifera L.) composite variety using morphological and microsatellite markers. UPLB, College, Laguna, Unpublished Ph D thesis. 230 p.

Ashburner, G. R., Thompson, W. K., & Halloran, G. M. (1997). RAPD analysis of South Pacific coconut palm populations. *Crop science, 37*(3), 992-997.

Baliñgasa, E. N., & Santos, G. A. (1978). Manual for coconut hand pollination technique. Breeding & Genetic Division. *PCA Agric. Res. Branch. Bago-Oshiro, Davao, Philippines*, 45.

Carcallas, R. J. U. (2001). Evaluation of microsatellite primers to determine effective number and sample size for genetic diversity analysis of coconut (Cocos nucifera L.). MS Thesis. University of the Philippines at Los Baños (UPLB). 92pp.

Carpena, A. L., Espino, R., Rafael, C., Rosario, T. L., & Laude, R. P. (1993). Genetics at the population level. Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA).

Eberhart, S. A., Harrison, M. N., & Ogada, F. (1967). A comprehensive breeding system. *Der Züchter, 37*, 169-174.

Falconer, D. S. and T. F. C. Mackay. (1996). Introduction to quantitative genetics. Longman Group Ltd. 464p.

Hallauer, A. R. and J. B. Miranda. (1981). Quantitative genetics in maize breeding. The Iowa State Univeristy Press.

Nei, M. (1973). Analysis of gene diversity in subdivided populations. *Proceedings of the national academy of sciences, 70*(12), 3321-3323.

Rivera, R., Edwards, K. J., Barker, J. H. A., Arnold, G. M., Ayad, G., Hodgkin, T., & Karp, A. (1999). Isolation and characterization of polymorphic microsatellites in Cocos nucifera L. *Genome, 42*(4), 668-675.

Rivera, R. L., Santos, G. A., Rivera, S. M., & Emmanuel, E. E. (2008). Development of Synthetic Variety of Coconut: PCA Syn Var 001 I. Status and Prospects. *CORD, 24*(1), 23-23.

Santos, G. A., Batugal, P. A., Othman, A., Baudouin, L., & Labouisse, J. P. (1996). Manual on standardized research techniques in coconut breeding. IPGRI-COGENT publication. Stanford Press, Singapore 100p.

Santos, G. A., Rivera, R. L., E. E. Emmanuel and S.M. Rivera. (1997). Production of hybrid coconut seeds through the assisted pollination technique. I. Pollen collection and processing. *Phil. J. Coco. Studies, 12*(2), 48-57.

Segovia, S. J. E., N. O. Bituin, R. J. U. Carcallas, C. C. Reaño, R. Rivera, G. A. Santos, & D. M. Hautea. (1999). Genetic diversity assessment in coconut using morphological and microsatellite markers. Abstract Paper. *The Philippine J. of Crop Sci., 24*(1), 106.

Weir, B. S. (1996). Genetic data analysis II Sinauer, Sunderland. Massachusetts.

Wright, S. 1922. Systems of mating. *Genetics, 6*, 11-178.

Practical Training Component of the 3rd International Certificate Course for Coconut Development Officers

Lalith Perera[1]

The Coconut Research Institute of Sri Lanka (CRISL) inaugurated the 15 days practical training component of the 3rd International Certificate Course for Coconut Development Officers on 19th of June, 2023, at the Coconut Research Institute in Sri Lanka as a continuation to the theory component of the course virtually conducted in 2021. The virtually conducted theory component of the course in 2021 was attended by 38 participants from 18 countries.

This comprehensive 15 days practical training course was conducted by the CRISL on behalf the International Coconut Community (ICC), providing training on systematic & scientific coconut cultivation, mother palm selection, artificial pollination & cultivar development, seed garden establishment & seed production, nursery establishment & management, land & soil suitability for planting coconut, fertilizers and fertilizer application, identification of nutrient deficiencies and corrections, soil and moisture conservation, organic fertilizers & compost production, suitable intercrops and intercropping models, irrigation methods, good agronomic practices, major and minor pests & their control measures, pheromones synthesis for red weevil & use, major coconut diseases and their control measures, machinery use for coconut cultivation and processing & value addition.

This certificate course was organized in association with the International Coconut Community (ICC). Some of the participants were sponsored by their respective countries, such as India & PNG, and other partner organizations such as International Trade Centre (ITC) and Non-Align Movement For South-South Technical Cooperation (NAM CSSTC).

The closing and graduation ceremony of the 3rd International Certificate Course was held at the Goldi Sands Hotel, Negombo, followed by the farewell dinner hosted by ICC on 4th July 2023. The ceremony was attended by Dr. Jelfina Allow, Executive Director of ICC, Ms. Sureka Attanayake, Director (Policy & Planning) of Ministry of Plantation Industries, Sri Lanka, representing the Secretary to the Ministry, Ms. Mridula Kottekate, Assistant Director of ICC Dr. C. S. Ranasinghe, Director, Dr. Lalith Perera, Additional Director & the Course Director, Dr. Nayani Arachchige and Dr. Sarath Idirisinghe, two Deputy Directors (Research), Dr. Auchithya Dissanayake and Dr. Anjana Attapattu, two Course Coordinators, and other Heads of Research Divisions and Senior Officials of CRISL.

There were nine international participants in the practical training component of the certificate course from six countries namely India, Papua New Guinea, Kenya, Indonesia, Dominican República, and New Caledonia. An updated third edition of the comprehensive training manual was presented to the Chief Guest by the Director of CRISL and a copy each was provided to participant as a handbook on coconut cultivation and management for their use.

Mr. David Napwora Makokha, the participant from Kenya speaking at the occasion on behalf of all the participants, expressed his gratitude to CRISL and Sri Lanka for conducting such all-inclusive training program and generously sharing the coconut technology generated by Sri Lanka for the benefit of the other coconut growing countries. Mr. Alan Aku, the Managing Director of the Kokonas Indastri Koporesen (KIK), Papua New Guinea, also sent complements to CRISL on this occasion, saying KIK is seen immense contribution for PNG's coconut development program from their previously trained staff in last two batches and for that his government is very pleased for CRISL and Sri Lanka in hosting this training.

The field work and practical were conducted exclusively at CRI owned and managed coconut sub-research stations and coconut seed gardens. The course is conducted by the senior research staff of the institute including more than 30 internationally and locally qualified research staff with long years of research and management experience in the coconut field.

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World Coconut Day 2023 Celebrations Around the World

Otniel Sintoro[1]

On September 2^{nd}, member countries of ICC celebrated World Coconut Day (WCD), marking the establishment of the ICC. This annual commemoration serves as a tribute to the vital economic and environmental role that coconuts play in the lives of millions of people including coconut farmers and their families, industries and consumers around the world. WCD festivities feature a variety of activities and events. These includes exhibitions showcasing the latest coconut products and technologies, educational workshops, training, and cultural performances that reflect the deep cultural significance of coconut in many societies. The theme for this year WCD was ***Sustaining Coconut Sector for the Present and Future Generation***.

In Indonesia, the World Coconut Day 2023 Celebration, was successfully conducted in Gorontalo Regency, Indonesia, 21-25 September 2023. Exhibitors from private sectors and government agencies showcased their activities. There were 30 exhibitors from private sectors and government agencies showcased their activities. Around 300 participants including international participants from countries like PNG, Malaysia, Philippines, India, Sri Lanka, US, UK and France attended the five days event. Thousands of local visitors including the school children enthusiastically visited the exhibition booths. Different competitions were also organized during the celebration.

The Opening Ceremony was held on 21 September 2023. Welcome address were delivered by Prof. Dr. Nelson Pomalingo, Regent of Gorontalo and Dr. Jelfina C. Alouw, Executive Director, ICC. Keynote Speech were delivered by Prof. Dr. Ir. Fadel

Muhammad, Deputy Chairman of the People's Consultative Assembly, Republic of Indonesia.

The International Coconut Conference was also part of the celebration and conducted on 23 September 2023, in which international speakers were participated. More than 300 participants attended the conference. A training program by the Indonesia National Research and Innovation Agency and other institutions to coconut farmers and processors was also organized. The training program included hands-on workshops, interactive sessions, and practical demonstrations. This aimed to enhance the skills and knowledge of participants, contributing to the sustainable growth of the coconut industry.

The unique activities about this year World Coconut Day were various competitions in which there were participation by international participants and local residents of Gorontalo. Those competitions are demonstration of coconut value-added product, culinary, fashion show, and coconut tree climbing.

As part of the Celebration, the foundation stone laid for the establishment of the World Coconut Garden, as the conservation of coconut germplasm, education, research, new hybrid development, and tourist attractions in Huyula Village. This is one of the initiative of the Gorontalo province government. The direct benefit of this garden will go to the coconut farmers. This is also one of the collaboration between businessmen, government, academics, students, young people including farmers, SMEs and cooperatives. Gorontalo has extensive coconut plantations covering an area of 100,000 hectares.

The winners of the WCD 2023 Competition were announced and facilitated in the closing ceremony.

SRI LANKA

The Coconut Research Institute of Sri Lanka celebrated the World Coconut Day 2023 on 12th September 2023 at CRISL premises. The function was graced by Dr. Ramesh Pathirana, the Hon. Minister of the Plantation Industries, as the Chief Guest invited by Mr. Malraj Peiris, and Dr. C. S. Ranasinghe, Chairman and Director of Coconut Research Institute respectively. The function was also attended by Mr. Janaka Dharmakeerthi, Secretary to the Ministry of Plantation Industries and other Ministry Officials, members of Coconut Research Board, Chairperson and Officials of Coconut Cultivation Board (CCB), Chairman and Officials of Coconut Development Authority (CDA), Chairmen and Officials from Kurunegala Plantations, and Chilaw Plantations, the two coconut plantation companies of the Ministry, members from Provincial Councils and other political establishments of the region, and representatives from coconut-related associations.

The program ceremonially began by the Minister declared opening a King Coconut Mother Plam Garden by planting the first King Coconut seedling, at the proposed Bandirippuwa Estate, the main sub-research station of CRI. This Mother Palm Garden is the first of its kind in Sri Lanka for King Coconut, which will serve as the future source of authentic and genetically superior King Coconut planting materials to the growers. The export demand for King Coconut as fresh nuts and canned water was radically rising and accordingly the demand for king coconut seedlings, from recent times. During the occasion, the Agronomy Research Division demonstrated and released to the growers the biochar recommendation for coconut whereas the Plant Physiology Division launched a coconut variety screening trial for climate change.

Honorable Minister addressed the gathering and highlighted the importance of development of the coconut industry as potential industry to boost the economy of the country. Exchange of a MOU between CRI & Alpitiya Plantations Company on establishment and maintenance of a tissue cultured coconut block, joint launching the toddy tapping training program by Agro-Properties Private Ltd., and CRI, presenting an analytical instrument to Central Analytical Laboratory of CRI, by Haycarb Plc. Sri Lanka, were some of other highlights of the function.

INDIA

Coconut Development Board in partnership with ICAR-CPCRI, Kasaragod organized the 25th World Coconut Day celebrations on September 2, 2023. Hon. Shobha Karandlaje, Minister of State for Agriculture and Farmers' Welfare, Government of India was the chief guest on the occasion. She mentioned that the government is giving importance of considering coconut cultivation and processing as a profitable business, and encouraged to focus on export markets to increase smallholder incomes. The minister encouraged farmers to utilize various government schemes such as Kisan Samman Yojana, Pradhan Mantri Fasal Bima Yojana, and Agricultural Infrastructure Fund to increase production, value addition, and trade. She expressed the need to diversify coconut processing, moving from copra-centered processing to processed products such as neera, virgin coconut oil, and coconut chips for better economic returns. Farmer Producer Organizations have been recognized as potential pioneers of change in the coconut sector, capable of uniting smallholders, promoting mechanization, and encouraging exports.

During the meeting, MLA Kasaragod Shri N. A. Nellikunnu lauded the work of CPCRI and Navibo, and urged the two institutes to collaborate and conduct research to reduce farming costs and improve fertilizer quality. Dr. V. B. Patel, Assistant Director General, ICAR, New Delhi, and others gave their address and support. B. Hebbar, Director of ICAR-CPCRI, welcomed the guests and highlighted the various technologies developed by the institute. He stated that ICAR-CPCRI's research commitment to lowering agricultural costs and increasing resilience to climate change has led to new directions. In addition, Hanumantha Gowda also briefed the audience on schemes that support coconut farmers.

Earlier the minister visited research laboratories of CPCRI including tissue culture and the agro processing laboratory. The Minister also witnessed drone based spraying on coconut plantation, ground pollination device demonstration, organic farming technology and integrated pest and disease management practices adopted by CPCRI.

Vadakara Coconut Farmer Producer Company Ltd, who secured the award instituted by the International Coconut Community for the best Farmer Organization globally was also felicitated at the event. At the event, the Minister also honored ten coconut entrepreneurs and facilitated technology transfer through the signing of a Memorandum of Understanding with seven entrepreneurs. Vatakara Coconut Farmers Producer Company Limited, a globally recognized farmer organization, was honored at the event.

The event, which was attended by over 500 progressive farmers from various states, featured an exhibition showcasing coconut farming technologies and products, which attracted the interest of 25 participating institutions, entrepreneurs, and FPOs. In addition, technical sessions and panel discussions on coconut business plans were also held.

Several regions in India also commemorated World Coconut Day which was organized by the CDB unit offices.

Furthermore, PG and Research Department of Biotechnology, Kongunadu Arts and Science College, Coimbatore and Tamil Nadu Coir Business Development Corporation (TANCOIR) also jointly commemorate World's Coconut Day 2023 on 1 September 2023. The event was started with guest lecture by Mr. Dhinesh Dharmaraj, Domestic Marketing Executive and Mr. S. Gowthamsivan, International Marketing Executive from Tamil Nadu Coir Business Development Corporation on Entrepreneurial Opportunities in Coir Sector. The welcome address was given by Dr. A. U. Thangavelu, HOD Department of Biotechnology. The Felicitation address was given by Dr. M. Lekshmanaswamy, Principal followed by the presidential address given by academic Co-ordinator, Dr. Saravanamoorthy.

The resource person discussed about Entrepreneurial Opportunities in Coir Sector and Various Government Schemes and they interacted with UG and PG students of the college.

The college also conducted inter-college competitions like coconut based Flameless cooking, arts and crafts and quiz. The students from various colleges in and around were actively participated in various events and won prizes.

JAMAICA

In Jamaica World Coconut Day celebrated with the aimed to raise awareness, encourage sustainability and spark innovation in the coconut industry. They emphasized the need for sustainable practices, including environmentally friendly farming and effective pest management and also to strengthen the sector and facilitate collaboration, education and exploration within the coconut industry, promoting sustainability, innovation and wider engagement in this important agricultural field.

The event also highlighted the versatile nutritional aspects of coconut and recognized its importance in economy, society, culture and history. Agricultural entrepreneurs and processors were given the opportunity to showcase innovative coconut-based products, with the aim to inspire a diverse audience, including youth, women, and people with disabilities, to engage in coconut farming and entrepreneurship.

Leading stakeholders and institutions such as the Ministries of Agriculture, Fisheries and Mines, along with others, were part of the World Coconut Day celebrations. The focus was on public education through exhibitions and booths, providing the public with an understanding of the various benefits of coconut, especially its potential in various industrial applications.

[1] *Information & Publication Officer, International Coconut Community*

Highlights of the 59th ICC Session & Ministerial Meeting

Mridula Kottekate[1] & Otniel Sintoro[2]

International Coconut Community's Session & Ministerial Meeting is the highest decision-making body of the Community and is held annually to discuss, deliberate and take policy decisions on the activities to be undertaken by the Community for the sustained development of the global coconut sector. The countries are represented at the Session by the Honorable Ministers of Agriculture/Trade/Commerce, Plenipotentiary Delegates authorized by the National Governments and Senior Officials from the concerned Ministries.

The three day long 59th ICC Session and Ministerial Meeting conducted physically from 5-7 December 2023 hosted by Government of Republic of Indonesia through Ministry of Trade. The Government of Republic of Indonesia held the Chair of International Coconut Community (ICC) for the CY 2022-2023 and was host for the 59th ICC Session & Ministerial Meeting.

The inauguration is an official opening ceremony and was organized by the host Government of Republic of Indonesia. Dr. Jelfina C. Alouw delivered the Introductory Remarks. She addressed that the development of the coconut sector must embed principles of sustainability into every facet of the journey–from cultivation to production and distribution and trade. The coconut's versatility extends from food to non-food sectors, where products like cosmetics, activated carbon, shell-based charcoal and cocopith cocofiber, coco board, building materials products hold promise. The diversification not only caters to market trends but also positions coconut as a key player in preventing deforestation and contributing to soil erosion prevention. The Session served as a

significant platform where member countries converge to exchange insights on progress, challenges, and share their national programs, wherein member countries collaboratively address challenges associated with the climate change, insufficient supply of raw materials, price dynamics, and farmer livelihoods, sustainable industry practices, policy and financial supports as well as unjustifiable negative campaign against coconut oil.

Hon. Arinal Djunaidi, Governor of Lampung Province, delivered the welcome remarks. He hoped that through the 59th Session and Ministerial Meeting, member countries can work together to strengthen the coconut industry through diversification and down streaming of coconut products that are needed by the global market.

H.E. Maiava Fuimaono Tito Asafo, Associate Minister of Samoa, delivered the special address as a representative Minister of ICC member countries. He mentioned that the main objective of ICC is to promote, coordinate and harmonize the activities of the global coconut community and industry for the sustainable benefits of their lives of millions of small farmers as well as those engage in production, processing and marketing of coconut products.

H.E. Dr. Zulkifli Hasan, Minister of Trade, Government of Republic of Indonesia officially opened the

meeting. In his remarks, His Excellency mentioned that coconut has a prominent role in our economy, social, culture and environment.

The 59th ICC Session & Ministerial Meeting was attended by Delegates and participants included Senior Government Officials of ICC member countries and Official Observers from the Centre for Agriculture and Bioscience International (CABI), Non Aligned Movement Centre for South South Technical Cooperation (NAM CSSTC), Philippine Council for Agriculture, Aquatic, and Natural Resources Research and Development (DOST-PCAARRD), Department of Science and Technology, Philippines and sustainable Coconut Partnership(SCP). The Governments of Guyana, Marshall Islands, Philippines Timor Leste and Vanuatu were not represented. A total of 75 participants registered for the Session.

Country Papers- Gateway for Exchanging Ideas and Programs

The session meeting started with the country paper presentation by member countries gave a brief update on the policies and programs for coconut development undertaken by National Governments including the legislations to promote the development of the sector. The delegates presented the status of coconut production, processing, and export in their countries. Presented the updates on the coconut replanting, new planting, and rehabilitation programs. The status of the research and development activities, policies and programs implemented in the country to enhance farm productivity and increase the farmers income were also shared by the member country delegates. The constraints faced by the sector and suggested road map for the way forward for the coconut sector were briefed by the delegates besides impact of Covid-19 on the coconut industry by some of the countries. The country papers helped in understanding the developmental activities undertaken by the countries and helps to identify the replicable models for customised implementation in other countries. It also helped in exchange of ideas and technology and paved way for possible collaborations between member countries, ICC and international partner organizations.

Observer Organizations

The International partner organizations attended and presented the nature and extent of their involvement in the coconut sector with reference to collaboration with community are CAB International (CABI); Non-Aligned Movement Centre for South South Technical Cooperation (NAM CSSTC), Philippine Council for Agriculture, Aquatic, and Natural Resources Research and Development (DOST-PCAARRD), Department of Science and Technology, Philippines, and Sustainable Coconut Partnership (SCP).

The other agendas discussed were ICC Annual Report which included the global scenario of sustainable and resilient coconut sector, highlights

of 2022, update of activities of 2023. The report was presented by Dr. Jelfina C. Alouw, Executive Director. The Session also discussed the various programs and projects proposed to be undertaken by ICC during CY 2024. During the year 2023, ICC's activities as planned were implemented physically. The program conducted during the year is International Conference on Trade and Marketing of Coconut Products in association with Coconut Development Board of India, International Seminar on

Harnessing Coconut Potential for Offsetting Carbon Emissions: Integrating Science and Economy for a Sustainable Future in collaboration with University of Sam Ratulangi, International Coconut Oil Conference, World Coconut Day 2023 Celebration in Gorontalo and the practical component of 3rd International Certificate Course for Coconut Development Officers. During the meeting renewal of MoU between ICC and CABI was signed. ICC Quality Standards of Coconut Products, New Structure of ICC-Scientific Advisory Committee on Health (SACH) and Term of Reference, followed by the appointment of New Assistant Director and extension of service for Secretariat staff reaching retirement age some other agendas discussed. There were fruitful discussions held on the different agenda in which some productive suggestions shared by the delegates.

The 59th ICC Session & Ministerial meeting adjourned with the acceptance of chair of ICC for 2023 by Government of Sri Lanka hosting the 60th ICC Session & Ministerial meeting in 2024 in Colombo, Sri Lanka.

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[1] *Assistant Director, International Coconut Community*
[2] *Information & Publication Officer, International Coconut Community*

Experts' Finding on the Health Benefits of Coconut

Dr. Fabian M. Dayrit

Chairman of ICC Scientific Advisory Committee on Health and Professor, Department of Chemistry, Ateneo de Manila University, Academician, National Academy of Science and Technology and President, Integrated Chemists of the Philippines

Virgin coconut oil is effective in lowering C-Reactive Protein levels among suspect and probable cases of COVID-19. There were two main indicators used: recovery from COVID-19 symptoms and level of C-Reactive Protein (CRP) in the blood. These two indicators showed that VCO can be used to treat mild COVID-19 cases.

CRP is a protein that is analyzed in the blood as a quantitative measure of inflammation or infection. CRP level less than 5 mg/L indicates recovery from inflammation or infection. The recovery from COVID-19 symptoms was more rapid in the VCO group compared with the Control group: 17% in the VCO group showed improvement compared to only 4% in the Control group. Full relief from COVID-19 was attained by day 18 in the VCO group compared to day 23 in the Control group.

The level of CRP in the VCO group dropped much more rapidly and completely compared to the Control group. By day 14, the CRP level in the VCO group had fallen below the 5 mg/L, and this continued to show a decreasing trend at day 28. In comparison, the CRP level in the Control group fell slowly to 5 mg/L at day 14 and stayed at this level until day 28.

Other beneficial effects of VCO were noted from the blood assay:

- HDL-cholesterol ("good cholesterol") increased
- LDL and triglycerides remain within normal range
- Fasting blood sugar (FBS) decreased

These results show that VCO, indeed, is a healthy oil.

Source: Proceedings of the XLIX Cocotech Conference, 30 August-2 Sept 2021, Jakarta, Indonesia.

Dr. Faizal C. Peedikayil

Professor & Head Department of Pedodontics & Preventive Dentistry, Kannur Dental College, India

Coconut oil rinsing reduces gingival inflammation. Oil rinsing is a type of traditional procedure that involves swishing edible oil in the mouth and then spitting it out. Virgin and regular coconut oil can be used to reduce plaque related gingivitis. However, the study shows that virgin coconut oil has better taste, odor, and texture in the mouth than regular cooking coconut oil. The advantage of coconut oil or virgin coconut oil as natural oils is that they neither cause any staining as seen in the use of mouthwashes nor there is any after taste or allergic reactions. and are readily available. Such practices cure about 30 systemic diseases and have an effect on the overall well-being of the individuals practicing it.

Source: CORD Journal, Vol. 37 2021

Experts' Finding
on the Health Benefits of Coconut

DR. D. P. Athukorale

Cardiologist, Pharmacologist, Academician, Colombo, Sri Lanka

Green Coconut has much water and is rich in proteins, minerals, vitamins, calcium, phosphores, iron, iodine, chlorine, sulphur, potassium, carbohydrates and vitamins, B1, B2, B5 and magnesium. The water also helps the hydration of the body. The green coconut has a ratio of amino acids arginine, alanine, cisteína (essential) and serina, greater than those found in cow's milk. It is perfect and natural isotonic to restitute energies in the human body.

Tender coconut water has been used in other areas of the world where intravenous solutions cannot be obtained. Japanese have used tender coconut water (T. C. W.) intravenously in Sumatra, Indonesia in World War I. Pradera et. al. have used intravenous T. C. W. for pediatric patients in Havana, Cuba without any serious reactions.

Source: Dr. D.P. Athukorale 2008. Tender Coconut Water – Its Health Benefits Cocoinfo International, 15 July: 14-16

Prof. Dr. Rabindarjeet Singh

Lifestyle Science Cluster, Advance Medical and Dental Institute, Universiti Sains Malaysia, Bertam 13200 Kepala Batas, Penang, Selangor, Malaysia

Coconut water (*Cocos nucifera* L.) is an ancient tropical beverage whose popularity has been increasing in recent years. This 'naturally canned' beverage is a sweet refreshing drink obtained directly from the inner part of the fruit. It is a beverage that has drawn the attention as a natural functional drink. Coconut water is sterile at source, and is very rich in potassium, and contains sodium, chloride, magnesium and carbohydrates. Therein, making it a healthier alternative to carbonated drinks including isotonic sports drinks. Apart from the lower calories due to lower sugar content, the non-carbonated coconut water is also a great source for replacing the electrolytes lost during sweating when compared to carbonated drinks. Ingestion of carbonated drinksis known to be associated with gastrointestinal discomfort in certain individuals. This "Mother Nature's" gift of coconut water, could be prized as the beverage above all other beverages for its health renewing properties.

Source: Proceedings of the XLVI Cocotech Conference 7-11 July 2014, Bandaranaike Memorial International Conference Hall Colombo, Sri Lanka.

Experts' Finding on the Health Benefits of Coconut

Dr. (Mrs.) E.R.H.S.S. Ediriweera
Senior Lecturer, Department of Nidana Chikithsa, Institute of Indegenous Medicine, University of Colombo, Rajagiriya, Sri Lanka

- Young coconut water could be drunk to alleviate the burning sensation during micturition
- Young coconut water, breast milk, treacle of *Saccharum officinarum* (*F. Graminae*) and sugar are mixed together and given for hiccough
- Leaves of *Dregia volubilis* (*F. Asclepiadaceae*) are to be pounded and mixed with tender nut water. The juice is extracted and given in treatment of poisoning of *Nerium indicum* (*F. Apocyanaceae*)
- Water of young king coconut (before flesh is formed inside) is given for fever and it can be consumed as a diuretic in dysuria.
- A King coconut is to be opened by slicing off the top.30 gms of powdered fruits (without seeds), of *Terminalia chebula* (*F. Combretaceae*) are added to the King coconut water inside and stirred. Sliced top is then replaced (as a cover) and kept outdoors in the dew overnight. Following morning, the mixture inside is to be filtered and drunk as a purgative. This is called El Vireka by Sri Lankan traditional physicians. The number of bowel motions will increase as the person continues to drink cold water from time to time during the morning. He should not consume hot or warm food and liquids. This is good for purifying blood and cooling the body.

Dr. Faizal C. Peedikayil
Professor & Head Department of Pedodontics & Preventive Dentistry, Kannur Dental College, India

Coconut oil rinsing reduces gingival inflammation. Oil rinsing is a type of traditional procedure that involves swishing edible oil in the mouth and then spitting it out. Virgin and regular coconut oil can be used to reduce plaque related gingivitis. However, the study shows that virgin coconut oil has better taste, odor, and texture in the mouth than regular cooking coconut oil. The advantage of coconut oil or virgin coconut oil as natural oils is that they neither cause any staining as seen in the use of mouthwashes nor there is any after taste or allergic reactions. and are readily available. Such practices cure about 30 systemic diseases and have an effect on the overall well-being of the individuals practicing it.

Source: CORD Journal, Vol. 37 2021

Bullish Market of Coconut Oil in the First Half of 2024

Alit Pirmansah[1]

The lauric oils market, having undergone a period of retraction in 2023, is poised for nuanced transformations in the upcoming year. This comprehensive analysis delves into the intricate dynamics that define the lauric oils landscape, exploring pricing trends, global production dynamics, and the anticipated shifts in demand for both coconut and palm kernel oils in 2024.

The intricate pricing trajectory of lauric oils in 2023 reflects the market's sensitivity to multifaceted influences. Commencing the year at US$1,071 per metric ton (MT) in January, coconut oil experienced a gradual decline, settling at US$993/MT by June. A pivotal positive shift occurred in July, propelling the oil into a robust recovery that culminated in a valuation of US$1,118/MT by December. In parallel, palm kernel oil demonstrated a parallel pattern, starting at US$928/MT in June, undergoing a

Table 1. Coconut Oil Production, 2022-2024 (000MT)

Countries	2022	2023p	2024F
Philippines	1,311	1,073	1078
Indonesia	886	893	856
India	360	368	369
Mexico	132	131	130
Sri Lanka	68	68	66
Malaysia	55	57	55
Vietnam	41	41	41
Papua New Guinea	47	45	45
Thailand	29	29	29
Other countries	**265**	**266**	**266**
World	3,196	2,971	2,935

Source: Oil World and ICC estimates

Bullish Market of Coconut Oil

Table 2. Palm Kernel Oil Production, 2022-2024 (000MT)

Countries	2022	2023p	2024F
Indonesia	4,835	4,902	4,987
Malaysia	2,097	2,101	2,129
Thailand	294	305	306
Nigeria	163	168	171
Other countries	**849**	**972**	**909**
World	8,238	8,448	8,502

Source: Oil World and ICC estimates

Table 3. Coconut Oil Imports, 2022-2024 (000MT)

Countries	2022	2023p	2024F
EU-27	691	656	650
USA	535	443	450
Malaysia	360	293	266
China	219	183	180
UK	24	24	24
Other countries	**518**	**531**	**525**
World	2,347	2,130	2,095

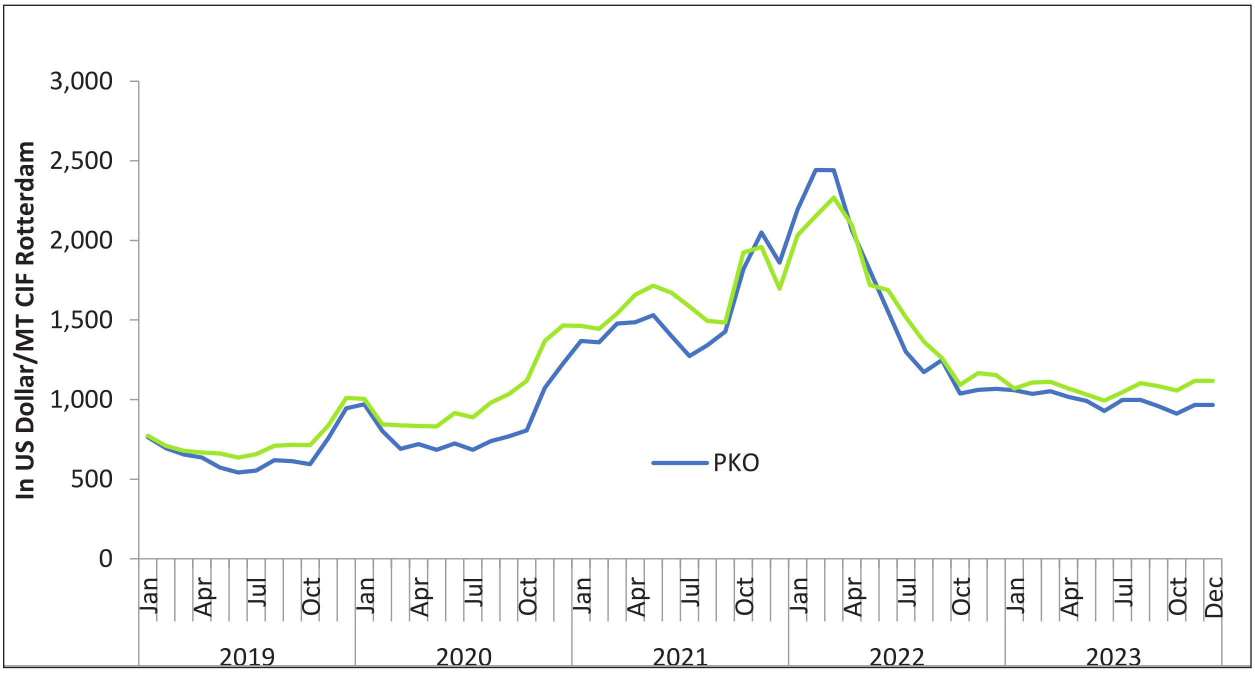
Source: Oil World, USDA, and ICC estimates

reversal in July, and concluding the year at US$966/MT in December. Projections for the first half of 2024 indicate that lauric oil prices will likely adhere to the prevailing pattern, influenced by anticipated reductions in production and weakened demand. These pricing dynamics underscore the market's responsiveness to both global and regional factors, necessitating a nuanced approach from industry stakeholders.

The global production of lauric oils is anticipated to experience a marginal increase in 2024, with a projected output of 11.437 million tons, as compared to the previous year's figure of 11.419 million tons. This upward trend is predominantly attributed to a notable rise in palm oil kernel production, offsetting an expected decrease in coconut oil production. The El Niño effects have been observed in the last quarter of 2023 and anticipated to exacerbate the projected decline in coconut tree productivity, following the elevated levels observed in 2022. Concurrently, the deteriorating age structure of coconut trees in the Philippines and Indonesia is posing an additional constraint on yield potential.

Analyzing the regional contributions to lauric oil production in 2024 unveils intriguing insights. The global production of coconut oil is anticipated to

Figure 1. Price Trend of Lauric Oils, January 2019-December 2023 (USD/MT)



Source: Oil World

Table 4. Palm Kernel Oil Imports, 2022-2024 (000MT)

Countries	2022	2023e	2024F
EU-27	600	644	665
USA	349	362	370
China	615	684	720
Malaysia	252	178	220
Brazil	230	259	260
Other countries	**925**	**1,066**	**1,122**
World	2,971	3,193	3,357

Source: Oil World, USDA, and ICC estimates

contract by over 36 thousand tons, driven primarily by a substantial reduction in Indonesian production. Conversely, the Philippines, another major producer, is expected to witness a modest increase in production from 1,073 thousand tons in 2023 to 1,078 thousand tons in 2024. In contrast, palm kernel oil production is expected to witness an uptick of 54 thousand tons in 2024, led by Indonesia and Malaysia, projected to produce 4.987 million tons and 2.129 million tons, respectively. This nuanced regional outlook emphasizes the need for industry stakeholders to discern and adapt to the unique production dynamics prevalent in key regions.

The projected shifts in lauric oil production are set to reverberate through global import demand. Coconut oil imports are expected to decrease by a minimum of 35 thousand tons in 2023. European countries are projected to witness a decline exceeding 6 thousand tons, with China's import demand forecasted to reduce by 1.6%. In contrast, the US market is poised to experience a notable increase of 7 thousand tons in coconut oil import demand. The distinctive price premium of coconut oil relative to palm kernel oil is anticipated to instigate a significant shift in demand towards the latter, resulting in an estimated 5% increase in global import demand for palm kernel oil in 2024. Europe is expected to contribute a 3% increase, the US market 2%, and China a substantial 36 thousand tons.

The expected decline in coconut oil production is likely to manifest in a reduction in global consumption. Exports of coconut oil are projected to drop by approximately 30 thousand tons, and domestic consumption is estimated to weaken by 83 thousand tons in 2024. However, these effects are expected to be mitigated to some extent by reductions in stocks, with global coconut oil stocks expected to decrease by approximately 109 thousand tons. This intricate interplay between production, consumption, and stock adjustments necessitates a strategic understanding to navigate the ensuing market dynamics successfully.

In conclusion, the lauric oils market is anticipated to witness a bullish trend in the first half of 2024, despite the challenges in the global market. The prices of these oils are expected to exhibit a gradual rise, reaching US$1,000/MT for palm kernel oil and US$1,150/MT for coconut oil by June 2024.

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[1] *Market and Statistics Officer, International Coconut Community*

Table 5. World Balance of Lauric Oils (000MT), 2022-2023

Countries	Coconut Oil		Palm Kernel Oil		Lauric Oils	
	2023	2024F	2023	2024F	2023	2024F
Beginning Stocks	452	414	1,484	1,446	1,936	1,860
Production	2,971	2,935	8,448	8,502	11,419	11,437
Imports	2,130	2,095	3,193	3,357	5,323	5,452
Total Supply	**5,553**	**5,444**	**13,125**	**13,305**	**18,678**	**18,749**
Exports	2,091	2,061	3,230	3,360	5,321	5,421
Domestic Consumption	3,063	2,980	8,313	8,534	11,376	11,514
Ending Stocks	399	403	1,582	1,411	1,981	1,814
Total Distribution	**5,553**	**5,444**	**13,125**	**13,305**	**18,678**	**18,749**

Source: Oil World, USDA, and ICC estimates

A GLOBAL SYMPOSIUM TITLED "HARNESSING THE POTENTIAL OF COCONUTS TO OFFSET CARBON EMISSIONS: INTEGRATING SCIENCE AND ECONOMICS FOR A SUSTAINABLE FUTURE" WAS HELD

The International Coconut Community, in collaboration with Sam Ratulangi University (UNSRAT) in Manado, Indonesia, organized the International Seminar on "Harnessing Coconut Potential for Offsetting Carbon Emissions: Integrating Science and Economy for a Sustainable Future" to address climate change challenges and promote sustainable development. Taking place at the Aryaduta Hotel in Manado on October 12 and 13, 2023, the conference brought together experts from five nations to share their latest findings on leveraging coconut potential for carbon emission reduction.

The first session focused on "Policy and Regulation of Energy Transition and Pathway to Net Zero," discussing governmental measures to lower carbon emissions and the role of corporations and scientists in this effort. Harmonizing techniques for carbon emissions was a key aspect.

The second session delved into "Carbon Sequestration and Carbon Sink in Agriculture Including Coconut and Its Implication to Net Zero." It explored coconut plants' capacity to absorb carbon, practical actions in the coconut industry, and the impact of intercropping systems on carbon emission mitigation.

The third session, "Empowering Communities for Climate Action and Sustaining High Coconut Productivity: The Role of Education and Research & Development," showcased superior coconut varieties resulting from research, emphasizing their attributes and benefits to motivate farmers.

"Incentivizing Carbon Capture and Making & Offsetting Carbon Credits: Economic Instruments and Implementation Strategies" was the focus of the fourth session. Experts detailed measures to minimize carbon, including carbon credit trading schemes, such as charcoal carbonization and the use of coconut shells for charcoal and briquettes.

The final workshop addressed "Sustainable Practices in Reducing Carbon Footprint, Community Engagement, Challenges, Opportunities, and Future Directions," discussing how communities can reduce carbon emissions through sustainable agricultural methods, along with challenges and innovative uses for coconut waste.

Each session concluded with in-depth discussions where presenters addressed questions. The formal seminar opening on October 12 featured speeches from notable figures, including Dr. Jelfina C. Alouw, Executive Director of the International Coconut Community, and Prof. Oktovian B. A. Sompie, Rector of Sam Ratulangi University.

The seminar aimed to contribute to a greener and more sustainable future, offering practical solutions for global climate change. Recommendations and a forward-looking approach were presented, laying a strong foundation for harnessing coconut potential to reduce carbon emissions.

INTERNATIONAL COCONUT OIL CONFERENCE: "RETHINKING SATURATED FAT, BOOSTING COCONUT OIL-LINKED HEALTH"

The International Coconut Community (ICC) organized the International Coconut Oil Conference to address global dietary guideline controversies. Held on October 30-31, 2023, at the Lumire Hotel & Convention Center in Jakarta, Indonesia, the conference aimed to provide a platform for experts to share recent research findings and promote collaboration for the benefit of producers and consumers. The theme, "Rethinking Saturated Fat, Boosting Coconut Oil-Linked Health," underscored the focus on coconut oil's impact on health.

The conference was inaugurated by Mr. Reza Pahlevi Chairul, Director of Inter-Regional Negotiations and International Organizations at the Ministry of Trade, Republic of Indonesia. He emphasized the significance of discussing coconut oil based on credible scientific evidence, acknowledging its contribution to addressing food security challenges and global supply chain disruptions. The need to counter negative campaigns with reliable evidence was highlighted, aiming to improve policies and regulations based on high-quality scientific research.

Dr. Jelfina C. Alouw, Executive Director of ICC, welcomed participants, emphasizing the conference's role in dispelling misconceptions about coconut oil and promoting evidence-based understanding. Dr. Fabian Dayrit, Chair of ICC Scientific Advisory Committee on Health, provided a brief introduction.

Distinguished experts from various countries covered topics in four sessions, discussing issues related to coconut oil, saturated fats, and their impact on health. Sessions included presentations from experts in Australia, Denmark, India, Indonesia, the Philippines, Sri Lanka, Thailand, and the USA.

The first session delved into the "Review and Status of Research Work Done on Facts and Misconception in the Dynamic World of Coconut Oil and Saturated Fats." It highlighted the unjust malignment of traditional saturated fats like coconut oil in dietary guidelines.

The second session, "Clinical Study Papers Contributed by The Researchers of Various Countries on the Nutrition & Health Aspects of Coconut Oil," explored diverse aspects of coconut oil's potential health benefits, such as anticancer properties, Alzheimer's disease management, and cardiovascular health.

The third session, "Country Presentations - Importance of Coconut Oil for Food Security," showcased the nutritional significance of coconut-based products and the challenges facing the coconut industry in different countries.

In the fourth session, "Technology Innovated and Adopted for the Sustainable Development of Coconut Oil Supply Chain," speakers discussed steps taken to ensure the sustainable development of the coconut oil supply chain, emphasizing the industry's commitment to sustainability.

Each session concluded with in-depth discussions and speakers addressing queries. The conference presented recommendations focusing on fostering collaboration among clinical scientists and medical professionals to bridge knowledge gaps, promoting the health benefits of coconut oil, and addressing global challenges in the coconut industry.

A NEW HOPE FOR FARMERS OF COCONUTS

The Philippine Coconut Authority (PCA), initially positioned at the economic base, received a directive from President Marcos in June of the previous year to improve the plight of coconut farmers. As the PCA marked its 50th anniversary, President Marcos expressed a bold vision for the Philippines to lead the world in coconut product exports. Despite past promises to revitalize the coconut sector, ongoing issues, especially related to the contentious coconut levy money, have left farmers among the poorest. The late Marcos regime collected these levies between 1971 and 1982, creating financial disputes and impacting the industry's modernization.

However, the current drive to revitalize the coconut sector offers renewed hope for farmers. Funding accessibility and a more comprehensive strategy are notable improvements. The Department of Finance estimates the coconut levy assets' value at P111.3 billion, providing a substantial financial base. President Marcos has initiated a plan to plant 100 million coconut trees by 2028 and instructed the PCA to invest in innovative projects and technology for long-term industry robustness.

The Coconut Farmers and Industry Development Plan (CFIDP), signed into law by former President Duterte, outlines a detailed roadmap for sector revival. The plan focuses on initiatives such as innovative research, support services, processing, social protection, and farmers' development. While expectations are raised, effective execution remains crucial. Challenges include delays in implementing the CFIDP, with only 8.78% of the budget utilized in 2022, attributed to changes in the PCA board under the new administration. Despite initial setbacks, the PCA needs to double its efforts and execute the President's directives for the industry's revitalization.

As President Marcos grants the family another opportunity to address past wrongs, the hope is that the revitalization efforts will uplift the lives of coconut farmers and empower them to break free from poverty. The success of these initiatives will be crucial before the current government concludes its term. The responsibility lies significantly with the Chief Executive, and the industry's revival remains a pivotal challenge that demands concerted efforts. *(Inquirer)*

INNOVATION AND SUSTAINABILITY ARE ASKED BY EXPERTS IN THE COCONUT SECTOR

As part of the celebration of World Coconut Day, the Council of Scientific and Industrial Research—National Institute for Interdisciplinary Science and Technology (CSIR-NIIST)—organized a technical seminar on "Sustainable Coconut Processing Strategies for the Global Market" on September 12, 2023, at the CSIR-NIIST, Thiruvananthapuram, Kerala, India.

The ICC's executive director, Dr. Jelfina C. Alouw, was invited as the seminar's principal guest to give a special speech. She stated that the coconut industry depends on quality, sustainability, and competitiveness. She emphasized how adaptable coconuts are, highlighting their use in both cooking and as a biofuel. She stated, "We have to leverage innovation to unlock the full market potential of coconuts."

The difficulties of reduced coconut production as a result of global warming were discussed by Dr. C. Anandharamakrishnan, Director of CSIR-NIIST, Thiruvananthapuram. Promoting research, study, and understanding of the scientific cultivation and management of important crops is a top objective for the CSIR-NIIST.

The challenges that farmers face stemming from price volatility and inadequate processing strategies were highlighted by Dr. B. Hanumanthe Gowda, the Chief Coconut Development Officer of the Coconut Development Board.

In his speech, Mr. Paul Francis, Managing Director of KLF Nirmal, emphasized the problems the sector had when it first started and some of the problems that still exist now and require government action to solve.

Technical sessions and panel discussions on research and development interventions for the cultivation, crop management, and value addition of coconut were held at the seminar on "Sustainable Coconut Processing Strategies for Global Market," in which a variety of experts from the government, industry, and farmers producer organizations actively participated.

Formulating agricultural plans, improving post-harvest value addition, and creating a stable worldwide market for coconuts and allied goods were the key goals of the sessions.

In the wake of September 2, World Coconut Day, a celebration with the theme "Sustaining Coconut Sector for the Present & Future Generation" was held to highlight the benefits of coconut cultivation and consumption, as well as to highlight the significance of coconuts and their contributions to the economy, agriculture, and public health. The International Coconut Community (ICC) and the Coconut Development Board (CDB) worked together to organize the event.

Agribusiness professionals, research and academic specialists, policy makers, corporate representatives, Farmer Producer Organizations (FPOs), members from the Central and State Government agencies, and officials from the International Coconut Community (ICC) were present at the event.

In order to capitalize on the sizeable domestic and international market for this adaptable crop that is grown throughout the nation, the experts stressed the critical need for innovation and sustainability in the coconut industry. They also stressed the significance of a comprehensive strategy that includes cultivation, scientific crop management, and value addition. *(ICC News)*

LAND IDENTIFICATION FOR COCONUT CULTURE BY RURAL MINISTRY

Deputy Prime Minister Datuk Seri Dr. Ahmad Zahid Hamidi has directed the Ministry of Rural and Regional Development to identify suitable land, including idle areas, for large-scale food security projects focusing on coconut cultivation. Drawing inspiration from successful initiatives in agricultural regions like Sungai Sembrong Kiri, Kluang in Johor, the project aims to yield 600 metric tonnes of raw coconuts annually, generating an estimated income of RM483,000. Additionally, it anticipates producing 180 metric tonnes of coconut milk with an income projection of RM1.4 million. Emphasizing the ministry's support for the unity government's food security program, Ahmad Zahid underscored its role in easing living costs, particularly for rural communities.

Aligning with the Rural Development Policy 2030 (DPLB 2030), the ministry is implementing various projects to enhance rural areas as hubs for national food security. The Integrated Village Economic Development Project (Prospek) stands out as an initiative maximizing vacant village land for specialized product cultivation, contributing significantly to the local economy. Another active project is the development of a 3,264-hectare rice estate in Seberang Perak, Perak, overseen by Felcra Berhad (Felcra), poised to yield 23,737 metric tonnes of rice annually in two seasons.

In addition to these endeavors, Felcra plans to collaborate with the governments of Sarawak and Sabah to initiate group rice-planting projects across 15,000–20,000 hectares, contributing to national food security. Ahmad Zahid emphasized the potential to enhance food security by stabilizing the buffer stock of rice, projected to reach 290,000 tons this year. Aquaculture projects, livestock farming, and fruit and vegetable production are part of the ministry's regional development board's initiatives to boost food security. The collaborative efforts with the Ministry of Agriculture and Food Security, especially in marketing, research, skills development, and training, are crucial to achieving the desired level of self-sufficiency in the nation. *(New Straits Times)*

PROFESSIONAL COCONUT CLIMBERS ARE AVAILABLE 24/7

Under the moniker "Friends of Coconut Tree," the Coconut Development Board (CDB) has established a call center to serve the needs of coconut growers for plant protection, harvesting, and other field activities utilizing knowledgeable coconut climbers. The State's call center will be run out of the board's Kochi offices.

In addition to Kerala, the call center will open concurrently through board unit offices in traditional coconut-growing regions like Tamil Nadu, Andhra Pradesh, and Karnataka.

A total of 1,552 Friends of Coconut Trees (FoCTs) have registered for the call center, according to a CDB announcement. At the block grama panchayat level in the corresponding districts, the services of FoCTs will be made available for carrying out operations relating to coconut agriculture, such as tree climbing, plant protection, harvesting, obtaining seed nuts, and managing nurseries. Through the contact centers, coconut farmers can use the services of FoCTs.

By connecting farmers, farmer-producer organizations, coconut entrepreneurs, and representatives of various agriculture departments and institutions with FoCTs and palm climbers, the call centers hope to innovate the coconut industry. FoCTs' services are available for more information at 0484–2377266 (Extn: 137).

In addition to providing professional tree climbers' services, interested and qualified climbers can register at the phone center. They can provide information such name, address, and block/panchayat details, or they can utilize the phone number, 8848061240.

Ten years ago, the CDB started the FoCTs effort to train people who climb coconut trees, including women, in the management of coconut trees, main pest and disease management, harvesting, collecting seed nuts, managing coconut nurseries, irrigation, and fertilizer application. *(The Hindu)*

PCA AND FARMERS CONSIDER A DEAL TO IMPROVE THE NATION'S COCONUT SECTOR

A memorandum of understanding (MOU) was signed on August 9 by the government, the Philippine Coconut Authority (PCA), the Confederation of Coconut Farmers' Organization of the Philippines (CCFOP-CONFED), and the Philippine Rural Reconstruction Movement (PRRM), with the intention of pursuing extensive planting and replanting and reviving the coconut industry.

The PCA administrator Bernie Cruz stated this on the sidelines of the MOU signing at the PCA office in Quezon City. "Under the leadership of President Ferdinand R. Marcos, Jr., and the Bagong Pilipinas brand of governance, we expect to significantly increase coconut productivity, boost diversified production, and engage more of our farmers in higher value-adding activities, which would contribute to economic growth and substantially increase and even double farmers' incomes," he added.

The MOU was signed by PCA administrator Cruz, PRRM president Edicio dela Torre, and executive director Charles Avila of CCFOP-CONFED. In keeping with PCA's objective to revitalize the Philippine coconut industry, the collaboration also intends to promote cooperation, build relationships with individuals and organizations that represent coconut farmers, and increase the accessibility of support services.

Cruz emphasized the necessity of assisting coconut farmers, setting up and supporting cooperatives, and offering assistance services like shared facilities and processing centers to support the program for planting and replanting coconuts. He continued that these initiatives ought to cover all regions that are suitable for growing coconuts and further improve the cutting-edge techniques used by the thriving coconut sector. *(UCAP Bulletin)*

PCA EYES 3K HAS AS ADDITIONAL COCONUT PLANT SITES IN CL

The Philippine Coconut Authority (PCA) is eyeing some 3,000 hectares of land in Central Luzon for additional coconut plantations to boost the production of farmers in the region.

During the recent 6th CARP Regional Trade Fair at Marquee Mall in Angeles City, the PCA said the new plantations will be set up in Bataan, Bulacan, Nueva Ecija and Zambales.

The project is funded under the Coconut Farmers and Industry Trust Fund by virtue of Republic Act 11524.

It has an allocation of P50 million in the 2024 budget of the agency, which will also allow coconut planters to access the 1972 collection from the Coconut Levy Fund.

An estimated 700,000 coconut trees will be planted in the identified areas, comprising the tall variety in

2,000 hectares in Zambales, and the dwarf variety in 1,000 hectares in Bataan. In Bulacan, 50 hectares at the foot of Sierra Madre will also be planted with the high-yielding varieties.

The PCA added that nursery seedlings will also be set up in the coconut plantations, which is part of the agency's priority programs for 2024. *(SunStar)*

A NOTICEABLE INCREASE IN COCONUT PRODUCTION IS RECORDED IN GUJARAT

The production of coconuts has significantly increased in Gujarat. Over the previous ten years, the State has added around 4,500 hectares of land for coconut farming. To increase coconut output in the state, the government of the state has started the Gujarat Coconut Development Programme and allocated specific funds for it.

Gujarat, which has the nation's longest coastline, has seen a notable rise in coconut output and cultivation throughout the past ten years. The State cultivated coconuts on about 21,000 hectares of land in 2012–13; by 2022–2023 that number had risen to over 25,000 hectares. According to State Director of Horticulture P.M. Vaghasia, the government supports farmers who grow coconuts financially through a number of programs and initiatives. Currently, the State produces more than 21 crore ripe coconuts.

Additionally, he mentioned that 33% of the state's total coconut crop is sold to states in the north, such as Uttar Pradesh, Madhya Pradesh, and Delhi. *(All India Radio News)*

A TANZANIAN COMPANY INTENDS TO PRODUCE COCONUT CREAM

The Simba Group of Companies, situated in Dar es Salaam, plans to construct a processing facility for the nutrient-dense coconut milk.

The company is investigating pertinent Indonesian technologies through its Simba Foods affiliate in order to start producing the recipe locally.

"We are now importing coconut cream in packs from Southeast Asia. The director of business performance and management for the Group, Simon Mukajanga, stated, "Now we want to use technologies from there to replicate production at home."

According to him, the establishment of the factory would provide jobs for the unemployed individuals back home, "in line with what our government wants us to do".

He said that imports, primarily from Southeast Asian nations like Indonesia, account for 24% of the nation's consumption of coconut cream, calling this a "not viable in the long term" condition.

Mr. Mukajanga was one of several Tanzanian businessmen in Jakarta for Indonesia's annual Trade Expo, which concluded this past weekend.

Tanzania might manufacture the cream and sell it to its neighbors in addition to using it domestically.

"We have a labor force, a large number of customers, and an abundance of raw materials for the production of coconut kernels," he stated.

The business executive claimed that when he was in Indonesia, he approached companies that produced coconut cream about partnering on the project.

"The purpose of my visit to Indonesia is to investigate potential technological applications in Tanzania. Simba Group of Companies is interested in establishing a factory through a joint venture with a foreign counterpart."

Rich and flavorful, coconut cream can occasionally be found in vegan and ketogenic recipes as a replacement. It gives deserts a deeper flavor and texture.

Despite being derived from coconut milk and being regarded as a staple in many Southeast Asian nations, the cream is not the same as coconut milk.

Mr. Mukajanga noted that the project was motivated by customer demand and that his company plans to produce the coconut cream in two sizes, 65 milliliters and 200 milliliters. *(The People's Advocate)*

AGAIN, IKM IN PUHUWATO EXPORTS LARGE QUANTITIES OF PROCESSED VIRGIN COCONUT OIL, COOKING OIL, AND OILCAKE.

Outstanding accomplishment for Iradats Small and Medium-Sized Businesses (IKM). The IKM, which is situated in Soginti Village, Paguat District, Pohuwato Regency, Gorontalo, has once again sent quite a few processed goods in big numbers, including cooking oil, oilcake, and virgin coconut oil.

A total of 16 tons, valued at Rp, worth of processed IKM Iradats products belonging to "Iradat Bagi" will be shipped to the East Javan city of Surabaya 500 million.

This was found out after Suharai Igirisa, the Deputy Regent of Pohuwato, promptly released the consignment of processed goods.

Deputy Regent Suharsi Igirisa took the opportunity to congratulate the Pohuwato Regency's Department of Industry, Trade and Cooperatives, in particular, for its assistance in guiding MSMEs.

Every two months, he explained, these products—cooking oil, virgin coconut oil, and oilcake—may be provided.

We are able to ship this product every two months, which makes it remarkable. "In the future, I hope that the production of virgin coconut oil, cooking oil and cake can be further increased so that the national market we can reach will be wider," Suharsi added.

Finally, he expresses his hope that IKM Iradats would be able to grow swiftly in the future to satisfy the demands of the global market.

"Hopefully this will be the beginning of an activity that will benefit everyone, especially the people in Pohuwato Regency," he said, adding, "We hope that in the future this export will be sustainable and not stop now." *(Newsnesia)*

CREATING A NOVEL ECO-FRIENDLY FIBER USING COCONUT WATER

Zuzana Gombosoava, a Slovakian material researcher and fashion designer based in Kerala, has created a product that could serve as a substitute for animal leather during a time when sustainability is a hot topic. Her raw material, called Malai, is made from fermenting leftover water from mature coconuts and other plant materials.

After moving to Kerala five years ago, Zuzana started Malai Biomaterials Design Pvt. Ltd., a company that collects waste coconut water from coconut processing units in South India and uses it to grow 150–170 kg of (dry weight) cellulose, which is then refined to make the finished product. Malai is produced as sheets and comes in a variety of colors made with natural dyes that do not contain preservatives.

Malai is a fully organic, long-lasting, and water-resistant textile that is manufactured from nata de coco, a fermented product made from leftover coconut water, hemp, sisal, and banana stem fibers.

"We met in Mumbai in 2015 where I had already been working for over three years on bacterial cellulose as a material. I was keen to explore the potential of coconut in India for employing a traditional bacterial-cellulose growth process used in the Philippines, where "Nata de Coco" is an important part of the food industry." Susmith Suseelan is a product designer and maker from Kerala. This is how she began production of Malai.

"We began working with a coconut processing unit in Karnataka at first, and we relocated to Kerala in 2018 because of the state's favorable climate and perfect fermentation process temperature," the spokesperson stated.

After obtaining the product, her company is now aiming for the sustainable fashion industry; each month, about 200 square meters of raw materials are manufactured, at a cost of roughly Rs2,000–Rs4,000 per square meter.

"We have supplied materials to a couple of fashion startups which focus on sustainable brands and leather accessory manufacturers. Currently, we are working with a handful of brands and companies that are within the space of alternative materials, vegan products in sustainable fashion both within the country and overseas," the spokesperson stated.

"Our primary goal is to supply raw materials to companies, but we have also made some accessory materials like small bags and wallets for gifting," she continued.

Three billion square meters of leather are produced in India, but sadly, the process frequently pollutes the land, water, and air. "I think the industry is noticing," she added, explaining why there are more startups in the leather substitute space.

"We have so far conducted two crowd-funding campaigns - one in Europe and one in India and also received some grants, winning few competitions," Zuzana remarked when asked about finance for her firm. *(The Hindu Business Line)*

COCONUT SHELLS MAY INCREASE THE DURABILITY OF CONCRETE

Researchers have discovered that a mere 5% coconut shell can enhance the compressive and flexural strengths of concrete by 4.1% and 3.4%, respectively. 6.1% more efficacy was achieved with the material in comparison to clear concrete. This outcome can be attributed to the cement paste, which acts as a connecting element among all solid concrete particles, penetrating the cavities of the shell and establishing a strong bond with other constituents.

Significant quantities of coconut shell can be recycled without negatively impacting the environment or compromising the quality of construction materials, as demonstrated by these results. Publication of the findings from this study in the journal Materials.

Sustainable development necessitates the complete elimination of all refuse, but there are currently no logical processes for recycling plant residues. Scientists are therefore attempting to discover applications for them in other economic sectors. For example, plant residues may be utilized in the production of new building materials, though material scientists still don't have enough information on how building materials that contain organic matter are formed, e.g., concrete.

Don State Technical University researchers determined the impact of coconut shell on the characteristics of concrete. As a byproduct of coconut refining, coconut shell is either incinerated or discarded. Significant quantities of this natural raw material could be produced without the concern of depletion if we had mastered its utilization. The researchers examined the impact of substituting shell for crushed sandstone in a concrete mixture on the resultant composition's density and durability.

The maximum compressive and bending strengths were observed in concrete containing 5% coconut shell, as determined by the researchers. In addition, bending strength and compressive strength increased by 3.4% and 4.1%, respectively, in comparison to clear concrete. As an additional sealing component, the shell adhered securely to the cement mortar as a result of its surface roughness and porosity.

In addition, the weight of the concrete was decreased by the shell, which had a lower density than sandstone, resulting in a 6.1% increase in the coefficient of structural quality. This metric represents the material's strength-to-density ratio. However, as the proportion of shell increased to 30%, the strength of the concrete diminished by 41.4%. This transpired due to the considerably lower durability of coconut shell in comparison to sandstone.

"We intend to investigate the use of agricultural and aquaculture byproducts in the development of environmentally friendly concrete technology in the future." Concrete may, for instance, incorporate sunflower fiber or jellyfish. "Our researchers will increase their knowledge of the consistent characteristics of the structure, composition, and properties of novel varieties of concrete," explains Don State Technical University's prominent researcher and candidate of technical sciences, Sergey Stelmakh, associate professor. *(Tech Xplore)*

Table 1. WORLD Exports of Coconut Oil, 2017-2023 (MT)

COUNTRY	2017	2018	2019	2020	2021	2022	2023F
A. ICC Countries	**1,584,413**	**1,805,748**	**2,046,921**	**1,687,810**	**1,730,114**	**2,110,218**	**1,924,847**
F.S. Micronesia	87	57	-	-	-	-	-
Fiji	1,957	3,261	2,487	2,533	1,460	1,211	2,152
India	11,726	6,831	7,828	11,096	14,445	28,321	13,374
Indonesia	510,441	675,138	610,812	577,645	611,452	685,878	665,000
Jamaica	6	5	6	9	-	1	5
Kenya	55	36	44	55	655	215	177
Kiribati	1,359	3,493	3,561	2,517	1,829	1,528	2,381
Malaysia	102,735	121,914	223,078	203,362	186,608	134,871	148,000
Marshall Islands	1,524	2,229	1,085	1,115	402	709	1,177
Papua New Guinea	15,740	12,566	20,975	17,732	10,099	16,269	37,000
Philippines	912,631	951,320	1,146,642	842,533	881,085	1,219,792	1,020,000
Samoa	116	141	424	8	116	183	165
Solomon Islands	5,515	5,432	4,561	5,272	5,225	5,019	5,171
Sri Lanka	6,310	4,606	4,056	5,180	3,825	4,712	14,000
Tonga	-	-	-	-	-	-	-
Thailand	1,331	1,266	1,337	1,745	1,686	1,062	1,405
Vanuatu	2,543	3,669	3,498	1,367	711	428	2,036
Vietnam	10,337	13,784	16,527	15,641	10,516	10,019	12,804
B. Other Countries	**369,896**	**317,883**	**317,407**	**341,233**	**330,307**	**202,794**	**143,153**
TOTAL	**1,954,309**	**2,123,631**	**2,364,328**	**2,029,043**	**2,060,421**	**2,313,012**	**2,068,000**

F: Forcasted figures;   Source: ICC, ITC and Oil World

Table 2. Prices of Coconut Products and Selected Vegetable Oils, December 2022 – November 2023 (US$/MT)

Products	2022	2023										
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Copra	641	621	630	627	625	626	620	642	637	608	599	618
Coconut Oil	1,167	1,071	1,107	1,111	1,069	1,031	993	1,047	1,102	1,084	1,058	1,118
Copra Meal[2]	302	300	299	300	288	277	269	270	266	255	247	248
Desicc. Coconut[2]	1,947	1,874	1,874	1,874	1,874	1,828	1,690	1,690	1,690	1,690	1,690	1,690
Mattress Fiber[1]	48	42	36	45	51	49	46	48	51	51	57	57
Shell Charcoal[2]	377	370	368	357	350	345	342	351	350	339	335	354
Palm Kernel Oil	1,067	1,060	1,037	1,052	1,017	993	928	998	998	958	912	968
Palm Oil	940	1024	997	1070	1,005	934	817	879	861	830	804	830
Soybean Oil	1,409	1,409	1,752	1,533	1,030	988	1,007	1,136	1,127	1,112	1,134	1,118

1: Sri Lanka (FOB);   2: Philippines (FOB);   r: revised;   Source: ICC and Oil World

Table 3. World Oil Balance 2021-2023 (million tons)

Oil/Year	Oct-Sept 22/23[F]	Oct-Sept 21/22	Oct-Sept 20/21
Palm Oil			
Opening Stocks	15.04	12.69	12.46
Production	80.29	79.16	76.32
Imports	51.47	49.43	51.17
Exports	50.71	50.56	50.33
Disappear	80.61	75.68	76.93
Ending Stocks	15.49	15.04	12.69
Soybean Oil			
Opening Stocks	6.45	7.03	6.39
Production	59.16	59.54	60.22
Imports	11.89	12.24	13.53
Exports	11.43	12.61	13.76
Disappear	59.25	59.75	59.35
Ending Stocks	6.83	6.45	7.03
Groundnut Oil			
Opening Stocks	0.35	0.37	0.28
Production	4.32	4.68	4.41
Imports	0.36	0.36	0.41
Exports	0.35	0.39	0.35
Disappear	4.39	4.67	4.37
Ending Stocks	0.29	0.35	0.37
Sunflower Oil			
Opening Stocks	3.99	3.05	3.26
Production	22.14	20.09	18.95
Imports	14.01	11.58	11.09
Exports	13.89	11.60	11.09
Disappear	21.93	19.14	19.16
Ending Stocks	4.32	3.99	3.05
Rapeseed Oil			
Opening Stocks	3.43	3.42	3.22
Production	30.19	26.82	27.00
Imports	6.97	5.41	6.60
Exports	7.02	5.44	6.35
Disappear	29.53	26.78	27.04
Ending Stocks	4.03	3.43	3.42
Cotton Oil			
Opening Stocks	0.35	0.34	0.35
Production	4.37	4.37	4.45
Imports	0.13	0.16	0.13
Exports	0.12	0.15	0.14
Disappear	4.38	4.37	4.44
Ending Stocks	0.34	0.35	0.34

Oil/Year	Oct-Sept 22/23[F]	Oct-Sept 21/22	Oct-Sept 20/21
Palm Kernel Oil			
Opening Stocks	1.48	1.34	1.35
Production	8.36	8.24	7.96
Imports	3.19	2.96	3.34
Exports	3.23	3.19	3.24
Disappear	8.31	7.88	8.07
Ending Stocks	1.50	1.48	1.34
Coconut Oil			
Opening Stocks	0.46	0.38	0.44
Production	2.97	3.20	2.76
Imports	2.13	2.35	2.00
Exports	2.09	2.31	1.92
Disappear	3.07	3.15	2.89
Ending Stocks	0.40	0.46	0.38

Source: ICC and Oil World *F: forecast figures*