Volume 32 No. 2, 2025 ISSN 0854-5006

COCOINFO INTERNATIONAL

Sulfur Nutrition of Coconut

Trends in Climate Variability and Extreme Events

in Coconut Growing Agroecological Regions in Sri Lanka

Adoption of High-Yielding Coconut Hybrids in India

Innovative Coconut Products Enhancing the Circular Economy:

A Brief Review

GOMA®

FULLY AUTOMATED SCADA based rigorous CLEAN IN PLACE (C.I.P) SYSTEMS

Head Office:

GOMA GROUP OF COMPANIES

Wagle Industrial Estate,Thane, Maharashtra 400604

CONTACT: +91 9322654236 / 5/ 2

E: export.pte@goma.co.in | W: www.goma.co.in

GLOBAL PRESENCE

Nepal |Sri lanka |Bhutan |Bangladesh | Vietnam | Iran Indonesia |Malaysia |Malaysia | Egypt | Saudi|UAE | Kenya Tanzania |Tanzania | Ethopia | Nigeria | Australia| Oman

VOLUME 32 NO. 2, 2025 | ISSN 0854-5006

COCOINFO INTERNATIONAL

Photo by Đinh Trung Quân (Vietnam), World Coconut Day Competition

4 FROM THE EDITOR-IN-CHIEF

5 SULFUR NUTRITION OF COCONUT
K. S. Shanmugam

12 TRENDS IN CLIMATE VARIABILITY AND EXTREME EVENTS IN COCONUT GROWING AGROECOLOGICAL REGIONS IN SRI LANKA
K. V. N. N. Jayalath, P. Silva, D. Hemachandra, and J. Weerahewa

20 ADOPTION OF HIGH-YIELDING COCONUT HYBRIDS IN INDIA
Prabhat Kumar, B. Hanumanthe Gowda, and Raghuramreddy Yeswanth

24 INNOVATIVE COCONUT PRODUCTS ENHANCING THE CIRCULAR ECONOMY: A BRIEF REVIEW
N Sai Prasanna, Nilesh Choudhary, and K. S. M. S. Raghavarao

33 HIGHLIGHT OF THE 61ST ICC SESSION & MINISTERIAL MEETING
Otniel Sintoro, A. H. N. Chinthaka, and Bahari Ilmawan

39 EXPERTS' FINDING ON THE HEALTH BENEFITS OF COCONUT

42 COCONUT OIL IN 2026: A MARKET CAUGHT BETWEEN SHORT-TERM RELIEF AND LONG-TERM CONSTRAINT

45 COCO EVENTS

50 NEWS ROUND-UP

56 STATISTICS

Editor-In-Chief: Dr. Jelfina C. Alouw
Managing Editor: Otniel Sintoro
Associate Editor: A. H. N. Chinthaka

Advertising Manager: Alit Pirmansah
Circulation Manager: Klaudio D. Hosang
Layout & Design: Bahari Ilmawan

Cocoinfo International is a popular journal on the coconut industry published twice a year by the International Coconut Community (ICC)
8th Fl. BAPPEBTI Building,
Jl. Kramat Raya No. 172 Kenari, Senen
Jakarta 10430, Indonesia
P.O. Box 1343, Jakarta 10013
Phone: (62 21) 3100 556 to 557
Fax: (62 21) 310 1007

Email address: icc@coconutcummunity.org
Website: www.coconutcommunity.org

Queries and information regarding subscription and advertisement insertion rates should be directed to the above address.
Foreign subscription rates excluding airmail postage for one year (two issues) is US$ 35.00 (ICC Member) or US$ 40.00 (Non-ICC Member Countries)

@CoconutCommunity

International Coconut Community

Strategic Pathways to Global Competitiveness through Innovation and Productivity

The global coconut industry is currently navigating a profound structural transformation that redefines the "Tree of Life" for the modern age. In 2024, the global market for coconut products reached an estimated valuation of **USD 20.10 billion**, yet this figure represents only a fraction of our true potential. If we fully commit to the transition from raw nut exports to high-value-added derivatives, we are projected to double this market value within the next decade. This momentum is fundamentally driven by a paradigm shift in consumer behavior, where global markets now demand functional, bio-based, and sustainable alternatives across the food, cosmetic, and industrial sectors.

Innovation serves as the primary catalyst for this growth as we witness coconut-derived compounds entering highly sophisticated technical applications. For instance, **Cetyl Palmitate**, a lipid ester synthesized from coconut-derived cetyl alcohol and palmitic acid, has become an indispensable staple in premium dermo-cosmetics due to its superior emolliency and skin-barrier support. Simultaneously, the industry is breaking new ground in sustainable technology with **Bio-based Phase Change Materials (PCM)**. By integrating coconut oil into "smart" building materials, we can leverage its unique thermal properties to mitigate indoor temperature fluctuations. These thermally stable PCMs are proving essential in reducing residential cooling loads in tropical climates, positioning the coconut as a key player in the global green energy transition.

However, to sustain this escalating industrial demand, we must prioritize the optimization of our upstream supply chain. Recent scientific research identifies **Sulfur (S)** as a critical, yet frequently overlooked, limiting factor in coconut palm health. While nitrogen, phosphorus, and potassium (NPK) often receive the most attention, sulfur is essential for the synthesis of vital amino acids like cysteine and methionine, as well as for chlorophyll production. The economic implications of sulfur deficiency are severe, as a lack of this nutrient disrupts nitrogen metabolism and reduces the efficiency of all other applied fertilizers. This "hidden hunger" often manifests as chlorosis in younger leaves and stunted growth, ultimately leading to a sharp decline in copra weight and nut yield. By restoring the sulfur balance, we can significantly increase fruit yield and prevent the cascading economic losses that our agricultural sector can no longer afford.

Building on this foundation of precision nutrition, the adoption of **high-yielding coconut hybrids** remains our most potent tool for revitalizing aging plantations. Current data reveals a stark contrast in productivity, where superior hybrids can produce over **180–200 nuts per palm annually**, nearly doubling the output of traditional varieties. Transitioning toward a sustainable and high-productivity future requires a truly holistic approach that integrates these high-value product innovations with precision agronomy, integrated pest management, and accelerated replanting programs. A coordinated effort involving all stakeholders—from research institutions to government agencies—is essential to ensure that the coconut sector remains a cornerstone of the global bio-economy and a resilient, reliable source of income for millions of farmers worldwide.

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

Sulfur Nutrition of Coconut

K. S. Shanmugam[1]

Coconut is an exhaustive crop that demands a considerable quantity of plant nutrients to maintain its sustainable performance and high yield. Traditionally, coconut farmers have focused almost exclusively on the application of the primary macronutrients: Nitrogen (N), Phosphorus (P), and Potassium (K). While these are essential, the exclusive focus on them means that other vital nutrients are continuously taken up by the palms from the soil, thereby depleting soil reserves without replenishment.

This continuous extraction leads to severe deficiencies in the soil. Such a phenomenon is now occurring at an alarming rate with respect to sulfur (S), causing widespread sulfur deficiency in both the soils and palms of many coconut gardens. It is time to recognize sulfur not merely as a secondary additive, but as a critical component of palm health.

Sulfur in Soils

Generally, soils containing less than 20 kg/ha of available sulfur (10 ppm S) are classified as deficient in sulfur. These soils invariably respond positively to sulfur application, showing improved crop health and yield.In India, soil composition varies significantly by region. Black soils are generally richer in available sulfur (40–45 kg S/ha), meaning sulfur is rarely a limiting factor for crop production in these specific zones. However, Red soils, with a sulfur content of typically 15–20 kg S/ha, and Alluvial soils, with only 10–12 kg S/ha, are frequently found to be deficient. These soil types respond readily and rapidly to sulfur application.Light-textured sandy soils are particularly prone to sulfur deficiency. This vulnerability is due to their low organic matter content and their reduced ability to hold onto sulfate anions (SO_4^{2-}), leading to significant leaching. Furthermore, soils that are generally low in organic matter (containing less than 0.5% organic carbon)

Table 1. Nutrient uptake by coconut palm (kg)

	Particulars	Nutrients*					
		N	P	K	S	Ca	Mg
1.	Nutrient uptake (kg) by 150 palms, yielding 100 nuts per palm i.e. 15,000 nuts per hectare.	49	7	96	**4**	5	8
2.	Nutrient uptake (kg) by palms producing 6.7 tons copra:						
	A. By whole palms	174	20	250	**30**	70	39
	B. By Nuts only	108	15	193	**9**	9	15
3.	Nutrient uptake (kg) per ton of copra.	16.1	2.2	28.8	**1.3**	1.3	2.2

** Nutrients are in elemental form*
Source: Wichmann (1992)

are highly likely to suffer from sulfur deficiency. In these environments, low productivity is more often the rule rather than the exception. Therefore, the sulfur nutrition of coconut palms cannot be taken for granted and requires active management.

Sulfur in Plants

The importance of sulfur is not a modern discovery; the German botanist Julius von Sachs demonstrated as early as 1860 that sulfur is essential for the growth and development of plants. As an essential plant nutrient, sulfur performs specific, non-negotiable functions within plant physiology.

Some key functions of sulfur in plants

- **Protein production:** Sulfur is a vital constituent of three essential amino acids: cystine (27% S), cysteine (26% S), and methionine (21% S). These amino acids serve as the fundamental building blocks of plant proteins. Without adequate sulfur, protein synthesis is inhibited.
- **Chlorophyll formation:** Although sulfur is not a direct constituent of the chlorophyll molecule, it is absolutely required for its formation. Chlorophyll is the green substance in leaves and stems responsible for photosynthesis, the primary metabolic function of green plants.
- **Biosynthesis of oils:** Sulfur is widely known as the "master nutrient" for oil production in plants. It is crucial for oil-yielding crops like coconut and oil palm, directly influencing the quantity and quality of the oil produced.
- **Enzyme and Vitamin Synthesis:** Sulfur is required for the biosynthesis of vital bio-compounds such as vitamins (specifically Biotin and Thiamin), glutathione, Coenzyme A, sulfolipids, and ferredoxin.
- **Stress Resistance:** Sulfur facilitates the formation of certain disulfide linkages, such as the sulfhydryl (-SH) group, which imparts crop resistance to environmental stresses like drought and extreme cold.
- **Metabolic Processes:** Sulfur is required for the formation of ferredoxin, an iron-sulfur-containing plant protein that acts as an electron carrier in the photosynthetic process and is also involved in biological nitrogen fixation.

Sulfur is associated with the production of crops that possess superior nutritional value and market quality. It is absorbed by plant roots primarily in the sulfate form (SO_4). Plants generally contain between 0.2% and 0.4% sulfur by tissue weight. Crucially, sulfur is relatively immobile within the plant, meaning the plant cannot easily move it from older leaves to newer ones, though it is mobile in the soil. The sulfur use efficiency in most crops is found to be approximately 10%.

As a plant nutrient, sulfur is becoming increasingly important in global agriculture, particularly in India. Increasing incidences of sulfur deficiency and positive crop responses to sulfur application are being reported from various parts of the country (Shanmugam, 2023). Consequently, sulfur is now recognized as the **Fourth Major Plant Nutrient**, taking its place alongside Nitrogen (N), Phosphorus (P), and Potassium (K).

Sulfur deficiency in coconut

Sulfur deficiency in coconut was first reported in 1959 by Baseden in Papua New Guinea. Shortly after, in 1960, Velasco et al. described the specific deficiency symptoms exhibited by young coconut palms grown in sand culture where sulfur was omitted. Southern (1967) further investigated sulfur deficiency by

Figure 1. Coconut leaves with severe deficiency of sulfur

conducting extensive field experiments in Papua New Guinea, illustrating the field symptoms with detailed color photographs. He recommended an application of 2 pounds (900 grams) of sulfur per palm to ameliorate the deficiency (Southern, 1969).

Since those early studies, sulfur deficiency in coconut has been reported in several countries, including the Ivory Coast, Madagascar, the Pacific Islands, the Comoro Islands, Mozambique, the Philippines, Indonesia, and Sri Lanka.

It is a paradox that sulfur deficiency in coconut has not been widely reported in India, despite the fact that all the causes of sulfur deficiency exist there. Many other crops in the region respond to sulfur application, confirming the prevalence of suboptimal levels of available sulfur in the soils. Systematic research on the "Sulfur nutrition of coconut" has rarely been attempted in India, leading to a database that is almost nonexistent. Even basic data regarding sulfur uptake and removal for coconuts in India is scarce.

A survey of coconut-growing tracts in Kerala, conducted in 1975, indicated that the sulfur content of the 14th leaf of the palm ranged from 0.10% to 0.16%. These values were well below the optimum level of 0.19% sulfur (Cecil and Khan, 1993). That survey strongly suggested the high probability of sulfur deficiency in coconut palms in Kerala, likely manifesting as "hidden hunger"—a state of deficiency without obvious visual symptoms.

Sulfur deficiency symptoms in coconut palms

Crop plants, including coconut, suffering from sulfur deficiency exhibit characteristic symptoms that are visible to the naked eye. However, because sulfur is immobile in the plant, these symptoms usually appear on the younger leaves first.

1. Coconut seedlings
In sulfur-deficient coconut seedlings, the youngest leaves are the worst affected. The color of the leaves varies from a pale green, transitioning through yellow, to a yellowish-orange. in severely affected seedlings, the leaves become necrotic (dead tissue), and without intervention, many seedlings will eventually die.

2. Young Coconut palms
In sulfur-deficient young palms, the length of leaves emerging after field planting is significantly shorter than normal. There is often abnormally early splitting of the leaflets. The leaf color ranges from yellow to

orange. The tips of the leaflets become gray, necrotic, and curled. This necrosis spreads rapidly all over the leaf, which eventually dries out completely. Growth in young palms essentially stops, and the palms remain stunted (Southern, 1967; Ollagnier & Ochs, 1972).

3. Adult Coconut palms

In adult palms, chlorosis and yellowing appear first in the oldest leaves and gradually spread to other leaves in the crown. The color of the leaves ranges from bright yellow to vivid orange. In individual leaflets, chlorosis starts from the tips and rapidly extends until the whole leaflet, including the midrib, becomes chlorotic.

The leaf size is drastically reduced. Abnormal arching of leaves appears prematurely because the midrib becomes weak and pliant. There is a marked tendency for sulfur-deficient palms to retain their dead leaves for more than a year. These dead leaves hang around the stem like a skirt or apron. The number of leaves in the crown is fewer than normal. The remaining live leaves are shorter in length and tend to stand in a stiff, upright position. A constriction is often seen in the stem diameter (penciling).

Regarding the fruit, nut production decreases significantly. The nuts are few and small. There is a high rate of premature nut fall, particularly of button-sized nuts (Ohler, 1999; Southern, 1960). While matured nuts may appear to have normal kernel thickness, upon drying, the kernel collapses into a thin, soft, flexible, and leathery copra. This is often brown and is usually referred to as "rubbery copra." This copra possesses poor physical and chemical qualities, particularly a very low oil content (often as low as 38%). This rubbery copra readily absorbs moisture, leading to rapid microbial deterioration (Southern, 1967).

Hidden hunger of sulfur deficiency

"Hidden hunger" in plants is a nutrient-deficient condition that depresses plant yield without showing clear visual symptoms (Wahid, 1984). This is the "iceberg effect" of nutrition; the visible damage is small, but the invisible damage to yield is massive.

In the coconut palm, hidden hunger occurs when the sulfur content in the 14th leaf is less than the optimum level of 0.19% S, but still above the critical level of 0.13% S where visual symptoms appear. It can be presumed that a vast number of coconut palms in India suffer from this hidden hunger, which has likely been overlooked due to the absence of dramatic visual cues.

Causes of Sulfur deficiency in India

It is now well established that sulfur deficiency is widespread in Indian soils and crops. Several factors contribute to this growing issue:

1. Increased uptake of sulfur by crops

The uptake of plant nutrients, including sulfur, is a function of crop growth and yield (Shanmugam, 2023). The average yield of coconut in India has increased from 5,238 nuts per hectare in 1950-51 to 9,018 nuts per hectare in 2022-2023. These increased yields have invariably increased the uptake of sulfur from soils, depleting soil sulfur reserves considerably over the years. With the production of over 20,535 million nuts annually, the coconut crop in India removes an estimated 5,476 tonnes of sulfur from the soil every year.

2. Use of sulfur-free fertilizers

In earlier decades, when Ammonium Sulfate and Superphosphate were the major sources of fertilizers, sulfur deficiency rarely occurred, as these fertilizers supplied 24% and 12% sulfur, respectively, as an incidental nutrient. With the large-scale shift toward high-concentration, sulfur-free fertilizers like Urea and Diammonium Phosphate (DAP), the incidental supply of sulfur has been reduced drastically (Shanmugam, 2023).

Research by S. K. Das and N. P. Datta showed that with the continuous use of sulfur-free fertilizers, soil sulfur reserves plummet. In their study, after the harvest of the 6th crop, the soil reached a deficient level, and the 7th crop began responding to sulfur application (Das & Datta, 1973). This finding serves as a stark warning regarding the imminent danger of relying solely on Urea and DAP.

The Mozambique lesson: This phenomenon is not unique to India. Due to a change in fertilizer policy, coconut planters in Mozambique switched to Urea from Ammonium Sulfate. As long as planters used Ammonium Sulfate (24% S), no symptoms of sulfur deficiency appeared. However, once Urea became the standard, leaf color turned yellow and orange, accompanied by numerous fungal lesions (Ohler, 1999). A similar situation now prevails in India due to fertilizer subsidy policies favoring Urea and DAP over sulfur-containing alternatives.

3. Low organic matter content of Indian soils

Soil organic matter acts as a warehouse for soil sulfur; approximately 50–90% of soil sulfur is found

Table 2. Extent of sulfur deficiency in Southern States

State	Percentage of soil samples in the category of		
	Low[1]	Medium[2]	High
Kerala	81	18	1
Tamil Nadu	26	41	33
Karnataka	43	32	25
Andhra Pradesh	56	34	10

[1&2] Soils of 'Low' and 'Medium' categories respond well to sulfur application
Source: FAI (2014)

Table 3. Sulfur status of soils

Soil sulfur category	Sulfur content
Low	Less than 7.5 mg S / kg soil
Medium	7.5 – 15.0 mg S / kg soil
High	More than 15 mg S / kg soil

within organic matter. Indian soils are invariably poor in organic matter because the hot tropical climate facilitates rapid decomposition and prevents high accumulation. Moreover, continuous cultivation with repeated tillage destroys soil organic matter through increased mineralization. This paucity of organic matter is aggravated by a reduction in the use of organic manures. In the early 1970s, 70% of cattle dung in India was used for manuring, but this has dropped to roughly 30% in recent years.

4. Leaching and erosion losses
Because of its anionic nature and high solubility, sulfate sulfur (SO_4) is highly susceptible to leaching. These losses are generally large, especially in coarse-textured soils (e.g., the coastal soils where coconut is predominantly grown) and in high rainfall areas (e.g., Kerala). Sulfur losses through erosion in India are estimated at 130,000 tonnes annually (Tandon, 2011).

5. Multi-story mixed cropping
The wide plant spacing of 7.5m x 7.5m and the specific canopy architecture of coconut palms permit multi-story, mixed cropping. Intercrops like banana, pineapple, cacao, and pepper remove significant quantities of sulfur from the soil, further aggravating the deficiency in the main coconut crop.

6. Higher deficiency in southern states
The extent of sulfur deficiency is found to be higher in the four southern states, which account for 90% of the coconut area and 93% of coconut production in the country. This regional concentration of deficiency is a major threat to the nation's overall coconut economy.

Diagnostic tests for sulfur deficiency

To manage nutrition effectively, accurate diagnosis is required.

1. Soil test for sulfur deficiency
Soil sulfur extracted by means of a 0.15% Calcium Chloride ($CaCl_2$) extractant provides a good correlation with sulfur uptake by plants. Hence, this method is commonly used for estimating plant-available sulfur. The sulfur status of soils are categorized as presented in Table 3.

Soils of 'Low' and 'Medium' sulfur category respond well to sulfur application. 10-13 mg sulfur per kg soil is found to be critical for optimum plant growth.

2. Plant test (leaf analysis)
Leaf analysis is accepted as the most reliable method for detecting nutrient deficiencies in perennial crops like coconut. Magat et al., studying sulfur deficiency in the Philippines, determined that the critical level and optimum level of sulfur content in the 14^{th} leaf are **0.13% S** and **0.19% S**, respectively (Ohler, 1999). It is important to note that the optimum level of sulfur depends on the nitrogen nutrition of the palm, as these two nutrients are intimately linked. The Nitrogen:Sulfur (N:S) ratio in coconut foliage should ideally be between 10:1 and 13:1.

3. Nut water test
Southern (1969) discovered that the sulfate content of nut water acts as an excellent indicator of sulfur deficiency. He reported that deficiency symptoms appeared when the sulfate content of nut water was less than 10 ppm S. No symptoms appeared when the content was above 20 ppm S.

Table 4. Sulfur content of some organic manures

No.	Organic manure	Nutrient content (%)			
		Sulfur	N	P_2O_5	K_2O
1.	Farmyard manure	**0.13**	0.50	0.30	0.50
2.	Neem cake*	**1.40**	5.20	1.00	1.40
3.	Mustard cake	**0.68**	4.50	1.80	1.40
4.	Cowpea green manure	**0.37**	0.71	0.15	0.58

** Among the oil cakes, Neem cake has the highest content of 1.40% sulfur.*

Management of sulfur nutrition

Organic manures

Soil sulfur is an integral constituent of soil organic matter, which serves as a slow-release source for crops. It is imperative to increase soil organic matter through the regular application of Farm Yard Manure (FYM), compost, or green manures. Results from Long Term Fertilizer Experiments (LTFE) reveal that annual application of FYM helps maintain soil sulfur status.The official recommendation from the Coconut Development Board in India is the regular application of organic manures at the rate of **25–50 kg per palm per year**, applied with the onset of monsoon rains. This improves the organic sulfur status, which is then released as inorganic sulfate (SO_4) upon mineralization.

Mineralization of organic sulfur: Plants cannot absorb organic sulfur directly; it must be converted to inorganic sulfate anions. This process, known as mineralization, proceeds best when the carbon:sulfur ratio is less than 200, soil moisture is at 60% of field capacity, and soil temperature is around 40°C. The presence of specific microorganisms, such as *Thiobacillus thiooxidans*, is necessary to facilitate this conversion.

Biofertilizers

Thiobacillus thioxidans is a sulfur-solubilizing bacterium that oxidizes sulfur in the soil into inorganic sulfate (SO_4) for easy absorption. These bacteria are isolated, cultured, and supplied as biofertilizers (e.g., "Symbion S"). Coconut farmers can use these biofertilizers to enhance the efficiency of sulfur uptake.

Sulfur content of some of the fertilizers

Improvement of leaf sulfur content and maintenance of leaf sulfur level at 0.20 to 0.23% in the 14th leaf of coconut palm due to regular application of sulfur containing fertilizers are observed (Cecil & Khan, 1993).

Guidelines for consideration

1. **Dosage:** Application of **300 grams of sulfur per palm per year**, along with regular NPK fertilization, is recommended.
2. **Synergy:** Due to the synergistic interaction between sulfur and nitrogen, combined application increases the uptake of both. Fertilizers like Ammonium Sulfate are preferable as they supply both nutrients simultaneously, helping maintain the optimum N:S ratio.
3. **Avoidance:** Continuous exclusive application of sulfur-free fertilizers like Urea and DAP should be avoided.
4. **Alternatives:** In the absence of sulfur-containing NPK fertilizers, apply **phosphogypsum** at the rate of 2 kg per palm per year.
5. **Supplements:** Application of neem cake (3–5 kg/palm/year) and FYM (30–50 kg/palm/year) is highly recommended.
6. **Drainage:** Sulfur availability is reduced in waterlogged soils. Therefore, drainage facilities in coconut gardens must be improved to ensure root zone aeration and nutrient uptake.

Conclusion

The current fertilizer recommendations for coconut crops are often dangerously confined to Nitrogen (N), Phosphorus (P), and Potassium (K). The continued application of NPK alone depletes soil sulfur reserves, leading to inevitable deficiency.

The causes are clear: the declining use of sulfur-containing fertilizers, the dominance of urea, increased crop removal due to higher yields, and the naturally low organic matter of Indian soils. These factors suggest a high probability that sulfur deficiency—specifically hidden hunger—is already prevalent in Indian coconut palms.

Table 5. Sulfur content of some of the fertilizers

No.	Organic manure	Nutrient content (%)			
		Sulfur	**N**	**P_2O_5**	**K_2O**
1.	Ammonium sulfate	**24**	20.6	0.0	0.0
2.	Superphosphate	**12**	0.0	16.0	0.0
3.	Ammonium phosphate sulfate	**13-15**	20.0	20.0	0.0
4.	Potassium sulfate	**18**	0.0	0.0	50.0
5.	Magnesium sulfate	**12**	0.0	0.0	0.0
6.	Agrl. grade mined Gypsum	**13-15**	0.0	0.0	0.0
7.	Phosphogypsum*	**18-20**	0.0	0.5-1.2	0.0

** Phosphogypsum is a by product from phosphate fertilizer factories. It is a high grade gypsum and is better than agricultural grade mined gypsum because of its higher purity of 90-95%, finer particle size of 100 mesh and higher sulfur content of 18-20%. Agricultural grade mined gypsum has a purity of 60-70%, particle size of 30 mesh and sulfur content of 13-15%. Phosphogypsum is preferable for sulfur nutrition of crops.*

It is high time to formally include sulfur at the rate of **300 grams per palm per year** in the State-level General NPK Fertilizer recommendations. Although the specific database on sulfur deficiency in coconuts may be meager, the ominous signs indicate that this is a "creeping sickness" in the industry. Unless appropriate action is taken, sulfur deficiency will become a major yield-limiting factor. This will not only cause a decline in production but will also reduce the efficiency of other applied nutrients, resulting in economic losses that the agricultural sector cannot afford.

[1] *Consultant Agronomist, Velachery, Chennai - India*

REFERENCES

Cecil, S. R., & Khan, H. H. (1993). Nutritional requirement of coconut and coconut based farming systems in India. In M. K. Nair, H. H. Khan, P. Gopalasundaram, & E. V. V. B. Rao (Eds.), *Advances in Coconut Research and Development* (pp. 257–275). Oxford & IBH Publishing Co. Pvt. Ltd.

Das, S. K., & Datta, N. P. (1973). Sulfur fertilisation for increased production and grain quality. *Fertilizer News*, 18(9), 3–10.

The Fertilizer Association of India (FAI). (2014). *Fertilizer Statistics 2013-14*.

Foale, M. (2003). *The coconut odyssey: the bounteous possibilities of the tree of life* [ACIAR Monograph No. 101]. Australian Centre for International Agricultural Research.

Ohler, J. G. (1999). *Modern coconut management: palm cultivation and products*. Intermediate Technology Publications.

Ollagnier, M., & Ochs, R. (1972). Sulfur deficiencies in the oil palm and coconut. *Oléagineux, 27*(4), 193–198.

Shanmugam, K. S. (2023). Sulfur nutrition of sugarcane. *Indian Journal of Fertilizers, 19*(2), 144–150.

Southern, P. J. (1967). Sulfur deficiency in coconuts, a widespread field condition in Papua and New Guinea. I. The field and chemical diagnosis of sulfur deficiency in coconuts. II. The effect of sulfur deficiency on copra quality. *Papua New Guinea Agricultural Journal, 19*, 18–37.

Southern, P. J. (1969). Sulfur deficiency in Coconuts. *Oléagineux, 24*(4), 211–220.

Tandon, H. L. S. (2011). *Sulfur in Soils, Crops and Fertilizers from Research to Practical Application*. Fertilizer Development and Consultation Organisation.

Wahid, P. A. (1984). Diagnosis and correction of nutrient deficiencies in coconut palm. *Journal of Plantation Crops, 12*(2), 98–111.

Wichmann, W. (1992). *IFA World Fertilizer Use Manual*. BASF AG.

Photo by Abdulla Faiz on Unsplash

Trends in Climate Variability and Extreme Events in Coconut Growing Agroecological Regions in Sri Lanka

K. V. N. N. Jayalath[1], P. Silva[2], D. Hemachandra[2], and J. Weerahewa[2]

The coconut industry is a key contributor to the Sri Lankan economy, where coconut is one of the major plantation crops covering an area of over 0.4 million ha (Department of Census and Statistics, 2015). Coconut, the legendary "Tree of Life", is important due to its contribution to the gross domestic product, domestic food security, exports and employment through its different harvestable components or derivatives. In Sri Lanka, and many coconut-producing countries, it is clear that coconut production is competing with other land uses in attracting and retaining investment and justifying resources to maintain the viability of existing coconut groves. Traditionally, coconut cultivation was concentrated in the area known as the "Coconut Triangle" in the north-western portion of Sri Lanka, spanning from north of Colombo from the west to Kurunegala in the Central west and linking back to Puttalam on the north-western coast. However, with increasing pressure on land due to rapid urbanization in this region the relative profitability of coconut as an economic land use is threatening, although ecologically it is the most favoured for coconut cultivation in Sri Lanka.

Hence, the local authorities have focused on expanding coconut into non-traditional areas over the past decades. According to the latest agricultural census, these efforts have succeeded to the point that the expansion is greater in the non-traditional coconut growing areas when compared to the traditional coconut growing areas (General Report Economic Census 2013/14, 2018). The traditional Coconut Triangle includes agroecological regions of the Low-country Wet zone (LW) and the Low-country Intermediate zone (LI). The non-traditional coconut growing areas include Low-country Dry zone (LD) and Mid-country Wet zone (MW).

The yield of coconut is determined by the combination of genetic and environmental factors along with the level of management, soil conditions, pests and diseases affecting coconut cultivation (Menon & Pandalai, 1958). Variety is the main genetic factor that determines the yield of coconuts. The widely grown coconut variety in Sri Lanka is the "Sri Lankan Tall". The average number of bunches produced by the palm within a year is genetically determined and it is 12-14 bunches per year for the Sri Lankan Tall variety.

The full expression of the above genetic potential of a coconut palm to produce its full yield is dependent upon the environment, primarily on weather and management. Rainfall, rainfall distribution and temperature are considered as the most important weather factors, while fertilizer application and soil water management are the most important management practices. To perform optimally, the coconut palm requires a well-distributed rainfall of 1,500-2,300 mm/year, a mean temperature of 27-29°C with a diurnal variation of 5-7°C and 2,000 sunshine hours per year with at least 120 h per month (Child, 1964; Mahindapala & Pinto, 1991). Variations from these optimum climatic conditions result in variations in growth and reproductive performance owing to effects on different palm physiological parameters. Hence, variations from optimum growing conditions result in suboptimal yield performance in commercial coconut plantations. The abiotic factors namely rainfall, maximum temperature and drought cause the main effects on the sustainability of coconut production.

It is found that coconut yield increased with increasing rainfall in the Low-country Dry Intermediate zone (Peiris & Peries, 2010). A strong positive relationship is present between annual mean rainfall and the nut yield of coconut (Rani et al., 2021). Climatic information has been used to predict coconut production (Peiris & Kularatne, 2008). An increase in both minimum and maximum ambient temperature and a decrease in rainy days are observed in many districts of Sri Lanka (Marambe et al., 2013; Premalal & Punyawardena, 2013). However, studies related to trends in climate variables in these non-traditional coconut-growing areas are lacking. Daily rainfall and air temperature for Hambantota district in the Low-country Dry zone was analysed and revealed that the expected future climate would not be suitable for coconut cultivation (Peiris & Kularatne, 2008). Hence it is important to find out whether the trend in climatic variables favours coconut production specially in non-traditional coconut growing areas. Hence, this study attempts to explore the trends of rainfall and temperature and extreme events in agroecological regions of WM_{3b}, DL_3 and DL_5 of Sri Lanka. The objectives of this study are;

(a) assessment of temporal monotonic trends in daily rainfall and temperature,
(b) assessment of temporal monotonic trends in seasonal rainfall and temperature, and
(c) trends in extreme events based on extreme event indices using non-parametric trend analysis technique of Mann Kendall trend test and Sen's slope.

METHODS OF ANALYSIS AND DATA

Trends and variability in precipitation (Karpouzoz et al., 2010; Portmann et al., 2009) and temperature have been studied to explore climate changes. This study examines trends in rainfall and temperature in agro-ecological regions of WM_{3b}, DL_3 and DL_5 of Sri Lanka.

Trend analysis in daily and seasonal rainfall and temperature

The trends were estimated using statistical tests. Parametric and non-parametric tests are performed in trend detection and analysis. However, outliers and missing data, which are frequently encountered in meteorological data, adversely affect normality and homogeneity of variance. Hence, non-parametric tests have the advantage over parametric tests for data series that are non-normally distributed and have outliers and missing data. In addition, the time series nature of data may violate some of the assumptions and may give rise to the problems of autocorrelation and heteroscedasticity. In general, this is an undesirable property for many statistical estimations. In meteorological time series data, autocorrelation in observed variables and unobserved error term is possible. Presence of autocorrelation makes the standard errors to be incorrect and therefore the usual hypothesis testing and confidence intervals also become incorrect.

Considering the above limitations, Mann-Kendall (MK) trend test (Kendall, 1962; Mann, 1945) were used to assess long-term upward or downward trends and their magnitude in observed climatic variables. This test is widely applied to statistically detect the long-term trend in meteorological time series (Brunetti et al., 2001; De Silva & Sonnadara, 2009; Duc et al., 2019). This is a non-parametric and rank-based test; hence assumptions for distributional properties are not required. The test also allows autocorrelation (Hamed & Rao, 1998). The test calculates Kendall's Tau statistic and tests the null hypothesis that no monotonic trend exists in the data series under investigation. When the

Table 1. Selected agriculture-specific extreme climate indices used for the analysis

Type	Short Name	Long Name	Description	Unit
Temperature base	TX	Maximum temperature	Warmest daily TX	°C
	TN	Minimum temperature	Minimum daily TN	°C
	Tx95t	Very warm day	Value of 95^{th} percentile of TX	°C
	SU35	Very hot days	Annual number of days when TX >= 35°C	Days
Rainfall base	R95p	Very wet days	Annual total rainfall exceeds 95^{th} percentile	mm
	R95pToT	Contribution from very wet days	Percentage of rainfall of 95^{th} percentile to total rainfall	%
	R99p	Extreme wet days	Annual total rainfall exceeds 99^{th} percentile	mm
	R99pToT		Percentage of rainfall of 99^{th} percentile to total rainfall	%
	R5mm	Number of customized rain days	Annual number of days when rainfall >= 5mm	Days
	SPEI	Standard Precipitation Evapotranspiration Index	Measure of drought on time scale of 3 and 6	Unit less

Table 2. Geographical characteristics of meteorological stations

Station	Latitude	Longitude	Altitude (m)	Ageo-ecological zone
Hambantota	6.12°N	81.13°E	15.5	Low-Country Dry Zone (DL_5)
Matale	7.47°N	80.62°E	365	Mid-Country Wet Zone (WM_{3b})
Jaffna	9.68°N	80.03°E	3	Low Country Dry Zone (DL_3)

Source: Department of Meteorology, Sri Lanka

trend parameter is significant, the rate of change can be calculated using Sen's slope (Sen, 1968) estimate. Sen's slope is expressed as the change in the response variable per unit change in time. The unit depends on the unit of the response variable and the time unit. MK trend test and Sen's slope are widely used for trend analysis in climate variables (Da Silva et al., 2015; Das et al., 2022; Diress & Bedada, 2021). In this study trend analysis was done using R software package (R version 4.1.0).

Trends in daily rainfall and minimum and maximum ambient temperature were analyzed. There are four main seasons in Sri Lanka namely i) First Inter Monsoon (FIM), ii) Southwest Monsoon (SWM), iii) Second Inter Monsoon (SIM) and iv) Northeast monsoon (NEM). Trends in rainfall and temperature in each season were also analyzed.

Extreme event analysis

Extreme climate indices developed by the World Meteorological Organization Commission for Climatology (CCI) Expert team on Sector-specific Climate Indices (ET-SCI) were used for the analysis. Extreme events were analyzed using six indices of extreme precipitation, five indices of extreme temperature and two indices of drought. In addition, two user-defined indices, i.e.

i) Very hot days when maximum temperature equal or exceeds 35°C (SU35) as beyond this temperature pollination of coconut is affected and thereby the coconut production is affected,
ii) Number of days when rainfall is more than or equal to 5 mm, as it the average daily rainfall for better growth and production were used. The

Table 3. Percentage of missing data 1961-2015

Station	**Percentage of missing data**		
	Rainfall	**Maximum Temperature**	**Minimum Temperature**
Hambantota	0.25	0.32	0.77
Matale	0.05	39.06	37.56
Jaffna	0.41	31.69	31.53

Table 4. Descriptive statistics with standard deviation of variables in base and analysed periods

District	**Period**	**RF (mm)**			**Tmax (°C)**				**Tmin (°C)**			
		Mean	**SD**	**Max**	**Mean**	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**
Hambantota	1961 - 1990	3.1	9.9	296.9	30.3	1.5	23.5	36.1	24.2	1.2	19.1	29.8
	1991 - 2015	3.1	10.1	181	31.1	1.6	23.0	37.0	24.5	1.3	18.5	32.6
Jaffna	1961 - 1990	3.22	12.19	253.4	30.37	1.52	23.4	36.7	25.4	1.95	18.3	37.2
	1991 - 2015	3.70	14.21	389.8	31.13	1.58	23	36.8	25.58	2.54	23	36.8
Matale	1961 - 1990	4.86	12.21	180	30.4	1.60	19.2	39.4	21.37	1.76	11.9	30
	1991 - 2015	5.24	13.24	268.3	30.8	1.94	21	38.2	20.95	1.99	9	28

indices developed by the World Meteorological Organization are applied to empirical studies (Bhattacharyya et al., 2022; Ogolo & Matthew, 2022). ClimPACT2 software package was used for the analysis (Alexander & Herold, 2016). The selected agriculture-specific extreme climate indices are presented in Table 1.

Data and Data Sources

Daily rainfall, daily maximum ambient temperature and daily minimum ambient temperature data of DL_5 (Hambantota), WM_{3b} (Matale) and DL_3 (Jaffna) agroecological regions for the period 1961-2015 were obtained from the Department of Meteorology of Sri Lanka. World Meteorological Organization has defined 'climate normal' as a three-decade average of meteorological parameters including temperature and precipitation. Hence, average rainfall and temperature for 1961-1990 were considered 'climate normal', representing long-term climatic conditions and calculating anomalies based on these values. The locations of the meteorological stations are presented in Table 2.

Missing data were a significant issue specially with temperature data in Jaffna and Matale. It is as high as nearly 30 to 40 per cent. The percentage of missing data for each station is presented in Table 3. Missing data for Jaffna and Matale were computed by stochastic imputation in R software employing Multivariate Imputation via Chained Equations (MICE) package which uses predictive mean matching.

RESULTS AND DISCUSSION

Table 4 presents the descriptive statistics of the three variables, rainfall (RF), maximum temperature (Tmax) and minimum temperature (Tmin) during the periods of 1961-1990 (base period) and 1991 – 2015. Minimum rainfall is zero and it is not presented in the table.

Results of trend analysis of daily rainfall and temperature

The trends in daily rainfall and temperature in the three selected agroecological regions are presented in Table 5. In DL_5 daily rainfall showed a declining trend while no significant trend was observed in WM_{3b} and DL_3. Maximum temperature showed an increasing trend in DL_5 and DL_3 while minimum

Table 5. Results of the trend analysis for daily rainfall and temperature

Station	Variable	tau value	p-value	Sen's slope	95% CI for Slope
DL_5	Rainfall	-0.0238	0.00*		
	Maximum temperature	0.212	0.00*	0.00081	7.8e-04 to 8.5e-04
	Minimum temperature	0.101	0.00*	0.000032	2.88e-05 to 3.47e-05
WM_{3b}	Rainfall	0.006	0.0.51	-	-
	Maximum temperature	0.08	0.10	-	-
	Minimum temperature				
DL_3	Rainfall	0.008	0.11	-	-
	Maximum temperature	0.20	0.0	0.00008	
	Minimum temperature	0.009	0.66	-	-

temperature in DL_5 showed an increasing trend. In summary, there is no trend in daily rainfall and the temperature in WM_{3b}. In contrast in DL_5 daily rainfall showed a declining trend while maximum and minimum temperatures showed an increasing trend. The Sen's slope for maximum temperature is 0.00081 which indicates that maximum temperature is increased by 0.00081°C per day in DL_5. In DL_3 only maximum temperature showed an increasing trend.

Results of trend analysis of seasonal rainfall and temperature

Table 6 represents the results of the trend analysis. In DL_5, the trend in rainfall is significant only during the SWM while other seasons have no trend. In SWM rainfall in DL_5 shows a significant declining trend. Maximum and minimum temperatures in DL_5 have shown a significant increasing trend in all four seasons. A decrease in rainfall and an increase in temperature would make the DL_5 towards unfavourable conditions for the growth of coconuts. In WM_{3b}, significant changes in rainfall and temperature are observed in FIM. Rainfall and maximum temperature are increased while minimum temperature is at a decreasing trend during FIM. In addition, the minimum temperature is at decreasing trend during NWM. An increase in maximum temperature may affect coconut production. However, the impacts may be lower due to an increase in rainfall. The effect of minimum temperature is lowest for coconut production. In DL_3, rainfall shows an increasing trend in FIM and SWM while it is a declining trend in SIM. Maximum temperature is in increasing trend in all seasons except FIM. Minimum temperature is in a decreasing trend in FIM. Maximum temperature is in an increasing trend in all three agroecological regions. An increase in maximum temperature may affect pollen germination and pollen tube growth (Ranasinghe, 2017). The analysis showed that no agroecological region showed a significant trend in rainfall in NEM. This same phenomenon is observed in other studies (Alahacoon & Edirisinghe, 2021).

Results of extreme event analysis

Table 7 shows the results of the extreme event analysis, In DL_5, Maximum and minimum temperatures showed an increasing trend indicating a warming trend. The number of days that equal or exceed 35°C suggested an increasing trend indicating unfavourable conditions for coconut cultivation. None of the extreme event indices related to rainfall is significant. Both three-month time SPEI and SPI showed a decreasing trend. These two indices are drought indicators. In WM_{3b}, no significant trend was observed for any indices except a negative trend in Tx95t and a positive trend in the 6-month SPI but no trend in 6-month SPEI. Results obtained for SPEI do not necessarily match with results obtained for SPI. In DL3, an increasing trend is observed in minimum and maximum temperatures while a decreasing trend is shown in Tx95t. None of the other indices showed a trend.

CONCLUSIONS

This study attempted to investigate changes in daily seasonal rainfall, and maximum and minimum temperature for agroecological regions DL_5, WM_{3b} and DL_3 for the period of 1960- 2015 during four main seasons. Maximum temperature is in an increasing

Table 6. Results of the trend analysis of seasonal rainfall and temperature

Agroecological region	Variable	Season	tau value	p-value	Sen's slope	95% CI for Slope
DL_5	Rainfall	FIM	0.028	0.77	-	-
		SWM	-0.191	0.04*	2.21	-4.54 to -0.11
		SIM	0.009	0.92	-	-
		NEM	0.023	0.81	-	-
	Tmax	FIM	0.541	0.00*	0.028	0.020 to 0.035
		SWM	0.574	0.00*	0.027	0.020 to 0.035
		SIM	0.508	0.00*	0.026	0.018 to 0.034
		NEM	0.647	0.00*	0.033	0.025 to 0.041
	Tmin	FIM	0.302	0.00*	0.013	0.005 to 0.019
		SWM	0.335	0.00*	0.011	0.005 to 0.017
		SIM	0.424	0.00*	0.014	0.008 to 0.019
		NEM	0.426	0.00*	0.015	0.008 to 0.022
WM_{3b}	Rainfall	FIM	0.223	0.02*	2.62	0.521 to 4.67
		SWM	-0.07	0.48	-	-
		SIM	0.02	0.87	-	-
		NEM	0.063	0.50	-	-
	Tmax	FIM	0.482	0.00*	0.048	.036 to 0.062
		SWM	0.185	0.05	-	-
		SIM	0.113	0.22	-	-
		NEM	-0.06	0.52		
	Tmin	FIM	-0.273	0.00*	-0.013	-0.022 to 0.004
		SWM	0.109	0.25	-	-
		SIM	-0.013	0.89	-	-
		NEM	-0.467	0.00*	-0.043	-0.053 to 0.034
DL_3	Rainfall	FIM	0.32	0.00*	5.13	1.67 to 10.98
		SWM	0.373	0.00*	4.64	2.39 to 6.87
		SIM	-0.466	0.00*	-11.96	-16.23 to -8.78
		NEM	-0.044	0.64	-	-
	Tmax	FIM	0.115	0.22	-	-
		SWM	0.633	0.00*	0.035	0.022 to 0.046
		SIM	0.435	0.00*	0.027	0.018 to 0.036
		NEM	0.298	0.00*		
	Tmin	FIM	-0.346	0.00*	-0.034	-0.034 to -0.01
		SWM	0.116	0.217	-	-
		SIM	0.053	0.57	-	-
		NEM	-0.012	0.91	-	-

trend in all three agroecological regions. An increase in maximum temperature may affect pollen germination and pollen tube growth hence leading to a reduction in coconut production. Changes in minimum temperature may not significantly affect coconut production as mostly in Sri Lanka minimum temperature is not a limiting factor for coconut production. Trends in rainfall have shown mixed results. Warming trends were revealed in extreme event indices related to temperature. Trends in none of the indices related to rainfall are significant in all three locations. In drought indices, SPI 3-month

Table 7. Results of extreme event analysis

Indices	Slope	DL_5 p-value	Trend	Slope	WM_{3b} p-value	Trend	Slope	DL_3 p-value	Trend
TXx	0.003	0.0*	Positive	0.002	0.472	No	0.002	0.0*	Positive
TXn	0.002	0.0*	Positive	-0.001	0.124	No	0.002	0.0*	Positive
Tx95t	0.0	0.543	No	-0.002	0.0*	Negative	0.007	0.0*	Nega-tive
SU35	0.112	0.011*	Positive	0.111	0.18	No	0.016	03.3	No
R5mm	-0.142	0.073	No	0.086	0.559	No	0.158	0.143	No
R95p	0.129	0.475	No	2.75	0.207	No	1.974	0.512	No
R95pToT	0.155	0.134	No	0.085	0.324	No	0.027	0.643	No
R99p	1.035	0.354	No	2.247	0.161	No	0.571	0.798	No
R99pToT	0.106	0.084	No	0.086	0.212	No	0.024	0.645	No
R5mm	-0.142	0.073	No	0.086	0.559	No	0.158	0.143	No
SPEI 3 months	-0.001	0.0*	Negative	0.0	0.611	No	0	0.179	No
SPEI 6 months	0.0	0.059	No	0.0	0.85	No	0	0.182	No
SPI 3 months	-0.001	0.0*	Negative	0.0	0.1	No	0	0.384	No
SPI 6 months	0.0	0.06	No	0.007	0.047*	Positive	0	0.489	No

showed a negative trend in DL_5 and 6-month SPI showed a positive trend in WM_{3b}. Hence, growers should be encouraged to adopt soil and moisture conservation measures in their coconut lands.

ACKNOWLEDGEMENT

This research was funded by the Coconut Research Institute (CRI) of Sri Lanka. Comments from Dr C. S. Ranasinghe, Director, CRI, are greatly appreciated. Support extended by Dr. I. M. S. K. Idirisinghe, Deputy Director of Research, CRI is kindly acknowledged. Dr. N. P. A. D. Nainanayake, Former Head and Suranga Wickkramaarachchi, Experimental officer, Plant Physiology Division, CRI is highly esteemed for providing climate data.

[1] *ISL Services Singapore Pte. Ltd., Singapore and Sri Lanka*

[2] *Faculty of Engineering, University of Peradeniya, Sri Lanka*

REFERENCES

Alahacoon, N., & Edirisinghe, M. (2021). Spatial Variability of Rainfall Trends in Sri Lanka from 1989 to 2019 as an Indication of Climate Change. *ISPRS International Journal of Geo-Information, 10*(2), 84.

Alexander, L., & Herold, N. (2016). ClimPACT2, *Indices and Software: A document prepared on behalf of the Commission for Climatology (CCI) Expert Team on Sector-Specific Climate Indices (ET-SCI)*. World Meteorologica Organization.

Bhattacharyya, S., Sreekesh, S., & King, A. (2022). Characteristics of extreme rainfall in different gridded datasets over India during 1983–2015. *Atmospheric Research, 267*, 105930.

Brunetti, M., Maugeri, M., & Nanni, T. (2001). Changes in total precipitation, rainy days and extreme events in northeastern Italy. *International Journal of Climatology, 21*(7), 861–871.

Child, R. (1964). *Coconuts*. Longmans.

Da Silva, R. M., Santos, C. A. G., Moreira, M., Corte-Real, J., Silva, V. C. L., & Medeiros, I. C. (2015). Rainfall and river flow trends using Mann–Kendall and Sen's slope estimator statistical tests in the Cobres River basin. *Natural Hazards, 77*(2), 1205–1221.

Das, L. C., Mohiul Islam, A. S. M., & Ghosh, S. (2022). Mann-Kendall Trend Detection for Precipitation and Temperature in Bangladesh. *International Journal of Big Data Mining for Global Warming, 4*(1), 2250001.

De Silva, G. J., & Sonnadara. (2009). Climate change in the hill country of Sri Lanka. *Proceedings of the Technical Sessions, 25*, 7–12.

Diress, S. A., & Bedada, T. B. (2021). Precipitation and temperature trend analysis by Mann Kendall test: The case of Addis Ababa methodological station, Addis Ababa, Ethiopia. *African Journal on Land Policy and Geospatial Sciences, 4*(4), 517–526.

Duc, K. N., Ancev, T., & Randall, A. (2019). Evidence of climatic change in Vietnam: Some implications for agricultural production. *Journal of Environmental Management, 231*, 524–545.

General report economic census 2013/14: Agricultural activities, Sri Lanka. (2018). Department of Census and Statistics, Ministry of National Policies and Economic Affairs.

Hamed, K. H., & Rao, A. R. (1998). A modified Mann-Kendall trend test for autocorrelated data. *Journal of Hydrology, 204*(1–4), 182–196.

Karpouzoz, D. K., Kavalieratou, S., & Babajimopoulos, C. (2010). Trend analysis of precipitation data in Pieria Region (Greece). *European Water, 30*, 31–40.

Kendall, M. G. (1962). *Rank correlation methods*. Hafner Publishing Company.

Mahindapala, R., & Pinto, J. L. J. G. (1991). *Coconut cultivation*. Coconut Research Institute.

Mann, H. B. (1945). Nonparametric Tests Against Trend. *Econometrica, 13*(3), 245–259.

Marambe, B., Pushpakumara, D. K. N. G., Silva, P., & Weerahewa, J. (2013). Climate change and household food security in homegardens of Sri Lanka. *Proceedings of the International Conference on Climate Change Impacts and Adaptation for Food and Environmental Security*, 87–100.

Menon, K. P. V., & Pandalai, K. M. (1958). *The Coconut Palm: A Monograph*. Indian Central Coconut Committee.

Ogolo, E. O., & Matthew, O. J. (2022). Spatial and temporal analysis of observed trends in extreme precipitation events in different climatic zones of Nigeria. *Theoretical and Applied Climatology, 148*(3–4), 1335–1351.

Peiris, T. S. G., & Kularatne, J. D. J. S. (2008). Assessment of Climate Variability for Coconut and Other Crops: A Statistical Approach. *CORD, 24*(1), 35–53.

Peiris, T. S. G., & Peries, R. R. A. (2010). Effects of bimonthly rainfall on coconut yield in the low country intermediate zone (IL) of Sri Lanka. *COCOS, 9*, 01–11.

Portmann, R. W., Solomon, S., & Hegerl, G. C. (2009). Spatial and seasonal patterns in climate change, temperatures, and precipitation across the United States. *Proceedings of the National Academy of Sciences, 106*(18), 7324–7329.

Premalal, K. H. M. S., & Punyawardena, B. V. R. (2013). Occurrence of extreme climatic events in Sri Lanka. *Proceedings of the International Conference on Climate Change Impacts and Adaptation for Food and Environmental Security*, 49–57.

Ranasinghe, C. S. (2017). Climate change impacts on coconut production and potential adaptation and mitigation measures: A review of current status. *Proceedings of the Workshop on Present Status of Research Activities on Climate Change Adoptions*, 71–82.

Rani, S., Maheswarappa, H. P., & Sudhalakshmi, C. (2021). Impact of temperature and rainfall on production and productivity of coconut. *Indian Journal of Horticulture, 78*(3), 287–291.

Sen, P. K. (1968). Estimates of the Regression Coefficient Based on Kendall's Tau. *Journal of the American Statistical Association, 63*(324), 1379–1389.

Adoption of High-Yielding Coconut Hybrids in India

Prabhat Kumar[1], B. Hanumanthe Gowda[2], and Raghuramreddy Yeswanth[3]

The coconut crop is majorly cultivated in coastal states of India, faces significant productivity challenges due to widespread cultivation of old, senile palms and local varieties. India ranks among the top global coconut producers, a majority of output is from southern states like Karnataka, Tamil Nadu, and Kerala. To address the prevailing low productivity, the adoption of high-yielding coconut hybrids has emerged as a promising strategy. The hybridization in India was initiated in the 1930s, has led to the release of 19 region-specific hybrids, exhibiting high yield, earlier flowering, and enhanced copra quality compared to traditional varieties. Hybrids like Chandra Sankara and Kera Sankara have demonstrated increased copra yields, while others, such as Kera Sankara and Chandra Laksha are drought tolerance and Kalpa Sankara provides resistance to root wilt disease. The challenges such as limited availability and higher costs of certified seedlings, the need for improved management practices, lack of awareness, slow replanting rates have hinder widespread adoption. The Coconut Development Board and other stakeholders played a crucial role to overcome these challenges through enhanced seedling production and distribution, financial support for replanting, and extension programs to realize the full potential of hybrid coconuts in transforming India's coconut sector towards greater productivity and economic sustainability.

Coconut (*Cocos nucifera*), often hailed as the "Tree of Heaven" or Kalpavriksha, is one of the most versatile and economically significant crops cultivated in tropical and subtropical regions globally. Coconut is grown in more than 93 countries throughout the tropics and subtropics, with an

Table 1. Coconut Hybrids released in India

Hybrids	Source population of parents	Important traits	Nut yield (Ha/year)	Copra yield (T/Ha/Year)	Area recommended
Chandra Sankara	COD x WCT	High yield	20,532	4.27	Kerala, Karnataka, Tamil Nadu
Kera Sankara	WCT x COD	High yield, drought tolerant	19,116	3.78	Kerala, Karnataka, Maharashtra, Andhra Pradesh
Chandra Laksha	LCT x COD	High yield, drought tolerant	19,293	3.76	Kerala, Karnataka
Kalpa Samrudhi	MYD x WCT	Dual purpose variety	20,744	4.35	Kerala, Assam
Kalpa Sankara	CGD x WCT	Tolerant to root (wilt)	14,868	3.20	Root (wilt) disease prevalent tracts
Laksha Ganga	LCT x GBGD	High yield	19116	3.73	Kerala
Ananda Ganga	ADOT x GBGD	High yield	16815	3.63	Kerala
Kera Ganga	WCT x GBGD	High yield	17700	3.56	Kerala
Kera Sree	WCT x MYD	High yield	23364	5.05	Kerala
Kera Sowbhagya	WCT x SSAT	High yield	23010	4.49	Kerala
VHC-1	ECT x MGD	High yield	21240	2.87	Tamil Nadu
VHC-2	ECT x MYD	High yield	25134	3.74	Tamil Nadu
VHC-3	ECT x MOD	High yield	27612	4.47	Tamil Nadu
Godavari Ganga	ECT x GBGD	High yield	18585	2.79	Andhra Pradesh
Konkan Bhatye	GBGD x ECT	High yield	20532	3.47	Maharashtra
Kalpa Ganga	GBGD x FJT	High yield & for ball copra	21417	3.38	Karnataka
Vasista Ganga	GBGD x PHOT	High yield	22125	3.88	Andhra Pradesh, Karnataka
VPM-5	LCT x CCNT	High yield	28497	4.22	Tamil Nadu
Kalpa Sreshta	MYD x TPT	High yield, Dual purpose for copra and tender nut	29227	6.28	Kerala, Karnataka

annual production of around 65674 million nuts obtained from an area of 12.257 million hectares with productivity of 5,440 nuts per hectare (CDB.2021). About 74.47 per cent of the global production of coconut comes from three countries, viz., the India (31.10 per cent), Philippines (22.07 percent) and Indonesia (21.29 percent). In India, coconut is cultivated majorly in 10 states and five union territories with southern states account for 91 per cent of country's coconut production, viz., Karnataka (28.78%), Tamil Nadu (28.50%), Kerala (25.84%) and Andhra Pradesh (7.99%) CDB 2023-24.

In India coconut sector is facing the problem of low productivity as 1/3rd of total area is under cultivation with old and senile palms and planting of local varieties from unknown mother palms. The productivity can be increased by cultivation of improved varieties is more economical in coconut. The

Figure 1. Photographs depicting different High-Yielding Coconut Hybrids in India

breeding methods like introduction, selection and hybridization, with necessary modifications have been successfully employed for yield improvement in coconut. In India, hybridization programme was initiated in the year 1932, at the Coconut Research Station, Nileshwar, and milestone in the hybridization of coconut on hybrid vigour in the progeny with parentages West Coast Tall and Chowghat Green Dwarf and later started in other coconut cultivating countries.

Hybrids are the inter-varietal crosses of two morphological forms of coconut. They show earliness in flowering, higher nut yield as well as higher quantity and better quality of copra when compared to the parents. When the tall is used as female and dwarf as male, they are all called T x D hybrids, while the reciprocals are known as D x T hybrids.

The horticultural research stations, Agricultural Universities, CPCRI and AICRP on palms have So far released 19 hybrids for cultivation across different states. The released hybrid varieties of coconut have a yield potential of 2.79 to 6.28 tonnes of copra per ha per year in comparison to 2 tonnes of copra yield realized by the tall, Drought tolerant, Root wilt. The release of the varieties and states recommended for cultivation is given below.

The adoption of these high-yielding coconut hybrids is a important to overcome the productivity challenges in the Indian coconut sector. As indicated in Table 1, several hybrids have been developed and recommended for cultivation in key coconut-producing states. Some of hybrids, Chandra Sankara (COD x WCT) and Kera Sankara (WCT x COD) are recommended for high yield in Kerala, Karnataka, and Tamil Nadu, demonstrating a potential copra yield of 4.27 and 3.78 tonnes per hectare per year, respectively. The development of drought-tolerant hybrids like Kera Sankara and Chandra Laksha (LCT x COD) is particularly important for regions facing water scarcity and Kalpa Sankara (CGD x WCT) have been specifically for tolerance to root wilt disease.

The adoption of hybrids coconut varieties in India is to boost coconut production and improve farmer incomes. These hybrids, developed through selective breeding, combine high yield potential with disease resistance, making them a popular choice for local farmers. The yield potential of these hybrids often significantly exceeds that of local varieties. The early bearing nature of hybrids allows Farmers to realize returns on their investment earlier compared to traditional tall varieties.

The adoption of high-yielding coconut hybrids in India is challenged by limited availability and higher cost of certified seedlings, management practices, insufficient farmer awareness and extension services, the slow rate of replanting, and the requirement for region-specific hybrid suitability. The adoption of hybrids, varies across regions and is influenced by several factors, including awareness, cultural practices, and government incentives. The CDB plays a crucial role in enhancing the production and distribution of quality seedlings and subsidizing seedling costs. Strengthening extension activities through awareness campaigns and training programs. Subsidy for the replanting of old palms. The comprehensive and coordinated efforts are vital for realizing the full potential of hybrid coconuts in transforming India's coconut sector towards higher productivity and greater economic sustainability for its farmers.

Conclusion

The adoption of high-yielding coconut hybrids is crucial for addressing the productivity challenges in India's coconut sector. The hybrids developed and recommended for cultivation by different research institutions, so farmers can benefit from theses hybrids that offer superior yields, drought resilience and disease resistance, significantly enhancing copra production. But challenges such as limited seedling availability, high costs, and slow replanting rates hinder widespread adoption. To overcome these, Coconut Development Board (CDB), research institutions, and government agencies are actively working to strengthen seedling production, provide financial support, and expand extension services. A coordinated effort involving all stakeholders is essential to adopt hybrids, enabling India's coconut sector to transition toward higher productivity, improved farmer incomes, and long term economic sustainability.

[1] *Chief Executive Officer, Coconut Development Board, Head Office, Kochi, Kerala*
[2] *Chief Coconut Development Officer, Coconut Development Board, Head Office, Kochi, Kerala*
[3] *Development Officer, Coconut Development Board, State Center, Junagadh, Gujarat*

Innovative Coconut Products Enhancing the Circular Economy: A Brief Review

N Sai Prasanna[1], Nilesh Choudhary [1], and K. S. M. S. Raghavarao[1]

Coconut tree, respected as the "tree of life" (Kalpa vriksha) and now cultivated in various tropical and subtropical areas around the world (Prasanna et al., 2024). Coconuts have good economic value as every part of it useful in many ways. Essential nutrients, minerals and vitamins are present in edible parts of coconut. Coconut-based products play a significant role in advancing a circular economy by maximizing resource utilization and minimizing waste, thus fetching maximum market value (Muriuki et al., 2024). This made the coconut processing industries, entrepreneurs and stakeholders focus more on product diversification, industrial utilization of by-products, and their value addition.

The four main products of coconut – fresh coconut kernel, coconut water, dried copra and coconut sap have been processed into various value-added products. Adoption of novel food processing technologies produces variety of advanced products from coconut. The latest processing methods also enhances the quality, marketability, and acceptability of both conventional and new coconut products. Development of new and variety of coconut-based products offers significant benefits for local communities and by utilizing every component of coconut contributes to the circular economy of processing industries. Here the innovative coconut products detailed in brief, that can make a difference.

COCONUT MILK BASED PRODUCTS

Coconut milk

Coconut milk is an oil-in water emulsion expelled from fresh coconut endosperm (10 – 11 months of maturity) and plays an important role as flavour enhancer in the culinary foods all over the world. Based on fat content and water percentage, coconut milk further classified into light

Coconut milk (left) and coconut cream (right)

coconut milk, coconut milk concentrate, high-fat coconut cream. Significant quantity of water is removed to create a thicker coconut milk product, which can be reconstituted again with water before use. Such product called as 'coconut milk concentrate' (Lu et al., 2024). Coconut milk is packed in storage cans and commercially sold in market. During storage and transportation, coconut will naturally separate into two (aqueous and cream) phases, thus limiting its applicability and marketability. Stability of coconut milk improved by reducing its droplet size through various emulsification techniques such as homogenization, ultrasonication, and microfluidization, along with the use of either natural or synthetic emulsifiers and stabilizers (For example, tea saponins, polyoxyethylene, sorbitan monostearate, guar gum, xanthan gum, gellan gum, whey protein, Tween 80, lecithin, sodium carboxymethyl cellulose, etc. techniques) (Thirukumaran et al., 2023).

Coconut cream

Coconut milk allowed to settle naturally or centrifuged to obtain thicker 'coconut cream' which have a high fat content of more than 20% (FAO, 2022). Coconut cream had good sensory quality; however, its stability and shelf life need to be ensured. Such high fat coconut-based cream can be used as plant-based high-fat ingredient in non-dairy food applications (Nimbkar et al., 2023). Coconut cream gets solidified under refrigerated environment, and whipped into a delightful vegan cream for topping desserts and beverages (Lu et al., 2024).

Coconut yogurt

This is a novel dairy product obtained from homogenized coconut milk and left for fermentation with starter culture containing Lactobacillus and/or Streptococcus strains (3% w/v). The fermentation develops characteristic tangy flavor and thicker consistency of coconut yoghurt. Fermentation is stopped in coconut yogurt by blast chilling at 10°C for 2 h and then stored at 4°C (Kumar et al., 2025; Lu et al., 2024).

Coconut Milk Kefir

The kefir grains soaked in cow milk and inoculated with Lactobacillus kefiranofaciens (2–5%) for 2 weeks and later the grains are washed. These kefir grains are transferred to coconut milk and fermented at room temperature for ~24 h and strained to remove kefir grains, followed by storing at refrigeration temperature. This fermented coconut milk beverage had viscous consistency, distinct sour smell and creamy taste similar to that of liquid yogurt or buttermilk (Kumar et al., 2025).

Coconut Cheese

Coconut milk blended and added with rennet, other microorganisms and salt; and this allowed to gel formation, whey expulsion, acidification and ripening. A non-dairy cheese developed by varying different compositions of coconut milk and soy milk (80:20; 70:30; 60:40) by direct acidification using lemon

Virgin coconut oil (left) and encapsulated VCO (right)

juice for lactose-intolerant individuals (Kumar et al., 2025; Lu et al., 2024).

VIRGIN COCONUT OIL-BASED PRODUCTS

Virgin coconut oil (VCO)

Fresh and mature coconut kernels expelled for coconut milk (emulsion) and destabilized into the oil phase (VCO) and whey (aqueous phase) through different wet processing methods such as centrifugation, freezing–thawing followed by centrifugation, fermentation and enzymatic treatment followed by centrifugation (Raghavendra & Raghavarao, 2010, 2011). (Prasanna et al., 2024) discussed production of VCO through recent methods such as ultrasonication, mega-sonication, microwave treatment, supercritical fluid extraction, etc. VCO being valued as a healthy functional food due to its due to its medium chain fatty acids (mainly lauric acid) and biological activities, thus the demand for VCO kept on rising day-by day. VCO-based formulations such as oleogels, emulsions, and encapsulated powders are being developed for functional food applications.

VCO-based oleogels

VCO based oleogels are robust gel network that are formed by incorporating gelators like stearic acid, natural waxes, etc. Oleogels improved oil binding capacity and stability, and enhances their functional properties (Thomas et al., 2023). VCO based oleogels also incorporated with natural compounds (such as lycopene) and found to offer healthier alternatives to traditional fats and trans-fats (Syed & Ahmed, 2025).

VCO-based emulsions

Emulsions is a mixture of two immiscible liquids, with VCO as oil phase and water as continuous phase. Emulsions leverage the unique properties of VCO, such as its high lauric acid content enhancing its functionality and stability. VCO based emulsions ease direct incorporation of VCO into food products and gained significant attention, particularly in drug delivery, antimicrobial formulations, etc (Prasanna et al., 2024).

Encapsulated VCO powders

Encapsulation technique provides a protective barrier around VCO with natural polymers as wall materials. This technique increases its dispersibility, oxidative stability, and bioavailability. These encapsulated powders extended the shelf life of VCO and also increased the convenience in functional food applications (Prasanna et al., 2024).

Enriched VCO

VCO can be used as a green solvent to extract bioactive compounds from natural sources such xanthone, a-mangosteen, g-mangosteen from mangosteen pericarp, sitosterol from green coffee, carotenoids from seaweeds, etc., Such enriched VCO could be directly

Coconut vinegar (left) and nata de coco (right)

applied in functional food formulations and cosmetic ingredients (Prasanna et al., 2024).

COCONUT WATER-BASED PRODUCTS

Tender coconut water (TCW) regarded as natural drink due to its natural electrolytes, essential minerals (like calcium, copper, iron, phosphorous, potassium, magnesium, sodium, and zinc), vitamins (B1, B2, B3, B5, B6, B7, B9, and C), nutritional value and low calories. It has immense rehydration potential, reduces hypertension and high blood pressure. Although, TCW has become the fastest-growing beverage in many other countries, TCW has less durability (24–36 h) after removing from green coconut. TCW is filtered and packaged in aluminium cans, pouches and bottles which were sold as 'bottled coconut water' and had storage life of 6 months in refrigerated conditions (Rolle, 2007). TCW has been minimally processed through methods such as thermal treatments i.e., pasteurization, sterilization (carried between $60\text{-}100^{0}C$). However, such processed TCW has altered its natural flavor and sensorial quality (after taste) which severely limited consumer acceptability. Karmakar & De (2017) developed hollow fibre membranes used in ultrafiltration to obtain cold sterilized TCW. Lamdande et al. (2020) developed ultrasound-assisted ultrafiltration for obtaining cold sterilized TCW. Development of the membrane process has the potential to sterilize TCW at cold conditions without affecting their nutritional and sensorial quality.

Mature coconut water (MCW) is a major by-product of during wet processing of coconut for products like VCO, coconut milk, desiccated coconut, etc and its disposal often causes environmental pollution. Thus, developing new products from MCW improves its value addition and also promotes waste reduction through redistribution, recycling, and valorization. MCW can be concentrated and subsequential dried for frozen concentrates and coconut water powder.

- **Coconut vinegar:** MCW contains about 2.5-3.0% sugars and converted to fermented liquids (coconut vinegar) with relevant bacterial cultures (Muralidharan & Jayashree, 2011). Fermentation process preserves the vinegar quality and suitable for up-scaling. Coconut vinegar is rich in antioxidants and known to have therapeutic properties such as anti-obesity and cholesterol reduction (Malakul et al., 2022).
- **Coconut water beverages:** MCW added with antimicrobial agents (like niacin, ascorbic acid, and citric acid) and other ingredients like stevia, turmeric, lemon or calamansi to produce coconut water beverages (Aba & Luna, 2024; Sumonsiri, 2019).
- **Nata de coco and packaging material:** Nata de coco is a traditional dessert produced by fermentation of MCW (Muralidharan & Jayashree, 2011). It is widely used ingredient in various beverages and desert making in many countries. This product has good amount of edible polysaccharides (cellulose) which are of high purity and having high tensile strength and good biocompatibility, thus can be a potential biodegradable plastic material (Fei et al., 2024). Thus, MCW also can be utilized for making edible food packaging

Coconut protein powder (left) and sap produced from influorescence (right)

materials, and also contributing towards environmentally sustainability (Barlina et al., 2023; Rahmayanti et al., 2024).

COCONUT (WHEY) PROTEIN POWDER

Coconut whey (coconut skim milk, and insoluble protein) is a rich source of proteins with total protein content of 29.9% (coconut skim milk) and 16.0% (insoluble solid residues) (Thaiphanit & Anprung, 2016). It can be used as emulsifiers, emulsion stabilizers, foaming agents, dietary supplements, etc. Recovery of coconut proteins leads to the value addition of coconut whey obtained in VCO processing industries. Thus, recovery and utilization of coconut proteins are an intriguing topic contributing to the circular economy by offering alternative sources of protein and environmental sustainability as well (Prasanna N. et al., 2024).

Coconut protein powder (CPP) is rich in essential amino acids, making it a valuable and alternative source of plant-based protein, vegan, or dairy-free diets, protein supplements, baked goods and snacks. Prasanna N. et al. (2024) discussed the various isolation methods for coconut proteins, and their functional and health benefits as well. Ultrafiltration has been explored to separate coconut protein from coconut whey. The retentate collected after ultrafiltration spray dried to get concentrated CPP with protein content (45.49% w/w), carbohydrates (34±3.8% w/w), and fat content (9.49% w/w) (Vijayasanthi et al., 2020).

OTHER COCONUT PRODUCTS

Coconut sap

Coconut sap is a fascinating and potential component for creating value-added products in the context of a circular economy. It is obtained by cutting coconut inflorescence (mature spadix) and serves as re-freshing drink or non-alcoholic beverage with a naturally sweet taste. In India, due to its potential health benefits, tapping of coconut sap increased the income of those farmer communities growing coconut plants and, as well exporting to countries like Canada, South Korea, USA, Norway, France, Japan, Australia, and the Middle East has also emerged. In Thailand, juice from coconut sap mixed with coconut water, canned and sold as non-alcoholic beverages or flavoured (with watermelon or pineapple) beverages (Saraiva et al., 2023). Coconut sap can be fermented to produce alcoholic beverages like coconut wine or vinegar.

Coconut sap evaporated to produce coconut sugar or syrup which can be used as natural and un-refined sweetener in various culinary applications. Coconut sugar have nutrient-rich sugar crystals and tastes similar to regular table sugar. It was reported to have a glycaemic index value of 35 and can be a better choice of healthier sugar in comparison with processed sugarcane sugar or palm sugar (Asghar et al., 2020). Small holder farmers, stakeholders and local communities can benefit from the cultivation and processing of coconut sap, and development of new products such as coconut sugar, coconut

Copra meal cake (left) and biofuel made from coconut waste (right)

vinegar, beverages, etc., from it providing more economic opportunities.

Coconut waste

Repurposing of coconut waste or by-products obtained during processing holds transformative potential for a circular economy through developing new products and increasing a company's competitiveness. The coconut husk contains moisture (3.10% w/w), cellulose (48.45% w/w), hemicellulose (16.19% w/w), lignin (26.04% w/w), extractives (8.92% w/w) and ashes (3.6% w/w) (Romão et al., 2022). Many strategies have been reported for valorising lignocellulosic fractions of coconut by-products/ residues and being used for civil constructions, manufacturing of adsorbent materials and filters, bio-oils, bio-char, briquettes and organic fertilizers (Clasen et al., 2022; Vieira et al., 2024). Through the biotechnological interventions, coconut waste is being emerged as a potential energy source for producing biofuels, such as bioethanol, butanol, bio-gas, bio-coke (D'Almeida & de Albuquerque, 2025). Coconut husk residues subjected to slow pyrolysis temperature range of 400-700°C to produce bio-oil and bio-char with yields of 31 and 30%, respectively (Romão et al., 2022). Bio-char is a black coloured carbon-rich and highly porous material with high degree of aromatization and strong anti-decomposition properties. Biochar produced from waste coconut husk and shells through methods such as pyrolysis, gasification and carbonization (Ajien et al., 2023). Thus, utilizing the lignocellulosic composition of coconut waste or by-products such as coconut coir, coconut husk, coconut shells and coconut cake/ residue can be converted to high-value bio-based materials contributing to circular economy of coconut processing industries and also to environmental sustainability.

Pressed coconut cake

After extraction of coconut oil at industrial processing, the dry copra meal as by-product and mainly composed of carbohydrates (39–43%) and proteins (18–25%). Such defatted coconut kernel/ endosperm composed of food-grade fiber and thus can be sufficient source to isolate polysaccharides and oligosaccharides (Yalegama et al., 2023). On incorporating plasticizers (like glycerol, coconut oil, cashew shell oil), copra meal is converted into bio-thermoplastics (such as cups and plates) and packaging films with properties comparable to synthetic plastics by compression moulding process. These bio-thermoplastics are inexpensive, safe for human consumption and can replace single-use plastics in food packaging and non-food material applications (Reddy et al., 2024).

Coconut oil as bio-lubricants

Vegetable oils such as coconut oil emerged as one of the potential and environmentally friendly alternatives to traditional lubricants (Abeysundara et al., 2001; Jayadas et al., 2007; Uppar et al., 2023). The intravenous use of coconut oil as a lubricant is an emerging area of interest due to its favourable physicochemical properties. Coconut oil blended with additives or nanoparticles make them work as nano-lubricants and provided better lubrication performance, reduced wear and tear in metal forming processes (Abdurahiman & Sajeeb, 2019; Hettiarachchi et al., 2023). Coconut oil as bio-lubricants and coolants can minimize hazardous waste generated, reduce health problems like skin irritation, etc., associated with the use of mineral oils in industries, machinery, and engine oil applications (Afonso et al., 2023). In future, the automotive and aerospace industries will grow drastically and expected major consumers of bio-lubricants from vegetable sources. As a result, it is anticipated that the market for coconut oil used for lubrication purpose would expand, presenting new opportunities for the stakeholders involved in the coconut industry.

Coconut Testa

Coconut testa (brown outer skin of coconut kernel) is a byproduct of the coconut flour, coconut milk and VCO processing process, and has least optimally utilized. Coconut testa peeled out from coconut endosperm, dried, and extracted for testa oil. Such coconut testa oils are rich in medium-chain fatty acids and high phenolic contents than coconut oil, thus emphasizing the untapped nutritional potential of the testa oils. Thus, coconut testa can be utilized for commercial production of testa oil and further explored for developing antioxidant-rich nutrient products, functional food and pharmaceutical applications (Shunmugiah Veluchamy et al., 2023).

After extraction of testa oil, the defatted residues utilized as coconut testa flour. Gunarathne et al. (2024) examined the prebiotic characteristic of coconut testa flour and can be used as functional food ingredients in developing stable food products (Ramya et al., 2023). For example, defatted flour (20% w/w) can be used as to replace wheat flour in unleavened bread or roti preparation which reported to enhance nutritional qualities with acceptable sensory attributes (Pathirana et al., 2023).

CONCLUSION

Due to its remarkable versatility, each part of the coconut, from kernel to husk, contributes significantly to various industries, reflecting its status as a cornerstone of both local and global economies. The advancements in processing technologies have unlocked a plethora of innovative coconut-based products, ranging from coconut milk and cream to VCO-based oleogels and emulsions, all of which are driving both economic value and nutritional security. The development of diverse products such as coconut yogurt, kefir, and coconut protein powders, alongside novel applications like coconut vinegar and biodegradable packaging materials, illustrates the vast potential of coconut by-products in enhancing food security and environmental sustainability. Focusing on research and development efforts on a diverse range of possibilities for value addition of coconut products is crucial for identifying impactful solutions and to bring enough profits to coconut processing industries. The limited research on stakeholder interactions within the coconut value chain still remains a challenge and also hindering the effective collaborative strategies for maximizing value.

The emphasis on maximizing coconut utilization and minimizing waste aligns with the principles of a circular economy, offering substantial benefits to local coconut communities. Furthermore, the transformative reuse of coconut waste into high-value bio-based materials and biofuels highlights the importance of environmental sustainability while creating new economic opportunities. As the global demand for sustainable and eco-friendly products grows, the coconut industry stands at the forefront of this transition, showcasing how a humble tree can significantly impact both economic development and environmental stewardship. By embracing and furthering these advancements, stakeholders can ensure that the coconut tree remains a vital and valuable resource for generations to come.

CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

[1] *Department of Chemical Engineering, Indian Institute of Technology Tirupati, Andhra Pradesh - India*
[*] *This article was submitted for the World Coconut Day Competition 2024, Writing Category*

REFERENCES

Aba, R. P. M., & Luna, M. B. Z. (2024). Optimization of mature coconut water with calamansi, stevia, and turmeric using mixture design. *Discover Food, 4*(1), 33.

Abdurahiman, K. T. A., & Sajeeb, A. M. (2019).

Characteristical Study of Coconut Oil Based Nano Lubricant. *Proceedings of the International Conference on Systems, Energy & Environment (ICSEE)*.

Abeysundara, D. C., Weerakon, C., Lucas, J. R., Gunatunga, K. A. I., & Obadage, K. C. (2001). Coconut oil as an alternative to transformer oil. *ERU Symposium*, 1–11.

Afonso, I. S., Nobrega, G., Lima, R., Gomes, J. R., & Ribeiro, J. E. (2023). Conventional and Recent Advances of Vegetable Oils as Metalworking Fluids (MWFs): A Review. *Lubricants, 11*(4), 160.

Ajien, A., Idris, J., Md Sofwan, N., Husen, R., & Seli, H. (2023). Coconut shell and husk biochar: A review of production and activation technology, economic, financial aspect and application. *Waste Management & Research: The Journal for a Sustainable Circular Economy, 41*(1), 37–51.

Asghar, M. T., Yusof, Y. A., Mokhtar, Mohd. N., Ya'acob, M. E., Mohd. Ghazali, H., Chang, L. S., & Manaf, Y. N. (2020). Coconut (Cocos nucifera L.) sap as a potential source of sugar: Antioxidant and nutritional properties. *Food Science & Nutrition, 8*(4), 1777–1787.

Barlina, R., Liwu, S., Wungkana, J., & Alouw, J. C. (2023). Potency of coconut water as raw material for biodegradable plastics. *IOP Conference Series: Earth and Environmental Science, 1235*, 012001.

Clasen, A. P., Bonadio, J. C., & Agostinho, F. (2022). Briquettes production from green coconut shells: technical, financial, and environmental aspects. *Engenharia Sanitaria e Ambiental, 27*(3), 585–596.

D'Almeida, A. P., & de Albuquerque, T. L. (2025). Coconut husk valorization: innovations in bioproducts and environmental sustainability. *Biomass Conversion and Biorefinery, 15*(9), 13015–13035.

FAO. (2022). *Codex Alimentarius: Standard for aqueous coconut products*.

Fei, S., Fu, M., Kang, J., Luo, J., Wang, Y., Jia, J., Liu, S., & Li, C. (2024). Enhancing bacterial cellulose production of Komagataeibacter nataicola through fermented coconut water by Saccharomyces cerevisiae: A metabonomics approach. *Current Research in Food Science, 8*, 100761.

Gunarathne, R., Wijenayake, S., Yalegama, C., Marikkar, N. M., & Lu, J. (2024). Exploring the prebiotic characteristics of crude polysaccharides from coconut testa flour: A comparative analysis of local cultivar. *Heliyon, 10*(9), e30256.

Hettiarachchi, S. J., Kellici, S., Kershaw, M., & Bowen, J. (2023). Enhancing physicochemical properties of coconut oil for the application of engine lubrication. *Tribology International, 190*, 109060.

Jayadas, N. H., Nair, P. K., & Ajithkumar, G. (2007). Tribological evaluation of coconut oil as an environment-friendly lubricant. *Tribology International, 40*(2), 350–354.

Karmakar, S., & De, S. (2017). Cold sterilization and process modeling of tender coconut water by hollow fibers. *Journal of Food Engineering, 200*, 70–80.

Kumar, S. A., Negi, A., Santhoshkumar, P., Moses, J. A., & Sinija, V. R. N. (2025). Coconut: Expanding avenues in processing and an exposition on non-conventional value-added products. *Journal of the Science of Food and Agriculture, 105*(3), 1522–1532.

Lamdande, A. G., Mittal, R., & Raghavarao, K. S. M. S. (2020). Flux evaluation based on fouling mechanism in acoustic field-assisted ultrafiltration for cold sterilization of tender coconut water. *Innovative Food Science & Emerging Technologies, 61*, 102312.

Lu, Y., Zhang, Y., & Wang, S. (2024). From Palm to Plate: Unveiling the Potential of Coconut as a Plant-Based Food Alternative. *Journal of Agricultural and Food Chemistry, 72*(27), 15058–15076.

Malakul, W., Seenak, P., Jumroon, N., Arikit, S., Kumphune, S., & Nernpermpisooth, N. (2022). Novel Coconut Vinegar Attenuates Hepatic and Vascular Oxidative Stress in Rats Fed a High-Cholesterol Diet. *Frontiers in Nutrition, 9*, 835278.

Muralidharan, K., & Jayashree, A. (2011). alue addition, product diversification and by-product utilization in coconut. *Indian Coconut Journal, 7*, 4–10.

Muriuki, T. E., Ayuya, O. I., & Oloo, B. O. (2024). Towards circular production system in the coconut value chain: actor, roles, linkage and constraints in Kilifi County, Kenya. *Cogent Social Sciences, 10*(1), 2362903.

Nimbkar, S., Negi, A., Thirukumaran, R., Moses, J. A., & Sinija, V. R. (2023). Effect of thermal and nonthermal techniques on the physicochemical quality of high-fat coconut cream. *Journal of Food Process Engineering, 46*(12), e14462.

Pathirana, H. P. D. T. H., Yalegama, L. L. W. C., Silva, A. M. L., & Marikkar, J. M. N. (2023). Nutritional Properties of De-fatted Coconut (Cocos nucifera L.) Testa Flour Incorporated Sri Lankan Traditional Food: Roti. *COCOS, 24*(1).

Prasanna N., S., Nandan, Y., Selvakumar, M., Choudhary, N., & Raghavarao, K. S. M. S. (2024). Coconut Protein Concentrate: An Invaluable Food Supplement. In S. Ramesh & S. Praveen (Eds.), *Coconut-Based Nutrition and Nutraceutical Perspectives* (pp. 125–149). Springer Nature Singapore.

Prasanna, N. S., Selvakumar, M., Choudhary, N., & Raghavarao, K. S. M. S. (2024). Virgin coconut oil: wet production methods and food applications – a review. *Sustainable Food Technology, 2*(5), 1391–1408.

Raghavendra, S. N., & Raghavarao, K. S. M. S. (2010). Effect of different treatments for the destabilization of coconut milk emulsion. *Journal of Food Engineering, 97*(3), 341–347.

Raghavendra, S. N., & Raghavarao, K. S. M. S. (2011). Aqueous Extraction and Enzymatic Destabilization of Coconut Milk Emulsions. *Journal of the American Oil Chemists' Society, 88*(4), 481–487.

Rahmayanti, H. D., Ginting, J. C., Kartika, T. R., Ardiani, S., Akmalia, N., & Zulfi, A. (2024). A Study of Optical Properties of Edible Film based Coconut Water for Sustainable and Environmentally Friendly Materials Packaging. *IOP Conference Series: Earth and Environmental Science, 1359*, 012109.

Ramya, H. N., Kumar, S. R. S., & Kandkur, S. (2023). Coconut Testa as a Functional and Healthy Ingredient in Food Products: A Review. *Food and Nutrition Science - An International Journal, 7*, 19–24.

Reddy, N., Guna, V., GS, N., Muppuri, S., & Aramwit, P. (2024). Converting coconut meal into biothermoplastics for industrial applications. *Biofuels, Bioproducts and Biorefining, 18*(1), 113–124.

Rolle, R. S. (2007). *Good Practice for the Small-scale Production of Bottled Coconut Water* (Vol. 1). Food and Agriculture Organization of the United Nations.

Romão, D., Santana Jr., C., Brito, M., Scapin, E., Pedroza, M., Rambo, M., & Rambo, M. (2022). Assessment of the Economic and Energetic Potential of Residues from the Green Coconut Industry. *Journal of the Brazilian Chemical Society, 33*, 938–947.

Saraiva, A., Carrascosa, C., Ramos, F., Raheem, D., Lopes, M., & Raposo, A. (2023). Coconut Sugar: Chemical Analysis and Nutritional Profile; Health Impacts; Safety and Quality Control; Food Industry Applications. *International Journal of Environmental Research and Public Health, 20*(4), 3671.

Shunmugiah Veluchamy, R., Mary, R., Beegum Puthiya P., S., Pandiselvam, R., Padmanabhan, S., Sathyan, N., Shil, S., Niral, V., Musuvadi Ramarathinam, M., Lokesha, A. N., Shivashankara, K. S., & Hebbar, K. B. (2023). Physicochemical characterization and fatty acid profiles of testa oils from various coconut (*Cocos nucifera* L.) genotypes. *Journal of the Science of Food and Agriculture, 103*(1), 370–379.

Sumonsiri, N. (2019). Effect of Nisin on Microbial, Physical and Sensory Qualities of Micro-Filtered Coconut Water (Cocos Nucifera L.) During Refrigerated Storage. *Current Research in Nutrition and Food Science Journal, 7*(1), 236–243.

Syed, S., & Ahmed, N. (2025). Balanced diet and heart health. *Avicenna Journal of Medical Sciences, 3*(2).

Thaiphanit, S., & Anprung, P. (2016). Physicochemical and emulsion properties of edible protein concentrate from coconut (Cocos nucifera L.) processing by-products and the influence of heat treatment. *Food Hydrocolloids, 52*, 756–765.

Thirukumaran, R., Nimbkar, S., Mahalakshmi, L., Leena, M. M., Moses, J. A., & Anandharamakrishnan, C. (2023). Impact of different emulsification techniques on the stability of coconut milk. *Journal of Agriculture and Food Research, 12*, 100608.

Thomas, P. E., Saravanan, M., & Prabhasankar, P. (2023). Virgin coconut oil oleogel: gelation mechanism, rheological, structural and thermal properties. *International Journal of Food Science & Technology, 58*(3), 1434–1443.

Uppar, R., Dinesha, P., & Kumar, S. (2023). A critical review on vegetable oil-based bio-lubricants: preparation, characterization, and challenges. *Environment, Development and Sustainability, 25*(9), 9011–9046.

Vieira, F., Santana, H. E. P., Jesus, M., Santos, J., Pires, P., Vaz-Velho, M., Silva, D. P., & Ruzene, D. S. (2024). Coconut Waste: Discovering Sustainable Approaches to Advance a Circular Economy. *Sustainability, 16*(7), 3066.

Vijayasanthi, J., Adsare, S. R., Lamdande, A. G., Naik, A., Raghavarao, K. S. M. S., & Prabhakar, G. (2020). Recovery of proteins from coconut milk whey employing ultrafiltration and spray drying. *Journal of Food Science and Technology, 57*(1), 22–31.

Yalegama, L. L. W. C., Karunaratne, D. N., & Sivakanesan, R. (2023). Partial Characterization of Polysaccharides Isolated from Defatted Desiccated Coconut Kernel. *CORD*, 39, 41–48.

Highlight of the 61st ICC Session & Ministerial Meeting

Otniel Sintoro[1], A. H. N. Chinthaka[1], and Bahari Ilmawan[1]

The global coconut industry currently finds itself at a historic crossroads, navigating a complex landscape defined by unprecedented demand alongside significant structural vulnerabilities. This duality of opportunity and crisis formed the central theme of the 61st Session and Ministerial Meeting of the International Coconut Community (ICC), convened at the Berkeley Hotel in Bangkok, Thailand, from 18 to 21 November 2025. As the highest decision-making body of the Community, the Session brought together ministers, plenipotentiary delegates, national liaison officers, and senior officials to deliberate on policies and collective actions required to ensure the sustained development of the sector. Under the chairmanship of the Government of Thailand, represented through its Department of Agriculture, the gathering united major coconut-producing nations to address what has been described as a compelling paradox: a rapidly expanding global appetite for coconut-based products contrasted against fragile and, in many regions, stagnating production systems.

Within this context, the 61st ICC Session served not only as a forum for dialogue, but as a platform for collective decision-making and action. Delegates from ICC Member Countries and observer organizations presented comprehensive country statements, reflecting diverse national realities while converging on shared challenges related to productivity, climate resilience, market access, and sustainability. The Session formally endorsed a series of strategic programs and governance measures, including initiatives on coconut germplasm exchange, biosecurity, data management, scientific collaboration through COGENT, capacity building, and market-oriented


H. E. Maiava Fuimaono Tito Asafo (left) and H. E. Elina Akinaga (right) delivering their special remarks in the Opening Ceremony


Mr. Rapibhat Chandarasrivongs (left) and Dr. Jelfina C. Alouw welcoming delegates

H. E. Amin Mayusoh, addressing opening remarks

development. Adopted through established ICC procedures, these decisions underscored a collective commitment to move from deliberation to implementation, supported by strengthened institutional frameworks and coordinated international cooperation.

The 61st ICC Session and Ministerial Meeting witnessed strong and diverse participation from across the global coconut community. The Session brought together 82 delegates representing 16 ICC Member Countries, alongside representatives from 8 international and observer organizations, including research institutions, development partners, and United Nations–affiliated agencies. Over the four-day programme, senior government officials, technical experts, scientists, and private-sector stakeholders engaged in structured dialogue and decision-making, underscoring the growing international relevance of the coconut sector in discussions on food security, climate resilience, and sustainable development.

In-Depth Deliberations on the Global Coconut Sector

The inauguration ceremony was marked by a strong sense of urgency and a call for collective resilience. Mr. Rapibhat Chandarasrivongs, Director General of the Department of Agriculture of Thailand and Chairman of the 61st Session, formally opened the proceedings by welcoming delegates and dignitaries from across the ICC membership. In his remarks, he emphasized the multifaceted importance of the coconut—not merely as a commercial commodity, but as a cultural asset and a critical source of livelihood for millions of smallholder farmers worldwide. Thailand's tenure as Chair for the 2024–2025 period, he noted, has been guided by a strong commitment to technology transfer and climate adaptation, which he identified as foundational pillars for a sustainable and resilient coconut sector. He urged Member Countries to transcend isolated national approaches and embrace deeper collaboration, ensuring that shared experiences translate into tangible, field-level improvements in productivity and sustainability

Dr. Jelfina C. Alouw, the Director General of the International Coconut Community, further articulated the gravity of the current market dynamics in her introductory address. After acknowledging the somber context of the meeting—including the loss of a National Liaison Officer from the Federated States of Micronesia and the official mourning period observed by the Royal Thai Government—she focused on the strategic trajectory of the industry. Dr. Alouw highlighted the expanding utility of the coconut, which has evolved from a traditional food source into a critical component of high-growth sectors such as health, wellness, advanced materials, and even the aerospace industry through the development of Sustainable Aviation Fuel. However, she warned that this growth is imperiled by a lack of stable, cost-competitive raw material supplies and the persistence of restrictive tariff barriers. To resolve this paradox, she called for a radical shift in policy, advocating for fiscal incentives, human capital development, and the removal of export barriers. Quoting Thomas Jefferson's assertion that agriculture is the wisest pursuit because it contributes most to real wealth and happiness, she challenged the delegates to define a new era of global coconut strategy.

The perspective of the Pacific Island nations was poignantly represented by Her Excellency Elina Akinaga, Secretary of the Department of Resources and Development for the Federated States of Micronesia, and His Excellency Malava Fuimaono Tito Asafo, the Minister of Agriculture and Fisheries for Samoa. Secretary Akinaga emphasized the deep-rooted connection between the coconut tree and the heritage of Micronesia, framing the International Coconut Community as an essential partnership for technical guidance and shared ambition. Minister Asafo highlighted the specific challenges faced by Samoa, where the aging of tree stocks and the devastating impact of the coconut rhinoceros beetle—specifically the Guam biotype—threaten the nation's economic resilience. Samoa's priorities, which include replanting with resilient varieties and strengthening farmer support systems, mirrored the concerns of many small island developing states that are on the front lines of climate change.

The official opening was concluded by His Excellency Amin Mayusoh, the Deputy Minister of Agriculture and Cooperatives for the Government of Thailand. He reiterated Thailand's dedication to market-driven policies and the advancement of agricultural innovation, such as the development of bio-pesticides and value-added processing techniques. Recognition of excellence within the community was also a highlight of the opening ceremony, as the International Coconut Community presented plaque awards to those who have made significant contributions to the sector. The honors for Best Scientist were awarded to Mr. Anupap Thirakul and Mr. Somchai Watanayothin, both of the Thai Department of Agriculture, for their pioneering work in coconut breeding. The award for Best Farmer and Entrepreneur was presented to Mr. Boonprasert Saapma, while Theppadungporn Coconut Co., Ltd. was recognized as the Best Coconut-Based Product Manufacturer, illustrating the vital role of private sector innovation in driving the industry forward.

Country Perspectives and Shared Challenges

The conclusion of the opening ceremony set the stage for the official session proceedings, which started with the country statement agenda, where member nations provided detailed updates on their domestic programs, policy initiatives, and legislative efforts. These presentations revealed a common thread of challenges, including the need for massive replanting efforts to replace senile palms, the importance of youth engagement to ensure the continuity of the sector, and the necessity of harmonizing germplasm regulations to facilitate the exchange of high-yielding varieties. The first day

saw contributions from a diverse group of nations, including Côte d'Ivoire, Fiji, India, Indonesia, Jamaica, Kenya, Malaysia, and Papua New Guinea, each offering replicable models for sustainable development.

As the session transitioned into its second day, the discourse shifted from identifying systemic crises to proposing transformative, and at times radical, solutions. A recurring theme was the necessity of global unity in trade. Several delegates advocated for the formation of a unified trading group among member countries, a strategic move designed to consolidate market power and provide the Community with the leverage needed to dictate prices and trade terms in an era of supply deficits. This proposal for a unified global coconut block was most forcefully articulated by Mr. K.S. Wijayakeerthi of Sri Lanka, who pointed out that the industry is currently grappling with a 32 percent supply deficit. He urged nations to cease competing with one another and instead collaborate to ensure that producers receive a fair share of the global market's value. Sri Lanka's own roadmap serves as an ambitious example, with the nation aiming to reach 1.5 billion dollars in exports by 2030, driven by the promotion of its premium King Coconut variety and extensive subsidy programs for replanting.

The Philippines, represented by Ms. Ma Odessa M. Pacaul of the Philippine Coconut Authority, detailed one of the most ambitious revitalization programs in the world. Facing the dual threats of aging palms and frequent typhoons, the Philippines

has committed to planting 100 million trees by the year 2028. This effort is coupled with investments in hybridization, fertilization, and the expansion of the biofuels sector, all aimed at securing the livelihoods of the millions of Filipinos who depend on the coconut for their survival. Similarly, Vietnam's presentation by Mr. Cao Ba Dang Khoa showcased a sector in the midst of a significant growth spurt. Vietnam generated over one billion dollars in export value in 2024, with a strategic shift toward organic fertilization and a 20 percent increase in new plantings to rejuvenate the national tree stock. The Vietnamese model emphasizes the importance of the food and beverage processing sector, which accounts for nearly half of its export turnover.

Science, Technology, and Institutional Strengthening

Technological and scientific advancement occupied a significant portion of the second day's deliberations. Dr. Wilaiwan Twhishsri of Thailand discussed the development of new varieties, such as Chumphon Hybrid No. 2 & Nam Hom, and the implementation of Good Agricultural Practices (GAP) Monkey Free Plus certification. On the scientific front, Dr. Fabian Dayrit, Chairman of the Scientific Advisory Committee for Health, presented a long-term development plan stretching to 2036. His work focuses on dismantling misinformation regarding coconut fatty acids and heart disease, advocating for clinical trials that highlight the benefits of a tropical diet and products like coconut sugar. Complementing this, Dr. Prabhath Kumar, Chairman of the Technical Working Group, outlined priorities for climate resilience and biosecurity. He emphasized the need for international research collaborations and the creation of robust project proposals to secure external funding for smallholder farmers.

The involvement of observer organizations further enriched the session, as representatives from entities such as the Non-Aligned Movement Centre for South-South Technical Cooperation, CIRAD, and the Sustainable Coconut Partnership presented opportunities for collaborative projects. These organizations provide the technical and financial scaffolding necessary to implement the ambitious goals set by

the member countries, particularly in areas like germplasm exchange and sustainable farming practices.

Governance Reform and the Global Coconut Strategy 2026

The third and final day of the meeting was dedicated to structural reforms and the endorsement of a global strategy for 2026. A major milestone was the ratification of a governance shift for the International Coconut Genetic Resources Network, known as COGENT. Under a new Standard Operating Procedure, the coordination of COGENT has been fully integrated into the ICC Secretariat. This move is designed to enhance the efficiency of germplasm exchange and biosecurity protocols. The session also approved the COCODIV molecular characterization project and a data modernization initiative using Genesys software, ensuring that the community's genetic resources are managed with the highest degree of scientific rigor.

Reports from Samoa and the Solomon Islands on the third day brought the focus back to the immediate logistical and biological threats facing the industry. Mr. Tanu J. Toomata of Samoa reported on the success of virgin coconut oil cooperatives but stressed the urgent need for technical assistance to combat the Guam biotype of the rhinoceros beetle. Mr. Cornelius Donga of the Solomon Islands highlighted the logistical challenges of island-based production, requesting support for inter-island transportation and infrastructure to reduce post-harvest losses and improve market linkages. These testimonies served as a reminder that policy decisions made at the international level must translate into tangible support for the infrastructure of rural economies.

The final phase of the 61st Session was started by the presentation of the ICC Annual Report for 2024. For the first time, this report was delivered in a video format, providing a dynamic overview of the year's achievements, including the 51st International COCOTECH Conference in Indonesia and the celebration of World Coconut Day in Papua New Guinea and India. The report underscored the success of the Youth Empowerment Program, which is vital for ensuring that the next generation of farmers and entrepreneurs is equipped to lead the sector. As the administrative business of the session concluded—including the approval of the 2026 budget and the nomination of future leadership—the symbolic handover of the Chair from Thailand to India took place.

Leadership Transition and the Path Forward

The 61st Session of the International Coconut Community in Bangkok succeeded in moving the global conversation from a state of passive observation of market trends to one of active strategic intervention. By focusing on the "paradox" of the industry, the delegates acknowledged that the current success of coconut products in the global marketplace is not guaranteed to last unless the underlying supply and structural issues are addressed with urgency. The call for a unified global block, the commitment to massive replanting, and the modernization of genetic resource management represent a comprehensive approach to securing a resilient future. As the Chairmanship passes to India, the community remains steadfast in its pursuit of an industry that contributes to real wealth, sustainability, and the well-being of the millions of people who call the "tree of life" their primary resource. The path forward is one of transformation, requiring the continued dissolution of barriers and the strengthening of the bonds that unite the coconut-producing world.

---

[1] *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, sulfur, 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. Bruce Fife
Certified Nutritionist and Doctor of Naturopathic Medicine, and Director, Coconut Research Center, based in USA

You cannot say LDL (low density lippoprotein) is bad and HDL (high density lippoprotein) is good. It is more complex than that. There are actually two types of LDL: one small and dense the other large and soft. The large LDL is a good cholesterol the type used to make bile, hormones, and vitamin D--it is essential to life! The small dense LDL is the type that becomes oxidized and can be harmful, as all oxidized lipids can be. Eating coconut oil (and other saturated fats) increases both HDL and the "good" LDL, thus lowering the risk of heart disease. This is one of the reasons why populations that eat a lot of coconut oil have the lowest heart disease rates in the world.

Source: Press Statement, APCC, 21 June 2017

Coconut Oil in 2026: A Market Caught between Short-Term Relief and Long-Term Constraint

Alit Pirmansah[1]

After two years of pronounced tightness, the global coconut oil market enters 2026 with tentative signs of near-term relief. Production is expected to recover modestly, trade volumes are improving from depressed 2025 levels, and prices are likely to soften in the first half of the year. Yet this apparent easing masks deeper structural constraints that continue to define the market. Coconut oil, once a niche edible oil, has become a strategic input for food, oleochemicals, cosmetics, and specialty industrial applications—an evolution that has permanently altered its supply-demand balance.

Unlike annual oilseed crops such as soybean or sunflower, coconut oil production depends on perennial trees with long gestation periods and limited short-term responsiveness to price signals. As a result, even modest changes in output or demand tend to generate outsized price movements. This structural rigidity will remain a defining feature of the market throughout 2026.

Table 1. Coconut Oil Production, 2024-2026 (000MT)

Countries	2024	2025p	2026F
Philippines	1,567	1,363	1,596
Indonesia	831	768	827
Others	1101	1024	1,091
Total	**3,499**	**3,155**	**3,515**

Source: ICC

Production: Incremental Gains, Enduring Limits

Global coconut oil production in 2026 is projected at approximately 3.5 million metric tons, up from an estimated 3.16 million metric tons in 2025, and broadly comparable to the 3.50 million metric tons recorded in 2024. The recovery reflects improved weather conditions and slightly better yields in key producing countries, particularly in Southeast Asia, following weather-related disruptions in recent years.

The Philippines continues to anchor global supply. After production fell sharply from around 1.57 million metric tons in 2024 to 1.36 million metric tons in 2025, output is forecast to rebound to nearly 1.60 million metric tons in 2026, restoring its position as the source of roughly 45 percent of global production. Indonesia, the second-largest producer, is expected to see output rise from about 768,000 metric tons in 2025 to approximately 827,000 metric tons in 2026.

Production in other countries—including India, Sri Lanka, Papua New Guinea, and Pacific island economies—is projected to increase from roughly 1.02 million metric tons in 2025 to about 1.09 million metric tons in 2026. Much of this output, however, is absorbed domestically, limiting its contribution to exportable supply.

Despite this cyclical recovery, the underlying supply picture remains constrained. Aging plantations, slow replanting, limited mechanization, and increasing competition for coconuts from higher-value products such as virgin coconut oil, desiccated coconut, and coconut milk continue to restrict the availability of copra for crushing. As a result, the production rebound

Table 2. Coconut Oil Exports, 2024-2026 (000MT)

Countries	2024	2025p	2026F
Philippines	1,672	1,194	1,249
Indonesia	677	562	624
Malaysia	121	111	128
Papua New Guinea	31	21	25
Others	386	412	417
Total	**2,887**	**2,300**	**2,443**

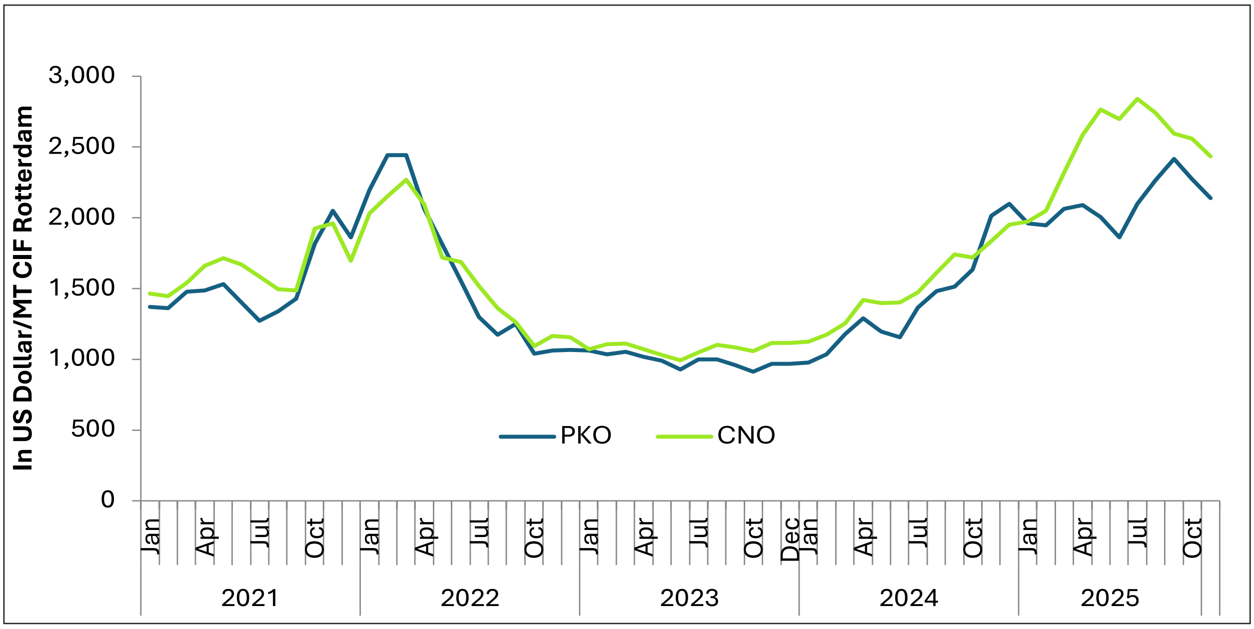
Source: Oil World and ICC estimates
p: preliminary figures; f: forecasted figures

Table 3. Coconut Oil Imports, 2024-2026 (000MT)

Countries	2024	2025p	2026f
EU-27	634	594	629
USA	496	380	410
Malaysia	286	167	178
China	170	155	164
UK	22	20	21
Other countries	**955**	**604**	**693**
World	2,563	1,920	2,095

Source: Oil World, USDA, and ICC estimates
p: preliminary figures; f: forecasted figures

Figure 1. Price Trend of Lauric Oils, January 2020-November 2025 (USD/MT)



Source: ICC

in 2026 represents stabilization rather than a structural loosening of the market.

Trade: Recovering Volumes, Persistent Tightness

Global coconut oil exports are forecast to recover to around 2.44 million metric tons in 2026, up from approximately 2.3 million metric tons in 2025, but still well below the 2.89 million metric tons recorded in 2024. Trade flows remain shaped primarily by supply availability rather than demand potential.

The Philippines is expected to increase exports from about 1.19 million metric tons in 2025 to roughly 1.25 million metric tons in 2026, following a steep contraction from 1.67 million metric tons in 2024. Indonesia's exports are projected to rise more moderately, from 562,000 metric tons to around 624,000 metric tons, reflecting both improved output and policy priorities that favor domestic processing and value addition.

Exports from Malaysia are forecast to edge up to approximately 128,000 metric tons, while shipments from Papua New Guinea and Sri Lanka together are expected to total around 35,000 metric tons. Although modest in scale, these volumes remain important for regional and niche markets.

On the import side, global purchases are projected at around 2.10 million metric tons in 2026, up from 1.92 million metric tons in 2025, though still below 2.56 million metric tons in 2024. The European Union remains the largest importing region, with imports forecast to rise from 594,000 metric tons to about 629,000 metric tons, underpinned by steady industrial demand. U.S. imports are expected to recover from 380,000 metric tons in 2025 to around 410,000 metric tons in 2026, while China's imports are projected to increase modestly to approximately 164,000 metric tons.

Price Outlook: Near-Term Easing, Elevated by Historical Standards

Against this backdrop, coconut oil prices in 2026 are expected to follow a two-phase trajectory. In the first half of the year, prices are likely to face downward pressure as production recovers, export volumes improve, and importers—still adjusting to the high-price environment of recent years—adopt a cautious purchasing stance. The rebound in global output from 3.16 million metric tons in 2025 to around 3.5 million metric tons in 2026, alongside the recovery in exports, is expected to ease immediate supply concerns.

However, this price softness is unlikely to be sustained. On an annual average basis, international coconut oil prices are projected to remain within the range of USD 2,000 to USD 2,300 per metric ton, well above pre-pandemic norms and at a persistent premium to major vegetable oils. The recovery in production merely restores supply to earlier levels rather than creating surplus capacity, while global export availability remains constrained at just over 2.1 million metric tons.

Structural factors continue to underpin prices. Coconut oil's limited substitutability—particularly in oleochemicals and personal care applications—renders a significant portion of demand relatively price inelastic. While elevated prices may curb consumption in cost-sensitive food uses, industrial demand is expected to remain resilient, providing a floor to the market. Downside risks to prices therefore appear limited unless exceptionally favorable weather coincides with a broader slowdown in global industrial activity.

A Market Redefined

What ultimately distinguishes the coconut oil market in 2026 is not the prospect of short-term price easing, but the persistence of long-term scarcity. Demand has shifted decisively toward industrial and specialty applications, while supply remains rooted in smallholder-based production systems vulnerable to climate risk and structural inefficiencies.

In this context, the modest recovery reflected in the 2026 data should be interpreted less as a turning point than as a pause. Coconut oil has become a strategic, high-value component of the global vegetable oils complex—one where prices may fluctuate, but where abundance remains elusive.

---

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

UNVEILING COCONUT'S HEALING POTENTIAL: 1ST INTERNATIONAL COCOHEALTH CONFERENCE SHOWCASES GLOBAL COMMITMENT TO COCONUT AND HEALTH

The 1st International COCOHEALTH Conference, held from 19–22 August 2025 in Coimbatore, India, marked a groundbreaking step toward mainstreaming coconut as a cornerstone of global health, nutrition, and sustainable development. Organized by the International Coconut Community (ICC) in collaboration with the Coconut Development Board (CDB), Ministry of Agriculture and Farmers Welfare, Government of India, the conference brought together leading researchers, policymakers, entrepreneurs, and stakeholders under the theme "Coconut – Nature's Treasure to Health."

The event featured 22 expert speakers from seven countries, India, Philippines, Indonesia, Thailand, Japan, Australia, and the USA, alongside 13 poster presentations by emerging scholars. It attracted over 150 in-person attendees and 85 online participants, blending deep scientific dialogue with visionary policy conversations to advance the coconut-health nexus.

In her inaugural address, Dr. Jelfina C. Alouw, Director General of ICC, emphasized that the evolving global health and wellness market presents an unprecedented opportunity for coconut-based solutions. She stressed the need to integrate research, innovation, farmer welfare, and fair trade models, and highlighted the conference as a critical platform to steer coconut into the health policies of the future. With the ICC session and ministerial meeting coming up in Thailand this November, she hope the Scientific Advisory Committee for Health (SACH) can present the latest research and prepare policy briefs for member countries. These briefs could advocate for more feasible studies, standardized methodologies, and specific health claims.

Delivering the keynote address, Dr. Prabhat Kumar, Chief Executive Officer of CDB and Horticulture Commissioner of the Government of India, urged the community to reframe coconut oil as a "health oil" rather than simply a cooking medium. He emphasized that the world is moving rapidly toward functional and therapeutic foods and called for systematic meta-analyses and comprehensive research to substantiate claims and reshape consumer perceptions.

Further reinforcing this message, Dr. P. Rethinam, Former Executive Director of APCC and Former Chairman of CDB, highlighted the vast potential of coconut water and proposed the formation of a Global Coconut Health Research Fund. He stressed that strategic funding is essential for deepening scientific discovery and scaling innovations that benefit producers and consumers alike.

A powerful message was also delivered virtually by the Secretary of Ministry of Agriculture

and Farmer's Welfare, Government of India, who hailed coconut as a "6D multidimensional crop", vital for diet, digestion, disease prevention, diabetes control, drug development, and daily life. He emphasized the need for new strategies to utilize every part of the coconut and positioned it as an essential component in India's quest for self-sufficiency in edible oils.

Over the course of two days of technical sessions, researchers and practitioners shared evidence on coconut's benefits across multiple domains—neurological health, metabolic disorders, cardiovascular wellness, dermatology, dentistry, traditional medicine, pharmacology, and food fortification. The sessions revealed the emerging science behind medium-chain triglycerides (MCTs), polyphenols, and other bioactives in coconut oil, water, and derivatives.

ICC – SACH Closed Group Discussion

A pivotal Closed Group Discussion brought together ICC's Scientific Advisory Committee on Health (SACH), chaired by Dr. Fabian Dayrit, to chart the strategic research and policy path forward. The session began with a review of ongoing challenges, including the scientific controversies surrounding saturated fats and coconut oil. Participants carried out a structured SWOT analysis focused on Virgin Coconut Oil (VCO) and coconut sugar, identifying areas for future research such as VCO's potential roles in managing diabetes, obesity, neurological disorders, and immune system regulation, and the positioning of coconut sugar as a natural sweetener beneficial for Type 2 diabetes management. The Committee emphasized the need for stronger scientific evidence through AI-assisted meta-analyses and multi-country clinical trials. A roadmap for the 2026–2036 period was outlined, categorizing research into short-, medium-, and long-term objectives, with an immediate priority to validate therapeutic claims of VCO and coconut sugar through clinical studies. Recommendations were made to seek funding from international bodies like the Asian Development Bank, national research grants, and industry partnerships. Importantly, the discussion underscored the value of intergovernmental collaboration in framing nutrition and health policies grounded in robust coconut-based scientific evidence, with a consolidated plan to be

presented at the upcoming ICC Ministerial Meeting in November 2025.

Field Visit

On 22 August, participants undertook a field and industry visit beginning at Jacobi Carbons, where they explored sustainable technology for producing various activated carbon from coconut shells for numerous applications. Company representatives detailed the company's eco-friendly processes, community engagement programs called "Kalpavriksha", and workplace safety standards, demonstrating how technology and social responsibility can go hand in hand in the coconut sector.

This was followed by a visit to a coconut plantation managed by Mr. Ranjeet Kumar, where delegates observed a multi-layered cropping system that included high-value crops like nutmeg. The farm, once a paddy field, had transitioned to coconut cultivation due to water and labor constraints. Mr. Kumar highlighted the effects of climate change, pest and disease outbreaks, and wildlife challenges, while showcasing organic farming practices, technology adoption, and cooperative marketing models aimed at enhancing resilience and profitability.

Special Industry Visit of the KIK PNG Delegation

In the lead-up and aftermath of the main conference, the delegation from the Kokonas Indastri Koporesen (KIK) of Papua New Guinea, led by

Mr. Alan Aku, ICC National Liaison Officer and Managing Director of KIK, engaged in strategic industry visits to strengthen their understanding of value addition in the coconut sector. On August 18, the delegates visited Marico Limited, where they gained insights into the company's global operations, diverse product portfolio, and market leadership. Marico's annual turnover and its success in marketing coconut-based personal and health care products illustrated the commercial scalability of coconut innovations. The team then visited Essar Engineers, a leading manufacturer of coconut processing machinery. The delegates observed state-of-the-art mechanical solutions for dehusking, shelling, drying, and oil extraction, underscoring the role of engineering in enhancing productivity, hygiene, and product quality in coconut processing. On August 23, the delegation visited T&I Global, where they were welcomed by Mr. Viraj Bagaria. He presented a range of advanced processing machinery for coconut milk, Coconut Water, Virgin Coconut Oil (VCO), and desiccated coconut, including filter

presses, vacuum dryers, pasteurizers, aseptic fillers, and automated nut handling systems. Of particular interest was a showcase of a 100,000 nuts/day coconut milk factory installed in Ivory Coast, demonstrating the company's global footprint. T&I Global also introduced real-time monitoring systems and data-integrated automation tools to enhance traceability and operational efficiency. These visits provided valuable learning and inspiration for the PNG delegation on industrial scale-up, machinery innovation, and market linkages, complementing the themes explored during the COCOHEALTH conference.

The 1st International COCOHEALTH Conference concluded with a strong consensus on the need for integrated strategies that combine science, technology, policy, collaboration, and community engagement to position coconut as a trusted ingredient in the global health ecosystem. The ICC remains committed to facilitating this transformation through collaboration, capacity building, and catalytic investment.

ICC–COGENT WORKSHOP IN INDIA MARKS WORLD COCONUT DAY 2025 WITH A FOCUS ON SUSTAINABLE AND RESILIENT INTERNATIONAL COCONUT GENEBANKS

The International Coconut Community (ICC), in collaboration with the Indian Council of Agricultural Research (ICAR) - Central Plantation Crops Research Institute (CPCRI), successfully organized the International Workshop on Strengthening Coconut Genebanks for a Climate Resilient and Sustainable Future alongside the celebrations of World Coconut Day (WCD) 2025. This year's WCD was observed under the theme "Uncovering Coconut's Power, Inspiring Global Action."

The programme was presided over by Dr. Sanjay Kumar Singh, DDG (Horticultural Sciences), ICAR, New Delhi, while Shri Rajmohan Unnithan, Honorable Member of Parliament, Kasaragod, formally inaugurated the celebrations. In his introductory remarks, Dr. K. Balachandra Hebbar, Director of ICAR–CPCRI, highlighted CPCRI's ongoing efforts to achieve sustainable yield and productivity, noting that adoption of scientific technologies can improve coconut yield by as much as 15%. He cautioned that sudden spikes in price due to production shortages risk adulteration, underscoring the importance of balanced production and consumption.

Dr. Jelfina C. Alouw, Director General of ICC, delivered the keynote address, emphasizing the importance of coconut genetic resources and the significance of celebrating World Coconut Day. She underlined that global challenges should be met through collaboration rather than competition. Shri Rajmohan Unnithan, MP Kasaragod, highlighted the challenges faced by coconut farmers, including pest pressures and fluctuating prices, and urged that research must be strengthened to address the real needs of the farming community.

In his presidential address, Dr. S. K. Singh emphasized ICAR's vision for strengthening the coconut sector and noted that the participation of representatives from 14 countries underscored the global importance of the event. He encouraged the development of new coconut varieties and products to expand international markets, while also advocating for microbial enrichment and sustainable practices over excessive fertilizer use.

H.E. Ambassador Diar Nurbintoro, Director of the NAM CSSTC, Jakarta, attended as Guest of Honour, calling on participants to work collectively for sustainability and prosperity, with ICC member countries playing a central role. Other dignitaries

included Dr. J. Dinakara Adiga, Director, ICAR–DCR, Puttur, who spoke about coconut's cultural significance in India, and Dr. Augustine Jerard, Project Coordinator (Palms), who emphasized the workshop's relevance for climate-resilient breeding. The event also featured the inauguration of exhibition stalls and a sales counter, showcasing coconut-based products and innovations.

The workshop itself brought together over 30 resource speakers and international participants from 14 countries, including Indonesia, Côte d'Ivoire, Brazil, Papua New Guinea, Sri Lanka, Philippines, Malaysia, Jamaica, Australia, Italy, Germany, France and Thailand, along with representatives of NABARD, state extension officers, entrepreneurs, scientists, farmers, FPOs, and NGOs.

Across four technical sessions and thirteen flash presentations by young researchers, the workshop provided invaluable insights into harmonized and standardized management practices for International and National Coconut Genebanks, the creation of a unified global database, the integration of genomics and AI tools, and improved systems of communication and collaboration. Discussions further emphasized in vitro and cryopreservation methods, forecasting of pest and disease risks, Article 15 agreements under the FAO Plant Treaty, and stronger donor engagement.

The sessions collectively paved the way for the drafting of a roadmap for strengthening coconut genebanks, which will be refined through ITAGs and focal points before being presented to the ICC COGENT Steering Committee and then ICC Session and Ministerial Meeting. The workshop concluded with a unique cultural and technical experience, including a field visit to the International Coconut Genebank for South Asia and the Middle East (ICG–SAME) at Kido, a traditional Onam feast, and a concluding discussion held aboard a houseboat in the Kerala backwaters, combining scientific dialogue with cultural immersion.

The joint celebration of World Coconut Day 2025 and the International Workshop reaffirmed ICC's role as the only intergovernmental organization exclusively dedicated to the coconut sector. It also highlighted India's leadership in conservation and research, and the importance of global collaboration in safeguarding coconut genetic resources for future generations.

UP TO 10,000 JOBS COULD BE CREATED BY A COCONUT DOWNSTREAM PROJECT IN INDONESIA

A China-backed coconut downstreaming project is expected to significantly boost Indonesia's economy, according to Rosan Perkasa Roeslani, Minister of Investment and Downstreaming and Head of the Investment Coordinating Board (BKPM).

According to Rosan, the project is anticipated to produce a variety of products derived from coconuts and generate between 5,000 and 10,000 jobs.

"In the first year, it will absorb 5,000 workers, and this will increase to 10,000 in the following year. The range of derivative products is also very diverse," Rosan said at the Kompas100 CEO Forum at the Indonesia Convention Exhibition (ICE) BSD in South Tangerang on Wednesday, November 26, 2025.

He emphasized that the initiative is designed to keep value creation within Indonesia. "This is how we ensure that added value stays in our country, and the jobs are also created here," he said.

The project carries an investment value of 100 million US dollars, or around Rp1.65 trillion.

"Compared to mineral investments, this is relatively small, especially in the plantation sector. But despite the 100 million dollars invested, the job creation can reach up to 10,000 people. That is very significant," Rosan said.

Rosan, who is also the CEO of Danantara, an agribusiness and investment organization that specializes in downstreaming commodities, emphasized that downstreaming a variety of commodities, including coconut, is essential for increasing added value and enhancing price stability for farmers in producing regions.

According to him, the great value potential of coconut when processed through an integrated downstreaming chain makes it particularly intriguing. In the past, farm-gate prices were lowered by the expense of shipping raw coconuts to China.

"This is why we encouraged them to invest here, so farmers can enjoy higher selling prices without the burden of shipping costs," he said.

Rosan added that the ongoing project will absorb around 500 million coconuts per year. *(Tempo)*

PEPSICO'S COCONUT FARM'S IMPACT ON REGENERATIVE AGRICULTURE

José Corrêa do Lago, the president of COP30, the first international climate conference hosted in the Amazon, has referred to it as the "COP of implementation."

In order to demonstrate how climate change may be prioritized in agriculture, PepsiCo has established a coconut "demonstration farm" in Brazil.

This is in line with the COP30 agenda, which includes biodiversity and food system sustainability.

PepsiCo oversees the growth of nearly 50 crops in more than 60 countries to produce its most popular food and drink brands.

One of these crops is the green coconut, which is the main ingredient in PepsiCo's Kero Coco coconut water.

Petrolina, Brazil is home to PepsiCo's one-of-a-kind coconut demonstration farm which helps educate farmers on regenerative agriculture techniques.

PepsiCo has started an intercropping program at the farm, growing cacao plants in between the coconut trees.

The cacao plants thrive in the shade of the coconut trees while the coconuts benefit from the rich nutrient-dense soil from the cacao plants.

This program has been adopted by local farms, which helps introduce crop diversity and is expected to increase farmers income by approximately 30% to 70%.

Alexsandro Castro Souza, Agricultural Manager for PepsiCo Brazil, says: "The most rewarding aspect has been witnessing the improvement of quality of life and financial sustainability of family farmers.

"Seeing them embrace regenerative techniques that enhance productivity and long-term sustainability is particularly fulfilling."

Crop irrigation that is sustainable

By 2030, PepsiCo wants to increase the use of restorative, protective, and regenerative agricultural practices on 10 million acres of land. PepsiCo takes care of the coconut trees at its Petrolina farm using regenerative methods.

It has established a sophisticated irrigation management system that uses real-time weather data, such as temperature, humidity, and sunlight, to determine each coconut tree's precise water requirements.

The system activates irrigation using tailored hoses which deliver the optimal amount of water to each tree.

During COP30, Jim Andrew, Chief Sustainability Officer at PepsiCo, says on LinkedIn: "Facing increasing climate risk and impacts, the global food system is fragile and in need of transformation.

"This matters for PepsiCo – as a company rooted in agriculture – and importantly, for the world's ability to sustainably grow the food it needs today and in the future.

"This requires accelerated action and impact, at scale."

How sustainable are green coconuts?

Kero Coco coconut water is made only with green coconuts which are grown in northeastern Brazil.

Green coconuts are chosen specifically as they contain more water and are naturally sweeter than mature brown coconuts.

After harvesting the coconut water, PepsiCo uses the outer husks for natural fertilizer.

They are used on crops to naturally prevent weed growth, which helps reduce chemical use, lower greenhouse gas emissions and improve soil moisture.

"Unlike annual crops such as potatoes or corn, coconut palms are produced for many years, requiring long-term planning and practices that sustain ecosystem health for over a decade," Alexsandro says.

"Harvesting green coconuts for water demands specific methods to preserve the fruit's integrity and ensure high quality." *(Sustainability Magazine)*

THE REASONS BEHIND THE DISAPPEARANCE OF KERALA'S COCONUTS

The evening rush has not decreased at Sriram Oil Mill in Thiruvananthapuram, Kerala. As usual, people come in to purchase coconut oil and its byproducts. However, Kerala, a state known for its coconuts, struggles to locate enough of them, revealing a tale it never would have imagined.

After 40 years of operating the mill, Hariharan claims he is now largely dependent on coconuts imported from Tamil Nadu.

"Production in Kerala is gradually declining. Earlier, every household had coconut cultivation and got enough yield for home use. That time has gone. We now depend a lot on Tamil Nadu," he says, adding that coconut tree climbers, once ubiquitous, are now hard to find.

Kerala, named after kera (coconut), once stood tall as the land of coconut trees. Today, it fears losing that identity. Prices tell the story too. The humble coconut, once under Rs 30, now costs Rs 70–Rs 72. Coconut oil? Around Rs 400–Rs 410 per kg. Households are cutting down on purchases, and restaurants have already switched to other oils.

Why are Kerala's coconuts dying?

The offenders are diverse. Heat waves, warmer nights, and heavier, shorter rainstorms have all been brought on by climate change, which has increased insect infestations, particularly the destructive red palm weevil.

At the same time, there is a lack of competent coconut climbers in the state. In the past, traditional climbers made sure that harvests were healthy and cleaned tree crowns. These days, migrant workers frequently use climbing tools to pluck coconuts, but these tools are unable to reach the crown, leaving trees susceptible.

The land itself is evolving as well. Real estate development, including homes, flats, and commercial buildings, is replacing coconut fields.

As per Santhosh Kumar T, Assistant Professor and Head of the Coconut Research Station in Thiruvananthapuram, land conversion is a key factor.

"If you collect data from village officers, you can see that a lot of our coconut farms were converted to buildings," he said.

Neighboring states like Tamil Nadu, Karnataka and Andhra Pradesh are now producing more coconuts by adopting scientific methods and better farm care, widening the gap further as Kerala turns into a buyer instead of a supplier.

Can Kerala save its coconut identity?

Experts believe Kerala can turn this around, but only with deliberate effort.

"We need to increase planting. Cleaning should be done using skilled laborers. Proper manure and fertilizer application, proper lining should be done to increase yield. Restricting the increasing construction is also important," said Santhosh Kumar.

He notes that one encouraging trend is rubber farmers shifting focus to coconut, which could boost production if supported with scientific agricultural practices.

More than a crop: an emotional anchor

To ask a Malayali why coconut is in everything is to misunderstand Kerala entirely. The coconut isn't just food, it's tradition, livelihood, flavor, memory and identity.

This crisis is not just about supply and price. It's about culture. It's about a symbol.

Kerala once took pride in being the land of coconuts. Today, as trucks bring in coconuts from Tamil Nadu to mills like Hariharan's, the irony is hard to miss.

But Kerala's coconut story is not over, it needs urgent tending. Or the state stamped by the coconut tree may soon find itself looking up at a disappearing crown. *(India Today)*

WITH INCREASING EXPORTS TO CHINA, VIETNAM'S COCONUT FARMERS THRIVE

Coconut farmers and exporters in Vinh Long province are celebrating a long-awaited economic triumph as fresh coconuts have been legally sold to China, with the sound of coconut processing gear reverberating throughout the southern countryside of Vietnam.

The first official authorization for fresh Vietnamese coconuts to enter the Chinese market was granted in August 2024 when China and Vietnam inked an agreement for exporting the fruit to China.

Nguyen Cong Tuan, a local farmer in Vinh Long province, believes that his everyday life is being drastically altered by the expanding coconut export route to China.

"Before exporting coconuts to China, I used to harvest about 1,000 to 1,500 coconuts a day and sometimes rested the whole day after," said Tuan, adding that he now cuts 3,000 to 4,000 coconuts daily and works every single day.

The increase in work means that his income is also higher.

"My income has increased by 300,000 to 400,000 Vietnamese dong (about 11 to 15 U.S. dollars) per day," Tuan said, noting that his earnings can now reach 1 million dong (about 38 dollars) per day.

Before exports to China opened officially, his coconuts were mainly shipped north to Hanoi and other domestic markets, but leftover coconuts often dried up and went to waste.

"Now, I can harvest continuously. It's much more convenient for my business," he said.

Le Minh Duc Khoa, chairman of KK Premium, a coconut processing and exporting company that started operations earlier this year, emphasized the central role the Chinese market plays in the company's strategy, with 99 percent of its coconut exports going to China.

For the Hung Thinh Phat Agricultural Cooperative, an economic model linking farmers and businesses, the official export of coconuts to China marks a major milestone.

"Since partnering with KK Premium for export to China, having access to official trade channels has stabilized incomes for our farmers," said Nguyen Trung Quy, director of the cooperative.

Vietnam's Ministry of Agriculture and Environment reports that the country grows coconuts on more than 200,000 hectares, yielding about 2.28 million tons annually.

Vietnamese farmers and exporters are increasingly confident about sending coconuts to the Chinese market because to standardized procedures that streamline logistics, particularly through rail and cross-border agreements.

Under the shade of a coconut palm, Tuan grinned and added, "The garden owners are happy too because they sell out their crop at good prices when I can export coconuts." *(Xinhua)*

AS VIETNAMESE RIVALS TAKE CONTROL OF THE CHINESE MARKET, THE THAI AROMATIC COCONUT INDUSTRY IS IN CRISIS

Local farmers are finding it difficult to deal with prices that have fallen to less than half of their production costs, which is causing a serious problem for the Thai aromatic coconut business.

Vietnam's aggressive market conquest, which gives them a competitive advantage in shipping proximity and scale while Thai quality is still uneven, is largely responsible for the sharp price reduction.

The scope of the disaster was disclosed by independent scholar and agriculture management specialist Tattawin Saruno.

As of October 21, 2025, the farm-gate price for aromatic coconuts in Songkhla province stood at a mere 2–3 baht per fruit.

This is critically low, especially when farmers' production costs average 4–5 baht per fruit. In some areas, buyers are refusing to purchase the coconuts, leaving crops to rot on the tree.

With Thailand's annual production standing at 500 million fruits, every 1 baht drop in price equates to a staggering 500 million baht loss for the sector, threatening an industry with an annual export value in the tens of billions of baht.

Vietnam's Rise and the China Protocol

Vietnam's successful entrance into the enormous Chinese market is the main cause of the issue.

Vietnam gained an essential advantage in 2024 when it signed a trade agreement with China, whereas Thai small-scale farmers saw prices fall.

Fresh coconuts could now be exported to the biggest consumer in the world thanks to this deal. Exponential increase and significant Vietnamese shipments started in late 2024 and early 2025, right after Thai prices fell.

According to Vietnamese media, the country's exports of processed and fresh coconuts to China increased by several hundred percent in 2025. *(The Nation)*

THE MTWAPA DEAF WOMEN'S SILENT REVOLUTION: CONVERTING COCONUT WASTE INTO ENVIRONMENTAL GOLD

In a world increasingly obsessed with noise, where influence is measured in volume and success in decibels, the most groundbreaking conversations are taking place without a single spoken word. In Mtwapa, Kenya, where waste coconut leaves are being transformed into environmental solutions and women who were previously invisible are redefining the future of sustainable agriculture, a silent alchemy is occurring while the media focus follows the loudest voices. Here, a circle of deaf ladies sits under the whisper of coconut palms, their hands moving with deliberate practice. They aren't making gifts for visitors or weaving baskets for décor; instead, one biodegradable seedling bag at a time, they are creating an environmentally friendly alternative to a global plastic crisis.

For a long time, Mtwapa has been well-known for its vibrant nightlife, with numerous bars, clubs, and restaurants that attract both locals and tourists. But beyond the nightlife and noise, in these quieter corners, something extraordinary is taking root. This group of deaf women is proving that disability is not a limitation by not only creating employment opportunities but also championing environmental conservation. They are crafting biodegradable seedling bags from coconut leaves and, in the process, challenging environmental norms, breaking down social exclusion, and reshaping gender roles in a space that has historically overlooked them.

At the center of this subtle metamorphosis is Akali Kyalo, a sign language interpreter, mother, craftswoman, and improbable change agent. Her efforts, and those of the women she works with, are assisting in redefining environmental conservation as a very human narrative that upholds dignity, resiliency, and inclusivity rather than merely as a scientific or financial imperative. She started her journey out of curiosity regarding the deaf population living in isolation around her, rather than for lofty environmental goals. She recalls that she first encountered sign language in 2018, driven by a desire to connect with the often isolated deaf community. Over time, she has trained, volunteered, and slowly become a bridge between two worlds. Today, seven years on, what began as personal curiosity has evolved into a calling as she leads a pioneering group of deaf artisans—the first deaf employees officially recognized at the local quarry.

The project is powered by a group of deaf artisans working under the Deaf Association banner. Their core product is biodegradable seedling bags made entirely from discarded coconut leaves. These eco-bags serve as a sustainable alternative to plastic polythene, which has long been known for clogging Kenya's rivers, choking soils, and contributing to long-term land degradation. Akali explains that this eco-friendly alternative offers farmers a sustainable option that aligns with global efforts to combat plastic pollution and soil degradation. The idea for these bags was introduced years ago in Mtwapa by Gabriel Sindani, a Congolese innovator living in Mozambique, whose environmental vision inspired Akali and her team to embrace the initiative. His foresight planted a seed that would grow into something much larger than anyone could have predicted.

The process begins with the gathering of coconut leaves, which are plentiful in the coastal area. Harvesting is the first step, followed by the leaves being painstakingly sorted, softened, and meticulously woven into square bags made especially for planting seedlings. Unlike conventional polythene bags, these do not need to be removed before planting. Instead, they naturally break down in the soil, serving as organic manure that improves the soil and promotes the growth of healthy plants. The invention is both sophisticated and practical. Akali describes it as a circular solution because they are not only protecting the seedlings but also feeding the soil, giving back what they take.

The statistics speak for themselves in terms of commitment and influence. The team makes an average of fifteen bags a day, a labor-intensive procedure that requires perseverance, skill, and steadfast dedication. Employees earn Sh440 a day, while Akali, acting as both coordinator and interpreter, earns Sh670. For many of the women, this is their first taste of economic freedom and their first official job. However, the effects extend much beyond the monetary. The project is a ray of hope in a nation where over 2.5 million people have hearing problems and deaf women frequently experience exacerbated discrimination.

When national statistics are considered, the significance of this work is further enhanced. According to the 2019 Kenya Population and Housing Census, there are approximately 153,381 deaf individuals aged five years and above in the country. A significant majority reside in rural areas, while a smaller portion lives in urban centers. This data provides a baseline but likely underrepresents the full extent of hearing impairment, as it only accounts for those officially identified as deaf and excludes those with partial or moderate hearing loss. Estimates from advocacy and health organizations suggest a much greater number; the Kenya Society for Deaf Children suggests over three million people, or 6.3% of the population, may have hearing loss. The Kenya National Association of the Deaf (KNAD) estimates approximately 5.5% of the population is deaf or has hearing loss. These figures indicate that a sizable section of Kenyans live with hearing-related difficulties, even if data is not always consistent.

Akali notes that many of these women were told they couldn't work, learn, or lead, but at the workshop, they are doing all three. The transformation is visible in every gesture and shared glance. Each woman contributes uniquely, with some focusing on harvesting while others weave or graft seedlings. The division of labor flows naturally from mutual understanding. Akali observes that communication flows through sign language and gestures where they have built their own rhythm, listening to each other even without hearing. Individual stories of transformation are compelling. Kadzo Karisa joined the project after years of staying home due to a lack of inclusive job opportunities; she now mentors newcomers. Veronica Muthoni, a mother of two, balances child-rearing with her work, noting that the routine has brought her self-worth and made her feel needed. The consistent bi-weekly pay enables them to save and plan for their families, fostering identity and emotional stability.

Despite these achievements, significant problems remain, primarily regarding communication. For this group, communication is a barrier impacting both their immediate work and their integration into broader society. According to the World Federation of the Deaf, Kenya has fewer than 500 certified interpreters for a population of over 2.5 million people with hearing impairments. This scarcity creates ripple effects, limiting access to education, healthcare, and legal support. Dr. Gertrude Musuruve Inimah, a former senator and lecturer at JKUAT, explains that deaf women in Kenya face unique, layered challenges. They experience double discrimination—for being women and for having a disability. Major barriers to education and a shortage of interpreters lead many to drop out early. Even those who complete their education struggle to find employment, as most workplaces are unwilling to accommodate them.

Back at the workshop, the seedling bags provide a sustainable solution to Kenya's plastic issue. The National Environment Management Authority (Nema) notes that agricultural polythene contributes to over 20,000 tonnes of plastic trash annually. Much of this waste ends up in the Indian Ocean, endangering coral reefs and marine life. A 2022 survey by the Kenya Marine and Fisheries Research Institute (KMFRI) found that over 70 percent of waste collected during coastal clean-ups was plastic. Kevin Lunzalu, a marine ecologist, explains that plastic pollution threatens marine biodiversity and hurts fisheries, impacting food security and local livelihoods, while littered beaches drive tourists away.

In the face of this environmental crisis, the biodegradable bags offer hope. They are locally sourced, low-cost, and low-carbon, embodying the principles of a circular economy. Kevin suggests that if adopted widely, they could revolutionize the agricultural sector. The Mtwapa program aligns with global initiatives addressing social inclusion and sustainability. UNCTAD Secretary-General Rebecca Grynspan emphasizes that biodegradable alternatives are viable substitutes for single-use plastics. Organizations like UN Women have long highlighted that women in the Global South are powerful drivers of change. This perspective transforms the Mtwapa project from a local initiative into a model for inclusive climate action.

Scaling up will require investment and policy support. Akali emphasizes the need for recognition and resources to replicate the project across the country. However, significant obstacles exist, including a lack of funds to expand operations or reach new markets. Without robust institutional backing, their work risks being ignored despite supporting national environmental goals. Nevertheless, Akali and her team hope to establish a nationwide cooperative run by deaf women to provide eco-friendly packaging across East Africa. Their idea demonstrates how local ingenuity can address global concerns.

Gertrude continues to advocate for systemic change, proposing legislation to officially recognize Kenyan Sign Language and improve inclusive education and employment policies. She asserts that changing the lives of deaf women requires investing in systems that support their full participation. Meanwhile, the group's stories continue to unfold with quiet strength. Kadzo teaches newcomers with patience, Veronica balances parenthood with skilled labor, and Akali leads one of the area's most creative green initiatives. Their effort is living evidence that the marginalized must be included in environmental justice. Akali maintains that sustainability and social inclusion go hand in hand, and that empowerment can come in silence. Yet challenges persist; Gertrude notes that few employers hire deaf women, and some individuals are hired only to meet quotas without real inclusion. Akali sees the Mtwapa project as a beginning, calling for the government and private sector to invest in inclusive infrastructure. Her message to policymakers remains direct: "Give us tools, not pity." *(Daily Nation)*

Table 1. WORLD Exports of Coconut Oil, 2019-2025 (MT)

COUNTRY	2019	2020	2021	2022	2023	2024	2025[F]
A. ICC Countries	**2,058,019**	**1,700,352**	**1,747,617**	**2,160,872**	**2,052,163**	**2,560,102**	**1,961,322**
Côte d'Ivoire	11,028	12,539	2,843	4,023	3,344	3,010	3,459
F. S. Micronesia	0	0	0	0	0	0	0
Fiji	2,485	2,532	1,460	1,210	1,948	2,409	7,699
India	7,828	11,096	14,445	28,320	16,201	19,119	17,892
Indonesia	610,812	577,645	611,452	685,797	722,517	677,377	561,727
Jamaica	6	9	16	29	2	1	11
Kenya	114	55	258	215	75	222	171
Kiribati	3,561	2,517	1,829	1,528	1,116	710	1,118
Malaysia	223,078	203,362	186,606	134,875	165,980	121,109	111,017
Marshall Islands	1,085	1,115	402	709	0	753	487
Papua New Guinea	20,975	17,732	20,991	30,129	31,704	21,224	24,686
Philippines	1,146,642	842,533	881,085	1,252,054	1,090,418	1,671,779	1,194,282
Samoa	424	8	115	100	122	40	87
Solomon Islands	4,561	5,272	5,225	4,554	5,974	4,472	5,000
Sri Lanka	4,056	5,180	3,825	4,712	5,518	7,391	9,253
Tonga	0	0	0	0	0	0	0
Thailand	1,337	1,745	1,689	740	836	677	237
Vanuatu	3,498	1,367	711	428	317	167	304
Vietnam	16,529	15,645	14,665	11,449	6,091	11,642	14,890
B. Other Countries	**306,368**	**328,693**	**347,549**	**343,749**	**354,767**	**344,746**	**347,754**
TOTAL	**2,364,387**	**2,029,045**	**2,095,166**	**2,504,621**	**2,406,930**	**2,886,848**	**2,300,074**

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

Table 2. Prices of Coconut Products and Selected Vegetable Oils, December 2024 – November 2025 (US$/MT)

Products	2024	2025										
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Copra	1,060	1,141	1,172	1,350	1,631	1,642	1,535	1,627	1,273	1,453	1,353	1,357
Coconut Oil	1,953	1,976	2,051	2,316	2,587	2,767	2,699	2,841	2,742	2,596	2,558	2,436
Copra Meal[2]	230	217	183	152	157	201	213	219	187	159	192	254
Desiccated Coconut[2]	2,296	2,315	2,462	3,101	3,711	3,718	3,748	3,748	3,718	3,835	3,799	3,799
Mattress Fiber[1]	71	67	78	102	107	111	109	110	111	113	124	122
Shell Charcoal[3]	522	544	604	696	724	765	815	860	930	943	932	923
Palm Kernel Oil	2,099	1,962	1,947	2,064	2,090	2,003	1,860	2,097	2,264	2,414	2,273	2,141
Palm Oil	1,190	1,070	1,067	1,068	994	908	935	976	1,026	1,037	1,038	970
Soybean Oil	1,064	1,048	1,069	1,011	1,120	1,163	1,178	1,307	1,245	1,159	1,132	1,126

1: Sri Lanka (FOB); 2: Philippines (FOB); 3: Sri Lanka (Domestic); r: revised; Source: ICC and Oil World

Table 3. World Oil Balance 2023-2025 (million tons)

Oil/Year	Jan/Dec 2025^F	Jan/Dec 2024	Jan/Dec 2023
Palm Oil			
Opening Stocks	12.73	14.75	14.86
Production	84.35	79.12	81.70
Imports	48.48	48.94	51.69
Exports	49.44	80.66	82.24
Disappear	82.28	80.66	82.24
Ending Stocks	13.84	12.73	14.75
Soybean Oil			
Opening Stocks	7.01	6.84	6.40
Production	68.67	64.98	59.72
Imports	15.74	13.55	11.67
Exports	16.12	13.81	11.42
Disappear	68.17	64.54	59.54
Ending Stocks	7.13	7.01	6.84
Groundnut Oil			
Opening Stocks	0.32	0.33	0.37
Production	4.63	4.39	4.39
Imports	0.52	0.39	0.35
Exports	0.52	0.40	0.34
Disappear	4.5	4.38	4.44
Ending Stocks	0.45	0.32	0.33
Sunflower Oil			
Opening Stocks	3.87	4.30	3.86
Production	20.87	23.35	22.63
Imports	13.72	16.09	14.43
Exports	13.61	16.26	14.46
Disappear	21.42	23.61	22.15
Ending Stocks	3.43	3.87	4.30
Rapeseed Oil			
Opening Stocks	4.11	4.29	3.32
Production	31.93	31.82	30.95
Imports	7.35	7.45	7.45
Exports	7.46	7.47	7.47
Disappear	31.70	31.97	29.96
Ending Stocks	4.24	4.11	4.29
Cotton Oil			
Opening Stocks	0.52	0.37	0.35
Production	2.74	3.30	4.47
Imports	1.88	2.41	0.10
Exports	1.92	2.40	0.10
Disappear	2.86	3.16	4.45
Ending Stocks	0.35	0.52	0.37

Oil/Year	Jan/Dec 2025^F	Jan/Dec 2024	Jan/Dec 2023
Palm Kernel Oil			
Opening Stocks	1.37	1.56	1.50
Production	8.63	8.15	8.42
Imports	3.46	3.42	3.25
Exports	3.51	3.37	3.25
Disappear	8.50	8.39	8.36
Ending Stocks	1.45	1.37	1.56
Coconut Oil			
Opening Stocks	0.52	0.42	0.46
Production	3.15	3.50	3.10
Imports	1.92	2.56	2.09
Exports	2.30	2.89	2.08
Disappear	2.94	3.07	3.14
Ending Stocks	0.35	0.52	0.42

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

DESICCATED COCONUT PROCESSING MACHINERY

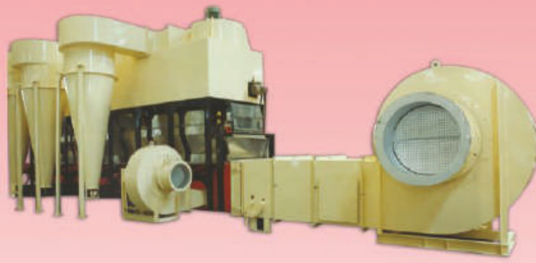
"Over 100 machines in operation worldwide"

BAND DRYER (APRON/CONTINUOS TRAY DRYER)

for Desiccated Coconut Granules, Chips & Toasted D/C
Output Capacity : 1000 to 2500 Kgs/hr.
Two Stage and Three Stage Dryers.
Apron width : 2640mm and 3250mm

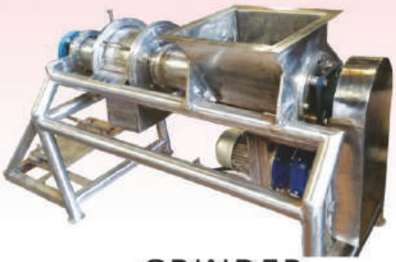
COMBINATION DRYER

for Desiccated Coconut Granules, Chips, Toasted D/C & Parings.
Output Capacity : 300 to 1000 Kgs/hr.



VIBRATORY FLUID BED DRYER

for Desiccated Coconut Granules & Parings.
Output Capacity : 300 to 1000 Kgs/hr.

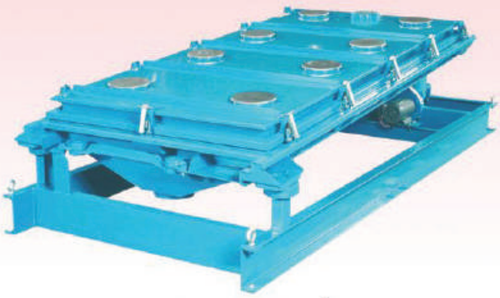


GRINDER

Output Capacity:
1000Kgs/hr.

BLANCHER

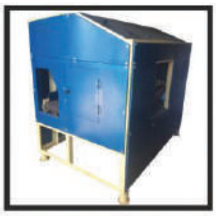
Output Capacity :
1000 to 4000 Kgs/hr.



NOVATEX SCREENER/GRADER

Output Capacity :
1000 to 1500 Kgs/hr.

DESHELLING MAHINE
Output Capacity :
250 to 300 nuts/hr.



DEHUSKING MACHINE
Output Capacity :
1200 nuts/hr.

OIL EXPELLER

RADIATOR
Extruded Fins or
Plate Fins Type

STAINLESS STEEL PERFORATED APRON TRAYS
Width: 2640mm & 3250mm

STAINLESS STEEL CHAIN

GEM

GEMTECH PROJECTS LLP.

10/C, Middleton Row, 3rd Floor, Kolkata - 700 071, India
Tel: +91-33-2217 7328 (4 Lines) | Mobile: +91 9831173874, +91 9831131196 | Fax:+91-33-2217 7333
E-mail: info@coconutprojects.com | sg@gemforgings.com | www.coconutprojects.com

INTEGRATED COCONUT PROCESSING MACHINERY AND SOLUTIONS

T & I Global Ltd

THE TIGL EXPERIENCE

- New Plant Engineering, Design & Suply
- Existing Factory Up-gradation & Expansion
- Plant Automation
- Machinery Customization
- Machinery Manufacturing & Supply
- Turnkey Solutions
- Electrical, Steam, Utility Engineering
- AMC, Spares & Training Installation & Commission
- Continous Process and Machinery R&D

50+ YEARS

500+ EMPLOYEES ACROSS T&I GLOBAL

40+ COUNTRIES SERVED

400,000+ SQ.FT. INTEGRATED MANUFACTURING AREA

100+ PROJECTS EXECUTED

500+ TRUSTED CUSTOMERS







COMPLETE TURNKEY COCONUT PROCESSING & ENGINEERING SOLUTIONS

DESICCATED COCONUT | VIRGIN COCONUT OIL | COCONUT MILK | COCONUT WATER | CRUDE COCONUT OIL
COCONUT CHIPS & FLAKES | COIR & FIBER

THINK COCONUT. THINK T&I GLOBAL

Contact Us www.coconutmachineryindia.com marketing@tiglobal.com +91 9874045634/+91 9345915893