Research Article

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From coast to Isle: exploring the morphological diversity of tender coconuts in selected Indian accessions

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Abstract

Coconut (*Cocos nucifera* L.) is an economically and nutritionally important tropical crop, particularly renowned for its oil and tender coconut water, a beverage known for its hydrating properties and health benefits. This study investigates the morphological diversity of tender nuts from various coconut accessions collected from coastal and island ecosystems in India. A total of 31 coconut accessions, including the Indian West Coast Tall (WCT) as a reference, were evaluated for tender nut traits. Significant variability was observed, with tender coconut weights ranging from 831.67 g in Andaman Horned Tall to 2940.83 g in Kodiaghat Brown Tall. Quantity of tender coconut water varied from 85.55 mL in Andaman Horned Tall to 545.58 mL in Kodiaghat Brown Tall followed by Dugong Creek Tall (495.83 mL) and Nicobar Tall AuckChung (485.0 mL). The average TSS was 5.0° Brix, with Andaman Horned Tall recording the highest TSS at 5.98° Brix. Accessions such as Kodiaghat Brown Tall and Dugong Creek Tall demonstrated superior traits, suggesting their potential in varietal breeding programs. The study underscores the genetic diversity present in coconut accessions, with implications for improving tender coconut production. The findings highlight the importance of understanding these traits for developing varieties that meet consumer and market demands, ultimately contributing to the sustainability of coconut.

***Keywords*:** Coconut, tender coconut, hydrating, morphological diversity, island, coastal, ecosystem, minerals

Introduction

Coconut (*Cocos nucifera* L.) is a versatile and economically significant palm tree that thrives in tropical and subtropical regions around the globe. Coconut is often referred to as the "tree of life" due to its multifaceted contributions to agriculture, economy, and nutrition as it provides food, oil, fibre, and various by-products that support livelihoods and economies in many developing countries (Hernández *et al.*, 2018). The tender coconut, particularly its water, has gained popularity globally, recognized for its refreshing taste and rich nutritional profile, making it a popular choice among health-conscious consumers. This nutrient-rich liquid is loaded with electrolytes and possesses a composition that is often compared to that of human plasma, making it a preferred choice for hydration (Rethinam and Nandakumar, 2001). Rich in electrolytes such as potassium, sodium, and magnesium, coconut water serves as an excellent natural rehydration drink (Ratnambal, 1999). Its popularity has soared in recent years, particularly as a health drink, due to its low calorie count and high nutrient content, which includes vitamins, minerals, amino acids, and antioxidants (Niral and Ranjini, 2018).

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The morphological traits of coconut accessions significantly influence both the yield and quality of tender coconuts. Variability in these traits can be attributed to genetic factors, environmental conditions, and agronomic practices. Variability in characteristics such as weight, water content, total soluble solids (TSS), endosperm weight, and colour among different coconut accessions influences consumer preference and marketability (Kanimozhi *et al.*, 2018). India is home to a rich diversity of coconut accessions, particularly in coastal and island ecosystems. These regions provide unique agro-climatic conditions that contribute to the variability observed in coconut morphology (Niral *et al.*, 2021). The Indian West Coast Tall and various indigenous accessions from the Lakshadweep and Andaman and Nicobar Islands exemplify this diversity. Such accessions often exhibit distinctive traits influenced by local environmental conditions, cultivation practices, and genetic makeup, making them invaluable for breeding programs focused on improving coconut quality and yield (Karun and Niral, 2019). Characterizing the morphological diversity of tender coconuts can provide critical insights for breeding programs aimed at enhancing desirable traits such as higher water yield, better taste, and improved nutritional quality. Previous studies have reported significant variability in tender coconut characteristics among accessions, underscoring the potential for selection in breeding initiatives (Ranasinghe *et al.*, 2015). Understanding this variability is essential for optimizing breeding strategies, enhancing the quality of coconut water, and meeting consumer preferences. India, being one of the leading producers of coconuts, harbours a wide range of genetic diversity across different ecosystems, particularly in coastal and island regions. This study aims to explore the diversity in tender nut morphology among coconut accessions conserved in the field gene bank of the ICAR-Central Plantation Crops Research Institute, located in Dakshina Kannada District, Karnataka. By analysing key morphological traits, the study seeks to assess the variability in tender coconut traits among different accessions and to identify superior accessions that can be utilized in breeding programs and contribute to the sustainable cultivation of coconuts.

Materials and Methods

The study was conducted at ICAR-Central Plantation Crops Research Institute, Research Centre, Kidu, Karnataka, situated at 12°30′N latitude and 75°20′E longitude during 2019-2021. The region experiences a tropical climate with an annual rainfall of 2800 to 4200 mm, supporting diverse agricultural practices. The experimental site is characterized by red laterite soil. A total of 31 tall coconut accessions planted during 2002 and conserved at ICAR-CPCRI, Research Centre, Kidu, which also hosts the International Coconut Gene Bank for South Asia and Middle East (ICG-SAME), were selected for evaluation. The accessions include 15 from the coastal ecosystem of Kerala, 4 from Lakshadweep Islands, and 11 from Andaman and Nicobar Islands, and the Indian West Coast Tall (WCT) as a standard check variety (Table 1). The accessions were planted at a standard spacing of 7.5m x 7.5m in a randomized block design (RBD) with three replications. For the study, six palms were selected from each accession, with two palms representing each replication. Freshly opened inflorescences were tagged, and tender coconuts at the seven-month stage were harvested for analysis. From each selected palm, two tender coconuts were used to record observations on both quantitative and qualitative characteristics.

Tender coconut weight (g)

To assess the tender coconut weight, two coconuts were carefully selected from each palm within the experimental plots. This selection aimed to ensure a representative sampling of the accessions under study. The coconuts were collected at the optimal age of seven months, each coconut was individually weighed using a precision digital balance, ensuring accuracy in measurements. The recorded weights were then averaged to calculate the mean weight for each accession.

Table 1. List of coconut accessions selected for morphological diversity analysis of tender coconuts

Sl. No.	Accession Number	Accession Name	Source
1	IND263	Pinarai Tall	Kerala
2	IND264	Mullasseri Tall	Kerala
3	IND265	Pavaratty Tall	Kerala
4	IND266	Pallissery Tall	Kerala
5	IND267	Chappadan Tall	Kerala
6	IND268	Ponnani Tall	Kerala
7	IND269	Ponnani Tall Yellow	Kerala
8	IND270	Kakkadipuram Tall	Kerala
9	IND271	Chengara Tall	Kerala
10	IND272	Manjeri Tall	Kerala
11	IND273	Koothali Tall	Kerala
12	IND274	Kutiadi Tall	Kerala
13	IND275	Quilandi Tall	Kerala
14	IND276	Mahi Tall	Kerala
15	IND281	Achamthruthy Tall- I	Kerala
16	IND222	Laccadive Ordinary Tall Agathi	Lakshadweep Islands
17	IND224	Laccadive Micro Tall Agathi	Lakshadweep Islands
18	IND226	Laccadive Micro Tall Agathi Oval fruited	Lakshadweep Islands
19	IND227	Laccadive Small Tall Agathi	Lakshadweep Islands
20	IND205	Champin Micro Tall	Andaman & Nicobar Islands
21	IND215	Nicobar Micro Tall Katchal	Andaman & Nicobar Islands
22	IND254	Nicobar Micro Tall	Andaman & Nicobar Islands
23	IND241	KodiaghatBrown Tall	Andaman & Nicobar Islands
24	IND221	Andaman Horned Tall	Andaman & Nicobar Islands
25	IND234	Carbin Brown Tall	Andaman & Nicobar Islands
26	IND249	Dugong Creek Tall	Andaman & Nicobar Islands
27	IND252	Malaca Tall	Andaman & Nicobar Islands
28	IND123	Nicobar Tall Katchal	Andaman & Nicobar Islands
29	IND119	Nicobar Tall AuckChung	Andaman & Nicobar Islands
30	IND120	Nicobar Tall Tamaloo	Andaman & Nicobar Islands
31	IND069	Indian West Coast Tall	Kerala **(check)**

Quantity of tender coconut water (mL)

Quantity of tender coconut water was determined as per Ratnambal *et al.*, 1995; 2000. To determine the quantity of tender coconut water, a small hole was carefully made in each coconut using a hand-held puncher. This method was chosen to minimize damage to the coconut while ensuring effective extraction of the water. The hole allowed for the free flow of coconut water, which was then collected into a wide-mouth measuring cylinder. The volume of coconut water collected was measured and recorded, with care taken to ensure that the measurement was precise and accurate. The mean quantity of tender coconut water was calculated for each accession by averaging the volumes

Total soluble solids (TSS) of tender coconut water (°Brix)

The TSS of the tender coconut water was measured using a hand-held refractometer, a device that allows for quick and accurate assessment of sugar concentration in liquids. Small sample of the coconut water was placed on the prism of the refractometer and the results were expressed in °B, with higher values indicating a greater concentration of sugars and, often, a sweeter taste. The mean TSS values for each accession were calculated, providing insights into the flavour profile and potential quality of the tender coconut water.

Weight of tender coconut endosperm (g)

To evaluate the endosperm weight, the solid endosperm was carefully extracted from each coconut. This process involved scraping the tender flesh from the inner walls of the coconut using a clean spoon. The scraped endosperm was then weighed on a precision electronic digital scale to ensure accurate measurement. The weights of the endosperm were recorded and mean values were calculated for each accession.

Colour of the tender coconut

To assess the colour of the tender coconuts, a standardized approach was employed using the Royal Horticultural Society (RHS) colour chart. This chart provides a comprehensive guide to a wide range of colours, ensuring that the assessment is both accurate and consistent across different accessions. The middle portion of the tender coconut was selected for colour matching, as it offers a representative view of the coconut's overall appearance. Two coconuts from each palm were collected, and their colours were compared against the RHS chart to identify the closest match. The specific colour names and codes were recorded for each accession, providing valuable data on the aesthetic traits of the coconuts.

Potassium and sodium content

Minerals like potassium and sodium were estimated using flame photometer (Jackson, 1973).

Statistical analysis

The two-year mean values for the observed quantitative characters of the 31 accessions were subjected to statistical analysis according to Panse and Sukhatme (1961). ANOVA was performed using WASP 2.0 of ICAR-CCARI, Goa (Jangam and Thali, 2004). This statistical approach allowed for a comprehensive understanding of the variability present in the traits under study.

Results and Discussion

Significant differences were observed among the coconut accessions for tender nut characteristics, indicating substantial diversity within the germplasm collection (Fig. 1 & 2). Across the accessions studied, the weight of tender coconuts ranged from 831.67 g to 2940.83 g, with a population mean of 1744.67 g (Table 2). The maximum tender coconut weight was recorded in Kodiaghat Brown Tall (2940.83 g), followed by Dugong Creek Tall (2886.94 g) and Nicobar Tall Auck Chung (2233.33 g). Conversely, the lowest weight was observed in Andaman Horned Tall (831.67 g), followed by Laccadive Micro Tall Agathi (1047.22 g) and Champin Micro Tall (1084.64 g). Twelve accessions had tender nut weights higher than the population mean, while three

surpassed the check variety weight (2174.86 g). The weight of tender coconuts is a crucial determinant of both productivity and marketability. As indicated, the highest weight recorded in the Kodiaghat Brown Tall, Dugong Creek Tall and Nicobar Tall Auck Chung aligns with findings from earlier studies that emphasized the potential for certain coconut varieties to yield larger tender nuts, thus enhancing water production (Niral *et al.*, 2014). In contrast, the low weights of the accessions like Andaman Horned Tall (831.67 g) highlight the diversity in tender nut size that can be targeted for breeding improvements. Research indicates that the weight of tender coconuts can vary significantly between accessions, influenced by genetic factors and environmental conditions (Ranasinghe *et al.*, 2015).

Figure 1. Tender coconuts of accessions native to coastal ecosystem of kerala

Figure 2. Tender coconuts of accessions native to Island ecosystem of Lakshadweep and Andaman and Nicobar Islands

Table 2. Mean variability for tender coconut parameters among the coconut accessions

Sl. No.	Accession	Tender nut weight (g)	Quantity of tender nut water (mL)	TSS of water (°Brix)	Endosperm weight (g)
1	Pinarai Tall	1450.28	225.58	5.21	41.17
2	Mullasseri Tall	1642.78	249.50	4.69	41.50
3	Pavaratty Tall	1932.50	237.92	5.44	49.47
4	Pallissery Tall	1722.92	272.75	4.96	54.92
5	Chappadan Tall	2098.33	334.67	4.74	40.25
6	Ponnani Tall	1696.95	246.00	4.70	26.17
7	Ponnani Tall Yellow	1658.33	238.17	4.68	27.00
8	Kakkadipuram Tall	1743.89	248.25	4.53	36.52
9	Chengara Tall	1830.83	296.17	5.10	28.44
10	Manjeri Tall	1862.08	267.25	5.30	45.15
11	Koothali Tall	1427.22	202.33	5.25	35.75
12	Kutiadi Tall	1868.33	283.33	4.90	54.88
13	Quilandi Tall	1697.22	281.58	5.30	43.08
14	Mahi Tall	1640.00	247.58	4.60	31.00
15	Achamthruthy Tall - I	1436.81	295.00	4.40	38.04
16	Laccadive Ordinary Tall Agathi	1601.25	207.83	5.07	37.70
17	Laccadive Micro Tall Agathi	1047.22	157.88	4.88	36.25
18	Laccadive Micro Tall Agathi Oval fruited	1360.00	178.46	4.71	15.61
19	Laccadive Small Tall Agathi	1517.50	366.13	4.18	32.52
20	Champin Micro Tall	1084.64	244.75	5.11	35.25
21	Nicobar Micro Tall Katchal	1390.00	336.33	4.77	43.39
22	Nicobar Micro Tall	1524.86	355.58	5.07	43.84
23	Kodiaghat Brown Tall	2940.83	545.58	4.29	42.67
24	Andaman Horned Tall	831.67	85.55	5.98	33.83
25	Carbin Brown Tall	1872.50	379.50	5.10	40.58
26	Dugong Creek Tall	2886.94	495.83	4.87	44.75
27	Malaca Tall	1920.42	452.00	5.66	39.28
28	Nicobar Tall Katchal	2087.50	300.25	5.42	29.92
29	Nicobar Tall Auck Chung	2233.33	485.00	5.50	58.67
30	Nicobar Tall Tamaloo	1902.78	330.28	5.46	53.17
31	Indian West Coast Tall	2174.86	416.58	5.14	57.25
	Mean	1744.67	298.83	5.00	39.94
	S. Ed	290.41	44.61	0.43	6.59
	CD at 5 %	580.83	89.21	0.86	NS
	CV (%)	20.39	18.28	10.53	20.23

The results present notable diversity in the tender coconut weights across different geographical regions, showing variability not only between ecosystems but also within each ecosystem itself. In accessions native to Kerala, the tender coconut weight ranged from 1427.22 grams in Koothali Tall to 2098.33 grams in Chappadan Tall, with a population mean of 1713.89 grams. This range indicates a moderate level of diversity within the accessions native to Kerala. The weight variability suggests, though some diversity exists, most of the accessions fall within a relatively narrow range. Chappadan Tall, with its higher weight, may represent a variety better suited to specific conditions or it could be a result of selection for larger coconuts. The mean weight of (1713.89 g) within Kerala accessions, indicates a moderate average size of tender coconuts, typical of the region's traditional coconut cultivars. In the accessions native to Lakshadweep Islands, tender coconut weights ranged from 1047.22 grams in Laccadive Micro Tall Agathi to 1601.25 grams in Laccadive Ordinary Tall Agathi, with a population mean of 1381.49 grams. The coconuts from Lakshadweep appear to be smaller compared to those from Kerala, with the mean weight of 1381.49 g being lower than the Kerala mean of 1713.89 g. The range, however, is narrower compared to the Kerala accessions. The most remarkable diversity in coconut weight is seen among accessions from the Andaman and Nicobar Islands. The range is quite extreme, from the smallest at 831.67 grams (Andaman Horned Tall) to the largest at 2940.83 grams (Kodiaghat Brown Tall), with a population mean of 1904.19 grams. The vast disparity in tender coconut weights from the Andaman and Nicobar Islands suggests a high degree of genetic diversity. The overall mean of 1904.19 g suggests that, on average, coconuts from this region are larger than those from Kerala or Lakshadweep, but the extreme variation points to significant environmental and genetic influences on size. The accessions from Andaman and Nicobar Islands exhibited greater diversity, suggesting a rich genetic reservoir. Similar results were reported by DevaKumar *et. al.* (2010). Overall, Kerala accessions show moderate variation, Lakshadweep coconuts are smaller and more uniform, while the Andaman and Nicobar Islands exhibit the greatest diversity. These findings highlight the role of geographical and environmental factors in shaping coconut size and diversity across India.

The quantity of tender nut water varied from 85.55 mL to 545.58 mL, with a population mean of 298.83 mL (Table 2). Kodiaghat Brown Tall recorded the highest quantity (545.58 mL), followed by Dugong Creek Tall (495.83 mL) and Nicobar Tall AuckChung (485.0 mL). In contrast, Andaman Horned Tall exhibited the lowest quantity (85.55 mL), indicating that larger nuts tend to contain more water while smaller nuts have less. This can be attributed to the anatomical structure of larger nuts, which typically possess greater internal volume to store more water.This metric is vital, as the volume of coconut water not only serves as an indicator of the quality and size of the tender nut but also has implications for consumer preference and commercial value (Kanimozhi *et al*., 2018).The data also reveals significant diversity in tender coconut water content across different regions, with notable intra-regional and regional variation. In the accessions native to Kerala, tender coconut water content ranged from 202.33 mL in Koothali Tall to 334.67 mL in Chappadan Tall, with an average of 261.74 mL. This suggests moderate diversity in the quantum of water present in tender coconuts from this region. The variation in coconut water content indicates most accessions fall within a relatively narrow range. Chappadan Tall, with the higher water content, may be a cultivar that is particularly suited to higher water retention, either due to genetic factors or environmental conditions. The average of 261.74 mL among the Kerala accessions indicates moderate water content typical of Kerala's coconut varieties. In Lakshadweep, coconut water content ranged

from 157.88 mL in Laccadive Micro Tall Agathi to 366.13 mL in Laccadive Small Tall Agathi, with a population mean of 227.58 mL. The coconuts from Lakshadweep have a lower average water content compared to Kerala, with the mean of 227.58 mL being notably smaller. The range, however, is still significant, with some varieties, like Laccadive Small Tall Agathi, offering higher yields. The greatest diversity in coconut water content was found in the Andaman and Nicobar Islands, where it ranged from as low as 85.55 mL in Andaman Horned Tall to as high as 545.58 mL in Kodiaghat Brown Tall, with a population mean of 368.94 mL. The extreme variation in coconut water content from the Andaman and Nicobar Islands is striking. The population mean of 368.94 mL, among the accessions of this region, is the highest indicating that, on average, coconuts from the Andaman and Nicobar Islands provide a larger yield of water. Previous studies conducted at ICAR-CPCRI have reported similar trends, indicating that coconut accessions from varying ecological zones exhibit differences in water volumes. The relationship between tender nut weight and the quantity of coconut water is particularly noteworthy. The data from this study indicate that bigger size with higher tender nut weights correspond with larger volumes of water, supporting previous findings by Niral *et al.* (2019), who observed that heavier nuts tend to yield more coconut water.

The TSS of tender coconut water ranged from 4.18° Brix (Laccadive Small Tall Agathi) to 5.98° Brix (Andaman Horned Tall), with a population mean of 5.0° Brix (Table 2). Other notable accessions with high TSS included Malaca Tall (5.66° Brix), Nicobar Tall AuckChung (5.50° Brix), and Nicobar Tall Tamaloo (5.46° Brix). The coefficient of variation for TSS was found to be 10.53%, indicating moderate variability among the accessions. The TSS content of tender coconut water is a critical determinant of its quality and acceptability. Variability in TSS levels among different accessions is well-documented, influenced by both genetic makeup and environmental factors such as soil health and climatic conditions (Apshara *et al.*, 2007; Sankaran *et al.*, 2012). Understanding TSS levels is crucial for assessing the desirability of tender coconut for consumer markets, as taste is a significant factor in consumer choice. Similar trends in TSS across different coconut varieties have been reported by Chikkasubbanna *et al.* (1990); Poduval *et al.* (1998) and Prades *et al.* (2012).

Potassium is one of the major mineral elements found in coconut water and is essential for hydration and maintaining electrolyte balance in the body (Pue *et al.*, 1992). The potassium content in coconut water varied considerably, with Chengara Tall (2,219.13 ppm) and Achamthruthy Tall - I (2180.75 ppm) exhibiting high levels (Fig. 3). The higher potassium content in Chengara Tall may indicate better potassium uptake, that could have positive implications for the nutritional quality of the coconut water, particularly for those seeking natural sources of potassium. Similarly, Kodiaghat Brown Tall (21.20 ppm) and Indian West Coast Tall (17.49 ppm) had the highest sodium levels, while Pinarai Tall (6.71 ppm) had the lowest (Fig. 4). Generally, coconut water is considered a low-sodium beverage, making it an attractive option for hydration (O'Brien*et al.*, 2023). The relatively low sodium concentrations in accessions like Pinarai Tall are consistent with the common perception of coconut water as a hydrating fluid with minimal sodium content.

Colour is an important attribute, influencing consumer appeal and marketability, thus making this assessment crucial in evaluating the overall quality of the tender coconuts. The variability in tender coconut fruit colour was noted among accessions. The use of the Royal Horticultural Society (RHS) colour chart allowed for a standardized assessment, is crucial for comparative studies across different accessions

(RHS, 2001). Ten accessions exhibited Moderate Yellow Green (146C), while seven showed Strong Yellow Green (144B). Other colours included Light Olive (152A), Moderate Olive Brown (199A) in two accessions, and various shades of brownish orange (165B and 165C) in others. The variability in colour among the accessions presents opportunities for breeding programs to cater to market preferences. While the traditional orange-yellow-green coconuts are popular, the presence of other colour variations may appeal to niche markets, enhancing the commercial value of these coconuts that can influence consumer preferences and marketability (Table 3).

The study underscores the diversity among the coconut accessions, contributing towards the observed differences in the tender coconut parameters. Understanding the interactions between genetics and the environment can provide a better understanding to make informed decisions for developing improved varieties customized for different localities for commercial tender coconut production.

Figure 3. Potassium content in tender coconut water of coconut accessions

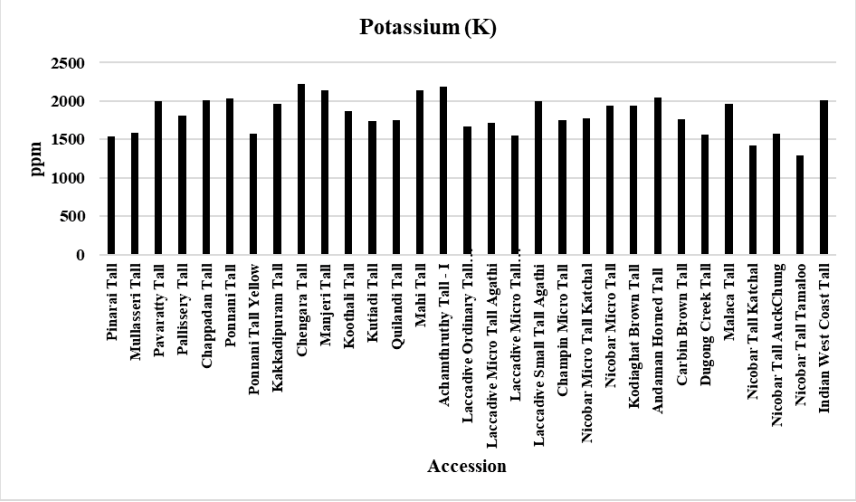

Figure 4. Sodium content in tender coconut water of coconut accessions

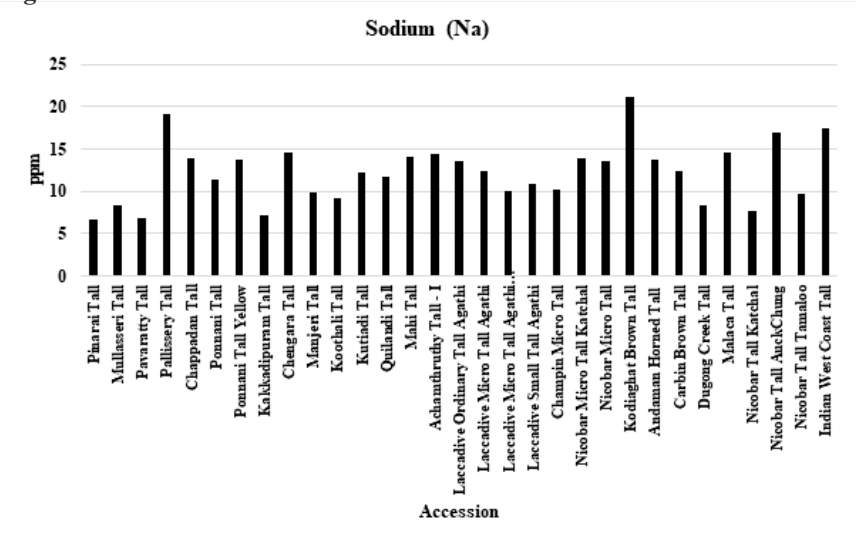

Table 3. Variability in fruit colour among the coconut accessions

Accession	Colour of the tender nut
Andaman Horned Tall	Strong Yellow Green (143A)
Mullasseri Tall, Pavaratty Tall, Pallissery Tall, Chappadan Tall, Kakkadipuram Tall, Indian West Coast Tall	Strong Yellow Green (144B))
Nicobar Tall Katchal, Ponnani Tall Yellow, Manjeri Tall, Koothali Tall, Quilandi Tall, Mahi Tall, Nicobar Micro Tall Katchal, Nicobar Micro Tall, Laccadive Micro Tall Agathi, Laccadive Micro Tall Agathi Oval fruited,	Moderate Yellow Green (146C)
Malaca Tall	Moderate Yellow Green (146D)
Pinarai Tall, Chengara Tall, Kutiadi Tall, Kodiaghat Brown Tall. Carbin Brown Tall, Dugong Creek Tall	Light Olive (152A)
Laccadive Ordinary Tall Agathi, Champin Micro Tall, Nicobar Tall Tamaloo	Brownish Orange (165B)
Nicobar Tall AuckChung	Brownish Orange (165C)
Ponnani Tall, Achamthruthy Tall - I Laccadive Small Tall Agathi	Moderate Olive Brown (199A)

Conclusion

This study successfully characterized the morphological diversity of tender coconuts from 31 coconut accessions native to coastal and Island ecosystem of India, highlighting significant diversity in key traits, including nut weight, water content, total soluble solids (TSS), and mineral composition. Nut weights ranged from 831.67 g to 2940.83 g, with larger nuts like Kodiaghat Brown Tall and Dugong Creek Tall correlating with higher water yields. The highest water content was found in Kodiaghat Brown Tall (545.58 mL) and the lowest in Andaman Horned Tall (85.55 mL). Kerala accessions showed moderate variability, while Lakshadweep coconuts were smaller and more uniform. The Andaman and Nicobar Islands accessions exhibited the greatest diversity. TSS ranged from 4.18° Brix to 5.98° Brix, with a mean of 5.0° Brix, and high levels seen in Malaca Tall and Nicobar Tall AuckChung. Potassium content varied, with Chengara Tall showing the highest levels (2,219.13 ppm), while sodium levels remained low, especially in Pinarai Tall (6.71 ppm), supporting coconut water's reputation as a hydrating, low-sodium beverage. The findings indicate potential for selection and breeding aimed at improving the quality and yield of tender coconut water. The data emphasizes the importance of geographical and environmental factors in shaping the size and diversity of tender coconuts, with each region demonstrating unique traits that contribute to the broader diversity of coconut varieties in India.

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