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## Qualitative Analysis Of Coconut Water: A Review

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### Abstract

Coconut (*Cocos nucifera* L.), an extensively cultivated palm tree, offers numerous uses, with its fruit being particularly valuable. The white kernel and coconut water from the nut are highly nutritious, serving both dietary and medicinal purposes. Coconut water, emerging from the fruit at five months and best consumed at 18 months, is rich in antioxidants, electrolytes, vitamins, and minerals, aiding hydration, blood pressure regulation, and digestion. Beyond its popularity as a beverage, coconut water has applications in biotechnology and the health industry, including traditional medicine and microbial growth mediums. Analytical studies reveal its composition varies with maturity, influencing its nutritional and therapeutic properties. This review explores coconut water's diverse applications, emphasizing its medical and biotechnological potential while identifying research gaps for further investigation.

**Keywords:** Coconut Water, Nutrition, Medicinal Properties, Physico-Chemical Properties. Natural Beverage.

### Introduction

Coconut (*Cocos nucifera* L.) [1]the most important and extensively grown palm tree globally, has various uses and benefits. The leaf and trunk provide building material, while the root is used as medicine[2]. The fruit is the most marketable part, with the husk processed into rope, carpets, geotextiles, and growing media. The inner part of the nut is divided into two edible parts: a white kernel and a clear liquid: coconut water. Coconut is now more than just an oil seed[3]. it is now a valuable fresh fruit. Coconut water, or coconut juice, is a sweet refreshing drink taken directly from the inner part of coconut fruits, often coming from small and scarce coconut tree plantations. It is a traditional medicine, microbiological growth[4] medium, and ceremonial gift, and can be processed into vinegar or wine. Current research on coconut water is rare, focusing on specific uses, biochemical composition, and preservation technology[5]. Coconut, a symbol of life and fertility in tropical regions, is often referred to as the 'tree of life' due to its versatile applications. One of its key factors making coconuts alluring is coconut water, which is derived from the liquid endosperm of the coconut fruit. Coconut water emerges when the fruit is approximately five months old and reaches its peak for consumption at around 18 months[6]. As the fruit matures, the sensory characteristics of the coconut water undergo changes, reducing its volume and transforming into solid endosperm (coconut meat). Coconut water is a rich source of antioxidants[7], electrolytes, and nutrients, including vitamins, minerals, amino acids, glucose, and fructose. It not only fulfils the roles of hydration and quenching thirst but also contributes to maintaining electrolyte balance, reducing high blood pressure and cardiovascular diseases[8], defence against free radical damage, and acceleration of food digestion. Current reviews on coconut water have primarily focused on its applications as a beverage and food additive. However, coconut water also finds extensive applications in biotechnology and the health industry[9]. This review focuses on the applications of coconut water in the medical and biotechnology fields, providing a comprehensive overview of existing research and

highlighting gaps in research where further investigation is needed. This consolidated information can serve as a valuable resource for coconut industry stakeholders[10].



## USES OF COCONUT WATER

**As a religious symbol:** Coconut water, a sterile and pure liquid, has long been a religious symbol in Asia, particularly in India, where tender, immature coconuts are offered as ceremonial gifts and purification media. In Hindu mythology[11], coconut water is considered as a sacred liquid and coconut is being a part of every ritual and custom performed. Even countries other than India are adding coconut for performing their rituals and custom.

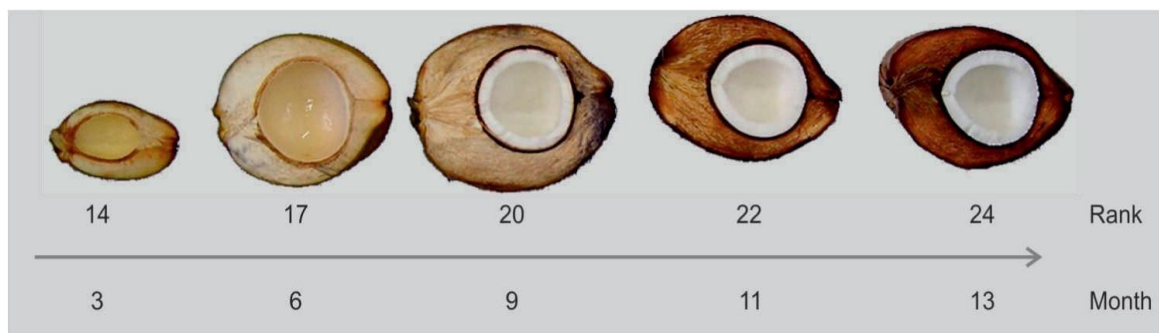
**As a natural beverage:** Coconut water is a popular, natural health drink with a lower calorie and sugar content, making it an alternative to sugary drinks. It contains electrolytes like potassium, sodium, calcium, and magnesium, aiding in hydration and electrolyte balance. Coconut water is also used in culinary endeavours, cocktails, and desserts, with its fresh taste and subtle sweetness enhancing flavours[12]. It is an integral part of a healthy lifestyle. As coconut water gains popularity, processing facilities use various methods to extract and package it, allowing for long-distance transportation. Coconut fruits were utilized as food and drink by Polynesian, Melanesian, and Micronesian seamen centuries ago, which helped them colonize the Pacific Ocean. Nowadays, many of people living in tropical regions drink coconut water made from immature nuts. With sales of coconut water rising from 60 million units in 2000 to 120 million units in 2006, Brazil is the most developed market for the product. PepsiCo purchased the best-selling brand, Amacoco, in 2009 in addition to its deliciousness, nutritional advantages, and inherent moisturizing properties. Coca-Cola has recently started investing in ZICO Beverages, a coconut water startup based in California.

**As a medicine:** Coconut water is a natural drink with significant medicinal uses, particularly in Indian ayurvedic medicine[13]. It is described as unctuous, sweet, and beneficial for increasing semen, digestion, and clearing the urinary path. In Sri Lanka, coconut is consumed daily and five out of the 40 raw or processed parts of the plant involve coconut water. Traditional uses include burning pain during urination, dysuria, gastritis, eye pain, indigestion, hiccups, and expelling retained placenta. In emergencies and during World War II, coconut water was used as a short-term intravenous hydration and resuscitation fluid. Coconut water has numerous health benefits, including blood pressure regulation, kidney health, cardiovascular health, antioxidant properties, weight management, blood sugar control, skin health, and anti-aging effects. Its high potassium content counteracts sodium effects, aiding in hypertension management. It dissolves kidney stones and promotes urine production, while its antioxidant properties neutralize free radicals, reducing the risk of chronic diseases. Coconut water is low in calories and fat, making it a good choice for hydration and weight management. It also helps control blood sugar and reduce oxidative stress, making it beneficial for diabetes patients[.]. Additionally, its antimicrobial properties make it a potential remedy for acne.

**As a growth medium for microorganisms and plants:** In the 1960s, coconut water was discovered to promote microbial growth, particularly the "Nata de coco" bacterium, a bacterial cellulose produced at the coconut water/air interface. Originating from the Philippines, it has since become popular in other Asian countries. Coconut water is traditionally processed into wine or vinegar due to its sugar content and fermentation ability[14]. It has been shown to induce cell division, as demonstrated in spinach tissue growth. Coconut water contains growth factors that stimulate bacterial strains and plant in vitro culture, with immature fruit water producing better results.

**As a biocatalyst:** Coconut water has been found to support protein synthesis from recombinant DNA vectors, and filtered water from young Brazilian coconuts showed high reductase activity in various aldehydes and ketones, suggesting it may be underutilized in organic synthesis research.

## COMPOSITION OF COCONUT WATER



Coconut water is a highly nutritious beverage derived from palm trees, with a rich array of macro and micro nutrients that can reduce lipid levels and provide protective benefits to the heart and liver. It has been used worldwide to treat oral rehydration, childhood illnesses, intestinal flu, and cholera. Coconut has been used in traditional Indian medicine for thousands of years, and in Sri Lanka, it is a staple food. Coconut water has been widely used to treat infectious diseases, dysentery, influenza, and other diseases that cause dehydration[14]. Recent research has shown that coconut water has the potential to lower blood sugar levels, similar to standard oral diabetes medications. It also contains vitamin-C, vitamins-B, and B9, which are important for preventing anaemia in pregnancy and mitochondrial toxicity caused by methanol metabolites. Coconut water has antioxidant properties and has been used as a sperm extender for equine and rabbit sperm. It has also been found to have antimicrobial properties, potentially contributing to the recovery of Covid-19 patients[15].

### PHYSICO-CHEMICAL PROPERTIES[16] :

**Volume of water:** In Figure 1, the volume of water present in coconut water is documented over the span of a year. Notably, the volume for the months of May to June is recorded at 684 mL. During the period from August to September, the volume decreases to 518 mL. For measurements taken beyond 12 months, the volume further declines to 332 mL. These data points highlight significant seasonal variations in the water content of coconut water throughout the year.

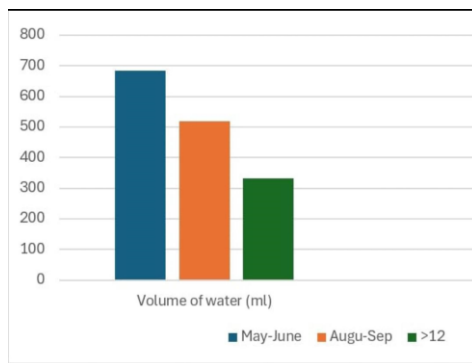


Figure -1: Volume of Water

**Total Soluble Solid:** In Figure 2, the total soluble solids in coconut water are tracked over a one-year period. During the months of May to June, the total soluble solid content is measured at 5.6%. This value increases to 6.15% between August and September, indicating a peak during this period. However, measurements taken beyond 12 months show a decrease to 4.85%. These findings suggest notable fluctuations in the soluble solid content of coconut water, corresponding to different times of the year.

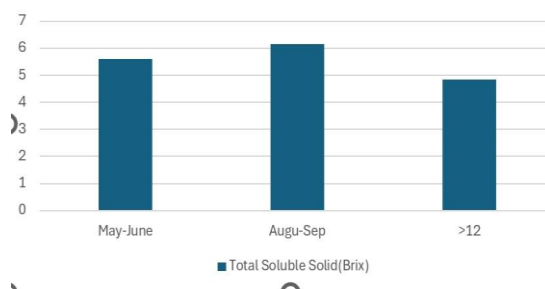


Figure -2: Total Soluble Solid

**Titratable Acidity:**

In Figure 3, the titratable acidity in coconut water is analyzed over a one-year period. The acidity levels for the months of May to June are recorded at 0.089%. During the months of August to September, the acidity decreases to 0.076%. Measurements taken beyond 12 months indicate a further reduction in acidity to 0.061%. These variations in titratable acidity highlight significant seasonal changes in the acidity levels of coconut water throughout the year.

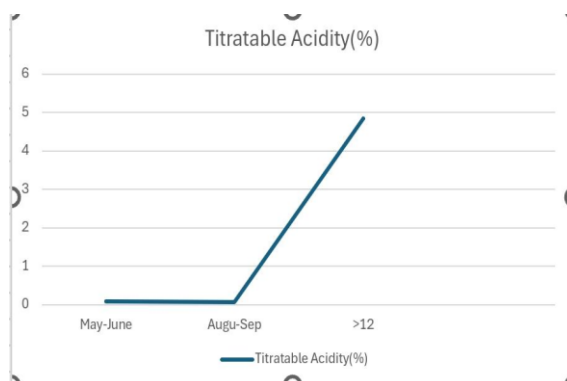


Figure -3: Titratable Acidity

**pH:**

In Figure 4, the pH levels of coconut water are examined over a one-year period. During the months of May to June, the pH is recorded at 4.78. This value increases to 5.34 between August and September, indicating a rise in alkalinity. For measurements taken beyond 12 months, the pH level further increases to 5.71. These results suggest significant seasonal variations in the pH of coconut water, with a trend towards increased alkalinity over time.

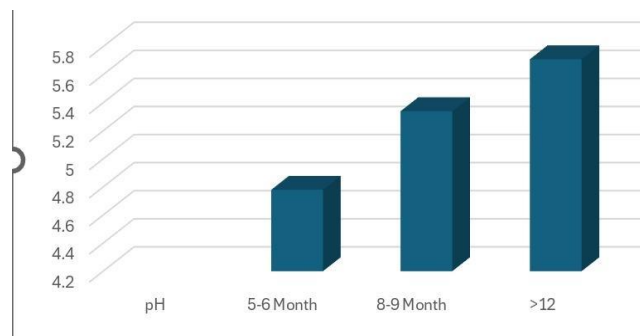


Figure -4: pH of Coconut Water

**Turbidity:** In Figure 5, the turbidity levels of coconut water are analyzed over a one-year period. The turbidity for the months of May to June is recorded at 0.031 NTU. This value increases significantly to 0.337 NTU between August and September. Measurements taken beyond 12 months show a dramatic rise in turbidity to 4.051 NTU. These findings indicate considerable seasonal variations in the turbidity of coconut water, with a notable increase over the course of the year.

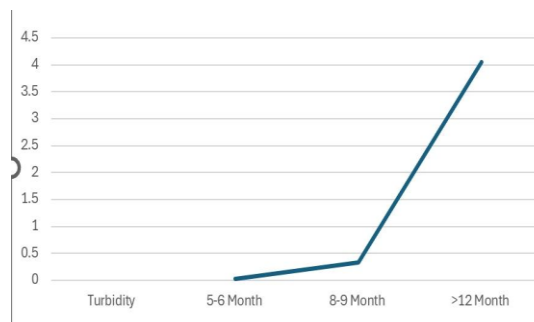


Figure -5: Turbidity of Coconut Water

**Sugar Content:****Fructose Content:**

Fructose, a natural sugar found in fruits, exhibits the following values in coconut water:

5-6 months: 39.04 mg/ml

8-9 months: 32.52 mg/ml

>12 months: 21.48 mg/ml

During the initial months (5-6), the fructose content is the highest, providing a sweeter taste compared to later months. As the year progresses, the fructose content decreases significantly. By the time the coconuts reach beyond 12 months, the fructose content has reduced to nearly half of what it was at 5-6 months.

### Glucose Content:

Glucose, another essential sugar contributing to the sweetness and energy value, shows the following levels:

5-6 months: 35.43 mg/ml

8-9 months: 29.96 mg/ml

>12 months: 19.06 mg/ml

Similar to fructose, glucose levels are at their peak during the early months (5-6), providing a higher energy boost. There is a noticeable decline in glucose content by the time the coconuts reach the 8-9 month mark. The glucose content continues to drop, reaching its lowest level beyond 12 months.

### Sucrose Content:

Sucrose, often referred to as table sugar, follows a different pattern compared to fructose and glucose:

5-6 months: 0.85 mg/ml

8-9 months: 6.36 mg/ml

>12 months: 14.37 mg/ml

Unlike fructose and glucose, sucrose content increases as the coconuts age. The lowest sucrose level is observed in the early months (5-6). However, there is a significant increase in sucrose content by the time the coconuts reach 8-9 months. The highest sucrose content is found in coconuts beyond 12 months, making them relatively sweeter in terms of sucrose concentration compared to earlier months.

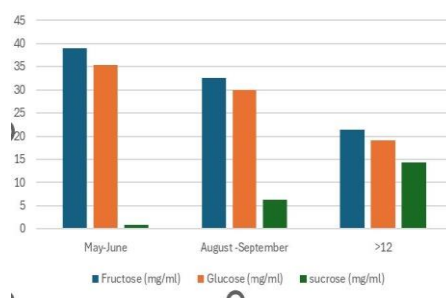


Figure -6: Sugar Content

### Potassium Content:

Coconut water is renowned for its rich nutrient profile, with potassium being one of its key electrolytes. Potassium plays a crucial role in maintaining proper cellular function, fluid balance, and overall health. This discussion focuses on the variations in potassium content in coconut water across different stages of coconut maturity: 5-6 months, 8-9 months, and beyond 12 months.



The potassium content in coconut water increases progressively as the coconuts mature. The early months (5-6) provide a good source of potassium, but as the coconuts reach the 8-9 month stage, there is a notable increase in potassium levels. The highest potassium content is found in coconuts beyond 12 months, making them the most nutrient-dense in terms of potassium concentration. This gradual increase in potassium content highlights the changing nutritional profile of coconut water as the coconuts mature, offering varying benefits depending on the stage of harvest.

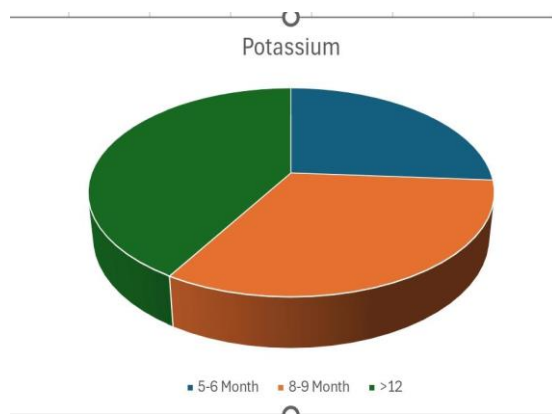


Figure -7: Potassium Content in Coconut

### Minerals Content:

The mineral content and total phenolic content of coconut water vary significantly with the maturity of the coconut. The concentrations of sodium, magnesium, calcium, and total phenolic content were analyzed at three different stages of coconut maturity: 5-6 months, 8-9 months, and over 12 months. The findings provide insights into the nutritional and biochemical changes occurring in coconut water as the fruit matures.

### Sodium

The concentration of sodium in coconut water shows a distinct pattern of increase with the maturity of the coconut. At 5-6 months, the sodium content is 7.61 mg/100 ml. This decreases slightly to 5.60 mg/100 ml at 8-9 months but then increases markedly to 36.51 mg/100 ml in coconuts older than 12 months. The substantial increase in sodium content in more mature coconuts may be attributed to the natural maturation process, where the accumulation of minerals in the water phase increases as the coconut develops. This suggests that older coconuts might be more suitable for individuals seeking higher sodium content, potentially beneficial for replenishing electrolytes after intense physical activities.

### Magnesium

Magnesium levels also show variability with the age of the coconut. At 5-6 months, the magnesium content is 22.03 mg/100 ml, which slightly decreases to 20.87 mg/100 ml at 8-9 months. However, in coconuts older than 12 months, the magnesium content increases to 31.65 mg/100 ml. This trend indicates a general increase in magnesium concentration as the coconut matures, which may enhance the nutritional value of older coconuts, particularly for individuals needing higher magnesium intake for muscle and nerve function.

### Calcium

Calcium concentration in coconut water increases consistently with the maturity of the coconut. At 5-6 months, the calcium content is 8.75 mg/100 ml, which nearly doubles to 15.19 mg/100 ml at 8-9 months and

further increases to 23.98 mg/100 ml in coconuts over 12 months. This progressive increase in calcium content suggests that older coconuts could be a better source of calcium, important for bone health and various metabolic functions.

### Total Phenolic Content

The total phenolic content (TPC) of coconut water shows a different trend compared to the mineral content. At 5-6 months, the TPC is 54 mg/L, which significantly decreases to 24.59 mg/L at 8-9 months and remains relatively stable at 25.7 mg/L in coconuts over 12 months. The higher phenolic content in younger coconuts suggests that they may have better antioxidant properties, which are beneficial for protecting cells against oxidative stress. The decrease in TPC with coconut maturity might indicate a dilution effect or changes in the coconut's biochemical pathways as it matures.

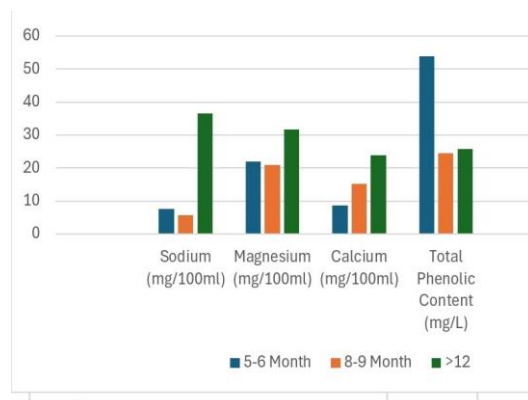


Figure -8: Minerals in Coconut Water

### Iron, Protein content in Coconut Water:

#### Iron

The concentration of iron in coconut water shows a gradual increase with the maturity of the coconut. At 5-6 months, the iron content is 0.294 mg/L, which slightly increases to 0.308 mg/L at 8-9 months, and further rises to 0.322 mg/L in coconuts over 12 months. The incremental increase in iron content suggests that older coconuts may provide a marginally higher amount of this essential mineral. Iron is crucial for oxygen transport in the blood and overall energy metabolism. Therefore, consuming coconut water from more mature coconuts might offer better iron supplementation, although the overall concentration remains relatively low compared to other dietary sources of iron.

#### Protein

The protein content in coconut water exhibits a more pronounced increase with the coconut's maturity. At 5-6 months, the protein content is 0.041 mg/L, which remains relatively constant at 0.042 mg/L at 8-9 months. However, in coconuts over 12 months old, the protein content significantly rises to 0.217 mg/L. This substantial increase in protein content in mature coconuts could enhance their nutritional value, especially for individuals seeking additional protein in their diet. Although coconut water is not typically considered a high-protein beverage, the increase in protein content as the coconut matures may make it a more attractive option for those looking for a natural source of protein.



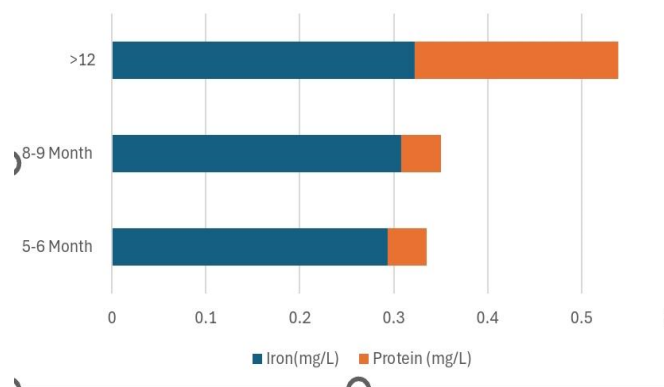


Figure -9:Iron, Protein in Coconut Water

Analytical studies have shown that coconut water contains nutrients such as glucose, amino acids and electrolytes such as potassium, calcium and magnesium. While the composition of coconut water is different in the coconut water obtained from young (7-9 months) and mature (10-13 months) coconuts. The composition, physicochemical, polyphenol oxidase (PPO) and peroxidases (POD) enzyme activities are influenced by factors such as geographical location and variety. The compositional differences relate to the effects deterioration reactions have as well as the quality aspects of coconut water. In general, young coconuts have higher sugar levels and total phenolic contents than mature coconuts. While mature coconuts have higher protein levels and pH values than young coconuts, the amount of minerals can also vary between young and mature coconuts. For example, the amount of potassium in coconut water increases as the coconut matures.

## Properties

Most of the original properties of coconut water are due to minor components such as minerals, volatile aromatic molecules, polyols or small peptides. Only a few of the molecules responsible for medicinal or nutraceutical properties have been scientifically investigated. As a beverage, the sensorial properties of coconut water have rarely been studied, especially colour and flavour.

**Antioxidant activity:** The antioxidant ability of coconut water was recently studied by a few authors, reflecting the increasing interest in the nutraceutical properties of natural products. Among 27 tropical fruits purchased in supermarkets and wholesale outlets in Singapore, coconut water had the lowest AEAC (L-ascorbic acid equivalent antioxidant capacity): 11.5 AEAC (mg·100 g<sup>-1</sup>) and an ascorbic acid (AA) content of 0.7 mg·100 g<sup>-1</sup>. The coconut kernel had higher values than the coconut water. The proportion of ascorbic acid in the AEAC of fruits varied greatly among species, from 0.06% in ciku (*Manilkara zapota*) to 70.2% in rambutan; it was only 6.1% for coconut water. According to Mantena et al., antioxidant activity was highest in fresh coconut water samples and decreased significantly on heating, acid or alkali treatments or dialysis. The maturity of coconut drastically decreased the scavenging ability of coconut water against DPPH (1,1-diphenyl-2-picrylhydroxyl), ABTS [2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid)] and superoxide radicals. Substantial antioxidant activity was also observed using the DPPH assay for extracts of two green and yellow coconut varieties obtained by hydro distillation and petroleum ether extraction.

**Growth-promoting factors:** The use of sterilized clarified coconut water as a growth medium has been found to reduce the lag phase and enhance the log phase of eight different microorganisms, including *E. coli* and *S. aureus*. After sterilisation and appropriate conditioning, a storage period of six months at ambient temperature did not affect the microbial growth capacity of coconut water. Growth-promoting substances extracted from

coconut water include sorbitol, myo-inositol, and scyllo-inositol. Cytokinin, a major group of phytohormones, have different functions in plants, including cell division, seed germination, and tissue differentiation. Singaporean researchers have regularly published papers on cytokinin in coconut water since 2004, identifying nine phytohormones detected and quantified in coconut water. The presence of both polyols and phytohormones could explain the growth-promoting action of coconut water. However, the authors worked on unidentified cultivars and purchased their coconut fruits in local supermarkets, which could have a major influence on the quality and amount of both polyols and phytohormones.

**Nutraceutical properties:** Coconut water, a natural medicine in various civilizations, has been screened to identify defense peptides with bactericidal properties to control antibiotic resistance. Three peptides, namely Cn-AMPs, with molecular masses of 858 Da, 1249 Da, and 950 Da, showed remarkable potential for developing novel antibiotics from natural sources. Coconut water is also suitable for intravenous and oral hydration, with no significant changes in electrolytic composition, blood pressure, pulse rate, or respiration. However, it is not an ideal solution for long-term resuscitation but may serve as a temporary alternative in emergencies. As an oral hydration fluid, coconut water is significantly sweeter, causes less nausea, fullness, and stomach upset, and is easier to drink in large quantities than carbohydrate-electrolyte beverage and plain water. A mixture of coconut water and Mauby bark syrup from Trinidad and Tobago could have a beneficial effect on human hypertension. The presence of L-arginine in coconut water could have a cardioprotective effect through its production of nitric oxide, which favors vasorelaxation. Coconut water has also been found to reduce histopathological changes in the brain induced by hormonal imbalance in menopausal women. A patented freeze-dried product, Cococin, was the main component of a dietary supplement and an anti-ageing skin cream. The anti-cancer properties of cytokinins previously isolated from coconut water have recently been the subject of medical research, with kinetin showing antithrombotic activity and potential power to reduce certain types of mammalian tumors.

**Contribution to the nanoworld:** Coconut water is now entering the nanoworld. A high-quality  $\text{NiFe}_2\text{O}_4$  nanosized powder was prepared by a new route using a natural protein solution of coconut water and metal ions. The interest in using coconut water was that it naturally contains a large protein chain which can easily bind to metal ions. The magnetic properties of the resulting nanoparticles were size-dependent. This new method of preparation was revealed to be a cheap and efficient way to obtain high-quality nickel ferrite nanosized powders.

## Conclusion

Coconut water, a low acid fruit juice with a well-balanced sugar content and isotonic mineral composition, is a potential rehydration and sports drink. Quality criteria like water per nut ratio, Total Soluble Solids content, total sugar per nut, and potassium content can determine the suitability of coconut cultivars for producing coconut water as a beverage. Dwarf coconut varieties are the most suitable for producing a sweet and tasty product. However, the quality of coconut water can also be attributed to its sugars and minerals, as well as its unique flavor and properties. Few studies have identified the components responsible for these properties and studied the potential therapeutic properties of combined coconut water hormones and sugars. Investigating the biodiversity of coconut palm is crucial, and an international survey could help identify suitable varieties for coconut water beverages or lead compounds for future medicine.

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