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Coconut water as a root hormone: Biological and chemical composition and applications

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Abstract
Coconut water is one of the world's most resourceful refreshing beverage consumed universally as it is wholesome and beneficial for health. Coconut water, which is nutrient rich and low calorie, naturally an energy drink for humans, is a wonderful supplement for plants too. It is a shell filled with organic nutrient solution. In third world countries, it is often used to overcome nutrient deficiencies. Coconut water conventionally acted as a growth supplement in plant tissue culture/micro propagation. There are wide varied applications of coconut water that can substantiate its distinctive chemical composition of sugars, vitamins, minerals, amino acids and phyto hormones. As it contains important phyto hormones which help in maintaining and initiating healthier growth of the plant. The review attempts to summarize the importance of coconut water as a root hormone.

Keywords: Coconut water, root hormone, nutrient analysis

Introduction
The coconut palm (*Cocos nucifera* L.) is one of the most important perennial tropical tree crops. The edible part of coconut was Endosperm, which is liquid unlike other fruits. In different parts of this palm, the nut plays a key role in terms of economic value. Immature nuts satiate the domestic demand of drinking nuts, an instant supply of refreshing beverage. The endosperm of mature nuts serves both as an indigenous food supply. When endosperm dried as copra, accommodate export purpose as a material for oil extraction and for the production of confectionery. Coconut water is signified by calling the "Fluid of Life" because, it is a source of many nutrients, minerals, low in sugars and calories; it is rich in essential electrolytes and vitamins.

Rooting hormone hastens root initiation, increase the number and percentage of cutting rooted as well as quality of root produced by cutting (Yeboah *et al.*, 2009) [35]. Coconut water possess the characteristics of a root hormone as it contains different plant growth regulators. Coconut water is a rich supplement that naturally contains plant growth regulators such as indole acetic acid (IAA) Cytokinin, Abscisic acid and Salicylic acid. Coconut water containing natural auxins (IAA) which helps in adventitious root development in vegetative propagation and it can also be the most prominent medium in micro propagation. According to a 2009 article in Current Science, the purity of coconut water makes it an ideal medium in which to grow a type of bacteria that is beneficial to plant propagation. Rhizobacteria exerts "a positive influence on the plant growth especially under stress conditions," according to the article. The rhizobacteria not only promote more rapid root formation but to create a barrier for diseases that could kill the roots and ultimately the entire plant.

Physical and chemical properties of Coconut water
The composition of coconut water depends on its maturity stage of coconut. Tender coconuts have maximum sugar content compared to the later stages.

Sugars
Sugars are the main proportion of soluble solids in coconut water [32, 33]. The prime proportion of sugars in mature coconut water are sucrose, sorbitol, glucose and fructose [34, 35], followed by minor sugars like galactose, xylose and mannose. Glucose and fructose sugars constitute an important component of the tender nut water. The concentration of sugars in coconut water steadily increases from about 1.5 per cent to about 5 - 5.5 per cent in early months of maturation and subsequently falls reaching about 2 per cent at the stage of the complete maturity of the nut.

During early stages of maturity, sugars are present in the form of glucose and fructose (reducing sugars) and sucrose (non-reducing sugar) appears only in later stages which increases with the maturity while the reducing sugars fall. In a completely mature nut, nearly 90 percent of sugars is sucrose.

Minerals

Tender coconut water comprise of major minerals such as potassium, sodium, calcium, phosphorus, iron, copper, sulphur and chlorides. Among the minerals, potassium constitutes the major proportion of which is markedly influenced by potash manuring. Tender coconut water being rich in potassium and other minerals.

Vitamins

Tender coconut water contains both ascorbic acid (Vitamin C) and vitamins of B group. The concentration of ascorbic acid ranges from 2.2 to 3.7mg per ml, which gradually decreases as the kernel surrounding the water begins to harden. The B group vitamins are presentin coconut water with 0.64 µg·mL-1 of nicotinic acid (B_{3}) and 0.52 µg·mL-1 of pantothenicacid (B_5). The B group vitamins are required as coenzymes in enzymatic reactions, which are essential for cellular metabolic processes [7]. Vitamin B_6 (pyridoxal, pyridoxine and pyridoxamine) serves as a coenzyme in various enzymatic reactions in metabolism, like transamination and decarboxylation reactions [10].

Table 1: Physicochemical properties of coconut water

Physicochemical properties	Coconut maturity stage (months)		
	5-6	8-9	≥12
Volume of water (mL)	684	518	332
Total soluble solids (°Brix)	5.6	6.15	4.85
Titratable acidity[1] (%)	0.089	0.076	0.061
pH	4.78	5.34	5.71
Turbidity[2]	0.031	0.337	4.051
Sugar Content			
Fructose (mg/mL)	39.04	32.52	21.48
Glucose (mg/mL)	35.43	29.96	19.06
Sucrose (mg/mL)	0.85	6.36	14.37
Minerals			
Potassium (mg/100mL)	220.94	274.32	351.10
Sodium (mg/100mL)	7.61	5.60	36.51
Magnesium (mg/100mL)	22.03	20.87	31.65
Calcium (mg/100mL)	8.75	15.19	23.98
Iron (mg/L)	0.294	0.308	0.322
Protein (mg/mL)	0.041	0.042	0.217
Total phenolic content[3] (mg/L)	54.00	24.59	25.7

[1]Titratable acidity expressed as malic acid percentage [2] Turbidity expressed as absorbance reading at 600 nm[3] Total phenolic content expressed as mg GAE/L

***Source*:** Tan *et al.*, 2014

Protein

Coconut water contains minute proportions of protein. The amounts of arginine, alanine, cystine and serine of tender coconut water are higher than those in cow's milk.

Table 2: Amino acids composition

Amino Acids	Composition in Coconut water (% total protein)
Alanine	2.41
Arginine	10.75
Aspartic acid	3.60
Cystine	0.97 -1.17
Glutamic acid	9.76 -14.5
Histidine	1.95 - 2.05
Leucine	1.95 - 4.18
Lysine	1.95 - 4.57
Proline	1.21 - 4.12
Phenylalanine	1.23
Serine	0.59 - 0.91
Tyrosine	2.83 - 3.00
Source: Pradera *et al*, 1942	

The Chemical composition of Phytohormones

Auxins

Coconut water contains Indole-3-acetic acid (IAA), the natural and primary auxin in plants (Ma *et al.*, 2008). IAA is a weak acid (pKa= 4.4).They are found in shoottip and then transfer to root tip to promote cell division and elongation, stem and root growth. They can also drastically affect plant orientation by promoting cell division to one side of the plant in response to sunlight and gravity. Auxin regulates various plant developmental processes, including embryogenesis, organogenesis, vascular tissue formation and tropisms [39-41]. The unique signal molecule transport mechanism of auxin largely underlies the remarkable developmental plasticity of plants that allows their growth to fit the environmental changes [41]. Auxins positively influence gibberlins that promote cell elongation. This increases plant length. Essentially, gibberillin and thereby auxins, increase the distance between nodes, spacing the branch points further apart. When an auxin is applied to a cut stem, the stem will initiate roots at the cut.

Cytokinins

Cytokinin, a phytohormone that compasses various roles in the different aspects of plant growth and development, e.g., cell division, formation and activity of shoot meristems, photosynthesis induction, gene expression, retardance of leaf senescence, morphogenesis nutrient mobilization, seed germination, root growth and stress response and resistance to diseases caused due to high or low temperature. Apparently, cytokinin-deficient plants generally develop stunted shoots with smaller apical meristems.

Coconut water is an important supplement in the tissue culture media of several plants, including orchids and traditional Chinese medicinal herbs. One advantage of coconut water is that it leads to considerable plant cell proliferation without increasing undesirable mutations [20]. Coconut water contains various cytokinins (Table 2). For this review, only kinetin, trans-zeatin and their derivatives are discussed in detail, as they are known to possess medicinal values [30]. The cytokinins found in coconut water stimulate cell division, and thus promote rapid growth.

Cytokinin compounds are present at different maturation stages of coconut water. Predominantly, the cytokinin concentration was found to be the maximum at the immature stage. Former studies primarily focused on young coconut water and used to propagate protocorm-like bodies of orchids in plant industries [18].

N6-Furfuryladenine (Kinetin)

The cytokinin, kinetin was discovered by Miller *et al.*, It was a by- product of herring sperm DNA and was discovered to be able to promote cell division in plants [22]. Kinetin was assumed to be an unnatural and synthetic compound, until in 1996 Barciszewski *et al.*, detected it in freshly extracted DNA from human cells and plant cell extracts [3]. And Ge *et al*., identified kinetin and kinetin riboside from coconut water [16]. Being included in cytokinins, kinetin affects the plant developmental processes such as leaf expansion and seed germination. Kinetin is known for its ability to retard senescence in plants [9].

Trans-Zeatin

This cytokinin was isolated from unripe maize grains or kernels by Letham (1964) [73]. It is called zeatin (6-hydroxy 3-methyl trans 2-butenyl amino-purine).

Application

The use of coconut water (often incorrectly stated as coconut milk) by Van Overbeek *et al*., (1941) [36] allowed for the culture of young embryos and other recalcitrant tissues, including monocots. Later, Gautheret, (1985) [13] used coconut water in callus cultures of different species of woody and herbaceous dicots and gymnosperms and that cells in culture underwent changes like loss of sensitivity to auxin (Gautheret, 1942, 1955) [11, 12] and variability in meristems (Gautheret, 1955; Nobécourt, 1955) [12, 25]. However, it was during this era that maximum *in vitro* techniques used today were extensively developed.

Studies of Skoog and his associates showed that the addition of adenine and high levels of phosphate allowed non meristematic pith tissues be cultured to produce shoots and roots, only in the presence of vascular bundle (Skoog & Tsui, 1948) [32]. Further studies using nucleic acids led to the discovery of the cytokinin (kinetin) isolated from herring sperm DNA (Miller *et al*., 1955) [22]. The use of kinetin further increased the number of species that could be cultured significantly and led to the exogenous balance of auxin and kinetin in the medium influenced the morphogenic future of tobacco callus (Skoog & Miller, 1957) [31]. A relative high levels of auxin to kinetin favored rooting, the reverse led to shoot formation, and intermediate levels to the proliferation of callus or wound parenchyma tissue. Domestic cytokinins were eventually discovered in several tissues, including coconut water (Letham, 1974) [20].

The culture of single cells (and small cell clumps) was attained by shaking callus cultures of *Tagetes erecta* andtobacco and eventually placing them on filter paper resting on well-established callus, promoting the so-called nurse culture (Muir *et al*., 1954, 1958) [23, 24]. Utilizing coconut water as a supplement to fresh medium, instead of using conditioned medium, Vasil and Hildebrandt (1965) [38] finally understand Haberlandt's dream of producing a whole plant (tobacco) from a single cell, thus substantiate the totipotency of plant cells.

Later, the use of coconut water as a medium became conventional. Further research on coconut water led to the usage of it as a root stimulant and growth promotor. Subsequently, coconut water used as a substitute for other rooting hormones.

Asma *et al*., 2008 [1], worked on *In vitro* propagation of kiwifruit (*actinidia deliciosa*) using coconut water. During the study, it was discovered that root induction was highly affected by the length of shoots and an appropriate length was pre-requisite for the efficient root formation. The use of coconut water also indirectly influenced *in vitro* roots induction since during shoot multiplication; adding coconut water to the culture media resulted in maximum shoot length (7.2 ± 0.16) and hence enabling the effective root formation. This improved root formation primarily resulted in the high survival rate (>95%) of the plants.

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