Pharmacological Activities and Benefits of Coconut Water in Plant Tissue Culture: A review

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ABSTRACT

Cocos nucifera (L.) belongs to Arecaceae family is a type of highly valuable plant species due to its medicinal values. It is a widespread fruit at the area of Southeast Asia and commonly known as "coconut tree". The fruit part of Cocos nucifera (L.) contains coconut water that have many pharmacological activities which can give benefits for human health and also give benefits for plant in tissue culture Therefore, coconut water has been associated very well in various tribes around the world with diverse biological effects for human such as anti-inflammatory, anti-fungal, antioxidant, renal protective and cardio protective activity. Besides that, coconut water was noted for its wide application in plant tissue culture due to its nutrients content. It was reported to be served as the organic additives for plant to enhance callus induction and proliferation, shoot and root elongation/regeneration and somatic embryogenesis in tissue culture. The present article will discuss the pharmacological activities of coconut water as well as its benefits for plant in tissue culture which had been proven based on recent scientific research.

Keywords: *Cocos nucifera (L.), Pharmacological properties, Plant tissue culture, Organic additives, Coconut water.*

INTRODUCTION

Cocos nucifera (L.) is a type of plant that come from the family *Arecaceae* and popularly known as “coconut tree”, “nyiur” or “nyior” in Malay word. Coconut plant are often associated with the tropical areas of the globe and also coastal area of Southeast Asia countries such as Malaysia, Philippines and Indonesia. Besides that, the fruit of the coconut palm is believed to have been first introduced in southern periphery of India including Sri Lanka, Maldives and Laccadives, then to East Africa and dispersed to other tropical regions. Its natural habitat is along shore lines on sandy beaches and also on pure or clay sands that moderately acidic to alkaline. Coconut plants flourish naturally under a warm and humid conditions but also can survive when temperature below 21^{o}C in short period of time. This plant is a monocotyledonous tree with height that can be reached around 20-40 m with a dense canopy that have a diameter of 8-9 m (Figure 1). Coconut palm tree is monoecious, meaning that it has both male and female flowers in the same inflorescence which known as spadix. The length of the spadix is 1-1.5 m and it is attached with 40-60 branches of spikelets around the flowers. The leaves of the coconut palm tree are feather-shaped with leaflets. The fruit is fibrous drupe comprises with thin and hard outside skin, thicker layer of fibrous mesocarp, endocarp, white endosperms and filled with liquid. The liquid is called as coconut water and it is thick, sweet and slightly acidic. The immature carp is usually green and sometimes bronze in color (Figure 2) with spherical to elongated shape (Chan and Craig, 2006)

Figure 1: *Cocos nucifera* (L.) tree

Figure 2: *Cocos nucifera* (L.) fruits

Coconut is considered as an important palm trees as it provides nutritious sources of meat, juice, milk and oil that can be fed by all of the populations in the world. The people in Pacific islanders used coconut as an alternative to cure illness and sources of foods for example, the people lives in Indonesia and Malaysia uses coconut cream derived from the grated kernel to cook with rice and the sweet water from the nut is use as a refreshing drinks. In Malaysia, the production of coconut had progressively increased from 550,140 metric ton (MT) in 2010 to 624,727 MT in 2013 for both local and international markets. This shows an increasing demand for coconut in industries hence, the productions of coconut need to be higher than before to prevent the insufficient in accommodating the needs of industries.

Currently, both traditional and international industries had developed one of the main products of coconut which is coconut water vinegar as one of the natural vinegars which had been promoted at many states in Malaysia. This coconut water vinegar is an agro-based product that used mature coconut fruits as the main sources. The purpose of Malaysian industry to develop this product is to minimize a huge waste quantity of mature coconut water to the environment. In addition to this innovation, Othaman *et al.,* (2014), had conducted a study to improvise the quality of coconut water vinegar in which the suitability of mature coconut water as vinegar had been tested in comparison with two commonly used substrates like coconut sap and pineapple juice. A lot of improvements had been introduced in this study including shorten the processing time of vinegar, yielding high concentration of acetic acid as well as resulting in low cost but high quality of vinegar. The results of this study indicated that, mature coconut water is suitable for making natural vinegar which can replace the synthetic vinegar in the markets.

All of these advantages that derived from coconut water such as curing illness and use as the sources of foods are based on its pharmacological activities which can be referred as any physiological or biochemical changes in the body produced by certain doses of coconut water intake. Recent studies had been done using coconut water and the results showed several pharmacological activities that possessed in coconut water including anti-inflammatory, anti-bacterial, antioxidant, renal protective and cardio protective activities.

Anti-inflammatory activity

In a study done by Rao and Najam, (2016), the coconut water had been reported to have anti-inflammatory activity against the inflammation induced by acetic acid in rat paw edema model. The presences of flavonoids and abscisic acid (ABA) caused coconut water to show positive effect in anti-inflammatory as it helps to inhibit the synthesis of prostaglandins (Kumar *et al,* 2013). Furthermore, a study done by Mahayothee *et al.,* (2016), also revealed that, young coconut water had increased the percent inhibition of edema in the second phase of inflammation which might be attributed by the presence of salicylic acid. According to Yong *et al,* (2009), the anti-inflammatory effect of coconut water might be due to its compositions of sugar, vitamins, minerals and cytokinins.

Anti-fungal activity

A study had been documented by Rajmohan *et al,* (2017), to investigate the anti-fungal activity of green coconut water (*Cocos nucifera* (L.)) on *Candida albicans*. The result of the study indicated that, green coconut water shows positive anti-fungal effects on *C. albicans*. However, the effect varies in concentrations of green coconut water. This study showed that 1000 µg/mL concentration of green coconut water was the best concentration to inhibit the growth of C. albicans and followed by 500 µg/mL and 250 µg/mL. Therefore, the anti-fungal preparations can be best formulated in higher concentrations of green coconut water extract in treating candidiasis.

Antioxidant activity

The study of antioxidant activity done on this species was found to be documented by Santos *et al.,* (2013), in which the evaluation of antioxidant activities was done by comparing four varieties of coconut such as green dwarf, yellow dwarf, red dwarf and Malaysian yellow with two industrialized coconut water and lyophilized water of green dwarf variety. The results indicated that all varieties shows positive effects against the free radical DPPH and among the four varieties of coconut, the green dwarf variety showed the best antioxidant activity as well as containing the highest levels of total phenols and vitamin C. In cell culture, the green dwarf water was much more efficient against the oxidative damage induced by hydrogen peroxide followed by the red dwarf, yellow dwarf and the yellow Malaysian.

Another antioxidant activity had been further identified following a research done by Loki and Rajamohan, (2003), in which the antioxidant effects of tender coconut water (TCW) were investigated in carbon tetrachloride (CCl_4) oxidative stress female rats. The results showed that, CCl_4 female rats that were treated with TCW shows normal levels of an antioxidant effect hence, proved the effectiveness of antioxidant activity in TCW that help to combat the CCl_4-induced oxidative stress.

Renal protective activity

Significant renal protective activity of coconut water had been proven through an experiment conducted by Gandhi *et al.,* (2013), using Wistar rat model. The rats were divided into three groups and had been fed with different diet. Group I which is the control group was fed with standard diet, Group II with 0.75% ethylene glycol in drinking water that help to induce nephrolithiasis and Group III were administered with coconut water in addition to ethylene

glycol. After 7 weeks, the results revealed that, the amount of calcium oxalate crystals had decreased for Group III and Nephrolithiasis was developed in Group II animals. Coconut water also caused the levels of creatinine and urea in group III animals to become lower hence, reduced the lipid peroxidation as well as the enzymes activities of superoxide dismutase and catalase. This study shows that, coconut water contains important properties against urolithiasis.

Cardio protective activity

The study of cardio protective activity in coconut water had been done by Anurag and Rajamohan, (2003), in which tender coconut water (TCW) was used on rats suffered with myocardial infarction. The results proved that, TCW able to reduce both concentrations of total VLDL + LDL and HDL cholesterols in treated rats that fed with TCW by decreasing the activities of serum glutamate oxaloacetate transaminase (SGOT), serum glutamate pyruvate transaminase (SGPT) and lactate dehydrogenase (LDH). This can be seen based on the low levels of cholesterols, triglycerides also phospholipid in the heart and aorta of treated rats. This study also concluded that, the positive effects of TCW upon cardio protective activity might be due to the high amount of potassium, calcium, magnesium and L-arginine contained in the water.

Another cardio protective activity had been further identified following a research done by Sandhya and Rajamohan, (2006), in which the result shows that, the level of total cholesterols, triglycerides and lipid in the liver, heart and kidney decreased in treated rats that fed with coconut water. This is because, the addition of coconut water had increased the activities of 3-hydroxy-3-methylglutaryl-CoA reductase, lipoprotein and cholesterol acyl transferase. In addition, coconut water also has significantly increased the levels of L-arginine, urinary nitrite and nitric oxide synthase. These results proved that coconut water has positive implications towards cardio protective activity.

The Benefits of *Cocos nucifera* (L.) for Plant in Tissue Culture Techniques

Coconut also had been widely used as one of the organic additives in enhancement and improvement of plant especially in tissue culture techniques. These followed with the combination of various types of plant growth regulators such as cytokinin, auxin and gibberellin to enhance plant growth and development (Roy and Banerjee, 2002). Organic additives including banana juice, honey, soybean and coconut water extracts had been applied for decades in improving and maintaining plant growth in tissue culture techniques. This is due to their additional nutrients which can give benefits in inducing the growth and development of several plant species (Arditti *et al.,* 1990) including shoot and root elongation, callus induction and proliferation as well as somatic embryogenesis.

Callus induction and proliferation

The use of coconut water for callus proliferation was documented in a study by Gnasekaran *et al.,* (2012), where it shows that, the Vacin and Went (VW) culture medium which had been supplemented with coconut water and 20% of tomato extracts increased the proliferations of protocorm-like bodies (PLBs) for Vanda Kasem's Delight (VKD) orchid plant. The productions of PLBs were also healthy, green and fresh looking. This is probably due to the biochemical compounds of coconut water including potassium, sodium, calcium and iron that help to accelerate the rate of proliferations in orchid plants.

Another study about the effects of coconut water for plant had been further identified following a research done by Baskaran *et al.,* (2005), in which plant regeneration from callus culture of *Sorghum bicolor* was investigated. Thin cell layers of hypocotyl from the germinated seedling were transferred on Murashige and Skoog's media containing 4.5-18.1 μM 2, 4-Dichlorophenoxy acetic acid (2,4-D), 5.4-21.5 μM Naphthalene acetic acid (NAA), 5.7-22.8 μM Indole acetic acid (IAA), 4.9-19.7 μM Indole butyric acid (IBA) and 10% (v/v) coconut water (CW) for callus induction. The calli also were cultured on MS media supplemented with 2.2-17.8 μM 6-Benzyl aminopurine (BAP), 5% (v/v) CW followed with 2.3 μM 2, 4-Dichlorophenoxy acetic acid (2, 4-D) or 2.7 μM Naphthalene acetic acid (NAA). The result revealed that, the media that were added with 10% of coconut water produced maximum callus production similar with media containing low concentrations of NAA (5.4-10.7 μM), IAA (5.7-11.4 μM) , IBA (4.9-9.8 μM) with 10% of coconut water. Besides that, the MS media containing 9 μM 2, 4-D and 10% coconut water produced white friable callus while MS media with 16.1-21.5 μM NAA, 17.1-22.8 μM IAA and 14.8-19.7 μM IBA and 10% of coconut water produced white compact callus.

An investigation had carried out to determine the effects of coconut water and plant growth regulator on callus induction of *Tinospora cordifolia* (Arunkumar *et al.,* 2014). Nodal parts of this species had been used as explants and were cultured on Murashige and Skoog's media containing different concentrations of auxin (2, 4-D, IAA, NAA), (1.0–7.0 mg/L) and cytokinins (BAP and kinetin), (2mg/L) alone and with combinations of coconut water in a range of 5-15% (v/v). The results indicated that, Murashige and Skoog's media containing NAA+ Kinetin (6.0+2.0 mg/L) and 5% (v/v) of coconut water similar to MS media added with 2,4-D + Kinetin (6.0+2.0 mg/L) along with 10% (v/v) of coconut water produced highest callus response (96.6%) in nodal explants. The second highest callus response (93.33%) was the Murashige and Skoog's media supplemented with NAA + BAP (4.0+2.0mg/L) and (7.0+2.0mg/L) along with 10% (v/v) of coconut water. Meanwhile, the media containing IAA + kinetin (7.0+2.0mg/L) and 10% (v/v) coconut water shows 96.6% of callus response. This study also revealed that, highest callus response in media added with coconut water might be due to the various phytohormones contained in coconut water including auxins, cytokinins and gibberellins.

Shoot and root elongation/regeneration

The study of coconut water for shoot regeneration and elongation was found to be documented by, Mondal *et al.,* (2012), in which the explants were taken from the shoot tips of a banana variety Dwarf Cavendish. The explants were inoculated in MS media (Murashige and Skoog) containing 5.0 mg/L BAP (Benzyleaminopurine) as plant growth regulator and different concentrations of coconut water (0, 50, 100, 150 and 200 ml/L) followed by various concentrations of ascorbic acid (0, 25, 50, 75 and 100 mg/L). Based on the data that they obtained, 75% of explants result in shoot regeneration when 100 ml/L of coconut water was supplemented in the media followed by 74% explants in 150 ml/L of coconut water. The data also estimated that, about 4.2 shoots per explant were observed in media containing 100 ml/L of coconut water and only 3.84 shoots per explant in media containing 150 ml/L of coconut water. Meanwhile, the highest shoot length which is 4.52 cm was observed in media added with 100 ml/L coconut water. This shows that, the optimum concentration of coconut water is within 100 ml/L while any concentrations that above this will not contributed any significant effect on shoot regeneration and elongation.

Moreover, a study that had been done by Hashim, (2014), on *in vitro* regeneration and acclimatization of rockmelon (*Cucumis melo*) stated that, the best media which produced multiple shoots regeneration of explants including the highest shoots length (2.07±1.47 cm), number of leaves (10.30±6.65) and number of nodal (2.26±1.43) was obtained from Murashige and Skoog's medium supplemented with 0.1 mg/L kinetin and 15% of coconut water.

In addition to that, a study conducted by Yun *et al.,* (2011), the Hyponex medium was used to determine the effects of various concentrations of coconut water on the growth of *Calanthe* hybrids. The Hyponex medium consists of various compositions including nitrogen, phosphorus and potassium that might help for *in vitro* seed germination and propagation of orchids (Park *et al.,* 2000). Based on the results obtained, it shows that, both shoot and root length as well as the shoot and root weight (fresh and dry weight) of the *Calanthe* hybrids increased in a medium which contained coconut water in a range of concentrations from 10 to 50 ml/L. Besides that, the leaf width and number of roots and leaf area also increase in media containing coconut water. However, the media containing 100 ml/L of coconut water failed to show any significant increase in plant growth and induced an abnormal plantlets growth. This study proved that, the addition of coconut water along with Hyponex medium can enhance the development and growth of cultured tissues hence, can help in more productions of orchid (Murthy and Pyati, 2001).

Additionally, Shakeel and Mueen, (2010), performed coconut water analysis through micropropagation of *Cyamopsis tetragonolobust* seeds. The germinated seeds of the *Cyamopsis tetragonolobust* were transferred into Murashige and Skoog's media supplemented with different concentrations of 2,4-D (1.5, 2.0 and 2.5 mg/L) and coconut water (15, 20, and 25% (v/v)) for shoot multiplications. After 5 weeks, it was observed that, the media containing 20% (v/v) of coconut water and 2mg/L of 2,4-D shows maximum increase in length of shoots (7.2 ± 0.16) followed with the highest number of nodes (4.2 ±0.12).

Somatic embryogenesis

The study on the effect of coconut water in somatic embryogenesis of date palm (*Phoenix dactylifera* L.) had been done by Al-Khayri, (2010). The data which had been analyzed by ANOVA indicated that, there was a significant increase on embryos formation in medium supplemented with 5% of coconut water. The increase in concentrations of coconut water in a range of 10 to 15% caused the embryos to reach its maximum formation which is 90% of their final embryo yield. However, the somatic embryogenesis was inhibited in 20% concentration of coconut water which proved that it reached the inhibitory level.

In a similar study, Takamura *et al*, (1997) evaluated the potential of 200 ml/L coconut water supplemented in Vacin and Went (VW) medium with or without 40 g/L sucrose for somatic embryogenesis of *Phalaenopsis* Richard Shaffer 'Santa Cruz'. They found that, Vacina and Went (VW) media supplemented with sucrose stimulated proliferation of Protocorm-like body (PLB) segments. To investigate the effect of coconut water on somatic embryogenesis of *Phalaenopsis*, the culture medium was supplemented with 200 ml/L coconut water together with 40 g/L sucrose. The result showed maximum multiplication of callus in medium containing both exact concentration of coconut water and sucrose.

CONCLUSIONS

In conclusions, coconut water can potentially give significant effects on human health through its pharmacological activities as well as development and growth of plant in tissues cultures.

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