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ANTIOXIDANT PROPERTIES OF ARECA PALM, *Areca catechu* L.

S. Keshava Bhat*

Oxidative stress caused by the formation of free radicals is one of the major causative factors for many degenerative and chronic diseases and disorders including cancer, heart problems, diabetes, aging, immuno-suppression, neurodegeneration, etc. (Pandey and Rizvi, 2009). Research evidences have proved that antioxidants can control oxidation either by interrupting the propagation or by inhibiting the formation of free radicals or by donating an electron to free radicals thereby reducing their reactivity without becoming reactive themselves and subsequently diminish oxidative stress, improve immune function and increase longevity (Tan *et al.*, 2018). Hence, diets having rich sources of antioxidants are necessary for good health.

The reactive oxygen species (ROS), produced in the body through normal metabolic process and the free radicals (FR) produced from environmental factors are unstable, highly active chemical entities capable of oxidising essential cellular components resulting cell damage (Mohammed *et al.*, 2015). Normally bodies defence systems are able to inhibit such oxidative cell damage to some extent. But, when the production of ROS or FR reaches beyond controllable limit the body is unable to restore its normalcy leading to the development of various chronic diseases (Hannan *et al.*, 2012).

Polyphenols and flavonoids, found in abundant in several plants possess antioxidant and free radical scavenging properties and there is a persistent demand from general public for such natural antioxidants (Scalbert *et al.*, 2005; Pandey and Rizvi, 2009; Al-Snafi, 2020). Epidemiological studies have proved that long term consumption of polyphenol rich diets increase the body's immune system and give a strong protection against several human diseases such as cancer, cardio vascular complications, diabetes, oesteoporosis and neurodegenerative disorders (Yang *et al.*, 1997; Arts and Hollman, 2005; Sari, 2021). The main dietary sources of polyphenols are of plant origins such as vegetables, fruits and nuts (Scalbert *et al.*, 2005). Areca palm (*Areca catechu* L.) is one such plant having ample polyphenols in it. The seed of this palm commonly called as arecanut contains as high as 30% polyphenols (including flavonoids and tannins) in it (Shivashankar *et al.*, 1976). Apart from the nuts of areca palm several other morphological parts of this palm such as leaf, flower, root, tender (green) stem, nut husk also possess lots of antioxidant properties. Most of such papers are collected and reviewed in this article.

Comparative antioxidant properties of various parts of areca palm

Among 100 plant extracts screened for their antioxidant properties, 14 plants including *A.*

* Arecanut Research and Development Foundation, Varanashi Towers, Mission Street, Mangaluru - 575 001, Karnataka.

catechu were identified as potential sources of antioxidants (Kim *et al.,* 1997). In a comparative study conducted on the antioxidant properties of various parts of areca palm such as its leaf, crown shaft, seed, fruit husk, adventitious root and underground root it was reported that areca seed exhibited highest antioxidant activity, almost equal to that of the positive control, Trolax (Wetwitayaklung *et al.,* 2006). The IC_{50} value for Trolax was 10.14 µg, whereas it was 10.51 µg for the methanol extract of 4-month old areca seed and 10.63 µg for the 8-month old areca seed. However, the IC_{50} values for areca leaf was 165.62 µg, for crown shaft 174.08 µg, for fruit husk 711.37 µg, for adventitious root 114.95 µg and for underground root it was 21.14 µg.

While studying the antioxidant properties of different parts of areca palm such as its seed, husk and flower it was again confirmed that areca seed exhibited best antioxidant property (Zhang *et al.,* 2009). The EC_{50} values obtained in DPPH radical scavenging activities for the ethanol extracts of areca seed, husk and flower were 0.409, 1.489 and 1.838 mg/ml, respectively. The figures obtained in hydroxyl radical scavenging activities were respectively 3.575, 5.380 and 6.754 mg/ml. The EC_{50} values obtained in reducing power assays were 0.188, 1.466 and 2.685 mg/ml, respectively. In all these experiments arecanut seed faired significantly better than that of arecanut husk and flower.

Among the arecanut husk, leaf, crown shaft, aerial root and ground root only the arecanut husk showed significant protection against H_2O_2-induced oxidative damage to DNA (Phaechamud *et al.,* 2009). Cells treated with 40 µM H_2O_2 exhibited an average normalized comet tail length of 7.38 whereas such cells when treated along with 1µM butylated hydroxytoluene (BHT) which served as positive control as an antioxidant showed a reduced comet tail length of 3.19 and with 0.1% methanol extract of 8-month old arecanut husk it was 4.89, not differing significantly from that obtained for BHT. Addition of other organic as well as aqueous extracts of arecanut husk did not show any significant reduction of comet tail length of H_2O_2 treated cells. In addition to 8-month old arecanut husk, 0.1% methanol extract of 1-month old husk was also found to inhibit (normalized tail length of 5.84) H_2O_2-induced DNA damage. It was also observed that the husk of 8- and 1- month old areca fruits exhibited antioxidant activities while other stages did not. Only lacuna was that the authors did not include areca seed in this study.

In a comparative study on the antioxidant property of ripe areca seed, unripe areca seed, underground and adventitious areca root it was reported that the extract of ripe areca seed exhibited the highest antioxidant activity than others. The IC_{50} value obtained in DPPH radical scavenging activitiy for the methanolic extract of ripe areca seed was 0.021 µg/ml, for unripe seed 1.87, for adventitious root 2.71 and for underground root 2.83 µg/ml, whereas the figure for ascorbic acid was 2.69 µg/ml (Hamsar *et al.,* 2011).

The husk of areca fruit, traditionally used for oral health and hygiene, was again reported to exhibit good antioxidant, reducing power and free radical scavenging activities (Jose *et al.,* 2011). An excellent scavenging effect of arecanut husk on DPPH radicals, which increased with the concentration of the extract,

was reported by these authors. At 200 µl/ml concentration, the ethanolic extract of arecanut husk showed more than 70% inhibition of DPPH radical scavenging activity. In addition, this extract also exhibited good scavenging activity on hydroxyl radicals, superoxide radicals and nitric oxide radicals with inhibition of 50%, 58% and 60%, respectively.

In a DPPH radical scavenging assay, the ethanolic extract of areca root exhibited a maximum scavenging activity of 95% at 1000 µg/ml concentration with an IC_{50} value of 65.7 ± 1.53 µg/ml and super oxide anion scavenging assay showed an IC_{50} value of 201.7 ± 0.76 µl/ml (Baby and Raphael, 2014). Preliminary screening of such root extract by these authors revealed the presence of several phytochemicals including tannins, phenols, flavonoids, terpenoids, alkaloids and steroids.

Areca seed / arecanut as potential antioxidant

Among the nine common medicinal plants and their parts which were traditionally used in Chinese medicine including the seed of areca, *A. catechu (var. dulcissima)*, the methanol extract of areca seed showed higher antioxidant activity than the positive control resveratrol (Lee *et al.*, 2003). The DPPH radical scavenging activity showed an IC_{50} value of 1.8 µg/ml for areca seed, much lower than that of resveratrol which was 4.8 µg/ml. The IC_{50} values for other plants ranged between 5.0 µg/ml to 6.7 µg/ml. Further, treatment of 100 µg/ml of areca seed extract increased the level of antioxidant enzymes such as superoxide dismutase, catalase and glutathione peroxidase levels by 45.0, 51.0 and 48.0% respectively, almost similar to those of resveratrol. In addition, the H_2O_2 induced apoptosis was reduced by 61% when such cells were pre-treated with areca seed extract at 100 µg/ml.

Analysis of results on the antioxidant activity of ethanol extract of areca seed by DPPH radical scavenging and reducing power assays revealed an EC_{50} value of 0.409 and 0.188 mg/ml, respectively which were found significantly more effective than that of ascorbic acid which showed an EC_{50} value of 0.964 and 0.401 mg/ml, respectively (Zhang *et al.*, 2014). The authors even advocated the use of areca seed in nutraceutical industry as an excellent food material with potential antioxidant property. In vitro antioxidant activity of hydroalcoholic extract of arecanut showed an IC_{50} value of 83.14 µg/ml in hydrogen peroxide assay (Bhandare *et al.*, 2010).

Aqueous extract of arecanut also exhibited potent antioxidant activity (Pithayanukul *et al.*, 2009). Lipid peroxidation was inhibited by 91% at 100 µg/ml concentration of arecanut extract and was found to be significantly at par with that of the positive control BHT which showed 94% inhibition. DPPH free radical scavenging assay also revealed very potent antioxidant activity with arecanut extract. The SC_{50} value for arecanut extract was 1.38 ± 0.08 µg/ml but for ascorbic acid it was 2.21 ± 0.06 µg/ml, both differed significantly. The SC_{50} value to scavenge hydroxyl radicals was 1,150 µg/ml for arecanut extract whereas it was 8,150 Âµg/ml for the positive control D-mannitol. Oral administration of Wistar albino rats with aqueous extract of arecanut at 2000 mg/kg for 28 days reversed the oxidative damage induced by CCl_4 on hepatic tissues significantly. The authors implicated procyanidins, the major condensed

tannin found in arecanut, for its antioxidant activity.

In vitro studies conducted with the aqueous extract of tender arecanuts reported very high antioxidant activity. The concentration of the aqueous extract of tender arecanut needed for 50% scavenging of superoxide was 19.5 µg/ml, to inhibit hydroxyl radicals 161 µg/ml, to inhibit lipid peroxide 28 µg/ml, DPPH radical scavenging activity 95 µg/ml, ABTS radical scavenging activity 9.5 µg/ml and to increase ferric reducing ability 0.247µg/ml (Anthikat and Michael, 2012). However, the lacuna was that there was no positive control in this study. The authors further opinioned that arecanut has a great potential as a health product and the results obtained in their study were sufficient enough to validate the use of aqueous extract of boiled and dried arecanut to promote and supplement anticancer therapy.

Oral administration of aqueous extract of fresh arecanut to Wistar albino rats for one month at 100 mg/kg body weight significantly increased the levels of antioxidant enzymes such as catalase, super oxide dismutase, glutathione and glutathione reductase in the blood serum of such rats (Sharafudheen *et al.*, 2015). In addition, the authors also reported that oral administration of arecanut extract at 500 mg/kg body weight for one month significantly increased the levels of certain antioxidant enzymes such as super oxide dismutase, glutathione peroxidase and glutathione -s-transferase levels in the liver of treated rats.

Erythrocytes (RBC), the carriers of oxygen in the blood, are highly vulnerable to oxidative stress causing haemolysis of cells. Ethanol extract of arecanut exhibited a strong protection against H_2O_2 induced haemolysis of such cells with 78% inhibition at 50 µg concentration of the extract (Amudhan and Begum, 2006).

Antioxidant properties of different types and stages of arecanut

In a comparative study on the antioxidant activities of raw and processed types of arecanut, it was noticed that there was no significant difference in the IC_{50} values between the extracts of these two types of arecanut which ranged from 3.175 ± 0.007 to 6.775 ± 0.014 µg/ml in the DPPH radical scavenging assay (Parthiban *et al.*, 2014). The authors also reported that there was no significant difference in the total phenol content of these two types of arecanut. However, the method of processing of arecanut was not described in this report. On the other hand, in another study carried out by soxhlet extraction method it was reported that unroasted arecanut was better than its roasted type in its antioxidant property. The IC_{50} value of the methanolic extract of unroasted arecanut was 13.98 ± 0.46 µg/ml and for roasted arecanut it was 32.43 ± 0.15 µg/ml (Paarakh, 2015). It was reported that all the major chemical constituents of arecanut including its polyphenol content decrease significantly while roasting (Awang, 1988). This might be the reason for the better antioxidant property of unroasted arecanut.

In a study to find out the antioxidant activities of various developmental stages of arecanut it was noticed that 4-month old arecanut had the highest antioxidant property, closely followed by 8-month old arecanut. They were followed by 6, 3, 2 and 1-month old nuts (Wetwitayaklung *et al.*, 2006). The IC_{50} values

of the methanolic extract of all such developmental stages of arecanuts were 10.51 µg, 10.63, 12.06, 12.10, 13.21 and 13.47 µg, respectively.

Ideal solvent for extraction

In a comparative study on the antiradical capacity of different extracts (100% methanol, 50% water + 50% methanol and 100% water) of areca seeds of Taiwan it was reported that the methanol extract of areca seed exhibited higher DPPH radical scavenging activity (38.77 ± 0.75%) than even ascorbic acid (32.21 ± 0.37%), followed by 50% methanol + 50% water (22.92 ± 1.79%) and water extract (21.47 ± 1.46%) at 25 µg/ml concentration (Li and Lin, 2010). Further, the superoxide radical scavenging activity of the methanolic extract of areca seed (78.04 ± 0.20%) was found to be significantly more than that of both gallic acid (33.89 ± 0.25%) and ascorbic acid (14.57 ± 0.20%) at 10 µg/ml.

Almost similar results were reported in another study conducted on the arecanuts of Assam, India (Hannan *et al.*, 2012). In this study also it was noticed that the methanol extract of arecanut exhibited higher reducing power and hydrogen peroxide scavenging ability in comparison to 50% methanol + 50% water, petroleum ether, ethyl acetate and water extract. Except ethyl acetate extract all other extracts exhibited significantly higher antioxidant activity in comparison to that of the well established antioxidant ascorbic acid. The IC_{50} values obtained for hydrogen peroxide scavenging assay for methanol extract was 41.87 ± 1.98 µg/ml and for ascorbic acid 65.69 ± 0.99 µg/ml. Such figure for methanol + water extract was 41.39 ± 2.46 µg/ml, for water 51.44 ± 1.41 µg/ml and for ethyl acetate extract 96.39 ± 1.67 µg/ml. The yield obtained was highest with methanol (10.35%) followed by water (7.25%), ethyl acetate (2.75%) and petroleum ether (1.4%) extracts.

The superiority of methanol in extracting antioxidant phytochemicals from different parts of areca palm was again established in certain other studies as well. The IC_{50} value for methanol extract of areca leaf was reported to be 165.62 µg, whereas it was 197.22 µg for methylene chloride, 377.49 µg for petroleum ether, 411.93 µg for ethylacetate and 871.38 µg for water extracts of areca leaves (Wetwitayaklung *et al.*, 2006). In another study also, when the antioxidant activities of methanolic and water extracts were compared the methanolic extract was found better than water extract. The IC_{50} value for the antioxidant activity based on DPPH radical scavenging assay for the methanolic extract of ripe areca seed was 0.021 µg/ml, whereas it was 2.49 µg/ml for its water extract. This was also true in the case of root extract where the IC_{50} value for the methanolic extract was 2.83 µg/ml whereas it was 3.35 µg/ml for its water extract (Hamsar *et al.*, 2011).

In a comparative study on the antioxidant effects of arecanut extract obtained by two different methods of extraction *viz.*, soxhlation extraction and microwave extraction techniques not much variation was noticed between these two methods (Paarakh, 2015). However, in both the methods, the methanol extraction of arecanut reported better antioxidant activity compared to that of water extraction. The IC_{50} values for methanol extract of unroasted

arecanut in soxhlet assisted extraction method was 13.98 ± 0.46 µg/ml and in water extraction 20.72 ± 0.80 µg/ml. Similar trend was noticed in microwave assisted extraction also. It was 14.07 ± 0.05 µg/ml for methanol extract of unroasted arecanut and 22.83 ± 0.28 µg/ml for water extract of such nuts.

Phenol content and its relation to antioxidant activity

It was reported that the antioxidant property of a substance directly corresponded to the total phenolic content of that material. Among certain ingredients of betel quid such as arecanut, gambir (*Uncaria gambir)*, betel leaf (*Piper betle*), betel quid (mixture of betel leaf, arecanut and gambir in the proportion of 46:3:1) and betel quid with calcium hydroxide; gambir had maximum phenolic content (1142.5 ± 106.8 µg/ml) followed by arecanut (858.8 ± 53.9 µg/ml), betel quid (140.0 ± 22.3 µg/ml), betel leaf (77.2 ± 12.6 µg/ml) and betel quid with calcium hydroxide (45.4 ± 3.7 µg/ml) in that order. Accordingly, the antioxidant property was highest in gambir followed by arecanut, betel quid, betel leaf and betel quid with calcium hydroxide. The IC_{50} value for gambir was 6.4 ± 0.8 µg/ml, arecanut 7.5 ± 0.5, betel quid 59.4 ± 4.4 and for betel leaf it was 179.5 ± 93.1 µg/ml (Sazwi *et al.,* 2013). Betel quid with calcium hydroxide, which had very less polyphenol in it, did not exhibit any detectable antioxidant activity. The extracts of arecanut, gambir and betel quid also exhibited strong cytoprotective effects at a concentration of 50 µg/ml with cell viability of 89.3 ± 9.4%, 100.1 ± 4.6% and 113.5 ± 15.9%, respectively. This effect was comparable to that of ascorbic acid at the same concentration with cell viability of 82.4 ± 2.1%.

Similar results were obtained by Zhang *et al.,* (2009) wherein it was reported that areca seeds which contained significantly more of phenolics and flavonoids (114.14 ± 3.4 mg/g and 77.36 ± 5.06 mg/g, respectively) when compared to its husk (59.22 ± 1.48 mg/g and 52.57 ± 3.02 mg/g, respectively) and flowers (20.09 ± 1.21 mg/g and 6.12 ± 0.24 mg/g, respectively), exhibited best antioxidant property. The EC_{50} value obtained in reducing power essays for areca seed was 0.188 mg/ml whereas it was 1.466 mg/ml for arecanut husk and 2.685 mg/ml for areca flower.

The methanolic extract of areca seed showed highest phenolic (466.70 ± 0.79 µg/ml) and flavonoid (933.33 ± 1.31 µg/ml) content when compared to its 50% methanol + 50% water (461.17 ± 0.55 and 731.98 ± 2.15 µg/ml, respectively) and water extracts (278.25 ± 0.54 and 286.36 ± 1.17 µg/ml, respectively). Accordingly, the DPPH radical scavenging activity was 38.77 ± 0.75% for the methanolic extract, 22.92 ± 1.79% for methanolic + water extract and 21.47 ± 1.46% for water extract (Li and Lin, 2010). Similarly, the methanolic extract of arecanut which had highest tannin and total phenolic content exhibited higher reducing power and hydrogen peroxide scavenging ability in comparison to methanol + water, petroleum ether, ethyl acetate and water extracts (Hannan *et al.,* 2012).

Compounds responsible for antioxidant activity in arecanut

The actual compounds responsible for the antioxidant activity of arecanut were identified by Xing *et al.* (2010). Altogether 11 phenolic compounds were isolated by these authors in

the ethanol extract of arecanut. All the compounds exhibited considerable scavenging activities on DPPH assay, but only the compound (*2S,3R*)-ent-catechin (No 10) and jacareubin (No 11) showed better scavenging ability than that of ascorbic acid. The SC_{50} value for radical scavenging activity was 28.9 µmol/l for ascorbic acid whereas it was 19.2 µmol/l for the compound (2S,3R)-ent-catechin and 19.7 µmol/l for the compound jacareubin.

Conclusion

Polyphenols, potential antioxidant phytochemicals present in most of the plants, protect cells from oxidative stress leading to decreased incidence of several health related problems including cancer and cardiovascular diseases. Almost all morphological parts of areca palm such as its nut, leaf, tender stem, flower, nut husk, root, etc contain such phytochemicals. However, areca seed, commonly called as arecanut which contains maximum amount of polyphenols (as much as 30%) in it is the most effective antioxidant and even found better than ascorbic acid. Methanolic extract of this nut faired better than other extracts in its antioxidant capacity. Thus arecanut has a great potential as a health supplement in reducing the progression of several diseases related to oxidative stress. Certain researchers even advocated that this nut could be used in nutraceutical industry as an effective natural antioxidant.

References

Al-Snafi, A.E. 2020. Phenolics and flavonoids contents of medicinal plants as natural ingredients for many therapeutic purposes - A review. *IOSR J Pharmacy* 10(7): 42-81.

Amudhan, M.S. and Begum, H. 2006. Inhibitory effect of arecanut extract on H_2O_2 induced RBC haemolysis. *Indian J. Arecanut, Spices and Med. Plants* 8(3): 85-88.

Anthikat, R.R.N. and Michael, A. 2012. Anti-inflammatory and antioxidant effect of Areca catechu. *Int J . Pharma. Sci. Res.* 3 (6): 2031-2037.

Arts, I.C.W. and Hollman, P.C.H. 2005. Polyphenols and disease risk in epidemiologic studies. *Am. J. Clin Nutr.* 81(Suppl): 317-325.

Awang, M.N. 1988. Fate of betelnut chemical constituents following nut treatment prior to chewing and its reaction to oral precancerous & cancerous lesions. *Dental J. Malaysia* 10: 33-37.

Baby, A.A. and Raphael, R.K. 2014. Potential antimicrobial, anthelmintic and antioxidant properties of *Areca catechu* L. root. *Int. J. Pharmacy Pharma. Sci.* 6(6): 486-489.

Bhandare, A.M., Kshirsagar, A.D., Vyawahare, N.S., Hadambar, A.A and Thorve, V.S. 2010. Potential analgesic, anti-inflammatory and antioxidant activities of hydroalcoholic extract of *Areca catechu* L. nut. *Food Chem. Toxicol*. 48(12): 3412-3417.

Hamsar, M.N., Ismail, S., Mordi, M.N., Ramanathan, S. and Mansor, S.M. 2011. Antioxidant activity and the effect of different parts of *Areca catechu* extracts on Glutathione-S-Transferase activity in vitro. *Free Radicals and Antioxidants* 1(1): 28-33.

Hannan, A., Karan, S. and Chatterjee, T.K. 2012. A comparative study of in-vitro antioxidant activity of different extracts of areca seed collected from *Areca catechu* plant grown in Assam. *Int J. Pharmacy Pharma. Sci*. 4(2): 420-427.

Jose, M., Varghese, I. and Shantaram, M. 2011. *In vitro* antioxidant activities and phytochemical analysis of five selected plant materials used for oral health and hygiene among people of Dakshina Kannada. *Int . J. Appl. Biol Pharma. Tech.* 2(4): 95-103.

Kim, B.J., Kim, J.H. Kim, H.P. and Heo, M.Y. 1997. Biological screening of 100 plant extracts for cosmetic use (II): Anti-oxidative activity and free radical scavenging activity. *Int. J. Cosmetic Sci.* 19: 299-307.

Lee, S.E., Hwang, H.J., Ha, J.S., Jeon, H.S. and Kim, J.H. 2003. Screening of medicinal plant extracts for antioxidant activity. *Life Sci.* 73: 167-179.

Li, C.C. and Lin, E.S. 2010. Antiradical capacity and reducing power of different extraction method of *Areca catechu* seed. *Afr. J. Biotech.* 9(46): 7831-7836.

Mohammed, M.T., Kadhim, S.M., Jassimand, A.M.N. and Abbas, S.I. 2015. Free radicals and Human health. *Int. J. Innovation Sci. Res.* 4(6): 218-223.

Paarakh, P.M. 2015. Comparison of *in vitro* antioxidant activity of *Areca catechu* Linn. nut by microwave extraction and soxhlation technique. *World J. Pharm Pharma. Sci.* 4(5): 778-789.

Pandey, K.B. and Rizvi, S.I. 2009. Plant polyphenols as dietary antioxidants in human health and disease. *Oxidative Med. Cellular Longevity* 2(5): 270-278.

Parthiban, P., Alagarsamy, V., Bose, S.C. and Anjana, G. 2014. Estimation of total phenol content and antioxidant activity of different forms of arecanut and banana. *Int J. Pharmacy Pharma. Analysis* 1(1): 61-67.

Phaechamud, T., Toprasri, P. and Chinpaisal, C. 2009. Antioxidant activity of Areca catechu extracts in human hepatocarcinoma HepG2 cell lines. *Pharma. Biol.* 47(3): 242-247.

Pithayanukul, P., Nithitanakool, S. and Bavovada, R. 2009. Hepatoprotective potential of extracts from seeds of *Areca catechu* and nutgalls of *Quercus infectoria. Molecules* 14: 4987-5000.

Sari, L.M. 2021. Antioxidant activity of arecanut to human health: Effect on oral cancer cell lines and immunomodulatory activity. *http://dx.doi.org/10.5772/intechopen.*96036. 23pp.

Sazwi, N.N., Nalina, T. and Rahim, Z.H.A. 2013. Antioxidant and cytoprotective activities of *Piper betle, Areca catechu, Uncaria gambir* and betel quid with and without calcium hydroxide. B*MC Comp Alter Med.* 13: 351. 12pp.

Scalbert, A., Manach, C., Morand, C. and Remesy, C. 2005. Dietary polyphenols and the prevention of diseases. *Critical Reviews Food Sci. Nut.* 45: 287-306.

Sharafudheen, J., Gopalakrishnan, S. and Mukkadan, J.K. 2015. Antioxidant, anti inflammatory and antinociceptive study on arecanut. *Indian J. Arecanut, Spices and Med. Plants* 17(1): 3-12.

Shivashankar, S., Mathew, A.G. and Natarajan, C.P. 1976. Post-harvest technology of arecanut. *Arecanut & Spices Bull.* 7: 59-63.

Tan, B.L., Norhaizan, M.E., Liew, W.P.P. and Rahman. H.S. 2018. Antioxidant and oxidative stress: a mutual interplay in age-related diseases. *Frontiers in Pharma.*, Article id 1162, 28pp.

Wetwitayaklung, P., Phaechamud, T., Limmatvapirat, C. and Keokitichai, S. 2006. The study of antioxidant capacity in various parts of *Areca catechu L. Naresuan Univ J.* 14(1): 1-14.

Xing, Z., Jiao, W., Zhuang, H., Li, M.W. and Fu, D.H. 2010. Antioxidant and cytotoxic phenolic compounds of arecanut (*Areca catechu*). *Chem. Res. Chinese Univ*. 26(1): 161-164.

Yang, C.S., Lee, M.J., Chen, L. and Yang, G.Y. 1997. Polyphenols as inhibitors of carcinogenesis. *Environi. Health Per*. 105 (Suppl. 4): 971-976.

Zhang, W.M., Huang, W.Y., Chen, W.X., Han, L. and Zhang, H.D. 2014. Optimization of extraction condition of areca seed polyphenols and evaluation of their antioxidant activities. *Molecules* 19: 16416-16427.

Zhang, W.M., Li, B., Han, L. and Zhang, H.D. 2009. Antioxidant activities of extracts from areca (*Areca catechu* L.) flower, husk and seed. *Afr J. Biotech*. 8(16); 3887-3892.

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