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Bactericidal properties of different morphological parts of areca palm, Areca catechu L. and their potential applications

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ABSTRACT: Areca palm (Areca catechu L.) is commonly grown in India and several other South and Southeast Asian countries. The nut of this palm is the popular chewing product in several countries since time immemorial. This nut is also used in several traditional medicines in countries such as India, Bangladesh, China, Indonesia, the Philippines, etc. Such medicinal values are now well validated by several scientific evidences. One among them is its bactericidal property. Almost all parts of areca palm show such property and lots of scientific literature is now available to substantiate this fact. Most of the available literature on such aspects are retrieved and reviewed in this paper. It is reported that the nut of this palm is very effective as antibacterial against so many pathogenic bacteria, including several oral and enteric pathogens, those infesting wounds, the ones responsible for several human diseases such as tuberculosis, typhoid, paratyphoid, cholera, etc. and those infesting food products as well. Hence, there is lot of scope to utilize this palm as the raw material to formulate several pharmaceutical products against such problems.

KEYWODS: Areca palm, Areca nut, Betel nut, Areca catechu, Antibacterial, Health benefits.

I. INTRODUCTION

Plants have been used for their medicinal properties since the beginning of human civilization. Such medicinal plants are well described in several classic textbooks and scientific literature [1-3]. Areca palm, Areca catechu L. (Family: Palmae) is one such medicinal plants whose pharmacological and medicinal properties are fairly studied [4-6]. The World Health Organization has already listed out as many as 25 beneficial effects of this palm [7].

In India, the presence of this palm was cited as early as 1300 BC [8] and chewing its nut noticed around 650 BC [9]. The use of arecanut in certain other countries goes back to Bronze Age [10]. This nut is used as medicine in several South and Southeast Asian countries [1,11-13] and well mentioned in several text books of ancient system of Indian medicine such as Ayurveda, Unani and Homeopathy [14].

Phenols, alkaloids and essential oils are important groups of plant metabolites known for their diverse actions including defence against several microbial pathogens. These compounds, especially the polyphenols and alkaloids are reported to be promising natural antibacterial agents [15, 16]. Areca palm is one such plants having very high amount of polyphenols and certain amount of alkaloids in most of its parts [17-19]. Ample scientific evidences are now available on the antibacterial properties of various morphological parts of this palm. Such reports are retrieved and presented in this compilation. Their possible applications in pharmacological industries are also discussed.

II. BACTERICIDAL PROPERTIES

Nuts of areca palm

Almost all types of areca nut extracts showed antibacterial properties. It was reported that hot water extract of areca nut was antibacterial against both gram-negative and gram-positive bacteria. The concentration needed for 100% inhibition of gram-negative bacteria was 3.3-7.0µg/ml and for gram positive bacteria 16 µg/ml [20]. Further, the authors speculated that chewing the nuts of areca palm might have significant disinfective properties. In another study, it was reported that such extract of areca nut at a concentration of 50µg/3ml (about 17µg/ml) inhibited the growth of Escherichia coli by 85% and Staphylococcus aureus by 90% [21]. Nisreen and Al-bayati reported effective antibacterial

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activity of such extract against S. aureus and to another bacterium, Streptococcus pyogenes [22]. The minimum inhibitory concentration (MIC) ranging from 0.78 to 3.13 mg/ml was reported for such extract against Bacillus cereus, S. aureus, E. coli and Salmonella typhimurium [23]

Acetone extract of the nuts of areca palm also exhibited potent antibacterial activity with the MIC values ranging from 0.78 to 1.56mg/ml against B. cereus, S. aureus, E. coli and S. typhimurium [23]. Another study showed a zone of inhibition of 18.00 ± 1.00 mm, 20.17 ± 0.76, 18.17 ± 0.76, 20.83 ± 1.26 and 15.50 ± 0.50mm against gram negative bacteria like Vibrio cholerae, Salmonella typhi, Salmonella paratyphi, E. coli and Pseudomonas aeruginosa respectively with such extract and to gram positive bacteria like S. aureus and Micrococcus sp 20.17 ± 1.04mm and 17.33 ± 1.53mm, respectively at a concentration of 100µl/well with the MIC of 0.625µg/ml for E coli and 2.5µg/ml for P. aeruginosa,0.625µg/ml for S. aureus, 1.25µg/ml for Micrococcus sp.[24]. Yet in another study, zone of inhibition of 12.0 ± 1.0mm and 11.0 ± 1.0mm were noticed against the gram-negative bacteria like E coli and Proteus mirabilis, respectively and 10.0 ± 1.0mm against the gram-positive bacterium like Staphylococcus epidermidis for the acetone extract of arecanut at a concentration of 250 µg/ml [25].

The ethanol extract of arecanut also showed antibacterial activity against B. cereus, S. aureus, E. coli and S. typhimurium with MIC ranging from 0.78 to 1.56mg/ml [23]. In another study, such extract showed antibacterial action against several gram-negative bacteria such as E. coli, Proteus vulgaris, P. aeruginosa, Salmonella non-typhi, S. typhi, Shigella flexneri and V. cholerae with zone of inhibition ranging between 7mm to 18mm at 30 to70% concentrations [26]. These authors reported highest antibacterial activity of such extract against P. vulgaris with the zone of inhibition of 18mm at 70% concentration and found it comparable to that obtained for the common antibiotic Ciprofloxacin with the zone of inhibition of 16mm. However, against E. coli, the zone of inhibition noticed with 70% ethanol extract of areca nut was much larger (13mm), than that obtained for Ciprofloxacin (8mm).

The ethyl acetate extract of areca nut was also reported to be antibacterial with MIC ranging from 1.56 to 6.25mg/ml against B. cereus, S. aureus, E. coli and S. typhimurium [23]. In another study, the ethyl acetate extract of arecanut at 1% concentration gave a zone of inhibition of 8.3mm against E. coli and 7.5mm against S. aureus [27]. The antibacterial activity of hydroalcoholic extract of arecanut was also reported. The zone of inhibition noticed in S. aureus, E. coli and Bacillus subtilis when treated with such extract at 200mg/ml concentration was 17mm, 18mm and 15mm, respectively [28]. The methanolic extract of areca nut showed potent antibacterial activity against B. subtilis and E. coli with the MIC of 1.25mg/ml and 5.0mg/ml, respectively [29].

Not only the mature nuts of areca palm but also the immature ones showed antibacterial activity. With water, acetone and ethanol extracts of immature areca nuts, the MIC ranged between 0.78 and 1.56mg/ml against B. cereus, S. aureus, E. coli and S. typhimurium, but with ethyl acetate extract the MIC was slightly higher, ranging between 1.56 and 6.25 mg/ml, for these bacteria [23].

Nanoparticles of areca nut

The nanoparticles of arecanut faired substantially better than its ordinary extracts in their antibacterial activities. At a dose of 50µL of 10mg/ml concentrated areca nut extract the inhibition zones against B. subtilis and P. aeruginosa were 11.0 ± 0.74mm and 13.0 ± 0.69mm, respectively, whereas the figures obtained with the same dose of copper nanoparticles of areca nut extract were 25.0 ± 0.59mm and 23.0 ± 0.62mm, respectively [30]. Silver nanoparticles of areca nut extract were also found much better than its plain extract. The MIC of arecanut aqueous extract against the gram-negative bacteria such as E. coli, S. typhimurium and Pseudomonas aeruginosa were reported to be 256, 64 and 256µg/ml, respectively, whereas such figures for silver nanoparticles of areca nut extract were only 4, 8and 8µg/ml, respectively [31]. Similarly, for gram positive bacteria such as S. aureus, B. subtilis and Listeria monocytogenes, the MIC figures reported by the authors for plain aqueous extract of areca nuts were 512, 256 and 512µg/ml, respectively whereas for silver nanoparticles of areca nut extract the figures were only 4, 16 and 16µg/ml extract, respectively. The authors concluded by saying 'the size-controlled silver nanoparticles synthesized by using the aqueous extract of areca nut can be used as a promising anti-bacterial agent'.

Areca leaf

The acetone extract of the leaf of areca palm was found to be very effective against several bacteria. At a concentration of 10µg/ml the zone of inhibition was reported to be 15.67 ±1.53 mm for

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Enterococcus faecalis, 13.00 ± 1.00 for Klebsiella pneumonia, 12.67 ± 1.15 for Enterobacter aerogenes, 12.33 ± 1.15 for S. epidermidis and 11.33 ± 2.31 mm for B. subtilis [32]. The phytochemical analysis of areca leaf extract showed the presence of saponins and tannins. Surendiran and Yuvaraj reported the antibacterial effect of areca leaf extract against B. cerus and Pseudomonas fluorescens [33]. They further informed that the aqueous extract of areca leaf was more potent than its ethanol, ether and dichloromethane extracts.

Areca root

The extract of areca root also exhibited antibacterial property against several bacteria. At a concentration of 10µg/ml, the acetone extract of the root produced a zone of inhibition of 8.33 ± 0.58 mm against E. faecalis, 12.33 ± 1.15 mm against K .pneumonia, 13.33 ± 4.93 mm against E. aerogenes, 10.67 ± 2.52 mm against S. epidermidis and 10.33 ± 2.08 mm against B. subtilis [32].The ethanol extract of areca root which contained secondary metabolites like alkaloids, steroids, flavonoids, terpenoids, cardiac glycosides, quinones, phlobatanins, tannins and phenols also showed prominent antibacterial activity [34]. They reported that such extract was found to be very effective against several bacteria such as S. aureus, B. cereus, S. pyogenes, K. pneumoniae, P. aeruginosa and S. typhi. The zone of growth inhibition at the recommended dose (25 µg) of the conventional chemical bactericide Chloramphenicol against these bacteria ranged from 9.3± 1.2 mm to 18.7± 1.2 mm, whereas with the ethanol extract of areca root at a concentration of 100µg/ml the figures ranged from 8.6± 0.57mmto 12.6± 0.57mm.

Areca flower and rachilla

Both areca flower and rachilla showed antibacterial activity. It was reported that the hydrosols of both these plant parts significantly inhibited the growth of E. coli and S. aureus [35].

III. POTENTIAL APPLICATIONS

Against oral bacteria

The aqueous extract of areca nut is reported to be very effective against E. faecalis, the most common and dominant anaerobic bacteria responsible for human endodontic infections and even found better than that of chlorhexidine (CHX) the chemical disinfectant presently used during root canal treatment. With areca nut extract, the growth inhibition was noticed at a concentration of as low as 0.062mg/disk whereas with CHX the inhibition was not noticed at such a low concentration and the inhibition with CHX commenced only at a concentration of 0.25mg/disc [36]. In another study, the areca nut aqueous extract treated group showed greater pixels of dead bacteria against E. faecalis followed by CHX and normal saline [37]. The authors suggested that arecanut extract could be considered and used as an alternative herbal disinfectant during root canal treatment.

Both methanol and ethanol extracts of areca nut also showed potent antibacterial activities against several oral bacteria. The zone of inhibition of the methanol extract of arecanut at a concentration of 150µl per well against E. coli was 10mm, S. aureus 21mm, S. typhi 12mm, S. flexneri 13mm, K. pnemoniae 20mm and against P. aeruginosa 12mm [38]. The MIC of the ethanol extract of areca nut ranged between 0.188 and 0.377mg/ml and the minimum bactericidal concentration (MBC) between 0.377 and 0.753mg/ml for gram positive bacteria such as B. subtilis and S. aureus, commonly found inside the human oral cavity and responsible for dental caries [39].

The ethanol, aqueous and methanol extracts of areca nut were all reported to be antibacterial against B. subtilis, the most common bacterium responsible for the formation of biofilm on human teeth [40]. The zone of inhibition noticed by these authors in the disc diffusion test using 50 mg/ml concentration of the ethanol, methanol and water extracts of areca nut were 8 ±0.05, 7 ± 0.05 and 8 ± 0.05 mm, respectively. They even suggested that such extracts of arecanut could be used in mouth wash formulations to avoid plaque formation on human teeth. Another study reported that 10% ethanol extract of areca nut inhibited the growth of other oral bacteria such as Lactobacillus casei, Branhamella catarrhalis and Streptococcus sp. with the zone of inhibition ranging between 9.00± 0.20 to 10.20 ± 0.10 mm [41]. In yet another study, the methanol extract of areca nut showed potent antibacterial activity against two common oral bacterial pathogens, S. aureus and E. coli with MIC of 5 and 7 mg/ml and MBC of 17 and 21mg/ml, respectively [42]. The ethyl acetate extract of areca nut at 2% concentration also showed a zone of inhibition of 9.8mm and 9.0mm against S. aureus and E. coli, respectively [27]. Several other studies also confirmed the antibacterial effects of areca nut against different oral bacteria such as Streptococcus salivarius, S.mutans and Fusobacterium nucleatum [20, 43-45].

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It was reported that areca nut chewing confers a degree of protection against dental caries [46-48]. In a population study carried out on areca nut chewers and non-chewers, it was reported that the prevalence of dental caries in non-chewers was 49% whereas in areca nut chewers it was significantly less at 23% [49]. Further, the amount of dental caries as measured by DMFT was also significantly more in non-chewers at 1.162 compared to 0.364 for chewers. The stain caused due to areca nut chewing may act as protective varnish on tooth surface. Xiong et al. reported that areca nut chewing significantly lowered the microbial diversity in the oral cavity [50].

Gargling with 10 ml of the ethanol extract of young areca nut twice a day for 30 seconds for three days completely cured gingivitis in the oral cavity. It was reported that the mean gingival index in areca extract gargling group which was 1.93 ± 0.704 on the first day reduced to 0.40 ± 0.507 on the second day and 0.00 on the third day [51]. In their study, almost similar results were obtained using CHX 0.2% solution. The figures obtained on the first, second and third days were 1.20 ± 0.561, 0.20 ±0.414 and 0.00, respectively. Similarly, there was no significant difference in the mean gingival healing time, which was 2.35 ± 0.45days with areca nut extract and 2.29 ± 0.66 days with CHX. The authors also reported that the more the frequency of areca nut chewing the lesser is the dental caries incidence. In an observational trial conducted on school children it was noticed that the caries status was significantly low in those children who chewed areca nut for more than 5 times a day when compared to those who chewed areca nut for 3-5 times a day [52]. Several other studies also reported lesser tooth problems in betel quid chewers compared to non-chewers [53, 54].

Against enteric bacteria

The aqueous extract of areca nut was reported to be antibacterial against certain pathogenic enteric bacteria such as E. coli, S. typhi, S. aureus and S. flexneri with the zone of inhibition of 8.0mm, 11.0mm, 9.0mm and 25.0mm, respectively [55]. The authors concluded by saying 'chewing of betel quid after every meal may be good for oral as well as enteric health'.

Against tuberculosis bacterium

The ethanol extract of areca nut exhibited potential activity even against tuberculosis causing bacterium, Mycobacterium tuberculosis. The MIC of such extract, which contained nearly 11 times more of polyphenol than other solvent extracts, was calculated to be 0.975 ± 0.02µg/ml much less than the one reported (4.0 ±0.005µg/ml) for ethambutol, the conventional drug used to treat tuberculosis [56]. The authors even suggested that areca nut should be exploited further as an effective antituberculosis drug.

Against typhoid and paratyphoid bacteria

Salmonella typhi and S. paratyphi, are mainly responsible for typhoid and paratyphoid fevers, respectively. Acetone extract of areca nut was reported to be very effective antibacterial against these pathogens with the zone of inhibition of 20.17 ± 1.04mm and 18.17 ± 0.76mm, respectively at a concentration of 100µl/well [23]. Another study also showed antibacterial activity of areca nut against S. typhi with a zone of inhibition of 11mm for 50% ethanol extract of this nut [26].

Against bacterium causing cholera

Cholera is an acute diarrheal illness caused by infection of the intestine mostly with the bacterium, V. cholerae. Acetone extract of areca nut was reported to be very effective against this pathogen with the zone of inhibition of 18.00 ± 1.00mm at a concentration of 100µl/well [23]. The ethanol extract of areca nut also showed antibacterial activity against this bacterium with a zone of inhibition of 16mm for 50% concentration of the extract [26].

Against bacteria infesting bakery products

It was reported that both methanol and ethanol extracts of areca nut at 100mg/ml concentration were effective against S. aureus, E. coli, Salmonella enteric and Enterobacter aerogenes, the four common bacteria infesting bakery products, and all the areca nut extract treated cakes at that concentration did not show any observable colonies of these bacteria up to the end of the experimental period of 80 days, whereas the control samples showed the count of 1.12×10^3 cfu/g for each pathogen during that period[57].

IV. CONCLUSION

It is observed that almost all morphological parts of areca palm were found very effective against several pathogenic bacteria including the ones responsible for dental caries, biofilm formation, dental plaque, diarrhea, tuberculosis, typhoid, cholera, etc. The extract of areca nut was also found effective against several bacteria infesting bakery products as well. The nanoparticles of areca nut were reported to be even

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more effective as antibacterial than its normal extracts. These results suggest that areca palm could be a valuable biological source for developing safe and effective pharmaceutical products and herbal medicines against several bacterial pathogens and also as a natural preservative in food industry.

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