AN OVERVIEW OF BETEL LEAF (*PIPER BETLE* L.): A REVIEW

Saikat Mazumder[1*], Aditi Roychowdhury[2], Soumitra Banerjee[2]
[1*] Department of Food Technology, Techno India University, EM-4, Salt Lake, Sector-V, Kolkata- 700091, West Bengal, India
[2] Department of Food Technology, Techno India, EM-4/1, Salt Lake, Sector-V, Kolkata- 700091, West Bengal, India
*E-mail: Saikat.23.1989@gmail.com

Abstract
The betel leaf is also known as Piper betle L. It is also commonly known as 'Paan' in India. It belongs to the family Piperaceae, i.e. the Black Pepper family. There are about 100 varieties of betel vine in the world, of which about 40 are found in India. The leaves are very rich in minerals and phyto-chemicals constituents. Besides that, India has an income of more than 7000 crore every year from betel leaf. It is estimated that about 20 million people derive their livelihood directly or indirectly, partly or fully from production, processing, handling, transportation and marketing of betel leaves in India, including about 5 million workers from state of West Bengal. The leaves has several beneficial effects like antioxidant, anti cancerous, anti bacterial etc. Though the leaves has several beneficial effect, still a huge amount of wastage of leaves takes place every year which ranging from 35-70% due to storage, transport, perishability. The aim of this review is to focus on the production, wastage scenario, different beneficial effects of betel leaf such as antibacterial, anti cancerous, antioxidant etc. The impact of betel leaf on Indian economy, different attempts to increase the shelf life and minimization of wastage also have been focused in this review.

Key words: betel leaf, phyto-chemicals, impact on Indian economy, wastage minimization, antibacterial effect, health effect of betel leaves

Submitted: 24.06.2016 Reviewed: 29.07.2016 Accepted:30.09.2016

1. INTRODUCTION

The deep green heart shaped leaves of betel vine are popularly known as *Paan* in India. It is also known as Nagaballi, Nagurvel, Saptaseera, Sompatra, Tamalapaku, Tambul, Tambuli, Vaksha Patra, Vettilai, Voojangalata etc in different parts of the country (CSIR, 1969; Guha and Jain 1997). The scientific name of betel vine is *Piper betle* L. It belongs to the family Piperaceae, i.e. the Black Pepper family (Gunther, 1952). The most probable place of origin of betel vine is Malaysia (Chattopadhyay and Maity, 1967). Though, there are also some other findings by Anthropologists about the traces of betel in the spirit caves in Northwest Thailand dating back to 5500-7000BC, which is even before systematic and organised agriculture came to be practiced. There have been similar findings in Timor in Indonesia going back to 3000 BC and in the black teeth of a human skeleton in Palawan in Philippines going back to 2600 BC. It had found a place in the most ancient Sri Lankan Historical Book "Mahawamsa" written in *palli* (Pradhan et al., 2013). The findings indicate that betel leaf was used by the people since ancient time.

There are about 100 varieties of betel vine in the world, of which about 40 are found in India and 30 in West Bengal (Guha, 1997; Maity, 1989; Samanta, 1994). The key varieties produced in West Bengal are Bangla, Satchi Mitha (Guha, 2006). There are also some other variety in parts of the India like calcuttia, Saunfia Pan, Vishnupuri Pan in Madhya Pradesh, desawari, Benarasi in Uttar Pradesh, Kapoori tuni in Andhra Pradesh etc. (Seetha Lakshmi and Naidu, 2010).

2. PROXIMATE COMPOSITION OF BETEL LEAF

It was reported that fresh leaves contains: moisture 85-90%, protein 3-3.5%, fat 0.4-1.0%, carbohydrate 0.5-6.10%, fibre 2.3%, minerals 2.3-3.3%, chlorophyll 0.01-0.25%, Nicotinic acid 0.63-0.89 mg/100g, calcium 0.2-0.5%, phosphorus 0.05-0.6%, iron 0.005-0.007%, iodine 3.4µg/100mg, Vitamin C

0.005-0.01%, Vitamin A 1.9-2.9 mg/100g, Thiamine 10-70 µg/100g, Riboflavin 1.9-30 µg/100g, Tannin 0.1-1.3%, Nitrogen 2.0-7.0%, Potassium 1.1-4.6%, energy 44 kcal/100gm. The leaves contain enzymes like diastase and catalase. The leaves also contain significant amount of all amino acids except lysine, histidine, arginine which occur in traces (Guha, 2006). Besides that, the leaves also contain potassium nitrate 0.26-0.42%. The indentified sugars in betel leaves are include glucose, fructose, maltose, sucrose. The average content of free reducing sugar varies from 0.38-1.46%. Steam distillation of leaves can give essential oil from 0.7% to 2.6% (Periyanayagam et al., 2012). The leaves also contain significant amount flavonoid and polyphenol content (Chakraborty and Shah, 2011; Durgaprasad et al., 2011). The aroma of betel leaf is due to the presence of essential oils, consisting of phenols and terpenes. The terpenoids include 1, 8-cineole, cadinene, camphene, caryophyllene, limonene, pinene, Chavicol, ally pyrocatechol, carvacrol, safrole, eugenol and chavibetol are the major phenols found in betel leaf.

2.1 Phyto-chemicals found in betel leaf

The various phytochemicals found in the betel plants are Chavibetol, Allypyrocatechol, Chavibetol acetate, Eugenol, Piperitol, Quercetin, Luteolin, β- sitosterol, Hydroxychavicol, α- terpineol, Allyl catecol, Eugenol methyl ether, D- limonene, 2-noanone, 4-allyl phenyl acetate, Piperlonguminine, α-cadinol, Ocimene, N-decanal, Cavacrol, 2-undecanone, Myrcene, Stearic acid, 2- Mono palmitin, Allo ocimene, Cymene, Terpinolene, α-Myrcene, Limonene, Vanillin, Thymol, Cis-piperitol, Tarpinolene, Propcatechuic acid, Gallic acid, β- pinene, Camphene, Linalool, Allyl diacetoxy benzene, Eucalyptol, Sabinene, 3-allyl-6-methoxyphenol, m-Cymen-8-ol, 4 cineole, α-pinene, Anethole, Estragol, Arecoline, Benzene acetic acid, Iso eugenyl acetate, Isoeugenol, Chavicol, Eugenyl acetate, 4-allyl phenol, α-bergamotene, Isoeugenyl acetate, Caffeic acid, (E)-ß-ocimene, Ferulic acid, Carryophyllene, Humlene, α- farnesene, Germacrene-A, Germacrene-D, (E)-ß-Damascenone, 4E-decadienamide, Isoascaridole, 4-Allyl anisole, Safrole, 5-Indanol, 4-allyl resorcinol, ß-iso safrole, α-muurolene, Cadinene, α- copaene, α-cubebene, α- selinene, Cuparene, Piperine, Piperbetol, Methylpiperbetol, Piperol-B, Piperol-A, Ellagic acid, Cepharadione-A, α- Bisabolene and many more (Pradhan et al., 2013).

3. BETEL LEAF IMPACT ON INDIAN ECONOMY AS WELL AS ON WEST BENGAL ECONOMY

The betel leaf has a vast impact on Indian economy and it can be established by several facts discuss following. In India betel leaf is cultivated around 55,000 hector of land encompassing about 20 lakhs Boroj and employing same number of agricultural families. In west Bengal 20,000 hector where the leaf is cultivated, encompassing about 4-5 Lakhs boroj and same numbers of families are associated. The annual yield of a good crop is about 60-70 leaves/ plant and 6-7 million leaves/ ha (Guha and Jain 1997; ICAR, 1997; Jana, 1996; Maity, 1996; Guha, 2006). So, as far the national employment is concerned about 20 lakhs people in India derive their livelihood partly or fully from betel leaf production, transport or handling which includes 5 lakhs people from West Bengal (Jana, 1996). The number of daily consumer in India is about 15-20 million (Jana, 1996) and over 2 billion around the world (Jeng et al., 2002). The leaves have also demands in different religious festivals like in different pujas, ceremonies, and cultural functions. Some times it is also used as a separate dish to show respect to the guests in India. Interestingly, among of such huge production in India, 66% is contributed by West Bengal (Guha, 2006), which includes around 30% contribution from Midnapore District (www.ttg-sric.iitkgp.ernet.in/ttg/tech.php).

So, from the gross production of leaves more than Rs. 7000 crore is contributed to the Indian economy every year including an income of more than Rs 5000 crore to the state of West Bengal [Table-1].

Table 1 State wise value output of betel leaves (*Rs. In lakhs)

State	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
Andhra Pradesh	33861*	36595*	38273*	42856*	43958*	63841*	104763*
Assam	17682*	19941*	21226*	23702*	26003*	28525*	28525*
Kerala	49655*	24998*	10198*	27360*	21016*	20319*	27336*
Meghalaya	158*	166*	195*	204*	204*	244*	296*
Mizoram	156*	135*	136*	156*	0	0	136*
West Bengal	152954*	295746*	302045*	379717*	375291*	550443*	575592*
Pondicherry	199*	23*	6*	89*	11*	11*	14*
Total	254664*	377604*	372078*	474084*	466483*	663384*	736661*

Source: Central Statistics Office, Ministry of statistics and programme implementation, Government of India, 2013.

The leaves are also in great demand in several other countries of the world where it is either not grown at all or the demand exceeds the local supply. Consequently, leaves worth about Rs 30-40 million are exported to the countries like Bahrain, Canada, Great Britain, Hong Kong, Italy, Kuwait, Nepal, Pakistan, Saudi Arab and many other European countries (Jana, 1996; Singh et al., 1990).

4. WASTAGE SCENARIO OF BETEL LEAF IN INDIA

The general shelf life of the leaves is 3-5 days in summer and 5-7 days in winter after harvesting. Being a very perishable commodity around 35-70% of the gross production is post harvest losses every year (Rao and Narasimham, 1977). Particularly in the rainy season a large portion of the leaves remain unsold or sold at a throw away price (Guha and Jain 1997). Moreover, the surplus leaves are fed to the cattle and sometimes buried in the ground to avoid environmental pollution and health hazards caused by millions of decaying leaves, which is a total wastage at present. Due to such reason the farmers try to reduce the production by curtailing the agricultural inputs (Guha, 2006).

5. DIFFERENT ATTEMPTS TO MINIMIZE WASTAGE OF BETEL LEAVES

5.1 Extending shelf life by natural/Chemical treatment or combination of both

Since, a long time several attempts have been tried to minimize the surplus wastage either by prolonging storage life of betel leaves or by development new machineries to increase the utilization of betel leaf. The main problem during storage are moisture loss, colour loss, microbiological infection etc. In the year 1977 a study has been performed to prolong the shelf life of betel leaves. The study was conducted by variation in chemical treatments and with mature leaves different position from the tip. It was found that 3rd to 6th from the tip was the best for storage and transport since they had minimum climacteric peak. Treatment with benzyl adenine (BA) reduced chlorophyll destruction with greater build up of carotenoids and yellowing was delayed by about 3 days (Rao and Narasimham, 1977). The same observation of positive effect of benzyl adenine to retain chlorophyll was found by Rayaguru et al., (2007). Addition of Mixture of sodium bicarbonate and tartaric acid in the packing, extend the storage life of the leaves. Disinfecting the packing material with sodium hypochlorite or aureofungin was found to be beneficial for reducing of spore load and for development of yellow colour (Rao and Narasimham, 1977).

Another study suggest that betel leaves treated with 25ppm benzyl adenine and 50 ppm kinetin and packed in vented polythene bags stored under refrigerated conditions prolonged the shelf life of the leaves. If the treated leaves packed in baskets and stored at room temperature the storage life can be extended up to 40 days (Singh, 1990). Whereas, leaves only treated with benzyl adenine solution (5mg/l) for 8 hours can store be stored in traditional package for 4-12 days in summer and 12-21 days in winter (Rayaguru et al., 2007). De-petiolation and de-midribbing can further increase the shelf life of leaves than 40 days.

A combined treatment of de-petiolation, de-midribbing and dipping in 25 ppm of BA for 6 h can further increase of shelf life by about 10 days (Singh, 1990).

In the recent year a study by faculties of Horticulture, Bidhan Chandra Krishi Viswa Vidyalaya, West Bengal with betel leaves produced in Simurali, West Bengal, India has been conducted. Nine different treatments was considered including the variation in level of chemical treatment, storage condition, packing with different material, seasonal variation for keeping the leaves fresh and marketable.

The treatments were, leaves packed in sterilized moist paddy straw lining (5 cm thickness) in a bamboo basket; Leaves packed in banana leaves and kept in a bamboo basket; leaves wrapped in moist Hessian cloth lined with mustard seeds and ice pieces and kept in a bamboo basket; leaves kept in a bamboo basket and stored in zero energy cool chamber; leaves treated in three different plastic trays containing 15, 30 and 45 ppm of Benzylaminopurine (BA) respectively for 6 hours and followed by washing with distilled water and bottled thereafter.

Then the leaves were packed in vented polythene bags (45 ´ 30 cm) of 200 gauge and kept at room temperature; leaves packed in vented polythene bags and kept under refrigeration (6–8°C); leaves kept in bamboo basket only and stored at room temperature. The study suggests that among different methods of storage, zero energy cool chamber was the best for longest period of storage followed by packing with banana leaves in bamboo basket. De-petiolated condition was always better than petiolated condition for enhancing storage life.

Chlorophyll degradation was minimum in petiolated condition either in packing with banana leaves or in treatment with Benzylaminopurine (BA) with 30 ppm compared to de-petiolated condition.

Ascorbic acid content was more in sterilized paddy straw packing and in hessian cloth lined with mustard seed and ice pieces compared to other treatments (Imam and Pariari, 2012).

5.2 Increasing Shelf life by Natural drying

Drying can be effective tool to preserve the betel leaf. The sun (28-38°C), shade (25-32°C), solar (40 to 47°C), and microwave drying have been applied and 8-8.5, 48-52, 5-5.5 hours and 10 min respectively, has been taken to lower the moisture content of the betel leaves to 3-6% (Ramalaksmi et al., 2002, Rayaguru et al., 2007). According to Rayaguru et al., (2007) compared to fresh betel leaf during sun and solar drying there were appreciable losses of volatile oil 30-35% and heat treatment can also provide the leaves a better storage life. Packing in traditional way (wet cloth wrapped leaves in bamboo baskets) and then subjected to heat for 1hour at 45^0C can provide a better storage life (Imam and Pariari, 2012).

There was a controversy have been found for determination of best drying condition. According to Ramalaksmi et al., (2002), solar drying was the best method of drying among of drying mentioned above, though sun drying is also a cause of chlorophyll destruction. Where as, according to Rayaguru et al. (2007), shade drying was best method because it can preserve maximum nutrients and only 10-15% chlorophyll destruction takes place.

5.3 Increasing Shelf life by Mechanical drying and microwave drying

Mechanical drying of betel leaf at 40^0C and 50^0C has been used and it takes 7 and 4.5 hours respectively to reduce the moisture content to 3-6% level. During hot air drying loss of volatile oil and chlorophyll was more than 40% and 50% respectively. Where as, according to Ramalaksmi et al., (2002), during mechanical and microwave drying loss of volatile oil and chlorophyll was 50% and 70% respectively. Microwave drying can take 10 minutes to lowering the moisture content at 3-6% level.

5.4 Increasing Shelf life by Vacuum drying

Vacuum drying has been applied to dry the betel leaves. The variation of temperature and in pressure was undertaken in the study. The drying characteristics and assessment of colour changes have been studied. It was seen that among the temperature (30, 40, 70^0C) and

vacuum pressure (1.0, 0.5, 0.0 atm.) applied 50^0C was best condition of drying irrespective of vacuum pressure (Puteri Farah Wahida, 2012).

5.5 Increasing shelf life by Modified atmosphere packaging of betel leaves

Modified atmosphere packaging can be effective way to maintain the chlorophyll content, phenolic content, and β carotene content. As per reported, polypropylene film packaging with partial pressures of 2.5 kPa for O_2 and 6.2 kPa for CO_2, and containing 750 g of betel leaves, resulted in better retention of chlorophyll, phenolic content. The packaging can be stored for 10 days at 20^0C. The build-up of CO_2 is necessary for the prevention of browning and maintenance of chlorophyll in the betel leaves. In contrary to above, the packaging film with appropriate permeabilities for O_2 and CO_2 or in-pack weight of betel leaves might be such that equilibrated O_2 partial pressures could be still higher (9 kPa) to effect only a beneficial increase in the phenolic content (Rai et al., 2010). Though the study suggest that the resultant is likely to benefit the wholesaler and the retailer in the value chain to better maintain its shelf-life and various physicochemical properties, as compared with that obtained using traditional storage techniques. But the price of betel leaf should be kept in consideration regarding this type of study.

5.6 Extraction of betel leaves oil

The wastage can also be minimized the extraction of essential oil from betel leaves. Such type of extractor has been developed by P. Guha in the year 2006 at Agricultural and Food Engineering Department, Indian Institute of Technology, Kharagpur, West Bengal, India. The special emphasis of this extraction system was the raw materials means betel leaves may be fresh, or stale or de-chlorophylled or even partially decayed. The essential oil extracted with this apparatus clearly revealed that the Mitha, Bangla and Sanchi varieties of betel leaves contained about 2.0%, 1.7% and 0.8% essential oil respectively, on dry weight basis. This oil of Bangla variety was constituted by a mixture of about twenty-one different compounds of which eugenol was the chief ingredient constituting about 29.5 % of the oil (Guha, 2006).

6. ANTIBACTERIAL EFFECTS OF BETEL LEAF

The betel leaf has antibacterial effect for different types of bacteria including pathogens. It was reported that against Streptococcus pyogens and Proteus vulgaris, the water, methanol, ethyl acetate and petroleum ether extract of betel leaf has a significant effect (Chakraborty and Shah, 2011). Staphylococcus aureus and Escherichia coli has stopped their activity against betel leaf extracted in water (Chakraborty and Shah, 2011), methanol (Chakraborty and Shah, 2011; Khan and Kumar, 2011), ethyl acetate (Chakraborty and Shah, 2011), petroleum ether (Chakraborty and Shah, 2011), chloroform (Jesonbabu et al., 2011) and ethanol (Khan and Kumar, 2011; Mahfuzul Hoque et al., 2011). The chloroform extract of betel leaf has also antibacterial effect against Shigella dysentrie, Salmonella typhi, and Streptococcus pyogenes (Jesonbabu et al., 2011). The betel leaf extracted in methanol and ethanol has significant negative effect on Pseudomonas aeruginosa (Khan and Kumar, 2011). The methanolic extract of betel leaf is more effective against Pseudomonas aeruginosa (Khan and Kumar, 2011) and Staphylococcus aureus (Khan and Kumar, 2011; Jesonbabu et al., 2011) than ethanolic extract. Where as, growth of Escherichia coli is inhibited more effectively by ethanolic extract (Khan and Kumar, 2011), ethyl acetate extract (Jesonbabu et al., 2011) of betel leaf. In addition, the water extract of has more inhibitory effect on Escherichia coli (extract concentration 100mg/ml), and the petroleum ether extract has on Proteus vulgaris (Chakraborty and Shah, 2011). The increment in extract volume addition in water, methanol, ethyl acetate, petroleum ether of betel leaf has more inhibitory effect (Jesonbabu et al., 2011). In contrary, the variety of betel leaf has shown

different outcome, when applied on Pseudomonas aeruginosa, Staphylococcus aureus, and Escherichia coli. The jaleswar variety (produced in Madhya Pradesh) extracted with methanol shows maximum inhibitory effect on Escherichia coli. The bangladesi variety extracted with ethyl acetate shows maximum inhibitory to both of Staphylococcus aureus and Pseudomonas aeruginosa.

The methanolic extract of betel also effective against some food born pathogen like E.coli O157:H7, Vibrio Cholerae, Shigella dysenteriae. The minimum concentration shows inhibitory effect was 0.75 mg/ml, 0.625mg/ml, 0.75mg/ml respectively for the name mention above. The ethanolic extract shoes more inhibitory effect on Vibrio Cholerae than E.coli O157:H7, and Shigella dysenteriae (Mahfuzul Hoque et al., 2011).

The antibacterial activity against Shigella dysentrie, Salmonella typhi, and S.pyogenes is mainly due to hydroxychavicol (Jesonbabu et al., 2011). Is has been also reported that bioactive molecule thought to be responsible for antibacterial activity is sterol which has been obtained in large quantities in *Piper betel* extracts. The probable mode of action is due to surface interaction of sterol molecules present in the extracts with the bacterial cell wall and membrane leading to alteration in the primary structure of cell wall and membrane, ultimately leading to pore formation and degradation of the bacterial components (Chakraborty and Shah, 2011). It has been reported that sterol works through the disruption of the permeability barrier of microbial membrane structures (Pelczar MJ, Chan ECS, and Kreig NR., 1993). Another potential reason is that *Piper betel* extracts containing high concentration of fatty acids like palmitic acid, stearic acid and hydroxy fatty acid esters shows potent antimicrobial activity against diverse pathogenic microorganism (Nalina and Rahim, 2007).

Ethanol extracts of betel leaf at 10,000 ppm can completely inhibited growth of Aspergillus flavus (TISTR 3366) and Fusarium verticillioides (TISTR 3175) (Srichana et al., 2009).

7. BETEL LEAF EFFECTS ON HEALTH

7.1 Beneficial health effect

Betel leaf is traditionally known to be useful for the treatment of various diseases like bad breath, boils and abscesses, conjunctivitis, constipation, headache, hysteria, itches, mastitis, mastoiditis, leucorrhoea, otorrhoea, ringworm, swelling of gum, rheumatism, abrasion, cuts and injuries etc as folk medicine while the root is known for its female contraceptive effects (Chopra et al., 1956; Khanra, 1997). Further, the essential oil contained in the leaves possesses antibacterial, antiprotozoan and antifungal properties. Therefore, the oil kills or inhibits growth of dreadful bacteria causing typhoid, cholera, tuberculosis etc that needs proper evaluation and exploitation (CSIR, 1969). Not only that, the betel leaves really does not have any match as a cheap, natural and easily available appetizer, digestive, mild stimulant, aphrodisiac and refreshing mastication. Chewing of betel leaves is producing a sense of well-being, increased alertness, sweating, salivation, hot sensation and energetic feeling with exhilaration. It also increases the capacity to exercise physical and mental functions more efficiently for a longer duration but it may produce a kind of psychoactive effect causing a condition of mild addiction leading to habituation and withdrawal symptoms (Chu, 2001; Garg and Jain, 1996). Further, the leaves are very nutritive and contain substantial amount of vitamins and minerals and therefore, six leaves with a little bit of slaked lime is said to be comparable to about 300 ml of cow milk particularly for the vitamin and mineral nutrition (Guha, 2006).

7.2 Harmful health effects from betel leaves

In spite of the nutritive, stimulating and refreshing properties, excessive consumption of betel leaves like any other edible items may also prove to be harmful particularly to the teeth. Such harmful effects are exerted by the

additional ingredients consumed along with the leaves for making the quid more palatable and attractive. These include in particular, the tobacco or allied products, which really call for a word of caution. This is because the tobacco based betel quid may cause dental caries, alveolaris, oral sepsis, palpitation, neurosis and even oral cancer (CSIR, 1969; Brunnemann and Hoffmann, 1992; IARC, 2004). Several studies have been performed with the individual constituents of the betel quid and observations have conclusively shown that tobacco (Sundqvist et al., 1989; Boffetta et al., 2008) and areca nut (Canniff and Harvey, 1981; Sundqvist et al., 1989; Wang and Peng, 1996; Jeng et al., 2000; IARC, 2004; Lee et al., 2005) are both carcinogenic and slaked lime to promote carcinogenesis (Jeng, 1994; Thomas and MacLennan, 1992). But the non-tobacco based betel quid are not known for sure to cause any such calamity particularly at a non-addictive level of consumption. However, there is no denial of the fact that the leaves may contain a good amount (15 mg/g) of Safrole (Chen et al., 1999; Guha, 2006), a carcinogen, but it is quickly metabolized in human body into dihydroxychavicol and eugenol, which are excreted along with urine (Chang et al., 2002; Guha, 2006).

7.3 Antioxidant activity of betel leaf

Recently, Manigauha *et al*., (2009) observed that the methanolic extracts of the betel leaves possess reducing power, DPPH radical, superoxide anion scavenging and deoxyribose degradation activities. The ethanol extracts of Bangla, sweet, and Mysore varieties of betel leaf were effective in scavenging DPPH radicals in vitro, with best effects being observed with the Bangla variety (Rathee et al., 2006). Lei *et al.*, (2003) have shown that the aqueous extract of the inflorescence of Piper betel extract was effective in scavenging H_2O_2, superoxide radical and hydroxyl radical.

7.4 Anti cancerous effect of betel leaf

The betel leaves are also reported to possess anti carcinogenic properties particularly against the tobacco carcinogens (Chang et al., 2002; Wu et al., 2004) due to the presence of ingredients like hydroxychavicol (Amonkar et al., 1989) and chlorogenic acid (TNN, 2004) in it. The latter compound is also reported to kill the cancerous cells without affecting the normal cells unlike the common cancer drugs and relevant therapeutic means. Therefore, possibility of manufacturing of a new blood cancer drug from it cannot be ruled out. In fact, some scientists from the Indian Institute of Chemical Biology, Kolkata have applied for a patent for the drug. If successful, the drug would also fetch substantial amount of foreign exchange to the country and highlight the significance of betel leaf to a further extent (TNN, 2004). It has also reported that the betel leaves can prevent prevents oral carcinogenesis, forestomach carcinogenesis, skin carcinogenesis, mammary carcinogenesis (Rai et al., 2011).

Contrary to the above, there are a few earlier reports which indicate that chewing betel leaves may independently produce carcinogenic effects (Chen et al., 1999; Merchant et al., 2000). However, the evidences are inadequate and do not match with the traditional history of betel leaf chewing in India and recent research. Interestingly, it is also claimed that the inflorescence of betel vine contains carcinogens whereas the leaves possess anti-carcinogenic agents (Guha, 2006).

8. CONCLUSIONS

The review shows that the betel leaf has wide range of beneficial effect on human health. Not only that the leaves have antibacterial effect and can prevent growth of food born pathogens. While extending shelf life of betel leaves and food product development from betel leaves, sensory profile for both of stored leaves or food products may be focused to know customer acceptance. We have seen in this review that drying has shown a negative effect on the chlorophyll content, colour etc. But the leaves also have a very good mineral and vitamin profile. So, after drying the dried leaves can be incorporated into food products for minerals and vitamins enrichment.

Though, India has a huge income from betel leaf still a huge wastage take place every year. So, only extending shelf life can not reduce the wastage. Value addition of betel leaf on large scale is very much necessary. Value addition may be by means of food product development or medicinal product development.

9. REFERENCES

[1] CSIR (Council of Scientific and Industrial Research, New Delhi), the Wealth of India, **8**, 1969, 84-94. CSIR, New Delhi.
[2] Guha, P., Jain, R.K., Status Report On Production, Processing and Marketing of Betel Leaf (Piper betle L.), Agricultural and Food Engineering Department, IIT, Kharagpur, India, 1997.
[3] Gunther, E., *the Essential Oils*, **5**, 1952, 160-161. D. Van Nostrand & Co, Inc. New York.
[4] Chattopadhyay, S. B., Maity, S., Diseases of Betelvine and Spices, 1967**.** ICAR, New Delhi.
[5] Pradhan, D., Dr. Suri, K. A., Dr. Pradhan, D. K., Biswasroy, P. (2013). ***Journal of Pharmacognosy and Phytochemistry***, 1 (6): 147-167.
[6] Guha, P., "Paan Theke Kutir Silpa Sambhabana" (In Bengali). "Exploring Betel Leaves for Cottage Industry", In: Krishi, Khadya-O- Gramin Bikash Mela –A Booklet published by the Agricultural and Food Engineering Department, IIT, Kharagpur, India, 1997, pp. 15-19.
[7] Maity, S., Extension Bulletin: *The Betelvine.* All India Coordinated Research Project on Betelvine, Indian Institute of Horticultural Research, Hessarghatta, Bangalore, India, 1989.
[8] Samanta, C., Paan chaser samasyabali-o-samadhan: Ekti samikkha (In Bengali): "A Report on the Problems and Solutions of Betel Vine Cultivation", A booklet published by Mr. H. R. Adhikari, C-2/16, Karunamoyee, Salt Lake City, Kolkata-64 (WB), India, 1994.
[9] Guha, P., Betel Leaf: The Neglected Green Gold of India, Journal of Human Ecology, **19**, 2, 2006, 87-93.
[10] Seetha Lakshmi, B., Naidu, K.C., Comparative Morphoanatomy of Piper betel L. cultivars in India, Annals biological Research, **1**, 2, 2010, 128-134.
[11] Periyanayagam, K., Jagadeesan, M., Kavimani, S., Vetriselvan, T., Pharmacognostical and Phyto-physicochemical profile of the leaves of Piper betle L. var Pachaikodi (Piperaceae) - Valuable assessment of its quality, Asian Pacific Journal of Tropical Biomedicine, **2,** 2, 2012, S506–S510.
[12] Chakraborty, D., Shah, B., Antimicrobial, antioxidative and antihemolytic activity of *piper betel* leaf extracts, International Journal of Pharmacy and Pharmaceutical Sciences, **3**, 3, 2011, 192-199.
[13] Durgaprasad, M., Amarendra. CH., Anusha, G., Knodeti, B., Durga Prasad, A., Durga Rao, A., Kuchi, R., Determination of Antioxidant Flavonoids and Phenolic Compounds in Betel Plant by High Performance Liquid Chromatography, International Journal of Science Innovation and Discoveries, **1**, 2, 2011, 109-114.
[14] ICAR (Indian Council of Agricultural Research, New Delhi), Annual Report of All India Coordinated Research Project on Betelvine (ICAR), Indian Institute of Horticultural Research, Hessarghatta, Bangalore, India, 1997.
[15] Jana, B.L., Improved technology for betel leaf cultivation, A paper presented in the "Seminar-cum-Workshop on Betel leaf Marketing", held at State cashew nut farm, Directorate of Agricultural Marketing, Digha, Midnapur (West Bengal), India, June 5-6, 1996.
[16] Maity, R., Paaner Arthaniti, Banijjya-o -paan chasider samasya (In Bengali). "Economics, Commerce and Problems of Betelvine Cultivators", A paper presented in the "Seminar-cum-Workshop on Betel leaf Marketing", held at State cashew nut farm, Directorate of Agricultural Marketing, Digha, Midnapur (West Bengal), India, June 5-6, 1996.
[17] Jeng, J. H., Chen, S.Y., Liar, C.H., Tung, Y.Y., Lin, B.R., Hahn, L.J. and Chang, M.C., Modulation of platelet aggregation by areca nut and betel leaf ingredients: Roles of relative oxygen species and cyclooxygenase, Free Radical Biology and Medicine, **32**, 9, 2002, 860-871.
[18] Singh, K.K., Balasubrahmanyam, V.R., Kochhar, V.K., Effect of different packing methods, temperature conditions, treatment with chemicals on the senescence and storage behaviour of betel (*Piper betle* L.) leaves, Journal of Plantation Crops, **18,** 1, 1990, 23- 28.
[19] Rao, V. M., Narasimham, B., Prolonging storage life of betel leaves, Indian Journal Horticulture, **34,** 2, 1977, 175-182.
[20] Rayaguru, K., Md. Khan, K., Mohanty, S. N., Sahoo, G. R., Effect of Drying and Storage on Quality of Betel Leaves, Journal of Agricultural Engineering, **44**, 1, 2007, 64-68.
[21] Imam, M.N., Pariari, A., Keeping quality of betel leaves (*Piper betle* L.) as influenced by different methods and seasons, Journal of Spices and Aromatic Crops, **21**, 2, 2012, 106–112.
[22] Ramalakshmi, K., Sulochanamma, G., Rao, L. J. M., Borse, B.B., Raghavan, B., Impact of drying on quality of betel leaf (*Piper betle* L.), Journal of Food Science and Technology, **39**, 6, 2002, 619-622.
[23] Puteri Farah Wahida, M.A., Luqman Chuah, A., Pin, K.Y., Law, C.L., Choong, T.S.Y., Vacuum Drying Characteristics for *Piper betle* L. Leaves, Journal of Applied Sciences, 12, 11, 2012, 1203-1206.
[24] Rai, D.R., Chourasia, V.K., Jha, S.N., Wanjari, O.D., Effect of Modified Atmospheres on Pigment and Antioxidant Retention of Betel Leaf (*Piper betel* L.), Journal of Food Biochemistry, 34, 5, 2010, 905-915.

[25] Khan, J., Kumar, N., Evaluation of Antibacterial Properties of Extracts of *Piper betel* Leaf, Journal of Pharmaceutical and Biomedical Sciences, **11**, 11, 2011, 1-3.
[26] Jesonbabu, J., Spandana, N., Lakshmi K, A., the Potential Activity of Hydroxychavicol against Pathogenic Bacteria, Bacteriology & Parasitology, **2**, 6, 2011, 1-4.
[27] Mahfuzul Hoque, M., Rattila, S., Asaduzzaman Shishir, M., Bari, M.L., Inatsu, Y., Kawamoto, S., Antibacterial Activity of Ethanol Extract of Betel Leaf (*Piper betle* L.) Against Some Food Borne Pathogens, Bangladesh Journal of Microbiology, **28**, 2, 2011, 58-63.
[28] Pelczar MJ, Chan ECS, Kreig NR., Microbiology. Vol. 5, 1993, Tata McGrow-Hill Publ. New Delhi, India.
[29] Nalina T, Rahim ZHA. The crude aqueous extract of *Piper betel* L. and it's antibacterial effect towards *Streptococcus mutans*., American journal of Biotechnology and Biochemistry, **3**, 1, 2007, 10-15.
[30] Srichana, D., Phumruang, A., Chongkid, B., Inhibition Effect of Betel Leaf Extract on the Growth of *Aspergillus flavus* and *Fusarium verticillioides*, Thammasat International Journal of Science and Technology, **14**, 3, 2009, 74-77.
[31] Chopra, R.N., Nayar, S.L. and Chopra, I.C., Glossary of Indian Medicinal Plants, 1956, pp.194, CSIR, New Delhi, India.
[32] Khanra, S., Paan Vittik Silpakendra (In Bengali), "Betel Leaf Based Industry". Nabanna Bharati, **30**, 2, 1997, 169.
[33] Chu, N. S., Effects of betel chewing on the central and autonomic nervous systems, Journal of Biomedical Science, **8**, 3, 2001, 229- 236.
[34] Garg, S.C. and Jain, R., Chavicol rich essential oil of *Piper betle* L., Cutivar Sagar Bangla, Euro Cosmetics, **5**, 1996, 27- 28.
[35] Brunnemann, K.D., Hoffmann, D., Chemical composition of smokeless tobacco products, In: Smokeless Tobacco or Health, An International Perspective (Smoking and Tobacco Control Monograph No.2), Bethesda (MD): National Cancer Institute, 1992.
[36] IARC, Betel-quid and areca nut chewing and some areca-nut derived nitrosamines, In IARC Monographs, **85**, 2004, International Agency for Research on Cancer, WHO, Lyon, France.
[37] Sundqvist, K., Liu, Y., Nair, J., Cytotoxic and genotoxic effects of areca nut-related compounds in cultured human buccal epithelial cells, Cancer Research, **49**, 1989, 5294-5298.
[38] Boffetta, P., Hecht, S., Gray, N., Gupta, P., Straif, K., Smokeless tobacco and cancer, Lancet Oncology, **9**, 7, 2008, 667–675.
[39] Canniff, J.P., Harvey, W., The aetiology of oral submucous fibrosis: the stimulation of collagen synthesis by extracts of areca nut, International Journal of Oral Surgery, **10**, 1981, 163-167.
[40] Wang, C.K., Peng, C.H., The mutagenicities of alkaloids and N-nitrosoguvacoline from betel quid, Mutation Research, **360,** 3, 1996, 165-171.
[41] Jeng, J.H., Ho, Y.S., Chan, C.P., Areca nut extract up-regulates prostaglandin production, cyclooxygenase-2 mRNA and protein expression of human oral keratinocytes, Carcinogenesis, **21**, 7, 2000, 1365-1370.
[42] Lee, C.H., Lee, J.M., Wu, D.C., Independent and combined effects of alcohol intake, tobacco smoking and betel quid chewing on the risk of esophageal cancer in Taiwan, International Journal of Cancer, **113**, 3, 2005, 475–482.
[43] Jeng, J.H., Kuo, M.L., Hahn, L.J., Kuo, M.Y., Genotoxic and non-genotoxic effects of betel quid ingredients on oral mucosal fibroblasts in vitro, Journal of Dental Research, **73**, 5. 1994, 1043-1049.
[44] Thomas, S.J., MacLennan, R., Slaked lime and betel nut cancer in Papua New Guinea, Lancet, **340**, 8819, 1992, 577-578.
[45] Chen, C., Chi, C., Chang, K., Liu, T., Safrole-like DNA adducts in oral tissue from oral cancer patients with a betel quid chewing history, Carcinogenesis, **20**, 12, 1999, 2331-2334.
[46] Chang, M. J.W., Ko, C.Y., Lin, R.F. and Hsiesh, L.L., Biological monitoring of environment exposure to Safrole and the Taiwanese betel quid chewing, Archives of Environmental Contamination and Toxicology, **43**, 4, 2002, 432-437.
[47] Manigauha, A., Ali, H., Maheshwari, M.U., Antioxidant activity of ethanolic extract of Piper betel leaves, Journal of Pharmaceutical Research, **2**, 3, 2009, 491-494.
[48] Rathee, J.S., Patro, B.S., Mula, S., Gamre, S., Chattopadhyay, S., Antioxidant activity of Piper betel leaf extract and its constituents, Journal of Agriculture and Food Chemistry, **54**, 24, 2006, 9046 -9054.
[49] Lei, D., Chan, C.P., Wang, Y.J., Antioxidative and antiplatelet effects of aqueous inflorescence Piper betel extract, Journal of Agriculture and Food Chemistry, **51**, 7, 2003, 2083-2088.
[50] Chang, M.C., Uang, B.J., Wu, H.L., Lee, J. J., Hahn, L. J. and Jeng, J.H., Inducing the cell cycle arrest and apoptosis of oral KB carcinoma cells by hydroxychavicol: Roles of glutathione and reactive oxygen species, British Journal of Pharmacology, **135**, 3, 2002, 619-630
[51] Wu, M.T., Wu, D.C., Hsu, H.K., Kao, E.L. and Lee, J.M., Constituents of areca chewing related to esophageal cancer risk in Taiwanese men, Diseases of the Esophagus, **17**, 3, 2004, 257-259.
[52] Amonkar, A.J., Padma, P.R. and Bhide, S.V., Protective effect of hydroxychavicol, a phenolic component of betel leaf, against the tobacco-specific carcinogens, Mutation Research, **210,** 2, 1989 249-253.

[53] TNN (Times News Network): Paan- Indian cure for leukemia, The times of India, Kolkata (31.7.2004), <http: //www.hvk.org/articles/0804/22.html>.
[54] Rai, M.P., Thilakchand, K.R., Palatty, P.L., Rao, P., Rao, S., Bhat, H.P., Baliga, M.S., Piper Betel Linn (Betel Vine), the Maligned Southeast Asian Medicinal Plant Possesses Cancer Preventive Effects: Time to Reconsider the Wronged Opinion, Asian Pacific Journal of Cancer Prevention, **12**, 2011, 2149-2156.
[55] Merchant, A., Husain, S.S.M., Hosain, M., Fikree, F.F., Pitifat, W., Siddiqui, A.R., Hyder, S.J., Halder, S.M., Ikran, M., Chuang, S.K. and Saeed, S.A., Paan without tobacco: An independent risk factor for oral cancer, International Journal of Cancer, **86**, 1, 2000, 128-131.