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RESEARCH ARTICLE

Bamboo Leaves: An Emerging Multi-functional Food

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ABSTRACT

Bamboos form a unique group of giant arborescent grasses belonging to the family *Poaceae* and sub-family *Bambuseae*. Bamboo leaves are the favorite food of pandas and many other animals and are much valued as fodder. Other than this, its uses in the food industry in various food products, bamboo wine and as packaging material are being explored. Anti-oxidant of bamboo leaves (AOB), a novel food anti-oxidant is used in many food products and has been found to contain antioxidants, flavanoids and other bioactive compounds that help in the prevention of various degenerative diseases like cancer, diabetes, heart problems etc. However, there is no systematic review that explores the nutritional value and uses of bamboo leaves in different sectors. Therefore, this paper reviews the nutritional composition and spectrum of usage in the food industry. Bamboo leaves have great potential as a food additive and more research attempts on its use as a nutraceutical and functional foods are needed.

1. Introduction

Non-timber forest products (NTFPs) are products derived from forests other than wood. NTFPs play an important role in the lives of tribal and marginalized people for livelihood generation and meeting nutritional requirements. The commercial value of these products has been increasing with time [1].

Bamboos a type of giant arborescent grass belongs to the family *Poaceae* and sub-family *Bambuseae*. More than 1250 species belonging to 75 genera are distributed worldwide, out of which 125 species are found in India indicating that India has rich bamboo resources after China [2]. It is of immense significance in environment protection as it prevents soil erosion and conserves soil moisture. Despite its variable usage in the structural sector, it forms an essential component in the rural sector in meeting livelihood requirements [3].

Various parts of bamboo are used for different purposes. For instance, young tender bamboo shoots serve as an important food source in fermented [4] and dried forms [5]

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to many tribal communities and it also holds a lot of medicinal value [6]. Apart from shoots, leaves of bamboo have been reported to have good antioxidant potential and are mainly used as fodder for ruminants and serve as a favorite food of elephants & giant pandas [7]. Recently, many biologically active components have been investigated in bamboo leaves by several researchers and their potential health benefits have been widely studied. Bamboo leaves extracts have shown a positive effect in controlling various degenerative diseases like diabetes, cancer, heart problems etc. Therefore, the addition of the extract containing bamboo leaves serves as a functional food and has various nutraceutical applications. However, there is no systematic review of the uses and therapeutic benefits of bamboo leaves. Therefore the present paper has made an effort to comprehend the data based on the nutritional composition, functional uses and therapeutic role of bamboo leaves.

2. Nutritional Composition of Bamboo Leaves

The nutritional composition of different species of bamboo leaves has been analyzed globally by different researchers. Bamboo leaves of 27 species were found to be good in crude protein (9-19%) and crude fiber (18-34%). However, they were rich in Ca, Mg, Cu and Mn, normal in Zn and poor in P, K and Na [8]. Seven bamboo leaf species in Tripura were found to contain all the major nutrients but deficient in minerals like P and rich in Ca, Fe & Mn [9].

In a study, it revealed that the concentration of N, P, K, Ca, Mg and S was 24.3, 1.34, 5.44, 4.08, 1.41, and 112.2 mg/kg respectively whereas the amount of micronutrients for Fe, Mn, Cu, Zn, B and Mo was 144.3, 269.5, 4.23, 27.1, 5.6 and 9.6 mg/kg respectively in the bamboo leaves (*Phyllostachys pubescens*) of Hubei Province of China [10]. The crude protein, Acid detergent lignin, Neutral detergent solubles and non-structural carbohydrates of 12 different bamboo leaves growing in the bamboo fields of Himachal Pradesh ranged from 14.61 to 20.39%, 9.43% to 4.87%, 21.47 to 34.62% and 1.10 to 12.06% respectively. All the leaves had higher Ca (1.028-1.832%) and low P (0.051-0.181%) and were also low in total phenols (0.158-0.534%) [11]. The CP, CF, Ca and P content in 2 species of Bamboo viz *D. strictus* and *B. arundiancae* was found to be 14.2, 23.5, 1.1, 0.2% and 18.6, 24.1, 0.6 and 0.2% respectively [12]. Another study done on three bamboo species viz. *Bambusa vulgaris, Bambusa ventricosa*, and *Oxytenanthera abyssinica* noticed that all the species contained saponins, general glycosides, coumarins and cyanogenic glycosides. However, alkaloids, carotenoids, triterpenoids and steroids, anthraquinones and anthracene glycosides were not found in any of the species. *B. vulgaris* was found to be the safest of the three species analyzed as it contained four classes of phytochemicals [13].

3. Antioxidant of Bamboo Leaves

The anti-oxidant of bamboo leaves (AOB) extracted from *Phyllostahys Sieb*. et Zucc. genus, represented by *Phyllostachys nigra* var. hnonis is a pale brown powder containing flavonoids, lactones and phenolic acids. Flavones *C*-glucosides represent the flavonoids in AOB. The four flavone *C*-glucosides found in AOB include orientin, homoorientin, vitexin and isovitexin. Other than these naringin-7-rhamnoglucoside, quercetin, luteolin, rutin, tricin, caffeic acid, chlorogenic acid and phydroxy coumaric acid are the other polyphenols present in AOB. AOB, a novel food anti-oxidant approved by the Food Additive Standardization Committee of the People's Republic of China on December 28, 2003, has been listed in the state standard GB-2760 (Hygienic Standards for Food Additives in Use) since April 2004. In addition to its multiple physiologic and pharmacologic activities, AOB can be used as a food antioxidantIt in edible oil, meat products, aquatic products and other foods with the maximum dosage of 0.50 g/kg [14-16]. It is important to evaluate the toxicity of the usage of AOB in food systems. The safety of AOB was examined using Kun-Ming mice and Sprague-Dawley rats in a 90-day oral toxicity study. Administration of AOB at levels of 1.43, 2.87 and 4.30 g/kg per day to the rats for 90 days did not stimulate any significant hematological, clinical, chemical or histopathological changes. The study clearly indicates that the maximum tolerated dose (MTD) of AOB showing no mutagenic evidence was > 10 g/kg body weight in both rats and mice [15]. Moreover in another safety study a no-observed adverse-effect level (NOAEL) of 4.30 g/kg per day indicated its safe use as food additive when tested for teratogenic effects of AOB [16].

Flavanoids in Bamboo Leaves

Flavonoids are a group of plant polyphenol secondary metabolites and generally occur as glycosylated derivatives. They are widely distributed in medicinal plants, fruit juices, teas and health beverages and contribute to the brilliant shades of blue, scarlet, and orange, in leaves, flowers, and fruits in seeds, nuts, grains, spices, and beverages, such as wine (particularly red wine), tea, and (at lower levels) beer [17,18]. In recent years the health effects of flavonoids have gained attention as epidemiological studies indicate that they act as antioxidants [19,20] and show an inverse association with risk of cardiovascular diseases [21-23] and different types of cancer [24].

Six phenolic acids namely chlorogenic, ferulic, coumeric, protocatechuic, vanillic and coffeic acids were

extracted from *Bambusa arundinacea* leaves [25]. In one study, flavanoid concentration varied in different parts of bamboo plant and it was found to be highest in bamboo leaves amounting to 3.44% [26]. Another study observed that the total flavonoid ranged from 0.67-1.71% in bamboo leaves [27]. As per a study, four flavone C-glycosides, i.e. Orientin, homoorientin, vitexin and isovitexin were extracted from concentrated AOB [28]. Food systems fortified by AOB such as high temperature sterilized milk, sunflower seed oil and extruded rice cake were found to contain these four flavone *C*-glucosides [29]. Phloroglucinol, hydrocaffeic acid & phloretic acid were found to be the metatiolites of flavone *C*-glucosides. The fate of metabolism studied in rats revealed its poor GI absorption, but prolonged retention time in the colon suggesting a strong antioxidant activity [30].

4. Uses of Bamboo Leaves

Bamboo leaves find their uses in a wide range of products and can prove to be a potent nutraceutical and an important food additive in different foods exhibiting antioxidant capacity, and free radical scavenging potential. It is also widely used as a favorite food for many animals (Figure 1).

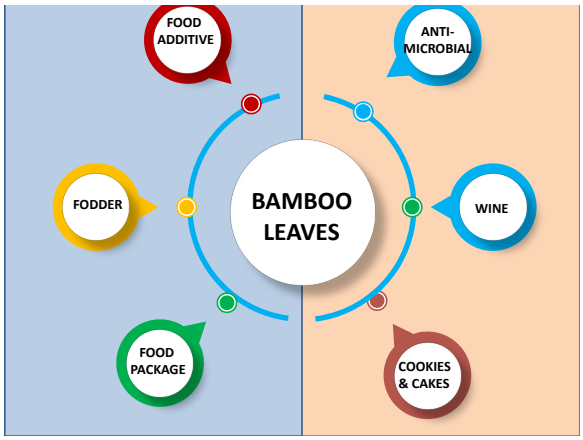

Figure 1. Multi-functional uses of bamboo leaves.

4.1 Potent Antioxidant

Sasa borealis (Poaceae), a perennial medicinal plant is a major source of bamboo leaves in Korea. Butanol extract of these leaves having two antioxidative flavonoid *C*-glycoside derivatives showed antioxidant activity against oxidative damage [31]. Similar results were found in another study where ethanol extracts of 17 species of bamboo leaves contained flavonoids and phenolic acids possessing strong antioxidative activity [32]. Tricin, a glycosidic form extracted from concentrated solution of AOB also occurring in rice bran is found useful for the prevention of cancer [33].

Three chlorogenic acid derivatives isolated from bamboo (*Phyllostachys edulis*) were 3-*O*-(3‘-methylcaffeoyl) quinic acid, 5-*O*-caffeoyl-4-methylquinic acid, and 3-*O*-caffeoyl-1-methylquinic acid were found to have a significant antioxidant activity [34]. The antioxidant potential of essential oils from the leaves of the 15 bamboo species using the DPPH assays was evident in all the oils with some showing greater antioxidant capacity obtained from *Bambusa multiplex* [35]. In another study, the bamboo leaf extract of *Phyllostachys praecox* leaves could show antioxidant activity at a concentration higher than 400 mg/L [36]. Bamboo leaf extract possessing goodness of Vitamin C showed strong anti-oxidative property [37]. Similar results were observed in the bamboo extracts (*Phyllostachys nigra var. henonis*) having dose-dependently anti-oxidant activity. Bamboo extracts inhibited xanthine oxidase directly. Bamboo extracts may thus prove beneficial in reducing cytotoxicity and could be used for the development of whitening agents [38]. Absolutely Hemicellulose Senanensis (AHSS), a novel extract from *Sasa senanensis* expressed antioxidative activity inhibiting the production of lipid peroxide. Thus AHSS could be considered an important ingredient in functional foods and other applications [39]. A study detected the characteristic compounds and evaluated the free radical scavenging capacity of the bamboo leaves extract and bamboo shavings extract (BSE). It contained characteristic flavonoids and phenolic acids, such as chlorogenic acid, caffeic acid, ferulic acid, p-coumaric acid, orientin, homoorientin, vitexin, and isovitexin exhibiting the highest total phenolic content, total flavonoids content and higher free radical scavenging indicating that the extracts from different parts of the bamboo possess excellent antioxidant activity [40]. Evaluation of leaf extracts from *B. textilis* McClure indicated it as a promising plant source of natural antioxidants [41].

4.2 Fodder

Bamboo leaves are valued as fodder for ruminants during scarcity of pasture. In some places bamboo foliage is considered the favorite food of giant pandas and elephants [42]. A study has proven that bamboo fodder promotes high milk, ghee production and has positive effects on animals, particularly young calves [43]. However, according to one report if bamboo leaves are fed to lactating cows and buffaloes, it is believed that the milk dries up very quickly and therefore bamboo fodder is only given to male bovines or old females [44].

4.3 Cookies and Cakes

Cookies with various levels of Bamboo leaves powder (0, 3, 6, 9 and 12%) were made and investigated for sensory characteristics. The result showed that cookies made with 9% powder showed the highest preference as compared to 3% which showed the lowest preference [45]. Another study found that bamboo leaf powder added at the rate 0%, 3%, 6%, 9% and 12% in the rice cake increased the hardness and chewiness whereas decreased the cohesiveness, springiness and adhesiveness of the cake. The sensory characteristics were found to be stronger with increasing powder content, whereas the softness and dampness were weaker. The greatest overall satisfaction was achieved by 6% added powder [46].

4.4 Bamboo Wine

A recent review article revealed that bamboo wine made from bamboo leaves is an alcoholic extract of fermented leaf and starchy food material rich in water-soluble B vitamins and essential, nonessential amino acids and various antioxidants and is considered safe for consumption [47]. Fermented bamboo shoots are traditionally used as flavoring agents when cooking different meats and wild edible plants. The activated fiber of bamboo shoots helps in the adsorption and neutralisation of heterocyclic aromatic amines, a potent carcinogen generated during the cooking of meats due to the Maillard reaction [48].

4.5 Reduces Carcinogen

In order to reduce the carcinogenic agent acrylamide formed during thermal processing of the food product, AOB is used in many food systems. Several studies have proved the efficacy and showed that the addition of AOB with a 32% flavanoid content and antioxidant ratio of 0.1 and 0.5% decreased 57.8 & 59% acrylamide formation in fried chickens wings with no change in original flavor & odour [49]. Similar studies done in fried bread sticks [50], potato crisps and french fries [51] revealed that AOB has the potential to reduce acrylamide content in fried bread sticks, potato crisps & french fries by 82.9%, 74.1% and 76.1% respectively.

4.6 Food Packaging

The food industry is always on the lookout of new packaging material. Research done on the chitosan film developed by using ZnO nanoparticles and antioxidant of bamboo leaves (AOB) showed the best mechanical strength and the highest light transmittance. The study suggests the use of chitosan/ZnO/AOB films as potential active packaging materials to extend the shelf-life of packaged food in various food industries [52]. In another recent study, antioxidant film prepared using carboxymethyl cellulose-gelatin (CMC-Gel) and antioxidant of bamboo leaves (AOB) mixture using casting method indicated that the antioxidant films could be utilized for food packaging for protecting food quality from the deterioration of mechanical force, heat, light, and oxidative stress [53]. In another similar study, the effect of chitosan coating containing antioxidant of bamboo leaves (AOB) on the shelf life extension of silver carp (Hypophthalmicthys molitrix) indicated that the coating treatments could effectively retard the water loss, inhibit the growth of total viable counts, reduce chemical spoilage, and increase the overall sensory quality of silver carp [54].

4.7 Antimicrobial Agents

A study on the antimicrobial activity against a range of food borne pathogens using natural essential oils derived from the leaves of *Phyllostachys pubescens* concluded that the bamboo leaves essential oil could disrupt the pathogen's membrane integrity and thus could be a potential antimicrobial agent for future use [55]. Another study investigated the antibacterial activities of essential oils (EOs) extracted from bamboo leaves viz. *Phyllostachys heterocycla* cv. *Pubescens* leaves. A study conducted on the antibacterial effect of the three major monomeric compounds (tricosane, cedrol and hexadecanoic acid) present in bamboo leaf EOs found that cedrol possessed the strongest antibacterial effect, followed by hexadecanoic acid [56].

Another study showed that the ethanol extract of the *Sasa borealis* leaves inhibited the growth of all the food poisoning bacteria indicating its use as an antimicrobial agent [57]. Another study explores an environment friendly process of developing antibacterial silver nanoparticles using bamboo leaves. It was found that the nanoparticles using bamboo leaves exert antimicrobial activities against *E. coli* and *S. aureus* strains [58].

5. Conclusions and Future Scope

Bamboo has become every man's favorite grass in recent times in view of its contribution to various sectors like environment, construction, food and fodder. It is clear from the study that bamboo leaves are valued as a source of fodder for ruminants. AOB is a unique innovation of a novel anti-oxidant approved by the Food Additive Standardization Committee of the People's Republic of China which can be used in edible oil, meat products, aquatic products and other foods. Various studies done by a number of researchers suggest that bamboo leaves are loaded with antioxidants and flavanoids which can help prevent

cancer, diabetes, heart diseases etc. and also have the ability to delay aging with their anti-inflammatory activity. Products made from bamboo leaves like bamboo beer and bamboo wine are now becoming the new age inventions as alcoholic beverages because of their potential health benefits. Thus it can be of great importance as a raw material to the functional food industry. Bamboo leaves being a sustainable crop have the potential to gain commercial popularity in the global market as functional food. Scientific research attempts are required to validate healthier products from the leaves and then popularize them in the market place.

6. Way Forward

Bamboo leaves showing great potential as a nutraceutical food should be approved and promoted commercially by the Indian government for various reasons. Firstly, it can prove to be a promising functional food for humans and help in preventing metabolic disorders like diabetes, cancer, hypertension etc. to keep up the health of human beings and ensure food security during times of famine amongst the tribal communities. Secondly, it is a resilient grass that is less impacted by the change in climate and can support communities with food security during tough times and can also help in combating the problems of malnutrition and can lead to zero hunger achieving the SDG formulated by the United Nations. Thirdly, the formulation of recipes, food products and drugs from bamboo leaves would provide a new avenue for income generation to the tribal people including women and youth and can strengthen skill development programs of the government. Therefore keeping all these points in mind it is important that research in this direction should be attempted.

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Conflicts of Interest

Individual Contributor.

Ethics Approval

Not applicable.

Consent to Participate

Not applicable.

Consent for Publication

As the corresponding and single author of the manuscript I give my consent to publish the article.

Availability of Data and Material

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

Code Availability

Not applicable.

Author's Contribution

Dr. Poonam Singhal is involved in the conception of the idea and drafting, editing of the manuscript.

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References

[1] Pandey, A.K., Tripathi, Y.C., Kumar, A., 2016. Non timber forest products (NTFPs) for sustained livelihood: Challenges and strategies. Research Journal of Forestry. 10(1), 1-7.

[2] Sharma, Y.M.L., 1980. Bamboos in the Asia-Pacific region. Bamboo research in Asia. World Publications: Singapore. pp. 99-120.

[3] Sharma, B.D., Hore, D.K., Pandey, G., 1992. Genetic resources of bamboo in the north-eastern region of India. Indian Journal of Forestry. 15(1), 44-51.

[4] Singhal, P., Singh, R.K., Satya, S., et al., 2017. Toxicity reduction in bamboo shoots: Field survey and scientific validation of a traditional knowledge system. Culture, Agriculture, Food and Environment. 39(2), 138-142. DOI: https://doi.org/10.1111/cuag.12089

[5] Singhal, P., Rudra, S.G., Singh, R.K., et al., 2018. Impact of Drying Techniques on Physical Quality of Bamboo Shoots: Implications on Tribal's Livelihoods [Internet]. Available from: http://nopr.niscpr.res.in/handle/123456789/43641

[6] Singhal, P., Bal, L.M., Satya, S., et al., 2013. Bamboo shoots: A novel source of nutrition and medicine. Critical Reviews in Food Science and Nutrition. 53(5), 517-534. DOI: https://doi.org/10.1080/10408398.2010.531488

[7] Singhal, P., Satya, S., Sudhakar, P., 2011. Antioxidant and pharmaceutical potential of bamboo leaves. Bamboo Science and Culture. 24(1), 19-28.

[8] Singh, K.A., 1999. Nutrient contents in tree fodders and Bamboo leaves of Eastern Himalaya. Indian Journal of Animal Nutrition. 16(2), 178-182.

[9] Datt, C., Niranjan, M., Chhabra, A., et al., 2006. Nutritional evaluation of different bamboo leaves of Tripura. Indian Journal of Dairy Science. 59(6), 376-379.

[10] Weiwen, C., Zhijiang, L., Fang, C., et al., 2004. The nutrition status and nutrition diagnosis of bamboo leaves in the South of Hubei. Journal of Northeast Forestry University. 32(2), 41-44.

[11] Sahoo, A., Ogra, R.K., Sood, A., et al., 2009. Chemical composition and nutritive value of leaves from different Bamboo cultivars. Indian Journal of Animal Nutrition. 26(4), 306-314.

[12] Suri, R.K., Mathur, K.C., 1984. Recent trends in forest utilization. Backhuys Biological Books: Kerkwerve, Netherlands. pp. 85-86.

[13] Coffie, G.Y., Antwi-Boasiako, C., Darkwa, N.A., 2014. Phytochemical constituents of the leaves of three bamboo (Poaceae) species in Ghana. Journal of Pharmacognosy and Phytochemistry. 2(6), 34-38.

[14] Hu, C., Zhang, Y., Kitts, D.D., 2000. Evaluation of antioxidant and prooxidant activities of bamboo *Phyllostachys nigra* var. *Henonis* leaf extract in vitro. Journal of Agricultural and Food Chemistry. 48(8), 3170-3176. DOI: https://doi.org/10.1021/jf0001637

[15] Lu, B., Wu, X., Tie, X., et al., 2005. Toxicology and safety of anti-oxidant of bamboo leaves. Part 1: Acute and subchronic toxicity studies on anti-oxidant of bamboo leaves. Food and Chemical Toxicology. 43(5), 783-792. DOI: https://doi.org/10.1016/j.fct.2005.01.019

[16] Lu, B., Wu, X., Shi, J., et al., 2006. Toxicology and safety of antioxidant of bamboo leaves. Part 2: Developmental toxicity test in rats with antioxidant of bamboo leaves. Food and Chemical Toxicology. 44(10), 1739-1743. DOI: https://doi.org/10.1016/j.fct.2006.05.012

[17] Walle, T., 2004. Absorption and metabolism of flavonoids. Free Radical Biology and Medicine. 36(7), 829-837. DOI: https://doi.org/10.1016/j.freeradbiomed.2004.01.002

[18] Pietta, P.G., 2000. Flavonoids as antioxidants. Journal of Natural Products. 63(7), 1035-1042. DOI: https://doi.org/10.1021/np9904509

[19] Burns, J., Gardner, P.T., O'Neil, J., et al., 2000. Relationship among antioxidant activity, vasodilation capacity, and phenolic content of red wines. Journal of Agricultural and Food Chemistry. 48(2), 220-230. DOI: https://doi.org/10.1021/jf9909757

[20] Kaneko, T., Baba, N., 1999. Protective effect of flavonoids on endothelial cells against linoleic acid hydroperoxide-induced toxicity. Bioscience, Biotechnology, and Biochemistry. 63(2), 323-328. DOI: https://doi.org/10.1271/bbb.63.323

[21] Hertog, M.G., Kromhout, D., Aravanis, C., et al., 1995. Flavonoid intake and long-term risk of coronary heart disease and cancer in the seven countries study. Archives of Internal Medicine. 155(4), 381-386. DOI: https://doi.org/10.1001/archinte.1995.00430040053006

[22] Knekt, P., Jarvinen, R., Reunanen, A., et al., 1996. Flavonoid intake and coronary mortality in Finland: A cohort study. BMJ. 312(7029), 478-481. DOI: https://doi.org/10.1136/bmj.312.7029.478

[23] Yochum, L., Kushi, L.H., Meyer, K., et al., 1999. Dietary flavonoid intake and risk of cardiovascular disease in postmenopausal women. American Journal of Epidemiology. 149(10), 943-949. DOI: https://doi.org/10.1093/oxfordjournals.aje.a009738

[24] Le Marchand, L., Murphy, S.P., Hankin, J.H., et al., 2000. Intake of flavonoids and lung cancer. Journal of the National Cancer Institute.

92(2), 154-160.
DOI: https://doi.org/10.1093/jnci/92.2.154

[25] Eyini, M., Jayakumar, M., Pannirselvam, S., 1989. Allelopathic effect of bamboo leaf extract on the seedling of groundnut. Tropical Ecology. 30(1), 138-141.

[26] Li, Y.F., 2009. Comparison of Bamboo Leaf Flavone and Vc Content in Different Species Bamboo [Internet]. Available from: http://en.cnki.com.cn/Article_en/CJFDTotal-HNNK200902014.htm

[27] Zhang, Y., Wu, X.Q., Yu, Z.Y., 2002. Comparison study on total flavonoid content and anti-free redical activity of the leaves of bamboo, phyllostachys nigra, and Ginkgo bilabo. China Journal of Chinese Materia Medica. 27(4), 254-257.

[28] Zhang, Y., Jiao, J., Liu, C., et al., 2008. Isolation and purification of four flavone C-glycosides from antioxidant of bamboo leaves by macroporous resin column chromatography and preparative high-performance liquid chromatography. Food Chemistry. 107(3), 1326-1336.
DOI: https://doi.org/10.1016/j.foodchem.2007.09.037

[29] Zhang, Y., Bao, B., Lu, B., et al., 2005. Determination of flavone C-glucosides in antioxidant of bamboo leaves (AOB) fortified foods by reversed-phase high-performance liquid chromatography with ultraviolet diode array detection. Journal of Chromatography A. 1065(2), 177-185.
DOI: https://doi.org/10.1016/j.chroma.2004.12.086

[30] Zhang, Y., Tie, X., Bao, B., et al., 2007. Metabolism of flavone C-glucosides and p-coumaric acid from antioxidant of bamboo leaves (AOB) in rats. British Journal of Nutrition. 97(3), 484-494.
DOI: https://doi.org/10.1017/S0007114507336830

[31] Park, H.S., Lim, J.H., Kim, H.J., et al., 2007. Antioxidant flavone glycosides from the leaves of *Sasa borealis*. Archives of Pharmacal Research. 30, 161-166.
DOI: https://doi.org/10.1007/BF02977689

[32] Zhang, Y., Ding, X.L., 1996. Studies on Antioxidative Fraction in Bamboo Leaves and Its Capacity to Scavenge Active Oxygen Radicals [Internet]. Available from: http://en.cnki.com.cn/Article_en/CJFDTOTAL-ZZYJ603.003.htm

[33] Jiao, J., Zhang, Y., Liu, C., et al., 2007. Separation and purification of tricin from an antioxidant product derived from bamboo leaves. Journal of Agricultural and Food Chemistry. 55(25), 10086-10092.
DOI: https://doi.org/10.1021/jf0716533

[34] Kweon, M.H., Hwang, H.J., Sung, H.C., 2001. Identification and antioxidant activity of novel chlorogenic acid derivatives from bamboo (*Phyllostachys edulis*). Journal of Agricultural and Food Chemistry. 49(10), 4646-4655.
DOI: https://doi.org/10.1021/jf010514x

[35] He, Y.J., Yue, Y.D., Tang, F., 2009. Detection of Antioxidative Capacity of Essential Oils from the Bamboo Leaves by Scavenging Organic Free Radical DPPH [Internet]. Available from: http://en.cnki.com.cn/Article_en/CJFDTOTAL-ANHU200903022.htm

[36] Liu, X., Mi, S.Q., Zhang, Y.X., et al., 2009. Anti-oxidative Activity of Extract of North Ph. Praecox Leaves [Internet]. Available from: http://en.cnki.com.cn/Article_en/CJFDTOTAL-HJYJ200903024.htm

[37] Lv, Z.L., Lin, X., Miao, Z.H., et al., 2012. Antioxidant activity of bamboo-leaf extracts from the species Dendrocalamopsis oldhami. Sci Res Essays. 7(44), 3789-3796.

[38] Song, H.S., Moon, H.J., Park, B.E., et al., 2007. Anti-oxidant activity and whitening activity of bamboo extracts. Yakhak Hoeji. 51(6), 500-507.

[39] Kurokawa, T., Itagaki, S., Yamaji, T., et al., 2006. Antioxidant activity of a novel extract from bamboo grass (AHSS) against ischemia-reperfusion injury in rat small intestine. Biological and Pharmaceutical Bulletin. 29(11), 2301-2303.
DOI: https://doi.org/10.1248/bpb.29.2301

[40] Gong, J., Xia, D., Huang, J., et al., 2015. Functional components of bamboo shavings and bamboo leaf extracts and their antioxidant activities *in vitro*. Journal of Medicinal Food. 18(4), 453-459.
DOI: https://doi.org/10.1089/jmf.2014.3189

[41] Wang, J., Yue, Y.D., Tang, F., et al., 2012. TLC screening for antioxidant activity of extracts from fifteen bamboo species and identification of antioxidant flavone glycosides from leaves of Bambusa. textilis McClure. Molecules. 17(10), 12297-12311.
DOI: https://doi.org/10.3390/molecules171012297

[42] Raizada, M.B., Chatterji, R.N., 1956. World distribution of bamboos with special references to the Indian species and their more important uses. Indian Forester. 82(5), 215-218.

[43] Thapa, B., Walker, D.H., Sinclair, F.L., 1997. Indigenous knowledge of the feeding value of tree fodder. Animal Feed Science and Technology. 68(1-2), 37-54.
DOI: https://doi.org/10.1016/S0377-8401(97)00027-8

[44] Turin, M., 2003. Ethnobotanical notes on Thangmi plant names and their medicinal and ritual uses. Contributions to Nepalese Studies. 30(1), 19-52.

[45] Jong-Chan, J., Eun-Shil, H., Jung-Hye, S., 2006. Quality characteristics of cookies with bamboo leaves powder. The Korean Journal of Food and Nutrition. 19(1), 1-7.

[46] Kim, D.H., Hwang, S.J., 2006. Effects of adding bamboo leaves powder on the quality of Jeolpyon. Korean Journal of Food and Cookery Science. 22(6), 869-874.

[47] Sangija, F., Wu, W., 2022. Bamboo wine: Its production technology and potential as a sustainable health beverage. Food Reviews International. 38(7), 1368-1388.
DOI: https://doi.org/10.1080/87559129.2020.1810699

[48] Bhardwaj, R., Singh, R.K., Wangchu, L., et al. (editors), 2005. Bamboo shoots consumption: traditional wisdom and cultural invasion. Proceedings of the National Conference on Arunachal Pradesh: Tradition in Transition, Link Ecology, Economics and Ethics; 2005 Sep 13-16; Nirjuli, India.

[49] Zhang, Y., Xu, W., Wu, X., et al., 2007. Addition of antioxidant from bamboo leaves as an effective way to reduce the formation of acrylamide in fried chicken wings. Food Additives and Contaminants. 24(3), 242-251.
DOI: https://doi.org/10.1080/02652030601064839

[50] Zhang, Y., Zhang, Y., 2007. Study on reduction of acrylamide in fried bread sticks by addition of antioxidant of bamboo leaves and extract of green tea. Asia Pacific Journal of Clinical Nutrition. 16(S1), 131-136.

[51] Zhang, Y., Chen, J., Zhang, X., et al., 2007. Addition of antioxidant of bamboo leaves (AOB) effectively reduces acrylamide formation in potato crisps and French fries. Journal of Agricultural and Food Chemistry. 55(2), 523-528.
DOI: https://doi.org/10.1021/jf062568i

[52] Liu, J., Huang, J., Hu, Z., et al., 2021. Chitosan-based films with antioxidant of bamboo leaves and ZnO nanoparticles for application in active food packaging. International Journal of Biological Macromolecules. 189, 363-369.
DOI: https://doi.org/10.1016/j.ijbiomac.2021.08.136

[53] He, B., Wang, W., Song, Y., et al., 2020. Structural and physical properties of carboxymethyl cellulose/gelatin films functionalized with antioxidant of bamboo leaves. International Journal of Biological Macromolecules. 164, 1649-1656.
DOI: https://doi.org/10.1016/j.ijbiomac.2020.07.286

[54] Wenjiao, F., Yongkui, Z., Pan, D., et al., 2013. Effects of chitosan coating containing antioxidant of bamboo leaves on qualitative properties and shelf life of silver carp during chilled storage. Czech Journal of Food Sciences. 31(5), 451-456.
DOI: https://doi.org/10.17221/149/2013-CJFS

[55] Tao, C., Wang, Y., Zhang, X., et al., 2019. Mechanism of action of essential oils extracted from bamboo (*Phyllostachys heterocycla* cv. *pubescens*) leaves: Chemical composition and

antimicrobial activity against four food-related microorganisms. BioResources. 14(1), 1419-1434.

[56] Tao, C., Wu, J., Liu, Y., et al., 2018. Antimicrobial activities of bamboo (*Phyllostachys heterocycla* cv. *Pubescens*) leaf essential oil and its major components. European Food Research and Technology. 244, 881-891.
DOI: https://doi.org/10.1007/s00217-017-3006-z

[57] Park, Y.O., Lim, H.S., 2010. Antimicrobial activity of bamboo (Sasa borealis) leaves fraction extracts against food poisoning bacteria. Journal of The Korean Society of Food Science and Nutrition. 39(12), 1745-1752.
DOI: https://doi.org/10.3746/jkfn.2010.39.12.1745

[58] Yasin, S., Liu, L., Yao, J., 2013. Biosynthesis of silver nanoparticles by bamboo leaves extract and their antimicrobial activity. Journal of Fiber Bioengineering and Informatics. 6(1), 77-84.
DOI: https://doi.org/10.3993/jfbi03201307