Advances in Bamboo Science 13 (2025) 100210

Contents lists available at ScienceDirect

Advances in Bamboo Science

journal homepage: www.journals.elsevier.com/advances-in-bamboo-science

Review

Bamboo consumption and health outcomes: A systematic review and call to action

Damiano Pizzol [a,*], Tobia Zampieri [b], Robert MacKinnon [c,*], Dong Keon Yon [d], Fiona Richardson [e], Guillermo F. López Sánchez [f], Susanna Caminada [g], Alessandro Bertoldo [h], Laurie Butler [i], Nicola Veronese [j], Pinar Soysal [k], Jae Il Shin [l,m,**], Lee Smith [i,n,***]

[a] Health Unit, Eni, Maputo, Mozambique
[b] Biotechnology Research and Development Department, Corte del Gallo Agricola Innovativa, Cervarese Santa Croce, Padova, Italy
[c] School of Psychology, Sport, and Sensory Science, Faculty of Science and Engineering, Anglia Ruskin University, Cambridge, UK
[d] Center for Digital Health, Medical Science Research Institute, Kyung Hee University College of Medicine, Seoul, Republic of Korea
[e] Queen Elizabeth Hospital King's Lynn NHS Foundation Trust, Norfolk, UK
[f] Division of Preventive Medicine and Public Health, Department of Public Health Sciences, School of Medicine, University of Murcia, Murcia, Spain
[g] Health Unit, Eni, Rome, Italy
[h] Unit of Assisted Reproductive Technologies, Ospedale di Oderzo, Treviso ULSS2, Italy
[i] Centre for Health, Performance and Wellbeing, Anglia Ruskin University, Cambridge, UK
[j] Saint Camillus International University of Health Sciences, Faculty of Medicine, Rome, Italy
[k] Department of Geriatric Medicine, Faculty of Medicine, Bezmialem Vakif University, Istanbul, Turkey
[l] Department of Pediatrics, Yonsei University College of Medicine, Seoul, Republic of Korea
[m] Severance Underwood Meta-Research Center, Institute of Convergence Science, Yonsei University, Seoul, Republic of Korea
[n] Department of Public Health, Faculty of Medicine, Biruni University, Istanbul, Turkey

ARTICLE INFO

Keywords:
Bamboo
Bamboo shoots
Bamboo extracts
Food
Nutrition

ABSTRACT

Despite the popularity and potential nutritional benefits of bamboo consumption in aiding the prevention and management of several health conditions, to date, no attempt has been made to collate and critically appraise all literature on bamboo and human health. We aimed to address this gap in the literature through a systematic review. We systematically searched Medline/PubMed and Web of Science electronic databases until 26th October 2024. All retrospective or prospective studies reporting the effects of human consumption of bamboo shoots or other bamboo products on health were included. In vitro findings related to the effect of bamboo extracts on human cells or in processing food were also included. In vivo studies demonstrated a protective effect against internal exposure to acrylamide and glycidamide, an improvement in glycemic control, improvement in lipid profile, improvement in bowel function, an increase in antioxidant and anti-inflammatory activity, a lower cell toxicity and increased cell viability but also an association with a high prevalence of goiters. In vitro studies demonstrated antioxidant activity, probiotic effects, inhibition of furan formation, high nutritional value and reduction of acrylamide formation during food processing. The findings from our systematic review, which included 16 studies, suggest that if appropriately prepared, the consumption of bamboo may have multiple health benefits for humans. However, more high-quality experimental trials are required to further elucidate on the health benefits before concrete recommendations can be drawn. We thus call on the academic community to further investigate this crop for its high potential for improving human health.

* Corresponding authors.
** Corresponding author at: Department of Pediatrics, Yonsei University College of Medicine, Seoul, Republic of Korea.
*** Corresponding author at: Centre for Health, Performance and Wellbeing, Anglia Ruskin University, Cambridge, UK.
E-mail addresses: damianopizzol8@gmail.com (D. Pizzol), Robert.MacKinnon@aru.ac.uk (R. MacKinnon), shinji@yuhs.ac (J.I. Shin), lee.smith@aru.ac.uk (L. Smith).

https://doi.org/10.1016/j.bamboo.2025.100210
Received 1 August 2025; Received in revised form 2 November 2025; Accepted 4 November 2025
Available online 5 November 2025

1. Introduction

Bamboos belong to the family Poaceae with over 1250 species (Lewington, 2003). Bamboo areas are mostly located in Asia, which accounts for 80 % of the global area covered by bamboo (Yeasmin et al., 2015). The Asia-Pacific region has the greatest species richness (around 900 bamboo species divided into 65 genera) (Li and He, 2019), followed by South America. Bamboos are found throughout the world, with the exception of Antarctica, although they do not occur naturally in Europe. The global area of bamboo forest is estimated to be up to 31.5 million ha., accounting for approximately 1 % of the total forest area. Between 1980 and 2010, the global forest area declined continuously, while the bamboo forest area experienced an average annual growth rate of 3 % (FAO, 2010). In terms of the bamboo forest area, India and China hold the largest areas of bamboo, with 9.57 million ha. and 6.01 million ha., respectively. Bamboo is regarded as the fastest-growing plant on the planet. The fast-growth and quick maturation, as well as the short production cycle, high biomass productivity and wide adaptability make bamboo valuable for rapid forest establishment, sustainable construction and environment-friendly furniture making (Wang et al., 2020). Indeed bamboo is considered one of the most versatile multiutility plants, with over 1500 uses (Lewington, 2003).

Bamboo is a popular food item, with both the bamboo shoots and leaves being consumed, although global estimates on bamboo consumption are unknown. Bamboo shoots are popular in Asian countries and form a major component of their traditional cuisines (Nongdam and Tikendra, 2014). This is of benefit as bamboo shoots likely have multiple positive outcomes on human health owing to the nutritional makeup, which includes a high protein, moderate fibre and low-fat content. They also contain essential amino acids, selenium and potassium (Zhang et al., 2024). Moreover, past studies have suggested the antioxidant, anti-microbial and anti-inflammatory activities of various extracts and components from bamboo leaves, which are mainly ascribed to the phenolic components in bamboo leaves such as orientin, homoorientin, isoorientin, vitexin, homovitexin, tricin, and phenolic acids (Nirmala et al., 2018). Interestingly, some literature has also suggested that bamboo shoots hold medicinal properties with potential to support in the control of several diseases or risk factors such as diabetes and high cholesterol, as well as having anti-helminthic, anti-diabetic and anti-ulcer properties (Singhal et al., 2013). Since 2004, bamboo leaf extracts have been authorized by the Chinese Ministry of Health as a novel food antioxidant with a maximum addition of 0.5 g/kg in edible oils, meat products, aquatic products, cereal products, puffed food fruit, vegetable juices and tea beverages (Wang et al., 2020). However, it is important to also note that bamboo shoots will liberate cyanide upon hydrolysis of taxiphyllin, which is detrimental to human health (Singhal et al., 2016). Cyanide poisoning poses a significant health risk, ranging from mild symptoms like nausea to severe respiratory distress and, in extreme cases, death (Niyogi et al., 2025). While some species of bamboo shoots can be eaten raw and without any pretreatments, there are many species whose shoots contain cyanogenic glucosides and must be pre-boiled in water for varying periods of time to make them fit for consumption (Haorongbam et al., 2009).

Despite the potential nutritional benefits of bamboo consumption and its potential use in aiding in the prevention and management of several health conditions, to date, no attempt has been made to collate and critically appraise all literature on bamboo consumption and human health. The aim of this systematic review was to address this gap in the literature. We believe that findings from this systematic review will inform the population and practitioners on the known health benefits of bamboo consumption, providing further evidence for its production in often low-income regions where farming bamboo can contribute to economic growth.

2. Materials and methods

This systematic review adhered to the PRISMA (Liberati et al., 2009) and MOOSE (Stroup et al., 2000) statements and followed a structured protocol registered on PROSPERO (CRD42024610007).

2.1. Search strategy

Two investigators (AB and DP) independently conducted a literature search using Medline/PubMed and Web of Science databases from inception to the 26th of October 2024. The following search strategy was used: (Bambusoideae OR Bamboo) AND (“food habits” OR “food consumption” OR “food intake” OR “nutritional intake” OR “nutrition” OR “nutrition assessment” OR “food choice” OR “diet” OR “eating behavior”). The references of retrieved articles together with the proceedings of relevant conferences were hand-searched to identify other potentially eligible studies for inclusion in the analysis missed by the initial search or any unpublished data. The literature search, assessment of inclusion and exclusion criteria, quality of studies and extraction of data were independently undertaken and verified by two investigators (AB, DP). The results were then compared, and in case of discrepancies, a consensus was reached with the involvement of a third senior investigator (LS). There was no language restriction applied.

2.2. Type of studies, inclusion and exclusion criteria

Following the PICOS (participants, intervention, controls, outcomes, study design) criteria, we included studies assessing:

P: All people

I: Bamboo shoots or bamboo extracts used in food, including lower and higher bamboo consumption

C: People not using bamboo in diet

O: Effects of bamboo shoots or bamboo extracts on health

S: All retrospective, cross-sectional or prospective, RCT and experimental studies reporting the effects of human food consumption of bamboo shoots or other bamboo extracts on health were included. Studies were excluded if they had no health data on human food consumption of bamboo shoots or other bamboo extracts.

2.3. Data extraction and statistical analyses

For each eligible study, two independent investigators (AB, DP) extracted the following data: name of the first author and year of publication, article type, study design, sample size, sample characteristics, intervention, outcome measures and findings.

2.4. Outcomes

The primary outcome was the effect of human food consumption of bamboo shoots or other bamboo extracts on any health outcomes. Secondary outcomes included in vitro findings related to the effect of bamboo shoots or other bamboo extracts in food utilization and possible application on food processing.

2.5. Assessment of study quality

Two independent authors (DP, AB) assessed the quality of studies using the Newcastle-Ottawa Scale (NOS) (Wells et al., 2000). The NOS assigns a maximum of 10 points based on three quality parameters: selection, comparability, and outcome. As per the NOS grading in past reviews, we graded studies as having a high (<5 stars), moderate (5–7 stars) or low risk of bias (≥8 stars) (Luchini et al., 2017).

3. Results

As shown in Fig. 1, we initially found 1052 potentially eligible

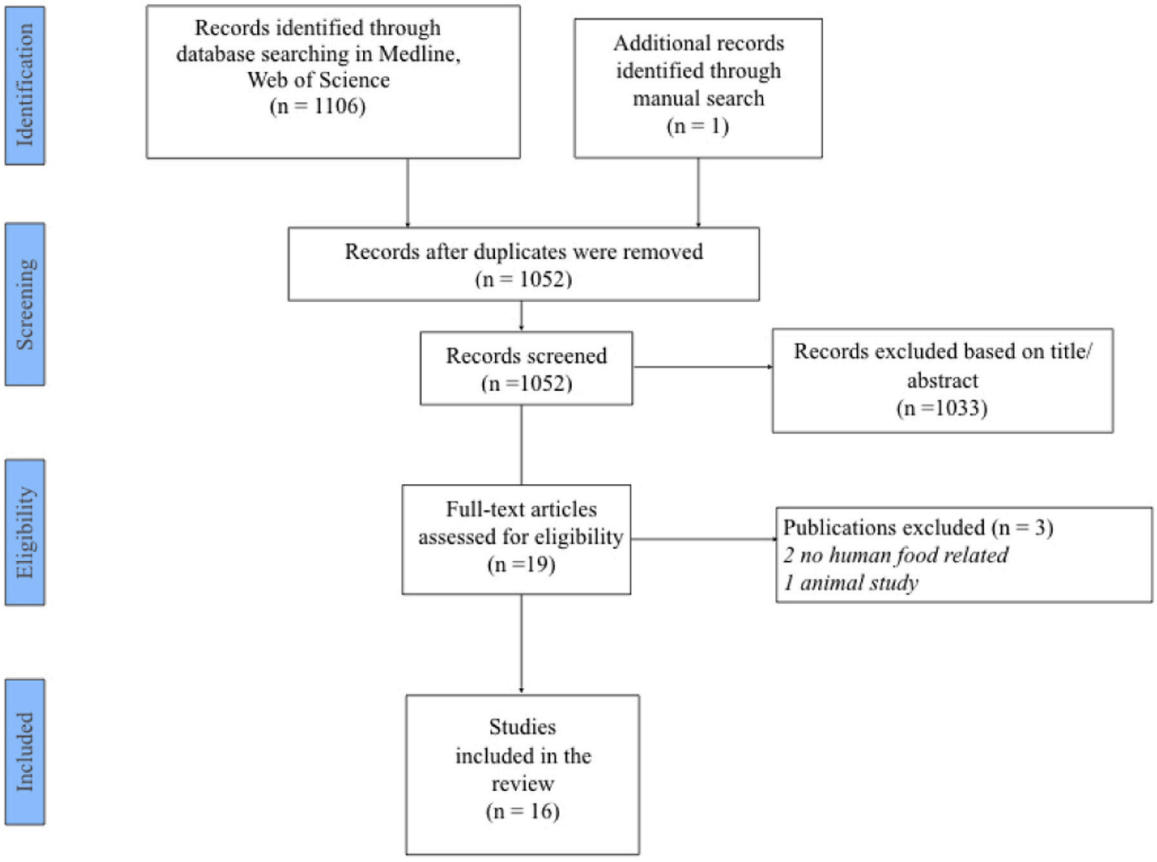

Fig. 1. PRISMA flow chart.

articles. After removing 1033 articles through the title/abstract screening, 19 were retrieved as full text. Of these 19, three studies were excluded (two were not related to human nutrition and one included a non-human population), leaving 16 studies to be included (Chandra et al., 2013; Chen et al., 2020; Choi et al., 2013; Choi et al., 2008; da Silva et al., 2024; Guo et al., 2019; Imdad et al., 2022; Li et al., 2024; Liu et al., 2014; Park and Jhon, 2009; Sadananda et al., 2023; Santosh et al., 2024; Xiao et al., 2022; Xie et al., 2024; Yang et al., 2020; Zhang et al., 2007). Among these, four were performed on humans (Chandra et al., 2013; Chen et al., 2020; Imdad et al., 2022; Park and Jhon, 2009), four were in vitro studies performed on human cells (Choi et al., 2013; Choi et al., 2008; Xiao et al., 2022; Xie et al., 2024), and eight focused on bamboo characteristics with potential application to nutrition (da Silva et al., 2024; Guo et al., 2019; Li et al., 2024; Liu et al., 2014; Sadananda et al., 2023; Santosh et al., 2024; Yang et al., 2020; Zhang et al., 2007). Most studies were conducted in Asia, with one in South America. The four in vivo studies included a total of 4934 participants and the descriptive characteristics of these studies, and their main findings are reported in Table 1. Chandra and colleagues showed a high prevalence of goiters (31 %) despite a successful salt iodine fortification program in schoolchildren (Chandra et al., 2013). Moreover, increased thyroid weight, hypertrophy and hyperplasia of follicular cells, decreased thyroid peroxidase activity, and low serum T4 and T3 levels were observed in rats fed bamboo shoots (Chandra et al., 2013). Flavonoid-rich antioxidants from bamboo leaves showed a significant protective effect against internal exposure to acrylamide and glycidamide promoting the excretion of acrylamide and shortened the distribution but prolonged the excretion of N-acetyl-S-(2-carbamoylethyl)-L-cysteine (AAMA) and N-acetyl-S-(2-carbamoyl-2-hydroxyethyl)-L-cysteine (Chen et al., 2020). Glycaemic control was improved through administration of bamboo shoots in cookies and an increased dose of bamboo shoots lowered blood glucose concentration with significant difference (Imdad et al., 2022). Finally, bamboo shoots, as a dietary fibre source, demonstrated beneficial effects on lipid profile and bowel function (Park and Jhon, 2009). Serum total cholesterol, low-density lipoprotein cholesterol, and atherogenic index were decreased with bamboo shoot diet feeding compared with the dietary fibre-free diet. Fecal volume and bowel movement frequency in participants fed the bamboo shoot diet were significantly increased (Park and Jhon, 2009).

Table 2 reports the characteristics and the main findings of different bamboo extracts on human cells indicating a key role in antioxidant activity, in particular versus reactive oxygen species, anti-inflammatory activity, increasing cell viability and low cell toxicity (Choi et al., 2013; Choi et al., 2008; Xiao et al., 2022; Xie et al., 2024). A water extract from *Sasamorpha borealis* (Hack.) Nakai (syn. *Sasa borealis* (Hack.) Makino & Shibata) reduced hyperglycemia-induced oxidative stress and apoptosis, reduced the high glucose–induced expression of endothelial nitric oxide synthase and attenuated the formation of peroxynitrite radicals (Choi et al., 2008). In addition, this bamboo extract modulated the high glucose–triggered mitogen-activated protein kinase–dependent upregulation of heat-shock proteins (Choi et al., 2008). Bamboo leaf extract at concentration of 0.1 mg/ml caused 63 % inhibition of monocyte adhesion in TNF-α-activated human umbilical endothelial cells, which was associated with 38.4 % suppression of vascular cell adhesion molecule-1, decreased to 47.9 % the ROS generation in TNF-α-induced cells and caused about 50 % inhibition of interleukin-6 secretion (Choi et al., 2013). Hemicellulosic polysaccharides demonstrated the potential to scavenge ROS and exhibited relatively high reducing ability in vitro antioxidant assays and showed high activity to prevent H_2O_2-induced damage (Xiao et al., 2022). Finally, the average concentrations of As, Pb, Cd and Cr in the bamboo shoot samples were 0.036, 0.056, 0.008 and 0.049 mg/kg respectively, while Pb contents in 21 collected fresh bamboo shoot samples exceeded the allowable limit value of 0.1 mg/kg by 1.00–4.60 fold (Xie et al., 2024). However, intestinal digesta of

Table 1
Main information and findings on bamboo utilization on human nutrition of included studies.

Author and date	Aim	Study type	Sample size and characteristics	Intervention	Outcome measures	Findings
Chandra, 2013[16]	To examine the role of BS in the pathogenesis of endemic goiter.	Cross-sectional	4852 schoolchildren of both sexes, aged 6–12 years	Goiter prevalence assessment. Confirmation of goitrogenic potential of BS feeding to rats as part of an iodine-sufficient diet	Goiter prevalence, urinary iodine, and thiocyanate excretion, iodine content in drinking water, and the household consumption of salt fortified with iodine	Goiter prevalence was 31 % and the median urinary I and SCN levels were 176.3 μg/L and 0.962 ± 0.190 mg/dL, respectively. Increased thyroid weight, hypertrophy and hyperplasia of follicular cells, decreased thyroid peroxidase activity, and low serum T4 and T3 levels were observed in BS-fed rats.
Chen, 2020[17]	To assess the protective effect of a water-soluble flavone-C-glycoside-rich antioxidant from bamboo leaves against acrylamide-induced toxicity	RCT	34 participants (50 %female) age of (21.9 ± 2.3) y and a BMI of (20.6 ± 2.8)	Served potato chips, corresponding to 12.6 μg per kg·bw of dietary exposure to acrylamide, followed by capsules containing 350 mg AOB-w or equivalent placebo.	The kinetics of acrylamide, glycidamide, and mercapturic acid metabolites was profiled, and their hemoglobin adducts were measured.	AOB-w promoted the excretion of acrylamide and shortened the distribution but prolonged the excretion of N-acetyl-S-(2-carbamoylethyl)-L-cysteine (AAMA) and N-acetyl-S-(2-carbamoyl−2-hydroxyethyl)-L-cysteine. AOB-w reduced the peak concentration and area under curve of AAMA by 42.1 % and 49.8 %, respectively. AOB-w gender-dependently altered the toxicokinetic profile and reduced the amount of a human-specific urinary biomarker, N-acetyl-S-(2-carbamoylethyl)-L-cysteine-sulfoxide in women. AOB-w accelerated the metabolism of hemoglobin adducts of acrylamide and glycidamide in blood of women.
Imdad, 2022[18]	To evaluate bamboo shoots on lowering blood glucose level in diabetic patients	Cross-sectional	40 diabetic participants (50 % female) Mean age 51 ± 0.78	Administration of cookies made with flour supplemented with bamboo shoots.	Glycemic levels each 15 min starting from 0 min to 120 min.	Increased dose of bamboo shoots lowered the blood glucose concentration with significant difference. Lowest blood glucose concentration was observed after taking highest dose of bamboo shoots of 20 g (T10 dose) (p value 0.00).
Park, 2009[19]	To evaluate the effect of BS on blood glucose, lipid profiles, hepatic function, and constipation.	Cross-sectional	8 healthy women 21–23 years	3 diets (fibre-free diet, a diet containing 25 g of cellulose, and a diet containing 360 g of bamboo shoots) each lasting 6 days.	At the end of each diet, glucose, lipid profile, glutamic pyruvic transaminase, glutamic oxaloacetic transaminase, and atherogenic index were measured. A questionnaire for fecal excretion was taken.	Serum total cholesterol, low-density lipoprotein cholesterol, and the atherogenic index decreased with the bamboo shoot diet feeding compared with the dietary fibre-free diet. Fecal volume and bowel movement frequency in subjects fed the bamboo shoot diet were significantly increased.

AOB= water-soluble antioxidant of bamboo leaves; BMI= body mass index; BS= bamboo shoot; I= iodine; RCT= randomized clinical trial; SCN= thiocyanate; T3 = triiodothyronine; T4 = thyroxine

high-risk samples did not trigger detrimental effects on Caco-2 cells, suggesting existing health risk assessment model may overestimate their health risks and should be adjusted for bio-accessibility and require cellular toxicity validation to accurately reflect their health risks (Xie et al., 2024).

Finally, Table 3 summarizes the main information and findings on laboratory results of possible bamboo utilization in nutrition and food processes (da Silva et al., 2024; Guo et al., 2019; Li et al., 2024; Liu et al., 2014; Sadananda et al., 2023; Santosh et al., 2024; Yang et al., 2020; Zhang et al., 2007). These studies on different bamboo extracts showed antioxidant activity, probiotic effects, inhibition of furan formation, high nutritional value and reduction of acrylamide formation during food processing (da Silva et al., 2024; Guo et al., 2019; Li et al., 2024; Liu et al., 2014; Sadananda et al., 2023; Santosh et al., 2024; Yang et al., 2020; Zhang et al., 2007).

The median quality of the studies measured by the NOS was 6 (range: 5–7), indicating an overall satisfactory quality. It is important to note that the NOS was only applied to in-vivo studies. Publication bias testing was not performed.

4. Discussion

At the time of writing, to the best of the authors' knowledge, this is the first review to systematically collate and appraise the literature on the potential health benefits of bamboo consumption including both in vivo and in vitro studies. The review identified a total of 16 studies on this topic demonstrating a growing interest in bamboo consumption and health outcomes within academic arenas. In vivo studies demonstrated potentially positive health outcomes from the consumption of bamboo including a protective effect against internal exposure to acrylamide and glycidamide, an improvement in glycemic control, improvement in lipid profile, improvement in bowel function, an increase in antioxidant and anti-inflammatory activity, lower cell toxicity and increased cell viability (Chen et al., 2020; Imdad et al., 2022; Park and Jhon, 2009).

Table 2
Main information and findings on in vitro outcomes of included studies.

Author and date	Aim	Sample size and characteristics	Intervention	Outcome measures	Findings
Choi, 2008[20]	To investigate the effects of SBwE on chronic hyperglycemia-induced oxidative stress and apoptosis in HUVEC.	HUVEC were isolated from umbilical cords using collagenase.	HUVEC were cultured in 5.5 mM low glucose, 5.5 mM glucose plus 27.5 mM mannitol as an osmotic control, or 33 mM high glucose for 5 days in the absence and presence of 1–30 lg/ ml SBwE.	Cells viability, intracellular ROS production, peroxynitrite anion formation.	SBwE reduced hyperglycemia-induced oxidative stress and apoptosis. SBwE reduced the high glucose–induced expression of endothelial nitric oxide synthase and attenuated the formation of peroxynitrite radicals. In addition, this bamboo extract modulated the high glucose–triggered mitogen-activated protein kinase–dependent upregulation of heat-shock proteins.
Choi, 2013[21]	To investigate the mechanism of anti-inflammatory activity of a BLE on TNF-α induced monocyte adhesion inHUVEC.	HUVECs and monocyte U937 cells were obtained from Clonetics and the American Type Culture Collection respectively.	HUVECs and U937 cell were incubated in an atmosphere of 95 % air and 5 % CO2 at 37℃. The effect of BLE on HUVEC viability was measured with an ADAM-MC automatic cell counter.	Cells viability, intracellular ROS production, TNF-α-induced monocyte adhesion, IL−6 secretion.	BLE did not inhibit cell viability or cause morphological changes at concentrations ranging from 1 μg/ml to 1 mg/ml. Treatment with 0.1 mg/ml BLE caused 63 % inhibition of monocyte adhesion in TNF-α-activated HUVECs, which was associated with 38.4 % suppression of vascular cell adhesion. molecule−1. BLE decreased to 47.9 % the ROS generation in TNF-α-induced cells and caused about 50 % inhibition of interleukin−6 secretion.
Xiao, 2022[22]	To assess the free radical scavenging ability of BLHP from bamboo leaves.	The HepG2, CL−0103 was purchased from Procell Life Science and Technology Co. Ltd.	DPPH·free radical scavenging tests were performed according to the standard DPPH·assay. Oxidative Stress Induced by H_2O_2 in HepG2 Cells was evaluated by the MTT method.	Antioxidant activity.	BLHP demonstrated the potential to scavenge ROS and exhibited relatively high reducing ability in vitro antioxidant assays. It also showed high activity to prevent H_2O_2-induced damages.
Xie, 2024[23]	To determine the concentrations of As, Cd, Pb, and Cr in natural and processed bamboo shoot products.	Fresh, canned, and instants bamboo shoots were analyzed. Human colonic epithelial cells Caco−2 were obtained from the Institute of Biochemistry and Cell Biology.	The total amount of (metalloid) was determined by mass spectrometry. The estimated daily intake was calculated based on metal(loid) concentrations and consumption rate. Cell viability was determined by a commercial CCK−8 cell viability assay kit.	Total, bio accessible and estimated daily intake of metal(loid). Caco−2 cells exposure and viability.	The average concentrations of As, Pb, Cd, and Cr in the collected samples were 0.036, 0.056, 0.008, and 0.049 mg/kg, while Pb contents in 21 collected fresh bamboo shoot samples exceeded the allowable limit value of 0.1 mg/kg by 1.00–4.60 folds. However, intestinal digesta of high-risk samples did not trigger detrimental effects on Caco−2 cells, suggesting existing health risk assessment model may overestimate their health risks and should be adjusted by bio-accessibility and require cellular toxicity validation to accurately reflect their health risks.

BLE= bamboo leaf extract; BLHP= hemicellulosic polysaccharides; DPPH= 1,1-diphenyl-2-picrylhydrazyl radical; HepG2, CL-0103 = human hepatocellular carcinomas cell line; HUVEC= human umbilical endothelial cells; ROS= reactive oxygen species; SBwE= Sasa borealis water-extract; TNF-α= tumor necrosis factor-alpha; XOS= Xylooligosaccharides

However, one study demonstrated that bamboo consumption was associated with a high prevalence of goiters, which is associated with multiple health complications (Chandra et al., 2013). In vitro studies demonstrated antioxidant activity, probiotic effects, inhibition of furan formation, high nutritional value and reduction of acrylamide formation during food processing (Choi et al., 2013; Choi et al., 2008; da Silva et al., 2024; Guo et al., 2019; Li et al., 2024; Liu et al., 2014; Sadananda et al., 2023; Santosh et al., 2024; Xiao et al., 2022; Xie et al., 2024; Yang et al., 2020; Zhang et al., 2007). The above identified studies predominantly demonstrate potential multiple health outcomes from bamboo consumption. Collectively these health outcomes are likely due to the rich nutritional contents of bamboo and its extracts. For example, bamboo is rich in proteins, amino acids, carbohydrates, minerals and vitamins (Nongdam and Tikendra, 2014). Indeed, thiamine, niacin, vitamin A, vitamin B6 and vitamin E are found in appropriate quantities in bamboo (Nongdam and Tikendra, 2014). A detailed discussion on the impact of each of these nutrients on human health is beyond the scope of this paper. However, as one example, adequate consumption of thiamine supports the nervous system, brain, skeletal muscles, heart, stomach, and intestines (Martel et al., 2024). Another example is that adequate consumption of vitamin E has been found to be associated with lower risk of stroke, age-related cataracts and obesity with a moderate level of evidence (Zhang et al., 2023). Importantly, the presence of tyrosine in bamboo facilitates biochemical metabolism as it is a major constituent of adrenals which are precursors for adrenaline, necessary for active body metabolic activities (Nongdam and Tikendra, 2014). Moreover, bamboo shoots are rich in dietary fibres (including cellulose, hemicellulose and lignin, forming a predominantly insoluble fibre content) (Fang et al., 2021) and phytosterols (including the predominant form beta-sitosterol, along with campesterol and stigmasterol) (Lu et al., 2009). The high fibre and phytosterol content in bamboo shoots potentially reduces fat and cholesterol levels in the blood. Indeed, dietary fibre possesses several positive health outcomes as it aids in the management and control of hypertension and obesity, and may offer protection against

Table 3
Main information and findings on laboratory results of possible bamboo utilization in nutrition and food process.

Author and date	Aim	Materials	Intervention	Outcome measures	Findings
da Silva, 2024[24]	To evaluate the digestibility, prebiotic, antioxidant effects, and production of short-chain fatty acids from short-chain XOS of the bamboo culm.	Bamboo culms of the species *Dendrocalamus latiflorus* Munro was supplied by Jatoba Farm (Campinas -SP, Brazil).	Bamboo culms were dried in a forced-air circulation oven at 65∘C for 24 h and passed through the milling and standardization process to a granulometry of 32 mesh (0.557 mm).	Digestibility, probiotic effects, antioxidant activity.	XOS presented a high and desirable resistance to digestion, considering that 97.65 % of the XOS remained intact in the simulated intestinal phase. XOS showed an expressive prebiotic effect, promoting the growth of Lactobacillus acidophilus and Bifidobacterium bifidum, fermenting the XOS and producing short-chain fatty acids, highlighting acetate, propionate, and butyrate.
Guo, 2019[25]	To investigate the effects of ingredients on furan formation and the reduction of furan by sugar alcohols and AOB.	No information on AOB extraction/procurament.	The milk beverage model system was formulated by mixing 6.0 g of sugar, 12.9 g of sugar-free skimmed milk powder and 18.0 mg of AA. The added amounts of AOB were 0, 0.2, 1 and 2 mg ml−1. The samples were heated and analyzed for furan content.	Furan formation inhibition.	AOB significantly inhibited furan formation and the inhibition rate reached 32.13 % and 28.52 % separately for the sucrose/HFCS-containing system.
Li, 2024[26]	To explore the quantities and distribution of nutrient components during the growth of bamboo shoots and to identify the optimal height for harvesting to obtain high-quality produce.	*Dendrocalamus brandisii* (Munro) Kurz shoots were harvested from an experimental understory bamboo cultivation in China.	CFC was determined by acid-base washing method, TSSC by anthrone colorimetry and SPC by Coomassie Brilliant Blue assay. For mineral elements, wet digestion was used. K was determined by ammonium acetate extraction. The IPC produced was used to indicate the ATPase activity.	Nutritional value of fresh shoots across five height grades: 20–30 cm; 31–40 cm; 41–50 cm; 51–60 cm; 61–70 cm.	The CFC and TSSC showed the highest values in the lower part at five growth heights. The SPC, AC, other mineral elements and high activity of metabolic enzymes were higher in the upper part. Bamboo shoots with a height of less than 40 cm had a higher TSSC, AC, Fe, and Zn, and a lower CFC.
Liu, 2014[27]	To evaluate the effect of carbon chain length of acyl donor on the antioxidant activity of cAOB-o.	AOB-w (total phenolics content 40 g p-hydroxybenzoic acid equivalent /100 g) was provided by Hangzhou Umate Technology.	The Rancimat test was used to determine the effect of cAOB-o on the oxidative stability of palm oil, lard, and fried potato chips. Furthermore, an acute oral toxicity test of cAOB-o was designed for safety evaluation.	Antioxidant activity and toxicity of cAOB-o.	Total phenolics content of cAOB-o was above 20 g HAE/ 100 g and total flavonoids content was above 8 g RE/100 g. cAOB-o was able to enhance oxidative stability of palm oil, lard, and fried potato chips. Acute oral toxicity test proved cAOB-o to be nontoxicity.
Sadananda, 2023[28]	To understand the anti-oxidative properties of products of both enzymatic and non-enzymatic origin derived from bamboo shoots.	Shoots from the selected species were purchased from local markets in Arunachal Pradesh.	1 g samples were homogenised with 0.1 M potassium phosphate buffer (pH 6.8) in a pre-cooled mortar and pestle. The supernatant was used for the assay of CAT and GPX.	CAT, peroxidase GPX activity, AA, CGA.	Fresh tender shoots had higher antioxidative properties of both enzymatic and non-enzymatic origin than fermented and processed forms. Higher antioxidant levels were observed in partially fermented Hidung than in the other two processed forms.
Santosh, 2024[29]	To evaluate potential impact of utilizing bamboo shoots as a natural fortificant in noodles.	Fortified noodles were prepared by replacing 10 % of the wheat flour with different processed dried bamboo shoot powders.	Noodles were analyzed for moisture, total protein, carbohydrate, crude fat, crude fibre, ash, free amino acids and starch, vitamin C and E and antioxidant activity. Fortified noodle results were compared with control (non-fortified).	Antioxidant activity and nutrients.	The fortified noodles fortified had a maximum content of amino acid (1.15 g/100 g), proteins (7.14 g/ 100 g), carbohydrates (40.4 g/ 100 g), starch (71.1 g/100 g). Vitamin C and E were higher compared to control noodles while the content of fat was lower. The antioxidant activity was highest in the fortified noodles, and the minimum antioxidant activity was observed in control noodles. The sensory score for fortified noodles was greater for texture, taste, and overall acceptability.
Wang, 2017[30]	To find the potential applications of DF from bamboo shoots in food and health products.	The bamboo shoots were obtained from Ningguo Maosheng Food Co.Ltd.	DFs were extracted through chemical treatment and enzymatic hydrolysis. Moisture, crude protein, crude fat, ash, TDF, IDF and SDF contents were determined according to the AOAC method.	Chemical composition, structural and functional properties of DFs extracted.	BSEDF and BSCDF had higher total DF and SDF, respectively. Both fibres showed good functional properties: WRC, WSC, OAC, GAC and GRI. WRC of BSCDF and BSEDF decreased with the increase in the mesh size (40−200) while WSC and OAC increased with

(*continued on next page*)

Table 3 (*continued*)

Author and date	Aim	Materials	Intervention	Outcome measures	Findings
					mesh sizes (40−120), followed by decrease above mesh 120. Both particle size and extraction methods significantly affected GRI.
Zhang, 2007[31]	To demonstrate the efficiency of AOB on the reduction of acrylamide during thermal processing.	AOB was prepared from the bamboo leaves of *Phyllostachys nigra* var. *henonis* (Mitford) Rendle.	Potato crisps and French fries were immersed into different contents of AOB solution. The acrylamide content was determined by mass spectrometry.	Acrylamide content	AOB addition (0.1 % and 0.01 %) reduced 74.1 % and 76.1 % respectively the content of acrylamide in potato crisps and French fries. The maximum inhibitory rate was achieved when the immersion time was designed as 60 s. Crispness and flavor processed by AOB solution had no significant difference compared to normal potato matrixes.

AA= ascorbic acid; AOAC= Association of Official Analytical Chemists; AOB= antioxidants of bamboo leaves; AOBw= water-soluble AOB; AC= ash content; cAOB-o= oil-soluble AOB; BSEDF= bamboo shoots enzymatic extraction dietary fibtr; BSCDF= bamboo shoots chemical extraction dietary fibre CAT= Catalase enzyme activities; CFC= crude fibre content; CGA= Chlorogenic acid; DF= dietary fibre; GAC= glucose adsorption capacity; GRI= glucose retardation index; HFCS= high fructose corn syrup; IDF= insoluble dietary fibre; IPC= inorganic phosphorus content; OAC= oil holding capacity; SDF= soluble dietary fibre; SPC= soluble protein content; TDF= total dietary fibre; TSSC= total soluble sugars content; WRC= water retention capacity; WSC= water swelling capacity; XOS= Xylooligosaccharides

coronary diseases and potential carcinogens (Nongdam and Tikendra, 2014).

Although the literature suggested positive health outcomes from bamboo consumption and its extracts, one study suggested that bamboo consumption is associated with a higher risk of goiters. The goitrogenic constituents of bamboo shoots, cyanogenic glycosides, glucosinolates and thiocyanate likely interfere with thyroid hormone synthesis when regularly consumed, which may lead to the increased risk of goiters (Chandra et al., 2013; Sarkar et al., 2021). However, the risk of goiters from bamboo shoot consumption may be mitigated from appropriately preparing the shoot prior to consumption, which can be achieved by pre-boiling the shoot in water for varying periods of time depending on the bamboo shoot type (Pandey and Ojha, 2014). Given these findings, and if appropriately prepared before consumption, bamboo may be considered as a potential sustainable food supplement, especially in low-income settings where it is often farmed and there is a general lack of consumption of nutrient-rich foods.

While the present review benefits from a robust search process and the inclusion of in vivo and in vitro studies, findings must be considered in light of its limitations. First, few studies exist on the present topic, with those that do exist using a variety of outcomes and exposure measures, meaning it was not possible to perform meta-analyses on the included studies. Second, the present study is a systematic review of scientific literature and thus it was not possible to control for inherent biases within included studies. Third, although the NOS assessment showed a generally satisfactory quality of assessed studies, it was applied only to in-vivo studies.

5. Conclusions

In conclusion, findings from the present systematic review which included 16 studies suggest that if appropriately prepared, human bamboo food consumption may have multiple health benefits. However, more high-quality experimental trials are required to further elucidate on the health benefits before concrete recommendations can be made. We call on the academic community to further investigate this crop for its high potential for improving human health.

CRediT authorship contribution statement

Pinar Soysal: Writing – review & editing. **Jae Il Shin:** Writing – review & editing. **Damiano Pizzol:** Writing – original draft. **Lee Smith:** Writing – review & editing. **Tobia Zampieri:** Writing – review & editing. **Robert MacKinnon:** Writing – review & editing. **Dong Keon Yon:** Writing – review & editing. **Fiona Richardson:** Writing – review & editing. **López Sánchez Guillermo Felipe:** Writing – review & editing. **Susanna Caminada:** Writing – review & editing. **Alessandro Bertoldo:** Writing – review & editing. **Laurie Butler:** Writing – review & editing. **Nicola Veronese:** Writing – review & editing.

Institutional review board statement

Not applicable.

Informed consent statement

Not applicable.

Funding

This research received no external funding.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

References

Chandra, A.K., Singh, L.H., Ghosh, S., Pearce, E.N., 2013. Role of bamboo-shoot in the pathogenesis of endemic goiter in Manipur, North East India. Endocri. Pr. 19 (1), 36–45. https://doi.org/10.4158/EP12162.OR.

Chen, X., Jia, W., Wang, Q., Han, J., Cheng, J., Zeng, W., Zhao, Q., Zhang, Y., Zhang, Y., 2020. Protective effect of a dietary flavonoid-rich antioxidant from bamboo leaves against internal exposure to acrylamide and glycidamide in humans. Food Funct. 11 (8), 7000–7011. https://doi.org/10.1039/d0fo00811g.

Choi, Y.-J., Lim, H.-S., Choi, J.-S., Shin, S.-Y., Bae, J.-Y., Kang, S.-W., Kang, I.-J., Kang, Y.-H., 2008. Blockade of chronic high glucose–induced endothelial apoptosis by Sasa borealis bamboo extract. Exp. Biol. Med. 233 (5), 580–591. https://doi.org/10.3181/0707-RM-2.

Choi, S., Park, M.S., Lee, Y.R., Lee, Y.C., Kim, T.W., Do, S.-G., Kim, D.S., Jeon, B.H., 2013. A standardized bamboo leaf extract inhibits monocyte adhesion to endothelial cells by modulating vascular cell adhesion protein-1. Nutr. Res. Pr. 7 (1), 9–14. https://doi.org/10.4162/nrp.2013.7.1.9.

Fang, D., Wang, Q., Chen, C., Li, Z., Li, S., Chen, W., Zheng, Y., 2021. Structural characteristics, physicochemical properties and prebiotic potential of modified dietary fibre from the basal part of bamboo shoot. Int. J. Food Sci. Technol. 56 (2), 618–628. https://doi.org/10.1111/ijfs.14709.

FAO, 2010. Global Forest Resources Assessment 2010. ⟨https://www.fao.org/4/i1757e/i1757e00.htm⟩.

Guo, J., Zhao, R., Li, J., Wu, D., Yang, Q., Zhang, Y., Wang, S., 2019. Furan formation from ingredient interactions and furan mitigation by sugar alcohols and antioxidants of bamboo leaves in milk beverage model systems. J. Sci. Food Agric. 99 (11), 4993–4999. https://doi.org/10.1002/jsfa.9739.

Haorongbam, S., Elangbam, D., Nirmala, C., 2009. Cyanogenic glucosides in juvenile edible shoots of some Indian bamboos. Proc. VIII World Bamboo Conf. Bangk. Thail. 6, 22–30.

Imdad, L., Shah, M.A.A., Hassan, J., Humayun, F., Sadiq, A., Javed, M., 2022. Probing the therapeutic effects of bamboo shoots supplementation on diabetic male and female patients: Therapeutic effects of bamboo shoots in diabetic subject. J. Aziz Fatimah Med. Dent. Coll. 4 (1). https://doi.org/10.55279/jafmdc.v4i1.169.

Lewington, A., 2003. Plants for people. Random House.

Li, W., He, S., 2019. Research on the utilization and development of bamboo resources through problem analysis and assessment. IOP Conf. Ser. Earth Environ. Sci. 300 (5), e52028. https://doi.org/10.1088/1755-1315/300/5/052028.

Li, L., Wen, Y., Xu, J., Bai, T., Yang, M., Jiang, W., 2024. Different parts of a *Dendrocalamus brandisii* (Munro) Kurz shoot, rather than the shoot's height, are more indicative of its nutrient properties. Horticulturae 10 (5), e438. https://doi.org/10.3390/horticulturae10050438.

Liberati, A., Altman, D.G., Tetzlaff, J., Mulrow, C., Gøtzsche, P.C., Ioannidis, J.P.A., Clarke, M., Devereaux, P.J., Kleijnen, J., Moher, D., 2009. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. J. Clin. Epidem 62 (10), e1–e34. https://doi.org/10.1136/bmj.b2700.

Liu, L., Xia, B., Jin, C., Zhang, Y., Zhang, Y., 2014. Chemical acylation of water-soluble antioxidant of bamboo leaves (Aob-w) and functional evaluation of oil-soluble AOB (cAob-o). J. Food Sci. 79 (10), C1886–C1894. https://doi.org/10.1111/1750-3841.12578.

Lu, B., Ren, Y., Zhang, Y., Gong, J., 2009. Effects of genetic variability, parts and seasons on the sterol content and composition in bamboo shoots. Food Chem. 112 (4), 1016–1021. https://doi.org/10.1016/j.foodchem.2008.06.059.

Luchini, C., Stubbs, B., Solmi, M., Veronese, N., 2017. Assessing the quality of studies in meta-analyses: advantages and limitations of the Newcastle Ottawa Scale. World J. MetaAnal. 5 (4), 80–84. https://doi.org/10.13105/wjma.v5.i4.80.

Martel, J.L., Kerndt, C.C., Doshi, H., Sina, R.E., Franklin, D.S., 2024. Vitamin B1 (thiamine) (StatPearls [Internet]). StatPearls Publishing.

Nirmala, C., Bisht, M.S., Bajwa, H.K., Santosh, O., 2018. Bamboo: a rich source of natural antioxidants and its applications in the food and pharmaceutical industry. Trends Food Sci. Technol. 77, 91–99. https://doi.org/10.1016/j.tifs.2018.05.003.

Niyogi, A., Bhattacharyya, S., Pal, S., Mukherjee, S., Ghosh, A., 2025. Uncovering taxiphyllin in bamboo shoots: an analytical perspective. Food Chem., 144048 https://doi.org/10.1016/j.foodchem.2025.144048.

Nongdam, P., Tikendra, L., 2014. The nutritional facts of bamboo shoots and their usage as important traditional foods of northeast India. Int. Sch. Res. Not. 2014 (1), e679073. https://doi.org/10.1155/2014/679073.

Pandey, A.K., Ojha, V., 2014. Precooking processing of bamboo shoots for removal of anti-nutrients. J. Food Sci. Technol. 51 (1), 43–50. https://doi.org/10.1007/s13197-011-0463-4.

Park, E.-J., Jhon, D.-Y., 2009. Effects of bamboo shoot consumption on lipid profiles and bowel function in healthy young women. Nutrition 25 (7–8), 723–728. https://doi.org/10.1016/j.nut.2009.01.007.

Sadananda, C., Singha, L.B., Tripathi, O.P., Dilip, S., Premkumar, K., Lulloo, P., 2023. Quantification of enzymatic antioxidants (catalase and peroxidase) and non-enzymatic antioxidants (ascorbic acid and chlorogenic acid) in the tender shoots of seven bamboo species and their products, found in Arunachal Pradesh, India. Adv. Bamboo Sci. 5, e100048. https://doi.org/10.1016/j.bamboo.2023.100048.

Santosh, O., Nirmala, C., Bajwa, H.K., Bisht, M.S., Indira, A., Bano, S., 2024. Fortification of noodles with processed bamboo shoots: evaluating the impact on nutritional composition, antioxidant activity and sensory characteristics. Adv. Bamboo Sci. 8, e100089. https://doi.org/10.1016/j.bamboo.2024.100089.

Sarkar, D., Chandra, A.K., Chattopadyay, S., Biswas, M., Das, S., Singh, L.H., Ray, I., 2021. Possible mechanism of bamboo shoots (*Bambusa balcooa*) induced thyroid disruption–an in vitro study. Hum. Exp. Toxicol. 40 (3), 483–496. https://doi.org/10.1177/0960327120958037.

da Silva, M.F., Sganzerla, W.G., Ávila, P.F., Carneiro, T.F., Clerici, M.T.P.S., Goldbeck, R., 2024. Evaluation of the functional properties of short-chain xylooligosaccharides obtained from the enzymatic hydrolysis of bamboo culm. Bioact. Carbohydr. Diet. Fibre 32, e100431. https://doi.org/10.1016/j.bcdf.2024.100431.

Singhal, P., Bal, L.M., Satya, S., Sudhakar, P., Naik, S.N., 2013. Bamboo shoots: a novel source of nutrition and medicine. Crit. Rev. Food Sci. Nutr. 53 (5), 517–534. https://doi.org/10.1080/10408398.2010.531488.

Singhal, P., Satya, S., N Naik, S., 2016. Cyanogenic toxicity and human health. Curr. Nutr. Food Sci. 12 (2), 150–154.

Stroup, D.F., Berlin, J.A., Morton, S.C., Olkin, I., Williamson, G.D., Rennie, D., Moher, D., Becker, B.J., Sipe, T.A., Thacker, S.B., 2000. Meta-analysis of observational studies in epidemiology: a proposal for reporting. Jama 283 (15), 2008–2012. https://doi.org/10.1001/jama.283.15.2008.

Wang, Y., Chen, J., Wang, D., Ye, F., He, Y., Hu, Z., Zhao, G., 2020. A systematic review on the composition, storage, processing of bamboo shoots: focusing the nutritional and functional benefits. J. Funct. Foods 71, e104015. https://doi.org/10.1016/j.jff.2020.104015.

Wells, G.A., Shea, B., O'Connell, D., Peterson, J., Welch, V., Losos, M., Tugwell, P., 2000. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses.

Xiao, Z., Li, J., Wang, H., Zhang, Q., Ge, Q., Mao, J., Sha, R., 2022. Hemicellulosic polysaccharides from bamboo leaves promoted by phosphotungstic acids and its atten,uation of oxidative stress in HepG2 cells. Front. Nutr. 9, e917432. https://doi.org/10.3389/fnut.2022.917432.

Xie, Y.-M., Zhang, M.-Y., Liu, F.-P., Wang, C.-C., Dong, W.-Y., Xu, C.-M., Li, X., Xu, W.-M., Xiang, P., 2024. Human health risk assessment and toxic effect of heavy metal (loid) s in bamboo shoot products. J. Environ. Chem. Eng. 12 (3), e112841. https://doi.org/10.1016/j.jece.2024.112841.

Yang, K., Yang, Z., Wu, W., Gao, H., Zhou, C., Sun, P., Wu, C., Xia, Q., Chen, J., 2020. Physicochemical properties improvement and structural changes of bamboo shoots (*Phyllostachys praecox* f. Prevernalis) dietary fiber modified by subcritical water and high pressure homogenization: a comparative study. J. Food Sci. Technol. 57, 3659–3666. https://doi.org/10.1007/s13197-020-04398-2.

Yeasmin, L., Ali, M.N., Gantait, S., Chakraborty, S., 2015. Bamboo: an overview on its genetic diversity and characterization. 3 Biotech 5 (1), 1–11. https://doi.org/10.1007/s13205-014-0201-5.

Zhang, Y., Chen, J., Zhang, X., Wu, X., Zhang, Y., 2007. Addition of antioxidant of bamboo leaves (AOB) effectively reduces acrylamide formation in potato crisps and French fries. J. Agric. Food Chem. 55 (2), 523–528. https://doi.org/10.1021/jf062568i.

Zhang, Y., Wu, L., Li, Y., Yang, J., Yang, H., Zhao, Y., Chen, G., 2024. Bamboo shoot and its food applications in last decade: an undervalued edible resource from forest to feed future people. Trends Food Sci. Technol., 104399 https://doi.org/10.1016/j.tifs.2024.104399.

Zhang, T., Yi, X., Li, J., Zheng, X., Xu, H., Liao, D., Ai, J., 2023. Vitamin E intake and multiple health outcomes: an umbrella review. Front. Public Health 11, e1035674. https://doi.org/10.3389/fpubh.2023.1035674.