Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2021; 10(6): 330-337
Received: 01-09-2021
Accepted: 03-10-2021

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Quality evaluation of biscuits fortified with bamboo shoot for their sensory properties

Oinam Santosh, Harjit Kaur Bajwa, Madho Singh Bisht and Chongtham Nirmala

Abstract
Bamboo shoots, considered as a 'superfood' are a good source of nutrients and health-promoting bioactive compounds. However, the presence of cyanogenic glycosides in the shoot causes acridity and toxicity which necessitates processing before exploiting them as food or additive in fortification. In the present investigation, shoots of *Dendrocalamus hamiltonii* processed by different methods were used in paste and powder form to fortify biscuits and their sensory acceptability (colour, aroma, texture, taste and overall) and cyanogenic glycoside content were evaluated. Fortified biscuit with 10% paste and 20% powder form was acceptable by consumers. The cyanogenic glycoside content was found much lower than the permissible level ranging from 21.49 mg/kg to completely removed in the biscuits fortified with oven-dried powder of boiled shoots. The study indicates that maximum sensory acceptability and cyanogenic glycoside removal were observed in bamboo shoots boiled for 20 min and the use of paste form is ideal for fortification of biscuits.

Keywords: bamboo shoot, fortification, cyanogenic glycoside, processing, sensory analysis

Introduction
Food systems are complex systems comprising multiple processes and practices which include processing, packaging and consumption (Den Boer *et al*., 2020) [1]. Constant challenges require the development and adoption of innovative approaches and food fortification provides an exciting opportunity. Food fortification is an effective intervention to deliver important nutrients especially vitamins and minerals to large populations. However, the success of any fortification program depends on the choice of a suitable food vehicle. Staple foods such as wheat flour and rice are very effective, simple and inexpensive strategies for supplying vitamins and minerals to the diets of a large segment of the population (Shah *et al*., 2016) [2]. However, cereals are low in proteins and their protein quality is also lower due to the deficiency of essential amino acids such as lysine, threonine, arginine and tyrosine (Jideani and Onwubali, 2009) [3]. Amino acids are prerequisites not only for protein synthesis but as precursors for the synthesis of many bioactive compounds that participate in the regulations of signalling pathways and metabolism in the body (Chongtham and Bisht, 2021) [4]. Thus, for the development of novel fortified products, bamboo shoot is a healthy alternative to cereals as it contains all the essential amino acids including arginine and tyrosine. Arginine plays a key role in the synthesis of glycoproteins and tyrosine is a major precursor of several neurotransmitters and may directly affect processes in the brain including cognitive function. Moreover, bamboo shoots are a rich repository of nutrients and minerals which are much higher than the commonly consumed vegetables and have the potential to prevent malnutrition and combat hidden hunger which is widely prevalent globally. Deficiency in mineral elements is the most common and widespread nutritional disorder globally which affects human health (Chongtham *et al*., 2021) [5]. Bamboo shoots low in fat and calories, rich in nutrients and bioactive compounds have been projected as a superfood for nutrition, health and medicine (Chongtham and Bisht, 2021) [4].

The incorporation of nutritionally rich ingredients for making bakery products is a common practice. Biscuits are convenient and inexpensive bakery products consumed by all ages. The enrichment of nutrients and bioactive compounds in biscuits may be achieved through the incorporation of natural sources rich in these compounds. Bamboo shoot is one of these sources, which have great potential due to its high nutritional and bioactive content (Nirmala *et al*., 2011) [6]. Freshly harvested bamboo shoot is a good source of proteins (3.5%), fiber (1.5%), minerals, vitamins and amino acids (Nirmala *et al*., 2011; Sood *et al*., 2013) [6, 7]. Bamboo shoots though a popular food source in many parts of the world, its consumption in fresh or raw form is hindered by the presence of cyanogenic glycosides namely taxiphyllin.

Taxiphyllin liberates hydrogen cyanide upon hydrolysis that is responsible for a bitter taste and toxic effect which is a matter of concern. Various processing methods have been employed since ancient times to reduce or remove cyanogen present in the shoot which includes boiling, soaking, fermentation, drying and canning (Nirmala *et al.*, 2011; Pandey and Ojha, 2013; Sarangthem and Singh, 2013a; Rawat *et al*., 2016) [6, 8, 9, 10]. Pandey and Ojha (2013) [8] investigated several parameters for maximum removal of cyanogen from bamboo shoots with different durations of boiling and different concentrations of brine and found that boiling of shoots in brine solution for 15 min is the best technique for maximum removal of cyanogen from the shoots of most of the bamboo species. However, the sodium content was reported to increase in brine preserved shoots (1879 mg/100g) as compared to the fresh shoots (30 mg/100g) of *D. hamiltonii* (Bajwa *et al.*, 2019) [11]. Since high sodium intake is associated with increased blood pressure and risk of cardiovascular events (O'Donnell *et al.*, 2015 [12]), brine preserved shoots may not be the best method for the antinutrient removal as it may alter the nutritional profile of the shoot.

The preparation of various bamboo shoot-based food products is mostly traditional and based on the taste of the local people. Recently, the shoots have been used for the development of several value-added products such as pickles candies, nuggets, crackers, chutney, chips, cookies, chapatis, and buns (Sood *et al*., 2013; Bisht *et al*., 2012; Choudhury *et al*., 2012 ; Pandey *et al.*, 2012; Mustafa *et al*., 2016) [7, 13, 14, 15, 16]. Santosh *et al*., (2018 [18]; 2019 [18]) reported enrichment of nutrient content, bioactive compounds and minerals in biscuits fortified with bamboo shoots. However, a detailed analysis of sensory properties and cyanogenic glycoside content of shoot fortified products has not been carried out so far. Sensory analysis of food products provides an understanding and control of key attributes for consumer satisfaction and is crucial for the commercial success of the products (Sirangelo, 2019) [19]. Appearance, flavor, texture and even the sounds of food can impart a desire to eat or cause us to dismiss the food as unappetizing or even inappropriate from a cultural standpoint (Chambers, 2019) [20]. The present paper is a study of the sensory acceptance of biscuit fortified with different processed forms of bamboo shoot and evaluation for the cyanogenic content of the fortified products.

Material and Methods

Bamboo shoot samples

Edible young shoot of *Dendrocalamus hamiltonii* Nees and Arn. ex Munro was collected during the peak season from June- September from the local vegetable market of Shillong, Meghalaya (India). It was transported by air to the Department of Botany, Panjab University, Chandigarh (India). In the laboratory, shoots were washed properly after removing the outer culm sheath. Edible shoots were chopped into small chunks and divided into three groups as unprocessed, boiled (20 minutes) and soaked (24 hours in plain water). These were further subjected to freeze-drying (24 hours at -55 °C and 0.10 mbar) and oven-drying (24 hours at 60 °C) for further analysis. The shoot chunks were grounded into paste and powder form. A total of nine bamboo shoot samples were prepared viz; (i) unprocessed shoot paste, (ii) boiled shoot paste, (iii) soaked shoot paste, (iv) unprocessed freeze-dried shoot powder, (v) boiled freeze-dried shoot powder, (vi) soaked freeze-dried shoot powder (vii) unprocessed oven-dried shoot powder, (viii) boiled oven-dried shoot powder, and (ix) soaked oven-dried shoot powder (Fig. 1). Processed shoot paste and powder were placed in glass containers with air tight lids, stored at 4 °C for further use in fortification of biscuits. For biscuit preparation wheat flour (Shakti Bhog Brand) was procured from the local market of sector 14, Chandigarh, India.

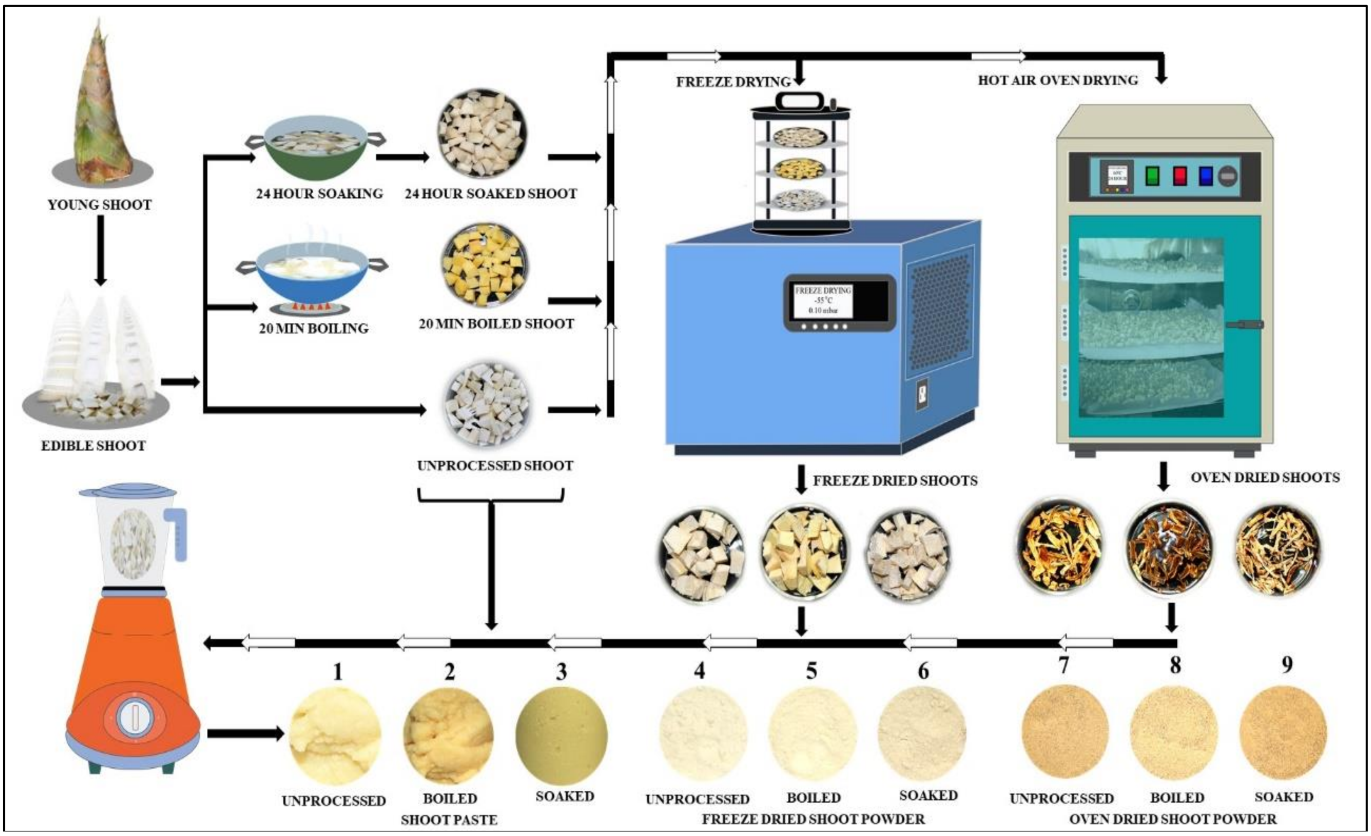

Fig 1: Processing of bamboo shoots (*D. hamiltonii*).

Preparation of bamboo shoot biscuits

Control biscuit was prepared using 100g wheat flour. Preliminary fortified biscuits were prepared by replacing wheat flour with 5%, 10%, 15%, 20% and 25% bamboo shoot paste and powder. Maximum acceptability level was selected at 20% in paste form of shoots and 10% in powder form of shoots. The other ingredients used for each batch were as follows: ghee or clarified butter (30 g), sugar (40 g), milk (60 ml) and baking powder (2 g). Dough was prepared by mixing all the ingredients and circular biscuits of 2.5 cm diameter with uniform thickness of 3 mm were cut and baked for 15-20 minutes at 200^0C in a baking oven (Morphy Richards 52RCSS). After baking, fortified biscuits developed were cooled at room temperature and packed in airtight containers, stored at 4 °C for further evaluation of cyanogenic glycosides and sensory acceptability. A total of ten biscuit formulations were developed and labelled as; 1. control biscuits (CB), 2. unprocessed shoot paste fortified biscuits (UB), 3. boiled shoot paste fortified biscuits (BB), 4. soaked shoot paste fortified biscuits (SB), 5. unprocessed shoot freeze-dried powder fortified biscuits (UFB), 6. boiled shoot freeze-dried powder fortified biscuits (BFB), 7. soaked shoot freeze-dried powder fortified biscuits (SFB), 8. unprocessed shoot oven-dried powder fortified biscuits (UOB), 9. boiled shoot oven-dried powder fortified biscuits (BOB), and 10. soaked shoot oven-dried powder fortified biscuits (SOB) (Fig. 2).

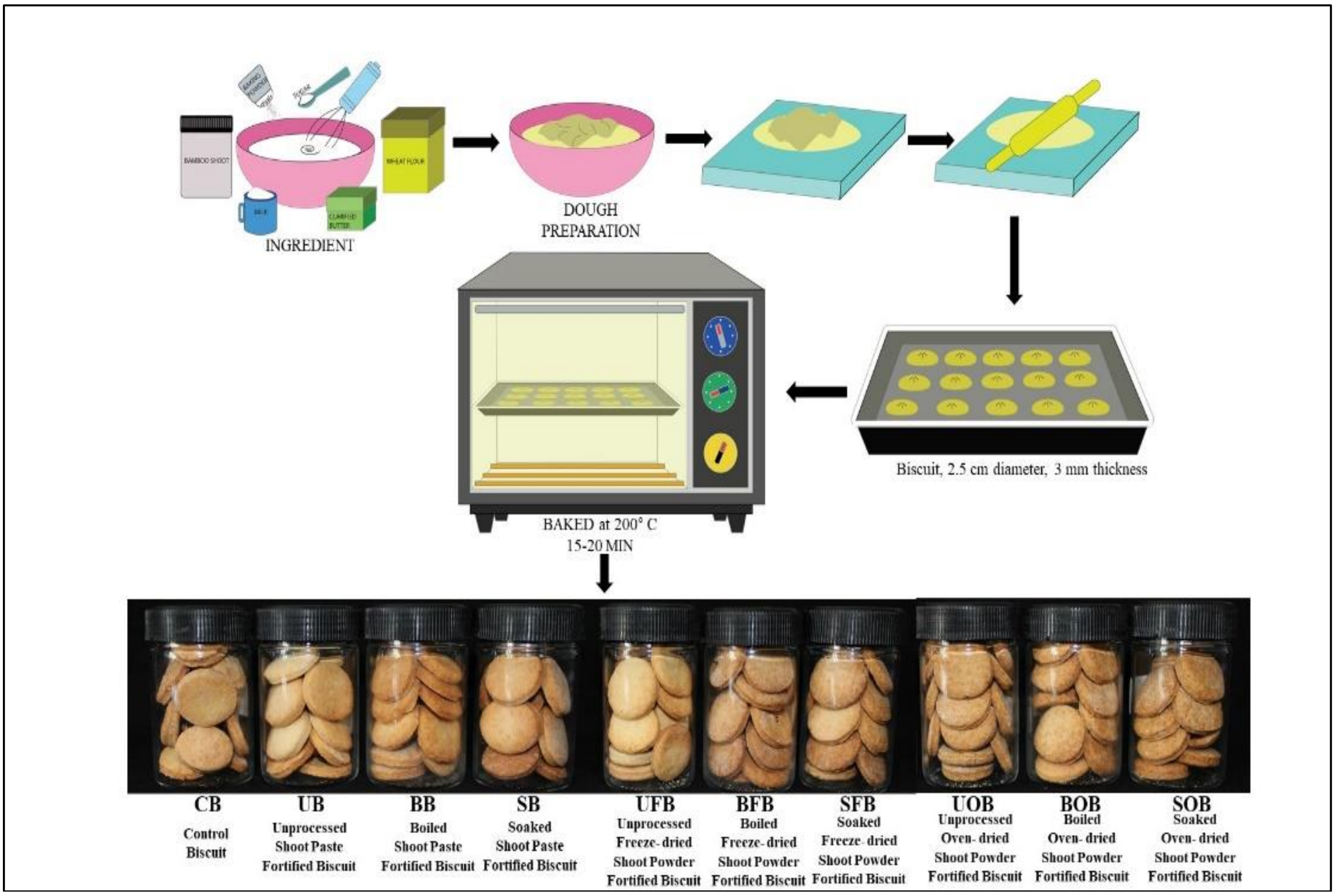

Fig 2: Preparation of bamboo shoot fortified biscuits.

Evaluation of organoleptic properties and total cyanogenic glycoside content

Biscuits were distributed to 40 individuals, after labelling each of the biscuit formulations with a secret code. The individuals were requested to record their ratings for colour, aroma, texture, taste and overall acceptability on a 9-point Hedonic scale using numerical values ranging from 1 to 9, where 1 represented disliked extremely and 9 represented liked extremely. The picrate method of Haque and Bradbury, (2002) [21] was followed for the estimation of total cyanogenic glycosides.

Statistical Analysis

Data were reported as mean ± standard deviation (SD), analysed through one-way analysis of variance (ANOVA) using PASW Statistics (version 18.0) to determine the level of significance. The separation of means or significant difference contrasts was done by the Duncan test. For sensory analysis, data (n=40) were analysed using the Tukey test to separate the means of other parameters that examined the acceptability of the biscuits. Spearman's rank correlations (r_s) were analysed to measure the strength of monotonic relationship between paired data among the sensory attributes and removed cyanogenic glycoside percent (RCG) for 10 different biscuit formulation. The numerical consequence was well-defined as $P \leq 0.05$.

Results and Discussion

Effect on organoleptic properties of fortified products

In food industries, organoleptic properties are an important tool for product development, research, quality control, and shelf-life studies. Analysis is important to test and evaluate the acceptability of new products by the consumers and is crucial for the commercial success of food products (Sirangelo, 2019) [19]. Though the processing of bamboo shoots is crucial to remove cyanogenic glucosides which are responsible for the bitter taste and pungent smell of the shoots, it alters some characteristics of the fortified products.

Different forms of processed shoots were used for making the fortified biscuits. Using shoots as paste or powder form for the fortification of food products is one of the best ways of enhancing the nutrients in the food products. The most widely used scale for measuring food acceptability in food industries is the 9-point hedonic scale. In the present experiment, the fortification of biscuits up to 20% of bamboo shoot paste was acceptable whereas, for powder form, the acceptance level was 10% only (Table 1). During the dough preparation for shoot paste fortified biscuit, the moisture content increased with the increase in fortification level and at 25% the dough was too soft to prepare the biscuits. Whereas, in biscuit formulation with freeze-dried powder and oven-dried powder of bamboo shoot, the dough increased in hardness with the increase in the fortification percent. At 15% level, the dough is very hard and correspondingly, the biscuits were hard in texture and led to decreased acceptability. Sensory analysis of bamboo shoot powder fortified biscuits conducted by Choudhury *et al*. (2015) [22] revealed that overall acceptance of biscuits was up to 10% fortification and above 10%, the biscuits were dark in colour with a very hard texture.

Table 1: Acceptable percent of bamboo shoot paste, freeze-dried powder, and oven-dried powder for fortifying biscuit.

Product	Bamboo Shoot	Percent of shoot fortification					
		0%	5%	10%	15%	20%	25%
Biscuit	Shoot paste	✓	✓	✓	✓	✓	X
	Freeze-dried powder	✓	✓	✓	X	X	X
	Oven-dried powder	✓	✓	✓	X	X	X

Note: '✓' signifies acceptable; 'X' signifies not acceptable.

Treatment during food production affects food sensory quality such as aroma, texture and food matrix. Use of hydrogen peroxide resulted in bleach in the carp fish used in surimi production process (Jafarpour *et al.*, 2008) [40]. Pre-fermentation treatments in wine slightly changed the aroma Zhang *et al.*, (2018) [24] and characteristics of emulsion affected the texture in the food matrix of mayonnaise (Olsson *et al.*, 2018) [25]. Sensory analysis of peanut skin supplemented cookies not only increased the polyphenol content but also showed consumer acceptability indicating potential commercialization of the product (De-Camargo *et al.*, 2014) [26]. A comparison for sensory attributes for colour, aroma, texture, taste and overall acceptability was analysed among all the biscuit formulations (Table 2). A significantly ($P<0.05$) higher sensory attribute for BB and UB was observed in all the parameters with a less significant difference between the two formulations. In the food industry, visual assessment and visual colour standards are very important to establish quality control of food products (Wrolstad and Smith, 2017) [27]. In the study, the attribute for colour was maximum in biscuit fortified with paste of boiled shoot (BB, 7.10) which decreased in the formulations involving dried shoot powder as follows,
BB>UB>UFB>BOB>BFB>SB>SFB>CB>UOB>SOB. The results for aroma of the fortified biscuits showed significantly ($P<0.05$) higher attributes in biscuit fortified with paste of boiled shoot (BB, 7) as compared to the control (CB, 6). The attribute for aroma was overall high in biscuits fortified with boiled shoots (BB, 7>BOB, 6.3>BFB>6.15) with lowest attributes in biscuit fortified with soaked shoots (SB, 5.45>SOB, 4.95>SFB, 3.9). The decrease in the sensory attributes in biscuit formulations involving soaked shoots may be due to the fermented aroma of the 24-hour-soaked shoots. Santosh *et al*., (2019) [18] also reported the minimum sensory attributes of biscuits fortified with paste of soaked shoots. Mustafa *et al*., (2016) [16] evaluated the overall acceptability of bamboo cookies, fortified with oven-dried powder of 3-4 hour boiled shoots and reported that consumer acceptance regarding aroma and taste was more for cookies fortified with 5% compared to the 10% and 15%. Texture of the biscuits was maximum in UB with sensory score 7.25 which was significantly ($P<0.05$) higher than control (CB, 5.55). The result for taste was maximum but not significant between BB (7.85) and UB (7.40), however, the attribute was minimum in formulation involving dried shoot powder. Overall, a marked decrease ($P<0.05$) was observed in all the biscuit fortified with freeze-dried and oven-dried powder of 24-hour water-soaked bamboo shoot with minimum attributes in SFB for colour (4.7) in SOB, aroma (4.75) in UFB and texture (5.15), taste (3.4), overall acceptability (3.65). Moreover, the sensory acceptance was high in biscuits fortified with boiled shoots compared to the control biscuit (CB).

Table 2: Sensory comparison of control and different bamboo shoot fortified biscuits using 9-point Hedonic scale (1-Extremely dislike to 9-Extremely like) and the corresponding removed cyanogenic glycoside percent (RCG).

Biscuit	Colour	Aroma	Texture	Taste	Overall	RCG*
CB	5.45 ± 2.19^{cd}	6.00 ± 0.92^{bc}	5.55 ± 1.73^{cd}	5.90 ± 1.99^{bc}	6.20 ± 1.51^{ab}	NA
UB	6.85 ± 1.53^{ab}	6.70 ± 1.53^{ab}	7.25 ± 1.48^{a}	7.40 ± 1.54^{a}	7.00 ± 1.38^{a}	97.87
BB	7.10 ± 0.85^{a}	7.00 ± 0.86^{a}	6.90 ± 1.12^{ab}	7.85 ± 0.74^{a}	7.55 ± 0.83^{a}	99.18
SB	5.80 ± 1.58^{bcd}	5.45 ± 1.64^{cde}	5.65 ± 1.93^{cd}	4.65 ± 1.13^{de}	4.80 ± 1.17^{c}	98.90
UFB	6.20 ± 1.40^{abc}	4.75 ± 1.59^{e}	5.65 ± 1.42^{cd}	4.40 ± 1.64^{def}	4.80 ± 1.61^{bc}	98.13
BFB	5.80 ± 1.36^{bcd}	6.15 ± 1.18^{abc}	6.35 ± 0.75^{abc}	6.35 ± 0.99^{b}	6.50 ± 0.83^{a}	99.40
SFB	5.70 ± 1.86^{cd}	3.90 ± 1.65^{f}	5.15 ± 1.56^{d}	3.40 ± 1.76^{f}	3.65 ± 1.93^{c}	98.83
UOB	5.30 ± 1.46^{cd}	5.70 ± 1.38^{cd}	5.45 ± 1.40^{cd}	5.05 ± 1.57^{cd}	4.95 ± 1.05^{bc}	99.20
BOB	5.85 ± 1.42^{bc}	6.30 ± 0.92^{abc}	6.20 ± 1.44^{bcd}	6.30 ± 1.45^{b}	6.50 ± 0.83^{a}	100
SOB	4.70 ± 1.84^{d}	4.95 ± 1.51^{de}	5.25 ± 1.74^{d}	3.70 ± 1.63^{ef}	4.15 ± 1.73^{c}	99.55

Values reported are measurement replication means ± standard deviation (n = 40 replicates).
Mean followed by different letters in the same column differs significantly ($P\leq0.05$).
*RCG - Removed Cyanogenic Glycoside Percent; NA- Not Applicable

Cyanogenic glycoside content of fortified biscuits

Antinutrients are a concern when a diet is composed mainly of uncooked plant foods such as vegetables, legumes and nuts (Popova and Mihaylova, 2019) [28]. Several plant foods are a good source of micronutrients that can enhance commercially available food products through fortification, but the presence of antinutrients may cause a hurdle in absorption and bioavailability (Srivastava, 2016) [29]. Some edible plants contain a high amount of cyanogenic glucoside of more than 1000 mg/kg such as almonds seeds, cassava leaf, bamboo shoots and lima beans (Nartey *et al.*, 1980; Nahrstedt, 1993; Chaouali *et al.*, 2013) [30, 31, 32]. Bamboo shoots are considered a superfood for nutrition, health and medicine[4], however, the presence of antinutrients, mainly cyanogenic glucoside makes it unacceptable in fresh form. According to Anon, (2005) [33], the acute lethal dose of hydrogen cyanide for humans is 0.5-3.5 mg/kg b.w. (body weight) whereas a short-term reproductive study in rats showed the permissible limit of cyanogen content in food is 500 mg/kg. The cyanide content of bamboo shoots decreases substantially through several traditional and modern methods of processing which includes soaking, boiling, fermentation, brined preserved, sun-drying, oven-drying, freeze-drying and canning (Chongtham and Bisht, 2021; Pandey and Ojha, 2013; Santosh *et al.*, 2019; Nirmala *et al.*, 2007; Nirmala *et al.*, 2008; Rawat *et al.*, 2015; Devi, 2019) [4, 8, 18, 34, 35, 36, 37].

In the present analysis, the unprocessed shoots of *D. hamiltonii* contained 1008.83 mg/kg f.w. (fresh weight) of cyanogenic glycoside which decreased substantially to a negligible amount to completely removed in the fortified biscuits. The content of cyanogenic glycoside was analysed in control and bamboo shoot fortified biscuit (Fig. 3). It was observed that cyanogenic glycoside decreased after heat treatment of the biscuits while baking process. The result showed a significant (P<0.05) decrease in the cyanogen content from unprocessed shoots (1008.83 mg/kg f.w.) to biscuits fortified with unprocessed shoots UB (21.49 mg/kg d.w., dry weight), UFB (18.83 mg/kg d.w.) and UOB (8.09 mg/kg d.w.). In the biscuits fortified with boiled shoots BB (8.27 mg/kg d.w.), BFB (5.98 mg/kg d.w.), the content significantly (P<0.05) decreased compared to biscuits fortified with unprocessed shoots. Cyanogen content was completely removed in biscuit fortified with oven-dried powder of boiled shoots (BOB). Santosh *et al.*, (2018; 2019) [17, 18] also reported the decrease in cyanogenic content from fresh shoots during the processing of freeze-dried powder and paste of boiled and soaked shoots of *D. hamiltonii*. The reduction in the cyanogen content up to 79.30-86.06% with 20 min boiling at 100^{0}C from fresh shoots of *D. giganteus* was also reported (Rawat *et al.*, 2015) [36]. A comparison of different processing methods revealed that biscuits fortified with freeze-dried powder (UFB, BFB, SFB) and oven-dried powder (UOB, BOB, SOB) had lower content of antinutrient as compared to the biscuit fortified with shoot paste (UB, BB, SB). Biscuit fortified with oven-dried powder of boiled shoots (BOB) showed complete removal of cyanogen. The antinutrient, taxiphyllin of bamboo shoots decomposes at around 116ºC, therefore drying methods such as oven, sun, freeze and superheated steam removed more than 95% of the content (Wongsakpairod, 2000 [38]; Lambri and Fumi, 2014) [38, 39]. Subsequently, heat treatment during processing and baking of biscuit resulted in maximum removal of cyanogenic glycoside. Biscuit fortified with soaked bamboo shoots showed decreased content as compared to the biscuit fortified with unprocessed shoots; however, the content was higher compared to the biscuit fortified with the boiled shoots. Devi, (2019) [37] reported the reduction in the cyanogen content in bamboo shoots up to 86.59% after soaking for 24 hours. The present results showed that the cyanogen content in all the fortified biscuits is much below the permissible limit in food with reference to 500 mg/kg (Anon, 2005) [33].

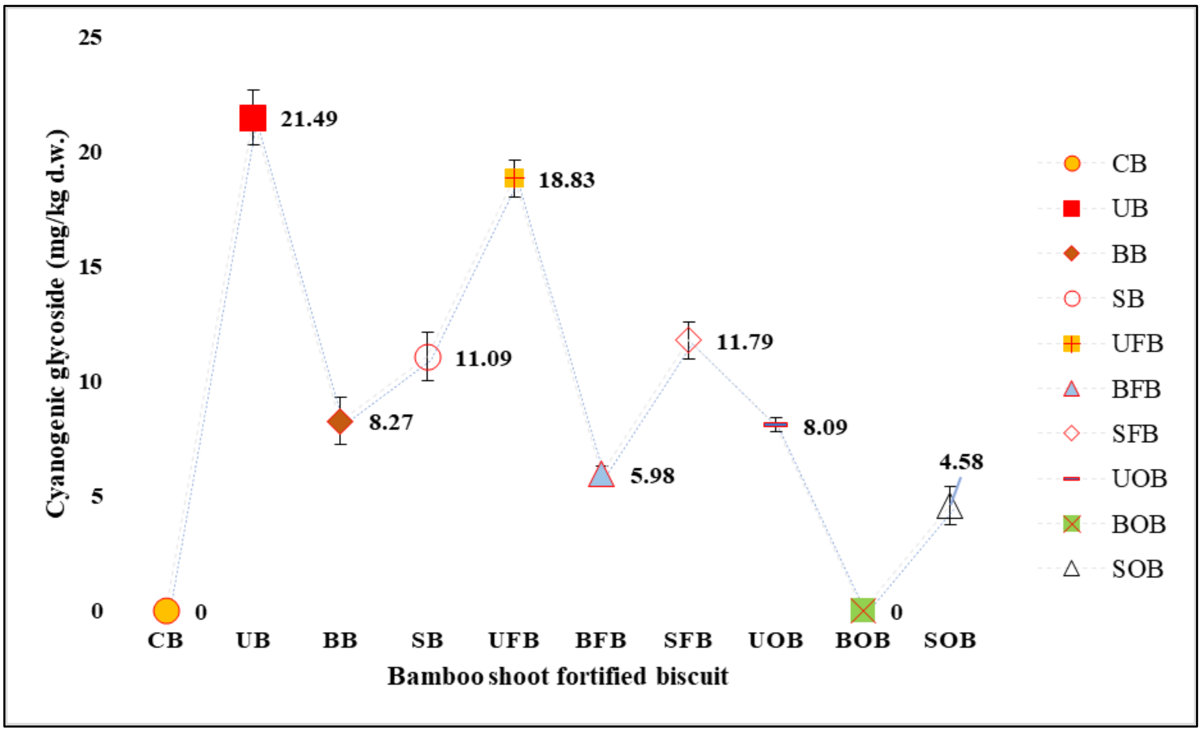

Fig 3: Assessment of cyanogenic glycoside content in control and bamboo shoot fortified biscuits (mg/kg d.w.). Each error bar indicates mean ± SD (n=03 replicates). (control biscuit- CB; Biscuits samples fortified with: unprocessed paste- UB; 20 min boiled shoot paste- BB; 24hr soaked shoots paste- SB; unprocessed freeze-dried shoot powder- UFB; 20 min boiled freeze-dried shoot powder- BFB; 24hr soaked freeze-dried shoot powder- SFB; unprocessed oven-dried shoot powder- UOB; 20 min boiled oven-dried shoot powder- BOB; 24hr soaked oven-dried shoot powder- SOB)

Correlation of sensory and cyanogenic glycoside content in shoot fortified biscuits.

Shoots of *Dendrocalamus sps*., *Bambusa* and *Thyrsostachys sps*. mainly growing in tropical to sub-tropical regions are bitter with acrid smell and various methods are applied to remove the cyanogenic glycoside to make them palatable (Rawat *et al*., 2016; 2015; Devi, 2019) [10, 36, 37]. In the present study, 97.9% to 100% cyanogenic glycoside was removed from the bamboo shoot fortified biscuits and is thus safe for consumption. Fortified biscuits UB and BB were observed with maximum sensory scores for taste and overall acceptability. In UB biscuits, paste for fortification was directly used from fresh shoots without processing and just baking temperature brought the cyanogenic glycoside from 1008.83 mg/kg f.w. level to 21.41 mg/kg d.w. (97.87% reduction). In BB biscuits, heat treatment during the boiling of shoots and baking of fortified biscuits reduced the cyanogenic glycoside content up to 99.18% level. The sensory scores for BB biscuits in all the attributes (colour, aroma, taste and overall) showed nearly or above seven, indicating public liking between 'like moderately' to 'like very much'. Other fortified biscuits though having zero to negligible amount of cyanogenic glycoside had very poor sensory scores. Likewise, in BOB biscuits fortified with boiled and oven-dried bamboo shoot powder, though 100% of cyanogenic glycoside was removed, the acceptability was very low. The overall score was 6.5 points on hedonic scale which indicates 'like slightly' to 'like moderately'. Similarly, fortified biscuits SOB, SFB, UOB, UFB had a negligible amount of cyanogen glycoside but the overall score was less than five which indicates 'neither like nor dislike' or 'dislike' (Table 2). It was also observed that biscuits fortified with bamboo shoot paste scored higher points on hedonic scale than powder form.

Spearman's rank correlations (r_s) was analysed among the sensory attributes (colour, aroma, textures, overall) and removed cyanogenic glycoside percent (RCG) for 10 different biscuit formulation viz. CB, UB, BB, SB, UFB, BFB, SFB, UOB, BOB, SOB (Table 3). All the sensory attributes viz; colour, aroma, texture, taste and overall showed very weak or negative correlation (r_s<0.2) against RCG. The overall sensory acceptability has a very strong correlation ($0.8<r_s<1$) with the aroma, texture and taste of the fortified biscuits which is highly significant at $P<0.01$. The colour of the fortified biscuit formulation also has a strong correlation (r_s=0.65) with the overall acceptability at a significant level of $P<0.05$.

There are several reports on fortification of food products with bamboo shoots, but this is the first report of sensory index or score on Hedonic scale and analysis of cyanogenic glycoside in bamboo shoot products. The study indicates that maximum sensory acceptability and cyanogenic glycoside removal were observed in bamboo shoots boiled for 20 min and the use of paste form is ideal for fortification of biscuits. The baking temperature of 100 to 200^{0}C is quite sufficient to remove the cyanogenic glycoside to nearly 100%. The most important result of the present study is that bamboo shoot fortification improved all the sensory attributes including colour, aroma, texture, taste and overall, with maximum acceptability on Hedonic scale above seven, whereas control biscuits, without bamboo shoot fortification scored around 6 or below in all the sensory attributes.

Table 3: Spearman's rank correlation for sensory and removed cyanogenic glycoside percent (RCG) of control and different bamboo shoot fortified biscuits using 9-point Hedonic Scale (1-extremely dislike to 9-Extremely Like).

Spearman's Rank Correlations								
			Color	**Aroma**	**Texture**	**Taste**	**Overall**	**RCG**
Spearman's rho	Color	Correlation Coefficient	1.000	.559	.838**	.626	.654*	-.488
		Sig. (2-tailed)		.093	.002	.053	.040	.153
		N	10	10	10	10	10	10
	Aroma	Correlation Coefficient	.559	1.000	.833**	.976**	.976**	.188
		Sig. (2-tailed)	.093		.003	.000	.000	.602
		N	10	10	10	10	10	10
	Texture	Correlation Coefficient	.838**	.833**	1.000	.888**	.887**	-.207
		Sig. (2-tailed)	.002	.003		.001	.001	.564
		N	10	10	10	10	10	10
	Taste	Correlation Coefficient	.626	.976**	.888**	1.000	.994**	.085
		Sig. (2-tailed)	.053	.000	.001		.000	.815
		N	10	10	10	10	10	10
	Overall	Correlation Coefficient	.654*	.976**	.887**	.994**	1.000	.089
		Sig. (2-tailed)	.040	.000	.001	.000		.808
		N	10	10	10	10	10	10
	RCG	Correlation Coefficient	-.488	.188	-.207	.085	.089	1.000
		Sig. (2-tailed)	.153	.602	.564	.815	.808	
		N	10	10	10	10	10	10
** Correlation is significant at the 0.01 level (2-tailed).								
* Correlation is significant at the 0.05 level (2-tailed).								
N =10, fortified biscuits formulation viz. (control biscuit- CB; Biscuits samples fortified with: unprocessed paste- UB; 20 min boiled shoot paste- BB; 24hr soaked shoots paste- SB; unprocessed freeze-dried shoot powder- UFB; 20 min boiled freeze-dried shoot powder- BFB; 24hr soaked freeze-dried shoot powder- SFB; unprocessed oven-dried shoot powder- UOB; 20 min boiled oven-dried shoot powder- BOB; 24hr soaked oven-dried shoot powder- SOB)								

Conclusion

Bamboo is one such plant popularly known for its industrial uses but the consumption of young shoots as food remains neglected. The emerging evidence indicates that bamboo shoot fortification in making common food products have the potential to nourish the malnourished population. The presence of cyanogenic glycoside in bamboo shoots is responsible for the bitter taste and moreover has safety issues. However, the cyanogen content can be removed easily using proper processing techniques. Fortification of biscuits with bamboo shoot was found to be acceptable up to 10% and 20% in powder and paste form respectively. The sensory attributes for colour, aroma, taste and overall acceptability were high in all the products formulated with paste of 20 min boiled shoots except for texture. The cyanogen content in bamboo shoot fortified biscuits was significantly lower and below the permissible level of intake. Hence, processed bamboo shoots can be safely used for making nutritionally rich functional biscuits.

Declaration of competing interest

The authors declare that they have no conflict of interest.

Acknowledgements

The authors are grateful to the Ned Jaquith Foundation and American Bamboo Society for providing financial assistance to conduct this research work.

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