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Quality evaluation of bamboo dietary fibre enriched paneer during storage

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Abstract
Bamboo shoot is a functional food due to the presence of biochemical components like dietary fibre, polyphenols and sterols. Therefore, there exists a great opportunity especially, for the extraction of dietary fibre from bamboo shoots and its utilization in food products as therapeutic agent. The bamboo dietary fibre extracted from the shoots of *Dendrocalamus hamiltonii* was evaluated for chemical characteristics and used for incorporation in paneer. Fibre of various sources is added to dairy products because of its water-holding capacity and its ability to increase the production yield, reduce the lipid retention, reduce syneresis, improve textural properties and structure, and reduce caloric content by acting as a bulking agent. The bamboo dietary was added at 0% (Paneer without enrichment), 0.5, 1.0, 1.5, 2.0 and 2.5% level to the milk. The prepared paneer with different treatments were evaluated for various quality attributes. Paneer with 2.5% bamboo dietary fibre was found to be the best among the treatments with moisture content of 50.23%, protein (15.71%), total dietary fibre (1.51%), titratable acidity as% lactic acid (0.21%) and pH (5.85).

Keywords: Bamboo dietary fibre, paneer, quality, storage

Introduction
Dietary fibre holds all the characteristics required to be considered as an important ingredient in the formulation of functional foods, due to its beneficial health effects. Therefore, it can be used in various applications in the food industry with excellent results. It is not only desirable for its nutritional properties, but also for functional and technological properties (Schieber *et al*. 2001) [26]. In view of the therapeutic potential of dietary fibre, many fibre deficient foods are fortified with dietary fibre from several sources to improve their nutritional value (Guillon and Champ, 2000) [11]. Most of the fibre used as an additive in foods is derived from wheat, oats, defatted rice bran, fractions of grains and multi-fruits, corn, date, apples, citrus, pineapple, pectins, ß-glucans, cellulose beet-root, polydextrose, potato peel and legume (Huang *et al.* 2011 and Yangilar, 2013) [12, 29]. Bamboo is recognized as nutraceutical (Pereira and Beraldo, 2016), hence, bamboo shoot dietary fibre obtained by enzymatic treatment can find potential applications in food and health products as a functional ingredient in different aspects (Wang *et al.* 2017) [28]. Young bamboo culm flour has also been found as a new ingredient for production of healthier food products. The bamboo shoot fibre market for food applications is already established, and it presents a wide variety of applications (Felisberto *et al.* 2017) [9]. Food fortification is a mean of overcoming micronutrient deficiency of some foods. It is also used to enrich some kind of foods by incorporation of nutritionally rich entities. Foods to be fortified are chosen in a way that it is commonly and regularly used by the target consumers. Paneer is a product obtained from the cow or buffalo milk or a combination thereof by precipitation with sour milk, lactic acid or citric acid (FSSAI, 2011). It shall not contain more than 70.00 per cent moisture and the milk fat content shall not be less than 50.00 per cent of the dry matter. The product has a shelf life of 6 days at 10°C (Jagannath *et al*. 2001) [13]. There is no fibre in dairy products (Lunn and Buttriss, 2007) [17]. So, fortifying dairy products with fibre is of increasing interest to create functional foods with health benefits and improve their functionality without compromising the taste and texture (Pal, 2008) [20].

Materials and Methods
The bamboo shoots of *Dendrocalamus hamiltonii* specie was procured from Giripul, Lakothi and Nauni villages of District Solan, in Himachal Pradesh, India. Standardized milk was purchased from local market. Chemicals were provided by Loba chemie, Solan.

The packaging material such as Low Density Polyethylene (LDPE) pouches were purchased from International Scientific and Surgicals, Solan, Himachal Pradesh.

Extraction of dietary fibre from bamboo shoot

The dietary fibre from bamboo powder of *D. hamiltonii* was extracted by following the enzymatic method given by Yi *et al*. (2014) [30]. The extraction was carried out by using three enzymes *viz*. heat stable α – amylase, protease and cellulase. These enzymes were incubated at different time-temperature combinations. The treated sample was filtered through a Whatman No. 1 filter paper and the filtrate was concentrated to one-third of its initial volume using a rotary evaporator at 50°C under vacuum. The concentrated sample was added into a quadruple volume of 95 per cent alcohol and kept undisturbed for 30 minutes. After removing the alcohol, the residue was collected and oven-dried at 60°C for 5 hours in order to obtain dietary fibre. The extracted dietary fibre was ground into fine powder using a grinder and sieved with stainless steel sieve (No. 36). The ground dietary fibre powder was then stored in LDPE pouches for further use.

Preparation of paneer

The paneer was prepared by using cow's milk and citric acid. Standard method described by Chauhan and Chandra (2016) [7] was followed for the paneer preparation. The whole milk (Verka packet milk - 6% fat) and rehydrated bamboo dietary fibre was heated to 82°C for 5 minutes and then allowed to cool to 70°C. At the same time, citric acid solution of 1.0% was heated to 70°C and added to the milk and dietary fibre mixture with continuous stirring till coagulation and clear transparent greenish yellow whey separated. After coagulation, the contents were left undisturbed for 5 minutes and filtered in order to remove the whey. The coagulum was transferred to hoops and pressure was applied for about 15 minutes. The paneer prepared was packed in LDPE pouch and stored at refrigerated condition.

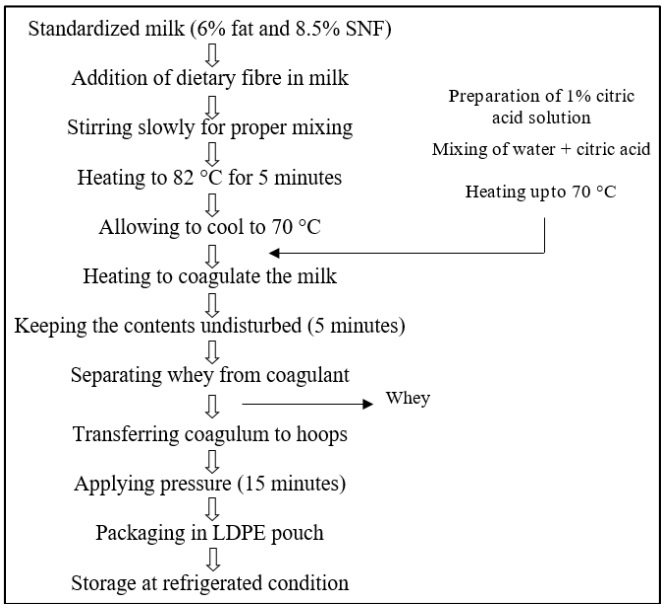

Fig 1: Unit operations for preparation of paneer

Chemical characteristics of fibre enriched paneer

Moisture and titratable acidity (% lactic acid) were determined using standard (AOAC, 2005) [4] methods, pH was determined by using a digital pH meter (CRISON Instrument, Ltd., Spain), total solids content was determined by (AOAC, 2012) [2]. Fat was determined according to Rose Gottlieb method (1988). Protein was determined by titration using Pyne's method (Pyne, 1932) [22]. The total dietary fibre was determined by AOAC (2016) [3] standard method.

Sensory analysis of fibre enriched paneer

The paneer prepared with different treatments was subjected to sensory evaluation (9-point hedonic scale) following standard procedure described by Ranganna (2009) [24]. Ten judges comprising of faculty members and post graduate students of the department of Food Science and Technology, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP) were selected to evaluate the products. The parameters considered for the evaluation were appearance, texture, aroma, taste and overall acceptability.

Statistical analysis:

Data on chemical and functional characteristics of bamboo shoot powder and pasta was analysed by Completely Randomized Design (CRD) suggested by Cochran and Cox (1967) [8]. While Randomised Complete Block Design (RBD) as described by Mahony (1985) [18] was used to analyze the data pertaining to sensory evaluation. The experiment for recipe standardization and storage studies was replicated three times.

Results and Discussion:

Chemical and functional characteristics of bamboo dietary fibre:

The proximate composition of dietary fibre extracted from the shoots of *Dendrocalamus hamiltonii* is shown in Table 1. The data showed that bamboo dietary fibre was rich in minerals, total dietary fibre, total carbohydrates, energy value, antioxidant activity, water holding capacity and very low in crude fat. The hydrogen cyanide content was also found to be in the safe limit for human consumption. All these quality attributes make the bamboo shoot powder an ideal food. The total dietary fibre and crude protein content of the bamboo shoot powder was found to be 20.34% and 10.49%, respectively. The high content of protein and total dietary fibre in bamboo shoot powder made it a suitable ingredient for nutritional supplementation in food.

Table 1: Chemical and functional characteristics of bamboo shoot powder

Characteristics	Bamboo dietary fibre (Mean ± SD)
Chemical characteristics	
Moisture (%)	6.12 ± 0.06
Crude fat (%)	0.12 ± 0.07
Crude protein (%)	2.52 ± 0.07
Total dietary fibre (%)	70.25 ± 0.06
Hydrogen cyanide (mg/100 g)	9.14 ± 0.05
Antioxidant capacity (%)	66.87 ± 0.04

Chemical characteristics of different treatments of paneer

The chemical characteristics of different treatments of paneer (T_1, T_2, T_3, T_4, T_5 and T_6) are shown in Table 2. The moisture content and titratable acidity (% lactic acid) decreased with increased level (2.5%) of bamboo dietary fibre incorporation. The decrease in moisture was recorded to be from 54.18 in T_1 to 50. 78% in T_6 (2.5% level of incorporation). The decrease in titratable acidity was observed to be from 0.26 in T_1 to 0.21% in T_6. Protein, total dietary fibre, pH and total solids increased with increased level of incorporation. Protein content varied from15.32 in T_1 to 15.47% in 1.5% in T_6.

Increase in total dietary fibre was from 0.00 in T_1 to 15.47% in T_6. With increased level of addition, the pH of paneer increased from 5.72 in T_1 to 5.83 in T_6. The total solids varied from 45.19 in T_1 to 49.22% in T_6.

Table 2: Analysis of bamboo dietary fibre enriched paneer

Treatment	Moisture (%)	Protein (%)	Total dietary fibre (%)	Titratable acidity as% lactic acid	pH	Total solids (%)
T_1 (100:0)	54.81	15.32	0.00	0.26	5.72	45.19
T_2 (100:0.5)	54.42	15.35	0.29	0.25	5.74	45.58
T_3 (100:1.0)	54.03	15.38	0.57	0.23	5.75	45.97
T_4 (100:1.5)	53.31	15.41	0.84	0.23	5.78	46.69
T_5 (100:2.0)	52.13	15.43	1.03	0.21	5.81	47.87
T_6 (100:2.5)	50.78	15.47	1.51	0.21	5.83	49.22
$CD_{0.05}$	0.10	0.09	0.07	NS	0.06	0.08

T_1 = 100 mL milk : 0% bamboo dietary fibre
T_2 = 100 mL milk : 0.5% bamboo dietary fibre
T_3= 100 mL milk : 1.0% bamboo dietary fibre
T_4= 100 mL milk : 1.5% bamboo dietary fibre
T_5= 100 mL milk : 2.0% bamboo dietary fibre
T_1 = 100 mL milk : 2.5% bamboo dietary fibre

Sensory analysis of different treatments of paneer

Sensory analysis results for all six treatments of paneer are given in Table 3. The appearance, texture, aroma, taste and overall acceptability of paneer was acceptable till 2.5% level of incorporation of bamboo dietary fibre. Considering the appearance, texture, aroma, taste and overall acceptability, paneer of acceptable quality can be prepared using 2.5% of bamboo dietary fibre. The treatment T_6 (2.5% bamboo dietary fibre) which had the highest sensory scores was selected and kept for storage and evaluated at an interval of 0, 5 and 10 days at refrigerated condition.

Table 3: Sensory analysis of different treatments of paneer

Treatments	Appearance	Texture	Aroma	Taste	Overall acceptability
T_1 (100:0)	8.07	8.03	7.89	8.03	8.08
T_2 (100:0.5)	8.15	8.13	8.11	8.13	8.16
T_3 (100:1.0)	8.18	8.19	8.15	8.15	8.19
T_4 (100:1.5)	8.23	8.25	8.18	8.19	8.22
T_5 (100:2.0)	8.29	8.28	8.24	8.21	8.26
T_6 (100:2.5)	8.34	8.31	8.28	8.27	8.29
$CD_{0.05}$	0.13	0.09	0.09	NS	0.06

T_1 = 100 mL milk : 0% bamboo dietary fibre
T_2 = 100 mL milk : 0.5% bamboo dietary fibre
T_3= 100 mL milk : 1.0% bamboo dietary fibre
T_4= 100 mL milk : 1.5% bamboo dietary fibre
T_5= 100 mL milk : 2.0% bamboo dietary fibre
T_1 = 100 mL milk : 2.5% bamboo dietary fibre

Effect of storage on chemical characteristics of paneer stored at refrigerated (4±1°C) condition

The data appended in Table 3 showed the changes in chemical characteristics of paneer during 10 days storage. The moisture increased from 54.81 to 56.65% in T_1 and increase from 50.78 to 52.18% was observed in T_2 during 10 days storage. An increase in moisture content of paneer during storage was also revealed by Rao *et al*. (1984) [25], Pal *et al*. (1998) [21] and Gokhale *et al*. (2016) [10] while Mistry *et al.* (1990) [19] noted no significant change in moisture content on storage of paneer for 7 days under refrigeration.

The protein content in paneer was found to decrease. The T_1 varied from 15.32 to 15.22% protein while T_2 decreased from 15.47 to 15.39% during 10 days storage. These changes might have been caused due to denaturation of thermally unstable protein during storage. Gokhale *et al*. (2016) [10] also noticed changes in protein content of paneer during storage. Total dietary fibre in paneer was found to increase from 1.51 to 1.48% in T2 during 10 days storage.

The titratable acidity (% lactic acid) in paneer increased with an advancement in storage period. The increase was from 0.26 to 0.33% in T_1 and 0.21 to 0.28% in T_2. The increase in acidity during storage period may be proliferation of microorganisms and changes brought therein. The results are in accordance with results obtained by Mistry *et al*. (1990) [19], Arora *et al*. (1996) [5], Rai *et al*. (2008) [23], Ahuja and Goyal (2012) [1], Khatkar *et al*. (2017) [14] and Kumar *et al*. (2019) [16]. Contrary to these findings, Kumar and Bector (1991) [15] noted no change in titratable acidity in paneer samples stored at 5 ºC for 14 days. However, at higher temperatures of 15 ºC and 25 ºC, pronounced changes in titratable acidity were observed.

The pH of paneer showed a decreasing trend during storage. The variation in T_1 was from 5.72 to 6.54 and 5.85 to 5.81 in T_2. Decrease in pH of paneer during storage was also reported by Bhattacharya *et al*. (1971), Pal (1998) [21] and Rai *et al*. (2008) [23]. On the other hand, Arora and Gupta (1980) [5] reported an increase in the pH of paneer on 3rd and 6th day of storage at 10 ºC.

Total solids in paneer decreased with increase in storage. The decrease was from 45.19 to 43.35% and 49.22 to 47.82% in T_1 and T_2, respectively during 10 days of storage. The decrease in total solids could be due to increase in moisture content during storage. Decrease in total solids of paneer during storage was also reported by Sughanya and Ramaswamy (2017) [27].

Table 3: Effect of storage on chemical characteristics of paneer

Parameters	Storage intervals (days)					
	0		5		10	
	T_1	T_2	T_1	T_2	T_1	T_2
Moisture (%)	54.81	50.78	55.13	50.99	56.65	52.18
Protein (%)	15.32	15.47	15.28	15.44	15.22	15.39
Total dietary fibre (%)	0.00	1.51	0.00	1.50	0.00	1.48
Titratable acidity (% Lactic acid)	0.26	0.21	0.29	0.24	0.33	0.28
pH	5.72	5.85	5.69	5.81	5.64	5.81
Total solids (%)	45.19	49.22	44.87	49.01	43.35	47.82

T_1 = Paneer (without enrichment)

T_2 = Paneer enriched with 2.5% bamboo dietary fibre

Conclusion

It can be concluded from the study that bamboo shoots are rich sources of dietary fibre which have functional properties and can be used for nutritional supplementation in dairy products such as paneer as milk products do not have fibre. Paneer enriched with 2.5% bamboo dietary fibre showed higher protein (15.47%), total dietary fibre (1.51%), pH (5.83) and total solids (49.22%) than the control sample. Thus, bamboo dietary fibre can helpful from the therapeutic point of view for the people suffering from digestive disorder, gut health, diabetes, congenital heart disease and obesity.

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