Nutrient, antioxidant and anti nutrient composition of value added products made with underutilized forest produce bay leaf (*Cinnamomum tamala)*

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Abstract: This study made an attempt to develop value added products (bay leaf tea powder, bay leaf saffron tea powder, bay leaf basil tea powder, bay leaf mint sparkle powder, bay leaf spice cubes and bay leaf spice mix) with underutilised forest produce bay leaf. The developed products were evaluated for sensory acceptability and the best acceptable products (bay leaf tea powder and bay leaf spice cube) were evaluated for nutrient, antioxidant and anti-nutrient composition in comparison with fresh bay leaf. The results indicated that bay leaf tea powder was rich in ash (18.67 ± 1.21) and protein (12.91 ± 0.81) content and bay leaf spice cube was rich in crude fiber (10.50 ± 2.79) content. The highest amount of proline (4.15 ± 0.11), phenols (8.73 ± 0.10), ascorbate (14.38 ± 0.40), flavonoids (36.58 ±0.61) and reduced glutathione activity (14.20 ± 0.25) were found in bay leaf tea powder compared to bay leaf spice cube and fresh bay leaf. 2,2-diphenyl-2-picryl hydrazyl (DPPH) (92.23 ± 0.24) and hydroxyl activity (0.03 ± 0.00) were higher in bay leaf spice cube. Tannin content (9.28±0.76) and phytic acid content (149.53±24.73) were higher in bay leaf tea powder compared to other products. Results of the study show that bay leaf and its products are sources of natural antioxidants and are rich in nutrients like fiber, minerals and proteins. The processing and marketing of this underutilized forest produce is capable of creating employment and economic opportunities through various value-added products processing activities, which can improve the food security of the forest communities.

Keywords: bay leaf, underutilized, nutrient, antioxidant, value addition

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1 Introduction

Bay leaf (*Cinnamomum tamala;* Family: *Lauraceae)*, an aromatic spice, is widely distributed in the tropical and subtropical Himalayas at an altitude of 900-2500 m in the regions of Khasi hills, Nilgiri hills, Meghalaya, Manipur and at the foot of Sikkim Himalayas (Shah and Panchal, 2010). Bay leaves commonly called as 'Tejpatta' are used as spice, stimulant, carminative, anti-bacterial and anti-fungicidal and also in the treatment of rheumatism, diarrhoea, colic, enlargement of spleen and snakebite (Virendra et al., 2012). Bay leaf, a famous culinary ingredient, is made with mature dried *cinnamomum tamala* leaves (Raman et al., 2017). These leaves are very aromatic and are used as medicines to treat various health ailments in Ayurveda (Peter, 2006) apart from its use as a

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condiment. The bark of bay leaf called as cinnamon is aromatic and is very commonly used as spice ingredient. These aromatic spicy leaves are used extensively to prepare delicious Biryani's, Mughlai's vegetarian and non-vegetarian dishes and spice powders etc (Katona-Apte, 1975). There are lots of health benefits with this herbal leaf as it works as the best antioxidant, anti-diabetic, diuretic and appetite stimulants (Magee, 2005). These leaves also contain many important chemical compounds, minerals, vitamins and essential oils like cineol (50%) eugenol, chavicol, acetyl eugenol, methyl eugenol, α and ß-pinene, phellandrene, linalool, geraniol, and terpineol (Leela, 2008). These essential oils are used in many traditional practices of medicine for the treatment of arthritis, muscle pain, bronchitis and flu-symptoms (Ebadi, 2010).

The fresh leaves are rich in vitamin C, dietary fiber and B-vitamins such as niacin, pyridoxine, pantothenic acid and riboflavin, vitamin A, natural antioxidants and also are proven to protect from lung and oral cavity cancers (Roberts and Moreau, 2016). The leaves help in enzyme synthesis, nervous system function and regulating body metabolism (Herman et al., 2006). Traditionally, bay leaves are picked and dried slowly under the shade away from direct sunlight to retain their volatile essential oils. The fresh dark-green leaves are used in tea preparation and culinary dishes to enhance the flavour. However, the dried leaves also give their best flavour after drying under the shade for few days till their bitterness is gone, but still retaining its aroma.

Over the years, *C. tamala* has emerged as a semi-domesticated tree that provides supplementary income to the forest dwellers and local tribal communities of in Manipur and Meghalaya states of India. About 2800 MT of bay leaf reaches the regulated market every year from Meghalaya at an average purchase price of Rs 7 kg^{-1}, bringing approximately Rs 20 million cash to the growers (Karki et al., 2003). The processing and marketing of this forest produce can create further opportunities for setting up of small-scale industries at the local and regional level. Though the bay leaf is found abundant in north east India, it is still not been utilized to its fullest potential. However, lack of knowledge on primary processing and secondary processing technologies, value addition, marketing, has inhibited the growth of its production. By developing products and processing technologies, bay leaf value added products can fetch more income to the farmers who can start their own enterprise with a variety of bay leaf products. In this context, the following processing methods were developed to make use of bay leaf in the present study.

2 Methodology

Fresh bay leaves were procured from ICAR- NEH complex of Manipur, Imphal, India. Other ingredients were purchased from local market in Hyderabad, India to develop different bay leaf value added products at Quality Control Laboratory, PJTS Agricultural University, Hyderabad.

2.1 Primary processing

Freshly plucked bay leaves were washed thoroughly under fresh tap water to remove dust and extraneous material. Later the petioles of the leaves were removed and adhering moisture was removed with dry muslin cloth. The cleaned fresh bay leaves were dried in a tray drier at 40 - 45°C for 8 hours followed by cooling in room temperature (Consuelo et al., 2002; Idris et al., 2011). The dried bay leaves were ground into course flakes by using pulveriser and sieved for even textured powder/flakes using Waring Commercial Blender (WCG75, Torrington, CT) at medium speed for 2 min. The powder obtained was sieved using a sieve analyser (Redmond and Griffith, 2003) and was vacuum packed in a Metalized Polyethylene Terephthalate (MPET) with OTR of 0.95 cc m^{-2} day^{-1} and WVTR of 1.2 g m^{-2} day^{-1} and stored at room temperature i.e., 33°C±3°C until further use. The bay leaf powder obtained was used in the preparation of secondary processed products.

2.2 Secondary processing

2.2.1 Bay leaf tea variants

Bay leaf Tea Powder (BTP) was prepared with bay leaf powder (75% by mass) in combination with dried ginger, cinnamon and cardamom powders. The bay leaf saffron tea powder (BSTP) was prepared using bay leaf (38% by mass) in combination with saffron, cardamom, dry ginger and cinnamon powders. Bay leaf Basil Tea

Powder (BBTP) was prepared using bay leaf powder (73% by mass) in combination with dehydrated basil, ginger powder, cardamom powder. Bay leaf Mint sparkle Powder (BMSP) was developed using bay leaf powder (77.80% by mass) along with other ingredients such as dehydrated mint leaves, ginger and black salt (Sparkle soda was added while serving the infusion). The infusion (tea) was prepared by adding ½ tea spoon of bay leaf tea powder to 200 mL water and boiled for 10 minutes and filtered. Later few drops of lemon juice and sugar were added to serve as tea.

2.2.2 Bay leaf spice cubes (BSC)

Bay leaf (18.01% by mass) Spice Cubes were prepared using a combination of various Indian spices (cinnamon, cardamom, Mace, caraway seeds, ginger garlic, nut mug, star anise, cloves, kapok buds, rice flour, mint and salt). All the spices were mildly roasted and powdered. Using a binding agent (rice flour gel), the spice mix was made into a thick paste and cut into cube shapes (about 15 mm ($^1\!/_2$ in) wide). The cut cubes were dried in tray drier at 45ºC - 50ºC for 48 hours, to get bay leaf spice cubes. These cubes were mildly roasted in oil before adding boiling water, vegetables and rice for making quick delicious biryani instantly without adding any spices**.**

2.2.3 Bay leaf spice mix (BSM)

Bay leaf Spice Mix was made using bay leaf (22.31% by mass) and other spices (dry king chilli, cinnamon, cloves, cumin seeds, cardamom, curry leaves, poppy seeds, ginger, garlic, coriander seeds). The spice mix can be added to fried or roasted gravy vegetarian or non-vegetarian dishes.

Bay leaf value added products were formulated after 6 to 8 trials to get the best taste and acceptability. After the final standardization, they were evaluated by 25 taste panel members for sensory acceptability for various sensory parameters like colour, flavour, texture, taste and overall acceptability (Meilgaard et al., 1999) at Post Graduate and Research Centre (PGRC), PJTSAU. The data was collected as mentioned on a 9-point hedonic scale with a maximum score of 9 (like extremely) and minimum score of 0 (dislike extremely) as per standard procedure. The results of all six products were analysed statistically by using simple CRD (Snedecor and Cochran, 1980). Two bay leaf products out of six products developed were chosen for further analysis in comparison with fresh bay leaf sample. Nutrient composition, anti nutrient composition, antioxidant potential and radical scavenging activity of the selected products were performed as per following procedures.

2.3 Nutrient composition

Moisture, ash, crude fat, crude fibre, crude protein of the samples was determined according to the AOAC (2012) methods.

2.4 Anti-nutrients

Malondialdehyde (MDA) content was determined by Buege and Aust (1978) method. MDA concentrations were calculated by means of an extinction coefficient of 155 mmol L^{-1} cm^{-1}. Tannin content was determined by using Vanillin hydrochloride method (Robert, 1971). Ground sample (0.5 g) in 5 mL methanol was centrifuged after allowing to stand for 20-28 hr. To 1 mL of the supernatant, 5mL of vanillin hydrochloride reagent was quickly added, homogenised and absorption was read at 500 nm after 20 min on a UV visible spectrophotometer. Vanillin hydrochloride reagent was used as blank and catechin as standard. Phytic acid content was determined by the method of Wheeler and Ferrel (1971). 100 mL of the sample was extracted with 3% trichloroacetic acid. The extract was treated with $FeCl_3$ solution and the iron content of the precipitate was determined using Atomic Absorption spectrophotometer (Elico SL159). A 4:6 Fe/P atomic ratio was used to calculate the phytic acid content (Okon and Akpanyung, 2005).

2.5 Anti-oxidant properties

Proline content was determined using method described by Bates and Schlabach (1973). A reaction mixture of 2 mL supernatant (0.5 g samples extracted with 10 mL) + 2 mL acid-ninhydrin + 2 mL glacial acetic acid was used for the determination. The chromophore containing toluene was read at 520 nm in a UV Visible spectrophotometer. Total phenol content was analysed by the method of Singleton et al. (1999). To 1 mL extract, 1 mL of Folin-Ciocalteau reagent, 2 mL of 20% Na_2CO_3 solution was added, heated in a boiling water bath for one

min and then cooled. The blue solution (diluted upto 25 mL) was recorded at 650 nm and Catechol (Hi Media, India) was used as a standard.

Ascorbic acid (ASA) was determined according to Mukherjee and Choudhuri (1983) method by reading the absorbance of reaction of the extract (0.2 g sample with 5 mL of 6% TCA; 2% dinitrophenyl hydrazine (in acidic medium); 10% thiourea in 70% ethanol) in acidic medium at 530 nm. Total carotenoid content was analysed using the protocol described by Jensen (1978) with slight modification. 100 mg sample was ground with 5 mL distilled acetone. After centrifugation, the supernatant was made up to 10 mL with 80% acetone and read at 480 nm and 510 nm. Carotenoids present in the sample was calculated and total carotenoid content were expressed as mg g^{-1} of sample. Reduced Glutathione was examined as per method described by Moron (1979). Homogenate of 0.1mL (extracted using 0.5 g sample) was used for the study and final absorbance of reaction mix was read at 412 nm and GSH was used as standard.

One gm of sample was extracted with 10 mL of aqueous methanol (80% v v^{-1}) at ambient temperature with agitation for 18-24 hr. The extracts were filtered and aliquot was analysed for flavonoid content and reducing power capacity. Total flavonoid content was determined according to Ordoñez et al. (2006). To 0.5 mL of the sample, 0.5 mL of 2% $AICl_3$ ethanol solution was added and kept for one hr at room temperature. Absorbance was measured at 420 nm.

2.6 Radical scavenging activities

Method described by Benzie and Strain (1996) was used for the study of FRAP (Ferric Reducing Antioxidant Power) activity. Exactly 2850 µL of freshly prepared FRAP solution was allowed to react with 150 µL of the extracts for 30 min at 37°C. Reading was taken at 593 nm and known concentrations of $FeSO_4$ was used as standard. Reducing power was analysed using the method of Oyaizu (1986). A 100 µl extract was mixed with 2.5 mL each of 0.2 M phosphate buffer and 1% potassium ferricyanide solution. The absorbance of reaction mix was measured at 700 nm and ascorbic acid was used as a standard.

DPPH (2,2-diphenyl-2-picryl hydrazyl) activity was estimated using Blois (1958) method. Solution mixtures of 100 µL of sample extracts and 3.9 mL of 0.5 mM DPPH were incubated for 30 min at 25ºC in dark. The discolourisation of the purple colour was measured at 518 nm. Percent scavenging activity was calculated. ABTS {2,2'-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid} activity was determined by using the method of Re et al. (1999). To 980 µL of ABTS solution, 20µL extract was added. The absorbance was read at 745nm after 10min and the percent inhibition was calculated. Hydroxyl Radical Scavenging activity (HRS) activity was carried out using the procedure reported by Elizabeth and Rao (1990). To a buffer reaction mixture of 0.98 mL, 20 µL was added to the mixture and then incubated for one hr at 37°C, followed by addition of 0.5 mL each of TBA and HCl. After heating the mixture in a boiling water bath for 20 min, it was cooled and measured at 532 nm. The percent inhibition was calculated.

3 Results and discussion

3.1 Sensory analysis of bay leaf products

The best two products which received high sensory acceptability ie., BTP and BSC were selected for further analysis (nutritive value, antioxidant properties, radical scavenging activity and anti nutrients) along with fresh bay leaf sample (as a control). Results of sensory evaluation are presented in Table.1. The highest score for colour was found for BSTP (7.93 ± 0.15), followed by BTP (7.80 ± 0.20) and BSP (7.73 ± 0.22). Saffron and its oleoresin extracted from flowers of *Crocus sutivus*, are known for their yellow orange colour and aroma, which are predominately used to give colour, flavor and aroma to various foods in the food industry (Wani et al., 2011). The BSTP colour was well appreciated by the panellists, which could be due the colour and aroma imparted by incorporation of saffron along with bay leaves. The highest score for flavour was recorded in BTP (8.20± 0.29), followed by BSC (7.80 ± 0.22), BMSP (7.33 ± 0.18), BSTP (7.26 ± 0.20) and BBTP (7.20 ± 0.26). BSC obtained highest score (7.66 ± 0.25) for its texture also. Taste was rated the highest for BSC (8.07 ± 0.15)

followed by BTP (7.66± 0.18), BBTP (7.46 ± 0.29), BMSP (7.40± 0.34).

Table1 Sensory scores of bay leaf products

S. No	Products	Colour	Flavour	Texture	Taste	O.A
1	BTP	7.80 ± 0.20 [a]	8.20±0.29 [c]	7.40± 0.34 [ab]	7.66± 0.18 [bc]	7.73± 0.20 [b]
2	BSTP	7.93± 0.15 [a]	7.26 ±0.20 [ab]	7.46 ± 0.29 [ab]	7.13± 0.32 [ab]	7.46± 0.25 [ab]
3	BBTP	7.46 ± 0.23 [a]	7.20 ±0.26 [ab]	7.53 ± 0.29 [b]	7.46 ± 0.29 [abc]	7.46± 0.25 [ab]
4	BMSP	7.33 ± 0.25 [a]	7.33 ±0.18 [ab]	7.46 ± 0.25 [ab]	7.40± 0.34 [abc]	7.60± 0.27 [ab]
5	BSC	7.73 ± 0.22 [a]	7.80 ±0.22 [bc]	7.66 ± 0.25 [b]	8.07 ± 0.15 [c]	8.00± 0.16 [b]
6	BSM	7.40±0.23 [a]	7.00 ± 0.35 [a]	6.66 ± 0.30 [a]	6.86 ± 0.32 [a]	6.93± 0.33 [a]

Note: Values are expressed as mean ± standard deviation of three determinations; Comparisons at P<0.05% level; OA-Overall acceptability

Results of overall acceptability indicated that BSC received the highest score (8.00± 0.16) among all other bay leaf products, followed by BTP (7.73±0.20), BMSP (7.60 ±0.27). BBTP and BSTP received the same scores for overall acceptability (7.46±0.25). Least overall acceptability score was obtained for BSM (6.93± 0.33) as compared to other bay leaf products. Ozek, (2012) reported that dried bay leaves were mainly used as a spice, which improved flavor for soups, meats, fish, vinegars, and beverages and had been an important part of the Mediterranean diet.

3.2 Nutrient composition of fresh bay leaf and selected bay leaf products

The moisture, ash, crude fat, crude fiber and protein content of the fresh and processed bay leaf products are given in Table 2. Moisture content of the processed products was 6.17% ± 1.76% in BTP and 5.73% ± 0.15% in BSC, indicating that the product can be stored (at ambient conditions in proper packaging) for a long duration due to the very low moisture content. However fresh bay leaf had a moisture content of 39.10% ±1.45%. Ash content increased considerably in BTP (18.67% ± 1.21%), which could be due to the addition of other ingredients, which in turn contributed to the increase in ash content. BSC had ash content of 6.40% ± 0.66% compared to that of 2.70% ± 2.09% in fresh bay leaf, which also could be due to the addition of various other ingredients. Crude fat content reduced in BTP (1.30 ± 0.38) and BSC (2.73 ± 0.20), when compared to fresh bay leaf (4.58 ± 1.18). Higher amount of fibre was present in fresh bay leaf (39.23 ± 4.78) followed by BSC (10.50 ± 2.79). Protein content was also higher in fresh bay leaf compared to BTP (12.91 ± 0.81) and BSC (10.35 ± 0.76 mg).

Table 2 Nutrient composition of fresh bay leaf, bay leaf tea powder (BTP) and bay leaf spice cubes (BSC)

Sl. No.	Products	Moisture content (%)	Ash content (%)	Crude Fat (%)	Crude Fibre (%)	Protein (mg g^{-1} FW)
1	Bay leaf Fresh	39.10±1.45	2.70±2.09	4.58±1.18	39.23±4.78	19.84±0.73
2	BTP	6.17±1.76	18.67±1.21	1.30±0.38	2.33±0.45	12.91±0.81
3	BSC	5.73±0.15	6.40±0.66	2.73±0.20	10.50±2.79	10.35±0.76

Note: Values are expressed as mean ± standard deviation of three determinations

3.3 Antioxidant properties of fresh bay leaf and selected bay leaf products

Results of antioxidant properties (Table. 3) indicated that BTP had the highest amount of proline (4.15 ± 0.11), phenols (8.73 ± 0.10), ascorbate (14.38 ± 0.40), flavonoids (36.58 ± 0.61) and reduced glutathione activity (14.20 ± 0.25) compared to BSC and fresh bay leaf. Various processes applied on bay leaf samples all through the supply chain ie., pre-harvest conditions, storage conditions, postharvest handling, processing, preparation and preservation, could contribute to the degradation of ascorbic acid. However, the maturity at harvest and the genetic variations between samples also can influence ascorbic acid content (Howard et al., 1999). Carotenoid content was the highest in the fresh bay leaf (9.52 ± 0.28) sample in the present study, which could be lost in the products during drying of the bay leaves. Antioxidant activity in wild *L. nobilis* leaves was reported in infusions by Dall'Acqua et al. (2009); methanol/water extracts by Conforti et al. (2006) and ethanol and aqueous extracts by Kaurinovic et al. (2010) and Ramos et al. (2012). Flavonoids namely as kaempferol, luteolin, quercetin, apigenin, myrcetin derivatives and flavanols have been reported as most abundant phenolic components found in bay leaves (Lu et al., 2011; Dall'Acqua et al., 2009). Antioxidant properties exhibited

in bay leaves were due to the hydroxyl groups attached to the ring structure of flavonoids, which enable them to act as hydrogen donators, reducing agents, radical scavengers and metal chelators, preventing oxidative stress, the main cause of death in cells (Carocho and Ferreira, 2013).

Table 3 Antioxidant properties in fresh bay leaf, bay leaf tea powder (BTP) and bay leaf spice cubes (BSC)

Sl. No	Products	Proline (µ moles gm^{-1} FW)	Phenol (mg g^{-1} FW)	Ascorbate content (mg g^{-1} FW)	Total Flavonoides (mg g^{-1} FW)	Total Carotenoides (mg g^{-1} FW)	Reduced glutathion (uM g^{-1} FW)
	Bay leaf						
1	Fresh	1.74±0.05	6.38±0.20	8.61±0.04	23.82±0.84	9.52±0.28	3.00±0.12
2	BTP	4.15±0.11	8.73±0.10	14.38±0.40	36.58±0.61	2.50±0.02	14.20±0.25
3	BSC	1.82±0.02	7.54±0.03	11.19±0.05	35.53±0.59	3.23±0.03	2.70±0.09

Note: Values are expressed as mean ± standard deviation of three determinations

Oxidative stress is identified as an imbalance between production of reactive species and antioxidant defence activity, and an increase in antioxidants is directly associated with the reduction of degenerative diseases like cancer, diabetes, neurodegenerative and cardiovascular diseases (Carocho and Ferreira, 2013). Reducing power assay measures the electron-donating capacity of an antioxidant and is indicative of higher reducing activity (Kavitha et al., 2015). Hence the study of radical scavenging activity is of importance in knowing the functional attributes of any product. Radical scavenging activity of fresh and bay leaves products is given in Table 4. FRAP (7.14 ± 0.18) and ABTS activity (97.31 ± 0.23) were higher in fresh bay leaf, where as DPPH (92.23 ± 0.24) and hydroxyl activity (0.03 ± 0.00) were higher in BSC. Reducing power (0.30±0.002) was the highest in BTP. DPPH activity also was high in BTP (90.81±0.33), compared to fresh bay leaf. The results indicated that processing (drying) had altered the radical scavenging activity as compared to fresh bay leaves. Papageorgiou et al. (2008) stated that use of different drying methodologies had an influence on the antioxidant activity of bay leaves.

Table 4 Radical scavenging activity (RSA) in fresh bay leaf, bay leaf tea powder (BTP) and bay leaf spice cubes (BSC)

Sl. No	Products	FRAP (mg equi Fe g^{-1} FW)	Reducing Power (mg g^{-1} FW)	DPPH (% activity)	ABTS (% activity)	Hydroxyl Radical (% activity)
1	Bay leaf Fresh	7.14±0.18	0.20±0.003	69.31±0.04	97.31±0.23	0.01±0.00
2	BTP	1.17±0.03	0.30±0.002	90.81±0.33	66.85±0.61	0.01±0.00
3	BSC	1.10±0.02	0.17±0.006	92.23±0.24	43.74±0.40	0.03±0.00

Note: Values are expressed as mean ± standard deviation of three determinations

There is an increasing interest in natural antioxidants and bioactive components, present in medicinal plants, that might help prevent oxidative damage (Behl and Mosmann, 2002). The results of antioxidant activity and reducing power of bay leaf products indicated that BTP infusion if consumed on a regular basis, can enable excellent antioxidant effect, due to the quantum of antioxidant activity, phenols and flavanoids present in the product.

3.4 Anti-nutrient composition of fresh bay leaf and bay leaf products

Malondialdehyde (MDA) is the most frequently used biomarker of oxidative stress in many health problems such as cancer, psychiatry, chronic obstructive pulmonary disease, asthma, or cardiovascular diseases. Estimating the extent of lipid peroxidation, has high significance in pathologies and in toxicology associated with oxidative stress (Grotto et al., 2009). According to Table 5, quantification of malondialdehyde as a biomarker of oxidative stress is of great importance, and the results of present study indicated that fresh bay leaf had the highest quantity of MDA (16.54 ± 0.52), followed by BSC (12.42±0.08) and BTP (11.55±0.22). The tannin content (9.28±0.76) and phytic acid content (149.53±24.73) was the highest in BTP as compared to others. Tannins and phytic acids are labelled as anti nutrients due to the binding of important minerals in the body, leading to poor bioavailability. However, several known compounds found in tea were shown to enhance insulin activity due to epigallocatechin gallate followed by epicatechin gallate, tannins, and theaflavins as reported by Richard and Marilyn(2002).

Table 5 Anti-nutrient composition of fresh bay leaf, bay leaf tea powder (BTP) and bay leaf spice cubes (BSC)

Sl. No	Products	MDA content (nmol mg^{-1} FW)	Tannin (mg g^{-1} FW)	Phytic Acid (mg g^{-1} FW)
1	Bay leaf Fresh	16.54±0.52	4.85±0.01	76.32±34.44
2	BTP	11.55±0.22	9.28±0.76	149.53±24.73
3	BSC	12.42±0.08	2.20±0.05	338.01±2.70

Note: MDA-Malondialdehyde ,FW-Fresh weight. Values are expressed as mean ± standard deviation of three determinations

As per the results of present study, it is evident that bay leaf and its products are good sources of natural antioxidants and are rich in nutrients like fiber, minerals and proteins. The processing and marketing of this underutilized forest produce is capable of creating opportunities for setting up of small-scale industries at the local and regional level through various value-added products. The bay leaf and its value-added products can help in improving the economy of people cultivating it, by providing additional source of income to the landowners, whereas the landless locals can obtain daily wages. In a cluster of villages near Dowki about 80 km south of Shillong, bay leaf tree (*Cinnamomum tamala*) sale has sizable national market. Bay leaf processing can enhance the utilization of the produce through value added processing which in turn can increase cash earnings to the local people (Karki, 2003). Medicinal plants like bay leaf and its products have the potentials to be served as green health alternatives (Bordeker, 2002). However, lack of knowledge, concerning the processing techniques and marketing of these products outside the local region, has inhibited the growth of its production and utilization. Training programmes on primary and secondary processing of bay leaf products can be imparted to enhance the livelihoods of the local tribals and farmers growing bay leaf.

4 Conclusion

Among the six products developed using bay leaf powder, BTP and BSC were well acceptable as per results of sensory evaluation. Anti-oxidant properties such as total flavanoids, ascorbate and phenol content were higher in BTP and BSC when compared to fresh bay leaves. DPPH activity increased in both the processed products (90.81±0.33 in BTP and 92.23±0.24 in BSC), when compared to that of fresh leaves (69.31±0.04). MDA content reduced after processing, while tannins and phytic acid content slightly increased. However, very few products are available in the current market which use bay leaf as major ingredients. Hence the products developed in the present study (BTP, BSTP, BMSP, BSC and BSM) can contribute to the additional income to the farmers growing bay leaf by starting small enterprises after getting required training in the processing techniques.

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