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Site factor on nutritional content of *Arundinaria alpina* and *Oxytenanthera abyssinica* bamboo shoots in Ethiopia

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The objective of this study was to characterise some of the nutritional values of the two bamboo species grown and consumed in western parts of Ethiopia. The bamboo shoots of each the two species were collected from each of the three sites and analyzed for their nutritional and mineral composition. The average moisture content of the bamboo shoots was more than 90% for both species but the fat content as determined on dry weight basis indicated a significant variation ranging from 0.6 to 2.2% for *Oxytenanthera abyssinica* and from 0.6 to 1.5% for *Arundinaria alpina.* Highland bamboo *(A. alpina)* shoots characterized with high nitrogen content (5.40%) implying that they may have high content of protein, but the lowland bamboo (*O. abyssinica)* was low in nitrogen content (3.10%). The average ash contents of the highland bamboo shoots collected from Tekur Incheny, Enjibara and Masha site were 14.20, 15.50 and 17.20%, respectively. The average nutrient elements in the shoots of *O. abyssinica* were in the order of K>N>P>Ca>Mg, whereas in *A. alpina* bamboo shoots observed to have slight variation in the arrangement of these elements with the order of K>N>P> Mg > Ca.

Key words: *Arundinaria alpina, Oxytenanthera abyssinica,* bamboo shoots, mineral elements, nutrients.

INTRODUCTION

Bamboo is a perennial grass with over 1200 species in 50 genera of bambuosidaea and grows mainly in the tropics and subtropics (Zhang et al., 2002). In different parts of the world, it is used as a source of raw material for fodder, construction materials, paper production, laminated boards, energy, food, beverage and medicine (Choudhury et al., 2010). The bamboo shoots have been used as food for centuries in Asia. Their protein content is as high as 1.49 to 4.04% with 17 kinds of essential amino acids accounting for 35% of the total protein. They are also rich in other mineral nutrients which are highly valuable for human being (Hunter and Feng'e, 2000; Choudhury et al., 2010).

Ethiopia has two bamboo species: The African alpine Bamboo *Arundinaria alpina* (K. Schumann Lin) which grows between 2200 and 4000 m above sea level (asl) and the lowland bamboo *Oxytenanthera abyssinica* (A. Richard Munro) which grows between 1200 and 1800 m asl (Sylvia, 1995; Embaye et al., 2005). In Ethiopia the common use of bamboo resource is limited to fencing, house construction (tukul), waving, household furniture and utensils but there are the experiences of bamboo shoots consumption in the western and south western parts of Ethiopia. In general, the most common use of bamboo is for the construction purposes. The area coverage of bamboo in the country is reported to vary

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from eight hundred thousand to one million ha (FRA, 1985; Embaye et al., 2003) but currently this figure may be reduced due to the expansion of mechanised agriculture in bamboo growing parts of the country. Recently, in response to the growing interest of utilizing the existing bamboo resource, some research activities have been going on in areas such as product characterization and different management options (Embaye et al., 2003, 2005; Seyoum et al., 2006, 2007).

In Ethiopia Bamboo shoots (BS) usually emerge after the spring rain, namely between April and June without disregarding its dependence on location and species. The quality of bamboo shoots for food depends on the biological characteristics of the bamboo such as species, shooting time, duration of shooting, the rate of shoot growth and the size of shoots.

Bamboo shoots are known for their low fat and cholesterol content and high content of protein, mineral and dietary fibre. Reports show that some species of BSs like other root crops such as cassava, have some cyanogenic glycoside composition which decrease following harvesting of the material and during the time of food preparation (Anonymous, 2004; Agatemor, 2009; Choudhury et al., 2010, 2012).

Bamboo has an immense potential in realizing the food security mechanism of the country. To achieve such objective, the indigenous knowledge of bamboo shoots consumption which accumulated over centuries can be easily introduced to other bamboo growing and potential areas. However, dissemination of such indigenous knowledge can be effective only when preceded by some improvement works which include taste and preparation ease that lead to getting fast adoption rate in the community. The traditional methods of preparing food from bamboo shoots by the indigenous people (ethnic community) of south western and western parts of Ethiopia demands some improvement work, especially with regard to nutritional analysis, the removal of the natural toxicants or bitterness prior to consumption and storability.

The objective of this paper was to identify and raise awareness on some of the parameters of the nutritional values of bamboo shoots of *O. abyssinica* and *A. alpina* species that used for food in south western and western parts of Ethiopia.

MATERIALS AND METHODS

Site description

The samples of bamboo shoots are collected from the following six sites. Masha forest which located in southwest Ethiopia (7° 30'N; 35° 30'E) has an altitude that ranges from 2400 to 3000 m asl, mean annual rainfall of over 2300 mm and annual temperature range 16 to 20°C (Embaye et al., 2005). Enjibara is located in northern parts of the country (10°56' N and 36°56'E) at elevation of 2560 m asl. Tikur Inchini is situated in western parts of the country (9°19' N and 38°24' E) and has an altitude of 2700 m asl. Pawe found in northwest Ethiopia (11° 09' N and 36° 03' E) and has an altitude of 1120 m asl and mean annual rainfall of 1587 mm. Didhessa is located in the south-western of the country (8°41' N and 36°24' E) at the altitude of ~ 1300 m asl. Assosa is located in the western region of the country (10°7' N and 34°37' E) with an altitude of 1510 m asl.

Sample preparation

Lowland bamboo shoots *(O. abyssinica)* were collected from Asossa, Pawe and Dhidhessa while the highland bamboo shoots (*A. alpina*) collected from Enjibara, Masha and Tikur Enchiny. Shoot samples of both bamboo species were transported to the laboratory under liquid nitrogen to avoid spoilage of the shoots.

The outer cover of the hard sheath, the bottom and top portions of the shoots were removed by hand and the remaining middle portions (the edible part of the shoots) which account for 45% of the emerging ones were washed three times in cold water, sliced at the thickness of 5 mm and then dried at a temperature of 45°C using oven drier for 40 h.

Moisture content

The moisture content of the bamboo shoots were determined by drying of the samples in an oven at 105 ± 2°C.

Fat extraction

The bamboo shoots were extracted with hexane in a Soxtec apparatus (a product of Germany) and the average reading of six replicate for each location were taken (Greenfield and Southgate, 2003).

Ash determination

A sample of the bamboo shoots was first heated on a burner in air to remove its smoke, and then burned in a furnace at 550°C. The ash content was expressed as a percentage ratio of the weight of the ash to the oven dry weight of bamboo shoots.

Nitrogen content

Nitrogen analysis was undertaken using Kehdjal Distillation Apparatus. The amount of nitrogen was calculated by the amount of acid added that change the colour of the distilled solution. The protein content was calculated using the nitrogen conversion factor (NCF) of 6.25 (Anonymous, 1998).

Mineral content

Ash obtained from samples of bamboo shoots were dissolved in concentrated sulfuric acid. Then the solution was used for the determination of the studied minerals by Atomic Absorption Spectrometer except for Phosphorous. Wet ash method was used for the determination of Phosphorous. Finaly the amount of Phosphorous was determined using UV-VIS spectrometer at 400 nm wave length (AOAC, 2000).

Statistical analysis

Results were expressed as the mean of three replicates. A one-way

Table 1. Mean nutritional values of *Arundinaria alpina.*

Components	Location		
	Injibara	Masha	Tikur Incheny
Nitrogen (%)	5.83[a]	6.22[a]	4.15[b]
Fat (%)	1.1[a]	0.64[b]	1.5[a]
Moisture (%)	93.3[a]	93.0[a]	91.9[a]
Ash (%)	15.6[b]	17.1[a]	14.2[c]
P (ppm)	9660[a] (0.97%)	9903.33[a] (0.99%)	7113.33 [b] (0.71%)
K (ppm)	90833.33[b] (9.08%)	97716.67[a] (9.77 %)	85350.00[c] (8.54%)
Ca (ppm)	2440.00[a] (0.24%)	2853.30[a] (0.29%)	1633.33[b] (0.16%)
Mg (ppm)	1890.00[a] (0.19%)	1850.00[a] (0.19%)	1386.67[b] (0.14%)
Fe (ppm)	72.67[b]	147.00[a]	41.67[c]
Mn (ppm)	25.33[a]	28.33[a]	11.00[b]
Zn (ppm)	107.00[b]	210.67[a]	97.67[b]

Means with similar letters for comparison between different sites are not significantly different at $p = 0.05$.

analysis of variance (ANOVA) was used to compare the mean using the least significant difference at 5% level.

RESULTS AND DISCUSSION

In Masha and Assosa areas where the bamboo shoots emerge between April and June the indigenous communities use it as a food during spring season of the year. The shoots are immediately picked within the first week of their development as they have a growth rate of up to 1 m per day for some species (Anonymous, 2004). Before serving, the shoots are boiled and drained the first water to reduce the bitterness or the toxic chemicals of the shoots which could be the cynogenic glycosides (Hunt and Feng'e, 2000; Agatemore, 2009; Choudhury et al., 2010, 2012).

In both shoot samples Ethiopian bamboo species the fat extract has a light yellow colour. The bamboo shoots of *A. alpina* were low in fat content with an average of 1.09% on dry weight basis (dwb). The statistical analysis of the fat content showed that the samples of Masha site was lower in fat content which differ significantly from the contents of the samples of the other two locations (Table 1). The average fat content of the lowland bamboo shoots collected from Assosa, Dhedhessa and Pawe sites was 1.44% on dwb. The average fat content of shoots collected from Pawe area was significantly different from those of the other two locations. The low fat content in bamboo shoots is also reported by others and this is one of the reasons that make the bamboo species as a preferred food items (Choudhury et al., 2010, 2011).

The mean ash content of highland bamboo shoots collected from the three sites range from 14.20 to 17.10% dwb. The ash content of the highland bamboo shoots was significantly varied with locations. The lowest ash amount of the shoot was 14% dwb and the highest was 18% dwb for samples of Tekur Incheny and Masha, respectively. The high amount of ash reveals the mineral richness of the biological material which serves as a source of mineral elements required in the nutrition. Whereas the average ash content for the lowland bamboo shoots collected from Assosa, Dhidhessa and Pawe were 11.17, 12.03 and 11.63% dwb, respectively. The lowest ash content in the lowland bamboo was obtained from Assosa (10.87% dwb) and the highest was obtained from Dhidhessa (12.38% dwb) areas. The ash amount of the lowland bamboo from Dhidhessa site showed a significant difference from that of Assosa sample (Table 2). High amount of ash also reported on bamboo shoots of *Fargesia yunnanensis (*Wang et al., 2009*).* High ash content of biological material is also observed in barks and annual crops, indicating that it is a phenomenon for fast growing plants, which can accumulate high amount of mineral materials in the growing season (Raveendran et al., 1995; Azarov et al., 1999). Similar with the BSs of *Bambusa balcoa, Bambus polymorpha, Dendrocalmus hamiltonii, D. strictus, D. gigantus, Phyllostachys praecox* the ash content of the studied species are high but their mineral contents depend on the species, location and season of harvesting (Zhang et al., 2011; Chouduhry et al., 2011). The high amounts of ash content in the bamboo shoots enable them to hold the macro- and micro-elements making them preferable.

The average nitrogen content of the bamboo shoots of *A. alpina* from Tekur Incheny, Injebara and Masha areas were in the range of 4.15 to 6.22% dwb. The lowest amount was 4.15% dwb and the highest was 6.22% dwb from Tekur Incheny and Masha areas, respectively. The nitrogen content of the bamboo shoots from Tekur Incheny site was low and significantly different from those of the other two locations (Figure 1). The average nitrogen content in *A. alpina* bamboo shoots are 8 to 10 times richer than the 1[st] to 3[rd] year old culms of Masha area (Embaye et al., 2005). Such high variation in nitrogen

Table 2. Mean nutritional values of *Oxytenanthera abyssinica*.

Components	Location		
	Assoa	Dehdhesa	Pawe
Nitrogen (%)	3.30[a]	3.99[a]	2.96[a]
Fat (%)	1.5[a]	2.2[a]	0.6[b]
Moisture (%)	91.65[a]	92.57[a]	92.54[a]
Ash (%)	11.17[b]	12.03[a]	11.63[ab]
P (ppm)	5686.67[c] (0.57%)	6166.67[b] (0.62%)	7453.33[a] (0.75%)
K (ppm)	66285[b] (6.63%)	70283.33[a] (7.03%)	71533.33[a] (7.15%)
Ca (ppm)	933.33[c] (0.09%)	1200.00[b] (0.12%)	1460.00[a] (0.15%)
Mg (ppm)	1903.33[a] (0.19%)	2020.00[a] (0.20%)	1986.67[a] (0.20%)
Fe (ppm)	33.67[c]	45.00[b]	88.00[a]
Mn (ppm)	19.67[a]	19.33[a]	18.67[a]
Zn (ppm)	71.67[c]	88.33[b]	106.67[a]

Means with similar letters for comparison between different sites are not significantly different at $p = 0.05$.

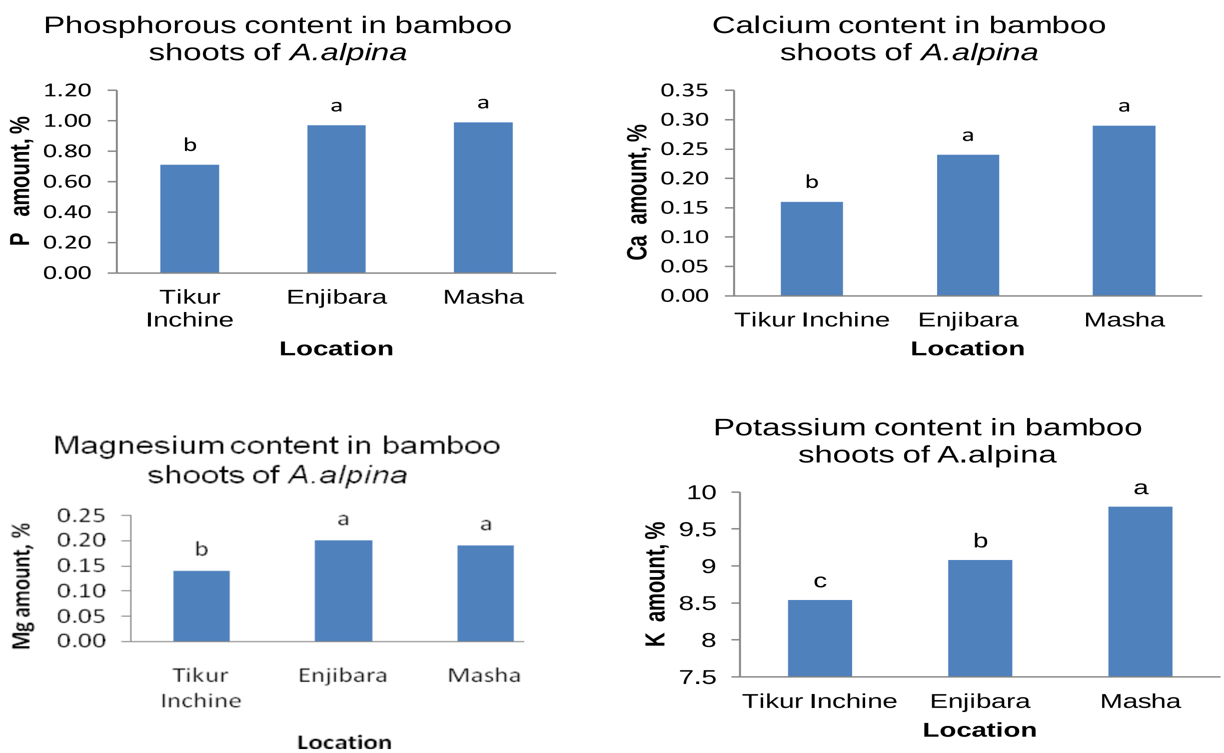

Figure 1. Mineral contents in bamboo shoots of *A. alpina* from different locations. Bars with the same letter are not significantly different at p = 0.05 level.

content is attributed to the active and fast growing stage of the plant which requires more nitrogen in the chlorophyll make up, cell differentiation of the growing bamboo shoots and biosynthesis of nitrogen containing compounds. The average nitrogen content for lowland bamboo shoots was 3.29, 3.99 and 2.95% dwb for samples from Assosa, Dhidhessa and Pawe areas, respectively. There was no significant difference in nitrogen content between the lowland bamboo shoots collected from the three locations. When the nitrogen content in the shoots multiplied by the factor 6.25 the total protein amount ranges between 2.88 and 4.13% of the fresh BS which is in the range of other BS of Asian species (Wang et al., 2009; Chouduhury et al., 2010, 2011).

The average phosphorous content of the *A. alpina* bamboo was 0.71, 0.97 and 0.99% for samples collected from Tekur Incheny, Injebara and Masha sites,

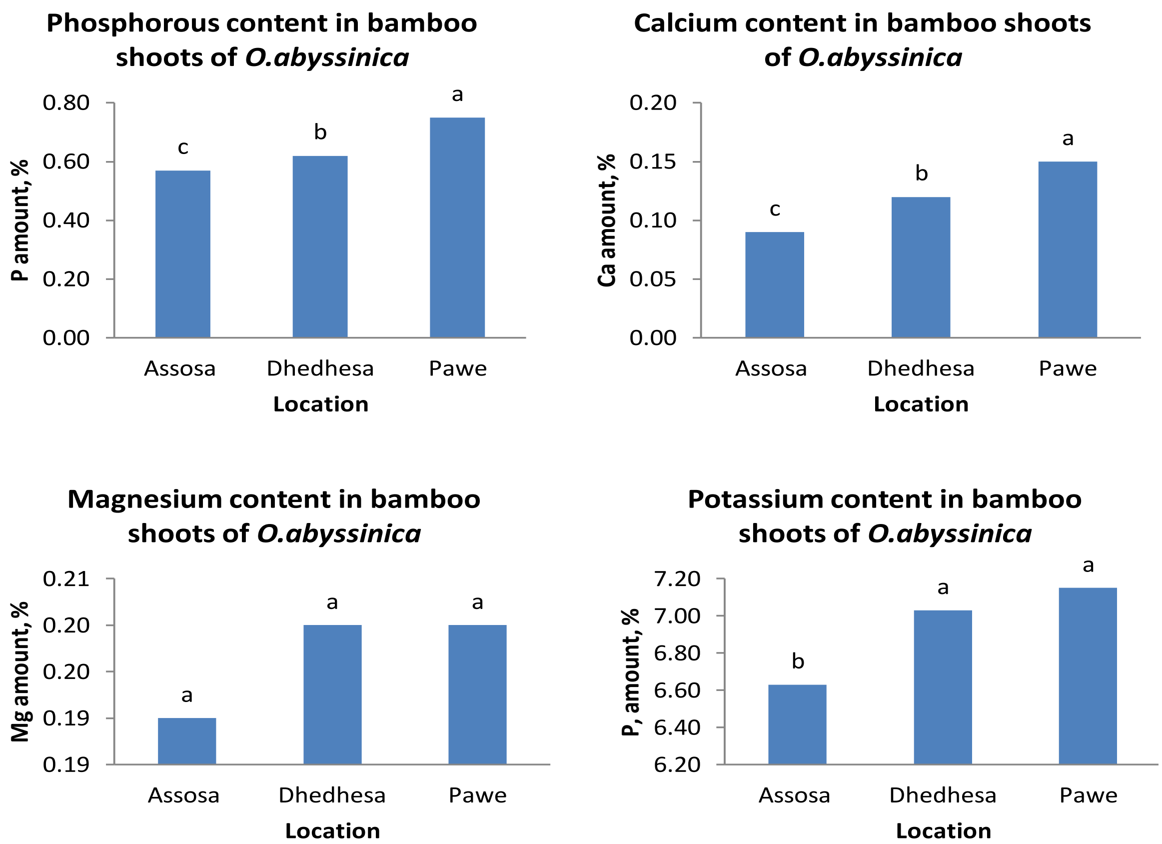

Figure 2. Mineral contents in bamboo shoots of *O. abyssinica.* Bars with the same letter are not significantly different at p = 0.05 level.

respectively. The phosphorous amount in the highland bamboo shoots from Tekur Incheny was significantly different from Injebara and Masha locations with its low content. Similarly, the average phosphorous content of the samples of lowland bamboo shoots of Assosa, Dhidhessa and Pawe were 0.57, 0.62 and 0.75%, respectively. The result of phosphorus content indicates strong differences between all the three locations. The phosphorous content of BSs of *A. alpina* and *O. abyssinica* is much higher than those of Bambusa and Dendrocalamus species (Choudhury et al., 2010, 2011).

The average calcium content of the bamboo shoots of *A. alpina* was analyzed and found the lowest content in the samples of Tekur Incheny site which was statistically different from those of Injebara and Masha areas. The average calcium contents were 0.16, 0.24 and 0.29% for bamboo shoot samples of Tekur Incheny, Injebara and Masha areas, respectively (Table 1). The low calcium content of the samples of Tekur Incheny is related to the low ash content of the sampled material. The average calcium content of the lowland bamboo shoot samples of *O. abyssinica* collected from Assosa, Dhidhessa and Pawe areas were 0.09, 0.12 and 0.15%, respectively. There was significant difference between the sites in average calcium content the lowest calcium content in the samples of Assosa area (Table 2). In both studied species, the calcium content accounts for less than 1% of the mineral content unlike the perennial plant wood which consists more than 50% (Fengel and Wegner, 1984; Azarov et al., 1999).

The average magnesium contents of *A. alpina* bamboo shoots collected from Tekur Incheny, Injebara and Masha was in the range of 0.14 to 0.19%. The highland bamboo shoots of Tekur Incheny site exhibited lowest amount which was significantly different from those of Injebara and Masha locations as indicated in Figure 1. On the other hand, the average magnesium content in the shoots of *O. abyssinica* collected from Assosa, Dhidhessa and Pawe areas was in the range of 0.19 to 0.20% with no significant difference between locations (Figure 2). The amount of magnesium in these bamboo shoots were 10 fold higher than the leafy vegetables of *Amaranthus spinosus, Hibiscus species, Solanum macrocarpon* consumed in Northern Ghana (Amagloh and Nyarko, 2012) and equal to *Eragrostis tef* an Ethiopian staple food called “Injera” made of it (Seyfu, 1997; Parish, 2006).

The average potassium contents in the bamboo shoots of *A. alpina* were 8.53, 9.08 and 9.77% for the samples of Tekur Incheny, Injebara and Masha areas respectively.

The statistical analysis for the average potassium content showed significant differences among all three sites. Whereas the average potassium content in *O. abyssinica* bamboo shoots collected from Assosa, Dhidhessa and Pawe areas were 6.63, 7.02 and 7.15%, respectively. The average potassium content of the samples of Assosa site was found to be lower and significantly different from those of the other locations. There are also reports which reveal similar high amounts of potassium in bamboo shoots of other species (Shanmughavel and Francis, 2003; Choudhury et al., 2011). In general the bamboo shoots exhibit higher amount of potassium than *A. spinosus, Hibiscus species, Solanum macrocarpon* leafs consumed in Ghana (Amagloh and Nyarko, 2012) and higher amount than teff (*Eragrostis tef)* grain (Seyfu, 1997; Parish, 2006).

The mean iron content in the *A. alpina* bamboo shoots of all the three sites was significantly different from each other with 41, 75 and 145 ppm for samples collected from Tekur Incheny, Injebara and Masha sites respectively. The iron content in the bamboo shots of *A. alpina* in Masha area is 2 to 5 folds higher than those of the other locations. The average iron content in *O. abyssinica* bamboo shoots collected from Assosa, Dhidhessa and Pawe were 33.67, 45 and 88 ppm respectively. The analysis for iron content for lowland bamboo shoots was significantly different from each other. The iron content of the bamboo shoots of *O. abyssinica* from Pawe area is 2 to 3 folds higher than the other locations. The iron content in the two bamboo shoots is higher than the leafy vegetables used in Northern Ghana and almost equal to the amount in teff (*Eragrostis tef*) grain (Seyfu, 1997; Parish, 2006; Amagloh and Nyarko, 2012).

Conclusion

The analysis of bamboo shoots of *A. alpina* collected from the three locations showed that the bamboo shoots collected from Tekur Incheny area was the lowest in all analyzed mineral content. The lowland bamboo shoots of *O. abyssinica* except for the magnesium, all samples differ in their content of mineral elements and the bamboo shoots from Assosa area showed the lowest values. Analysis of both shoot samples of bamboo species nutrient elements were in the order of K>N>P>Ca>Mg for *O. abyssinica* bamboo shoots and K>N>P> Mg > Ca for the *A. alpina.* In general the result of this study and the experiences of southwest Ethiopia strongly indicate the great potential of bamboo shoot for food security mechanism of the country.

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