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CONTENTS

Performance of improved varieties of true Cinnamon (*Cinnamomum verum* J. Presl.) in Andaman Islands, India

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ABSTRACT: True cinnamon is an ancient, perennial spice grown for its sweet aromatic barks and is known to possess antioxidant and antimicrobial properties. However, cinnamon in trade is adulterated with barks of other species, some of which are known to have potentially harmful coumarins. The agro-climatic conditions of Andaman Islands are highly suitable for cultivation of this important spice. However, cinnamon is grown mostly in backyards, while few commercial plantations do exist in these islands. In order to promote cultivation of this spice, introduction of improved varieties is important and hence, morphological and biochemical studies were carried out in five improved varieties and Local check (control) in open condition. Results revealed considerable differences among the genotypes for morphological and biochemical parameters. Total chlorophyll content ranged between 0.67 and 1.08 mg/g, while variations were also noticed within the studied varieties for essential oil content (0.4- 2.0%), oleoresin content (7.8- 11.5%), leaf total phenolic content (18.7- 27.9 mg GAE/100g), bark total phenolic content (30.4- 60.3 mg GAE/ 100g), dry recovery of leaf (46.5- 66.7%), leaf moisture content (46.2- 58.6%) and dry recovery of bark (31.31- 45.92%). Variety Konkan Tej was found to be superior for cultivation under open condition in Bay Islands. Considering performance of 'Local' collection for leaf morphological parameters, bark recovery (%) and dry bark yield, seedling progenies in the islands could be utilized for identification of superior genotypes.

Key words: Bay islands, Ceylon cinnamon, essential oil, oleoresins, total phenolic content

The spice cinnamon in domestic and international markets is constituted by a number of related species of Lauraceae family, major being *Cinnamomum verum* (true cinnamon/ Ceylon cinnamon), *C. cassia* (cassia cinnamon), *C. burmannii* (Indonesian cinnamon), *C. loureiroi* (Vietnamese cinnamon) *etc*. Bark and leaf of true cinnamon are employed as spices since ancient times in culinary preparations, confectionaries and are known to possess medicinal properties (Farooqi *et al.*, 2005). True cinnamon is commonly adulterated with other species owing to their cheaper prices (Jose *et al.*, 2019). However, most of these adulterant species are characterized by presence of higher levels of coumarins (Shimna *et al.*, 2017), consumption of high doses of which are known to have adverse effects on human health (Felter *et al.*, 2006). As per Food Safety and Standards Act of India (2006), sale of other species as cinnamon in the market is an offense (Thomas *et al.*, 2016); however, adulterations of such species in powdered and processed products have commonly been detected (Shimna *et al.*, 2017; Jose *et al.*, 2019).

Due to increasing awareness about its medicinal properties, demand for cinnamon has been increasing; however, production is not sufficient to meet the ever increasing demand (Thomas *et al.*, 2016). In India, it is being cultivated in parts of Kerala, Karnataka, Andaman and Nicobar Islands, Maharashtra and other coastal regions in smaller quantities. Most of cinnamon/ cassia demand of Indian market is met by supplies from China, Vietnam, Indonesia and Burma (Jose *et al.*, 2019), because of which significant foreign exchange is lost. During 2016-17, 22,280 tons of cassia worth Rs. 29,062.45 lakh was imported by India (www.indianspices.com). Considering this, promotion of cultivation of true cinnamon is advocated in India (Thomas *et al.*, 2016) and as a part of it, a number of production technologies have been developed (Thangaselvabai *et al.*, 2009; Waman and Bohra, 2018).

Improved varieties are an important component in improving productivity and quality of any crop. So far, eight improved varieties of cinnamon *viz*. IISR-Navasree and IISR-Nithyasree (ICAR-IISR, Kozhikode, Kerala); Konkan Tej and Konkan Tejpatta (Dr. B.S.K.K.V., Dapoli, Maharashtra); YCD-1 and PPI (C) 1 (TNAU, Coimbatore, Tamil Nadu); Sugandhini (KAU, Vellanikara, Kerala) and RRL (B) C-6 (CSIR- Institute of Minerals and Materials Technology, Bhubaneswar, Odisha) have been developed in India (Farooqi *et al.*, 2005; Thangaselvabai *et al.*, 2009). Andaman and Nicobar Islands (also called as Bay Islands) in the Bay of Bengal have been considered as potential areas for production of spices owing to congenial agro-climatic conditions. Most of the perennial spices cultivation in these islands is without the use of chemical inputs (Waman, 2020), which could fetch premium price in the markets. Cinnamon grows well as an intercrop as well as in open space. However, existing cinnamon plantations are of seedling origin (Waman and Bohra, 2018) and no improved varieties are available, resulting in considerable variability in yield and quality of produce. To determine the quality of Locally grown produce, surveys were conducted and essential oil content was determined in produce from different islands, which are presented hereunder. To promote cultivation of cinnamon in the islands, five improved varieties were introduced from mainland India and present report concerned their morphological and biochemical evaluation for area expansion in Andaman Islands.

MATERIALS AND METHODS

Sample collection

In order to know the essential oil content in Locally grown cinnamon, pooled samples of dried bark were collected from Little Andaman, Katchal and Middle Andaman Islands. Furthermore, leaves and stem pieces of improved varieties *viz*. Konkan Tej, Konkan Tejpatta, YCD-1, IISR-Nithyasree, IISR-Navasree and Local (control) were collected from three years old mature plants grown in an experimental farm of ICAR-Central Island Agricultural Research Institute, Port Blair, Andaman and Nicobar Islands, India. Plants were grown under open condition at 2 m × 2 m spacing following standard cultivation practices.

Leaf related parameters

Fully mature, disease/ pest free leaves were used for recording various parameters. Leaf length (cm), leaf width (cm) and petiole length (cm) were recorded using a scale, while leaf weight (g) was determined using precision balance. Leaf dry recovery (%) was determined by shade drying of the produce, while for moisture content (%) determination, known quantities of samples were dried in hot air oven (103 °C) till constant weight was obtained. Calculation was done as (fresh weight - dry weight)/ fresh weight × 100.

Leaf photosynthetic pigment content (mg/g) was determined using dimethyl sulphoxide as solvent and calculated as per formula given by Wellburn (1993). Leaves were dried, powdered and cold percolated in methanol (80%, v/v) for 72 h. Solvent was evaporated and extract was used for determination of total phenolic content (TPC) using Folin-Ciocalteau method.

Bark related parameters

Stems were harvested during September, 2019 and bark was peeled out following standard harvesting practices. Freshly peeled bark was left for one day in shade prior to subjecting them for drying in hot air oven (42° C). Bark recovery was calculated and expressed as percentage. Essential oil content and oleoresin content in bark were determined using procedure described earlier (Singh *et al.*, 2007). Briefly, dried bark was powdered, passed through 50 mesh sieve and hydro-distilled using Clevenger's apparatus for 6 h for estimation of essential oil (%). Sieved sample was extracted using Soxhlet with acetone for 2 h and oleoresin content (%) was determined by evaporating the solvent. TPC content was estimated in bark powder as described above for leaf samples.

Statistical analysis

Data for various parameters was presented as mean ± standard error of mean. Analysis of variance was done using Web Agri Stat Package (WASP, v. 2.0, ICAR-RC for Goa, Ela, India) and mean separation was done with least significant difference, wherever appropriate.

RESULTS AND DISCUSSION

Determination of essential oil content in Locally grown cinnamon

In order to know the quality of Locally grown cinnamon from different parts of the islands, bark essential oil content was estimated in samples collected from three islands of Andaman and Nicobar groups of islands (Fig. 1). Essential oil content was found to be as low as 0.13% in sample collected from Little Andaman Island and highest content was recorded in sample collected from Middle Andaman Island (0.79%). Values of oil content obtained in this study were lower than improved varieties of cinnamon in other parts of India *i.e.* 2.7% (Rema *et al.*, 2003). Non availability of improved varieties, non-adoption of selective seedling progenies (purple flush types) and non-scientific drying/ storage of produce could be the major reasons for this poor quality of produce and hence, need was felt to introduce and evaluate improved varieties of cinnamon in the islands.

Morphological parameters of leaves of improved varieties

Significant differences were noticed for leaf morphological and biochemical parameters of studied genotypes (Table 1). Leaf length varied between 11.6 cm (IISR- Navasree)

Table 1: Morphological parameters in leaves of improved varieties of cinnamon

Variety	Leaf length (cm)	Leaf width (cm)	Leaf weight (g)	Petiole length (cm)
Local	14.3 ± 0.39a	6.8 ± 0.18ab	2.0 ± 0.08a	1.6 ± 0.06a
Konkan Tej	12.7 ± 0.32b	5.9 ± 0.19c	1.7 ± 0.08b	1.7 ± 0.09a
Konkan Tejpatta	13.0 ± 0.42b	7.1 ± 0.22a	1.7 ± 0.08b	1.7 ± 0.05a
YCD-1	14.4 ± 0.34a	6.9 ± 0.31ab	1.9 ± 0.15ab	1.6 ± 0.05a
IISR- Nithyasree	12.3 ± 0.28bc	6.3 ± 0.17bc	1.5 ± 0.06c	1.6 ± 0.06a
IISR- Navasree	11.6 ± 0.27c	5.1 ± 0.18d	1.3 ± 0.06c	1.6 ± 0.06a

Values are presented as mean ± standard error of mean. Values followed by similar alphabets in a column do not differ significantly following least significant different at 5% level of significance

Table 2: Photosynthetic pigment content, dry recovery and moisture content in leaves of improved varieties of cinnamon

Variety	Chlorophyll content (mg/g)			Chlorophyll a: Chlorophyll b	Leaf dry recovery (%)	Moisture content (%)
	Chlorophyll a	Chlorophyll b	Total Chlorophyll			
Local	0.71 ± 0.033	0.22 ± 0.009	0.93 ± 0.042b	3.29	54.9 ± 3.29b	55.2 ± 0.27b
Konkan Tej	0.68 ± 0.005	0.21 ± 0.004	0.88 ± 0.007b	3.29	63.9 ± 3.55a	46.2 ± 0.03c
Konkan Tejpatta	0.68 ± 0.031	0.19 ± 0.003	0.87 ± 0.034b	3.68	66.7 ± 1.86a	46.8 ± 0.17c
YCD-1	0.68 ± 0.014	0.22 ± 0.004	0.90 ± 0.011b	3.03	52.4 ± 0.84b	54.4 ± 1.39b
IISR- Nithyasree	0.52 ± 0.003	0.16 ± 0.003	0.67 ± 0.000c	3.28	53.0 ± 1.15b	54.5 ± 0.34b
IISR- Navasree	0.82 ± 0.005	0.27 ± 0.004	1.08 ± 0.008a	3.08	46.5 ± 5.47b	58.6 ± 0.04a

Values are presented as mean ± standard error of mean. Values followed by similar alphabets in a column do not differ significantly following least significant different at 5% level of significance

Table 3: Total phenolic content in leaf powder and bark powder in improved varieties of cinnamon

Variety	Total phenolic content (mg GAE/ 100 g)	
	Leaf powder	Bark powder
Local	18.7 ± 1.62	49.3 ± 5.46
Konkan Tej	27.6 ± 0.07	38.4 ± 2.57
Konkan Tejpatta	21.6 ± 0.14	36.1 ± 0.89
YCD-1	26.6 ± 0.35	38.5 ± 2.22
IISR- Nithyasree	27.9 ± 1.71	30.4 ± 3.83
IISR- Navasree	24.3 ± 0.24	60.3 ± 2.27

Values are presented as mean ± standard error of mean.

and 14.4 cm (YCD-1); leaf width, 5.1 cm (IISR-Navasree)- 7.1 cm (Konkan Tejpatta); leaf weight, 1.3 g (IISR-Navasree)- 2.0 g (Local); petiole length, 1.6-1.7 cm. Existence of protogynous dichogamy phenomenon, which is characterized by stigma receptivity on first day of anthesis and anther dehiscence on second day, makes cross pollination in cinnamon a rule (Azad *et al.*, 2015). Created variability is commonly reflected in leaf morphology, which along with qualitative traits are considered vital for selection of superior types and varieties (Krishnamoorthy *et al.*, 1996; Azad *et al.*, 2015). Variability in the leaf parameters of studied varieties was partly due to their diverse genetic make-up. Further, genotype × environment interaction also plays an important role in expressing these characters (Azad *et al.*, 2016) and hence, variations in studied varieties from their original descriptions are expected. For example, leaf length/ leaf width of 15.4 cm/ 5.7 cm and 13.4 cm/ 4.69 cm were reported in IISR-Nithyasree and IISR- Navasree, respectively by Rema *et al.* (2003), while in present study the values were 12.3 cm/ 6.3 cm and 11.6 cm/ 5.1 cm. It means leaf length was reduced under island condition in both varieties, while its width increased probably due to adaptation to new agro-climatic conditions. Variability in morphological parameters in cinnamon genotypes has been reported by earlier researchers as well (Azad *et al.*, 2016).

Photosynthetic pigments, dry recovery and moisture content in leaves of improved varieties

During present investigation, chlorophyll a, chlorophyll b, total chlorophyll content and ratio of chl a: chl b were estimated in the improved varieties. Quantity of chl a varied between 0.52 mg/g (IISR-Nithyasree) and 0.82 mg/ g (IISR-Navasree), while chl b content varied from 0.16 mg/g (IISR-Nithyasree) to 0.27 mg/g (IISR-Navasree). Total chlorophyll content in leaf samples showed significant variations among the varieties studied. Though values for leaf morphological parameters were found to be the lowest in IISR-Navasree, it had the highest total chlorophyll content (1.08 mg/g). Lowest total chlorophyll content was reported in IISR-Nithyasree (0.67 mg/g). The content in other varieties was in the range, 0.87- 0.93 mg/ g (Table 2). Near normal ratio of 3.03 and 3.08 were noticed in YCD-1 and IISR- Navasree, respectively. Varieties Konkan Tej and Konkan Tejpatta showed highest leaf dry recovery of 63.9 and 66.7%, respectively; while

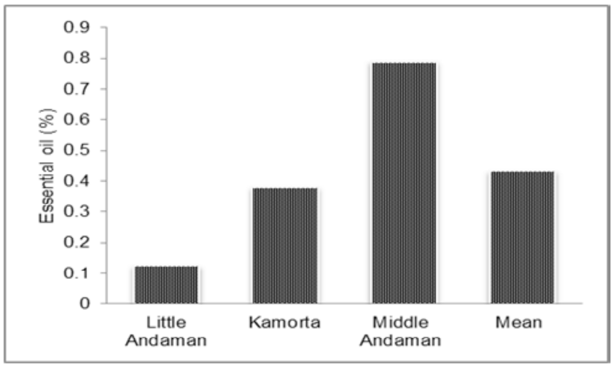

Fig. 1: Essential oil content (%) in bark of cinnamon collected from different parts of Andaman islands

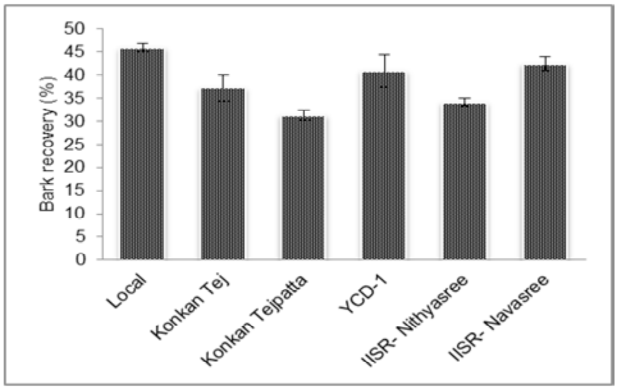

Fig. 2: Bark recovery (%) in improved varieties of cinnamon under island condition

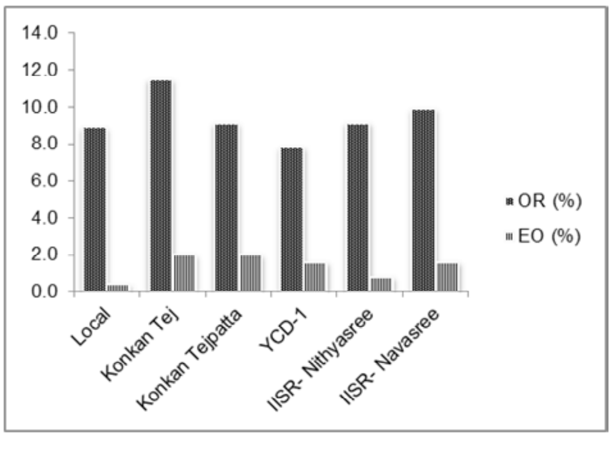

Fig. 3: Essential oil and oleoresin content (%) in bark of improved varieties of cinnamon

moisture content in these varieties was the lowest (Table 2).

Chlorophyll is one of the vital pigments responsible for photosynthesis and subsequent plant growth. Internal and external factors are known to alter synthesis and accumulation of these pigments in plants to better suit to the environment in which they grow (Li *et al.*, 2018). However, when grown under similar conditions, variations in chlorophyll content are largely caused due to genotype (Hussain *et al.*, 2017) and hence, the variations seen in present study could be expected. Though bark of true cinnamon is the economic part of the species, dehydrated leaves are being used as spice in some areas. Further, for preparation of spice mixture powders, *Garam masala etc*., cinnamon leaf powder is used at times. Hence, higher dry recovery in leaves is desirable. Considering higher recoveries in Konkan Tej and Konkan Tejpatta, these varieties could be suitable for leaf powder production.

Bark yield and quality related parameters

Bark is the commercial produce of cinnamon; hence, dry recovery and yield per plant determine the total output. Dry recovery of bark was found to be the highest (45.92%) in Local followed by 42.43% in IISR- Navasree (Fig. 2) and lowest in Konkan Tejpatta (31.31%). Dry bark yield of 220.04 g per plant was reported in Konkan Tej, which was followed by 93.87 g in Local and 60.60 g in IISR-Navasree.

Genotype dependent variations in bark yield and dry recovery have been reported by earlier researchers in West Coast of India (Khandekar *et al.*, 2012). Bark yield of 33 to 85 g have been reported in genotypes studied under Konkan region of Maharashtra (Haldankar *et al.*, 1994). Variable growth and development of genotypes due to diverse genetic makeup might have resulted in differential accumulation of nutrients and thereby yield/ recovery of bark (Hartmann *et al.*, 2002; Khandekar *et al.*, 2012). Bark recovery of 35.3% in variety YCD-1 has been reported by Kennedy and Balakrishnamoorthy (2000), which was lower than that observed in present study. Interestingly, all the studied collections had higher bark recovery than the 'Local' (28 to 31%) studied earlier in the island condition (Jaisankar *et al.*, 2010). Further, low bark recovery in IISR- Nithyasree than IISR-Navasree as observed in the present study is in accordance with earlier report (Rema *et al.*, 2003). Superior characters in studied genotypes under islands suggest that the maritime climate of Bay Islands is highly suitable for cinnamon cultivation. Essential oils are responsible for imparting peculiar aroma in spices and aromatic crops and hence, it is considered as an important quality determinant in these crops. In present study, essential oil content in Local collection was 0.4% (Fig. 3), while it was five times higher in case of

Konkan Tej and Konkan Tejpatta (2.0%), four times higher in YCD-1 and IISR-Navasree (1.6%) and two times higher in IISR-Nithyasree (0.8%). Essential oil content is known to vary with a number of factors including varietal differences, growing conditions *etc*. This could be the possible reason for lower oil content noticed during present study in Konkan Tej, IISR-Nithyasree and IISR Navasree than those reported by studies conducted in their parent institutes (Khandekar *et al.*, 2012; Rema *et al.*, 2003). Earlier study (Zachariah *et al.*, 2016) reported 0.4 to 2.8% essential oil content in Kerala condition, while it was between 1.88 and 3.20% in germplasm studied in Maharashtra (Haldankar *et al.*, 1994). Oleoresin content of 11.5% was reported in Konkan Tej (Fig. 3), which was distinctly higher than that observed in Local (8.9%). Oleoresin content of 8 to 10% has been reported earlier in improved varieties under Kerala condition (Rema *et al.*, 2003) and hence, results obtained in present study are valuable.

Total phenolic content in leaf and bark powder

Total phenolic content was determined in dried leaf samples, which revealed that all the varieties had higher TPC than 'Local' collection (Table 3). Lowest TPC was observed in 'Local' collection (18.7 mg GAE/ 100 g), while it was significantly highest in IISR-Nithyasree (27.9 mg GAE/ 100 g), Konkan Tej (27.6 mg GAE/ 100 g) and YCD-1 (26.6 mg GAE/ 100 g). In bark powder, highest TPC was obtained in IISR-Navasree (60.3 mg GAE/ 100 g) and lowest in IISR-Nithyasree (30.4 mg GAE/ 100 g). Cinnamon leaves and barks contain phenolic compounds, which are known to contribute to antioxidant properties (Zachariah *et al.*, 2016) and hence, identification of genotype with higher phenolic content is desirable.

CONCLUSION

It could be concluded that wide variations were noticed for studied morphological and biochemical parameters in the tested varieties. However, based on superior dry bark yield, leaf dry recovery, essential oil content, oleoresin content and leaf total phenolic content, variety Konkan Tej was found to be the most suitable for open cultivation in the island condition. Further, considering the seedling origin of existing cinnamon plantations and superior performance of Local collection for some of the studied parameters, the native diversity could be systematically studied for identification of superior genotypes.

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