J. Farm Sci., 36(2): (219-224) 2023

RESEARCH PAPER

Leaf morphometric variation among the different natural sources of *Cinnamomum zeylanicum* Blume. in Uttara Kannada district

SOURAV MANOHARAN[1] AND HANUMANTHA M[2]

[1&2]Department of Forest Products and Utilization, College of Forestry, Sirsi
University of Agricultural Sciences, Dharwad - 580 005, India
E-mail: souravmanoharan2013@gmail.com

(Received: February, 2023 ; Accepted: June, 2023)

Abstract: *Cinnamomum zeylanicum* Blume., native to Sri Lanka and the West coast region of India, belongs to the family Lauraceae.True cinnamon leaves are valuable NTFP and also used for the commercial extraction of essential oil. The protogynous dichogamy of the cinnamon flower is a natural adaptation for cross-pollination. An enormous diversity of Cinnamon has been produced by this special type of pollination behaviour. Thus, the current study aimed to determine the extent of morphological variation within and among the sources. The study was conducted during the period of 2020-22 at the various sites in the Uttara Kannada district, Karnataka. Sixty phenotypically superior cinnamon trees were selected among the six different natural sources, for the evaluation of five leaf morphometric parameters. In this study, the dark green coloured leaves were predominately expressed in all six sources and all tree had only green coloured petiole. Five types of leaf shape *viz*., elliptic, oblong, ovate, ovate-elliptic and ovate lanceolate and four types of leaf apex (acuminate, acute, sub-acute and obtuse) were noticed among the six sources. Elliptic leaf shape and acuminate leaf tip was predominantly expressed. Leaf morphometric traits could be easily used to measure the magnitude of the diversity.

Key words: Cinnamon, Leaf morphometric traits, Source,Variation

Introduction

Cinnamomum zeylanicum Blume. popularly known as true cinnamon is native to Sri Lanka and the West coast region of India (Sasikumar *et al.,* 1999).It is an evergreen tree belongs to the family Lauraceae in the genus *Cinnamomum*, which comprises about 340 species of trees and shrubs, out of which 20 occur in India (Liyanage *et al*., 2020; Rana *et al.,* 2008). Cinnamon leaf is widely used as spice as well as for the extraction of essential oil (Hanumantha, 2020). Because of a vast amount of scientific evidence on its potential therapeutic and medicinal values it has gained more attention during recent years (Zare *et al.,* 2019; Sadeghi *et al.*, 2019). These properties are attributed by unique secondary metabolic profiles present in the leaf of Cinnamon, including eugenol, cinnamic aldehyde, benzaldehyde, pinene, phellandrene, methyl eugenol, geraniol, caryophyllene, *etc.* (Zachariah and Leela, 2018).

Cinnamon leaf morphometric traits are important markers that can be adopted for measuring the magnitude of the genetic diversity (Lizawati *et al*.,2018). By understanding and evaluating morphometric parameters of leaf could help in the taxonomical classification and differentiation of closely related species and verities of Cinnamon (Bandusekara *et al*., 2020) and also helpful in indirect selection of high yielding plant (Wijesinghe and Gunarathna, 2001). The big leaves and large round leaves had high bark yield. Further more, bark oil quality (higher per cent of Cinnamaldehyde) is higher in the tree of inwardly curved leaves and high-quality leaf oil is obtained from the small round leaves.

Cross-pollination behaviour of Cinnamon, due to the protogynous dichogamy (Joseph, 1981) has created a vast genetic diversity in offspring (Liyanage *et al*., 2020) and the genetic diversity is reflected in the chemical properties, yield and yield-related morphological features (Liyanage *et al*., 2020; Oliveira *et al*., 2012). Hence, it is necessary to understand the extent of morphological variation within the species and among the sources before formulating any selection programme to identify superior trees and to apply them for increasing the yield.

Cinnamon shows great variations in Karnataka in terms of leaf morphometric traits (Hanumantha, 2020). However, there are no documented data regarding the leaf morphometric traits of Cinnamon in the natural forest of Karnataka. Hence the current study was undertaken to determine the variation of leaf morphometric traits of Cinnamon among the six different sources of Uttara Kannada district of Karnataka.

Material and methods

The study was carried out during the period of 2020-22 at the College of Forestry, Sirsi and at various natural sources in Uttara Kannada district. Uttara Kannada district is located in the Central Western Ghats between 13°55' to 15° 32' N latitude and 74° 05' to 75° 05' E longitude with a geographical area of 10,291 km2. The study site consists of six natural sources of cinnamon in the six taluka of Uttara Kannada district. Within these talukas, the study sites were selected at Sirsi (Sirsi), Joida (Joida), Yellapur (Yellapur), Gerusoppa (Honnavar), Hosakambi (Ankola) and Bhatkal (Bhatkal). The details of the study site are given in the Table 1.

The six sources were selected based on the distribution and population status of *Cinnamomum zeylanicum* by enquiring with the officers and subordinate staff of Karnataka State Forest Departmentand local people. By considering the topography of the Uttara Kannada, three sources, namely Sirsi, Joida and Yellapur were selected in the higher altitude (>500 m msl) and three sources namely Gerusoppa, Hosakambi and Bhatkal from lower altitude (<50 m msl).

Table 1. Geographical features and other details of the study sites

Source	Taluk	Latitude	Longitude	Altitude(m)	No.of trees considered for assessment	No. of trees selected
Sirsi	Sirsi	14°36' 40.53''	74° 49' 43.62''	583	100	10
Joida	Joida	15° 10' 13.40''	74° 29' 05.02''	532	100	10
Yellapur	Yellapur	14° 57' 51.51''	74° 42' 43.46''	541	100	10
Gerusoppa	Honnavar	14° 13' 41.95''	74° 40' 08.0''	48	100	10
Hosakambi	Ankola	14° 38' 29.07''	74° 18' 24.02''	17	100	10
Bhatkal	Bhatkal	13° 58' 54.98''	74° 33' 17.93''	35	100	10

Table 2. Descriptors used for evaluating the variation in leaf traits among trees and sources

Leaf traits	Procedure/descriptors used	References
Leaf shape	Elliptic, Ovate, Ovate-elliptic Ovate-lanceolate, Oblong	Hanumatha *et al.* (2020); Azad *et al.* (2016); Joy *et al.* (1998)
Leaf tip shape	Obtuse, Sub-acute, Acuminate, Acute	
Leaf colour	Light green, Green, Dark Green	
Leaf margin	Entire and Wavy	
Petiole colour	Green, Light purple, Purple	Hanumatha *et al.* (2020)

From each source hundred trees were evaluated based on the eye ball screening and top ten superior trees were selected among them by considering growth characteristics. During evaluation and selection of trees, equal sized trees were selected based on girth class (50-150 cm). A minimum distance of 500 m was maintained between trees during selection process. Totally sixty trees were selected from the six sources. The trees were marked and data was recorded (Table 2). The selected trees were given source specific code and their geo-coordinates were recorded.

Sirsi	S1 to S10
Joida	J1 to J10
Yellapur	Y1 to Y10
Gerusoppa	G1 to G10
Hosakambi	H1 to H10
Bhatkal	B1 to B10

Results and discussion

Wide variation in leaf parameters was observed among the six sources through leaf colour, leaf shape, leaf tip shape and leaf margin (Table 3-8). No variation was observed in petiole colour among the different sources. Leaf colour varied from green colour to dark green colour. The dark green coloured leaves were predominately expressed in all sources. Leaf margin varied from entire to wavy however, only five tree (S2, S6, G5, H6 and H10) recorded wavy leaf margin and remaining tree exhibited entire margin. Leaf shape and leaf tip shape (leaf apex) showed high variation among the sources and within the

Table 3. Variation in leaf parameters of selected trees of *C. zeylanicum* in Sirsi source

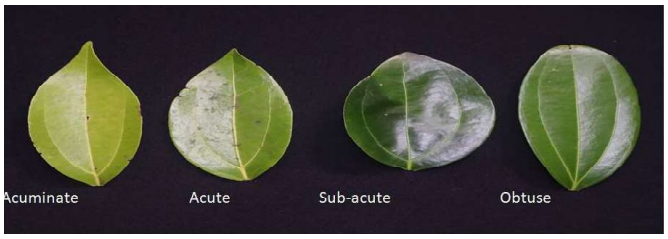
Tree No.	Leaf parameters				
	Leaf colour	Petiole colour	Leaf shape	Tip shape	Leaf Margin
S1	Green	Green	Elliptic	Acuminate	Entire
S2	Dark Green	Green	Ovate	Acuminate	Wavy
S3	Dark Green	Green	Ovate-lanceolate	Acute	Entire
S4	Dark Green	Green	Elliptic	Acute	Entire
S5	Green	Green	Elliptic	Acuminate	Wavy
S6	Green	Green	Ovate-elliptic	Acuminate	Entire
S7	Dark Green	Green	Ovate	Sub-acute	Entire
S8	Dark Green	Green	Oblong	Sub-acute	Entire
S9	Dark Green	Green	Elliptic	Acute	Entire
S10	Dark Green	Green	Oblong	Acute	Entire

Table 4. Variation in leaf parameters of selected trees of *C. zeylanicum* in Joida source

Tree No.	Leaf Parameters				
	Leaf colour	Petiole colour	Leaf shape	Tip shape	Leaf Margin
J1	Dark Green	Green	Ovate	Acuminate	Entire
J2	Dark Green	Green	Oblong	Acuminate	Entire
J3	Dark Green	Green	Elliptic	Acute	Entire
J4	Dark Green	Green	Ovate	Acute	Entire
J5	Dark Green	Green	Ovate-elliptic	Acute	Entire
J6	Dark Green	Green	Ovate	Acuminate	Entire
J7	Dark Green	Green	Ovate-elliptic	Acute	Entire
J8	Dark Green	Green	Oblong	Obtuse	Entire
J9	Dark Green	Green	Ovate-elliptic	Acuminate	Entire
J10	Green	Green	Ovate-elliptic	Acute	Entire

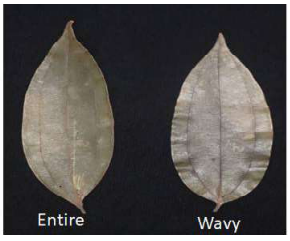
sources. With respect to leaf shape, five types *viz*., elliptic, oblong, ovate, ovate-elliptic and ovate-lanceolate were recorded. Four types of leaf tip shapes *viz*., acuminate, acute, sub-acute and obtuse were recorded (Plate 1).

a) Variation in leaf shape



b)Variation in leaf tip shape

c) Variation in leaf colour



d) Variation in leaf margin

Plate 1. Variation in leaf morphology among the selected trees of *Cinnamomum zeylanicum*

The variation in leaf parameters of selected trees of *C. zeylanicum* at Sirsi source are depicted in Table 3. The dark green colour was predominately expressed by the trees, only three trees (S1, S5 and S8) showed green coloured leaf. All the five types of leaf shapes were observed in the Sirsi source. Acuminate (4) and acute (4) leaf tips were equally expressed by selected trees. The wavy type of leaf margin was noticed only in S2 and S5 whereas, all other showed the entire leaf margin.

In the Joida source, there was no variation in leaf petiole colour and leaf margin. Only tree number J10 had a green leaf; the others all had dark green leaves. The majority of the selected trees showed ovate elliptic (4) leaf shape followed by ovate shape (3). Elliptic leaf shape was least expressed (1). A similar trend was noticed in the leaf tip shape where, acute leaf tip (5) was predominantly expressed (Table 4).

Among ten trees of Yellapur source, eight had dark green coloured leaf and only two had green coloured leaf. Leaf shape and leaf tip shape showed wide variation among the trees studied, where most trees exhibit elliptic leaf shape. The majority of trees showed acuminate (4) tip shape followed by acute (3), sub-acute (2) and least was an obtuse (1) tip shape. All trees possess the entire leaf margin without any variation (Table 5).

The leaf colour, leaf shape and leaf tip shape of selected trees in Gerusoppa varied greatly (Table 6). Tree numbers G5 and G9 were recorded green colour leaf whereas, ovate leaf shape was only noted in G4. The majority of trees showed elliptic leaf shape (5). With respect to leaf tip shape, the majority of trees (6) had recorded acuminate leaf tips, three trees showed acute leaf tips and one tree showed sub-acute leaf tips. Although the majority of trees had entire margin, one tree had wavy leaf margin.

In Hosakambi source also leaf shape and tip shape exhibit considerable variation (Table 7) among the selected trees, even though leaf colour and petiole colour did not have any variation. Four trees showed ovate elliptic leaf shapes and three trees showed elliptic leaf shape. Similar trend was also noted in the leaf tip shapes where six trees showed acuminate leaf tip shape and four trees showed acute leaf tip. With respect to leaf margin two trees showed wavy leaf margins and the remaining two showed the entire leaf margin.

Wide variation was observed in the leaf shape and leaf tip shape among the selected trees of Bhatkal source (Table 8). Elliptic leaf shape was recorded in five trees, ovate elliptic in three trees and ovate shape in two trees. With respect to tip shape six trees showed acuminate leaf tip, two trees showed acute leaf tips, one tree showed obtuse and one tree showed sub-acute tip shape. However, every selected tree showed dark green colour leaf, green colour petiole and entire leaf margin.

In the study no variation was observed in petiole colour; all were showed green coloured petiole. Leaf colour varied from

Table 5. Variation in leaf parameters of selected trees of *C. zeylanicum* in Yellapur source

Tree No.	Leaf Parameters				
	Leaf colour	Petiole colour	Leaf shape	Tip shape	Leaf Margin
Y1	Dark Green	Green	Ovate-lanceolate	Acuminate	Entire
Y2	Dark Green	Green	Elliptic	Acuminate	Entire
Y3	Green	Green	Oblong	Acute	Entire
Y4	Dark Green	Green	Ovate-elliptic	Acute	Entire
Y5	Dark Green	Green	Ovate	Sub-acute	Entire
Y6	Dark Green	Green	Elliptic	Acuminate	Entire
Y7	Green	Green	Ovate-elliptic	Acuminate	Entire
Y8	Dark Green	Green	Elliptic	Acute	Entire
Y9	Dark Green	Green	Elliptic	Sub-acute	Entire
Y10	Dark Green	Green	Elliptic	Obtuse	Entire

Table 6. Variation in leaf parameters of selected trees of *C. zeylanicum* in Gerusoppa source

Tree No.	Leaf Parameters				
	Leaf colour	Petiole colour	Leaf shape	Tip shape	Leaf Margin
G1	Dark Green	Green	Ovate-lanceolate	Acuminate	Entire
G2	Dark Green	Green	Elliptic	Acuminate	Entire
G3	Dark Green	Green	Ovate-lanceolate	Acute	Entire
G4	Dark Green	Green	Ovate	Acuminate	Entire
G5	Green	Green	Ovate-lanceolate	Acuminate	Wavy
G6	Dark Green	Green	Ovate-lanceolate	Acuminate	Entire
G7	Dark Green	Green	Elliptic	Sub-acute	Entire
G8	Dark Green	Green	Elliptic	Acute	Entire
G9	Green	Green	Elliptic	Acuminate	Entire
G10	Dark Green	Green	Elliptic	Acute	Entire

Table 7. Variation in leaf parameters of selected trees of *C. zeylanicum* in Hosakambi source

Tree No.	Leaf Parameters				
	Leaf colour	Petiole colour	Leaf shape	Tip shape	Leaf Margin
H1	Dark Green	Green	Elliptic	Acute	Entire
H2	Dark Green	Green	Ovate-elliptic	Acuminate	Entire
H3	Dark Green	Green	Elliptic	Acute	Entire
H4	Dark Green	Green	Ovate-lanceolate	Acuminate	Entire
H5	Dark Green	Green	Ovate-elliptic	Acute	Entire
H6	Dark Green	Green	Ovate	Acuminate	Wavy
H7	Dark Green	Green	Ovate-elliptic	Acuminate	Entire
H8	Dark Green	Green	Elliptic	Acuminate	Entire
H9	Dark Green	Green	Ovate	Acuminate	Entire
H10	Dark Green	Green	Ovate-elliptic	Acute	Wavy

Table 8. Variation in leaf parameters of selected trees of *C. zeylanicum* in Bhatkal source

Tree No.	Leaf Parameters				
	Leaf colour	Petiole colour	Leaf shape	Tip shape	Leaf Margin
B1	Dark Green	Green	Elliptic	Obtuse	Entire
B2	Dark Green	Green	Ovate-elliptic	Acuminate	Entire
B3	Dark Green	Green	Ovate	Acuminate	Entire
B4	Dark Green	Green	Ovate-elliptic	Acuminate	Entire
B5	Dark Green	Green	Elliptic	Acute	Entire
B6	Dark Green	Green	Ovate	Acuminate	Entire
B7	Dark Green	Green	Elliptic	Acute	Entire
B8	Dark Green	Green	Ovate-elliptic	Acuminate	Entire
B9	Dark Green	Green	Elliptic	Sub-acute	Entire
B10	Dark Green	Green	Elliptic	Acuminate	Entire

green colour to dark green colour, but all sources did not show this variation. In Hosakambi and Bhatkal sources only dark green leaves was recorded. Not much variation was observed for leaf margin. Leaf shape and leaf tip shape showed high variation among the sources and within the sources. Majorly five types of leaf shape *viz*., elliptic, oblong, ovate, ovate-elliptic and ovate lanceolate (Fig. 1) and with respect to leaf tip shape, four types (acuminate, acute, sub-acute and obtuse) were observed (Fig. 2). Elliptic shape was predominantly expressed in all sources except Joida; where, ovate shape was enormous. In case of leaf tip shape, acuminate leaf apex was principally recorded in all sources; whereas, in Joida source acute leaf tip was dominated. These leaf morphometric traits were less influenced by the environment, because these were controlled by the oligo gene. So, variation in the genetic make of the plants is the reason for the variations (Syukur *et al*., 2012).

Ravindran *et al*. (2004) reported that, the form of cinnamon leaves varied from oval or elliptic to lanceolate-oval or narrowly

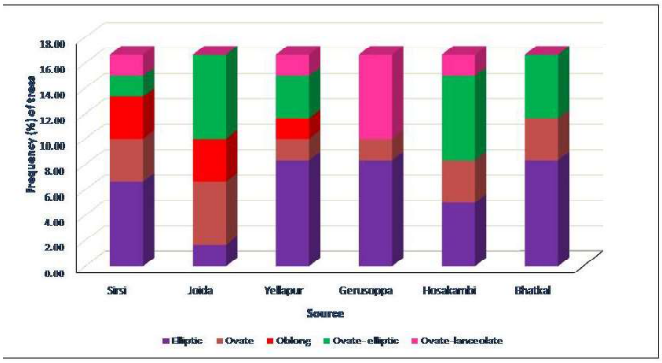


Fig. 1. Variation in the leaf shape among the different sources of *C. zeylanicum*

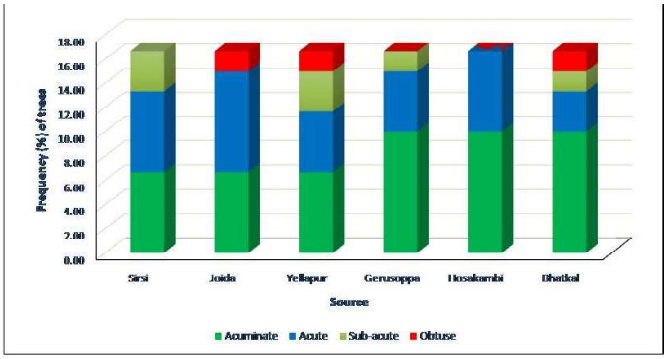


Fig. 2. Variation in the leaf tip shape among the different sources of *C. zeylanicum*

elliptic, with a short or widely acuminate leaf apex and an acutish or cuneate leaf base. Hanumantha *et al*. (2020) conducted work on the same species in Karnataka also recorded similar types of leaf shape and leaf apex. But they observed ovate shape (41.51%) was predominant and with respect to leaf tip shape sub-acute shape (66.98%) was dominated but in the Manchale and Jaddigadde source elliptic was in great well. This might be due to the work was carried in the farmers field but the current work was conducted in the natural forest as variation is higher in the natural forest compared to farm land.

The study outcomes of the Azad *et al*. (2019 and 2016)are supporting the results of the present study. High variation in leaf parameters were observed in Sri Lanka; nine types of leaf shape and eight types of leaf apex among the different sources. In present study also elliptic leaf shape and acute leaf apex were majorly expressed in all sources. Moreover, in Sri Lanka nine types of leaf shape and eight types of leaf apex was also noticed by Liyanage *et al.* (2021). The majority of the accessions had narrowly elliptic leaf shapes with an apex of acuminate shape and an obtuse base. They illustrated that, the eugenol content of leaves is positively correlated with leaf shape and base. The high variation in types of leaf shape and leaf apex was due to the enormous diversity of cinnamon in Sri Lanka compared to India.

The trees from various sources exhibited a predominant expression of dark green coloured leaf. Additionally, all trees shared the common characteristic of green-coloured petioles. Among the observed leaf characteristics, five distinct shapes were identified; elliptic, oblong, ovate, ovate-elliptic, and ovate lanceolate. Likewise, four types of leaf apexes were noted; acuminate, acute, sub-acute, and obtuse. Notably, the elliptic leaf shape and acuminate leaf tip were found to be the most prevalent features across the six sources. These findings highlight the diverse range of leaf morphology present within the studied population.

References

Azad R, Jayasekara L, Ranawaka R A A K, Senanayake G, Kumara K W, Pushpakumara D K and Geekiyanage S, 2019, Development of a core collection for Sri Lankan cinnamon germplasm based on morphological characterization using an eco-geographic survey. *Australian Journal of Crop Science*, 13(9): 1473-1485.

Azad R, Ranawaka R A A K, Senanayake G, Kumara K L W, Pushpakumara D K N G, Wijesinghe K G G, Geekiyanage and Sudarshanee, 2016, Morphological variation of cinnamon (*Cinnamomum verum* Persl.) germplasm in Matara District of Sri Lanka. *International Journal of Minor Fruits, Medicinal and Aromatic Plants*, 2(1): 6-14.

Bandusekara B S, Pushpakumara D K N G, Bandaranayake P C G, Wijesinghe K G G and Jayasinghe G G, 2020, Field Level Identification of Cinnamomum Species in Sri Lanka Using a Morphological Index. *Tropical Agricultural Research,* 31(4): 43-53.

Hanumantha M, 2020, Assembling genetic evaluation and selection of superior types in *Cinnamomum zeylanicum* Blum. *Ph.D. Thesis*, University of Agricultural Sciences, Dharwad, Karnataka, India.

Hanumantha M,Inamati S S, Krishna A, Manjunatha G O and Vasudeva R, 2020, Seed source variation for leaf morphological traits of *Cinnamomum zeylanicum* in the central western ghats of Karnataka: Implications for Domestication. *Journal of Pharmacognosy and Phytochemistry,* 9(5): 3229-3236.

Joseph J, 1981, Floral biology and variation in cinnamon. In: *4th Plantation Crops Symposium (Placrosym)*, The Indian Society for Plantation Crops, Central Plantation Crops Research Institute, Kasaragod, Kerala, India,pp. 431 - 434.

Joy P P, Thomas J, Mathew S and Ibrahim K K, 1998, Growth, leaf oil yield and quality investigations in cinnamon (*Cinnamomum verum* Presl.). *Journal of Medicinal and Aromatic Plants Sciences*, 20(2): 401-406.

Liyanage N M N, Bandusekara B S, Kanchanamala R W M K and Hathurusinghe H A B M, 2021, Identification of superior *Cinnamomum Zeylanicum* Blume. germplasm for future true cinnamon breeding in the world. *Journal of Food Composition and Analysis,* 96 (2021): 103747.

Liyanage N M N, Ranawake A L and Bandaranayake P C G, 2020, Cross-pollination effects on morphological, molecular, and biochemical diversity of a selected cinnamon (*Cinnamomum zeylanicum* Blume) seedling population. *Journal of Crop Improvement,* 35(1): 21-37.

Lizawati L, Riduan A, Neliyati N, Alia Y and Antony D, 2018, Genetic diversity of cinnamon plants (*Cinnamomum burmanii* BL.) at various altitude based on morphological character. *Materials Science and Engineering,* 434: 1-7.

Oliveira A P, Baptista P, Andrade P B, Martins F, Pereira J A, Silva B M and Valent˜ao P, 2012, Characterization of *Ficuscarica* L. Cultivars by DNA and secondary metabolite analysis: is genetic diversity reflected in the chemical composition. *Food Research International,* 49: 710-719.

Rana V S, Devi C B, Verdeguer M and Blázquez M A, 2008, Variation of terpenoids constituents in natural population of *Cinnamomum tamala* (L.) leaves. *Journal of Essential Oil Research*, 21(6): 531-534.

Ravindran P N, Nirmalbabu K and Shylaja M, 2004, Cinnamon and Cassia: The genus Cinnamomum. Medicinal and Aromatic Plants - Industrial Profiles. CRC Press, Florida, USA., 15-20.

Sadeghi S, Davoodvandi A, Pourhanifeh M H, Sharifi N, ArefNezhad R, Sahebnasagh R, Moghadam S A, Sahebkar A and Mirzaei H, 2019, Anti-Cancer Effects of Cinnamon: Insights into Its Apoptosis Effects. *European Journal of Medicinal Chemistry,* 178: 131-140.

Sasikumar B, Krishnamoorthy B, Saji K V, George J K, Peter K V and Ravindran P N, 1999, Spices diversity and conservation of plants that yield major spices in India. *Plant Genetic Resources Newsletter*, 118: 19-26.

Syukur M, Sujiprihati S and Yunianti R, 2012, Teknik PemuliaanTanaman. Jakarta, Penebar Swadaya Publishers, Jakarta, Indonesia, pp. 25-35.

Wijesinghe K G G and Gunarathna W D L, 2001, Characterization of true Cinnamon (*Cinnamomum verum* Persl) based on leaf morphology and their relationship with yield and quality. In: *57th Annual Sessions of the Sri Lanka Association for the Advancement of Science,* Sri Lanka, pp. 42

Zachariah T J and Leela N K, 2018, Spices: secondary metabolites and medicinal properties. In: *Indian Spices* (Ed. Sharangi A B), *Springer International Publishing, New Delhi*, pp. 277-316.

Zare R, Nadjarzadeh A, Zarshenas M M, Shams M and Heydari M, 2019, Efficacy of cinnamon in patients with type II diabetes mellitus: A randomized controlled clinical trial. *Clinical Nutrition,* 38(2): 549-556.