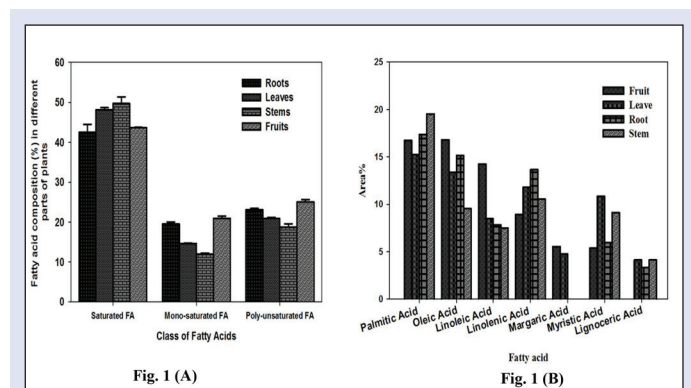






**Table 2:** Half maximal inhibitory concentration ( $IC_{50}$ ) of *L. cephalotes* plant parts ethanolic extract in comparison with standard drug on acarbose on porcine pancreatic  $\alpha$ -amylase inhibitory activities. The results are represented as mean  $\pm$  SD

Plant extract	$IC_{50}$ value ( $\mu\text{g/mL}$ )
Fruits	92.86 $\pm$ 0.89
Leaves	98.09 $\pm$ 0.69
Stems	218 $\pm$ 0.93
Roots	109.00 $\pm$ 0.97
Acarbose	88.28 $\pm$ 0.94



**Figure 1:** (A) The major classes of FAs. (B) Percentages of major FAs present in different parts of *L. cephalotes*

positive control in the concentration range 40–160  $\mu\text{g/mL}$ . The  $IC_{50}$  values were determined from plots of percent inhibition versus log inhibitor concentration and calculated by nonlinear regression analysis from the mean inhibitory values.

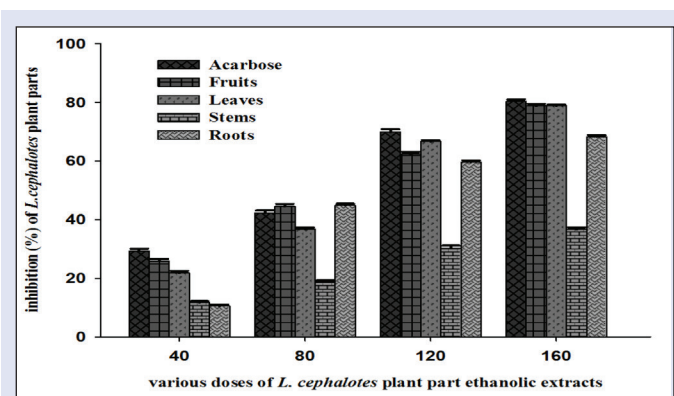
## RESULTS AND DISCUSSION

Indian has a rich heritage of medicinal plants that have been used since the ancient times to treat many diseases, including diabetes. *L. cephalotes* is used by tribes for treatment of diabetes. In this present study, we focused on antihyperglycemic potential and essential FA study of *L. cephalotes*. All parts of *L. cephalotes* were extracted with ethanol and extractive yield was 8.57% w/w (fruit), 6.93% w/w (leaves), 4.23% w/w (stem), and 3.35% w/w (roots), respectively.

### FA analysis

Hexane extract of *L. cephalotes* plant parts were derivatized into FAME in which fruits (0.22%) and leaves (0.21%) showed the highest yield of FAs percentage. FAs analysis of hexane extract of all parts of *L. cephalotes* was analyzed by GC-MS. The analysis enabled the identification of 19 FAs in fruits, leaves, stems, and roots. Comparative study of FAs in *L. cephalotes* fruits, leaves, stems, and roots are listed in Table 1. Major FFAs present in all parts of *L. cephalotes* are represented in Figure 1B, in which the concentration of palmitic acid was higher in all parts of the plant [Figure 1B]. The present study revealed that *L. cephalotes* is a rich source of unsaturated and essential FA. Percentage yields of saturated FA, mono-unsaturated FA, and polyunsaturated FA represented in Figure 1A.

To the best of our knowledge, it is the first study of comparative analysis of FA of *L. cephalotes* plant parts. Insulin secreted from pancreatic  $\beta$ -cells response to elevated plasma glucose level, which is modified by various factors and one of the major factor is FFAs. FFAs is an important source of nutrients and also acts as signaling molecules in various cellular processes including insulin secretion.<sup>[12]</sup>



**Figure 2:**  $\alpha$ -Amylase inhibitory activities of ethanolic extracts of *L. cephalotes* various plant parts by using acarbose as a standard

Major essential FAs in *L. cephalotes* are oleic acid, linoleic acid, linolenic acid, palmitic acid, and stearic acid, which are all beneficial for lowering body cholesterol.<sup>[13]</sup> Linoleic acid is one of the major constituent of all plant parts; it also helps to prevent diabetes and its late complications.<sup>[14]</sup> Most of the saturated FAs like palmitic and stearic acid are used for dietary supplements; they increase the nutritional value of the product and add to the overall health benefits. Although FA composition of *L. cephalotes* seed has already been reported,<sup>[15]</sup> in the present study, whole plant part has been found to have beneficial saturated and unsaturated FAs; thus, the study proves that *L. cephalotes* whole plant may be used as a novel source of beneficial FAs. Many studies have concluded when FFA level decreased in diabetic and obese patients; the level of insulin secretion is also decreased up to 30–50%.<sup>[16]</sup>

### $\alpha$ -Amylase inhibition assay

The dose-dependent  $\alpha$ -amylase inhibitory activity of ethanolic extracts of *L. cephalotes* all parts was tested in triplicates. Among these ethanolic extracts of all parts of the plants, maximum inhibition percentage was shown by fruits (79%) then leaves (78.59%) in comparison to standard acarbose (80.34%) at 160  $\mu\text{g/mL}$ , while roots (68.26%) showed moderate and stems (36.38%) showed the minimum inhibition percentage. Acarbose at concentrations (40–160  $\mu\text{g/mL}$ ) showed  $\alpha$ -amylase inhibitory activity from 29.37  $\pm$  0.69 to 80.34  $\pm$  0.67  $\mu\text{g/mL}$ , with an  $IC_{50}$  value of 88.28  $\pm$  0.94  $\mu\text{g/mL}$  [Table 2]. Ethanolic extract of fruit showed highest inhibitory activity, which varied from 25.94  $\pm$  0.68 to 78.83  $\pm$  0.67  $\mu\text{g/mL}$ , with an  $IC_{50}$  value of 92.86  $\pm$  0.89  $\mu\text{g/mL}$ , whereas inhibitory activity in leaves varied from 21.80  $\pm$  0.96 to 78.91  $\pm$  0.37  $\mu\text{g/mL}$  inhibition with  $IC_{50}$  (98.09  $\pm$  0.69  $\mu\text{g/mL}$ ) [Figure 2]. The significant ( $P < 0.001$ ) decrease was found in starch breakdown at dose range from 120 to 160  $\mu\text{g/mL}$ . Table 2 shows  $IC_{50}$  ( $\mu\text{g/mL}$ ) values of ethanolic extracts of different parts of *L. cephalotes*.

The approach to reduce postprandial glucose level by inhibiting  $\alpha$ -amylase is an effective strategy for diabetes management.<sup>[17]</sup> This study revealed that the ethanolic extract of the fruits and leaves of *L. cephalotes* have potent  $\alpha$ -amylase inhibitory activity. The present study, therefore, seems to be the first endeavor to reveal the potential  $\alpha$ -amylase inhibitory activity in the ethanolic extract of fruits and leaves of *L. cephalotes*.

## CONCLUSION

In our study, we found total 19 FAs, in which fruits showed highest area percentage 88.97% of FFAs as well as highest inhibition percentage of  $\alpha$ -amylase. The result indicates that *L. cephalotes* has potential to inhibit  $\alpha$ -amylase and this therapeutic potential could be beneficial in the

management of postprandial hyperglycemia in the treatment of type 2 DM. Further, this study directs future research in separating the bioactive compound responsible for this activity. The present investigation revealed that the FAs from the *L. cephalotes* can be used in various pharmaceutical products, as it contains different bioactive FAs.

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## Conflicts of interest

There are no conflicts of interest.

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