PLANT SCIENCE TODAY
ISSN 2348-1900 (online)
Vol x(x): xx–xx
https://doi.org/10.14719/pst.3107

HORIZON
e-Publishing Group
HePG

RESEARCH ARTICLE

Exploration of marketing strategies through resource quantification and economic evaluation in *Elaeocarpus serratus* L., unlocking its potential

R.M Deepthy & E.A. Siril*

Department of Botany, University of Kerala, Kariavattom, Thiruvananthapuram, Kerala, 695 581, India

*Email: easiril@yahoo.com

OPEN ACCESS

ARTICLE HISTORY

Received: 20 November 2023
Accepted: 30 March 2024

Available online
Version 1.0 : 23 May 2024

Check for updates

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information is available at https://horizonepublishing.com/journals/index.php/PST/open_access_policy

Publisher's Note: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting

Copyright: © The Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited (https://creativecommons.org/licenses/by/4.0/)

CITE THIS ARTICLE

Deepthy RM, Siril EA. Exploration of marketing strategies through resource quantification and economic evaluation in *Elaeocarpus serratus* L., unlocking its potential. Plant Science Today (Early Access). https://doi.org/10.14719/pst.3107

Abstract

Elaeocarpus serratus L. is an indigenous tree that yields edible fruits with high nutritional value, yet the cultivation, marketing in mainstreams and consumption have not intensified so far despite its potential. So, this work aims to realize the unexplored potential of *E. serratus* as an agroforestry resource by evaluating the economic as well as marketing status of the fruits. The methodology consists of assessing the resource distribution, fruit yield, constraints for domestication and economic viability of *E. serratus*. According to resource quantification data, cluster 1 had the highest average fruit yield (32.5 kg). The respondents' opinionated harvesting challenges, with a mean Likert score of 3.711, underscore that the majority of fruits were wasted. The processed, salt dipped fruits have the highest selling profit of 150 INR (USD 1.80) per kg. The selling of fruits through different market channels and the t-test analysis of profit of raw and processed fruits indicated a significant difference ($P<0.001$). The raw and processed fruits have a total marketing cost of 995 INR (USD 12) and 1030 INR (USD 12.44) (for 10 kg). However, the marketing efficiency and degree of market performance were observed to be poor. The lack of value-added products, scattered distributions, seasonal availability and priority for exotic fruits affect their demand. Further, the study emphasizes the need to address marketing challenges and explore the economic potential of *E. serratus*. This aligns with the broader goal of sustainable management and commercial feasibility of other underutilized fruits globally and the report is the first of our knowledge.

Keywords

Elaeocarpus serratus; economic analysis; market channels; resource quantification; underutilized fruits

Introduction

Underutilized fruits have the potential to serve as a source of livelihood and food for local communities throughout the world. *Elaeocarpus serratus* (family Elaeocarpaceae), commonly known as Ceylon Olive, is a tropical evergreen tree distributed in India, Sri Lanka, some parts of South East Asia and Africa. The fruit of *E. serratus* is a drupe and edible with a sweet-sour taste. Various studies on fruits reported a wide array of bioactive compounds, including flavonoids, phenols, vitamin C and simple sugars (1). In South India, the fruiting period of *E. serratus* extends from February to July. The fruits are traditionally prescribed for treating diarrhoea and dysentery. The fruit pulp is known to stimulate secretions from taste buds, increasing appetite (2). Fruits with a high pulp-fruit ratio are preferred for

consumption. Conversely, the small fruit with a high seed-fruit ratio must be excluded and this selection criterion enhances the productivity of the tree (3). The leaves are a good source of bioactive compounds such as fatty acid esters, hydrocarbons, aldehydes, alkenes, fatty acids and amides that justify the use of plants for various ailments by traditional practitioners (4). The extract of *E. serratus* leaves contains polyphenols, flavonoids and myricitrin (5). Myricitrin is reported to ameliorate toxic liver damage by several mechanisms, acting as guardians of an antioxidant defense system, inhibitors of inflammation and suppressors of profibrotic response as well as enhancers of liver regeneration (6). The HR-MS analysis revealed the presence of 5 novel compounds in the methanolic leaf extract, of *E. serratus viz.,* clotrimazole, etamiphylline, 2'-O -Methylcytidine, aspidocarpine and leupeptin (7). On phylogenetic assessment, the trnL-trnF based phylogeny the *E. serratus* trees cladded with *E. stipularis, E. tectorius, E. dongnaiensis* and *E. glaber* (8). For the preparation of nutraceuticals, the extracts and fermented products of *E. serratus* leaves can be used as a nutritional supplement in foods such as black soymilk products (9). *E. serratus* is a potential fruit crop but is neglected due to the following reasons; (i) though the fruit is rich in bioactive constituents, this fruit tree is not at all commercialized or cultivated on a large scale anywhere in the world, (ii) unavailability of superior planting material restricting the cultivation and popularization of this potential fruit crop (10). However, to a limited extent, the propagation through conventional vegetative means supports cultivation by farmers (11). Based on the present utilization pattern, *E. serratus* fruits can be categorized as minor and underutilized since their growth and marketing are limited.

Most underutilized, minor fruit resources are essential in overcoming malnutrition and are used as therapeutic for various ailments, thus satisfying the demands of health-conscious consumers (12). The minor fruits have less production input cost and maximum yields with high nutritional value. The *E. serratus* is one such indigenous fruit crop that requires minimum maintenance. The efficient and sustainable crop production is related to minimizing the input costs while maximizing both the quantity and quality of crop yields, with a focus on nutritional richness. The establishment and maintenance of a diversified, self-sustaining low input farming system, which is economically viable for the indigenous minor underutilized fruits, could be managed to maximize net production without causing long term changes to the environment (13). The balanced quantities of organic and inorganic fertilizers with specific microorganisms maintains the soil fertility thus optimizing the level of yield, maximizing the profitability and can be applied for those underutilized fruits to enhance their cultivation (14). In most cases, no advanced cultivars are available for the important minor fruit species due to the lack of characterization studies. But germplasm exploration studies have been conducted and superior genotypes that have been screened for *E. serratus* and the screened germplasm have fruits with high weight and pulp yield, serving as a source tree for cloning through conventional methods or micropropagation and as a parent type for breeding programmes (15). Vegetative cloning was also applied to multiply elite germplasm and conserve elite germplasm in the natural stands of *E. serratus* (16). The application of novel technologies can assist in boosting the productivity of minor fruits like *E. serratus* and improving their economic benefits. The application of digestate biochar reduces the need for chemical fertilizers; biochar can increase crop yields and improve crop quality, by promoting nutrient availability to plants and enhancing the fertility of soil resulting in higher profits for farmers (17). Studies suggest that using silica nanoparticles made from coir pith, an eco-friendly method could benefit farmers by improving the germination rate of seeds, which subsequently increases the yield and recommended for the economic feasibility (18). Application of mineral phosphorous fertilizers can support higher crop yields but their immobilization in soil due to edaphic factors can restrict their availability for the uptake by plants and can cause environmental issues (19). It is observed that crops can use calcium-based phosphates (CaP), and to a limited extent, also some aluminium-based phosphates (AlP), whereas Phosphorous is present in ferric-based phosphates (FeP) and in this scenario the researchers have developed a new sorbent material for recovering phosphorus from sludge water and can be reused a fertilizer which is agronomically viable (20). When improvement efforts in such potential tree crops are explored in conjunction with that, it is important to study the economic aspects, marketing and livelihood supporting of such crops. Past experiences suggest that many indigenous crops are well adapted to marginal land with low-cost inputs, thus benefiting villagers by ensuring sustainable income.

In the case of most of the indigenous fruits, area and productivity are unaccounted or uncatalogued. As such, the potential of *E. serratus* as a fruit crop is not fully explored in Kerala, the southernmost state of India. The *E. serratus* trees are not cultivated on a large scale and are sparsely distributed in Kerala. Even though its fruits are sold in some regions of South Kerala, at the same time, there are no linkages between the sales, market and distribution of these fruits. These fruits have only limited mainstream markets despite their bulk quantity. Currently, the salt-dipped fruits from major city centres are brought from the street vendors at price lesser than other commercially processed fruits. The key business players involved in the marketing of the *E. serratus* are farmers, pre-harvest contractors, wholesalers and retailers. To gain the attention from further business players like agro processors, exporters, Government institutions and NGO's, more innovative post harvesting and marketing techniques attracting the investors for popularizing them should be developed. To draw attention from the investors and generate profit, a suitable investment strategy should be proposed to address the investor's preferences, attitude of investor to risk factor, financial possibilities, expected return, and the self interest (21). This can be achieved by joining the hands of investment–industrialist

specialists and experts from the food and agriculture industry. For the marketing of underutilized fruits like *E.serratus*, some microstructural shocks can influence investment decisions, resource allocation, market dynamics and economic outcomes and understanding the dynamics of microstructural shocks on private investment behaviour can inform investors making decisions that promote economic growth (22).

As previously mentioned in the literature, various studies were carried out on the phytochemistry, diversity, propagation, morphometric variations and phylogenetics and characterization of bioactive compounds from *E. serratus.* However, studies addressing the market potential, economic analysis and value addition of fruits at a commercially viable level are not available. Investigations of market potential, including social, cultural, economic and policy aspects, are to be explored to foster the conservation and effective utilization of this species (23). In view of these, an analysis was performed on the economic status of *E. serratus* fruit resource with the following objectives; 1. Investigate the population structure and availability of the species to determine its distribution pattern. 2. Fruit harvesting, yield estimation and marketing pattern 3. Analyzing the factors affecting the marketing of *E. serratus* and 4. Propose novel strategies for a better utilization of *E. serratus* fruit resources. The current research work is formulated for the betterment of beneficiaries involved in the marketing of *E. serratus* by implicating critical economic investigations and dissecting the market channels.

Materials and Methods

Resource quantification and yield analysis

Extensive exploration surveys were conducted across Kerala state, South India from February to July (2019-2022), searching for fruit-bearing trees of *E. serratus*. The map of the selected study area in Kerala state is described in Fig. 1. The resource quantification studies were done in the Thiruvananthapuram district of Kerala as the distribution of this tree is high in the area. However, distribution lack any distinct pattern thus, locations were grouped into 7 different clusters. Enumeration of trees in each cluster was performed, and yield analysis was conducted. Annual fruit yield per tree, number of fruits required to weigh 1 kg, was determined as the primary assessment of yield parameters (24, 25).

Likert scale analysis

The Likert scale survey was attended by a total of 45 participants since they have *E.serratus* in their homesteads or neighbourhoods during the period from 2020 to 2022.The quantitative data were statistically analyzed using SPSS (Statistical Package for Social Sciences) software, v. 22 (Inc. Chicago, IL, USA). A Likert scale interval based on multiple-choice plus questionnaires was used for grading the activities between 1 to 5. The responses are classified into various classes. The response score from 1 to 1.8 indicates strongly disagree, 1.81 to 2.6 indicates disagree and 2.61 to 3.40 is a neutral response. Whereas the score of 3.41 to 4.20 indicates that the respondents agree with the statement and finally, from 4.21 to 5, the respondents strongly agree with the statement (26).

Market Survey and Economic analysis

Survey regarding the marketing of *E. serratus* were conducted during the fruiting season for three consecutive years (2020-2022). During the ripening of *E. serratus*, which usually occurs between February to April, data on collection, sale, and profit were recorded from fresh fruit stores and street fresh fruit vendors. Direct interviews were conducted, and the data were procured from street vendors, local and mainstream markets, homesteads, and school premises from various locations in Kerala state. A total of 26 sellers participated in the surveys performed using questionnaires and direct interviews about the collection and sales of *E.serratus* fruits. About 49 *E.serratus* fruit collectors and consumers have participated in personal interviews. The student t-test analysis for comparing the prices and profits of raw and processed fruits was determined using SPSS v.22.The analytical

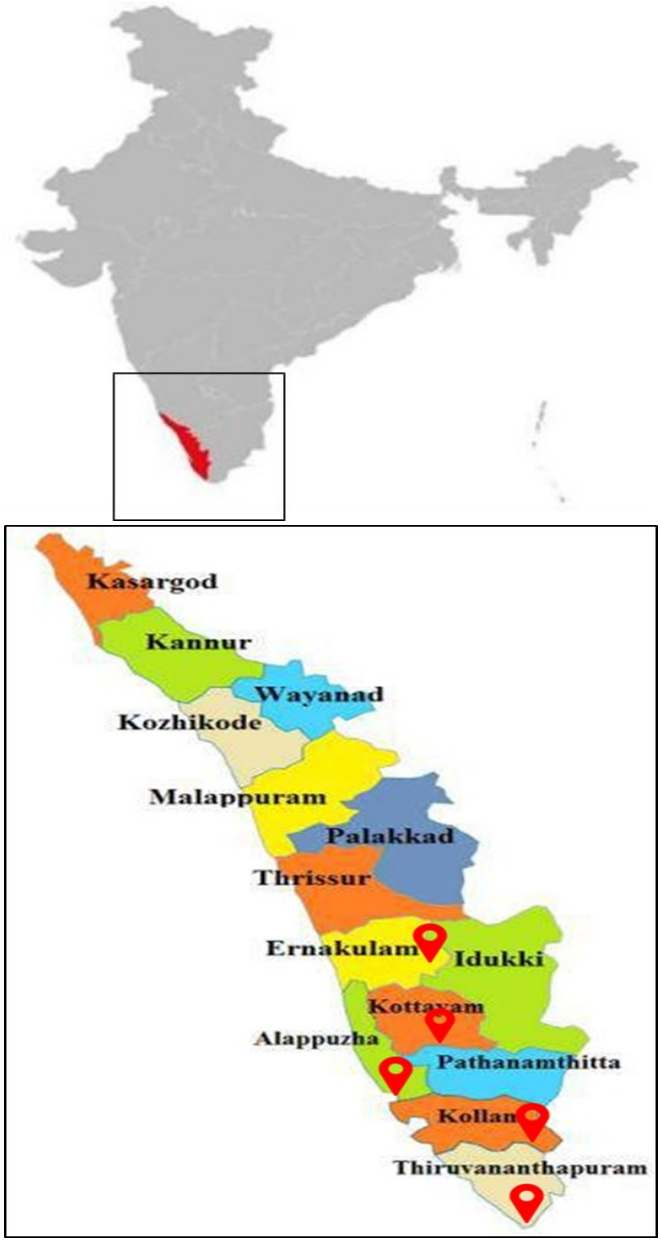

Fig. 1. Map of the study sites in Kerala, India.

techniques were applied to find out the marketing margins and net margins of intermediaries using the following formula, with the efficiency of marketing investigated by examining price spread, producers share and marketing efficiency (27).

Gross marketing margin:

Gross marketing margin = Sale price - purchase price (Eqn.1)

Net margin:

Net margin = Gross marketing margin - marketing cost (Eqn.2)

Price spread:

Price spread = Price paid by the consumers – Price received by the producer (Eqn.3)

Producer share (%) :

$$\text{Producer share (\%)} = \frac{\text{Price received by the producer}}{\text{Price paid by the consumers}} \times 100 \quad \text{(Eqn.4)}$$

Marketing efficiency :

The marketing efficiency was estimated using the Acharya - Agarwal modified method (28).

$$ME = \frac{FP}{(MC+MM)} \quad \text{(Eqn.5)}$$

Where, ME - Marketing efficiency

FP - Net price received by farmers

MC - Total marketing cost

MM - Total net marketing margin of intermediaries.

Results

Resource Quantification and Yield Analysis

The resource quantification was performed by selecting seven model clusters from different locations in the Thiruvananthapuram district of Kerala state. The average yield from each clusters were estimated and recorded in Table 1. The first cluster had the highest mean fruit yield (32.5 kg). Despite high yield, less than 10 kg of fruits are harvested or consumed. In turn, most fruits remain wasted. Cluster 5 has the next highest yield from the selected clusters. The trees are found on riverbanks and homesteads in these clusters. Clusters 6 and 3 have the next highest yield regarding resource quantification. In other clusters, the yield is low since the resources have limited availability.

Likert Scale Analysis

Perception of people on *Elaeocarpus serratus* utilization:

The *E. serratus* trees is mainly growing in homesteads in different localities of Kerala (Fig. 2). The survey revealed that certain constraints exist in popularizing *E. serratus* in the homesteads and those limitations from the perceptions of participants recorded in Table 2. The statement indicating that manual plucking of fruits is strenuous, had a high mean value of 3.711, meaning most participants agreed that fruit harvesting is difficult and time-consuming. The manual labour for plucking fruits from large-sized *E. serratus* trees is a strenuous process, hindering the owners and local people from harvesting the fruits. It is followed by mean score values of 3.6 and 3.53, with the statements indicating the lack of proper storage facilities and perishability of fruits after harvesting generates only a little interest in owners. The owners have a mixed response to the fact that the production of value-added products from *E. serratus* fruits is not much

Table 1. Geographical location of *Elaeocarpus serratus* trees and resource quantification from different clusters of Thiruvananthapuram district of Kerala

Location	Altitude (msl)	Latitude	Longitude	Cluster	Number of trees	Mean fruit yield (kg ha^{-1} year^{-1})
Tripadapuram	40	8°32'49"N	76°52'57"E	Cluster 1	8	32.50
Kazhakkoottam	38	8°32'53"N	76°52'05"E			
Kariavattom	62	8°33'51"N	76°53'04"E			
Pangappara	53	8°33'25"N	76°54'04"E			
Chenkottukonam	82	8°35'00"N	76°54'18"E	Cluster 2	2	5.25
Chempakamangalam	68	8°38'52"N	76°50'08"E	Cluster 3	4	12.45
Challimukku	146	8°47'14"N	77°01'03"E	Cluster 4	3	10
Karumancode	114	8°43'59"N	77°01'48"E			
Moongodu	72	8°30'02"N	77°01'07“E	Cluster 5	7	22.67
Kattakada	79	8°30'00"N	77°03'32“E			
Mylakkara	76	8°31'19"N	77°07'43"E			
Neyyardam	96	8°32'06"N	77°08'45"E			
Tholicode	128	8°36'34"N	77°02'08"E	Cluster 6	5	18.50
Vithura	140	8°40'24"N	77°04'58"E			
Palode	136	8°43'26"N	77°01'29"E			
Neyyatinkara	37	8°24'02"N	77°05'02"E	Cluster 7	3	7.75
Parasuvaikkal	74	8°22'37"N	77°08'56"E			

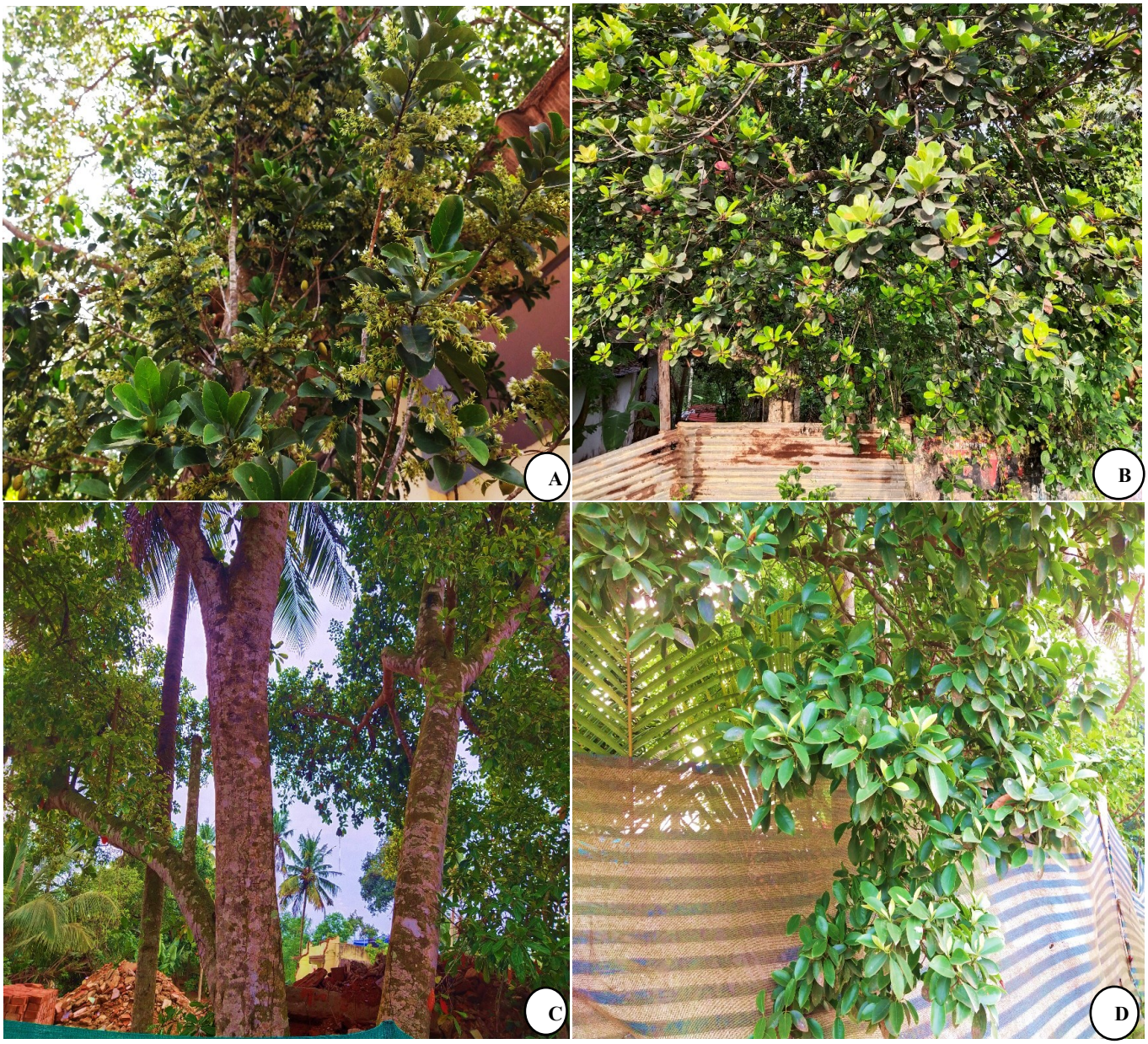

Fig. 2. *Elaeocarpus serratus* trees in the homesteads across the state: (A)- Neyyatinkara; (B)- Korani; (C)- Karuvatta; (D)- Veloor.

Table 2. Assessment of constraints in the domestication and popularity of *Elaeocarpus serratus* in homesteads and institutions

Statement	Mean
Difficulty in the market accessibility of fruits	3.177 ± 0.177
Plucking of fruits is strenuous	3.711 ± 0.181
Easy decaying of fruits	3.600 ± 0.169
Less storage facilities	3.533 ± 0.178
Not familiarised with the production of value-added products from *E. serratus*	3.111 ± 0.183

Score value: 5 strongly agree, 4 agree, 3 Neither agree or disagree, 2 disagree, 1 strongly disagree Minimum 1, Maximum 5 (The 5 Point Likert Scale Ranking).

explored or popularized. Similarly, the other constraint is the difficulty in accessing urban markets due to transportation charges.

Mode of disposal of *Elaeocarpus serratus* fruits:

The Likert scale analysis data on the different consumption patterns of *E.serratus* according to respondents is recorded in Table 3. In homesteads, the fruits of *E. serratus* are used for pickling or dipped in a salt solution for their own domestic use (Table 3). The mean value of 3.8 indicates that owners and the local community agree to consume fruits other than raw fruits by pickling or preserving them in a salt solution after boiling them. The fresh raw fruits of *E. serratus*, pickled *E. serratus* fruits and the salt dipped boiled fruits of *E. serratus* are depicted in Fig. 3a, 3b and 3c respectively. About 2 to 3 kg of fruits from these trees are collected by street vendors, wholesalers, or middlemen, according to a mean value of 3.45. The statement 'fruits are collected by passers-by, and the local community' has the highest mean value of 3.87, with which most people agree on the fact. Most of the

Fig. 3. Modes of consumption of *Elaeocarpus serratus* fruit: **(A)**- Raw fruit; **(B)**- Pickled fruits; **(C)**-Salt dipped fruits.

fruits were wasted, despite their bulk quantity, according to the respondents supporting the mean value of 3.73 in the statement.

Market survey and Economic analysis

The market prices of *E. serratus* from various stations were surveyed and tabulated (Table 4). The table 4 gives a comprehensive report on buying price and selling price along with profit in both raw and processed fruits in different study sites by classifying them into urban and rural centres. The data were collected from farmers, middle agents, wholesalers and retailers from the study sites. The price of fruits is subjected to fluctuations according to season and localities. The market locations in urban centres have more buying prices, selling prices and profit from the sales of *E. serratus* fruits. In urban centres, processed fruits have more demand than fresh ones. They have a higher profit of 150 INR in markets compared with the sales of raw fruit in rural centres. The profit from the sales of raw fruits ranges from 15-30 INR and the profit sometimes varies according to demands from consumers. In urban areas, the retailers process the fruits into preserved form and sell the processed fruits after packing them into polythene covers at the rate of 30 INR per packet. A packet usually contains 10-17 fruits with approximately 140-150 g. Most of the buyers purchase 250 g to 500 g. The student's t test analysis was conducted to compare the price and profit for raw and value-added products (Table 4). The data shows that the sales of processed fruits gain a significant ($p<0.001$) profit than the raw fruits. The mode of sales of *E. serratus* fruits across study sites is shown in Fig. 4, indicating the sellers adopt different methods for the sales of these crops and there is no uniformity in assembling or packing the fruits.

Table 3. Mode of disposal of *Elaeocarpus serratus* fruits

Statement	Mean
Most of the fruits from the trees are wasted off	3.733 ± 0.180
Usually prefer raw consumption of fruit	2.933 ± 0.180
Usually, prefer pickled /salt solution-dipped fruits	3.800 ± 0.181
The fruits are usually sold at the market	2.933 ± 0.189
The fruits are collected by passers-by and natives	3.866 ± 0.157
The fruits are sold to middlemen/street vendors	3.448 ± 0.184

Score value: 5 strongly agree, 4 agree, 3 Neither agree nor disagree, 2 disagree, 1 strongly disagree: Minimum 1, Maximum 5 (The 5 Point Likert Scale Ranking).

Table 4. Price and profits of *Elaeocarpus serratus* fruits per kg at different sites

Market location	Rural/Urban	Buying price/kg* (INR)	Raw fruits		Processed fruits	
			Selling price (INR)	Profit (INR)	Selling price (INR)	Profit (INR)
Kattakada	Rural	60	75	15	200	100
Moongodu	Rural	65	80	15	….	….
Jagathy	Urban	180	….	….	230	50
Pothencodu	Urban	180	….	….	250	70
Shangumugham	Urban	150	….	….	300	150
Chakai Airport Road	Urban	130	….	….	220	90
Vettucaud	Urban	150	….	….	250	100
Kottamala	Rural	75	….	….	120	45
Chalai	Urban	80	100	20	…..	….
East Fort	Urban	100	150	50	….	….
Museum Lane	Urban	150	….	….	180	30
Kazhakuttom	Urban	50	75	25	100	50
Neyyardam	Rural	60	….	….	100	40
Chathanoor	Urban	50	80	30	…..	….
Paripally	Rural	50	80	30	…..	….
T test value			5.021***	3.570**	6.330***	4.919***

*Including processing and transportation charges

***Significant t value at $p<0.001$; **significant t value at $p<0.01$ level determined by independent sample t-test analysis

*1 INR (Indian currency) = 0.012 USD (US Dollars) in 2024

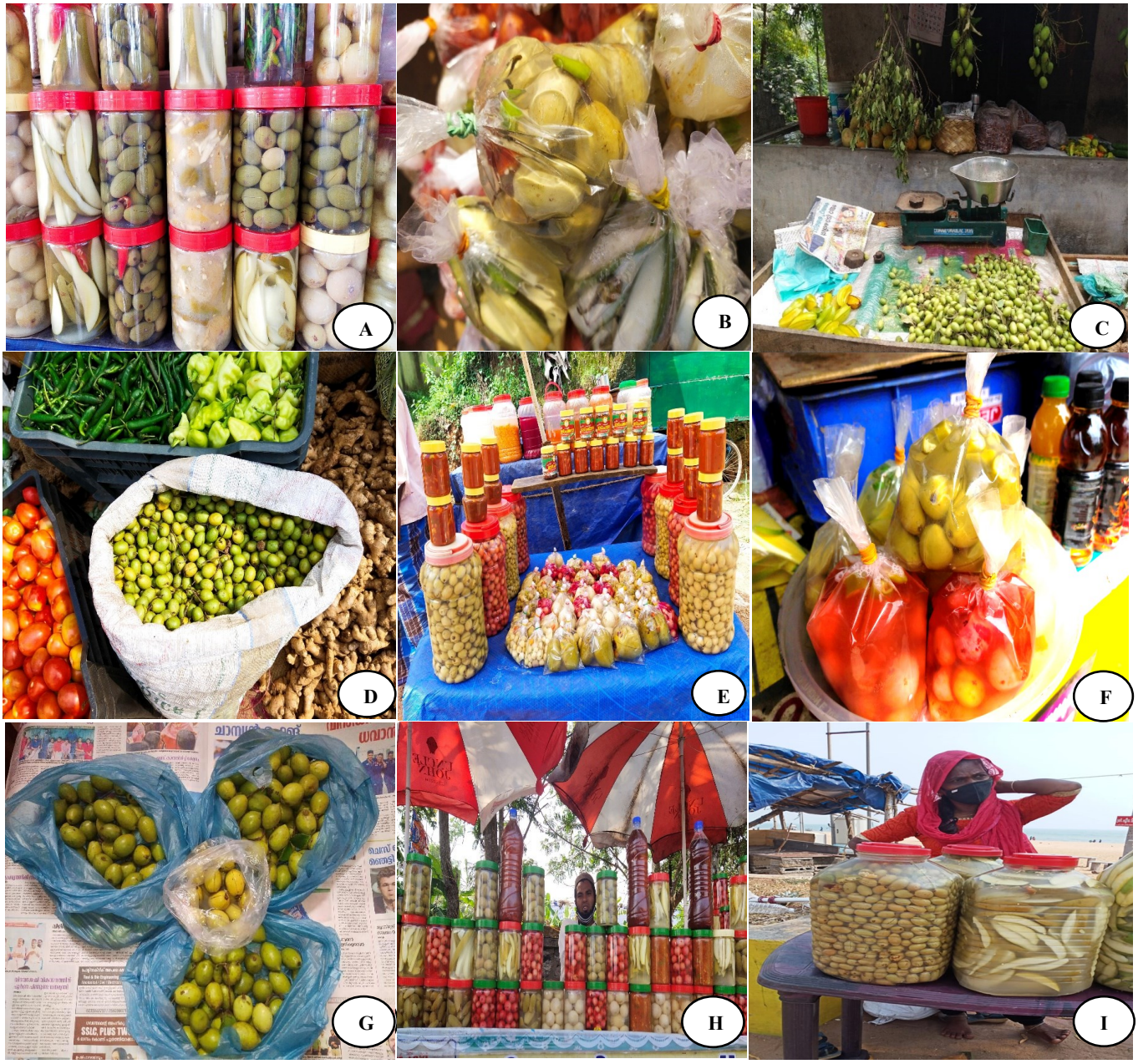

Fig. 4. *Elaeocarpus serratus* fruit marketing at various locations at the study sites: (A)- Jagathy; (B)- Pothencodu; (C)- Moongodu; (D)- Kattakada; (E)- Kottamala; (F)- Nanthencode; (G)- Kazhakkuttom; (H)- Chakai airport road; (I)- Shangumugham.

Marketing channels

The marketing channels are the routes for the product movement from the source or production site to the consumers. The market channels for the sales of *E. serratus* are simple and direct and there are no producers' or traders' organizations. Fig. 5 depicts a generalized marketing channel model for the sales of *E. serratus*, formulated from the responses of participants. There are different marketing channels related to the sales of *E. serratus* fruit (Fig. 5). A straightaway market channel functions from the producers or households where fruits are gathered, and they are directly sold to the consumers. This channel is efficient, as the producer gets a maximum price for their products through direct selling apart from the transportation charges. The transportation charges and other miscellaneous expenses are the only additional marketing costs in this channel. In the next marketing channel, the producers lent fruit trees for the preharvest contractors/ middle agents at a price range of INR 500-1000. Here the producers or households are subjected to make a marginal profit without any additional marketing costs. From the contractors, the fruits are collected by a middle agent to processors, wholesalers and retailers, reaching consumers. This is the longest supply chain and the marginal costs fluctuate among wholesalers and retailers. The middlemen or third parties earn the marginal shares. The marketing costs are higher in this channel. Another value chain involves the vendors or street sellers procuring the fruits from the producers at a reasonable price and selling to the consumers in processed or unprocessed form by adding related expenses, including transportation costs. In another market channel, middlemen or wholesalers collect processed fruits from the producer. The producer only gets a profit ranging from INR 20-50 from the middlemen or wholesalers. Retailers, then purchase the fruits at a rate of 50-100 INR. They are processed and finally sold to the consumer.

Table 5. Marketing costs of different persons employed in *Elaeocarpus serratus* processed and raw fruit marketing for 10 kg in INR.

Type of intermediaries	Transportation charges (INR)		Processing and packing charges (INR)		Shop Rent and salary (INR)		Spoilage and damage (INR)		Personal expenses including loading and unloading (INR)		Total (INR)	
	Processed	Raw	Processed	Raw	Processed	Raw	Processed	Raw	Processed	Raw	Processed	Raw
Farmer/ Direct sellers	-	-	-	-	-	-	-	-	75	75	75	75
Middle agent	125	125	25	25	-	-	25	30	100	100	275	280
Wholesalers	-		65	65	150	150	50	35	100	100	365	350
Retailer	120	120	65	40	-	-	30	30	100	100	315	290

*1 INR (Indian currency) = 0.012 USD (US Dollars) in 2024

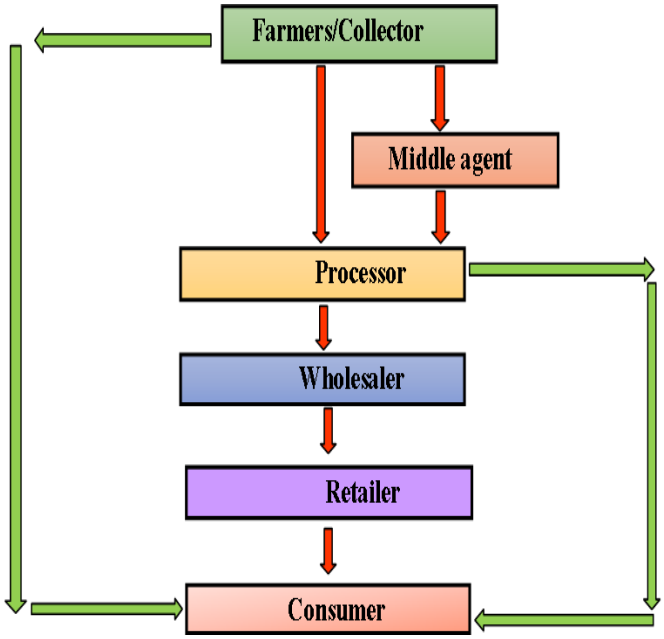

Fig. 5. Generalized marketing channel for *Elaeocarpus serratus.*

Marketing costs and margin of intermediaries in Elaeocarpus serratus

Marketing cost involves the movement of products from the producers to the consumers and varies with the channels through which the product passes. The cost of packing, transport, loading, unloading, losses and spoilages are included in marketing costs. The marketing cost for selling 10 kg of *E. serratus* fruits was estimated (Table 5). Table 5 gives an insight into the distribution of marketing costs among various intermediaries involved in the sales of *E. serratus*. The farmer or producer was the first person involved in the marketing channel. In some cases, the farmer directly sells his product to the consumer or engages in selling *E. serratus* fruits to contractors/ middlemen/local traders. Since the *E. serratus* trees require only low maintenance, the marketing costs are very low as they involve some personal expenses only. The contractors, middlemen, or local traders buy the products directly from farmers' or producers' fields and sell them to the wholesaler. The total marketing cost of middle agent for *E. serratus* was 275 INR/10 kg and 280 INR/10 kg for processed and raw fruits where the transportation cost was the highest among the cost items. The middlemen sell the fruits to the wholesalers in urban markets. The marketing cost of wholesalers is higher than other intermediaries, including loading and unloading, shop rent, salary and wages and personal expenses and the total marketing cost of the wholesaler was 365 INR and 350 INR. The retailers purchase fruits from wholesalers and directly sell the products to the consumer. The spoilage and damage were the main market costs of a retailer. Due to the processing charges, the processed fruits have more marketing costs (315 INR) than the raw ones (290 INR).

The margin of *E. serratus* fruit resource depicts the marking efficiency and inefficiency; it includes the various costs of intermediaries and the profits of intermediaries earned in the transfer of goods from the producer to the consumers (29). The marketing and net margins of intermediaries and producers from selling 10 kg *E. serratus* fruits were calculated (Table 6). Table 6, provides the data on dissipating market margin among various intermediaries in the channels. Retailers have the highest market margin and net margin than other intermediaries. The market margin for raw and processed fruits for retailers was 600 INR and 680 INR respectively, in turn, we can expect margins of 310 INR and 365 INR for raw and processed fruits. Since processed fruits have more demand and have long-term storage capacity, net margins may increase accordingly. The second highest market margin and net margin were observed for the wholesalers. Usually, the fruits are processed by retailers. Therefore, no significant difference was noticed in net margins and market margins for raw and processed fruits in the case of middlemen and wholesalers. Since the market margin for the farmers or producers is zero, the net margin is also absent. The total net margin for raw and processed fruits was 830 INR and 885 INR respectively. The higher marketing margin observed in the intermediaries indicates marketing inefficiency. The price spread, producer's share, and marketing inefficiency were estimated (Table 7). The price spread was 1150 INR and 1160 INR for raw and processed fruits, meaning a significant difference between the consumer's price and the producer's net price. The producers' share was determined as 16.66 % and 15.98 %. The marketing efficiencies of raw and processed fruits of *E. serratus* were only 0.19 and 0.18 respectively.

Table 6. Marketing margin of 10 kg *Elaeocarpus serratus* fruits

Type of intermediaries	Sales price (INR)		Purchase price (INR)		Marketing margin (INR)		Marketing cost (INR)		Net margin (INR)	
	Processed	Raw	Processed	Raw	Processed	Raw	Processed	Raw	Processed	Raw
Farmer/Direct sellers	350	350	-	-	-	-	75	75	-	-
Middle agent	850	850	350	350	500	500	275	280	225	220
Wholesalers	1510	1500	850	850	660	650	365	350	295	300
Retailer	2190	2100	1510	1500	680	600	315	290	365	310
Total							1030	995	885	830

*1 INR (Indian currency) = 0.012 USD (US Dollars) in 2024

Table 7. Price spread, marketing efficiency and producer's share of 10 kg *Elaeocarpus serratus* fruits

Type of fruit	Price spread (INR)	Marketing efficiency	Producer's share (%)
Raw fruit	1150	0.19	16.66
Processed fruit	1160	0.18	15.98

*1 INR (Indian currency) = 0.012 USD (US Dollars) in 2024

Discussion

The study focuses on assessing the market status and evaluating the economic potential of a neglected fruit crop, *E. serratus,* despite its high nutritional value. The findings of the study can be employed for conducting more related works on those crops which are facing negligence and can be utilized for promoting the lives of rural livelihoods depending on such crops. The popularization of these underutilized fruits by underscoring their dynamic economic potential can also effectively lead to their sustainable management and conservation. Since the *E. serratus* trees have scattered distribution and fruits do not occupy the mainstream markets and are seasonal, the surveys and further economic analysis are done with limited data, which is a drawback.

The clusters were formulated to group dispersed trees of the same locality and to estimate the average mean yield. The variation in mean fruit yield ranging from 32.5 to 5.25 kg was noticed among the selected clusters, mainly attributed to age, the genetic makeup of the trees, and edaphic conditions. Despite high yield in the first cluster, less than 10 kg of fruits are harvested or consumed. In turn, most fruits remain wasted. In this cluster, most of the family members are employed and thus have a regular income, attributed to not engaging in the collection and selling of *E. serratus* fruits. Most fruits in the 5, 6 and 7 clusters were sold directly as fresh harvest or processed form. The salted and ripened fruits are sold at the nearby local markets and city centres. The fruits are seasonal and have a considerable demand among the local community at the peak of the fruiting season. Minor tropical fruits are not so extensively cultivated, and consumption and trade tend to be more limited, geographically and quantitatively, still, many are of considerable economic importance in their respective regional markets (30). The *E. serratus* fruits from clusters 5 and 6 together generate a substantial income for street vendors, small shop owners, and especially rural women. Villagers, especially small farmers and farm labourers collect the minor fruits from the scattered trees during the season as a part of their collection is retained for their consumption as raw or in dried form and the surplus will be sold to the local traders or roadside trading (31).

The Likert scale analysis indicates that *E. serratus* is not cultivated commercially, and people do not consider it as a significant fruit crop despite its potential and nutritional value. The seasonal availability and asynchronous maturity of fruits limit the economic dependency on *E. serratus* fruits. Most of the locally processed fruit products are usually consumed at the household level and rarely make their way to the market (32).

The fruits are primarily sold with major fruits and other crops in local markets. So, *E. serratus* fruits add a share to achieve significant profit for the sellers. The fruits for sale are mostly collected from nearby sources. Since the fruits are highly seasonal and market channels are scattered, there is no set pattern for the price of *E. serratus* fruits. Minor fruits are characterized by limited use, relative to their economic potential, poor documentation, and an almost non-existent or poorly organized marketing system (33). The marketing of fresh fruits opens in March and extends and the processed fruits are even after the end of harvest season. The local people mainly sell raw fruits at rural and wholesale markets. The consumers of these fruits are mainly local people, passers-by or tourists. The processed, salted fruits have more demand during festival seasons and special occasions. They are prepared by boiling the collected fruits, dipping them in water, mixed with salt and finally seasoning them with red chilli or green chilli flakes. They are finally transferred to small bottles containing 25-40 or food containers containing 10-16 salt-dipped fruits. The raw fruits are sold without grading or proper packaging. The fruits are mostly sold in the Thiruvananthapuram district, followed by the Kollam

district. Even though trees are available in the natural habitats and homesteads of the Alappuzha, Kottayam and Eranakulam districts, little attention is given to their trading. In Thiruvananthapuram and Kollam districts, the fruits are sold in neighbourhood markets by the villagers. Sometimes, the fruits are collected by middlemen and sold in urban markets. The interaction with householders revealed the unawareness of bio prospecting and the feasibility of the value-added products from *E. serratus* fruits leading to the wastage of this resource. This fruit tree is not cultivated commercially on a large scale, and they are sold with only limited processing, causing the minimal market value of fruits. Based on the survey, it is reported that the prices of salted fruits are higher in tourist spots in the Thiruvananthapuram districts. During the fruiting season, in the villages, fresh fruits are available in ample quantity, thus promoting the consumption of fresh fruits. In rural markets and villages, raw and processed fruits are sold below market prices. The storage facilities, especially refrigerated conditions are unavailable in both villages and urban markets.

Marketing of the underutilized fruit sector in India has no definite channels (34). The lack of a defined market channel diminishes the profit of the value addition that reaches the farmers and primary processors (35). The lack of organization and cooperation in selling the fruits, a small number of markets, and a lack of market information limit the financial returns (36) in underutilized fruits like *E. serratus*. The harvesting of fruit is usually done by house owners or local people. At the same time, harvesting 5-10 % of the fruits remain on the tree because of the difficulty in accessing tree branches. Usually, the mature as well as immature fruits are collected once or twice a week and subjected to marketing. In the fruiting season of *E. serratus*, the complete harvesting may take up to one and a half months due to asynchronous flowering and fruiting. For each collection, 2-3 hours are required. The plant dwellers directly sell the fruits to the market or sell them to wholesale vendors or retailers. After harvesting, only a small quantity of fruits is stored for their own use. Generally, people with subsistence economies among lower-income groups were involved with collecting and selling such underutilized fruit species (37). The income-sufficient families usually do not promote the collection and marketing of fruits as they do not generate substantial income. The fruit dwellers in urban centres are generally not engaged in its bulk harvesting and usually deal with pre-fixed sellers. Some of the house owners from urban centres ignore the fruit tree and show no interest in the collection and selling of fruits. Usually, the fruit dwellers from the villages harvest the fruits, which are directly sold to consumers or retailers. While passing through different stages of marketing, the value of the resource changes considerably (38). According to the collectors, the income of the owners of the tree also fluctuates during the harvest of *E. serratus*. There is no pre-set price for selling fruits and at the stage of marketing, a standard quantity or volume of units of measurement is absent. Unlike the marketing system for exotic fruits, the local fruits were not graded, packed or even washed (39). Due to unsustainable harvesting and economic inefficiency in trading *E. serratus* fruits, the marketing systems remain informal. Such crops are regarded as underutilized from a market perspective and their limited use also fails to reflect their public value. The development of markets increases the incentive for producers to collect or cultivate the crops, but their use at a socially optimum level may also require public intervention (40). The selling of fruits is by street vendors, indicating that there are no well-defined market patterns for the distribution and sales. Since the fruits are highly seasonal and show asynchronous maturity, they are not sold frequently in markets. The retailers occasionally collect the fruits from wholesalers. The fruits are then immediately processed to increase their shelf life. The salted fruits attract consumers, especially in tourist centres near the city premises. The processing of fruits requires only minimal effort and with this more income can be generated to sellers. Processed fruits have a high profit compared to raw fruits attributed to the easy spoilage of raw fruits. After harvesting, the ripened fruits may start to decay within 3-4 days. Therefore, the bulk of the raw fruit resources cannot be used. In spite of this, the processed fruits, preserved in the salt solution with chilli flakes, have a long-term storage period. So, processed fruits have more demand and sale periods.

The profit for fruit dwellers usually ranges from 10-20 INR/kg, if the middlemen and other harvesters are included. For the dwellers who directly collect the fruit, the profit ranges up to 60-80 INR after deducing the transportation charges. However, the labour charges are involved in the harvesting of fruits, the labour varies from 50 INR to 100 INR per hour. In this scenario, including the labour charge, the direct sales of fruits to consumers may not be profitable. So, to enhance the demand, the fruits can be sold after processing. Apart from the salting of fruits, raw fruits can be pickled and sold commercially. This facilitates the storage of fruits for a longer period. About 200 g of pickled fruit is sold at a price of 60 INR and by selling one 1 kg of processed fruit, 300 INR is obtained with around 50 INR as expenses for the pickling supplement. Thus, selling in pickled form is more profitable than selling raw fruits at the rate of 100 INR/ kg. Marketing efficiency was mainly governed by the margin of retailers (41) and the marketing efficiency values were low indicating poor marketing efficiency.

Indigenous fruit resources can ensure nutritional and social security and have a vast potential for producing value-added products (42). Novel eco-friendly technologies can be encouraged to improve the crop quality and production to enhance the substantial farming of underutilized fruit crops like *E. serratus*. Studies show that the application of biochar amalgamated with phosphorus fertilizer by developing biochar derived from fruit crop waste positively impacts fruit crop production and offers a sustainable solution for improving soil health and enhancing the productivity of fruit crops (43). Biochars can be widely applied for the crop improvement of underutilized fruits enhancing their nutritional quality. The studies show that fertilization of crops with sodium salt-enriched biochar resulted in better water retention in the

topsoil which can prevent nitrate accumulation (44). They have broader relevance in the agronomy sectors for crop improvement and food security of underutilized fruits. For the industrial development and processing of underutilized fruits, the optimization of waste management processes is important in a way that maximizes economic benefits while minimizing costs and environmental impacts (45). Further research regarding the market aspects of *E. serratus* fruits with dynamic economic models can create an impact for improving their commercial viability. Innovative processing and modernized post-harvesting techniques can create new value-added products with market appeal. Based on the survey it is noticed that value-added products can be evolved from the small-scale cottages and Kudumbashree (rural women's self-help group by the social welfare department, Govt. of Kerala, India) units after collecting the fruits from farmers and by providing them with a reasonable price. Optimizing the supply chain and establishing effective distribution channels by linking the stakeholders can attract more investors for the commercialization of these fruit crops. Fossil fuels play a significant role in the fruit economy in various aspects, affecting the production costs, transportation, market dynamics and higher operating costs. More research works focusing on how the fuel substantially enhances the productivity and marketing of minor underutilized fruits such as *E. serratus* should be crafted. Since international oil prices affect the economy in the areas of agriculture and fruit marketing, emerging technologies like predicting the Brent oil price by artificial neural network LSTM- (Long Short-Term Memory) with regard to the current situation in global markets (46) are gaining attention. The studies show that the EUR/USD exchange rate is strongly dependent on the international price of oil, and the impact of fluctuations in the price of oil on the EUR/USD exchange rate can, therefore, be accurately predicted, which can be used to enhance competitiveness (47), in the fruit economy sector focusing on minor fruit crops.

The resource quantification data of *E. serratus* indicates that they produce significant yield amidst seasonal fruiting and low maintenance. However, the inefficiencies in utilization and distribution lead to the bulk spoilage of fruits and poor marketing efficiency, with raw and processed fruits having high marketing costs and low market performance values. The market efficiency can be improved by enhancing sustainable farming practices to improve fruit quality and nutrition. The superior genotype of the *E. serratus* tree producing good quality fruits must be selected and domesticated. Appropriate post-harvesting techniques for the prolonged shelf life can reduce the spoilage of fruits. Market research must be conducted to understand consumer preferences and trends to receive attention from people. Establishing a robust relationship with the stakeholders in the supply chain, including farmers, producers, processors, distributors, retailers and government agencies, expands market research, increasing sales opportunities. The broader socio-economic linkages promote *E. serratus* fruit marketing, including its potential contribution to rural development, poverty mitigating sustainable agriculture practices. *E. serratus* can be considered a promising multi-purpose tree (MPT) in the agroforestry systems of Kerala. If the resources are advisably used, they can generate a substantial income for the state.

Strategies for the better utilization of fruits of Elaeocarpus serratus

The population stock of *E. serratus* in its natural habitats has been depleting due to certain factors such as habitat fragmentation, over-exploitation and other anthropogenic activities (48). Clearing land for housing projects, redevelopment programmes and road construction are the major threats to *E. serratus* in the study areas. Based on the realized profit from collection and marketing the steps to scaling up the domestication of should be initiated. Suitable technologies should be evolved for the post-harvest management and value addition of fruits. Promotion drives through workshops and awareness programs should be conducted to develop value-added products from these fruits. Procuring harvested fruits by Government agencies and providing an incentive to the farmers should be initiated. To enhance the marketing development of *E. serratus* fruit, the infrastructure for transportation and communication must be expanded. The linkages should be developed between small and marginal farmers and retailers. Technical and financial support should be provided to farmers, processors and retailers by the Government and non-governmental organizations (NGOs).

Conclusion

In the present investigation, on underexplored fruit tree *E. serratus* L., several reasons were identified as bottlenecks in the domestication and marketing of fruits, including fewer storage facilities, perishable nature and strain in plucking the fruits, causing the bulk of fruits to get wasted. The development activities, road widening and felling of trees have exclusively affected the distribution of *E. serratus*. The research is essential in analyzing the market value and economic viability with significance in global markets. Since the farmers or processors get a reasonable profit through direct selling only, to attract more farmers and processors, a strong market linkage should be established to give them a fair profit. Addressing the challenges and formulating innovative eco-friendly techniques can gain attention for the *E. serratus* fruits from the global perspective. With the employment of convenient strategies and dynamic economic modelling, industrialization of *E. serratus* fruits leads to significant economic benefits for farmers and processors. So, effective marketing techniques with a well-developed supply chain should be applied and a good profit can be expected with low capital. There is a lack of effective processing techniques noticed during the study that necessitates the development of superior quality products for national and international markets to generate more employment opportunities, thereby popularizing *E. serratus* as table fruit.

Acknowledgements

The authors thank Dr. T.S Swapna, Former Head, Department of Botany, for providing all the facilities. The authors are also grateful to all the respondents who shared their valuable time and knowledge. The research was supported by Kerala State Council for Science Technology and Environment (KSCSTE) via Research grant No. KSCSTE/972/2018-FSHP-MAIN. So, the authors are thankful to KSCSTE for providing the grant.

Authors' contributions

RM participated in data collection, drafted the manuscript and the statistical analysis. EA reviewed and edited the manuscript. Both the authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None.

References

1. Fernando FDL, Caroline AB, Claudia ALC, Marta CTD, Eliana JSA. Evaluation of nutritional composition, bioactive compounds and antimicrobial activity of *Elaeocarpus serratus* fruit extract. Afr J of Food Sci. 2019; 13(1): 30-37.https://doi:org/10.5897/AJFS2018.1760.
2. Sriti K, Sahoo AM, Chakraborti CK. Correlation between phytochemical screenings, antibacterial and anthelmintic activities of *Elaeocarpus serratus*. Int Res J of Pharm .2011; 2 (9):133-136.
3. Raji R, Siril EA. Genetic diversity analysis of promising Ceylon olive (*Elaeocarpus serratus* L.) genotypes using morphological traits and ISSR markers. Curr Plant Biol. 2021; 26:100201. https://doi:10.1016/j.cpb.2021.100201.
4. Geetha D, Rajeswari M, I. Jayashree I. Chemical profiling of *Elaeocarpus serratus* L. by GC-MS. Asian Pac J of Trop Biomed.2013; 3 (12): 985–987. https://doi:10.1016/s2221-1691(13)60190-2.
5. Chen YH, Yang CY. Ultrasound-Assisted extraction of bioactive compounds and antioxidant capacity for the valorization of *Elaeocarpus serratus* L. leaves. Processes .2020; 8: 218. https://doi:10.3390/pr8101218.
6. Domitrović R, Rashed K, Cvijanović O, Vladimir-Knežević S, Škoda M, Višnić A. Myricitrin exhibits antioxidant, anti-inflammatory and antifibrotic activity in carbon tetrachloride-intoxicated mice. Chem Biol Interact. 2015; 230:21-9.https://doi.org/10.1016/j.cbi.2015.01.030.
7. Das P, Kar P, Hasnu S, Nath S, Tanti B. Phytochemical screening and antioxidant activity of *Elaeocarpus serratus* L. of Assam. J Pharmacogn Phytochem. 2017; 6(4):866-9.
8. Sumanarathne WGAS, Ranaweera LT, Weebadde CK, Sooriyapathirana SDSS. Assessment of the morphometric variation of fruits and phylogenetics of *Elaeocarpus ganitrus* (Woodenbegar) and *Elaeocarpus serratus* (Ceylon Olive). J Agric Sci .2020; 15(3): 362-377.
9. Tsui CY, Yang CY. Evaluation of semi-solid-state fermentation of *Elaeocarpus serratus* L. leaves and black soymilk by *Lactobacillus plantarum* on bioactive compounds and antioxidant capacity. Foods. 2021;104:704
10. Raji R, Siril EA. Assessment of different pretreatments to breakage dormancy and improve the seed germination in *Elaeocarpus serratus* L.-an underutilized multipurpose fruit tree from South India. Forest Sci Technol. 2018; 14(4): 160-168. https://doi:10.1080/21580103.2018.1507951
11. Raji R, Siril EA. Alteration of media enables efficient in vitro cloning of mature *Elaeocarpus serratus* L. (Ceylon olive): a commercially important fruit tree. Physiol Mol Biol Plants. 2021; 27:429-443. https://doi:10.1007/s12298-021-00955-x.
12. Gajanana TM, Gowda IND, Reddy BMC. Exploring market potential and developing linkages–A case of underutilized fruit products in India. Agric Econ Res Rev. 2010; 23: 437- 444. https://doi:10.22004/ag.econ.96918.
13. Kiley Worthington M. Ecological agriculture. Integrating low input, high productive farming with wildlife conservation: Results from the experimental farm La Combe, Drome France. Open J Ecol. 2014; 744–763.
14. Selim, M. M. (2020). Introduction to the integrated nutrient management strategies and their contribution to yield and soil properties. Int J of Agron. 2020; 2: 2821678
15. Raji R, Siril EA. Germplasm exploration, elite selection and fruit trait association analysis with ISSR markers in *Elaeocarpus serratus* L.—An underutilized fruit tree. *Erwerbs-Obstbau*.2022;64:4741-752. https://doi:10.1007/s10341-022-00745z.
16. Raji R, Siril EA. Cloning of Ceylon olive (*Elaeocarpus serratus* L.) using conventional methods. J Hortic Sci and Biotechnol. 2016; 91:292-298. https://doi:0.1080/14620316.2016.1155318.
17. Maroušek J, Minofar B, Maroušková A, Strunecký O, Gavurová B. (2023). Environmental and economic advantages of production and application of digestate biochar. Environ Technol Innov. 2023; 30: 103-109. https://doi.org/10.1016/j.eti.2023.103109.
18. Maroušek J, Maroušková A, Periakaruppan R, Gokul GM, Anbukumaran A, Bohatá A, Kříž P, Bárta J, Černý P, Olšan P. Silica nanoparticles from coir pith synthesized by acidic sol-gel method improve germination economics. Polymers. 2022;14 (2):266. https://doi.org/10.3390/polym14020266.
19. Bindraban PS, Dimkpa CO, Pandey R. Exploring phosphorus fertilizers and fertilization strategies for improved human and environmental health. Biol Fertil Soils. 2020; 56, 299–317. https://doi.org/10.1007/s00374-019-01430-2.
20. Stavkova J, Maroušek, J. Novel sorbent shows promising financial results on P recovery from sludgewater. Chemosphere.2021;130097. https://doi.org/10.1016/j.chemosphere.2021.130097.
21. Pavolova H, Bakalár T, Kyšeľa K, Klimek M, Hajduova Z, Zawada, M. The analysis of investment into industries based on portfolio managers. *Acta Montan Slovaca.* 2021; *26*(1): 161-170. https://doi.org/10.46544/AMS.v26i1.14
22. Akbari M, Loganathan N, Tavakolian H, Mardani A, Štreimikienė D. The dynamic effect of micro-structural shocks on private investment behavior. Acta Montan Slovaca. 2021; 26(1): 1-17. https://doi.org/10.46544/AMS.v26i1.01
23. Giuliani A, Karagöz A, Zencirci N. Emmer (*Triticum dicoccon*) production and market potential in marginal mountainous areas of Turkey. Mt Res Dev. 2009; 29(3): 220-229. https://doi:10.1659/mrd.00016.
24. Dhyani PP, Khali MP. Fruit yield and economics of jelly and jam production from fruits of some promising *Ficus* (Fig) tree crops. Ecol Food Nutr.1993; 30(3-4):169-178. https://doi:10.1080/03670244.1993.9991334
25. Vishnu B, Remya R, Gangaprasad A, Siril EA. Selection of promising candidate of Malabar Tamarind *Garcinia gummi-gutta* (L.) Roxb.- a multipurpose fruit tree. Int J Fruit Sci.2022;

221:664-674. https://doi:10.1080/15538362.2022.2095552.

26. Joshi D, Banjade D, Singh AK, Chauhan B. Value chain analysis of kidney beans (*Phaseolus vulgaris*L.) in the Api region of Darchula District, Nepal. Agric Econ Rev. 2022; 2(2): 46-56. https://doi:10.26480/faer.02.2022.46.56.

27. Hajong P, Rahman MH, Kobir MS. Marketing system of summer tomato in Jashore district of Bangladesh. Int J of Agric Res Innov Technol. 2022; 12(1): 12-17. https://doi:10.3329/ijarit.v12i1.61025.

28. Acharya SS, Agarwal NL. Agricultural Marketing in India.5th ed. New Delhi: Oxford & IBH Publishing Co; 2014.

29. Dukpa P, Ezung TZ. Analysis of vegetable marketing efficiency in Phek District, Nagaland. Econ Aff 2020; 65(3):427-432. https://doi;10.46852/0424-2513.3.2020.16.

30. Saúco VG. Potential of minor tropical fruits to become important fruit crops. Acta Hortic. 2013; 975: 581–591. https://doi:10.17660/actahortic.2013.975.74

31. Nandal U, Bhardwaj RL. The role of underutilized fruits in nutritional and economic security of tribals: A review. Crit Rev Food Sci and Nutr. 2014; 54: 880-890. https://doi:10.1080/10408398.2011.616638.

32. Nemapare P, Gadaga TH, Mugadza DT. Edible indigenous fruits in Zimbabwe: A review on the post-harvest handling, processing, and commercial value. Cogent Soc Sci. 2023; 9(1): 2229686.

33. Roy TN. Minor (under-utilized) fruits in Coochbehar district of West Bengal, India–an analysis on marketing status for economic viability. Int J Bio-Resour Stress Manag.2014; 5:1122-127. https://doi:10.5958/j.0976-4038.5.1.024.

34. Rathore DS. Processing and marketing of underutilized fruits in India. In: Haque N, Huges A, editors. Fruits for the future in Asia. Southampton: ICUC; 2012.p. 134-152.

35. Daniel JN. Value chain analysis in relation to processing and marketing of three underutilized fruits in India. Acta Hortic.2008;806:505-512. https://doi:10.17660/ActaHortic.2009.806.63.

36. Adam YO, Pretzsch J, Pettenella D. Contribution of non-timber forest products livelihood strategies to rural development in drylands of Sudan: potentials and failures. Agric Syst. 2013; 117: 90-97. https://doi:10.1016/j.agsy.2012.12.008.

37. Sundriyal M, Sundriyal RC. Wild edible plants of the Sikkim Himalaya: Marketing, value addition and implications for management. Econ Bot. 2004; 58:300 315. https://doi:10.1663/0013-0001(2004)058[0300:WEPOTS]2.0.CO;2.

38. Bhatt ID, Rawal RS, Dhar U. The availability, fruit yield, and harvest of *Myrica esculenta* in Kumaun (West Himalaya), India. Mt Res Dev. 2000; 20 (2): 146–153. https://doi:10.1659/0276-4741(2000)020.

39. Ramadhani T, Schmidt E. Marketing of indigenous fruits in Southern Africa. In: Akinnifesi FK, Ajayi OC, Leakey RRB, editors. Indigenous fruit trees in the tropics: domestication, utilization and commercialization. Oxfordshire: CAB International; 2008.p. 224-236.

40. Grue`re G, Giuliani A, Smale M. Marketing underutilized plant species for the benefits of the poor: A conceptual framework. In: Kontoleon A, Pascual U, Smale M, editors. Agro biodiversity Conservation and Economic Development. Oxfordshire: Routledge Publishers; 2009.p. 8-105.

41. Ladaniya MS, Wanjari V Mahall BC. Price Spread of Pomegranates. Indian J Agric Econ. 2003; 58(4):800-811. https://doi:10.22004/ag.econ.297988.

42. Krishna H, Saroj PL, Maheshwari SK, Singh RS, Meena RK, Chandra R, Parashar A. Underutilized fruits of arid & semi-arid regions for nutritional and livelihood security. Int J of Med Aromat. 2019; 5: 1-14

43. Sharma S, Rana VS, Rana N, Prasad H, Sharma U, Patiyal V. Biochar from fruit crops waste and its potential impact on fruit crops. Sci Hortic. 2022; 299:111052. https://doi.org/10.1016/j.scienta.2022.111052.

44. Maroušek J, Kolář L, Vochozka M, Stehel V, Maroušková A. Novel method for cultivating beetroot reduces nitrate content. J Clean Prod. 2017; 168:60-62. https://doi.org/10.1016/j.jclepro.2017.08.233.

45. Maroušek J. Economically oriented process optimization in waste management. Environ Sci Pollut Res. 2014; 21(12):7400-7402. https://doi.org/ 10.1007/s11356-014-2688-z

46. Vochozka M, Horak J, Krulický T, Pardal P. Predicting future Brent oil price on global markets. Acta Montan Slovaca. 2020; 25 (3): 375-392. https://doi.org/10.46544/AMS.v25i3.10

47. Vochozka M, Rowland Z, Suler P, Marousek J. The influence of the international price of oil on the value of the EUR/USD exchange rate. J Compet. 2020; 12(2): 167–190. https://doi.org/10.7441/joc.2020.02.10

48. Baruah PS, Deka K, Lahkar L, Sarma B, Borthakur SK, Tanti B. Habitat distribution modelling and reinforcement of *Elaeocarpus serratus* L.-a threatened tree species of Assam, India for improvement of its conservation status. Acta Ecol Sin. 2019; 39(1): 42-49.