Research Report No. 3

Analysis of Economic Characteristics of Value Chains of Three Underutilised Fruits of India

Joshua N. Daniel and Prashant A. Dudhade

The International Centre for Underutilised Crops

Championing underutilised plant species for food, nutrition and sustainable development

Table of Contents

List of Acronyms

BAIF	-	BAIF Development Research Foundation
BIRD-UP	-	BAIF Institute for Rural Development - Uttar Pradesh
ICUC	-	International Centre for Underutilised Crops
INR	-	Indian Rupee
RIDMA	-	Rajasthan Rural Institute of Development Management
UK DFID	-	United Kingdom Department for International Development
USD	-	United States Dollar

Abstract

The diverse agro-climatic conditions in India make it possible for the cultivation of a large number of fruit species. As the population in general prefers to consume fresh fruits, the processing industry is relatively small. Individual aspects such as processing and marketing of fruits have been studied, but the value chains, especially those of underutilised species, have not been adequately analysed. Hence, a study was conducted to understand the value chains of amla (*Emblica officinalis*), tamarind (*Tamarindus indica*) and kokum (*Garcinia indica*). Although underutilised these species have the potential to become a component in farming systems of smallholders. Driven by its nutritional value, medicinal properties and the suitability for processing into a wide range of products, amla is emerging as a favoured species for small-farm agroforestry in many parts of India. The traditional practice of having a few scattered trees of tamarind or kokum is changing with the availability of superior genotypes and the benefits of grafted plants.

The BAIF Development Research Foundation, a non-government organisation in India, has been collaborating with the International Centre for Underutilised Crops (ICUC) to promote underutilised fruit species through the production and distribution of extension literature and small-scale processing units. In continuation of this collaboration, a value chain analysis was carried out during October to December 2006 by collecting information through personal interview, individual interaction and group discussion. Secondary data from literature and unpublished documents were referred as well. Information for amla was collected from three locations in the states of Rajasthan and Uttar Pradesh while the study for tamarind and kokum was within the state of Maharashtra at four and two locations, respectively. The key information collected for each species was on the cost of orchard establishment and aftercare, fruit production and returns, quantity and income of intercrops and by-products, all aspects related to processing and prices at processor, wholesaler and retailer level.

Amla orchards are generally established in dry areas of Rajasthan at a population of 40 grafts in 0.4 ha of land and fruit production begins in the fourth year. The total expenditure on establishment and aftercare up to the age of eight years is INR 12,950 and the cumulative value of fruits produced is INR 22,250. In the Uttar Pradesh location, however, soil fertility and moisture availability are more favourable and amla trees produce about 20% more fruits while the yields of intercrops are even higher than those in Rajasthan. Therefore, the investment is recouped in 4-5 years under favourable environmental conditions whereas it takes 7-8 years for this to happen in dry areas. Farm operations are such that the labour requirement for amla is mainly during the winter season when fruits mature. A processing unit can obtain fresh fruits for about 5-6 months in a year and the main processed products are pickle, squash, sweets and candy. Value addition in amla ranges from INR 5.25 for mouth freshener to INR 51 for candied pulp. An analysis of profit distribution of candied pulp showed that the returns per kg of amla is only INR 1.50 to the farmer compared to more than INR 8 to others in the chain.

Returns from tamarind start in the sixth year and the investment on establishment and aftercare of the orchard can be recovered by the eighth year. On the other hand, farmers who had irrigation facilities raised annual crops in the interspaces, which was a highly remunerative intervention. Such orchards had a income surplus by the second year itself. New product development in tamarind is limited and the condiment value of pulp still remains its predominant use. Sauce, pickle, toffee and dried pulp powder are the other products. Value addition when one kg of fruit is processed into pulp is INR 33, but it is INR 60 if made into toffee. However, there is no established demand for products like tamarind toffee and amla candy. Small processors appeared to be averse to the risk associated with such value-added products because the profit margins are unattractive at present. A practice of small units that process several fruit species is to keep tamarind pulp in storage and process small quantities whenever there is a break in the processing of other fruits.

Kokum production in orchards is not widespread and the bulk of the produce comes from homesteads and common lands. The economics of kokum production is similar to that of amla in orchards planted with 30-40 grafts with intercropping for additional income. Presently, there are several kokum-based production practices where its presence ranges from a few trees to naturally-established dense plantations. Depending upon the number of trees, size and vigour, the income from kokum varies from INR 300 to INR 3,350. The scattered occurrence of kokum trees provides a livelihood opportunity for fruit collectors. Those engaged in this activity collect or buy fruits and supply them to processing units, earning INR 5,000-7,000 during the fruiting season of 2-3 months. The cost of rind and syrup, the common products of kokum processed by households, is more than 30% lower than that of commercial processing units.

Fruit yields are below the potential for all three species in the study. The probable reasons for low productivity are the inferior quality of land allotted for these species, inadequate input application and management, high tree-to-tree and year-to-year yield variation. If more growers are to take up these species, it is necessary to ensure stable returns every year through the efficient utilisation of land and other resources. Small-scale processing with appropriate market linkages can help reduce the number of intermediaries in the value chain and thereby increase the share of the profit that goes to the growers. Enhanced processing technologies that can preserve the nutraceutical value of the study species have to be developed. Credit facilities and information support systems dealing with all aspects of the value chains are other requirements for the successful promotion of underutilised fruit species.

1. Introduction

The diverse agro-ecological conditions, rich native vegetation and introductions since time immemorial have made India a repository of edible fruit species. A vast majority of these species can be categorised as underutilised because their contribution towards the fruit production sector and the overall economy is small. At the same time, many of them are important in the livelihoods of local communities in areas of their prevalenc. Traditional herbal medicine and tonic formulations include these fruits as ingredients. For these purposes, the common practice was to source the fruits and other plant parts from trees growing wild in forests and common lands. While some of these species still remain largely undomesticated, there are others that have seen significant advances in genetic improvement and cultivation practices.

Studies on value chains of agricultural produce appear to be limited in India. Some studies are available for species like cashew (Hassan and Raghuram, 1987) and tomato (Subramanya and Sudha, 1993), but value chains of underutilised fruits have not been analysed. Individual aspects of the chain like processing of cashew (Raut, 1995), market potential of processed amla (Brueckner, 2006) and marketing of underutilised fruits (Gajanana *et al.* 2007) have been studied. Encouraged by the growing demand, farmers in India have been including underutilised fruit species in their farming systems. In an effort to promote the production and use of these crops, the BAIF Development Research Foundation, a non-government organisation in India, has been collaborating with the International Centre for Underutilised Crops (ICUC). Besides the production and distribution of extension literature on crops like amla and tamarind, this association also resulted in the establishment of small-scale demonstration units for fruit processing.

The present BAIF-ICUC collaboration analysed the value chains of amla (*Emblica officinalis*), tamarind (*Tamarindus indica*) and kokum (*Garcinia indica*). The geographical distribution and production systems of these species are different from each other. Improved production technologies in the form of high-yielding varieties and crop management practices, easier availability of farm credit and the emergence of marketing linkages for the produce are positive developments for these crops. Their importance to select local communities has been increasing and there have been efforts in organising them into cooperatives to realise better returns. Another development is the entry of new stakeholders, especially in post-harvest aspects. As a result of these developments, the value chains of underutilised fruit species are getting more clearly defined and organised. Hence, the present study was conducted to understand the value chains of amla, tamarind and kokum so that farmers can evolve strategies to realise higher returns for their produce.

2. Species Information

2.1 Species Description

*2.1.1 Amla (*Emblica officinalis*)*

Amla is indigenous to tropical South-east Asia and thrives well throughout tropical India. One of the richest sources of vitamin C in nature (Chadha, 1992), the ascorbic acid content of amla is about 700 mg per kg of dry powder (Sardesai and Bodhankar, 2005). Because of its many medicinal properties, amla was extensively used as an ingredient in herbal health preparations. Uses of amla are mentioned in ancient literature (Tripathi *et al.*, 1979) and it is included often by practitioners of native health systems in their formulations. It has diuretic, laxative and antibiotic properties (Ray and Majumdar, 1976) and different parts of the plant are used for treating chronic

dysentery, diarrhoea, jaundice, dyspepsia and cough (Chadha, 2001). In the past, fruits were mostly sourced from trees growing wild in forests and community lands (Champion and Seth, 1968). A few trees were also found on farmland and homesteads. These naturally-established trees were of seed origin with small fruits.

For an underutilised species of its economic stature, the genetic improvement work on amla is noteworthy. It is a species researched by several national research institutions and this has resulted in the development of a large number of varieties and the standardisation of cultivation practices. Fruit maturity is attained around September in southern latitudes and moves progressively northwards. Harvesting is usually completed by November in southern locations like Karnataka whereas it may extend up to February in Uttar Pradesh in the north.

*2.1.2 Tamarind (*Tamarindus indica*)*

In India, tamarind trees are found on farmland, common land, roadsides, forests and homesteads. It is mentioned in Indian scriptures dated earlier than 200 B.C. But the origin of tamarind is believed to be the African continent. Traders probably brought the seeds into the country a long time ago and tamarind became naturalised in India. Major tamarind growing states in India are Madhya Pradesh, Bihar, Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra. Tamarind is the richest natural source of tartaric acid, which is found in leaves as well as fruits of the species. The tartaric acid content of leaves is in the range of 12-28% and that of fruit pulp is 8-18%. It is common for most fruits to have a high acid content when they are immature and it gets converted to sugar during the ripening process. Unlike other acids, tartaric acid cannot be converted to sugars or other substances, so the sour taste persists in mature tamarind fruits. Commercial uses of tartaric acid are minor and include baking and tanning industries.

Making use of the genetic diversity among existing trees, several elite selections / varieties of tamarind have been identified. Unlike the huge size and dense canopy of old trees, many of the new selections have lax canopies. Moreover, they are propagated vegetatively with grafts, which results in dwarfing of trees. Fruits mature during February-March in Maharashtra.

*2.1.3 Kokum (*Garcinia indica*)*

Popularly known as kokum butter tree or Indian butter tree, this species grows in the states of Gujarat, Maharashtra, Karnataka and Kerala along the western mountain range. Trees of seedling origin require 7-8 years for bearing while grafts begin fruit production in 4-5 years. The thick rind of the fruit is dried and stored for use as a condiment to impart a sweet and sour taste in local food preparations. The medicinal uses of kokum are many: kokum butter is a remedy for dysentery, piles, tumours and heart ailments besides a skin cream during winter; the rind juice is a remedy for stomach acidity and related digestive problems. Because it is a rich source of hydroxy-citric acid, about 23% (Joshi, 2005), it is used by the pharmaceutical industry in fat-reducing formulations.

It is a medium-sized tree that is traditionally propagated by seed. Some elite kokum genotypes have been identified from germplasm collected in native stands. The usual practice is to propagate this elite material by vegetative propagation so that the propagules are true-to-type. Because kokum is a dioecious species, vegetative propagation has the added advantage of ensuring that all the trees established are female. Fruits reach maturity for harvest during March to June.

2.2 Geographical Distribution

The three species in the study show dissimilarity in their distribution within the country. As the distribution of amla and tamarind are not concentrated to specific regions, their maps show states that are the major producers for each crop. Kokum is confined to the western coast of peninsular India.

2.2.1 Amla

Farmers in some areas of the state of Uttar Pradesh have been growing amla as a sole crop for a very long time. One of the oldest plantations in the state has been established in 1936 in Pratapgarh and is still in production. Establishing small orchards

with amla as sole crop or amla-based agroforestry systems is gaining popularity at present. Its cultivation is increasing in dry lands of Gujarat, Maharashtra, Rajasthan and Madhya Pradesh (Figure 1). In Maharashtra, the area under amla has increased rapidly from 122 ha in 1990-91 to 5936 ha in 2001-02 (Anonymous, 2003). According to an estimate, the area under amla in India is 49,620 ha (Singh, 2003). These plantations are mostly planted with grafts of improved varieties of amla. Domestication efforts in amla probably began very early as there are many varieties of amla (Bajpai and Shukla, 1985) and most of the cultivation aspects have been studied in detail.

Figure 1: Map showing the Indian states in which amla is predominant (shaded areas) and the survey locations.

2.2.2 Tamarind

Tamarind is found in most parts of the country (Figure 2), but farmers seldom established it as an agroforestry crop. This was probably due to the popular belief that tamarind does not allow other crops to grow around it. Therefore, its presence on farms is mostly limited to a few trees. In recent years, however, the availability of grafts of elite germplasm and the possibility of using practices such as drip irrigation has resulted in the establishment of tamarind-based orchards in some areas. In spite of not having an organised promotion or large-scale planting effort, the annual production of tamarind in the country was 0.30 million tons (Anbu, 2005). This is achieved because of the presence of a large number of trees on common lands such as temple or community lands and as avenue trees along roadside. Besides the agricultural universities and research institutions, some forest departments are also actively engaged in domestication work on tamarind.

Figure 2: Map showing the Indian states in which tamarind is predominant (shaded areas) and the survey locations.

2.2.3 Kokum

As shown in the map (Figure 3), the distribution of kokum is limited to a narrow long strip in the western mountain region extending from Kerala in the south to Maharashtra in the north. Even within this region, it is mostly known as a species growing wild in forests and to a limited extent in homesteads. In recent times, there are attempts to grow it as a plantation crop. These efforts are further aided by the emergence of improved cultivars. Domestication work on kokum is being carried out at the Regional Fruit Research Station in Vengurle where a collection comprising of 108 promising genotypes is under evaluation.

Figure 3: Map showing the Indian states in which kokum is predominant (shaded areas) and the survey locations.

2.3 Processing

The fruits of the three species selected for the study are highly acidic in nature and their consumption in raw form is generally small. The use of tamarind as condiment does not need further processing, but amla and kokum have to be at least dried before their use. Mature fresh fruits of tamarind have the highest storage life followed by amla and kokum. A light sun drying immediately after harvest is adequate for it to be stored for several weeks.The traditional practice is to separate the pulp from the outer shell, seed and fibre and then mix it with salt for storage. In this state, the pulp can be stored for about one year. Amla fruits can be stored for about 10 days at room temperature and for about 20 days in cold storage. The juicy fruit of kokum has a short shelf life and cannot be stored for more than three days after it is picked from the tree.

The processed product range for amla has increased considerably in recent times. Important items are pickle, squash, candied fruit, sweets, mouth freshener and fruit leather. Tamarind pulp can be processed into products such as sauce, pulp juice, sweets and dried powder (Kulkarni, 2005). Tender tamarind can also be processed into chutney. Popular kokum products are dried rind, squash and butter (Gawas, 2005). Considering the emerging importance of these species in increasing the choice of production options for marginal farmers, value chain analyses were carried out in selected locations.

2.4 Commercial Status

Accurate statistics with regard to quantity produced and processed is unavailable for these three species because a sizeable quantity of the fruits produced is self-consumed, exchanged or sold locally. Figures available are presented in Table 1. The volume processed is very high for all the species, as it refers to primary processing, which mainly involves the removal of pulp and drying.

Table 1: Quantity of amla, tamarind and kokum produced and processed in India.

Species	Produced (tons)	Processed (tons)	Reference
Amla	250,000	225,000	Nagarajan, 2005
Tamarind	300,000	280,000	Anbu, 2005
Kokum	10,200	9,000	Sawant, 2005

The underutilised status of the three species are due to different reasons. Although it was never a major crop, the use of amla probably became less because the purposes for which it was used were met through other species or other means. Its traditional use was mostly in health-related preparations. Although not cultivated in the scale of plantations, rural communities protected the trees in forests and raised them in homesteads and sacred groves (Arora and Nayar, 1984). The demand for the produce of amla declined with the advent of allopathic medical practices and it became underutilised. The current upsurge in the interest on herbal health preparations and the development of novel products has revived the interest in amla.

Tamarind, unlike amla, has all along remained underutilised as the efforts to make fuller use of its potential are inadequate. Tamarind has always been a single-use species with its fruit pulp used as a condiment in food preparations. Attempts to diversify its product range are relatively recent and not concerted. In the absence of linkages for processing and marketing, tamarind remained underutilised and organised efforts to increase its cultivation were limited. The third species in the study, kokum, resembles amla and tamarind in its utility. As a condiment, it is a substitute for tamarind. Additionally, like amla, it has several medicinal applications. Nevertheless, it has remained underutilised at the national level because of its geographical restriction. The use of kokum products is limited to its native range of the western hilly region and the reasons why it did not get introduced in other areas of similar soil and climatic conditions in the country are not known.

The overall objective of this study is to understand the value chains of the three species with a view to provide a clear picture on their potential for small holder farming systems.

3. Study methodology

The majority of the fruits available in the country is consumed as fresh fruits and less than 4% of the produce is processed (Biswas *et al*., 1994). The percentage is likely to be even smaller for underutilised fruits. The problems associated with fruit processing have been identified (Baisya, 1980), but many of them still remain. A few underutilised fruits are processed primarily into a single product; for example, the main product of karvanda (*Carissa congesta*) is pickle and that of the Himalayan Yellow raspberry (*Rubus ellipticus*) is jam. In the case of most other fruits, including the three species selected for this study, there are several processed products. The absence of a stronger demand for any product over the others of the same fruit origin results in relatively small quantities of several items being turned out. Hence, instead of individual products, value chains were analysed for the key processed products of each species.

Information for the study was collected by conducting surveys in selected areas of prevalence of each species. The methodology for obtaining information from farmers consisted of personal interview and group discussion. Information from those engaged in processing and marketing was obtained by direct interaction. Secondary data from literature and other unpublished documents were also referred. The number of respondents surveyed under each category and location are summarised in Table 2.

Table 2: Respondents in each category and location.

Species and Survey Locations	Category of Respondent				
	Farmer	Processor	Wholesaler	Retailer	Consumer
Amla					
- Prathapgarh	5	4	2	2	5
- Sultanpur	10	-	1	0	5
- Udaipur	10	2	5	3	5
- Other	8	1	-	-	-
Tamarind					
- Ahmednagar	15	2	3	5	10
- Aurangabad	13	-	2	4	3
- Beed	12	1	4	3	9
- Dhule	17	1	1	2	3
- Other	3	-	1	2	7
Kokum					
- Ratnagiri	12	3	4	5	10
- Sindhudurg	14	7	6	7	14
- Other	6	1	2	4	9

Survey for amla was carried out in Udaipur district of Rajasthan and Prathapgarh and Sultanpur districts of Uttar Pradesh. Additional information was obtained in each location by discussing relevant issues with other farmers. Group discussions were held immediately after the meetings of amla growers cooperatives in Prathapgarh and Udaipur. Information on processing was obtained from the units under these cooperatives, those operated by self-help groups, farmers and two commercial units. Information from the processing facility of the Mahatma Phule Agricultural University in Maharashtra was also obtained. Marketing information was obtained from wholesalers and retailers in Udaipur, Sultanpur and Prathapgarh.

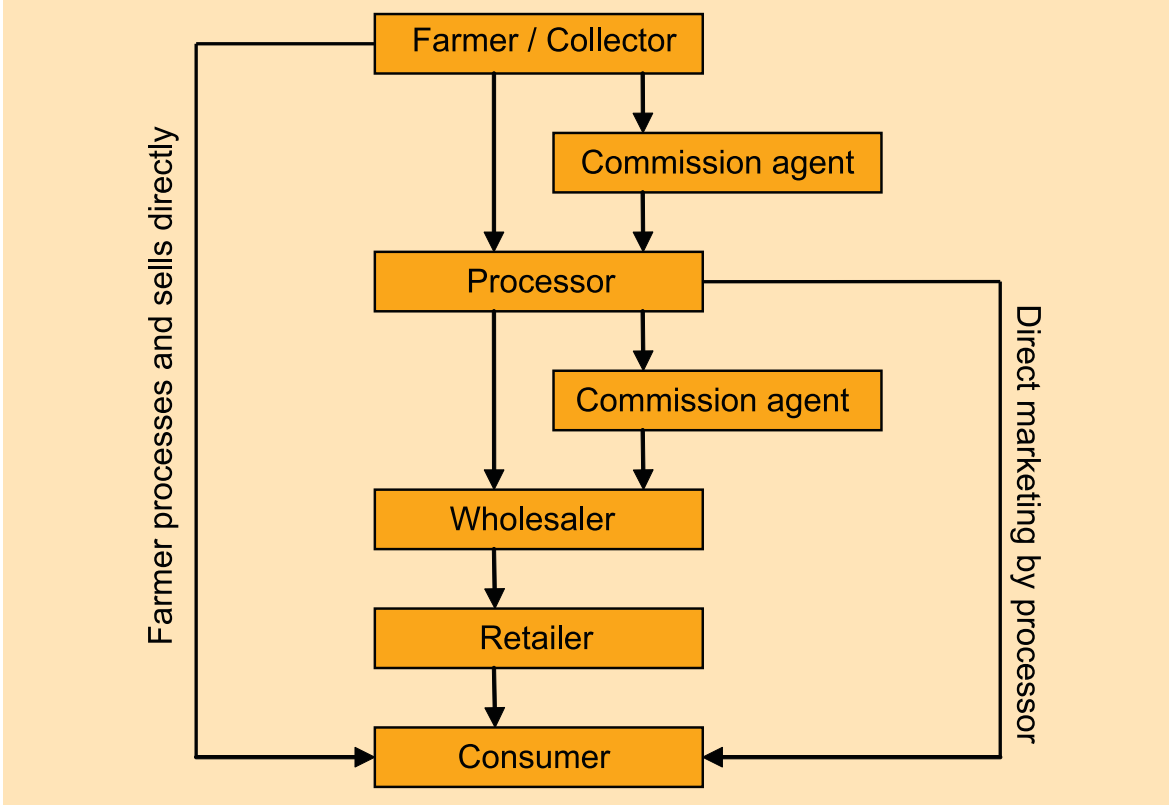
Data for tamarind was collected from farmers in Aurangabad, Beed, Ahmednagar and Dhule Districts of Maharashtra. Tamarind cultivation is concentrated in these districts of the state. Information was also obtained from commercial plantations that belong to an agricultural institution, a farm of the agricultural university and the regional fruit research station. Processing information was obtained from a household unit as well as that of the Mahatma Phule Agricultural University. Marketing information was collected from wholesale dealers, retailers and consumers in the study areas.

The survey for kokum was carried out in Sindhudurg and Ratnagiri districts of Maharashtra. In this natural habitat of this species, it is commercially exploited. Personal interviews were conducted with a questionnaire to collect production-related information. Other sources of information were a discussion with a group of farmers and visit to the farm of a university that has a commercial plantation of kokum and a fruit research institution. Processing, marketing and consumer-related information was collected in the same districts. The following information was collected for each species: (a) cost of orchard establishment and aftercare; (b) production and returns from fruits; (c) quantity and income of intercrops and by-products; (d) establishment and operational expenses of processing unit; (e) quantity processed and income realised; and (g) prices at processor, wholesaler and retailer level.

4. Results and Discussion

The flowchart in Figure 4 illustrates the key stakeholders in the value chains of the three species. In general, it includes farmers, commission agents, processors, wholesalers and retailers. Commission agents are intermediaries who enter the chain to link farmers with processors or processors with wholesalers. They do not represent any of the stakeholders in the chain, but provide a necessary linkage to earn an income for themselves. In the case of tamarind and kokum, collectors also contribute to the chain together with farmers. In certain situations, one or more of the intermediaries may be by-passed.

Figure 4: A generalised value chain for the three species.



4.1 Value Chain of Amla

Amla is usually established at a spacing of 7 m x 7 m, 7 m x 8 m or 8 m x 8 m. Typically, a small farmer in the Udaipur study location plants 30-40 amla grafts in 0.4 ha of land. The establishment cost of such an orchard include land development, planting material and manure. The cost on these for an orchard is INR 7,200 (one USD = INR 44). The aftercare costs are relatively higher during the first two years as supplementary irrigation has to be provided and then declines gradually to stabilise around INR 600 by the fourth year. Fruit production in amla begins in the fourth year and mature yields are attained by about the tenth year.

Details of average fruit yield, expenditure and income from establishment to the eighth year of amla orchards are presented in Table 3. The total expenditure of amla establishment and aftercare up to the age of eight years is INR 12,950 and the cumulative value of fruits produced is INR 22,250. The raw material for all the processed products of amla is the mature fruit. Therefore, fruit yield and value are not influenced by the product for which amla is used. The cumulative returns become positive only in the eighth year of cultivation, which does not make this an attractive investment up to this stage.

Table 3: Average fruit yield, expenditure and income from a 0.4 ha orchard having 30 amla trees in Udaipur.

Age of tree (Years)	Establishment and aftercare (INR)	Cumulative expenditure (INR)	Fruit yield (kg)	Cumulative income from fruit (INR)
0	7,200	7,200	-	-
1	1,400	8,600	-	-
2	750	9,350	-	-
3	600	9,950	-	-
4	600	10,550	150	750
5	600	11,150	450	3,000
6	600	11,750	1,050	8,250
7	600	12,350	1,300	14,750
8	600	12,950	1,500	22,250

The cropping systems adopted by small farmers enable other income from the farm as well. The interspaces in the orchard are used for growing annual crops and grass is allowed to grow during the off season. The multipurpose trees planted along the farm border also produce foliage and wood that is periodically harvested for fodder and fuel, respectively. Including the value of these products to returns improves the economics of la-based system marginally as shown in Table 4.

Table 4: Income from an amla-based 0.4 ha farm in Udaipur.

Age of tree (Years)	Income from components of amla-based system (INR)			
	Amla	Other crops	Fodder / Wood	Net income
0	-7,200	2,500	500	-4,200
1	-8,600	2,500	500	-5,600
2	-9,350	2,500	500	-6,350
3	-9,950	2,500	750	-6,700
4	-9,800	2,500	750	-6,550
5	-8,150	2,500	750	-4,900
6	-3,500	2,500	1,000	0
7	2,400	2,500	1,000	5,900
8	9,300	2,500	1,000	12,800

The above situation is for farms of low soil fertility that have newly introduced amla. The situation is different in Prathapgarh where the soils are more fertile and amla is a familiar crop among farmers. As a result, amla yields in this area are about 20% higher than that of Udaipur at all stages of growth. Moreover, intercrop yields are much higher, making the overall economics more appealing and a surplus in cash flow is realised by the fourth or fifth year. Some projections assume a price of INR 10 per kg of amla fruit (Hegde, 2007), but the present study found that farmers can actually get only INR 5, so the break even period is 7-8 years. If farmers can get INR 10 per kg, the investment on establishment and aftercare of the plantations can be recovered by the sixth year.

The amla-based small farms in the study are operated with family labour. Occasionally farmers may assist each other for tasks such as harvesting, but this involves no payment. Table 5 shows the division of labour by men and women for different farm activities during the three seasons. Both men and women spend more time on amla during the winter season, which is the time of fruit maturity. During the rainy season, the time spent in the farm is for both amla and annual crops and hence the time given for each activity separately is approximate. During this season, farmers devote most of their time to the cultivation of annual crops in amla interspaces and on any other land they may have. Water scarcity does not allow farmers to do much land-based activities during the summer. As fodder availability is also low during these months, more time is spent on livestock-related activities and as labourers in nearby towns, construction sites and farms of large landholders.

Table 5: Percentage of working time spent by a farm family on various activities during the three seasons in Udaipur.

Season	Amla		Annual crops		Livestock		Labour	
	Men	Women	Men	Women	Men	Women	Men	Women
Winter	75	62	6	6	6	18	12	3
Summer	12	14	7	14	31	24	50	48
Monsoon	25	12	50	51	19	31	6	6

Amla has a diverse product range in the form of pickle, sweets, dried pieces, powder and candied fruit. Because of its high shelf life, low moisture content and simple packaging requirement, the costs on storage and transport of fresh amla are not very high compared to most other species. The main initial fund requirements are for the establishment of the processing unit and working capital. The processing units visited during the study can be categorised into large, medium and small.

Large units have been established by entrepreneurs or amla producer cooperatives with sizeable investment. They have the necessary backward and forward linkages for raw material purchase and marketing of produce.

Medium-sized units were found in the amla belt of Prathapgarh where enterprising farmers have their home-based processing units. Besides processing the fruits from their own farms, they source raw material from neighbouring farms and nearby villages. Part of the produce is sold through roadside stalls run by them and the remainder supplied to retailers in nearby towns. Another option they have is to sell to wholesalers in which case their brand name and a large portion of profit is lost. The wholesalers, in this case, do the packaging and market the produce in their brand name.

The third category of processing units is small, unorganised and is an attempt to create income-generation opportunities together with value addition of farm produce. An example of this is small groups (self-help groups) making use of the facilities available at community processing centres.

Influenced by climatic conditions, flowering in amla begins in the south and moves northward. Accordingly, the harvesting season in the south is from August to October whereas the season in the north is from October to February. A processing unit can depend on nearby areas for 2-3 months in a year for raw material, but can get fruits for another 2-3 months from distant places. Information about the three types of processing units are presented in Table 6. Establishment cost for the large unit includes land and building costs. These costs are not taken into account in medium and small units as they were housed in community premises or farmer's home.

Table 6: Economics of establishment and operation of amla processing units.

Particulars	Large	Medium	Small
Capacity (tons per year)	60-70	20-25	2-4
Establishment cost (INR)	1,000,000	200,000	50,000
Operational cost per year (INR)	500,000	250,000	50,000
Gross income per year (INR)	1,350,000	450,000	90,000
Net income per year (INR)	850,000	200,000	40,000

The net income per kg of amla processed (average of all the products) is INR 14 for large units, but it is only INR 10 for medium and small units. Large commercial operations have several advantages such as ability to source raw material at a cheaper rate and to distribute the processed products to cities away from competitive markets. They also have access to market information with regard to products in demand. Amla fruits can be processed into more than 20 products and the profit margins in some of them are more attractive than others (Table 7).

Table 7: Processed products, costs and returns from 100 kg of amla.

Product	Units of Processed product (kg or l)	Cost of raw material + processing (INR)	Retail value of produce (INR)	Value addition (INR per kg of fresh amla)
Candy (kg)	50	2,900	8,000	51.00
Squash (l)	58	1,780	3,160	13.80
Pickle (kg)	75	2,400	5,250	28.50
Mouth freshener (kg)	15	975	1,500	5.25
Burfi (kg)	50	1,750	4,000	22.50

Among the amla products studied, the highest value addition of INR 51 per kg is for processing fresh fruit into candy. This is a labour-intensive process and hence the production cost is higher than others. Unlike other amla products, people are not generally familiar with making candied fruit at home. With increasing popularity, it has the potential to emerge as a product of high demand. Pickle and burfi (a sweet cake), which follow candy in value addition, already have well-established market demand. Their volumes of sale being higher than that of candy, small processors appeared to prefer them as the risk of rejection is lower.

The distribution of benefits in the value chain of amla candy is shown in Table 8. It is a known fact that farmers do not always get satisfactory returns for their produce. Amla is no exception with the fruits garnering a mere INR 5 per kg. It requires only 2 kg or INR 10 worth of raw material to produce 1 kg of candy, which is worth INR 160 at the consumer level. The stakeholders who enter the chain at different stages incur expenses. Important among them are transport, storage, depreciation on equipment, labour and inputs for processing and sales tax. Even after allowing for these expenses, it is evident that compared to farmers the share of the profit is much higher for the other players in the chain.

Table 8: The profit distribution from 1 kg of amla candy (processed from 2 kg of fresh fruit) among stakeholders in the chain.

Stakeholder	Value realised (INR)	Cost incurred (INR)	Profit (INR)	Main items of expenditure
Farmer	10.00	8.50	1.50	Establishment and aftercare of orchard, harvesting
Commission agent	22.00	12.50	8.50	Transport, storage, labour, harvesting, tax
Processor	58.00	50.00	8.00	Ingredients, labour, power and water charges, tax, packaging, depreciation
Wholesaler	30.00	20.00	10.00	Transport, advertising, labour, excise tax, storage
Retailer	40.00	31.50	8.50	Storage, sales tax
Total (price to consumer)	160.00			

Value addition by processing is one way of improving the returns for the produce. The cost of producing a kg of candy at farm level involves INR 10 of raw material, INR 3 of labour and INR 36.30 of other inputs. According to farmers in Prathapgarh who process the fruit into candy themselves, the rate at which wholesalers buy it from them is INR 100 per kg, a value addition of about INR 25 per kg of fresh fruit. This is a better option than selling the fruits, but there is a likelihood of the processed items remaining with them for a longer time, resulting in funds not being readily available for other purposes. The sum of the costs and profits in the entire value chain should be the price paid by the consumer, but discrepancies may appear due to ignoring certain benefits or costs. An example of this is the use of the amla fruit residue after the extraction of juice (for syrup making) in the preparation of sweet. Similarly, several waste materials during processing are used for other products.

The acceptance by farmers and subsequent success of any new crop will depend on the availability of technology and additional income generated by producers. Technology for amla has been standardised and production is not a problem. It is the income realisation that is likely to be the major constraint to amla cultivation. Many a time farmers are forced to sell the fruits of their entire orchard at a price pre-determined by middlemen and this makes the situation even worse. Processing by themselves or farmer cooperatives is an option, but inadequate professional management skills and market linkages appear to be their major constraints.

4.2 Value Chain of Tamarind

It can be assumed that tamarind trees that are more than 25 years old are of seed origin. These are huge trees with a dense canopy that does not allow other vegetation to grow underneath. The grafted trees in the farms studied are much smaller in stature and have been established at a spacing of 10 x 10 m. The cost of establishment of 40 tamarind grafts on a ha of land is INR 6,100 (Table 9). The expenditure on aftercare, according to respondents, is about INR 2,300 in the second year. It declines gradually and stabilises in the fifth year at INR 1,000. The first commercial harvest of about 5 kg became available in most farms when the trees were six years old. The yields are expected to peak at 12-15 years when a tree will yield 100 kg or more. However, there were farmers in the study who expressed disappointment of grafted tamarind not yielding harvestable quantities even at ten years of age.

Table 9: Average fruit yield, expenditure and income from 0.4 ha tamarind orchard in Maharashtra.

Age of tree (Years)	Cumulative expenditure (INR)	Fruit yield per tree (kg)	Fruit yield per 0.4 ha (kg)	Cumulative income from fruit @ INR 8 per kg
6	15,300	15	600	4,800
7	16,300	25	1,000	12,800
8	17,300	40	1,600	25,600

The total expenditure on tamarind establishment and aftercare up to the age of six years is INR 15,300 and the returns commence at this stage. The sale price for tamarind fruits is INR 8 per kg and this enables total income to exceed the cumulative expenses by the eighth year. In the areas of western Maharashtra where the present study was conducted, vegetables, onion and millets are grown as intercrops in an intensive production system with irrigation. Contrary to popular belief that tamarind does not allow other species to grow near it, these systems are successful and the overall productivity of land is high.

The net income from intercrops in a 0.4 ha area after deducting the expenses on labour and inputs is approximately INR 15,000 for a year. Hence the establishment cost on tamarind is effectively recovered in the second year itself by having intercrops. In the case of unirrigated land, the annual net income from intercrops help the tamarind-based system attain break even in 5-6 years. The annual income and expenditure (not the cumulative amounts) of tamarind and intercrops from the sixth year is shown in Table 10 for irrigated and unirrigated conditions.

Irrigation did not always result in higher yields of tamarind although some farmers reported a positive response. Therefore, the main difference in income between irrigated and unirrigated tamarind farms was the income from the intercrops. The highly intensive irrigated cropping of vegetables such as egg plant, okra and tomato in the interspaces of tamarind resulted in very high returns to farmers. In irrigated farms two or three crops are grown annually, whereas unirrigated farms grow only one crop during the rainy season. In farms older than ten years, according to farmers, there was a marginal reduction in intercrop yields. As intercrops are grown with irrigation or during the rainy season only, the competition does not appear to be serious at present.

Table 10: Cumulative net income of tamarind-based farms of 0.4 ha with and without irrigation.

Age of tree (Years)	Net income from tamarind (INR)	Net income from tamarind and intercrops (INR)*	
		With irrigation	Without irrigation
6	4,800	20,400	7,300
7	8,000	23,600	10,500
8	12,800	28,400	15,300

*Net income from intercrops was INR 15,600 and INR 2,500, respectively, for irrigated and unirrigated conditions

Tamarind pulp is traditionally used as a condiment in most Indian households. It can be easily extracted from the fruit and stored. Processing the pulp into powder is also a simple process. There are new products like sauce and paste that are yet to enter the market at large scale. The growing demand for convenience food ingredients and lifestyle products can result in greater opportunities for processed products of tamarind. This should result in more attractive prices for processed tamarind products in the future. At the moment, however, the number of products in this category is small and the market is dominated by few established players. The main products together with their economics are presented in Table 11.

Table 11: Processed products, costs and returns from 100 kg of tamarind fruit.

Product	Processed product (kg)	Cost of raw material + processing (INR)	Retail value of produce (INR)	Value addition (INR per kg of tamarind fruit)
Pulp (kg)	89.0	4,200	7,500	33
Sauce (kg)	87.5	3,325	6,560	32
Toffee (kg)	162.0	13,400	19,500	60
Powder (kg)	37.5	1,425	3,000	15

The processors in the survey were mostly those who produced the fruits or were engaged in small-scale processing in the tamarind-growing area. The price realisation by them for different products showed that their profit margins were low (Table 12). The larger benefits, as it happens often, were realised by the wholesalers and retailers. For example, it costs INR 38 for producing a kg of sauce and the wholesaler buys it for INR 48. By the time it reached the consumer, the price was INR 75 where the profit for the wholesaler was INR 17 and that for the retailer was INR 10. There was some direct sale by the processors themselves, but again they had to sell the produce at comparatively low profit margins. This was because of the concentration of processors within a small area and the consumers they targeted were the same. In addition, the wholesalers improve the packaging which gives greater confidence to the consumer about the quality of the product.

Table 12: Price of tamarind products at different stages of the value chain.

Product	Cost of production (INR)	Price (INR) paid by		
		Wholesaler	Retailer	Consumer
Pulp	42	50	65	77
Sauce	38	48	65	75
Toffee	82	102	105	120
Powder	38	52	64	76

Being the raw material supplier, the farmer's profit is the same irrespective of the product it is processed into. Small-scale processing initiatives by farmers can make a substantial difference to their returns as they can identify the products that have a larger margin of profit. The net profits in Table 13 were calculated with the cost of production in Table 11. The main items of expenditure incurred by the different stakeholders are similar to those listed in the last column of Table 8.

Table 13: Net profit realised by stakeholders in the value chains of tamarind products.

Stakeholder	Net profit per kg of product (INR)			
	Pulp	Sauce	Toffee	Powder
Farmer	2.50	1.50	1.50	1.50
Commission agent	4.50	7.50	7.50	8.00
Processor	6.00	8.50	9.25	12.00
Wholesaler	2.00	16.50	16.50	14.50
Retailer	1.50	11.50	12.00	11.50

Tamarind is harvested in Maharashtra during February-March, a period that is not too hectic for farmers. Because all the fruits on a tree do not ripen at the same time, 2-4 harvests are required. The main advantage in value addition of tamarind is the storability of pulp. It can be stored after the initial handling which involves the removal of shell, seed and fibre. A processing unit can store and use the pulp as and when required. Small processing units are usually engaged in processing several fruits. They process fruits of low shelf life during the season of their availability and when others are unavailable take out the tamarind pulp from storage. Hence, inclusion of tamarind greatly improves the capacity utilisation of the processing machinery. Nevertheless, not all the small-scale processing units appeared to be in a position to adopt this strategy because they do not have the resources to tie up part of their working capital in the form of stored tamarind pulp.

4.3 Value Chain of Kokum

Kokum is produced on farm land, homestead and common land (Table 14). Establishment of kokum farms is relatively new and is emerging as a land use system. In such systems, kokum may be the main crop with annuals like pulses and leafy vegetables grown in the interspaces. The spacing for kokum is usually 6 m x 6 m, 6 m x 7 m or 7 m x 7 m when it is the main crop. The resultant interspaces combined with the upright growth habit of kokum enables the cultivation of annual crops. There are also practices where kokum is inter-planted with perennial species like mango or cashew. These are not clearly-defined systems, but are practices that may vary from farmer to farmer. In mango and cashew orchards, for instance, the tree rows are 7-10 m apart. Instead of intercropping with annuals, a farmer may introduce kokum in that space. Bulk of the kokum is still produced in homesteads. A few scattered trees may be found in the garden or a row of trees may be planted along the boundary or by the side of the house. Besides the fruits, they add to the greenery around the house. The other source of kokum fruits is the common land. Presently, there is no strict regulation with regard to who can harvest fruits from trees on common land. Those engaged in collecting fruits harvest from these trees.

The economics of kokum cultivation is similar to that of amla. The tree starts bearing in the fourth year and most of the farmers in the study recouped their investment on establishment and aftercare by about the seventh year. In irrigated farms with annual intercrops, the break even was achieved a year or two sooner. The natural grass, that grows if the interspaces are left unused, has fodder value. In the system with mango, the income from kokum is only supplementary. The area is famous for the Alphonso mango and farmers rely on it for their main income. Having kokum in the system gives an additional income, but it does not appear to be substantial at present.

Table 14: Species composition with net income of 7-year old kokum-based systems.

Production unit	No. of trees		Net income (INR)		
	Kokum	Associate	Kokum	Associate	Total
Sole kokum (0.4 ha)	40-60	Grass	3,350	-	3,350
With mango (0.4 ha)	12	15 mango	1,100	15,900	17,000
With annuals (0.4 ha)	40-60	Vegetables	3,350	2,750	6,100
Home garden or border row	4-10	Trees & crops	300	500	600-900

The coincidence of the fruiting period with the lean season for agricultural activities provides marginal farmers and those who work as farm labourers an income-earning opportunity through the collection of kokum fruits. Although the surplus available from each homestead may be small, together they add up to a sizeable quantity of kokum fruits. It was found that homesteads usually have 4-10 kokum trees, and the fruit produced in each household can range from about 50 kg to more

than 200 kg. Each household processes fruits and reserves about 10 kg of rind and 10-15 l of syrup for its own use through the year. A small quantity may be distributed among relatives and friends. The remainder is sold to those collecting fruits at the rate of INR 3 per kg. Depending upon the number of trees, the income per household through the sale of fruits is in the range of INR 100-400 in a year, which is an insignificant amount for the household. The collector sells the fruits to the processor or the commission agent and realises a net profit of about INR 1 per kg of fruit. During the fruiting season of 2-3 months, some collectors earn about INR 5,000-7,000 through this activity.

The main processed products of kokum are dried rind and syrup. The dried rind, locally known as amsol, has the same use as tamarind pulp in food preparations. The syrup is the acidic juice extracted from the rind and preserved with sugar. The methods adopted for processing rind and syrup are traditional and simple, so most households process kokum at home for own use (Powar, 2005). The economics of processing kokum fruits is presented in Table 15.

Table 15: Economics of processed kokum products from 100 kg of fresh fruit.

Product	Processed quantity (kg)	Production cost (INR)	Gross returns (INR)	Net profit (INR)
Rind	60	1,100	1,700	600
Syrup	85	2,500	3,025	475

The processing costs at home are lower than in commercial units as this activity is done almost as a routine household chore (Table 16). There are several units in the study area with processing capacity ranging from 5-15 tons of fresh fruit. The profit distribution in the value chain of kokum products shows that the highest net profit is at the level of the processor. Besides this profit, commercial processing has an additional expenditure on collection and transport. Consequently, the price the consumer pays for the commercial product is more than 60% than that processed at home. This margin will be even larger if the household sells the products directly to the consumer.

Table 16: Net profit distribution in the value chain by household and commercial unit in 1 kg of rind and 1 l of syrup.

Activities	Rind (INR)		Syrup (INR)	
	Household	Commercial	Household	Commercial
Production of fruit	5.00	5.00	3.50	3.50
Collection and transport	-	6.30	-	5.85
Processing	4.30	6.30	9.75	13.30
Marketing - Wholesale	3.50	3.50	7.00	7.00
Marketing - Retail	2.00	2.00	4.00	4.00
Total	14.80	23.10	24.25	33.65

5. General Discussion and Recommendations

The value chains for the study species are a function of production, processing and marketing. The successful expansion of cultivation of amla, tamarind and kokum in the survey locations as well as in new areas will depend on their profitability. This will be determined by the fruit yield and the price realisation for the produce. Availability of improved germplasm and their propagation by grafting has resulted in favourable attributes in the form of high yields, early bearing and dwarfing of trees. Thus, improved technology available for the cultivation of these species, elite planting material and improved crop management practices, have been made use of by the farmers in the study.

Being underutilised fruit species, generally the land allotted for these species is marginal in fertility and there is no assured irrigation. This results in overall reduction in growth and yield of the trees. The yields recorded by farmers in the study were lower than their potential. The yield potential of amla in the seventh year is 50 kg per tree (Hegde, 2007), but the yields in both Udaipur and Prathapgarh locations of the study were 30-35 kg. More importantly, tree stands lacked uniformity: some trees have died and there was a high degree of tree-to-tree variation in many of the farms. Because the returns from the orchard depend on the number of trees per unit land area (Tables 3, 9 and 14, respectively for amla, tamarind and kokum), it is essential to have the required number of trees. In addition, management efforts should ensure that each tree in the stand contributes almost equally towards the total fruit production of the farm.

Year-to-year yield variation is another factor that seems to be affecting the financial stability of farms. Several farmers in Rajasthan stated that the amla yield in 2006 was lower compared to 2005, sometimes by 30-50%. Soil moisture status influenced by rainfall often brings about yield fluctuations. But a more likely reason is the low fertility of soils where the crop removal of nutrients is not adequately replenished by a systematic fertiliser or manure application schedule. In so far as the systems approach is concerned, a consideration is the output of all the species components rather than the yield of individual species. In amla and tamarind farms, annuals are included as intercrops (Tables 4 and 10) while kokum fits in as the main crop and intercrop in agroforestry systems (Table 14). There is scope to increase the benefits from associate species in all these systems.

Amla and kokum realise value appreciation only if they are processed. In this regard, tamarind is better placed as its primary processing involves only the separation of the pulp from the remaining fruit parts. The pulp also has a long shelf life. Therefore, tamarind fetches INR 8 per kg as against INR 3-5 by the other two fruits. Processing of amla fruit into products like candy, pickle and squash involve somewhat complicated steps. As a result, small-scale processing of amla is limited and farmers have to sell the produce to intermediaries who in turn supply them to commercial processing units. The situation for kokum is different as its processing is simple. However, the market for the products is very small in areas where the fruit is produced because most households process the fruit for their own requirement. Therefore, the intervention of an intermediary to collect the surplus fruits from homes and supply to large processors becomes necessary.

Processors achieved reasonably satisfactory returns among the stakeholders in the value chain (Tables 8, 13 and 16). Kokum has low storability followed by amla. The value realisation at present is not attractive enough for cold storage to be resorted to. Hence processing is seasonal for amla and kokum while tamarind is stored as pulp and processed when the demand arises. In both these situations, funds get fixed in the form of produce and the amount is larger for amla and kokum as they are finished products. According to a kokum processor, processing has to be completed by June. The peak demand for kokum syrup is during the summer months from March to June, meaning that the funds are locked up in the produce for about eight months. Similarly, a farmer who has his own unit in Prathapgarh does not find it profitable to process amla into dried candy because of the high cost of production. In his view, demand for candy is expanding in other states, but small-scale operators like him are unable to take advantage of

this opportunity due to their inability to establish appropriate market linkages.

The scattered nature of production and processing of underutilised fruits has been a constraint to the emergence of an organised marketing network for the produce. There are many small players and they are often concentrated in localities where the products have familiarity. Promotional efforts to widen the consumer base are almost totally absent. This is evident in products like tamarind chutney and kokum syrup remaining unfamiliar outside their traditional areas of use. Volumes of trade being small, the outreach of a wholesaler usually extended to not more than two districts. Moreover, they marketed several other products as well, which reduced the focus on underutilised fruit produce. This is also true for retailers. In the absence of strong brand identity for underutilised fruit produce, the natural tendency of retailers is to favour suppliers who provided the highest margin of profit. This is undesirable as it can have an adverse effect on product quality and consumer confidence. Any negative impact can harm the interests of all the stakeholders in the value chain because the crops and their value-added products do not enjoy a firmly established status at present.

The issues associated with the promotion of underutilised fruits are so many that it is possible to put forward a long list of recommendations. However, so as not to dilute the aspects highlighted in the foregoing discussion, the important recommendations are presented selectively.

1. Extension services for the production systems of the study species have to be strengthened to (a) intensify production of all component species of the system and (b) minimise the yield fluctuation from year to year and among the trees within a year. The objective is to ensure stable returns every year through the efficient utilisation of land and other resources.
2. Considering the suitability of the fruits of the study for small-scale processing, the benefits of value addition through cooperative or group initiatives have to be taken advantage of. This will reduce the number of intermediaries in the value chain and thereby make the income to the grower attractive.
3. Credit facilities for production and processing have to be made more favourable, especially in situations where the stakeholders are unable to invest because of conditions unique to the crops in the survey. This will enable them to address concerns (such as low yield in a particular year due to climatic conditions and the working capital getting locked up in the form of produce over a prolonged period) without impairing their subsequent schedule of activities.
4. Enhanced processing technologies together with information on nutraceutical value in relation to specific constituents in the processed products (for example, hydroxyl citric acid in kokum syrup and vitamin C in amla candy) have to be evolved to make the produce attractive and competitive with others on offer in the market.
5. A comprehensive information support system that can be easily accessed for matters related to the entire value chain of the underutilised fruits has to be developed. Besides technical data, it can carry information on availability of fresh fruits, processed items and prevailing prices that can be updated everyday. It should also have a provision for stakeholders to post messages on what they can supply or purchase.
6. Specific policies have to be evolved at national and state level to encourage the production and utilisation of underutilised fruits. These policy measures should be targeted at priority sectors such as small-farm horticulture, degraded land rehabilitation and rural development.

All those engaged in the promotion of underutilised fruits will be able to contribute in some way towards the realisation of each of the above recommendations. The following are indicative of the possibilities. Research institutions, government extension services and agencies like the International Centre for Underutilised Crops can address technology and extension-related issues. Voluntary organisations can play a key role in the mobilisation of growers for group action and their access to latest market information. Financial institutions can work out modalities for extending credit facilities.

Acknowledgements

This activity is part of the research project "Strengthening Underutilised Crops Research and Development in Africa and Asia" funded by the United Kingdom Department for International Development (UK DFID). The authors gratefully acknowledge the financial assistance provided by the International Centre for Underutilised Crops in Sri Lanka for conducting this study, the cooperation extended by all the respondents during the survey, Dr. Irmgard Hoeschle-Zeledon and Dr. Hannah Jaenicke for reviewing the manuscript, and the support of BAIF field staff of BIRD-UP and RIDMA in data collection and local arrangements.

References

Anonymous. 2003. Area and production of fruit crops. Directorate of Horticulture publication, Maharashtra, Pune, India.

Arora, R. K. and Nayar, E. R. 1984. Wild relatives of crop plants in India. NBPGR Science Monograph No. 7, New Delhi: National Bureau of Plant Genetic Resources, India.

Anbu, S. 2005. Market opportunities for tamarind. In National Consultation Meeting on Underutilised Fruits, 2nd December 2005, Pune, India. Pp. 75-79.

Baisya, R. K. 1980. Fruit and vegetable processing industry in India - its problems and prospects. *Indian Food Packer*. 34(6): 29-32.

Bajpai, P. N. and Shukla, H. S. 1985. Fruits of India: Tropical and Subtropical (T. K. Bose, Ed.) Naya Prakash, Culcutta, India. Pp. 757-767.

Biswas, S., Chandrasekhar, T., Rajan, Y. S., Singh, D. N. and Amudeswari, A. 1994. Long-term technology vision: an Indian experience. In Agro-Food Processing: Technology Vision 2020. TIFAC Publication, New Delhi, India.

Brueckner, D. 2006. An analytical study of the marketing potential of the processed amla in Pratapgarh and adjoining districts. Unpublished Report, BIRD-UP, Allahabad, India.

Chadha, K. L. 1992. Vitamin A and C in food. *Indian Horticulture* 37(3): 4-8.

Chadha. K. L. 2001. Dryland Horticulture crops. *Indian Horticulture*. 46: 18-20.

Champion, H. G. and Seth, S. K. 1968. A revised survey of the forest types of India. Government of India Press, Nasik, India.

Kulkarni, D. N. 2005. Post-harvest management and processing of tamarind. In National Consultation Meeting on Underutilised Fruits, 2nd December 2005, Pune, India. Pp. 88-100.

Gajanana, T. M., Reddy, T. M. C. and Gowda, I. N. D. 2007. Small-scale processing and marketing of underutilised fruits. Pp. 8-11. In Proceedings of the National Workshop on Underutilised Fruit Species for Food-Nutrition Security and Enhanced Rural Livelihood. BAIF Development Research Foundation, Pune, India.

Gawas, M. M. 2005. The economics of processing kokum fruits. MSc Thesis, BS Konkan Krishi Vidyapeeth, Dapoli, India.

Hassan, A. and Raghuram, P. 1987. Cashew processing and marketing. *Agricultural marketing*: 30:13-19.

Hegde, R. N. 2007. Role of NABARD in promoting horticultural crops. Pp. 12-16. In Proceedings of the National Workshop on Underutilised Fruit Species for Food-Nutrition Security and Enhanced Rural Livelihood. BAIF Development Research Foundation, Pune, India.

Joshi, G. D. 2005. Production, post-harvest management and processing of kokum. In National Consultation Meeting on Underutilised Fruits, 2nd December 2005, Pune, India. Pp. 7-12.

Nagarajan, A. R. 2005. Market opportunities for promotion of aonla. In National Consultation Meeting on Underutilised Fruits, 2nd December 2005, Pune, India. Pp. 37-38.

Powar, S. S. 2005. Kokum in a Konkan Village. *MPTS Newsletter* 30: 9-11.

Raut, P. G. 1995. Economics of processing of cashew apples and nuts in Goa state. MSc Thesis, BS Konkan Krishi Vidyapeeth, Dapoli, India.

Ray, P. G. and Mujamdar, S. K. 1976. Antimicrobial activity of some Indian plants. *Economic Botany*. 30(4): 317-320

Subramaniya, K.V. and Sudha, S. M. 1993. Economics of linking tomato processing with production and marketing. *Indian Food Packer*. XLVII: 25-32.

Sardesai, V. R. and Bodhankar, S. L. 2005. Evaluation of the effects of aonla powder on skin toning and skin texture. In National Consultation Meeting on Underutilised Fruits, 2nd December 2005, Pune, India. Pp. 61-65.

Sawant, A. 2005. Commercialisation of Kokum. In National Consultation Meeting on Underutilised Fruits, 2nd December 2005, Pune, India. Pp. 3-6.

Singh, H. P. 2003. Augmentation of production and utilisation of aonla. Proceedings of National Seminar on Production and Utilisation of Aonla, Salem, Tamil Nadu, 8-10 August 2003: 3-8.

Tripathi, V. K., Singh, R. S., Tiwari, C. M. and Upadhyay B. N. 1979. Fruit use in Indian *unani* system of medicine. *Indian Med. Yoga and Homeopathy*, 14(3-4): 156-169.

The International Centre for Underutilised Crops (ICUC) is an autonomous, non-profit, scientific research and training centre. ICUC promotes the use of underutilised crops for food, medicinal and industrial products, and also for environmental protection. The Centre provides expertise and works collaboratively for tropical, sub-tropical and temperate crop development.

Our Mission

Our mission is to promote the use of underutilised plant species for the benefit of humankind and the environment.

Our Goal

Our goal is to reduce poverty and suffering through the improvement and promotion of underutilised species for food, medicines, fodder and industrial needs, and for environmental protection.

Also in this series:

Abeyrathne, A. H. M. S. W. B. and Jaenicke, H. 2006. Potential for Small-Scale Processing and marketing of Tropical Fruits in Kandy, Galle and Horana Divisional Secretariat Divisions of Sri Lanka. Research Report No. 1. International Centre for Underutilised Crops, Colombo, Sri Lanka. 23 pp

Barry, I.N. 2007. A value-chain analysis for the Sri Lankan rambutan subsector. Research Report No. 2. International Centre for Underutilised Crops, Colombo, Sri Lanka. 55 pp

Preferred citation: Daniel, J. N. and Dudhade, P. A. Analysis of economic characteristics of value chains of three underutilised fruits of India. Research Report No. 3. International Centre for Underutilised Crops. Colombo, Sri Lanka. 22 pp

ISBN: 978-955-1560-06-6 ISSN: 1800-2293

Design: ASM Graphics. Printing: Gunaratne Offset Limited. Cover photo: Amla (*Emblica officinalis*) flowers. Hannah Jaenicke, ICUC.

The International Centre for
Underutilised Crops

ICUC Headquarters
PO Box 2075, Colombo, Sri Lanka
Tel: +94-11-2787404 Fax: +94-11-2786854
Email: icuc-iwmi@cgiar.org
www.icuc-iwmi.org

BAIF Development Research Foundation
Dr. Manibhai Desai Nagar,
NH 4, Warje, Pune 411 029, India
Tel: +91-20-25231661 Fax: +91-20-25231662
Email: baif@vsnl.com
www.baif.org.in

ISSN No. 1800-2293
ISBN No. 978-955-1560-06-6