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Supply of Medicinal Raw Materials

The Achilles Heel of Today's Manufacturing Sector for Ayurvedic Drugs in Kerala

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Abstract

The growth of the manufacturing sector in Ayurveda seems to be slowing down in the Indian state of Kerala as the prices of raw materials have increased inordinately, challenging the sustainability of ayurvedic drug production. Several reasons are responsible; in particular, the dwindling availability of plants, the excessive complexity of supply chains, the growing distances between plant sources and manufacturing units, and the control over the medicinal plant market by powerful middlemen. Substitution, adulteration, and quality control have become sensitive issues and may eventually damage the reputation of the ayurvedic drug sector in a context of high competition between manufacturers. Cultivating medicinal plants is considered to be the main solution for solving the supply crisis, but manufacturers' demands are often too constraining for cultivators and this may not be such a viable alternative in a context of continuous modernisation efforts for production efficiency.

Keywords

raw materials – supply chain – cultivation – quality control – traceability

Introduction

The huge development of the Ayurveda pharmaceutical sector in Kerala since the 1980s is nowadays challenged by the sector's difficulty to get a steady supply of raw materials that is necessary for pursuing smooth production. In 2006, 91% of the herbal raw material used in Ayurveda came from the wild. Of the material sourced by the manufacturers from Kerala, 43% grew in forests, 16%

in non-forested areas, 18% came from both ecosystems, and 14% from outside Kerala, mostly North India. Only 9% were cultivated, which showed a decrease compared to a 14% evaluation in 2000.¹ Medicinal plant cultivation has declined despite strong political involvement to promote it as the solution to ensure supply for the ayurvedic industry. In 2013, at the time of our latest fieldwork, cultivation remained very limited, and the share of material sourced outside Kerala, even outside India, was in constant growth. This evolution raises many questions about Kerala's resource capacities to meet industrial demand, the structure of the supply network, the impact of industrial demand on resource availability and quality, and company strategies for securing the needed supply.

In 2000, the Government of India's *Report of the Task Force on Conservation & Sustainable Use of Medicinal Plants* warned of destructive practices observed in more than 70% of collection activity in India.² This claim—whether true or overestimated, mixing bad practices and overexploitation—was the reason for encouraging cultivation of medicinal plants and their protection in their natural environment, mostly by limiting collection and starting *in situ* conservation projects. Accessible resources have decreased, however, and some species can no longer be marketed because they are not available in enough quantities or because their collection has been banned. For many raw materials, and not only the endangered species, supply prices have doubled or tripled over the past five years. Destruction of the resources by overcollection is only one of the reasons for the price rise, as there are many factors involved in explaining the supply difficulties encountered by the ayurvedic sector.

This spectacular price increase is highly limiting if not damaging for pursuing ayurvedic development objectives, as the prices at which the medicines are sold (their highest increase is 5–10%) cannot match this evolution and the industry's profit margins have dwindled. Waning availability and the search for lower prices have produced a context favouring bad practices in the supply chain, and quality control has, as a consequence, become critical in the ayurvedic sector. This situation has motivated a change in the main manufacturers' development strategies. Compared to other industrial sectors, the fluctuation of costs, quantities and quality of raw materials is above average. Medicinal plant supply is seasonal, fresh material has to be processed quickly, and the medication always combines several ingredients that need to be available to the production sector at the same time. These specificities explain that the industry is fully dependent upon raw material supply and at the mercy of

1 Sasidharan and Muraleedharan 2000, 2009.

2 GoI 2000.

the suppliers. It is even more problematic that manufacturers do not enjoy full visibility over their raw material supply network; they get their materials directly from some suppliers but have limited information on their sources and on the middlemen's supply network.

The sector is currently engaged in a modernisation and standardisation process aiming at an increase of its market share, while trying to meet the demand to deliver better quality ayurvedic production. The latter policy was issued in 2002 by the Department of Indian Systems of Medicine and Homeopathy. Ayurvedic industries have been strongly encouraged to adopt Good Manufacturing Practices (GMP) and the ISO standards used in the biomedical sector.³ To reach these standards, manufacturers must oversee every step of the production process. The traceability of raw materials has therefore become crucial. Big manufacturers with the capacity to improve their production methods are shifting their development strategies, modernising their manufacturing units and sometimes specialising their production, but they are still determined to develop an integrated supply chain and diminish the risk factor. Good manufacturing practices, integration of the full supply chain, modernisation of the technical aspects of production, quality control at every stage of production, and a just-in-time raw material supply strategy are the manufacturers' ambitious goals. They will entail a major change in the industry's traditional practices, especially in the current organisation of supply chains.

In order to understand what this shift means and if the manufacturers have the structural capacity to achieve their objectives of a better transparency and more control over their supply chain, we need to analyse the context of these evolutions and how the supply networks operate. First, we shall consider the evolution of need for raw materials by the ayurvedic industry in Kerala and characterise the price rise of medicinal plants. This will then raise questions about the reasons for the increase in the value of raw materials and show that ayurvedic manufacturers rely primarily on the informal sector for their supply. Quality control has become a very important issue because of the risk of weakening the reputation of the ayurvedic manufacturing sector in a context of high competition amongst different producers. Checking the quality of huge quantities of raw materials is, however, a difficult and an increasingly technical as well as expensive task. Finally, we will focus on the intended solution to the problem of raw material supply and quality—the cultivation of medicinal plants—and on the question of the ability of cultivation to adjust to the new development strategies of ayurvedic firms.

3 Pordié and Gaudillière 2013, pp. 136–7.

Medicinal Plants: A Highly Valued Raw Material

Research on Ayurveda reveals that many things are claimed but very few are easy to check. First, the development of the ayurvedic sector: overall statistics seem to show an increase in production, but a closer look shows that this overall increase hides great disparities between companies. Second, the need for medicinal raw materials: are companies developing so much that they need increasingly levels of supply? This is not at all certain. The most successful companies are recently established ones working mainly on extracts and active ingredients, while there has only been limited increase in production of traditional drugs among older companies. Medium-sized firms are restricted in their development because they cannot invest in bigger production units. All companies, however, are affected in the same way by the increase in prices, with some being able to adapt their more flexible production planning, while others less flexible now see their profits decline.

Stabilisation of the Production Sector

It seems that the ayurvedic sector in Kerala has currently reached a new stage characterised by a stabilisation of its expansion. It is quite difficult, however, to present a definitive argument on its evolution, given the great confusion in the available data. The Drug Controller's Office in Thiruvananthapuram (Kerala) considers the number of 713 manufacturing units to be valid for 2010, based on an evaluation between 2004 and 2006 undertaken by N. Sasidharan and P. K. Muraleedharan.⁴ However, according to AYUSH⁵ reports, already in 2007 Kerala comprised 1,121 pharmaceutical production units; while in the following year their number increased slightly to 1,177; yet, in 2010 only 880 were registered. This apparent and prompt decline in pharmaceutical production units is related to the removal of non-operating units. According to the Ayurvedic Medicine Manufacturers Organisation of India (AMMOI) located in Thrissur, there were only 639 manufacturing units registered in 2007 in Kerala but 876 units registered in 2013, 100 of which may have no production activity today. According to AMMOI data and despite the uncertainty about closed units, it seems that, these last years, the number of manufacturers increased slightly in every district of Kerala.

Amongst the new firms there are a large number of companies specialised in herbal, cosmetic, or nutritional production as well as research laboratories. This development is a response to the high growth in demand for cosmetic

4 Sasidharan and Muraleedharan 2009.

5 Department of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homeopathy.

and food supplements in India and abroad.⁶ These companies are active contributors to the growth of the ayurvedic manufacturing sector. A large number of unregistered units also seem to constitute an 'informal sector' made up of local traditional healers and small household units. Estimations of their number vary from the same figures given for registered manufacturing units to more than twice that number.⁷ Little information is available on this small-scale production sector. Although it provides drugs to local customers, and its role is important in local health care in villages, it is unrealistic to compare its needs in raw materials with the demand of bigger manufacturers, or the flows of medicinal plants from collectors to these small production units with the larger flows to local middlemen who are marketing medicinal raw materials to larger ones.⁸

In the 1990s, demand for ayurvedic drugs in Kerala increased at a rate of 10–12% per year.⁹ Sales (in value) by Kerala's major ayurvedic industries grew overall by 19% between 1993 and 1998, slowing down to 16% between 1993 and 2002.¹⁰ For two of the main Kerala firms, Oushadhi and Vaidyaratnam, growth in the value of sales has remained constant since the mid-1990s: Oushadi's compound annual growth rate went from 6% between 1996 and 2003 to 15% between 2003 and 2010, then levelled at 17.5% in 2011 and at 19.5% in 2012; Vaidyaratnam's was 8.5% between 1996 and 2003, then 14.5% between 2003 and 2010, stabilising at 15% in 2011 and declining slightly to 12.5% in 2012.¹¹ These figures may be influenced by rising prices of the final product, but the percentages show that despite growing competition amongst manufacturing units, the main firms have continued to improve their sales. The technical services manager at Kottakkal AVS considered the company's annual growth rate (10%) to be low compared to that of other firms using advertising and/or specialising in specific drugs.¹² Kottakkal AVS's market share in Kerala has in fact declined from about 65% sixty years ago to only around 45% in 2013. Other firms, for instance Indulekha or Dhathri Ayurveda, are experiencing huge growth because their entire production is focused on just a few drugs. The Kottakkal AVS manager nevertheless advised caution when considering the commercial success of Ayurveda medicine and its growth capacity, given that

6 Madhavan 2010; Jayaraman and Anitha 2010.

7 Jayaraman and Anitha 2010, p. 64.

8 Dejouhanet 2014.

9 Suneetha and Chandrakanth 2001.

10 Madhavan 2010, p. 49.

11 Data kindly provided by H. Madhavan.

12 Interview on 27 March 2013.

according to some reports only 7% of Kerala's inhabitants are using Ayurveda for treatment.¹³

Adjustments of Ayurvedic Supply Strategies

Growth in the ayurvedic production, whether high or moderate, may induce a greater need for raw materials. This must also be questioned. According to the 2006 to 2010 activity report of the Kerala State Medicinal Plants Board, consumption of medicinal plants by the ayurvedic industry in Kerala is considered to be growing at a rate of 15–20% per year. It is difficult to assess this increase in consumption because the growth rates differ depending upon the type of raw material being considered. The Kerala Forest Research Institute (KFRI) compared consumption by ayurvedic firms of 125 raw plants in the Northern Districts in 2000 and in 2006, finding an overall 1,943-tonne increase in consumption. Though significant, it turns out that 101 plants were used in larger quantities while 24 were used in lesser amounts.¹⁴ After collecting data on the quantities of each plant used by Oushadhi in 2005 and in 2013, we found an overall increase of about 40 tonnes. However, of the 443 different materials,¹⁵ only 173 were consumed in larger quantities, 167 were used in lesser amounts, and 45 were no more used. Out of these items that disappeared, 23 were no longer used in fresh form, but they were still consumed in dried form. Current demand includes 49 new materials and most of these are in dried form complementing the quantities of the same material in fresh form, or sometimes replacing it, especially in the case of bark materials. The new increase in the share of dried materials in the annual consumption selection may signify a change in the supply of some raw materials that are no longer available in fresh form in the surrounding areas and are coming from farther away in dried form. The need for fresh materials is still important, but for some usually very commonly used plants, such as palmuthuku (*Ipomoea mauritiana*), chittamruthu (*Tinospora cordifolia*), sathavari (*Asparagus racemosus*), and brahmi (*Bacopa monnieri*), the fresh forms have been largely supplemented by the dry ones, even if overall consumption has diminished.

Of the 10 items listed by the KFRI as having shown high consumption increases in 2006, only four were consumed by Oushadhi in larger quantities in 2013 than in 2005: nellika (*Emblica officinalis*), kadukka (*Terminalia chebula*), chukku (dried ginger, *Zingiber officinale*), and karimkurunji (*Strobilanthes cili-*

13 Ibid.

14 Sasidharan and Muraleedharan 2009, p. 63.

15 50 plants are required in both their dried and fresh forms; they are consequently considered as 100 different items.

atus). On the other hand, the industry is using lesser quantities of sathavari, palmuthuku, chittamruthu, brahmi, kurunthotti (*Sida rhombifolia*), kanjunnii (*Eclipta prostrata*), amukkuram (*Withania somnifera*), and karingali (*Acacia catechu*). These materials were supposed to 'reveal the growth of the Ayurvedic Medicine Industry', especially sathavari, which was used as a substitute for an important traditional ingredient.¹⁶ Nellika, kanjunnii, chittamruthu, and kadukka are often used in cosmetics. Although the declining use of quantities of kanjunnii and chittamruthu points to a stabilisation in production, nellika is still very much used by Oushadhi, as it is a component of many energy drinks and hair oils. Oushadhi has also promoted production of soft drinks based on this Indian gooseberry by women's self-help groups (The Seven Sisters).

This decline in consumption of important materials shows a slowdown in market diversification and new choices in production made by the company. Since 2005, some previously little-used materials have highly increased in terms of the quantities being used, including cherukataladi (*Cyathula prostrata*), ungin (an oleaginous plant, *Pongamia pinnata*), inchi (ginger, *Zingiber officinale*), thulasi (holy basil, *Ocimum sanctum*), paruvakodi (*Pothos scandens*), valiyakadaladi (*Achyranthes aspera*), and dandappalayila (*Wrightia tinctoria*). These plants are available in North India or other tropical regions, or cultivated, which may mean that the Oushadhi pharmacopoeia has nowadays a preference for easily available species.

Industrial demand for medicinal raw material fluctuates as it adjusts to market supply capacities, and changes with opportunities opened up by the development of the medicinal plant supply network and by globalisation. State policies regarding medicinal plants have been evaluated on the basis of industrial needs for some species, but the ayurvedic sector is more like a variable entity: basing its production on traditional, unchanged formulations but being flexible enough—at least until now—to adapt to supply constraints and opportunities, and to the prices and availability of raw materials. Strategies differ depending upon the firm and its production choices, but all of them have to factor in the rising cost of their raw materials.

Excessive Increase in Raw Material Prices

To evaluate the increase in the prices of raw materials, we examined heterogeneous data collected from different ayurvedic manufacturers. Firms were often reluctant to provide information on their suppliers and we could only get information from Oushadhi for 2005, Kottakkal AVS for 2007, and from three producers in 2013, namely Vaidyaratnam, Ashtavaidyan Thaikkattu Mooss (ATM)

¹⁶ Sasidharan and Muraleedharan 2009, p. 71.

Vaidyaraj Oushadhasala and, for just a few products, Sitaram.¹⁷ Evaluating the prices demonstrated an increase of most of the raw materials between the two periods, an average of a 250% increase between 2005 and 2013. The average of mean annual growth rates stood at 19% for the period between 2005 and 2007 and 13% for 2007 to 2013, showing a slowdown in the average increase.¹⁸ Despite the heterogeneity of our data, these developments definitely point to a steep upward trend in the prices of raw materials. A more detailed look shows that the price of nellika, for instance, increased by 40% during the period, while its use remained high. While kadukka increased by almost 200%, chukku lost 27% of its value and karimkurunji increased its price by 76%. Price hikes may explain that formerly important materials came to be less consumed: the price of sathavari was multiplied by three, of karingali by 3.7, of palmuthuku by 2.5, of kurunthotti by 1.5, while the price of chittamruthu increased by 170%, of brahmi by 95%, of kanjunni by 210%, of amukkuram by 244% with a huge increase between 2007 and 2013 (280%).

Market prices for medicinal raw materials are published in the AMMOI's monthly journal *Oushadhan*. They are collected from a wholesaler in Thrissur, J. M. Ayurvedics, and medium-sized and small firms use these prices as references. Comparison of the wholesale market prices of a few products between 2007 and 2013 shows an equivalent trend, with some products like kurunthotti and thippali (*Piper longum*) being even more expensive on the open market, with a 267% increase for the former, and a 322% increase for the latter, compared to the 255% increase of the price for thippali paid by the previously named big companies.

Price increases in raw materials are a challenge for the firms, but also for the accessibility of medicines to users. The cost of raw materials amounts to 46% of the price of the final drug products at Kottakkal AVS. Large quantities of oil, ghee, and jaggery are also used and their prices have also risen. Prices of final drug products cannot go up by more than 5–10%, yet remain attractive and ensure that most patients can still afford their treatment. Increase in the

17 Within the data from these companies, we took a sample of raw materials for which the prices were available for at least two periods. In 2013, the three manufacturers might have been paying different prices for the same materials and a deeper analysis would be interesting in order to compare the companies' respective networks of suppliers and evaluate their negotiation capacities. For now, the 2013 series of prices allowed us to calculate average prices.

18 This cannot be explained by a weaker negotiation capacity by Kottakkal AVS, as the average of the prices it is paying is lower than that being paid by Oushadhi for the same products.

prices of raw materials can be explained by high demand, which guarantees good value for raw materials on the market as well as a diminishing availability of the resource. It can also demonstrate how the supply chain is organised.

Understanding the Supply Crisis of Ayurvedic Raw Material

Diminishing Plant Availability: A Socio-Political Issue

Some plant species serving as raw materials have been banned from the market by the government because they have become endangered, while others have become so scarce that their collection requires an additional effort, which collectors deem not to be worth it. Their supply is therefore irregular and their availability has become unpredictable. The problematic species include the well-known ashoka tree (*Saraca asoka*), which is extensively used in Ayurveda especially to treat menstrual pains and digestive problems, but which is endangered and is not to be marketed officially. The plant comes from North India or, increasingly, from outside India; it has been registered amongst priority plants for protection and cultivation. Kanjuni also becomes problematic at the end of the summer season, when it is less available, and when its quality is too poor due to lack of rain. Supply of brahmi and devatharam (*Cedrus deodara*) is erratic, with the latter being brought in from Uttarakhand. Guggul (*Commiphora mukul*) has been coming in from North India, and is now mainly bought in Afghanistan. Of the fresh plants collected in village fields and grounds, chittamruthu, a vine used partly as an antibiotic, has become scarce and is now on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species; its price varies widely depending on the season. All these plants are, however, essential ingredients of many ayurvedic drugs.

One major argument given for the price increases is the depletion of medicinal natural resources due to their overexploitation and unsustainable collection practices. This commonly shared opinion, developed by the administration and a few research scholars, is partly true. During our fieldwork, we found evidence of resource destruction in the forest area. The reasons observed were low prices offered to local collectors for wild non-wood forest products, insecurity relating to access to the resource or to the market, competition from non-local collectors—i.e. those not interested in local conservation of the resource, just collecting to complete their income—and a lack of efficiency by state authorities in implementing tribal monopoly over the marketing of forest products.¹⁹

19 Dejouhanet 2013.

Despite the aforementioned factors, the idea of depletion of resources due only to bad local practices and industrial demand needs to be reconsidered. Medicinal plants are also becoming scarcer on the market for other reasons: there are fewer and fewer persons involved in collecting wild plants; forest protection laws are discouraging locals from exploiting the forest and encouraging them to develop alternative sources of revenue; children are getting an education and prefer to go for qualified jobs; and finally, the new regulations improving employment in rural areas are providing enough work to attract traditional collectors who are now staying away from this former activity. The application of the 2005 National Rural Employment Guarantee Act (NREGA) in Kerala allowed one member of each rural family to get 100 days of work per year, paid at the rate of Rs 125 per day. The programme provides work in unskilled jobs mainly for women, such as cleaning and maintaining ponds and planting trees, and for most of the working days clearing roadsides and village grounds. Not only has the programme been highly criticised for its inefficiency,²⁰ it has also had terrible consequences for the collection of medicinal plants. Women involved in the collection prefer to take the programme jobs. Potentially more problematic is that the systematic clearing of natural-growth ecosystems of medicinal plants near roads and village areas is causing their depletion. Kurunthotti and thulasi, for example, are removed from roadsides before they flower, which prevents them from propagating. In addition, the national highway NH 47 linking Kanyakumari to Salem (Tamil Nadu) via Thiruvananthapuram, Kochi, Thrissur, Palakkad, and Coimbatore was widened to four lanes, which involved a huge removal of the vegetation alongside the road.

As a result of a particularly poor 2013 rainy season in Kerala, many medicinal plants were simply not to be found, and the quality of those that were available was inferior. Lack of rain and climate change are often invoked to explain why prices have risen and quality has deteriorated. In addition to the supply problems encountered at the collection stage, however, the marketing channels for plants have also played a critical role in the geography of medicinal plant supply, contributing to the opacity of the itineraries taken by raw materials to reach manufacturing units.

Opaque Supply Networks and Raw Material Chains Controlled by Middlemen

A good way to evaluate the gap between the upstream and downstream segments of the supply chain is to compare the prices afforded to medicinal plant

²⁰ For critics of the application of the Act, see Pramod Kumar 2013.

collectors and the prices paid by the ayurvedic industry for the same material. According to our own surveys, in 2007 wild kurunthotti was bought at between Rs 1.5 and 2.5 per kilo from collectors living at the foot of forest-covered mountains. Then it was passed through two or three middlemen, and finally sold to Kottakkal AVS at Rs 31 per kilo, while sathavari was bought from collectors at Rs 4 or Rs 5 per kilo and sold to the manufacturer at Rs 15 per kilo. This very significant difference in value between the start and the end of the chain highlights the weight of middlemen in ayurvedic development capacity.

At the very end of the 1970s, the Government of Kerala set up an institutional supply chain made up of a network of cooperatives intended to gather non-wood forest products, mostly medicinal plants, from *adivāsi* (tribal) collectors in order to supply the state ayurvedic industry, Oushadhi. The system is based on monopolies: monopoly of collection by *adivāsis*, monopoly of marketing by the cooperatives and their federation, monopoly of purchase by Oushadhi and later Ayurdhara Pharmaceuticals, the second Kerala state manufacturing unit. This official, integrated chain excluded from the start a large number of stakeholders—non-*adivāsi* collectors, private merchants, and local middlemen—who were involved in collecting, marketing, and processing ayurvedic raw materials beforehand. Supplying private ayurvedic companies was considered to be secondary. The result of what was intended to guarantee an income to the *adivāsi* population, to organise the supply for the state company and to limit access to natural resources, was also that a part of the sector became illegal. In the context of the Indian market economy, however, the state monopolies were not able to stand up to what had become an illegal sector. The excluded stakeholders organised themselves and soon overtook the official system. New and scarcely integrated channels developed, deepening the gap between manufacturers and collectors due to the complexity and informality of their organisation.

Currently, each manufacturer works with its own network of suppliers, with whom it has direct connections. Suppliers either work with different manufacturers or are attached to only one, such as Kottakkal AVS, which relies on long-term business relationships with a network of 40 to 50 agents spread around different parts of Kerala. In September, the start of the supply year, the firm establishes its annual need in raw materials and negotiates their prices with its suppliers. Kottakkal AVS has such an enormous demand that it will buy any quantity available from its full-time, exclusive suppliers. The down side is that the firm depends completely on its suppliers, who until recently had the monopoly of supply to Kottakkal AVS. Currently, the AVS unit in Kanjikode is also buying products from a few local providers. Although the firm derives trust and flexibility from this monopoly situation and long-term collaboration,

where for instance an urgent need can be dealt with quickly with just a phone call, the drawback is that the suppliers, very well-connected by their supplying networks and their community affiliation (they are all Muslims), carry significant bargaining weight. It seems that these agents would sometimes inform AVS that the needed material is not available, while storing it in neighbouring Tamil Nadu, then set a higher price when the firm needs it most. The system is thus double-edged: on the one hand it facilitates organising production based on an efficient, cost-reducing suppliers' network; on the other it generates dependency adding a risk factor to the supply process.

The other big Kerala company, Oushadhi, has a very different way of organising its supply network. It operates with a large network of wholesalers and private agents located in several Indian states, but for the most part in the nearby city of Thrissur. Oushadhi was supposed to benefit from the raw materials collected through the state-organised channel, but this channel provides only 10%, in terms of value, of the total raw materials purchased by the company. Oushadhi's supply is contract-based. Tendering is usually made once a year (currently twice a year), at which suppliers offer the cheapest price for the full quantity of each material needed. The supplier secures the contract by paying a deposit (5% of the total value), which works as a guarantee for Oushadhi in case the contract is not honoured (i.e., if the full quantity is not supplied, timing is not respected, or bad quality forces the company to reject the bulk). Oushadhi's supply contractors' activity is actually quite risky because to get the sale through the tender they have to offer the cheapest prices, which limits their profit margin. Suppliers providing the largest variety of materials focus on low-value materials.

These middlemen are actually investors who not only have enough financial backing to pay the deposit and get the contract through tender in the case of Oushadhi, but also to manage a large network of local suppliers efficiently and to counter delays and problems arising in the supply process. All the risks linked to local transactions (collectors or small middlemen preferring a better offer, lorry accidents, etc.), and to the difficulty of finding less available materials, and/or to the uncertainty of being able to collect the required quantities, weigh primarily upon the small-scale agents, not on the manufacturers. Of course, the potential profit is worth the risk: the cost is high, especially if the network is large, but between the price for materials paid to the collectors and the price they are sold to the manufacturer, the value may be multiplied by fifteen. The margins are high enough for covering the uncertainty factors as well as the manufacturers' payment period. In the case of Oushadhi, suppliers can sell materials cheaper than to other manufacturers because they are certain to sell large quantities.

Oushadhi contractors also work for other companies; there are nodes of various networks, which converge through them to reach the manufacturing units.²¹ There are few suppliers interacting directly with manufacturers but they carry a lot of weight in the medicinal plant market, generating an oligopolistic situation. Most of the firms are therefore dependent on the prices and qualities decided upon by these few important suppliers. The activity of the latter is built on a large number of local middlemen, who work with different agents. Geographical distance and location are determining factors in the constitution of this complex network. Most of those who supply the manufacturers are located in Kerala, mainly in two centres for ayurvedic raw material marketing: Thrissur and Kozhinjampara. Many wholesale shops are concentrated in Thrissur, which is surrounded by several ayurvedic drug-makers, forming a proximity market for the town's suppliers. Kozhinjampara is a village located at the border of Kerala and Tamil Nadu, which is specialised in ayurvedic plant collection and supply. The suppliers living there benefit from the inhabitants' know-how in the collection of village plants and also from the proximity of Tamil Nadu, where plants are not collected as much, manpower is cheap, and climate differences make the collection season longer and the drying process more flexible. Suppliers from Tamil Nadu are also important stakeholders in the supply chains, but for the Kozhinjampara agents, the opportunity to collect plants from Tamil Nadu allows them to diversify the origins of the materials, to complete the local offer, and to counter the monopoly of some local suppliers over collection in certain areas.

Thrissur and Kozhinjampara suppliers provide mostly fresh herbs and local materials. These are needed in huge quantities and the firms favour nearby suppliers, who provide several seasonal plants regularly, guarantee their freshness, and bear the cost of transport to the manufacturing units. Until recently, distant providers or wholesalers used to supply only expensive materials in small quantities, but with the difference in prices becoming smaller, these materials, provided in big quantities from abroad or North India, are more and more in demand. Local suppliers still benefit from the industrial need of fresh herbs and from their capacity to respond to emergency demands because of their direct connection with small middlemen and groups of collectors. But the oligopolistic position of these suppliers, who keep the origins of the provided materials secret, motivates many firms to increase the share of materials supplied from faraway places, which are not easier for the industry to locate, but which nevertheless eases dependency upon a few suppliers. Extension of

21 The contracts work differently depending on the manufacturer, but we will not go into the details of these differences here.

the supply area, either to Tamil Nadu, North India, or outside India, makes it more and more difficult for manufacturers to control the supply chain. The growing distance reveals the constitution of a centre-periphery duality with resources being further away from the production hubs. Moreover, collection of resources in distant places inhibits the implementation of programmes for the protection and renewal of plant resources, in which manufacturers might be involved. As the gap between resource collectors and industrial users widens, integrating the supply chain seems an unattainable goal.

It is true that the current decline in available medicinal plant resources contributes to the rise in prices of ayurvedic raw materials. Furthermore, the importance for suppliers of securing contracts, and the fact that they have to keep enlarging their area of supply, both contributes to an increase of the financial risk that middlemen have to take and tempts suppliers to provide a heterogeneous quality of raw materials. This situation creates an under-valuation of raw material items at the collection stage. Segmentation of the channels into several levels of middlemen and the complexity of supply networks under each middleman prevent the collectors from benefiting from rising demand and prices. This in turn reduces local inhabitants' interest in collection activity and contributes to unsustainable collection practices and to the declining quality of the materials provided.

Quality Control and the Future of Raw Material Supply: A Challenge for Ayurvedic Manufacturers

Starting in June 2002, the Department of Indian Systems of Medicine and Homeopathy—renamed Department of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homeopathy (AYUSH) in November 2003—adopted Good Manufacturing Practices (GMP) for Ayurveda manufactured products. This was done in order to ensure quality control at every step of the production process. Based on World Health Organization (WHO) recommendations for pharmaceuticals, GMP progressively included all the aspects of the manufacturing process: location, manufacturing premises, water supply, waste disposal, health and hygiene of workers, quality control, etc.²² According to the department, of the 1,127 registered Ayurveda, Siddha, or Unani medicine producers, 510 comply with GMP standards in Kerala. The GMP certificate is currently valid for five years.

To ensure the authenticity and safety of raw materials, the department published the *Ayurvedic Pharmacopoeia of India (API)*, a book of references for identifying ayurvedic raw materials and for respecting quality standards.

22 Madhavan 2010, p. 59.

Descriptions are based on organoleptic criteria, chemical properties, and quantitative limits regarding moisture level, presence of metals, etc. Manufacturers judge the raw material they obtain from suppliers based on these indications. The raw materials are delivered in bulk to the manufacturing units. When these are fresh herbs, a competent botanist or biologist, or an experienced industrialist, checks random samples from the bulk based on organoleptic factors (colour, shape, taste, and smell). This 'acquired collective wisdom at the operation level', as it is portrayed at Kottakal AVS, is shared by the workers at the units.²³ Fresh herbs, leaves, and fruits are pressed and transformed to juice as fast as possible for better conservation. These herbs are routinely controlled, but if there is any doubt, they may be sent to a laboratory. Most of the units have their own labs with at least microscopes and plant samples. In most companies, each bag of plants stored for transformation has a certificate of approval, which is the condition for the supplier to be paid.

The main problem encountered for the fresh materials supplied is their early drying, when they have been transported too late to the manufacturing unit, or have been affected by summer drought and heat. They then yield less juice. To keep the plants moist, some suppliers submerge them in ponds before transport and when they reach the manufacturing units. The plants are also regularly put into water for cleaning. Actually, wet plants are heavier and water may be added to increase the value of the bulk. Unfortunately, water inside the bundles of plants may cause the herbs to rot. It is essential for the company to open the bundles before weighing in order to check the moisture level and the homogeneity of the whole. With declining plant availability, suppliers or collectors may be tempted to mix other plants in with the requested material. When such mixing of plants is detected, the bulk is rejected.

While fresh materials are taken directly to the production units, dry items, also called 'crude drugs' or 'bazaar drugs' coming mostly from wholesalers, are generally stored before processing. After delivery, they are chopped, dried again for better conservation, and put into bags with certification stamps. The drying process at the manufacturing unit is done naturally under the sun, in a storage room or, as in the Kottakal AVS manufacturing unit in Kanjikode, in big ovens. Previous to this, the moisture content is checked, which should be low in order to avoid fungus problems. This test is carried out in laboratories.

Dried roots or stems may be difficult to identify using only organoleptic methods so, at companies that are equipped to do so, the anatomy of dubious plant fragments is analysed. At Kottakal AVS, the Standardisation Division developed a computerised database for plant identification based on their

23 We conducted interviews at Kottakal AVS twice, once in 2007 and again in March 2013.

description, the structure of the minerals, chemical profiles, etc. Most of the products do not get full laboratory checking but some, such as ashoka, guggul, and koovalam (*Aegle marmelos*), are systematically tested because of their scarcity and the frequency with which they are replaced by substitutes. Other more usual items, those needed in large quantities such as sathavari, koduveli (*Plumbago indica*), and kurunthotti, are also checked with care due to substitution inside the bundles.

One major quality problem for natural drugs has become the presence of heavy metals in the plants. Pollution of farmlands, increase in road traffic and heavy-industry development are amongst the reasons that plants and roadside weeds are contaminated by metals, pesticides, and chemicals. A few companies have laboratories to evaluate the heavy-metal toxicity of the plants, while other manufacturers cannot afford to test materials in the government-approved laboratories. This checking is usually done on final products only, because metals can still be washed out by cleaning and during the transformation process. The problem of heavy-metal presence in the plants is well known, but it has not yet been clearly addressed at government level. It may also question the development capacity of nature-based pharmacy. Wild plants are submitted to their environment and the absence of traceability for the raw materials makes it impossible for manufacturers to influence the quality of the plants at the collection stage. Locally, although collectors may be aware of potential pollution, they have neither the knowledge nor the concern to evaluate its influence on the medicinal properties of the plants, nor do they have economic incentives to avoid certain locations where plants would grow anyway. The financial interests involved in marketing medicinal plants, the absence of clear rules regarding checking for heavy-metal presence in the raw materials, and the lack of scientific evidence that such presence has an impact on the final product, are all currently playing down the problem of pollution in the supply chain.

Facing the problems of supply crisis and quality deterioration, not every company has adopted the same strategy. Companies like AVP Coimbatore chose to modernise the whole production process. In the manager's office, a screen shows images from in-house cameras of long white corridors, closed hygienic rooms, and workers dressed like biochemists. To check the raw materials being supplied, the company has hired a consultant, a senior professor of botany and taxonomy, who assists the Quality Control department specialised in chemical and microbiology tests. A private laboratory at Kochi is also used for heavy-metal testing. AVP Coimbatore aims to obtain Current Good Manufacturing Practices (CGMP) certification, in line with US Food and Drug Administration guidelines, so it has developed its in-house standard protocol for testing species and established a documented system. Their quality test of

raw materials is considered as a prerequisite for future development.²⁴ In most companies though, the quality checking of raw materials is only included as a part of a more general standardisation process of the production.

Between the official discourse and the realities of production, it is not easy, however, to get a proper idea of the kinds of compromises companies may make. If an ingredient is no longer available on the market, some firms may decide to postpone the production of the corresponding drug, but other firms may still produce it. This instills doubt regarding compliance with the complete formulation and the quality of the drugs. When this occurs, the former firms suffer from the competition of the latter and lose business for having maintained quality standards, while the reputation of the whole sector is also brought into question by the latter firms. Other questions emerge from this potential situation, regarding the opportunity of substitutions in ayurvedic formulations, their control, and the potentiality of unjustified substitutions within the factories.²⁵

To counter the supply crisis, a few companies also favour using plant extracts, and the number of private laboratories specialising in the extraction of active components has grown. This evolution brings with it a drastic change in the production methods and of the very concept of Ayurveda, and traditional ayurvedic pharmacies do not consider it to be a solution. Research and development departments are seeking new strategies to save on raw materials. In Kottakkal AVS, new production techniques are being explored based on sustainability concepts. These include closing the decoction vessels to save water and energy and to optimise the use of medicinal vapours. Innovative research is also being conducted on plant metabolism to improve bioactive properties and thus to use lower quantities.

When we visited the different manufacturing units about six to 10 years ago, the issue of supply sustainability was not considered critical, nor, especially, a problem that ayurvedic companies had to deal with. Now the main ayurvedic company managers are cooperating to find solutions to the problems they all encounter in the sector, whether clinical-trial obligations, reformulation patent issues, or raw material sourcing. Some of them are requesting a regulation institution for improving transparency regarding the traceability of the raw materials, the use of different ingredients in the formulations, and the sustainable management of medicinal resources. Substituting one ingredient with another is no longer legally possible if its compatibility has not been proven

24 Interview on 6 April 2013.

25 Inappropriate plant substitutions may occur within the factories but we did not find evidence of such practices.

by scientific methods. There is strong demand for the academic field to study plant-substitution possibilities, as well as to ensure that the requested validity tests are relevant in terms of the Ayurveda conception of medicine. In this context, concentrating innovation through a 'cluster' strategy is attractive for the industry.

Cluster and Culture: Two Ways to Counter the Supply Crisis

The Cluster Opportunity: Modern Science at the Service of Raw Material Supply

To improve quality standards, and hence the ability for Ayurveda drugs to gain legitimacy and recognition on the global market, the department of AYUSH has sponsored a cluster project called 'Care Keralam' run by the Confederation for Ayurvedic Renaissance-Keralam Limited (CARE-Keralam Ltd.). The cluster unit is located in the Kerala State Industrial Infrastructure Development Corporation (KINFRA) Park, a small industrial area in Koratty (Thrissur district). The project has registered 150 ayurvedic manufacturers and entrepreneurs. Care Keralam is defined as an 'innovation cluster'.²⁶ The project, a public-private venture promoted and funded by the Kerala state, connects private-sector companies through a regional network centralised at KINFRA Park. The proximity involved in the development of the cluster fosters creative emulation with a view to improving the Ayurveda sector, while the results of the research conducted are spread to the whole network and can retroactively influence the policies implemented by the department of AYUSH.

The goal of the project is to work on the standardisation of ayurvedic medicines. High-technology labs have been set up in the KINFRA Park, including analytical labs, modern packaging units, and clinical-trial blocks with toxicological studies on rodents. One of the objectives of Care Keralam is to ensure, for manufacturers and Ayurveda patients alike, the safety of the medicinal raw material. As a government-approved structure, they are entitled to certify the quality of raw material provided by the companies or sold to them. The structure sells its own material, which is stored within the Park and stamped with a quality certificate. The analytical and process-validation laboratories carry out specific tests such as the identification of plants through fingerprint or phytochemical analysis, evaluation of the purity of components and of the consistency of medicinal properties, search for evidence of pesticide residues, detection of bacteria and adulteration, presence of heavy metals, and so on.

²⁶ See Leducq and Lusso 2011.

This latter test is of particular interest to the firms using Care Keralam services. The technology used by the cluster generates admiration, and all its elements converge to take Ayurveda to international standardisation. In 2013, after a year and a half's activity, Care Keralam capacities were still underused despite their annual turnover of Rs 5 crores.²⁷

Nevertheless, the standardisation of quality checking questions the compatibility of modern methods with the Ayurveda concept of material quality for medicine. The high-performance liquid chromatography (HPLC) equipment or the gas chromatography-mass spectrometry (GC-MS) method, for example, analyse the organic compounds and chemical properties of the plants. However, separating the different compounds of a mixture, and evaluating the efficacy of a plant through its bioactive property is contrary to the essence of ayurvedic medicine, which is based on mixing ingredients in order to compensate or improve one property with another. The HPLC machine is currently used mainly to estimate the biochemical value of turmeric material.²⁸ The quality standards used are those referenced in the *API*. While checking for heavy metals is important for detecting environmental pollution of the plants, the presence of heavy metals in traditional Indian drugs is a question under debate because the effects on the body of these carefully detoxified metals have not been clearly defined.²⁹ The Care Keralam cluster is not just a service unit offering its members scientific verification and the proficient use of costly medical equipment (500 samples of raw material can be checked per day), it is also an innovation centre and think tank on official quality standards and the adaptability of Ayurveda to modern medicine standards and current ways of consuming drugs.

The geographical concentration of these technological tools aims to make the Care Keralam site indispensable in every step of the production of Ayurveda drugs. CARE-Keralam Ltd. owns a 25,000 square-foot raw materials storage unit with a mini lab attached to it to check the quality of the stored materials. The idea is that '[a]ll the basic raw materials needed for the production of ayurvedic drugs in the consortium will be procured and supplied by CARE-Keralam Ltd. thus doing away with exploitation of small- and medium-scale manufactures by middlemen'.³⁰ In 2013, CARE-Keralam supplied 65 different materials to manufacturers and marketed an average of 20 tonnes per material in the one year. The storage and quality checking have increased

27 Visit to KINFRA Park on 20 March 2013.

28 Interview with the R&D Manager of CARE-Keralam on 20 March 2013.

29 Sébastia 2011; Banerjee 2013; Gerke 2013.

30 CARE-Keralam brochure 2013.

the prices of raw materials by nearly 14%.³¹ Small manufacturers with lesser demand and negotiation capacities may, however, find the prices better than what they are used to, especially if they usually purchase their materials from wholesalers. CARE-Keralam supply capacities also appear more secure than those of local suppliers. CARE-Keralam also has some economically attractive materials on offer, including rare or endangered species such as guggul or mara manjal (*Coscinium fenestratum*, also known as tree turmeric) and others that either come from North India or may be difficult to obtain in Kerala. The materials stored at CARE-Keralam, however, come from private suppliers and the structure still depends on 40 to 50 local middlemen, some of them in Kozhinjampara. Were it not for their quality criteria, CARE-Keralam could be seen as just another kind of supplier or as an additional middleman raising the prices of raw materials to manufacturers based on its guaranteed quality certification. Although the origin of the bulk materials is recorded on their arrival, traceability still remains weak.

Cultivation of medicinal plants by Kerala farmers, though part of the initial cluster project, has not yet been implemented. But, as in many ayurvedic sites we visited, cultivation was enthusiastically advocated as a solution for the supply of safe raw materials and to improve traceability. It is interesting to note that, though in 2007 the widespread opinion was that cultivated medicinal plants did not have the same medicinal properties as those of wild ones, by 2013 this reasoning had disappeared from the usual discourse due to the emergency of finding solutions to sustain the supply.

Organised Medicinal Plant Cultivation Projects: The Unsolved Issue of Market Integration

Starting in 2000, cultivation of medicinal plants was highly encouraged at the national level. The *Report of the Task Force on Conservation & Sustainable Use of Medicinal Plants* published that year by the Government of India's Planning Commission defined reference guidelines for the management of the medicinal plant sector.³² The National Medicinal Plants Board (NMPB) was set up the same year as the first step of a policy strategy for the management of medicinal plant resources. The NMPB was intended to coordinate all actions related to

31 For 45 raw products, we could compare the prices proposed by CARE-Keralam to its members—the quality certificate is included but transportation charges are additional—and the average prices that we calculated as paid in 2013 by three ayurvedic medium-sized to large companies. These manufacturers would have paid, as an average, 13.8% more to CARE-Keralam than to their own suppliers.

32 GoI 2000.

medicinal plants and to promote projects focused on increasing the marketing and export of plants, and improving plant conservation and cultivation. In the 2000s, National and State Medicinal Plants Boards invested funds in medicinal plant cultivation.

In its 2006 to 2010 activity report, the Kerala State Medicinal Plants Board (SMPB) stated that it was involved in the funding of 193 cultivation projects in Kerala. The report also emphasises that the industry has a major need for ayurvedic plants, but in fact the Board aims mainly to develop awareness of the importance of conserving medicinal plants and to encourage the perpetuation of traditional ways of healing based on home gardening. Cultivation is therefore promoted and partly funded for home gardens, school gardens, jail compounds, church, temple, and mosque yards, as well as on hospital and clinic land. Training is offered for marketing the plants yielded by this type of cultivation, and although these cultivation projects are not necessarily meant to supply raw material for ayurvedic manufacturers, they do constitute nurseries for medicinal plants.

The SMPB works as a facilitator for farmers and industries to meet and work together. It is supposed to help implement buyback agreements but its funds are especially directed towards agricultural purposes (field preparation, distribution of seedlings, inputs, etc.) and amount to only part of a farmer's overall budget. The projects that were funded were mostly of benefit to ayurvedic firms—for instance, Vaidyaratnam, Sitaram, and AVP Coimbatore—which were willing to launch a nursery, a medicinal plant garden, or a farm. These companies are not currently using their grounds much for producing their own raw material supply. In 2013, out of the farmers who benefited from the SMPB project funding, we visited two in Varandarapilly, Thrissur district: the Vikasana Society, a service cooperative working locally for rural development, and a private farmer.

The Vikasana Society worked on an SMPB project from 2007 to 2010. Under the Vikasana umbrella, 42 farmers cultivated 16 medicinal plants for sale to a number of ayurvedic firms. A buyback agreement was signed for three years between Vikasana and an Ayurveda pharmacy. All the seeds were provided by the Oushadhi nursery and, through Vikasana, every farmer got a loan to start cultivation. The first two years, Vikasana bought materials from the farmers and trained them in collection, drying, storing, and supplying methods. Certain plants like thippali, however, need two years to grow and farmers tended to lose interest. The agreement with SMPB stipulated that some farmers were to plant endangered species such as ashoka, koovalam, and kanikkonna (*Cassia fistula*) trees. Profits only slowly came in, and the farmers brought fewer and fewer materials to Vikasana, which consequently lost part of its invested money.

By the third year, only 10 farmers were still delivering materials to Vikasana, which eventually stopped buying them. The farmers then went to sell their goods to Thrissur wholesalers for low prices. In addition, the manufacturers were not willing to pursue their involvement in the project because when a given material was needed for drug production, it was not necessarily available at the farms and when the material was ready for harvesting, the industry was not willing to store it, and the farmers, having no storage capacities, would lose their production. Currently, only three to four members of Vikasana still cultivate medicinal plants but ayurvedic manufacturers are no longer involved. We met with one farmer who has kept up cultivation. In his one-acre field he still grows only koduveli, as an intercrop under banana trees, but he is not selling it because its sales price is too low to cover manpower and transport to the buyer.

Another non-governmental organisation (NGO) involved in cultivation of medicinal plants is the Evangelical Social Action Forum (ESAF) located in Mannuthy, in the Thrissur area. It deals with regional microfinance projects. In 2006, ESAF began cultivating 10 marketable medicinal plants with the involvement of women's self-help groups from different districts. The project lasted until 2010 and was funded by a loan from a private bank. The women had been trained in plant cultivation, collection, and processing methods and the ESAF had set up three storage units. The ESAF responded to an Oushadhi call to tender and was supposed to provide the manufacturer with 55 tonnes of kurunthotti in 2008. By 2007, it was delivering medicinal plants to Vaidyaratnam and SNA Oushadhasala, and then it extended its sales to Medimix for one material.

The project was assessed during our visit to the ESAF office in Mannuthy during March 2013. The conclusion was that it had been a failure. The first mistake had been the Oushadhi tender. The ESAF had deposited Rs 2 lakhs to secure the order and offered a very low sales price, but when Oushadhi requested large quantities of kurunthotti at very short notice, ESAF was not able to meet the request. Oushadhi then bought the material from other suppliers with the deposit money. Problems abounded: local middlemen offered higher prices to farmers who then preferred to sell them the materials they had cultivated; some farmers sold materials directly to Vaidyaratnam for higher prices and the NGO was not able to meet Oushadhi's request; there were also incidents of fraudulent practices—farmers mixing roots with other plants such as bamboo, adding stones to the bundles, or pouring too much water on the plants—and the materials were rejected by manufacturers. The experience also showed that cultivating medicinal plants sometimes had ecological consequences, as for instance when the taste of cultivated padwal (*Trichosanthes cucumerina*), consumed as a vegetable, was made bitter through cross-pollination with its

wild variant growing in nearby fields. Cultivation of this plant also had to be stopped for reasons of pest development. Currently there is little documentation on the cultivation methods for many medicinal plants.

In 2011, the ESAF signed another project agreement with the Agricultural Technology Management Agency (ATMA). The project was funded by the SMPB and aimed to produce seedlings for the expanding medicinal plant cultivation. Six species were then cultivated in a nursery centre with 10 satellite nurseries, maintained mostly by rural women. The project introduced members of self-help groups to medicinal plant cultivation and gave them tips to sell their seedlings to manufactures or farmers. Based on this network of nurseries, the ESAF attempted to sell seedlings and grown materials to the Care Keralam cluster, but its prices could not compete with those Care Keralam was getting from wholesalers. The government encourages cultivation, especially in medicinal plant nurseries. The buyback agreement part is not, however, supervised by the SMPB, which only acts as a go-between. SMPB funding only covers cultivation, especially now that it is provided by the Horticulture Department, so farmers and NGOs involved in rural development have to take up loans for the marketing side of their activity.

These are all examples showing the foremost problems in Ayurveda medicinal plant cultivation. First, the projects do not get official follow-up and in the first years, the NGOs involved suffered losses due to their lack of knowledge in marketing constraints. Second, manufacturers do not comply with buyback agreements. They need huge quantities of material at short notice with only small regard for growing seasons, require farmers to adjust to their needs, and refuse to store materials in order to avoid risking their alteration before use. This is worsening with firms modernising their production schemes and increasingly adopting just-in-time delivery strategies to reduce their operational costs. Third, market prices for the different materials change frequently as a factor of season, availability, and quality. It is thus difficult to settle on a fixed-price agreement. In season, if the price of a given plant falls, farmers with no storage capacities will make less profit. This price uncertainty is then a discouraging factor for farmers. Fourth, cultivation is costly. Land in Kerala is expensive, workers' salaries are high, and farmers have to add inputs and irrigate their fields. All of these expenditures have made cultivation less competitive than collection of wild plants. In addition, Ayurveda firms also pay for the materials after a time-lapse that farmers cannot assume. Fifth, middlemen are crucial stakeholders who are never sufficiently included in these development actions. Buyback agreements jeopardise their position in the market, thus they have no interest in letting cultivation develop through these channels. They either have to kill the business or use it for their own supply. The unrecognised status

of private suppliers within the Ayurveda supply chain is also an obstacle for Kerala state cultivation schemes in integrating them as partners.

The National Bank for Agriculture and Rural Development (NABARD) is currently financing the cultivation of medicinal plants with buyback agreements by pharmaceutical industries. Despite all the problems involved in adjusting cultivation and production modernisation, some companies are trying to develop farmers' supply of medicinal plants. Kottakal AVS is currently seeking farmers prepared to cultivate five crops in a buyback scheme: palmuthuku, adapathiyan (*Holostemma ada-kodien*), padwal, sathavari, and koduveli. These same plants have already been tried for cultivation, but although they are important for the industry, they were not necessarily identified by the SMPB as prioritised species. A major problem is the absence of SMPB project follow-up, as the companies willing to develop cultivation in association with farmers are not connected with those who have already invested in the activity. A network of project stakeholders remains to be developed.

These examples tend to show that so far, cultivation of medicinal plants has been developed only as a minor source for raw materials, compared to wild plant collection. It seems not to have found yet its proper place in the supply chain of most ayurvedic companies. In light of this, it is interesting, however, to look at a few success stories and the reasons and the ways of their development.³³

Success Stories: A Few Examples of Integration of Cultivation Activity into the Supply Chain

We will present three different cases of cultivation success stories that will allow further examination of the integration of farming into the supply chain.³⁴ The first one concerns a farmer who managed, over all other suppliers, to become the main provider to manufacturers for one particular plant. The second illustrates how ayurvedic firms can develop their own cultivation schemes and integrate them into their production unit. The third shows how cultivation

33 A good example of success in cultivation supported by the SMPB and Oushadhi is the farming of amla. The market of the fruit, dry or fresh, is expanding and the bay is used as a pickle or pressed into different types of juice. This is not directly related to Ayurveda industrial supply so we will not develop it further here.

34 Here, integration means that plant cultivation is fully included in the supply channel of ayurvedic companies, as a source of medicinal materials, and that this type of material is managed, with its specificities, through operative cooperation between providers and industries.

activity can develop by being integrated into suppliers' networks as a complementary source for raw materials.

Close to Thrissur, there is a farmer who for almost 30 years has been cultivating five acres of land with a single medicinal plant, the indigo plant neelamari (*Indigofera tinctoria*). In 2001, he won the Nagarjuna Oushadha Mithra Award for the best medicinal plant cultivator in Kerala, and in 2008 he opened his own website for wholesale deals.³⁵ According to his testimony, medicinal plant cultivation is generally not profitable in Kerala, but he has benefited from his long experience and long-standing connections with ayurvedic manufacturers in the Thrissur area.³⁶ These long-term relationships have allowed companies to trust in his capacity to provide good-quality neelamari in the required quantities and at the needed time. His position is not easy because he only supplies one fresh item when manufacturers always need many ingredients at the same time. Only trust has allowed him to stay in the market. He is still trying to win manufacturers' tenders for neelamari, and he also completes his quantities by buying wild neelamari. Irrigation allows him to provide the herb all year round and his condition for supplying manufacturers off-season is that they also buy material from him in the rainy season when wild neelamari is largely available. His geographic location in proximity to many manufacturers allows him to respond to demand at short notice, while his monopoly in neelamari cultivation helps him to keep his strong position amongst Oushadhi, Vaidyaratnam, and Sitaram suppliers, something aided by his sense of business and his personal involvement in selling his material. Nonetheless, the losses he suffers when manufacturers' demand is in conflict with the natural cycle of the plant leads him to advise that cultivation should be developed within manufacturers' premises.

Few manufacturers have explored this path. ATM Vaidyaraj Oushadhasala already owns between four and five acres of land where it cultivates common crops, as well as medicinal plants like kurunthotti and mara manjal.³⁷ However, the company most advanced in medicinal plant cultivation on its own grounds, and in raw material self-supply, is Kottakkal AVS. Through its Centre for Medicinal Plants Research, funded partly by the SMPB, the NABARD, and the Department of Biotechnology, it has developed cultivation methods and research on plant propagation. The centre provides seedlings to farmers, as well as technical assistance, and endeavours to increase the involvement of self-help groups in the activity with buyback agreements. What is most

35 <http://www.neelamari.com/> [accessed 2 December 2013].

36 Interview on 4 April 2013.

37 Interview on 1 April 2013.

interesting here is that Kottakkal AVS allocated 200 acres of land on its own estates for growing medicinal plants in the Malappuram and Palakkad districts. Forty-seven plants are currently being cultivated, mostly in small quantities, with the exception of a few plants in which there has been significant investment. The plants were selected in terms of their importance to the supply chain and due to their scarcity. Four of these plants are nowadays substantially meeting AVS needs: the full quantity (50,000 kg per year) of adalodakam (*Adhatoda beddomei*) is used and meets the requirement for one drug; the estates yield 50,000 kg of karinkurinji (*Strobilanthes ciliatus*) and 60,000 kg of brahmi per year, making the different AVS manufacturing units self-sufficient for these materials; and nagadanthi (*Baliospermum montanum*) crops (5,000 kg per year) also fully match the needs of the AVS units in Kerala.

The AVS manufacturing unit in Kanjikode is surrounded by a 20-acre estate, which provides raw materials for it and for the older unit in Kottakkal. Brahmi grows there in wet soil under coconut trees. The two-acre field produced 12 tonnes of brahmi in March 2013. This was sold at market price to the manufacturing unit.³⁸ Five acres are planted with adalodakam and five others with nagadanthi. Many other species are grown and used in the manufacturing unit. The estate has an annual income of Rs 13 lakhs and expenditure of Rs 7 lakhs. Part of the water used for irrigation is processed water from the manufacturing unit. Despite the investment cost, having an estate within the manufacturing premises is profitable and allows for self-sufficiency in terms of the supply of a few important materials. In this example, cultivation is integrated downstream into the supply chain in the sense that the manufacturer is directly involved in managing this form of supply and can adopt a sustainable strategy for it by taking into account the natural cycles of the plants, the renewal capacity of the field and potential progress in cultivation methods. For the manufacturing unit, collecting from plantations that are this close resembles collecting from a home garden, reflecting the relationship to nature of traditional Ayurveda. This example shows a vertical integration and brings a solution at factory level to the problems of the fluctuation of demand, of production flexibility, and storage constraints.

Kozhinjampara is our third example. This is where a few middlemen developed cultivation of medicinal plants with farmers by providing them with seedlings and buying their production. These ayurvedic manufacturer-suppliers work mostly with collectors in the wild during the rainy season, but when summer comes cultivated plants are available in the irrigated fields and can be provided to the manufacturers that need them. We met one farmer through one of the middlemen when he was planting thulasi under a flooded coconut-tree

38 Visit to the Kanjikode manufacturing unit and the estate on 6 April 2013.

plantation.³⁹ He was also producing adalodakam and vellamari on three acres of land. Vellamari is used as a substitute for neelamari.⁴⁰ Its colour is different and it grows abundantly in Tamil Nadu, but vellamari, which is green, is often considered as less powerful than neelamari, which is purple. Companies are increasingly requesting vellamari because it is cheaper. The farmer was formerly a local middleman for the supply of ayurvedic materials. Now he is combining his supply business with cultivation, using only family manpower on his land. He began with thulasi, then, satisfied, he diversified his production. This farmer's main advantage compared to that of the farmers previously described is his direct connection with a private supply middleman who takes care of properly filling the industrial requirement. The private agent uses his own knowledge of the sector, will deliver full sets of combined raw materials to the factories, and has enough financial backing for bearing payment delays. This partnership reduces the marketing risk for the farmer, although he may eventually fall into a constraining dependence relationship, which may affect his sales prices in future. This farmer is thus integrated upstream of the chain as he works with a middleman, fulfills his offer, and therefore finds his place in the network of supply flows.

These examples show that the success of medicinal plant cultivation depends on whether farmers are integrated into the sector, be it through their own capacity to conquer a share of the supply market, through their privileged interaction with a private supplier, or through inclusion of the cultivation activity in the manufacturer's range of activities, including direct management of the cultivated resource. Government and NGO-promoted projects failed to integrate cultivation of medicinal plants into system dynamics, mostly because of the lack of a channel perspective and of flexibility in industrial supply. But the small and medium-sized industries unable to develop their own plantations, or unable to assume the cost of a change in their supply strategies, still have a strong demand for state oversight of cultivation projects, for state solutions to seasonal supply problems, and for improvement of collective storage capacities.

Conclusion

The ayurvedic raw material supply sector is characterised by the opacity of its operations and by serious disconnections between the different elements of the supply chain. On the one hand, Ayurveda manufacturers are willing to

39 Interview on 9 April 2013.

40 K. Narayana Aiyer and M. Kolammal identify as well two varieties of *Indigofera tinctoria* based on their colour. Aiyer and Kolammal 1960.

pursue their development but suffer from huge increases in their raw material prices; they have to adjust their drug production to this constraint, as well as to declining plant availability on the market. On the other hand, medicinal plant collection is declining in intensity: collectors of wild material are fewer, and the protection of forest biodiversity, new sources of employment, and the destruction of accessible resources is discouraging collection activity. Progressively, raw materials are sourced from more distant places, where manpower is cheaper and plants are more available, but also come from more distant suppliers. This diminishes the industry's dependency on local middlemen but widens the gap between raw material collectors and manufacturers, and therefore reduces even more the companies' visibility on their supply chain.

Ayurvedic manufacturers rely on a complex network of suppliers, whose activity is usually informal, hence under no state control or company supervision. Lack of traceability of raw materials, increase in their prices, and waning availability have all contributed to a decline in quality, thus challenging the credibility of ayurvedic manufacturers. Forced to adjust to biomedical safety standards for their drugs, ayurvedic manufacturers need to emphasise quality control in their entire production process, from the raw materials to the finished drugs. Integrating the supply of raw materials into their development strategy is therefore crucial. The higher standards promoted by the department of AYUSH regarding the safety of materials has encouraged companies to develop innovating clusters, which are specialised in modernising their production process and certification capacity; in other words, in preparing the future of Ayurveda in a globalised world. The prospects of this natural medicine depend on the supply of raw materials, and cultivation desperately needs to be developed. Such development is, however, meeting enormous obstacles, mostly because the structure and specificities of ayurvedic plant supply have not been properly apprehended in terms of their complexity and their informality by the Government of Kerala, which has not yet found an appropriate form of regulation.

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