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CORRESPONDENCE

How cheap can a medicinal plant species be?

It is indeed fascinating that two thirds of the world's population depend upon plant resources for their primary health care needs[1], and a fairly large number of modern drugs are derived from, modeled after, or discovered from plant natural products, following leads provided by indigenous knowledge systems[2]. This has added to the growing popularity of herbal products, as part of new health programme in developed countries, and together with the traditional demand of the third world nations, has led to a steady increase in market for medicinal plants, the world over[3].

The article 'Ethnotherapeutics and modern drug development: The potential of ayurveda' (Sukh Dev, *Curr. Sci.*, 1997, **73**, 909–928) makes valuable reading on this traditional plant-based knowledge in curative therapies. However, the rapidly changing scenario on the current status of medicinal plants raises some vital questions like, where do these species come from? What should a medicinal species cost?

It has been reported that nearly 95% of the plants used traditionally as ingredients in crude drugs are collected from forest and other natural sources[4]. These species, collected as minor forest produce, however, show wide disparity in their market values, due to lack of information on their life cycles, maturity and regeneration times[5], all of which change the quality and quantity of the active chemical ingredients present. Besides, very little is known about the biotransformation that take place once the crop is harvested (post-harvest handling). Broad estimates on the market value of tropical forests species range from about $ 1 to about $ 420/ha/year (ref. 6). In India, the total value of non-timber goods from a tropical deciduous forest is estimated at $ 4034 to $ 6662 per hectare (ref. 7).

At the individual species level, an average price paid to herb gatherers and small farmers for medicinal plants in the Peruvian Amazon forest is estimated[8] at US$ 2.80 per kg, which is quite comparable to many of the Himalayan medicinal species (Table 1). Amazingly, several of these species sold in Indian market have been shown either to be 'unrealistically cheap' or with too much variation in the rates.

Table 1. Variation in the market price of medicinal plants

Species	Rates (Rs/kg dry wt)			
	Our survey*	Ref. 12	Ref. 13	Ref. 14
Aconitum ferox	600	–	60–80	–
A. heterophyllum	1000	50	250–300	160–200
Acorus calamus	18	18	18–20	
Angelica glauca	20	–	–	50–60
Berberis sp.	20	–	1–2	–
Bergenia sp.	10	–	12–14	6–9
Centella asiatica	–	15	20–32	–
Dactylorhiza hatagirea	600–800	–	–	500–1000
Hedychium spicatum	30–50	200	–	–
Jurinea macrocephala	60–100	–	–	20–25
Nardostachys grandiflora	–	100	85–95	10–12
Picrorhiza kurrooa	80–140	75	60–80	10–20
Rheum australe	–	27	–	15–20
Swertia chirayita	45	115	80–100	–
Taxus baccata	30	–	–	3–7
Valeriana jatamansi	70	45	85–90	–
Viola spp.	400	–	350–400	–

*Information based on our surveys in Himachal Pradesh.

Acorus calamus, *Angelica glauca*, *Bergenia ligulata*, *Nardostachys grandiflora*, *Picrorhiza kurrooa*, *Rheum australe*, etc. have been quoted to sell at a meagre rate of around Rs 20, or even less, per kg dry weight biomass. This is far cheaper than most of the seasonal vegetables sold in hills, calculated on the dry weight basis, for which well-established agro-packages are available.

A lot of these high-altitude mountain species are habitat-specific and may flourish only within narrow range of environmental suits. *A. calamus*, *Hedychium* spp. and *Dactylorhiza hatagirea* are restricted to moist or wet areas, *Bergenia* prefers sloppy, rocky sites, species of *Valeriana* and *Viola* are essentially shade-loving, while species of *Aconitum*, *Jurinea macrocephala*, *Picrorhiza kurrooa* and *Rheum australe* are herbs of temperate and alpine zones, which grow in sparser plant densities per unit area in their natural habitats[8], and may require more than one growing season to develop appropriate proportions of the desired secondary metabolites.

The stated lower cost of many species therefore, is not only grossly misleading the commercial estimates but also greatly under-value our valuable natural resources.

Another major issue requiring our immediate attention refers to the adulteration of industrial raw material with related plant species[9]. For instance, most of the species of *Swertia* are sold under

Dactylorhiza hatagirea (D. Don) Soo. A medicinal plant of temperate-alpine regions of western Himalaya distributed between 2800 and 4000 m above mean sea level.

the trade name *chirayita*, the most sought-after species of the genus. The species has been highly valued in the Tibetan system of medicine, and like other medicinal plants, was collected across the Himalaya by Lamas in earlier days. It is now said to be purchased in the open market at Amritsar.

Plant samples in the market are stored under undesirable conditions, over the years, and often contain multiple species mixture[10], thus adversely affecting their bioefficacies. It is generally felt by Lamas, practising medicine in the Tibetan School at Dharamshala in Himachal Pradesh, that the efficacy of many of their drugs, prepared on the same traditional formulation, is fading now, apparently because of the adulteration in the dried raw material purchased in the market. This may not be an exclusive case but holds true for several other formulations prepared in other indigenous system of medicine as well[11].

Adulteration seems, therefore, challenging not only the curative capacity, but the very faith in crude drug approach. The efficacy of schools of medicine, once built upon the tests and trials spanning hundreds of years, are being challenged, for reasons unrelated.

At a stage of uncertain raw material supply, and undefined limits of sustainability, while species continue to be extracted despite claims of cultivation, our joy of phytochemical discoveries is deeply shadowed by the fear of extinctions.

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AKSHEY K. GUPTA
S. K. VATS
BRIJ LAL

Institute of Himalayan Bioresource Technology,
P.O. Box 6,
Palampur 176 061, India

How intangible is the outside world?

The recent article of Mukunda[1] based on his lecture 'Existence and reality in mathematics and natural science' gives an interesting account of the debate on the subject, and leaves no doubt that he prefers the company of believers though it ends on a somewhat ambiguous note. He states: 'Strange as it may initially seem and hard as it may be to accept, we seem driven to this conclusion – because mathematics is essential to describe nature, we have to adopt a more open view of existence and reality going beyond space, time and the tangible. The problem of existence and reality is much subtler than our naive expectations may have been. Mathematics then, like nature, has also an intangible level of existence.' The argument is far from persuasive and is in fact erroneous as I discuss in the following (see note 1).

The root of the error lies in using 'knowledge' and 'capacity for knowledge' as biologically equivalent when he states[1], 'And what is the result of slow learning through evolution for a species as a whole, lasting hundreds of thousands of years, seems to the individual member of the species as a priori, as *knowledge*, or better as *capacity for knowledge*, he is *born with* in advance of experience' (emphasis added). Delbruck's statement quoted in its support is valid strictly for 'the capacity for knowledge' which should be interpreted as the appropriate biological organ, the brain, and not the knowledge that is acquired by learning processes facilitated by this organ. Instincts, viewed as innate rational behaviours which are demonstrably genetically inherited, do not form a body of conscious knowledge of the category acquired by higher-order learning processes and embodied in symbolic knowledge such as mathematics implied in the article. No serious biologist today would dispute the impossibility of inheriting symbolic knowledge by encoding it in the DNA to be passed on to