# WILD EDIBLE PLANTS OF THE SIKKIM HIMALAYA: NUTRITIVE VALUES OF SELECTED SPECIES[1]

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**Sundriyal, Manju and R. C. Sundriyal** (*G. B. Pant Institute of Himalayan Environment & Development, North East Unit, Vivek Vihar, Itanagar-791 113, Arunachal Pradesh, India; email: rcsundriyal@yahoo.com*). WILD EDIBLE PLANTS OF THE SIKKIM HIMALAYA: NUTRITIVE VALUES OF SELECTED SPECIES. *Economic Botany 55(3):377–390, 2001. The wild edible plants form an important constituent of traditional diets in the Himalaya. In the Sikkim Himalaya a total of 190 species have been screened as edible species out of which nearly 47 species come to the market. The present paper deals with nutritive values of 27 most commonly consumed wild edible plants in the Sikkim Himalaya. Of 27 plant species that were analyzed for their nutritive values, 22 were edible for their fruits and five for leaves/shoots. Among different plant parts, generally higher nutrient concentration was recorded for leaves, followed by new shoots and fruits. For different species the crude fiber content ranged between 2.15–39.90%, and the total soluble salts between 4.66–21.0%, and the vitamin C content from 6–286 mg/100 g. The fat content was determined high in the fruits of* Castanopsis *species,* Machilus edulis, *and* Cinnamomum *species, while the protein content was highest in* Hippophae rhamnoides, Cucumis melo, *and* Eleagnus latifolia. *The total carbohydrate content ranged from 32–88% in the fruits of various wild edibles, the reducing sugar from 1.25–12.42%, total sugar from 2.10–25.09%, the lignin content varied from 9.05–39.51%, the hemicellulose between 25.63–55.71% and cellulose content varied from 9.57–33.19% in different species. Among the various macronutrients estimated in the plant samples of different wild edible species, nitrogen was present in highest quantity, followed by potassium, calcium, magnesium, phosphorus, and sodium. Micronutrients, such as iron, zinc, magnesium, and copper contents were analyzed in different plant parts of various wild edible species. The iron content was higher in leaves and new shoots. The study shows that wild edible plants are good source of nutrient for rural population, and also well comparable with various commercial fruits. It is suggested that a few wild edible species need to be grown for commercial cultivation and adopted in the traditional agroforestry systems, which will lead to reduced pressure on them in natural forest stands as well as producing economic benefits for poor farmers.*

**Key Words:** wild edible plants; nutritive values; proximate analysis; macro- and micronutrients; Sikkim Himalaya.

India faced a series of famine and major food shortage before the 1940s. The national food grain production was merely $50.82 \times 10^7$ tons during 1950–1951, which has risen to $198.17 \times 10^7$ tons in 1996–1997, thus increasing by three times in a span of four decades. At present the country is carrying a buffer stock of $36 \times 10^7$ tons of food grain (Anonymous 1997). In addition, there has been an increasing awareness about the nutritional status of the community particularly regarding young children and nursing mothers during recent years. Nutrients derived from plants are important to human health and complement other food sources (Abdoellah and Marten 1986; Sims and Peterkin 1987). The government of India is carrying out a large number of programs for community development on a nutritional status to overcome the problem of malnutrition. In 1993 the government adopted a National Nutritional Policy, which can be considered a significant achievement on the nutrition scene of the country. Through this program a National Plan of Action on Nutrition (NPAN) emerged in 1995 for different sectors of government to combat malnutrition. During 1960s and 1970s various supplementary nutrition programs for pre-school children (Aganwadi), against anemia in women and nutritional blindness in children were launched. Malnutrition in children has

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TABLE 1. PLANT DISTRIBUTION RANGE, PLANT PARTS USED AND MARKETING OF THE WILD EDIBLE SPECIES IN THE SIKKIM HIMALAYA.

| Distribution range | Fruit/seed | Flower/ flower bud | Leaves/shoot | Root/rhizome | Others |
|---|---|---|---|---|---|
| Distribution (190 species): | | | | | |
| Low hill | 37 | 4 | 5 | 1 | 2 |
| Mid hill | 28 | 3 | 3 | 1 | — |
| Low mid hill | 35 | 5 | 11 | 1 | 2 |
| Mid upper hill | 12 | 3 | 7 | — | 2 |
| Upper hill | 12 | 3 | 9 | 4 | 2 |
| Low-upper hill | 1 | 1 | 4 | 2 | — |
| Marketing (43 species): | | | | | |
| At Gangtok | 16 | 2 | 16 | 2 | — |
| At Namchi | 12 | 1 | 10 | 2 | — |
| At Singtam | 7 | 2 | 8 | — | — |

Low hill = 300–900 m; low-mid hill = 300–1500 m; Mid hill = >900–2000 m; Mid upper hill = 1500–2500 m; Upper hill ≈ >2000 m; Low to upper hills = 300–2500 m.

come down by 15% in 1975–1979 to 87% in 1988–1990 (Anonymous 1997), which is remarkable by any standards. Despite food self-sufficiency at the national level, the country has not attained food security at a household level particularly in rural areas. A considerable proportion of rural population is still undernourished. People living in most of the rural and remote areas do not produce enough food grains to meet yearly food requirement and at times food supplies are not easily available. Therefore a large share of rural population is meeting their nutritional requirement through nonconventional means, by consuming various wild plants and animal resources (Singh and Arora 1978). Wild edible plants play a major role in meeting the nutritional requirement of the tribal population in remote parts of the country. A wide variety of plant leaves, fruits, roots, and other parts are collected from the wild and consumed by rural masses. In Sikkim Himalaya the natives consume nearly 190 such wild edible species (Sundriyal 1999). Selection of a particular species for inclusion in the diet is location specific and influenced by the availability of plant material.

During recent years there has been a growing interest to evaluate various wild edible plants for their nutritional value (Arora and Pandey 1996; Bokhary et al. 1987; Bokhary and Parvez 1993, 1995; Dhyani and Khali 1993; Franke 1982; Ifon and Bassir 1980; Maikhuri 1991; Maikhuri et al. 1994; Mazza 1995; Muthukrishnan and Abdul Khader 1990; Sadhu 1990; Singh et al. 1967; Wesche-Ebeling et al. 1995). Nevertheless, a careful examination of the literature reveals that there are still a large number of wild edible species which are inexpensive and commonly used by locals and whose nutritional potential have not yet been adequately studied. The present study examines the nutritional status of 27 wild edible plants that are most commonly preferred and consumed in the Sikkim Himalaya and helps identify some potential species that can be included in traditional agriculture system based on their nutritional values.

## MATERIALS AND METHODS

Sikkim state falls in the eastern Himalayan zone of India (27°4′46″–28°7′48″ N and 88°58″–88°55′25″ E), covers 7096 km$^2$ area, and is bounded by Nepal on the west, by Tibet on the north, Bhutan and Tibet on the east, and Darjeeling district of West Bengal on the south. The state forms the entire upper catchment of the river Tista drainage system. The state is rich in cultural and biological diversity. Lepchas, Bhutias, Nepalese, and Limbus are main ethnic groups of Sikkim state and they differ from each other in their food habits, dresses, and living styles. Besides growing food grains, all indigenous people collect large quantities of wild edible plants from natural habitats. A project was undertaken since 1994 until 1999 to identify wild edible plants of the Sikkim Himalaya, their distribution, marketing, nutritive values, and multiplication of potential species for their adoption in the traditional agroforestry system of the state.

Detailed surveys were made of the villages, local markets, natural habitats, and formal and informal interviews conducted with the local people in different parts of the Sikkim Himalaya to gather information on the wild edible plants (Sundriyal 1999). Various wild edible species were collected and records were made on weekly quantities available and retailers involved in the markets. For analyzing nutritive values, samples of edible parts of various wild edible plants, which were healthy and free from any inflection, were collected from different forest stands as well as from the local markets when available. All samples were washed thoroughly to remove any attached soil and other impurities, and blotted dry. Thereafter all the samples were oven-dried at 60°C until constant weight. All the dried materials were ground separately to fine powder using a mixer/blender, sieved, and stored in an airtight container for nutrient analysis. For analyzing nutrients where fresh samples are required (e.g., acidity, vitamin C, TSS, etc), nutrient examinations were done within two days of the sample collection.

Various recommended methods for analyses of nutrients in plant materials were used as given by Allen (1989), Anderson and Ingram (1993), AOAC (1984), and Rangana (1979). The quantitative analysis of the fruit samples was broadly done for proximate analysis as well as ultimate analysis. The proximate analysis provides useful information, particularly from a nutritional and biochemical point of view, and constitutes primary organic groups of the plant samples, e.g., fats, carbohydrates, proteins, sugars, fibers, ash, acidity, etc. It accounts for most of the organic dry matter of the foodstuff. The ultimate analysis refers to the determination of a particular element (e.g., N, P, K, Ca, Mg, Na, etc.) or a compound present in the material (Allen 1989; Rangana 1979). Details of the procedures are provided by Sundriyal (1999), however, a brief presentation of various methods used in the analysis is given below.

*Proximate Nutrient Analysis.* The ash content was determined by combusting the plant material in silica crucibles in a muffle furnace at 550°C for three hours. Crude fiber was determined by acid and alkaline digestion methods using Fibretec apparatus. Total Soluble Solids (TSS) content of fruits was measured through Hand Refrectrometer, while the acidity of fruit juices was determined by titration of a known weight of sample with NaOH using phenolphthalein indicator. The value was calculated with reference to percent anhydrous citric acid. Ascorbic acid was determined through reduction method using a dye (2,6-dichlorophenol indophenol), which turns blue in alkaline solution and red in acid solution, and is reduced to a colorless form by ascorbic acid. Chlorophyll and anthocynin were estimated through calorimetric method.

Crude fat in plant samples was determined by extracting a known weight of powdered plant material with petroleum ether using Soxhlet apparatus. The sugar content in the plant samples was estimated by determining the volume of unknown sugar solution required to completely reduce a measured volume of Fehling's solution to red, insoluble cuprous oxide. Acid detergent lignin (ADL) was determined using Fibretec apparatus by de-fating a known weight of plant sample with acetone (cold extraction) and with acid detergent solution (hot extraction). Cellulose was determined by difference of acid detergent fiber minus acid detergent lignin. Hemicellulose was determined as the difference of neutral detergent fiber and acid detergent fiber.

*Determination of Minerals (Macronutrients).* Nitrogen was determined through the microkjeldahl method by digesting a known weight of plant sample and treating it with alkali. The liberated ammonia is collected in boric acid and titrated with HCl. Phosphorus was estimated colorimetrically by treating the digested sample with ammonium molybdate and freshly prepared ascorbic acid. Spectrophotometer apparatus was used to measure the absorbance at 880 nm. Potassium and sodium was determined through Flamephotometer. Calcium and magnesium in plant samples were determined by EDTA (the disodium salt of ethylene-diamine-tetra-acetic acid) titration method (Allen 1989; Anderson and Ingram 1984; Rangana 1979).

*Determination of Micronutrients.* The micronutrients (Fe, Zn, Cu, Pb, Mn) were determined through the atomic absorption spectrophotometer method. The plant samples, which were digested in a tri-acid solution of $HClO_4$, $HNO_3$, and $H_2SO_4$, were passed through atomic absorption spectrophotometer using different lamps, and calibrated for different micronutrients (Allen 1989).

*Comparison with Nutritive Values of Commercial Fruits and Other Wild Edible Species.*

TABLE 2. GENERAL CHEMICAL ANALYSIS (PROXIMATE ANALYSIS) OF SOME IMPORTANT WILD EDIBLE FRUITS OF THE SIKKIM HIMALAYA.

| Plant species | Moisture (%) | Ash (%) | Fibre (%) | TSS (%) | Acidity (%) | Vitamin C (%0 | Total chlorophyll (mg $g^{-1}$) |
|---|---|---|---|---|---|---|---|
| *Baccaurea sapida* Muell. Arg. | 35.59 | 3.85 | 20.40 ± 0.38 | 13.96 ± 2.02 | 2.67 ± 0.06 | 0.273 ± 0.0544 | 0.519 ± 0.120 |
| *Diploknema butyracea* Roxb. | 68.58 | 3.20 | 5.10 ± 0.17 | 21.00 ± 1.25 | 0.29 ± 0.03 | 0.026 ± 0.0024 | 0.091 ± 0.001 |
| *Eleagnus latifolia* L. | 87.31 | 3.16 | 9.30 ± 3.14 | 8.63 ± 0.24 | 5.16 ± 0.15 | 0.072 ± 0.0016 | 0.072 ± 0.003 |
| *Eriolobus indica* Schn. | 80.39 | 3.03 | 21.20 ± 0.31 | 15.53 ± 0.36 | 1.94 ± 0.02 | 0.085 ± 0.0062 | 0.221 ± 0.009 |
| *Machilus edulis* Roxb. | 71.97 | 2.65 | 10.30 ± 0.49 | 4.66 ± 0.27 | 5.54 ± 0.52 | 0.006 ± 0.0016 | 0.214 ± 0.048 |
| *Spondias axillaris* Roxb. | 65.68 | 2.70 | 39.90 ± 0.15 | 9.90 ± 1.06 | 0.96 ± 0.02 | 0.036 ± 0.014 | 0.861 ± 0.134 |
| *Rubus ellipticus* Smith | 80.60 | 4.10 | 7.90 ± 0.24 | 6.60 ± 0.78 | 4.20 ± 0.78 | 0.011 ± 0.006 | — |
| *Elaeocarpus sikkimensis* Roxb. | 68.92 | 4.00 | 12.80 ± 9.38 | 15.04 ± 3.11 | 3.75 ± 0.55 | 0.006 ± 0.002 | — |
| *Passiflora indica* Linn. | 80.14 | 3.20 | 15.41 ± 2.15 | 7.50 ± 2.13 | 3.30 ± 0.08 | 0.028 ± 0.0013 | 0.205 ± 0.051 |
| *Cucumis melo* Linn. | 89.00 | 3.10 | 9.35 ± 1.06 | 8.20 ± 0.09 | 1.11 ± 0.01 | 0.010 ± 0.0021 | — |
| *Hippophae rhamnoides* D.Don | 80.50 | 2.50 | 5.06 ± 2.37 | 7.60 ± 0.02 | 5.32 ± 0.13 | 0.263 ± 0.0036 | 0.836 ± 0.130 |
| *Prunus cerasoides* D.Don | 83.00 | 3.11 | 7.32 ± 1.13 | 6.50 ± 0.23 | 1.41 ± 0.02 | 0.319 ± 0.001 | 0.133 ± 0.051 |
| *Morus alba* Wall. | 84.10 | 2.10 | 2.15 ± 0.56 | 6.50 ± 0.08 | 1.49 ± 0.09 | 0.286 ± 0.0054 | — |
| *Terminalia chebula* Retz. | 53.00 | 3.91 | 7.10 ± 1.56 | 5.30 ± 0.56 | 3.23 ± 0.60 | — | — |
| *Mangifera sylvatica* Roxb. | 78.00 | 3.25 | 8.53 ± 0.56 | 10.56 ± 2.13 | 4.53 ± 0.44 | 0.012 ± 0.0012 | 0.653 ± 0.150 |
| *Cinnamomum* sp. | 7.23 | 4.15 | 5.41 ± 2.16 | — | — | — | — |
| *Ardisia macrocarpa* Wall. | 59.95 | 3.82 | 10.23 ± 2.33 | — | 5.20 ± 0.002 | — | 0.005 ± 0.001 |
| *Zanthozylum rhetuza* Wall. | 25.55 | 3.44 | 11.51 ± 3.13 | 7.00 ± 1.07 | 2.60 ± 0.37 | — | 0.123 ± 0.012 |
| *Castanopsis* sp. | 15.95 | 2.30 | 2.10 ± 0.001 | — | — | — | — |

— Not estimated.

Nutritive values of the most prominent and commercial fruits and wild edible species were collected from different sources (compiled by Sundriyal 1999) and data are provided in this paper for a comparison with the nutritive values of present study.

## RESULTS

High diversity of wild edible plants has been recorded from the Sikkim Himalaya, which consisted a total of 190 species from 78 families and 143 genera, and all kinds of life forms (Table 1). Low to mid hills (<2000 m elevation) have a higher diversity of wild edible plants than the upper hill zone (>2000 m elevation). Wild edible species were consumed for various plant parts, i.e., fruit/seed (123 species), flower/buds (13 species), leaves/shoot (43 species), root/rhizome (6 species), and pulp or pith (Table 1). They were either eaten raw (mainly fruits), or

TABLE 2. EXTENDED.

| Anthocynin (mg 100 g$^{-1}$) | Fat (%) | Protein (%) | Carbohydrate (%) | Reducing sugar (%) | Total sugar (%) | Lignin (%) | Hemicellulose (%) | Cellulose (%) |
|---|---|---|---|---|---|---|---|---|
| 4.160 ± 0.25 | 0.73 ± 0.64 | 5.58 | 51.90 | 9.08 ± 0.108 | 10.87 ± 1.16 | 17.10 ± 0.20 | 31.84 ± 0.99 | 13.78 ± 1.93 |
| 0.615 ± 0.001 | 1.57 ± 0.50 | 3.81 | 81.63 | 6.26 ± 0.013 | 8.21 ± 0.22 | 39.51 ± 1.42 | 42.26 ± 0.73 | 13.72 ± 1.05 |
| 1.58 ± 0.26 | 0.52 ± 0.035 | 7.80 | 74.06 | 1.71 ± 0.042 | 2.10 ± 0.03 | 22.65 ± 0.84 | 36.55 ± 1.01 | 12.87 ± 1.39 |
| 0.435 ± 0.006 | 0.35 ± 0.023 | 1.75 | 71.73 | 12.42 ± 0.38 | 12.89 ± 0.95 | 22.75 ± 0.61 | 45.68 ± 0.42 | 31.65 ± 9.35 |
| 0.391 ± 0.013 | 25.50 ± 1.24 | 4.51 | 51.50 | 1.25 ± 0.010 | 2.40 ± 0.02 | 9.05 ± 0.25 | 29.63 ± 1.40 | 9.57 ± 0.35 |
| 0.59 ± 0.01 | 0.05 ± 0.006 | 4.11 | 52.28 | 1.91 ± 0.035 | 2.31 ± 0.07 | 19.44 ± 1.25 | 55.71 ± 3.45 | 25.81 ± 2.19 |
| 3.81 ± 0.008 | 7.10 ± 1.55 | 4.00 | 72.70 | 4.92 ± 0.68 | 8.50 ± 0.66 | 15.10 ± 0.18 | 25.63 ± 1.50 | 17.30 ± 4.39 |
| 2.98 ± 0.067 | 0.21 ± 0.001 | 5.37 | 73.87 | 4.11 ± 1.003 | 6.90 ± 1.30 | 28.11 ± 0.50 | 40.21 ± 1.31 | 33.19 ± 2.12 |
| 1.31 ± 0.013 | 0.10 ± 0.011 | 4.94 | 73.05 | 6.36 ± 1.61 | 12.18 ± 1.18 | 20.13 ± 2.33 | 28.53 ± 6.16 | 10.32 ± 2.50 |
| — | 0.30 ± 0.12 | 8.29 | 77.85 | 2.12 ± 0.085 | 25.09 ± 1.86 | — | — | — |
| — | 9.33 ± 2.34 | 10.32 | 32.53 | 4.30 ± 0.67 | 10.50 ± 1.20 | — | — | — |
| 2.430 ± 0.48 | 0.59 ± 0.015 | 3.50 | 84.07 | 5.51 ± 0.078 | 6.96 ± 0.313 | 18.11 ± 3.15 | 28.51 ± 4.32 | 11.56 ± 0.087 |
| — | 0.21 ± 0.011 | 5.50 | 87.55 | — | — | — | — | — |
| — | 3.90 ± 0.59 | 1.25 | 80.61 | 2.51 ± 0.78 | 2.30 ± 0.55 | — | — | — |
| — | 0.56 ± 0.237 | 2.32 | 80.81 | 7.78 ± 1.56 | 13.15 ± 2.54 | 16.66 ± 4.13 | 32.53 ± 6.23 | 10.32 ± 1.11 |
| — | 21.50 ± 1.90 | 2.94 | 66.00 | — | — | 16.20 ± 2.69 | 30.55 ± 5.11 | 23.56 ± 3.16 |
| 2.156 ± 0.54 | 0.10 ± 0.002 | 2.90 | 77.75 | — | — | — | — | — |
| 0.896 ± 0.32 | 0.53 ± 0.130 | 5.56 | 76.36 | 3.56 ± 0.66 | 3.61 ± 0.80 | 17.13 ± 3.90 | 34.34 ± 7.12 | 16.15 ± 1.11 |
| — | 30.50 ± 1.00 | 4.69 | 60.41 | — | — | 21.20 ± 1.01 | 33.34 ± 1.31 | 28.80 ± 2.31 |

cooked as vegetables, flour, or as beverages. Most of the wild edible species were flowering plants, although a few other important ones belong to lower groups of plants. Fruit was most common edible form at all elevations, though the numbers of species consumed for fruit purpose decreased with the elevation. A total of 48 species were sold in three different local markets, i.e., Namchi, Gangtok, and Singtam. The nutritive values were estimated for the 27 most prominent wild edible species that came to market after collection from natural habitats. The details of the nutritive values are presented in Tables 2 and 3.

*Proximate Nutrient Analysis.* The moisture content was high (>80%) in the fruits of *Cucumis melo, Eleagnus latifolia, Prunus cerasoides, Hippophae rhamnoides, Eriolobus indica,* and *Passiflora indica.* Fruits of other species contained relatively lower moisture content (Table 2). The ash content in different wild edible species varied from 2.10–4.15%. Crude fiber

TABLE 3. MINERAL CONTENT IN DIFFERENT WILD EDIBLE SPECIES OF THE SIKKIM HIMALAYA.

| Species | Plant part used | N (%) | P (%) | Na (%) |
|---|---|---|---|---|
| *Agaricus* sp. (Chiple) | Fr. body | 4.040 ± 0.042 | 0.476 ± 0.017 | 0.053 ± 0.007 |
| *Agaricus* sp. (Patpate) | Fr. body | 4.101 ± 0.085 | 0.765 ± 0.022 | 0.059 ± 0.002 |
| *Ardisia macrocarpa* Wall. | Fruit | 0.567 ± 0.023 | 0.137 ± 0.0018 | 0.037 ± 0.003 |
| *Arisema utile* Hook. f. | N. sh. | 3.670 ± 0.093 | 0.687 ± 0.002 | 0.087 ± 0.001 |
| *Baccaurea sapida* Roxb. | Fruit | 0.780 ± 0.114 | 0.132 ± 0.003 | 0.035 ± 0.0012 |
| *Castanopsis* sp. | Fruit | 0.750 ± 0.001 | 0.086 ± 0.001 | 0.019 ± 0.001 |
| *Cucumis melo* Linn. | Fruit | 1.320 ± 0.076 | 0.153 ± 0.010 | 0.690 ± 0.098 |
| *Diplazium esculentum* (Retz.) Sw. | Fronds | 3.766 ± 0.066 | 0.500 ± 0.010 | 0.079 ± 0.001 |
| *Diploknema butyracea* Roxb. | Fruit | 0.546 ± 0.027 | 0.090 ± 0.002 | 0.065 ± 0.002 |
| *Elaeocarpus sikkimensis* Roxb. | Fruit | 0.860 ± 0.005 | 0.0683 ± 0.012 | 0.042 ± 0.001 |
| *Eleagnus latifolia* L. | Fruit | 1.250 ± 0.074 | 0.096 ± 0.001 | 0.051 ± 0.001 |
| *Eriolobus indica* Schn. | Fruit | 0.280 ± 0.016 | 0.142 ± 0.019 | 0.033 ± 0.002 |
| *Hippophae rhamnoides* D.Don | Fruit | 1.650 ± 0.002 | 0.311 ± 0.013 | — |
| *Machilus edulis* King. | Fruit | 0.726 ± 0.056 | 0.118 ± 0.0001 | 0.024 ± 0.002 |
| *Oroxylum esculentum* Vent. | Fruit | 2.165 ± 0.009 | 0.292 ± 0.012 | 0.095 ± 0.0002 |
| *Passiflora indica* Linn. | Fruit | 1.360 ± 0.076 | 0.090 ± 0.016 | 0.071 ± 0.006 |
| *Pentapanax leschenaultii* Seem. | N. sh. | 3.430 ± 0.136 | 0.477 ± 0.013 | 0.600 ± 0.221 |
| *Polygonum molle* D. Don | N. sh. | 3.157 ± 0.654 | 0.270 ± 0.0003 | 0.094 ± 0.001 |
| *Prunus cerasoides* D. Don | Fruit | 3.790 ± 0.091 | 0.179 ± 0.008 | 0.023 ± 0.001 |
| *Spondias axillaris* Roxb. | Fruit | 0.353 ± 0.030 | 0.156 ± 0.059 | 0.039 ± 0.005 |
| *Terminalia chebula* Retz. | Fruit | 0.200 ± 0.001 | 0.041 ± 0.021 | 0.078 ± 0.001 |
| *Urtica diocea* L. | N. sh./leaves | 2.508 ± 0.048 | 0.274 ± 0.001 | 0.068 ± 0.003 |
| *Zanthoxylum rhetusa* Wall. | Fruit | 0.870 ± 0.026 | 0.139 ± 0.010 | 0.021 ± 0.001 |

Fr.—fruiting body; N. sh.—New shoot; ND—not detected.

content was estimated highest in the fruits of *Spondias axillaris,* followed by *Eriolobus indica, Baccaurea sapida,* and *Passiflora indica.*

The total soluble salts (TSS) determined for the fruits of various wild edible species varied from 4.66% (*Machilus edulis*) to 21.0% (*Diploknema butyracea*). Acidity in the fruits of different species ranged between 0.29–5.54%.

The vitamin C content was high in the fruits of *Morus alba* (286 mg/100 g), *Baccaurea sapida* (273.33 mg/100 g), and *Hippophae rhamnoides* (263 mg/100 g) (Table 2).

The chlorophyll content was also determined in the fruits of various wild edible species. Among fruits of various species, *Spondias axillaris* and *Hippophae rhamnoides* recorded 0.861 mg/g and 0.836 mg/g chlorophyll. Chlorophyll was recorded as 0.653 mg/g in the fruits of *Mangifera sylvetica* and 0.519 mg/g in *Bacaurea sapida* (Table 2). The chlorophyll content was much lower in other species. The anthocyanin content in the pulp of various fruits was determined to be highest in *Baccaurea sapida* and *Rubus ellipticus.* It was low in *Machilus edulis* and *Eriolobus indica.* Other species had intermediate range of anthocyanin (Table 2).

*Fats and Proteins.* Fat content was determined high in the fruits of *Castanopsis* species (30.50%), followed by *Machilus edulis* (25.50%) and *Cinnamomum* species (21.50%). It was moderately high in the fruits of *Hippophae rhamnoides* (9.33%) and *Rubus ellipticus* (7.10%). Low fat content was estimated in the fruits of other wild edible species (Table 2). Protein content was determined highest in the fruits of *Hippophae rhamnoides* (10.32%), *Cucumis melo* (8.29%), and *Eleagnus latifolia* (7.80%). The protein content was low in *Terminalia chebula* and *Eriolobus indica* (Table 2).

*Carbohydrate, Sugars, Lignin, and Cellulose.* The total carbohydrate content varied from 32–88% in the fruits of various wild edible species (Table 2). It was calculated highest in *Morus alba,* followed by *Prunus cerasoides, Diploknema butyracea, Terminalia chebula,* and *Mangifera indica.* Lowest value of carbohydrate content was calculated for *Hippophae rhamnoides.* Other species showed an intermediate range of

TABLE 3. EXTENDED.

| K (%) | Ca (%) | Fe (%) | Zn (μg/g) | Mg (%) | Cu (μg/g) |
|---|---|---|---|---|---|
| 1.920 ± 0.022 | 1.842 ± 0.103 | 0.130 ± 0.032 | 738.42 ± 15.31 | 0.239 ± 0.007 | 71.33 ± 5.17 |
| 2.176 ± 0.115 | 1.530 ± 0.001 | 0.113 ± 0.010 | 665.81 ± 70.71 | 0.344 ± 0.040 | 93.33 ± 2.18 |
| 0.893 ± 0.032 | 0.296 ± 0.069 | 0.021 ± 0.001 | 308.66 ± 79.30 | 0.315 ± 0.046 | 65.00 ± 2.36 |
| 2.400 ± 0.035 | 0.923 ± 0.001 | 0.831 ± 0.035 | ND | 0.621 ± 0.036 | ND |
| 0.730 ± 0.009 | 0.158 ± 0.001 | 0.075 ± 0.001 | 600.00 ± 154.13 | 0.504 ± 0.043 | 76.67 ± 69.46 |
| 0.420 ± 0.110 | 0.634 ± 0.128 | 0.110 ± 0.003 | 1490.00 ± 26.25 | 0.468 ± 0.127 | 70.00 ± 8.16 |
| 0.920 ± 0.024 | 0.354 ± 0.171 | 0.101 ± 0.001 | 360.33 ± 28.52 | 0.560 ± 0.020 | 41.66 ± 1.36 |
| 2.370 ± 0.118 | 1.020 ± 0.130 | 0.560 ± 0.001 | 576.18 ± 131.00 | 0.505 ± 0.035 | 39.33 ± 4.62 |
| 0.816 ± 0.017 | 0.817 ± 0.283 | 0.178 ± 0.001 | 860.00 ± 152.97 | 0.611 ± 0.035 | 35.66 ± 2.84 |
| 1.010 ± 0.010 | 0.631 ± 0.112 | 0.151 ± 0.021 | 638.89 ± 105.33 | 0.353 ± 0.074 | 80.00 ± 6.24 |
| 0.910 ± 0.002 | 1.470 ± 0.758 | 0.180 ± 0.031 | 1186.66 ± 162.73 | 0.544 ± 0.026 | 46.66 ± 5.44 |
| 0.431 ± 0.012 | 0.124 ± 0.001 | 0.110 ± 0.015 | 816.67 ± 160.65 | 0.446 ± 0.074 | 33.33 ± 5.44 |
| — | 0.166 ± 0.033 | 0.056 ± 0.022 | 880.00 ± 160.53 | 0.308 ± 0.068 | 23.33 ± 5.44 |
| 0.610 ± 0.012 | 0.150 ± 0.0002 | 0.253 ± 0.001 | 392.50 ± 23.28 | 0.339 ± 0.067 | 100.66 ± 7.91 |
| 1.445 ± 0.006 | 0.732 ± 0.031 | 0.018 ± 0.0003 | 323.31 ± 113.01 | 0.285 ± 0.023 | 55.00 ± 4.71 |
| 0.981 ± 0.004 | 0.514 ± 0.307 | 0.035 ± 0.001 | 1060.00 ± 208.86 | 0.464 ± 0.023 | 45.00 ± 6.24 |
| 1.896 ± 0.137 | 0.311 ± 0.034 | 0.601 ± 0.301 | ND | 0.259 ± 0.053 | ND |
| 2.016 ± 0.202 | 0.154 ± 0.017 | 0.317 ± 0.0003 | 284.66 ± 35.73 | 0.430 ± 0.055 | 60.38 ± 2.59 |
| 0.470 ± 0.021 | 0.204 ± 0.113 | 0.211 ± 0.002 | 201.66 ± 3.60 | 0.585 ± 0.098 | 11.33 ± 3.81 |
| 0.673 ± 0.034 | 1.583 ± 0.919 | 0.109 ± 0.039 | 831.25 ± 55.69 | 0.675 ± 0.012 | 60.00 ± 14.14 |
| 1.270 ± 0.0003 | 0.811 ± 0.001 | 0.031 ± 0.061 | 442.12 ± 59.10 | 0.300 ± 0.024 | 42.66 ± 5.89 |
| 1.870 ± 0.016 | 1.310 ± 0.103 | 1.310 ± 0.004 | ND | 0.415 ± 0.040 | ND |
| 0.718 ± 0.214 | 0.883 ± 0.603 | 0.054 ± 0.018 | 1163.33 ± 69.97 | 0.353 ± 0.109 | 116.66 ± 25.96 |

carbohydrate content. The reducing sugar and total sugar content in the fruits of various studied species varied from 1.25–12.42% and 2.10–25.09%, respectively. The reducing sugar was determined highest in the fruits of *Eriolobus indica,* followed by *Baccaurea sapida, Mangifera sylvetica, Passiflora indica,* and *Diploknema butyracea.* Fruits of other species contained a lower amount of reducing sugar. Total sugar content was high in the fruits of *Cucumis melo,* followed by *Mangifera sylvetica, Eriolobus indica,* and *Passiflora indica.* It was low in the fruits of *Eleagnus latifolia, Machilus edulis, Terminalia chebula,* and *Spondias axillaris* (Table 2). Lignin content varied from 9.05–39.51% in various fruits (Table 2). Low lignin content was determined in the fruits of *Machilus edulis* and it increased in *Rubus ellipticus, Mangifera sylvetica,* and *Elaeocarpus sikkimensis,* and reached a maximum in the fruits of *Diploknema butyracea.* Hemicellulose and cellulose contents of the fruits were estimated as 25.63–55.71% and 9.57–33.19%, respectively, in different species (Table 2). Hemicellulose was highest in the fruits of *Spondias axillaris,* while cellulose content was determined as maximum in the fruits of *Elaeocarpus sikkimensis.*

*Mineral Contents.* A total of 23 wild edible species consisting of edible fruits, leaves, and tender shoots were evaluated for their mineral contents. Among the various macronutrients, nitrogen was present in highest quantity, followed by potassium, calcium, magnesium, phosphorus, and sodium (Table 3). The nitrogen content varied from 0.02% (*Terminalia chebula*) to 4.10% (*Agaricus* sp.). Nitrogen content was also higher in the leaves of *Diplazium esculantum* and *Urtica diocea* (Table 3). The phosphorus content determined in various species varied from 0.041–0.765% (Table 3). The highest phosphorus content was determined in *Agaricus* sp., followed by *Arisema utile* (0.687%), *Diplazium esculantum* (0.50%), and *Pentapanax leschenaultii* (0.477%). The potassium was determined highest in shoots and new leaves of various species with a range of 1.87–2.40% (Table 3). The potassium content in the fruits of various wild edible species ranged between 0.42 (*Castanopsis* species) to 1.27% (*Terminalia chebula*). In shoots and leaves of different species, the highest potassium content was estimated for *Arisema utile*, followed by *Diplazium esculantum*, *Agaricus*, *Pantapanax leschenaultii*, and *Urtica diocea*. The calcium content in different species was estimated highest in the fruiting bodies of *Agaricus*, fruits of *Spondias axillaris*, *Eleagnus latifolia*, and tender leaves/shoots of *Urtica diocea* and *Diplazium esculantum*.

*Micronutrients*. Iron, zinc, magnesium, and copper contents were analyzed in different plant parts of various wild edible species. The iron content of various plants showed relatively higher values in leaves and new shoots. Tender leaves/shoots of *Urtica diocea* was estimated having maximum iron content, followed by *Arisema utile*, *Pantapanax leschenaultii*, and *Diplazium esculantum* (Table 3). The zinc content varied from 1490 μg/g (*Pantapanax* sp.) to 212 μg/g (*Prunus cerasoides*) (Table 3). The magnesium (Mg) content ranged between 0.675–0.239% in different species, while the copper (Cu) content varied from 117 μg/g (*Zanthoxylum* sp.) to 11 μg/g (*Prunus cerasoides*) (Table 3).

The sodium (Na) content was highest in the fruits of *Cucumis melo* and it was estimated lowest in the fruits of *Castanopsis* species. The other species showed intermediate range (Table 3).

*Comparison with Nutritive Values of Commercial Fruits*. Nutritive values of some important and most commercial fruits are presented in Table 4 for comparison with the results of this investigation. The protein content ranged between 0.20–21% and fat content between 0.10–64%. Fiber content of the commercial fruits (0.30–4.80%) was less in comparison to wild edible species. The carbohydrate content ranged from 7.60–67%, and vitamin C is reported between 1.00–68 mg/100 g (Table 4). These values are comparable with our study. In this investigation the protein content was highest in the fruiting bodies of *Agaricus*, fruits of *Prunus cerasoides*, fronds of *Diplazium esculantum*, young shoots of *Arisema utile*, and leaves of *Pentapanax leschenaultii*. These values are higher than the protein content of various commercial fruits, such as cashew (21%), almond (21%), and walnut (16%). The fiber content in the fruits of various wild edible species ranged between 2.10–39.90%, which is high in comparison to various commercial fruits. Only three commercial fruit species had higher fat content than recorded in this study—walnut (64%), almond (59%), and cashew (47%). Among the different wild edible species, the highest fat content was recorded for *Castanopsis* species (30%), wild avocado *Machilus edulis* (25.50%), and *Cinnamomum* species (21.00%), which is comparable with the fat content of the commercial avocado *Perkia americana*.

*Comparison with Other Wild Edible Species*. Table 5 represents the nutritive values of important wild edible species. It is clear from the table that few nutritive parameters have been reported for most of the species and there is a further need to cover more species with diverse parameters for detailed nutritive values. The data represent that wild edible species are good source of nutrients, particularly protein, carbohydrate, fat, vitamin C, and various other minerals. The nutritive values reported in Table 5 are well within the comparable range with data presented in Tables 2 and 3 for the Sikkim Himalaya.

## Discussion

Wild plants are gathered in the form of fruits, shoots, leaves, twigs, flowers, roots, tubers, stems, piths, etc., and these plants still share a good proportion of tribal dishes world over (Anonymous 1970–1988; Duke and Atchley 1986; Neog and Mohan 1994; Samant and Dhar 1997). Traditionally wild edible species have been meeting the protein, carbohydrate, fat, vitamin, and mineral requirement of the local residents to a greater extent (Sundriyal 1999). In the Himalaya, there are few studies that address the relationship of elemental content at the time of food consumption (Dhyani and Khali 1992, 1993; Maikhuri 1991; Maikhuri et al. 1994; Negi 1991; Neog and Mohan 1994; Singh 1995). For most of the studies the fiber and protein content are considered as the main determinants of food type and less is known about elemental composition of various wild edible species (Anonymous 1970–1988). A large section of the population in Sikkim Himalaya, particularly in remote areas, depends upon a variety of plants for their survival. People also use a large number of medicinal plants as well as plants of miscellaneous use for house construction, fuel wood, and other purposes (Sundriyal and Sharma 1996). During recent years there has been a greater shift in the tribal culture and now a large section of people practice agriculture. However, use of wild edible plants is still continued when they are available.

TABLE 4. NUTRITIVE VALUES OF MOST PROMINENT COMMERCIAL FRUITS OF INDIA (COMPILED BY SUNDRIYAL, M. 1999).

| Name of fruit | Moisture (%) | Protein (%) | Fat (%) | Mineral matter (%) | Fibre (%) | Carbohydrate (%) | Ca (%) | P (%) | Fe (%) | Vitamin C (mg/100 g) |
|---|---|---|---|---|---|---|---|---|---|---|
| Almond | 5.20 | 20.80 | 58.90 | 2.90 | 1.70 | 10.50 | 0.23 | 0.49 | 3.50 | — |
| Apple | 85.90 | 0.30 | 0.10 | 0.30 | — | 13.40 | 0.01 | 0.02 | 1.70 | 2.00 |
| Avocado | 73.60 | 1.70 | 22.80 | 1.10 | — | 0.80 | 0.01 | 0.08 | 0.70 | 13.00 |
| Banana | 61.40 | 1.30 | 0.20 | 0.70 | — | 36.40 | 0.01 | 0.05 | 0.40 | 1.00 |
| Bel | 64.20 | 1.30 | 0.20 | 1.50 | 2.20 | 30.60 | 0.09 | 0.05 | 0.30 | 15.00 |
| Ber | 85.90 | 0.80 | 0.10 | 0.40 | — | 12.80 | 0.03 | 0.03 | 0.80 | — |
| Cashewnut | 5.90 | 21.20 | 46.90 | 2.40 | 1.30 | 22.30 | 0.05 | 0.45 | 5.00 | — |
| Fig | 80.80 | 1.30 | 0.20 | 0.60 | — | 17.10 | 0.06 | 0.03 | 1.20 | 2.00 |
| Grape | 86.70 | 0.90 | 0.10 | 0.40 | 3.00 | 10.10 | 0.03 | 0.02 | 0.30 | 17.00 |
| Guava (hills) | 85.30 | 0.10 | 0.20 | 0.60 | 4.80 | 8.10 | 0.05 | 0.02 | 1.20 | 16.00 |
| Jackfruit | 77.20 | 1.90 | 0.10 | 0.80 | 1.10 | 18.90 | 0.02 | 0.03 | 0.50 | — |
| Jamun | 28.20 | 0.70 | 0.10 | 0.40 | 0.90 | 19.70 | 0.02 | 0.01 | 1.00 | — |
| Karonda | 18.20 | 2.30 | 9.60 | 2.80 | — | 67.10 | 0.16 | 0.06 | 39.10 | — |
| Lemon | 85.00 | 1.00 | 0.90 | 0.30 | 1.70 | 11.10 | 0.07 | 0.01 | 2.30 | 39.00 |
| Lime | 84.60 | 1.50 | 1.00 | 0.70 | 1.30 | 10.90 | 0.09 | 0.02 | 0.30 | 63.00 |
| Litchi | 84.30 | 0.70 | 0.30 | 0.70 | 2.25 | 9.40 | 0.21 | 0.31 | 0.03 | Trace |
| Mango (ripe) | 86.10 | 0.60 | 0.10 | 0.30 | 1.10 | 11.80 | 0.01 | 0.02 | 0.30 | 13.00 |
| Orange | 87.80 | 0.90 | 0.30 | 0.40 | — | 10.60 | 0.05 | 0.02 | 0.10 | 68.00 |
| Papaya | 89.60 | 0.50 | 0.10 | 0.40 | — | 9.50 | 0.01 | 0.01 | 0.40 | 46.00 |
| Passion fruit | 76.30 | 0.90 | 0.10 | 0.70 | — | 22.00 | 0.01 | 0.06 | 2.00 | — |
| Peach | 90.10 | 1.50 | 0.20 | 0.60 | — | 7.60 | 0.01 | 0.03 | 1.70 | 1.00 |
| Pear | 86.90 | 0.20 | 0.10 | 0.30 | 1.00 | 11.50 | 0.01 | 0.70 | Trace | — |
| Pineapple | 86.50 | 0.60 | 0.10 | 0.50 | 0.30 | 12.00 | 0.02 | 0.01 | 0.90 | 63.00 |
| Plum | 89.80 | 0.70 | 0.20 | 0.40 | — | 8.90 | 0.02 | 0.02 | 0.50 | 1.00 |
| Walnut | 4.50 | 15.60 | 64.50 | 1.80 | 2.60 | 11.00 | 0.10 | 0.38 | 4.80 | — |

In the present investigation, a total of 190 wild edible species have been recorded from the Sikkim Himalaya, of which nutritional values were estimated for 27 of the most frequently used species. As the fruit was most commonly used plant part, detailed general chemical analysis (16 parameters) was done for 19 fruit species, while mineral estimation (nine parameters) was completed for 23 species. Fifteen species were covered for the analysis of all 23 nutritional parameters. Most of these species come to the market and are sold, therefore information on the chemical constituents of these food plants adds to the existing knowledge about the nutritional values of wild edible species in the Himalaya. High protein content was determined in different plant parts in the present study and these values are comparable with other wild edible species (Dhyani and Khali 1992; Maikhuri 1991; Singh 1995). Wild edible plants are also good source of sugars and vitamin C contents. *Cucumis melo, Mangifera sylvetica, Eriolobus indica,* and *Baccaurea sapida* had high sugar contents. Fruits of *Prunus cerasoides, Morus alba, Baccaurea sapida,* and *Hippophae rhamnoides* had high vitamin C content. The carbohydrate content was high for most of the wild edible species of the Sikkim Himalaya, which is similar to the wild edible species reported from other parts of the Himalaya (Anonymous 1970–1988; Dhyani and Khali 1992; Kapur and Sarin 1990; Maikhuri 1991; Samant and Dhar 1997; Singh 1995). It is reported that the wild edible species form a good source of minerals for the local residents at different parts of the globe (Akpanyung, Udoh, and Akpan 1995; Bokhary and Parvez 1995; Duke and Atchley 1986).

A comparison of the mineral contents of various wild edible species with the commercial fruit species revealed nearly 5–50 times higher calcium content in *Agaricus, Diplazium esculantum, Eleagnus latifolia, Spondias axillaris,* and *Urtica diocea* than most of the commercial fruits. Phosphorus content was also high in wild edible species of Sikkim Himalaya. High iron content was recorded in the leaves of *Urtica di-*

TABLE 5. NUTRITIVE VALUES OF SOME OF THE WILD EDIBLE PLANTS FROM DIFFERENT REGION (VALUES ARE COMPILED FROM ANONYMOUS 1970–1984, DUKE AND ATCHLEY 1986, KAPUR AND SARIN 1990, DHYANI AND KHALI 1993, MAIKHURI 1991, MAIKHURI ET AL. 1994, NEGI AND GAUR 1994, SINGH V. 1995, BOKHARY AND PARVEZ 1995, AKPANYUNG ET AL. 1995, ARORA AND PANDEY 1996, SAMANT AND DHAR 1997).

| Plant species | Part used | Moisture (%) | Protein (%) | Fat (%) | Carbohydrate (%) | Fibre (%) | Vita. C (mg/100 g) | K (%) | P (%) | Ca (%) | Na (%) | Fe (mg/100 g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Allium rubellum* Bieb. | WP | 78 | 1.61 | — | 18.46 | — | — | — | — | — | — | — |
| *A. ampeloprassum* Linn. | St. | 79 | 1.80 | 0.10 | 17.20 | 1.30 | 116 | 2.37 | 0.45 | 0.54 | 0.035 | 25.5 |
| *A. sikkimensis* Baker | Lv. | 4 | 20.43 | 0.68 | 9.00 | 21.58 | — | 0.62 | 0.53 | — | 1.28 | 0.04 |
| *Alpina malaccensis* Linn. | P | 85 | 1.60 | 1.10 | 8.40 | — | — | 0.125 | 0.202 | 1.62 | 0.012 | — |
| *Amaranthus paniculatus* Wall. | S | — | — | — | 55.87 | — | — | — | — | — | — | — |
| *Amaranthus gangeticus* Linn. | Lv. | 73 | 4.90 | 0.50 | 5.70 | — | 21 | — | 0.10 | 0.50 | — | — |
| *Amaranthus hybridus* Spreng. | Lv. | 81 | 27.03 | 4.80 | 51.00 | 11.40 | — | 4.29 | — | 2.78 | 0.07 | 5.00 |
| *Angiopteris evecta* (Forst.) Hoffin. | P | 77 | 1.90 | 0.70 | 16.72 | — | — | 0.078 | 0.075 | 0.825 | 0.011 | — |
| *Arisaema speciosum* Inart. | R | — | — | 1.60 | 76.00 | 6.10 | — | — | — | — | — | — |
| *Atrocarpus lakoocha* Roxb. | F | — | 0.70 | 1.10 | 13.30 | 2.00 | — | — | — | — | — | — |
| *Bambusa arundinacea* Willd. | T. sh. | 89 | 3.90 | 0.50 | 5.70 | — | 4.00 | — | 0.041 | 0.033 | — | 0.40 |
| *Bauhinia variegata* Linn. | Fl. | 79 | 1.80 | 0.20 | 17.80 | 1.30 | — | — | 0.074 | 0.07 | — | 18.40 |
| *Calamus hamiltonii* Roxb. | St. | 6 | 4.26 | 1.62 | — | 10.50 | — | 4.16 | 0.23 | — | — | 16 |
| *C. tenuis* Roxb. | P | 86 | 2.60 | 0.60 | 10.50 | — | — | 0.11 | 0.18 | 1.28 | 0.016 | — |
| *Chenopodium album* Linn. | WP | 83 | 4.63 | — | 8.32 | — | — | — | — | — | — | — |
| *Castanea sativa* Mill. | S | 29 | 10.90 | 1.84 | 32.64 | — | — | 1.70 | 0.18 | 0.045 | 0.03 | 3.50 |
| *Coix lachrymajobi* Linn. | Pt. | 5 | 4.90 | 2.16 | — | 11.26 | — | — | 0.33 | — | — | 22 |
| *Colocasia esculenta* H. | F | — | 17.50 | 6.00 | 63.40 | — | 0.00 | — | 0.41 | 0.023 | — | 4.00 |
| *Colocasia esculenta* (Linn.) Schott. | R | — | 0.30 | 0.30 | 4.10 | 0.60 | — | — | 0.02 | 0.06 | — | 50.00 |
| *Crotalaria medicaginea* | S | — | 23.31 | 6.76 | 42.04 | — | — | — | — | — | — | — |
| *Cycus pectina* Griff. | F | 7 | 8.50 | 1.30 | — | — | — | 1.55 | 0.005 | — | — | 16 |
| *Cyphomandra betacea* (Cav.) Scndt. | F | 83 | 1.50 | 0.20 | 10.30 | 4.20 | 17–29 | — | 0.036 | 0.10 | — | 0.80 |
| *Cyathea gigentea* (Wall & ex. Hook.) Holt. | P | 74 | 1.80 | 0.62 | 14.80 | — | — | 0.063 | 0.082 | 0.69 | 0.008 | — |
| *Dendrocalamus hamiltonii* Nees & Arn. | T. sh. | 88 | 3.90 | 0.50 | 5.70 | — | — | 0.057 | 0.065 | 1.12 | 0.039 | — |
| *Diplazium esculentum* (Retz.) Sw. | F | 86 | — | — | 8.00 | — | — | — | — | — | — | — |
| *Emblica officinalis* Gaertn. | F | 81 | 0.50 | 0.10 | 14.10 | 3.40 | — | — | — | — | — | — |
| *Euphorbia hirta* Linn. | Lv. | 78 | 4.65 | — | — | — | — | — | — | — | — | — |
| *Fagopyrum esculentum* Moench Ln. | S | 11 | 10.30 | 2.40 | 65.00 | 8.60 | — | 0.50 | 0.36 | 0.12 | — | 64.90 |
| *Ficus bengalensis* Linn. | F | 13 | 8.10 | 6.10 | 35.50 | 31.00 | 156.60 | — | 0.11 | 0.11 | — | 4.10 |
| *F. glomerata* Roxb. | F | 14 | 7.40 | 5.60 | 49.00 | 17.90 | — | — | 1.05 | — | — | — |
| *F. palmata* Forsk. | F | — | 13.27 | — | — | — | — | — | — | — | — | — |
| *F. religiosa* Linn. | F | 10 | 7.90 | 5.30 | 34.90 | — | — | — | 0.006 | — | — | — |

TABLE 5. EXTENDED.

| Plant species | Part used | Moisture (%) | Protein (%) | Fat (%) | Carbohydrate (%) | Fibre (%) | Vita. C (mg/100 g) | K (%) | P (%) | Ca (%) | Na (%) | Fe (mg/100 g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *F. semicordata* Ham. ex J.E. Str. | F | — | 8.70 | 5.70 | 43.10 | — | — | — | — | — | — | — |
| *Fragaria vesca* Linn. | F | 88 | — | 14.30 | 4.50 | — | 481.80 | 1.62 | 0.32 | 0.20 | 0.01 | 6.40 |
| *Juglans regia* Linn. | F | 43 | 15.60 | 64.50 | 11.00 | — | 0.00 | — | 0.38 | 0.10 | — | 5.00 |
| *Morus alba* Wall. | F | 87 | 1.50 | 0.40 | 8.30 | 1.40 | 33.30 | 1.01 | 0.21 | 0.20 | 0.25 | 15.20 |
| *Nasturtium officinale* Br. | WP | 89 | 2.90 | 2.20 | 5.50 | — | 564.10 | 3.61 | 0.68 | 1.00 | 0.66 | 42.60 |
| *Nelumbo nucifera* Gaertn. | Rh | 84 | 2.70 | 0.11 | 11.30 | 0.80 | 92.60 | — | — | 0.37 | — | — |
| *Oenanthe javanica* (Bl.) DC. | Lv. | 6 | 17.13 | 2.56 | — | 12.20 | — | 4.96 | 0.22 | — | — | 13 |
| *Phytolacca acinosa* Roxb. | Lv. | 7 | 27.25 | 1.53 | 16.80 | 9.60 | — | 5.60 | 0.21 | — | — | 17 |
| *Platago major* Linn. | Lv. | 8 | 17.50 | 1.48 | — | 11.15 | — | — | 0.36 | — | 0.04 | 2300 |
| *Phaeangium lefebvrei* Pat. | Fr bo. | 61 | 23.20 | 1.30 | 18.30 | 2.6 | — | 1.65 | 0.51 | 0.065 | 0.168 | 11.00 |
| *Polygonum alpinum* All. | St. | — | 1.70 | 0.70 | 5.10 | 3.90 | — | — | — | — | — | — |
| *Polygonum alpinum* All. | R | — | 10.75 | 1.08 | 12.70 | 12.10 | — | — | — | — | — | — |
| *Polygonum bistorta* Linn. | St. | — | 3.00 | 0.80 | 7.90 | 3.20 | — | — | — | — | — | — |
| *P. cirnifolium* (Wall.) Royle. | R | 9 | 4.75 | 0.56 | — | 10.00 | — | 0.0004 | 0.0003 | — | 0.01 | 0.13 |
| *Polyporus sulphureus* Bull. | Fr. | 7 | 13.87 | 0.64 | — | 2.70 | — | 1.68 | 0.35 | — | — | 10 |
| *Psidium guajaya* Linn. | F | 82 | 0.90 | 0.30 | 11.10 | 5.20 | 680.40 | 0.49 | 0.12 | 0.05 | 0.02 | 3.60 |
| *Pteridium equilinum* (L.) Kunth. | Fr. | 9 | 24.18 | 1.29 | — | 6.70 | — | 4.08 | 0.46 | — | — | 17 |
| *Pterocarpus mildbraedii* Linn. | Lv. | 85 | 25.84 | 7.56 | 59.92 | 7.56 | — | 2.08 | — | 0.48 | 0.002 | 3.00 |
| *Pueraria tuberosa* (Roxb. ex Willd.) DC. | R | — | 23.80 | — | — | 10.90 | — | — | — | — | — | — |
| *Punica granatum* Linn. | F | — | 89 | 2.12 | — | 14.81 | — | 14.00 | — | 0.07 | 0.01 | 0.90 |
| *Randia tetrasperma* Roxb. | F | — | 0.90 | 0.20 | 17.70 | — | — | — | — | — | — | — |
| *Rheum nobile* Hk f. & Rhoms. | Lv. | 9 | 12.00 | 4.87 | — | 15.00 | — | 4.10 | 0.12 | — | 0.11 | 360 |
| *Rubus ellipticus* Smith | F | 4 | 8.10 | 9.50 | — | — | — | 1.50 | 0.16 | — | — | 509 |
| *R. niveus* Thumb. | S | 85 | 1.23 | — | 5.24 | — | 17.70 | 0.002 | 0.028 | 0.04 | 0.002 | 1.21 |
| *Rumex acetosa* Spreng. | WP | 90 | 2.60 | 0.50 | — | — | 124.00 | 0.10 | 0.05 | 0.044 | — | — |
| *Semecarpus anacardium* Linn. f. | S | 4 | 26.40 | 36.40 | 28.40 | 1.40 | — | — | 0.84 | 0.29 | — | 6.10 |
| *Sapindus mukorosii* Gaertn. | S | — | 31.00 | — | — | — | — | — | — | — | — | — |
| *Sapium sebiferum* Roxb. | S | — | 75.00 | 53.00 | — | — | — | — | — | — | — | — |
| *Shorea robusta* Roxb. | S | — | 10.12 | — | 50.00 | — | — | — | — | — | — | — |
| *Solanum nigrum* Linn. | F | — | 17.50 | 21.50 | 20.00 | — | 11.00 | — | 0.07 | 0.41 | — | 20.50 |

TABLE 5. EXTENDED.

| Plant species | Part used | Moisture (%) | Protein (%) | Fat (%) | Carbohydrate (%) | Fibre (%) | Vita. C (mg/100 g) | K (%) | P (%) | Ca (%) | Na (%) | Fe (mg/100 g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Sonchus oleracea* Linn. | Lv. | 8 | 18.70 | 5.38 | — | 10.10 | — | 0.03 | — | — | 0.003 | — |
| *Spondias pinnata* Linn. f. | F | 90 | 0.70 | 3.00 | 4.50 | 1.00 | 216.50 | — | 0.11 | 0.37 | — | 40.20 |
| *Syzygium cuminii* (Linn.) Skeel. | F | 84 | 0.70 | 0.30 | 14.00 | 0.90 | 42.30 | 0.34 | 0.075 | 0.046 | 0.05 | 11.30 |
| *Taraxacum officinale* Wigg. | Lv. F | 89 | 3.60 | 1.60 | 3.70 | 0.04 | 195.80 | 2.75 | 0.44 | 1.05 | 0.52 | 21.50 |
| *Terfezia claveryi* Chatin. | Fr bo. | 80 | 16.00 | 4.00 | 28.00 | 2.00 | — | 1.13 | 0.43 | 0.05 | 0.13 | 11.00 |
| *Trichosanthes diocea* Linn. | F | 92 | 2.00 | 0.30 | 2.20 | — | 362.50 | 1.04 | 0.50 | 0.37 | 0.037 | 21.30 |
| *Urtica dioica* Linn. | WP | — | 30.40 | 3.40 | 10.30 | 10.30 | — | — | — | — | — | — |
| *Zizyphus mauritiana* (Linn.) Gaertn. | F | 82 | 0.80 | 0.30 | 17.00 | — | 50.60 | 1.59 | 0.05 | 0.021 | — | 4.30 |

WP = Whole plant; Lv = Leaves; F = fruit; St = Stem; R = Root; Fr. = Fronds; T.sh = Tender shoots; Fl. = Flower; P = Pith; Pt = Petiole, Fr bo = Fruiting bodies.

*ocea,* shoots of *Arisema utile* and *Pantapanax leschenaultii,* and fronds of *Diplazium esculantum.* The iron content of wild edible species was higher than the various commercial fruits except Karonda, cashew, almonds, lemon, and passion fruits. The overall trend of nutrients in different plants parts was determined highest in fruiting bodies (mainly *Agaricus* species), followed by leaves, new shoots, and least in fruit parts. Similar results are reported by other workers also (Akpanyung, Udoh, and Akpan 1995; Ifon and Bassir 1980; Oke 1968; Umoh and Oke 1977). The nutritive values of different wild edible plants of Sikkim Himalaya are in well within the comparable range with the wild edible species from different parts of the Himalaya as well as other region (Akpanyung, Udoh, and Akpan 1995; Bokhary et al. 1987; Bokhary and Parvez 1995; Dhyani and Khali 1992, 1993; Franke 1982; Kapur and Sarin 1990; Maikhuri 1991; Maikhuri et al. 1994; Negi et al. 1993; Pareek and Sharma 1993; Samant and Dhar 1997; Singh 1995; Wesche-Ebeling et al. 1995). It can be concluded that the wild edible species are a good source of various nutrients, which are often comparable with the most commercial species and also cheaply available. Therefore the consumption of these species by the rural population thus may be considered significant.

## CONCLUSION

The high diversity of wild edible plant species play a significant role in the food and nutrient security of the tribal population of the Sikkim Himalaya, and the nutritive values are at par with various commercial fruit species. In view of the ever-increasing problem of human population and depleting natural resources, there is a need to exploit the role of wild edible plants to the fullest extent possible. These wild edible plants form a good source of protein, fat, vitamins, sugars, and minerals, and interestingly they are available during different months/seasons of the year. These species also provide ecological security as they are disease resistance, grow in diverse climatic and habitat conditions, and ensure sufficient production despite adverse conditions. The production potential of different species and sustainable harvests of useful parts can boost the local economy. Such species may be promoted for large-scale multiplication, which may ultimately benefit the poor socioeconomic conditions of the tribal population. In the

Sikkim Himalaya farmers have shown their willingness to grow a few identified priority species, i.e., *Eleagnus latifolia, Diploknema butyracea, Eriolobus indica, Machilus edulis, Spondias axillaris,* and *Baccaurea sapaida* (Sundriyal 1999). There is also a need to start research leading to the genetic improvement and manipulation through plant breeding, genetic engineering, and tissue culture on various wild edible species. As the nutritional quality of the edible parts of a species changes at different growth stages (maturation stages), there is a need to develop a best growth stage versus harvest calendar for obtaining the highest nutrient content available for different species. It will also be worthwhile to study the antinutritional factors available in different edible plant parts. It will greatly enhance the existing knowledge about the nutritional values as well as will be helpful in dietary consumption of various wild edible species.

Recently the Prime Minister of India has launched a low-cost nutritious food scheme for the school children. The Department of Biotechnology has undertaken the project with the assistance from National Dairy Development Board, Ananad, the Central Food Technological Research Institute, Mysore, and the National Institute of Nutrition, Hydrabad. A package has been developed for school children between 6–14 years. The package contains 15% protein, 25% fat, and 35% carbohydrate with 400 Kilocalories in 100 g weight (Taneja 1999). It is considered that the package will help to save children from malnutrition and encourage them to go to school. Unfortunately a large number of schools in the mountain region are in remote and inaccessible areas, and accessibility of such packages in these schools will not be an easy task. It is, therefore, suggested that the wild edible plants with rich nutritive values may be grown in and around the schools. The consumption of these plants will help to meet the nutritional requirement of the children. Furthermore it will help in conservation of various species in the forest areas as well as enhance children knowledge about their plant wealth.

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