CHAPTER II

Determination of Proximate Composition of Wild Edible Plants

II.1 Introduction

The wild edible plants growing in the natural habitats are being used as the sources of food to fulfil the daily requirements of nutrients by the rural people inhabiting in the remote areas. The green vegetables are the only nutritious, healthy foods and sources of energy for proper growth and maintenance of physiological processes in the body. The wild edible plants are considered as one of the cheapest sources of energy for human consumption. It provides the defence system to many diseases by boosting the immune system of our body. Like other vegetables, wild edible vegetables also act as a very important component of human food which can be consumed throughout the year. This non-conventional food sources are utilised during food scarcity and also used as a source of income generation for the rural people [1, 2]. The wild edible vegetables are essentially important in the biochemical and nutritional aspects as they are the best sources of proteins, amino acids, carbohydrates, fibre, vitamins, minerals and bioactive compounds which are very important for health and play an active roles in prevention of many diseases like cancer, diabetes, coronary heart diseases, etc. [3, 4]. Hence, these wild edible plants can be integrated into the normal diet to achieve daily requirements of important nutrients from food.

The large varieties of wild edible plants are mostly consumed by the Bodo people and other tribal communities of Assam of North East India since time immemorial. Bodos have a rich cultural practice of enjoying the flavour of several wild plants in the form of a mix vegetable and also there is a traditional belief that consumption of these mix vegetables acts as a medicine for many diseases [2]. In view of its food and medicinal importance, in this study a total of 17 wild edible plants were selected which have been traditionally consumed as vegetables by the Bodos of Assam.

Sphenoclea zeylanica **(Fig.II.1)** locally known as *Sibung* in Bodo is small seasonal herbs growing 6–10 inches in marshy land, paddy field or water banks which are

available from the month of July to October. The stems and leaves are very weak with smooth leaf margin. These are slightly bitter in taste and eaten as vegetable (fried or boiled) and the rural people use to sell this in the market at Rs. 10 per bundle (around 250 g fresh weight). It has been reported that the methanol extract of this plant has the antimicrobial activity against many pathogenic bacteria and fungi [5].

Cardamine hirsuta **(Fig.II.2)** locally known as *Singsab* in Bodo grows in stream, rivers and lakes as floating on the surface of water as well as in the muddy area. They have a pungent smell like mustard oil. Leaves are similar to the leaves of mustard oil and belong to the same family Brassicaceae**.** The leaves and the stems are eaten as vegetable. It is found available from the month of July to August and in the local markets at Rs. 10 per bundle. There is no available report in the literatures about the study of this plant to the best of our knowledge.

Natsiatum herpeticum **(Fig.II.3)** is called *Jwheo* in Bodo and it grows throughout the year but the most available time is from May to August. It is a climber and the leaves are smooth hairy. The tender leaves and young shoots are eaten as vegetables. The Bodo people use to cook it with small fishes and eaten. It can also be cooked with chicken and consumed during common fever. It has been reported that a new anticancer drug-camptothecine has been reported from *Natsiatum herpeticum* species [6]. Other nutritional status and phytochemical studies including antioxidant and antimicrobial activities of this plant are still not reported in the literatures.

Blumea lanceolaria **(Fig.II.4)** locally known as *Jwglaori* in Bodo is available during the months from May to September. It is a herb, leaves are serrate, elongated; inflorescence is racemose cyme and flowers are head, yellow in colour. The leaves are edible with aromatic smell and spicy in taste. The rural people prefer this plant for preparation of hot mixed vegetable soup which is consumed for curing cough and illness. It has been reported that the ethanolic extract of *B. lanceolaria* has the antimicrobial and antioxidant properties [7].

Sphaerantus peguensis **(Fig.II.5)** commonly known as *Jolonga bantu* in Bodo is available during the month of August to December. It grows in the paddy field as a weed. The leaves and stems are eaten as vegetables by the local people. The plants are small herb, inflorescence becomes rounded like head, matured leaves have smooth hairs on both the surface, and the leaves have spicy aromatic smell. It is also preferred during

preparation of hot mixed vegetable soup for curing cough and illness by the local people. There is no available information in the literatures about the study of this plant to the best of our knowledge.

Tetrastigma angustifolium **(Fig.II.6)** locally known as *Dousrem* are annual plants, and weak stem climber. Its leaves are tri-pinnate, serrate, flowers are compound umbel, stem bears tendril for climbing. The tender leaves are eaten as vegetables by the local people and it has market value of Rs. 10 per bundle. Young tender shoots are available from the month of March to July. This vegetable is sour in taste and can be prepared with fishes and meat. It has been reported that the hydro-alcoholic leaf extracts of *Tetrastigma angustifolium* have anti-hyperglycaemic activities against diabetes mellitus [8].

Oenanthe javanica **(Fig.II.7)** commonly known as water dropwort and locally known as *Daopenda* is a perennial herb grows on wet land or marshy area. The leaves are compound, stems are short swollen at the base, hollow internodes, inflorescence compound umbel, and flowers are white. These plants are available from the month of March to June. It has been reported that *O. javanica* plant from China are used to treat jaundice, hypertension, fever, and abdominal pain [9]. It has also been reported that this plant has antioxidant property [10] and hepatoprotective activity [11-13].

Melothria perpusilla **(Fig.II.8)** locally known as *Timijora* is a climber and most commonly grows in lakes and ponds, leaves are serrate having hard, rigid margin, flowers are yellow, fruits show distinct margin diagonally at the middle through which it breaks into two equal halves on ripening, and it is available during the summer. These are eaten as a vegetable by the local people. The Bodo people have a traditional belief that this plant has medicine values and it is used for curing joint pain, and jaundice. There is no available report in the literature about this plant also, to the best of our knowledge.

Stellaria media **(Fig.II.9)** locally known as *Tuntini* is an annual herb with simple leaves, weak stem which grows in moist soil. These plants are available from the month of December to March. Howard in 1987 [14] reported that *S. media* is used to cure inflammation, skin diseases, arthritis, bronchitis, asthma, etc. The plant has also been reported for antioxidant and antifungal properties [15-17].

Cryptolepis sinensis **(Fig.II.10)** locally known as *Parukia* in Bodo is a thin and hard stem climber, its leaves are opposite, flowers are very small, yellow in colour, fruits are long, bears in pair, and looks like a pencil. This plant bears latex and its tender leaves are traditionally used as vegetables by Bodo tribes especially for lactating mother to increase the milk production. To the best of our knowledge, there is no available information about the study of this plant in the literatures.

Drymaria cordata **(Fig.II.11)** commonly known as chickweed and locally known as *Jabsri* is a seasonal wild vegetable that grows from the month of December to March in the crop field as a weed. The stems are very weak with opposite sessile leaves, flowers are pale yellow with a distinct character of Caryophyllaceae. The plant has been reported for anti-inflammatory activity [18], antibacterial activity [19] cytotoxic characters [20] anxiolytic activity [21], analgesic properties [22] and antipyretic properties [23]. Other studies like proximate composition, metal contents, vitamin C content, antioxidant property and anti-nutritional contents were not reported yet in the literature to the best of our knowledge.

Persicaria chinensis **(Fig.II.12)** locally known as *Mwisungka* in Bodo is small herbs growing under the canopy of forest, leaves are simple, hairy with polygonous margin, inflorescence spikelet, and remain prostrate on the ground. The young shoots are edible and sour in taste. It is available during the month of June to November. There is no available report in the literatures about the study of this plant to the best of our knowledge.

Antidesma acidum **(Fig.II.13)** locally known as *Lapasaiko* is a woody shrub, growing on the sandy soil and belongs to Euphorbiaceae family. Its leaves are simple, and stems are hard and woody. The tender leaves are eaten as a vegetable by the local people and it contains a sour taste. The Bodo tribes believe traditionally that these plants have medicinal values and used for curing headache, jaundice, stomach pain etc. It is available from the month of March to May. It has been reported that water extract of its leaf is used in anti-diabetic treatment [24]. No other studies are yet reported in the literatures to the best of our knowledge.

Eryngium foetidum **(Fig.II.14)** commonly known as Mexican coriander or fit weed, and locally known as *Gonger dundiya* in Bodo is an annual or perennial herb which is used to flavour delicious food items. The local people use it to flavour foodstuff and

also for flavouring salad, chutney, and other items of food. It has been documented that this plant is traditionally used in the treatment of various ailments such as fevers, chills, vomiting, burns, hypertension, headache, earache, stomach-ache, asthma, arthritis, snake bites, scorpion stings, diarrhoea, malaria, and epilepsy [25, 26]. Its aromatic smell is due to the presence of essential oil eryngial (*E*-2-dodecenal) [27]. It has also been reported that this plant has anthelmintic, anti-inflammatory, analgesic, anti-carcinogenic, anti-diabetic, and antibacterial activity [28, 29]

Lippia javanica **(Fig.II.15)** locally known as *Ontaibajab* in Bodo is a small woody shrub. The leaves have aromatic smell. The inflorescence spike, flowers are sessile, purple or pink in colour, and generally grow in sandy soil near a river or pond bank. The leaves are eaten as vegetables by the Bodo people and cooked with meat and fish also. It is used as herbal tea [30], vegetables [31, 32], insect repellent [33], in respiratory disorder [34], wounds, injuries, pain and skin infection [35].

Polygonum perfoliatum **(Fig.II.16**) locally known as *Mwitasikla* in Bodo is an annual or perennial climber, and it grows on sandy soil. The petiole and stems are angular bearing recurved prickles. The fruits are metallic blue in colour, sub-globose, fleshy, and berry-like, 4 to 6 mm in diameter. The tender leaves are eaten as vegetables by the Bodo people, especially with fish or edible insects. These vegetables are available from the month of March to June. It has been reported that *P. perfoliatum* extracts possess cytotoxicity effects against human mammary carcinoma, colon carcinoma, hepatocellular carcinoma, prostate carcinoma, and erythro-leukaemia cells [36]. It has been reported that *P. perfoliatum* have anti-inflammatory [37], anti-bacterial properties [38]. Other studies like proximate composition, metal contents, vitamin C content, amino acid composition, antioxidant property and anti-nutritional contents were not reported yet in the literatures to the best of our knowledge.

Enhydra fluctuans **(Fig.II.17)** locally known as *Alangshi* in Bodo is an aquatic or semi aquatic annual herb of the Asteraceae family. The leaves are sessile, hollow internodes, roots at node; sometimes float on the water, inflorescence head with dull yellow or white colour flower. It has also distinctive smell and bitter in taste and is available from the month of March to July. The plant has been reported for anti-inflammation [39] antibacterial activity [40], anti-diabetic activity [41], hepatoprotective activity [42] and analgesic activity [43].

Fig.II.1: *Sphenoclea zeylanica.*

Fig.II.2: C*ardamine hirsuta.*

Fig.II.3: *Natsiatum herpeticum.*

Fig.II.4: *Blumea lanceolaria.*

Fig.II.5: *Sphaerantus peguensis.*

Fig.II.6: *Tetrastigma angustifolium.*

Fig.II.7: *Oenanthe javanica.*

Fig.II.8: *Melothria perpusilla.*

Fig.II.9: *Stellaria media.*

Fig.II.10: *Cryptolepis sinensis.*

Fig.II.11: *Drymaria cordata.*

Fig.II.12: *Persicaria chinensis.*

Fig.II.13: *Antidesma acidum.*

Fig.II.14: *Eryngium foetidum.*

Fig.II.15: *Lippia javanica.*

Fig.II.16: *Polygonum perfoliatum.*

Fig.II.17: *Enhydra fluctuans.*

II.2 Materials and Methods

II.2.1 Chemicals

Boric acids, NaOH, H_2SO_4, K_2SO_4, $CuSO_4$, HCl, petroleum ethers were obtained from Merck, New Delhi.

II.2.2 Collection and identification of plants

A total of 17 wild edible plants listed in the **Table II.1** were collected during their seasonal availability from the village markets of Kokrajhar and Chirang districts of Bodoland Territorial Area District (BTAD) of Assam. After collection of samples, the herbarium sheets of all the plant species were prepared and submitted at Herbarium of Botanical Survey of India (Meghalaya) and authenticated (Reference No. BSI/ERC/Tech./Plant Iden./2014, Dated 19/12/2014; BSI/ERC/Tech/ Plant Iden./2015/77, Dated 05/05/2015; BSI/ERC/Tech./Plant Iden./20l5/432, Dated 30/09/2015).

II.2.3 Sample preparation

The samples were collected in plastic bags and after collection, all the samples were washed with tap water followed by distilled water. The fresh samples were taken for determination of moisture and vitamin C contents. For other experiments, the samples were dried in the hot air oven at 50^{o}C and it was grinded into uniform powders and stored in cool and dry place in a sealed plastic container for further use.

II.2.4 Determination of moisture content

The moisture contents of the samples were evaluated by following the AOAC [44] method. In brief, 5 g of fresh sample was taken and it was dried for 3 h in the hot air oven at 105^{o}C. The final weight was measured after cooling in a desiccator, and it was calculated as per the formula given below.

$$\text{Moisture content (\%)} = \frac{FW - DW}{FW} \times 100$$

Where, FW = Fresh weight (g), DW = Dry weight (g).

II.2.5 Determination of ash content

The AOAC method [44] was followed for determination of ash content. At first the silica crucible was heated in a furnace for 1 h and initial weight was taken after cooling

it in a desiccator till the constant weight is obtained. Then, the dry sample (2 g) was taken in crucible weighted previously and heated at 550^{o}C for 6 h in the muffle furnace. After that it was cooled in the desiccator and the final weight was measured and the ash content was calculated as per the formula given below.

$$\text{Ash (\%)} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

II.2.6 Determination of crude fat

The AOAC method [44] was followed for the determination of crude fat content. The clean and empty flask was preheated overnight at 105^{o}C followed by cooling in a desiccator and its pre-weight was recorded. After that, 5 g of dry sample was measured, wrapped in Whatman No. 1 filter paper, placed into the extraction thimble of a Soxhlet apparatus and was extracted for 12 h with 500 mL of petroleum ether. The solvent was completely removed using rotary evaporator and the final weight of extracted fat was recorded.

$$\text{Crude fat (\%)} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times 100$$

II.2.7 Determination of crude protein

The AOAC method [44] was followed for the determination of crude protein content using the Kjeldhal apparatus. In this experiment, the sample (1 g) was taken in Kjeldhal digestion chamber and to this, conc. H_2SO_4 (20 mL) and 10 g of Kjeldhal catalyst (one part $CuSO_4$ and 9 parts K_2SO_4) was added, digested and then distilled by using Kjeldhal distillation apparatus. The condensed ammonia was collected and titration was performed against 0.1 N HCl. The blank test containing the entire reagents except the sample was also performed as a control. A similar process was also performed for blank solution. The nitrogen concentration was calculated as per the formula given below.

$$\text{Nitrogen (\%)} = \frac{(A - B) \times N \text{ of HCl} \times 14}{\text{Weight of the sample}} \times 1000$$

Where, A = Volume (mL) of (0.1 N) HCl used in sample titration.

B = Volume (mL) of (0.1 N) HCl used in blank titration.
14 = Atomic weight of nitrogen.

The protein content was calculated by multiplying the nitrogen content with 6.25 of protein conversion factor.

Protein (%) = Nitrogen (%) × 6.25.

II.2.8 Determination of crude fibre

The AOAC method [44] was also followed for the determination of crude fibre content of the sample. In this experiment, the dry sample (1 g) was digested for 30 min with 0.25 N H_2SO_4 and it was filtered with the muslin cloth. The residue was washed with hot water for three times and it was heated for 30 min with 0.3 N NaOH till it boils. After that, it was filtered again, followed by washing with hot water, 0.5 N H_2SO_4 and ethanol solution (50%). The residue obtained was completely dried in the hot air oven at 130^{o}C. The dried weight obtained was incinerated in a furnace at a temperature of 600^{o}C for 30 min. The ash obtained was weighted and the crude fibre content calculated using the formula given below.

$$\text{Crude fibre (\%)} = \frac{\text{(Dry weight of digested sample – Weight of ash)}}{\text{Weight of the sample}} \times 100$$

II.2.9 Determination of total carbohydrate

The total carbohydrate content of the plant sample was measured using the difference method given by James [45] as per the equation mentioned below.
Total carbohydrate (%) = 100 – [% of (Moisture + Ash + Crude protein + Crude fat)].

II.2.10 Determination of calorific value of plant sample

The total calorific value or total energy value (in kcal/100 g) of the wild edible plants was determined using an equation prescribed by FAO [46] which is given below.

Calorific value (kcal/100 g FW) = 4 (Protein %) + 9 (Fat %) + 4 (Carbohydrate %).

Table II.1: Wild edible plants collected for the study

Botanical name	Family	Local name (*Bodo)*	Parts used and taste	Availability
Sphenoclea zeylanica Gaertn.	Lobeliaceae	Sibung	Whole plants except root, slightly bitter	July-October
Cardamine hirsuta L.	Brassicaceae	Singsab	Whole plants except root, slightly bitter	July-August
Natsiatum herpeticum Buch. -Ham. ex Arn.	Icacinaceae	Jwheo	Leaves and tender shoot, no significant taste	Throughout the year
Blumea lanceolaria (Roxb.) Druce	Asteraceae	Jwglaori	Leaves, spicy	May-September
Sphaerantus peguensis Kurtz ex C.B. Clarke.	Asteraceae	Jolonga bantu	Tender shoot and leaves, spicy	August - December
Tetrastigma angustifolium (Roxb.)	Vitaceae	Dousrem	Young leaves, sour	March-June
Oenanthe javanica (Blume) DC.	Apiaceae	Daopenda	Leaves & petiole, slightly bitter	March-June
Melothria perpusilla (Blume) Cogn.	Cucurbitaceae	Timijora	Tender shoot, bitter	March-August
Stellaria media (L.) Willd.ex Schult	Caryophylla-ceae	Tuntini	Whole plants, no significant taste	December-March
Cryptolepis sinensis (Lour) Merr.	Apocynaceae	Parukia	Tender shoot, no significant taste.	March-July
Drymaria cordata L.	Caryophylla-ceae	Jabsri	Whole plants, slightly sour.	December-March
Persicaria chinensis (L.) H. Gross	Polygonaceae	Mwisungka	Young shoot and leaves, slightly sour	June-November
Antidesma acidum Retz.	Euphorbia-ceae	Lapasaiko	Tender shoot, sour	March-May
Eryngium foetidum L.	Apiaceae	Gongar-dundia	Leaves, no significant taste but flavours	May-August
Lippia javanica (Burm.f.) Spreng	Verbenaceae	Ontaibajab	Young leaves, no significant taste but flavours	March-June
Polygonum perfoliatum L.	Polygonaceae	Mwitasikla	Young leaves & shoot, sour	March-June
Enhydra fluctuans Lour.	Asteraceae	Alangshi	Whole plants, bitter	March-July

II.2.11 Statistical analysis

All the experiments were carried out for three independent replicates. The results were presented per 100 g of fresh weight in terms of mean ± standard deviation. OriginPro 8.5 software (MA 01060, OriginLab Corporation, USA) was used for statistical analysis and executed by the one-way ANOVA *t*-test at $p < 0.05$.

II.3 Results and Discussion

The use of wild edible plants as vegetables and medicinal purposes by various indigenous people in Assam is very common. They try to fulfil their daily requirements of food and nutrition from the nature. In this study, a total of seventeen wild edible plants have been selected which belongs to twelve different families. The botanical name, family, vernacular name in Bodo, parts used, taste, time of availability of selected wild plants are presented in **Table II.1** and it has been found that all the aerial parts of the selected plants are eaten as vegetable. Likewise, the proximate compositions of the wild edible plants studied are given in the **Table II.2** in which the moisture content, ash content, crude fat content, crude fibre content, crude protein content, total carbohydrate content and total calorific values were specified. The proximate composition was expressed in g/100 g of fresh weight (FW), whereas the total calorific value was expressed in kcal/100 g of FW. The proximate compositions of all these selected wild vegetables are significantly different from each other at $p < 0.05$.

It is seen in the **Table II.2** that the moisture content of each plant species is more than 80% which ranges from 81.96 ± 0.45 g to 92.89 ± 0.44 g per 100 g fresh weight (FW) of plant sample. The moisture content was found to be the highest in *C. hirsuta* (92.89 ± 0.44 g/100 g FW) and the lowest in *C. sinensis* (81.96 ± 0.45 g/100 g FW). However, more than 90% of moisture contents were also found in the six samples *viz. S. zeylanica, C. hirsuta. S. peguensis, O. javanica, S. media* and *P. chinensis.* The moisture content was found to be similar to the values of some underutilized green leafy vegetables reported by Saha *et al*. [47] and Gupta *et al.* [48]. The moisture content varies due to the environmental factors such as humidity, temperature, soil type, their habitat and harvest time of the sample. Higher moisture content affords greater activity of water soluble enzyme and co-enzyme needed for metabolic activity of leaves [49]. Moreover, the moisture of the green vegetables is considered as an excellent source of

water and 20% of total water required by the body is fulfilled by these vegetables [50]. Thus the higher moisture content signifies the most refreshing vegetable.

Table II.2: Proximate analysis of wild edible plants per 100 g of fresh weight (FW)

Plants	Moisture (g)	Ash (g)	Crude fat (g)	Crude fibre (g)	Crude protein (g)	Carbohy-drate (g)	Calorific value (kcal)
Sz	92.81±0.64^{a}	1.41±0.01^{a}	0.12±0.11^{a}	1.25±0.21^{a}	3.08±0.01^{a}	2.55±0.63^{a}	23.70±2.54^{a}
Ch	92.89±0.44^{a}	1.78±0.07^{a}	0.24±0.01^{a}	1.64±0.01^{a,b}	3.99±0.21^{b}	1.70±0.51^{b}	22.45±2.06^{b}
Nh	83.72±2.36^{b}	3.42±0.04^{b}	0.67±0.01^{a}	1.99±0.03^{b,c}	5.37±0.05^{c}	6.80±2.40^{c}	54.72±9.61^{c}
Bl	88.87±0.52^{c}	1.96±0.00^{a,c}	0.31±0.01^{a}	1.23±0.00^{a}	1.84±0.01^{d}	7.00±0.52^{d}	38.24±2.08^{d}
Sp	90.89±2.22^{d}	2.35±0.12^{d}	0.25±0.03^{a}	1.92±0.07^{b,c}	3.18±0.01^{a}	3.32±2.23^{e}	28.30±8.91^{e}
Ta	87.46±0.71^{e}	1.15±0.00^{a}	0.52±0.01^{a}	1.28±0.01^{a}	1.86±0.01^{d}	8.99±0.71^{f}	48.13±2.84^{f}
Oj	90.44±0.26^{d}	1.60±0.00^{a}	0.16±0.00^{a}	1.07±0.01^{a}	1.22±0.01^{e}	6.55±0.26^{c}	32.61±1.03^{g}
Mp	82.83±1.30^{f}	0.66±0.01^{e}	0.21±0.22^{a}	3.03±0.02^{d}	2.64±0.13^{f}	13.64±1.32^{g}	67.03±5.23^{h}
Dc	89.23±0.04^{g}	2.71±0.00^{d}	0.16±0.00^{a}	1.19±0.00^{a}	2.58±0.01^{f}	5.29±0.04^{h}	33.00±0.19^{i}
Cs	81.96±0.45^{h}	1.97±0.00^{c}	0.64±0.00^{a}	2.67±0.01^{e}	2.92±0.00^{f}	12.48±0.45^{i}	67.42±1.82^{h}
Sm	90.84±0.16^{d}	2.09±0.00^{c,d}	0.24±0.00^{a}	3.44±0.01^{d}	1.83±0.01^{d}	4.97±0.02^{j}	29.48±0.12^{j}
Pc	92.35±0.61^{a}	1.58±0.11^{a}	0.33±0.02^{a}	2.57±0.52^{e}	3.66±0.22^{b}	2.07±0.61^{a}	25.93±2.43^{k}
Aa	87.57±0.96^{e}	1.32±0.00^{a}	0.70±0.00^{a}	1.19±0.01^{a}	1.47±0.01^{e}	8.92±0.96^{f}	47.96±3.67^{l}
Efo	87.24±0.53^{e}	1.44±0.07^{a}	0.33±0.00^{a}	1.19±0.01^{a}	2.09±0.13^{f}	8.87±0.63^{f}	46.90±2.03^{m}
Lj	84.53±1.40^{i}	3.15±0.00^{b}	0.27±0.01^{a}	2.63±0.00^{e}	4.38±0.01^{b}	7.65±1.39^{d}	50.64±5.63^{n}
Pp	85.23±0.32^{j}	1.37±0.00^{a}	0.76±0.00^{a}	6.80±0.01^{f}	3.38±0.00^{a}	9.23±0.32^{f}	57.38±1.29^{o}
Ef	89.28±0.60^{g}	1.51±0.00^{a}	0.51±0.02^{a}	1.11±0.00^{a}	1.39±0.00^{e}	7.29±0.58^{d}	39.38±2.55^{p}

Sz = S. zeylanica, Ch = C. hirsuta, Nh = N. herpeticum, Bl = B. lanceolaria, Sp = S. peguensis, Ta = T. angustifolium, Oj = O. javanica, Mp = M. perpusilla, Dc = D. cordata, Cs = C. sinensis, Sm = S. media, Pc = P. chinensis, Aa = A. acidum, Efo = E. foetidum, Lj = L. javanica, Pp = P. perfoliatum and Ef = E. fluctuans. Values were expressed as mean of three replicates ± standard deviation and the data with different letters in a column are significantly different from each other at $p < 0.05$.

The total ash content of the sample gives the indirect measurement of minerals in a food item and in the present study it ranges from 0.66 ± 0.01 g to 3.42 ± 0.04 g/100 g FW. The highest ash content was found in *N. herpeticum* (3.42 ± 0.04 g/100 g FW) and the lowest ash content was found in *M. perpusilla* as 0.66 ± 0.01 g/100 g FW. High ash content was also found in *S. peguensis, D. cordata, S. media,* and *L. javanica* which were 2.35 ± 0.12, 2.71 ± 0.00, 2.09 ± 0.00, and 3.15 ± 0.00 g/100 g FW, respectively. All the selected plant species were found to contain poor amount of crude fat which is

below 1 g/100 g FW and the value ranges from 0.12 ± 0.11 g to 0.76 ± 0.00 g/100 g FW in *S. zeylanica* and *P. perfoliatum*, respectively. Similar fat content was observed in *N. herpeticum, T. angustifolium, C. sinensis, A. acidum* and *E. fluctuans* as 0.67 ± 0.01, 0.52 ± 0.01, 0.64 ± 0.00, 0.70 ± 0.00 and 0.51 ± 0.02 g/100 g FW, respectively. The ash and crude fat contents were compared with the works of Odhav *et al*. [51] and Gupta *et al*. [48] and the result of current study were found to be similar to their works. Similar values were also reported in American wild edible plants and some edible species of Asteraceae family as reported by Phillips *et al.* [52] and Garcia-Herrera *et al*. [53] respectively. Dietary fat is important as it provides energy and fat soluble vitamins because it dissolves many vitamins and make available to the health [52]. It is found from the **Table II.2** that *N. herpeticum* has the highest protein content of 5.37 ± 0.05 g/100 g FW and the lowest was observed in *O. javanica* (1.22 ± 0.00 g/100 g FW). The higher protein content was also found in some of the samples like *S. zeylanica, C. hirsuta, P. chinensis, L. javanica* and *P. perfoliatum* as 3.08 ± 0.01, 3.99 ± 0.21, 3.66 ± 0.22, 4.38 ± 0.01 and 3.38 ± 0.00 g/100 g FW, respectively. These values were also found to be similar to the crude protein content of some underutilized vegetables reported by Gupta *et al*. [48]. Thus, the selected wild vegetables are not good sources of proteins (1.22 ± 0.00 to 5.37 ± 0.05 g/100 g FW) which are obtained based on the amount of total Kjeldhal nitrogen content multiplied by the conversion factor of 6.25 [44]. As proteins are the most essential components of food that provide adequate amount of amino acids and play an important role in all biochemical, and physiological processes [54]. Our findings also agree with the results of some non-conventional vegetables [52, 53]. The fibre content varied from 1.07 ± 0.00 g/100 g FW in *O. javanica* to 6.80 ± 0.01 g/100 g FW in *P. perfoliatum*. These values are in accordance with the results reported by Saha *et al*. [47], Phillips *et al.* [52], Garcia-Herrera *et al.* [53] and Gupta *et al.* [48]. Fibres in the food are necessary for digestion and effective elimination of wastes. Fibres can lower the risk of coronary heart disease, serum cholesterol, hypertension, diabetes, constipation, colon and breast cancer [55-57]. Thus, the consumption of these vegetables can potentially increase the dietary fibre intake in the poor family of rural areas. Total carbohydrate content was found the highest in *M. perpusilla* (13.64 ± 1.32 g/100 g FW) and the lowest in *C. hirsuta* (1.70 ± 0.51 g/100 g FW). It was also found that *T. angustifolium, C. sinensis, A, acidum, E. foetidum* and *P. perfoliatum* have a promising source of carbohydrate as 8.99 ± 0.71 g, 12.48 ± 0.45 g, 8.92 ± 0.96 g, 8.87 ± 0.63 g and 9.23 ± 0.32 g/100 g of FW respectively. Saha *et al*. [47] reported the carbohydrate contents of some leafy vegetables of Assam (India) ranged

from 11.16 g to 5.45 g/100 g FW which is very similar to the results of our findings. Similar results of total carbohydrate contents were also reported in wild edible herbs [58] and some edible species of Asteraceae family [53]. The higher carbohydrate content indicates higher energy content in the food which can provide sufficient energy responsible for doing several activities in one's daily life [59]. The carbohydrate, fat and proteins are the main sources of the total energy or calorific value of food. In the present study, the calorific value per 100 g of the fresh sample ranged from 22.45 ± 2.06 kcal (*C. hirsuta*) to 67.42 ± 1.82 kcal (*C. sinensis*). High calorific values were also found in *N. herpeticum, T. angustifolium, M. perpusilla, A. acidum, E. foetidum, L. javanica* and *P. perfoliatum* as 54.72 ± 9.61, 48.13 ± 2.84, 67.03 ± 5.23, 47.96 ± 3.67, 46.90 ± 2.03, 50.64 ± 5.63 and 57.38 ± 1.29 kcal/100 g FW, respectively. Similarly, Ullah *et al.* [60] reported the similar calorific values in some selected medicinal plants. Similar value of energy was also reported in some American wild edible plants [52]. The plants with a higher calorific value can be considered as a nutritious food. The high calorific value suggests that these wild edible plants can be used in the formulation of various dietary supplements. The results of proximate composition of our study were also closely related to the nutrient contents of African leafy vegetables reported by Jaarsveld *et al.* [61]. However, higher levels of the proximate compositions were reported in *B. lanceolaria, D. cordata,* and *L. javanica* except moisture content [62] in comparison to that of current study. The proximate food composition of *E. fluctuans* reported by the Satter *et al.* [63] is also similar to our findings.

II.4 Conclusion

In this study, all the selected wild plants were found to contain varying proximate compositions. *C. sinensis* was found to contain the highest calorific value (67.42 ± 1.82 kcal/100 g FW) due to higher contents of carbohydrate (12.48 ± 0.45 g/100 g FW), fat (0.64 ± 0.00 g/100 g FW) and protein (2.92 ± 0.00 g/100 g FW). *M. perpusilla, P. perfoliatum, N. herpeticum* and *L. javanica* were also found to contain higher amount of calorific values as 67.03 ± 5.23, 57.38 ± 1.29, 54.72 ± 9.61, and 50.64 ± 5.63 kcal/100 g FW, respectively. Thus, these wild plants can be considered rich sources of energy and consumption of these plants can meet the daily nutritional requirements which can eliminate the malnutrition problems.

References

[1] Chipurura B. Wild leafy vegetables consumed in Buhera district of Zimbabwe and their phenolic compounds content. *Ecol. Food. Nutr.* 2013; 52: 178–189.

[2] Narzary H, Brahma S, Basumatary S. Wild edible vegetables consumed by Bodo tribe of Kokrajhar District (Assam), North- East India. *Archives of Applied Science Research* 2013; 5(5): 182–190.

[3] Saikia P, Deka DC. Mineral content of some wild green leafy vegetables of North-East India. *Chem. Pharm. Res.* 2013; 5(3): 117–121.

[4] Aregheore EM. Nutritive value and inherent anti-nutritive factors in four indigenous edible leafy vegetables in human nutrition in Nigeria: A review. *J. Food Resour. Sci.* 2012; 1(1): 1-14.

[5] Gowri J, Sahayaraj AP, Amaladasan M. Antimicrobial activity of the leaf, flower and stem extracts of *Sphenoclea zeylanica*. *Int. J. Appl. Sci. Biotech.* 2016; 4(3): 325–329.

[6] Ramesha BT, Suma HK, Senthil KU, Priti V, Ravikanth G, Vasudeva R, Kumar TRS, Ganeshaiah KN, Uma Shaanker R. New plant sources of the anti-cancer alkaloid, camptothecine from the *Icacinaceae taxa*, India. *Phytomedicine* 2013; 20: 521– 527.

[7] Mishra VK, Pasari AK, Vanlalhmangaihi K, Kumar NS, Shing BP. Antimicrobial and antioxidant activities of *Blumea lanceolaria* (Roxb.). *J. Med. Plant Res.* 2015; 9(4): 84–90.

[8] Junejo JA, Mondal P, Verma VK, Rudrapal M, Zaman MK. Anti-diabetic assessment of the hydro-alcoholic leaf extracts of the plant *Tetrastigma angustifolia* (Roxb.), a traditionally used North-Eastern Indian vegetable. *Biomedical and Pharmacology Journal* 2014; 7(2): 635–644.

[9] Jiang Q, Wang F, Li MY, Ma J, Tan GF, Xiong AS. Selection of suitable reference genes for qPCR normalization under abiotic stresses in *Oenanthe javanica* (BI.) DC. *PLoS One* 2014; 9: 922–962.

[10] Kwon D, Yoon S, Carter O, Bailey GS, Dashwood RH. Antioxidant and antigenotoxic activities of *Angelica keiskei*, *Oenanthe javanica* and *Brassica oleracea* in the *Salmonella* mutagenicity assay and in HCT116 human colon cancer cells. *Biofactors* 2006; 26: 231–244.

[11] Han YQ, Huang ZM, Yang XB, Liu HZ, Wu G. *In vivo* and *in vitro* anti-hepatitis B virus activity of total phenolics from *Oenanthe javanica*. *J. Ethnopharmacol.* 2008; 118: 148–153.

[12] Kim JY, Kim KH, Lee YJ, Lee SH, Park JC, Nam DH. *Oenanthe javanica* extract accelerates ethanol metabolism in ethanol-treated animals. *BMB Rep.* 2009; 42: 482–485.

[13] Yang SA, Jung YS, Lee SJ, Park SC, Kim MJ, Lee EJ, Hepatoprotective effects of fermented field water-dropwort (*Oenanthe javanica*) extract and its major constituents. *Food Chem Toxicol.* 2014; 67: 154–160.

[14] Howard M. Traditional folk remedies: A comprehensive herbal. *Century Hutchinson*, London, 1987.

[15] Bordoloi M, Bordoloi PK, Dutta PP, Singh V, Nath S, Narzary B, Bhuyan PD, Rao PG, Barua IC. Studies on some edible herbs: Antioxidant activity, phenolic content, mineral content and antifungal properties. *J. Func. Foods* 2016; 23: 220–229.

[16] Slavokhotova AA, Odintsova TI, Rogozhin EA, Musolyamov AK, Andreev YA, Grishin EV, Egorov TA. Isolation, molecular cloning and antimicrobial activity of novel defensins from common chickweed (*Stellaria media* L.) seeds. *Biochimie.* 2011; 93: 450–456

[17] Abbasi AM, Shah MH, Li T, Fu X, Guo X. Ethnomedicinal values, phenolic contents and antioxidant properties of wild culinary vegetables. *J. Ethnopharmacol.* 2015; 162: 333–345.

[18] Barua CC, Barua AG, Roy JD, Buragohain B, Borah P. Studies on the anti-inflammatory properties of *Drymaria cordata* Leaf Extract. *Indian J. Anim. Sci.* 2010; 80: 1268–1270.

[19] Mukherjee PK, Bhattacharya S, Saha K, Giri SN, Pal M, Saha BP. Antibacterial evaluation of *Drymaria cordata* Willd (Caryophyllaceae) extract. *Phytother. Res.* 1998; 11: 249–250.

[20] Sowemimo A, Van-de-Venter M, Baatjies L, Koekemoer T. Cytotoxic activity of selected Nigerian plants. *Afr. J. Tradit. Complement. Altern. Med.* 2009; 6: 526–528.

[21] Barua, CC, Roy JD, Buragohain B, Barua AG, Borah P, Lahkar M. Anxiolytic activity of hydro-ethanolic extract of *Drymaria cordata* Willd. *Indian J. Exp. Biol.* 2009; 47: 969–973.

[22] Akindele AJ, Ibe IF, Adeyemi OO. Analgesic and antipyretic activities of *Drymaria cordata* (Linn.) Wild (Caryophyllaceae) Extract. *Afr. J. Tradit. Complement. Altern. Med.* 2012; 9: 25–35.

[23] Barua CC, Pal SK, Barua AG, Roy JD, Buragohain B, Bora RS, Lahon LC. Analgesic activity of methanolic extract of *Drymaria cordata* Willd (Caryophyllaceae). Pharmacologyonline 2009; 2: 470–476.

[24] Khan MH, Yadava PS. Anti diabetic plants used in Thoubal district of Manipur, Northeast India. *Indian J. Trad. Knowledge* 2010; 9 (3): 510–514.

[25] Ramcharan C. Culantro: A much utilized, little understood herb, in perspectives on new crops and new uses, Janick J. *ASHS Press*, Alexandria 1999; 506–509.

[26] Paul JHA, Seaforth CE, Tikasingh T. *Eryngium foetidum* L.: A review *Fitoterapia* 2011; 82(3): 302–308.

[27] Yarnell A. Home field advantage, Chemical & Engineering News 2004; 82(23): 33.

[28] Lingaraju DP, Sudarshana MS, Mahendra C, Rao PK. Phytochemical screening and antimicrobial activity of leaf extracts of *Eryngium foetidum* L. (Apiaceae). *Indo. Am. J. Pharm. Res.* 2016; 6(2): 4339–4344.

[29] Saenz MT, Fernandez MA, Garcia MD. Anti-inflammatory and analgesic properties from leaves of *Eryngium foetidum* L. (Apiaceae). *Phytother Res.* 1997; 11(5): 380–383.

[30] Bhebhe M, Chipurura B, Muchuweti M. Determination and comparison of phenolic compound content and antioxidant activity of selected local Zimbabwean herbal teas with exotic *Aspalathus linearis*. *South Afr. J. Bot.* 2015. 100, 1: 213–218.

[31] Patiri B, Borah A. Wild Edible Plants of Assam. *Geetakhi Printers*, Guwahati, India, 2007.

[32] Narzary H, Basumatary A, Basumatary S. Proximate and vitamin C analysis of wild edible plants consumed by Bodos of Assam, India. *Journal of Molecular Pathophysiology* 2015; 4(4): 128–133.

[33] Narayana VL, Narasimharao GM. Plants used in ethnoveterinary medicine by tribal of Visakhapatnam and Vizianagarm districts, Andhra Pradesh, India. *Int. J. Pure Appl. Biosci.* 2015; 3(2): 432–439.

[34] Coopoosamy RM, Naidoo KK. An ethno-botanical study of medicinal plants used by traditional healers in Durban, South Africa. *Afr. J. Pharm. Pharmacol.* 2012; 6(11): 818–823.

[35] Afolayan AJ, Grierson DS, Mbeng WO. Ethno botanical survey of medicinal plants used in the management of skin disorders among the Xhosa communities of the Amathole District, Eastern Cape, South Africa. *J. Ethnopharmacol.* 2014; 153(1): 220–232.

[36] Wang KW, Zhu JR, Shen LQ. A new lignin with antitumor activity from *Polygonum perfoliatum* L. *Nat. Prod. Res.* 2013; 27: 568–573.

[37] Huang HF, Zhang CC, Yuan D, Zhou ZY. Anti-inflammatory and antibacterial effects of *Polygonum perfoliatum* L. *Anhui Medical and Pharmaceutical J.* 2008; 12: 595–596.

[38] Fu YX, He XR, Li JC, Liu XX. Study of chemical constitution and antibacterial effect of herb *Polygonum perfoliatum* L. *Progress in Veterinary Medicine* 2008; 29: 45–49.

[39] Pradhan DS. Natural flavonoids isolated from the leaves of *Enhydra fluctuans* inhibits cyclooxygenase-2 and 5-lipooxygenase inflammation in various models. *Int. J. Res. in Pharmacology & Pharmacotherapeutics* 2012; 1(1): 2278–2648.

[40] Ullah MO, Haque M, Urmi KF, Zulfiker AHM, Anita ES, Begum M. Antibacterial activity and brine shrimp lethality bioassay of methanolic extracts of fourteen different edible vegetables from Bangladesh. *Asian. Pac. J. Trop. Biomed.* 2013; 3(1): 1–7.

[41] Rahmatullah M, Azam NK, Khatun Z, Seraj S, Islam F, Rahman A. Medicinal plants used for the treatment of diabetes by the Marakh sect of the Garo tribe living in Mymensingh district, Bangladesh. *Afr. J. Tradit. Complement. Altern. Med.* 2012; 9(3): 380–385.

[42] Sannigrahi S, Majumdar UK, Pal DK, Mondal A, Roy S. Hepatoprotective potential of flavonoid rich fraction of *Enhydra fluctuans* against CCl_4 –induced oxidative damage in rats. *PhOL* 2009; 2: 575–586.

[43] Rahman MT, Begum N, Alimuzzamum M, Khan MOF. Analgesic activity of *Enhydra fluctuans*. *Fitoterapia* 2002; 73(7-8): 707–709.

[44] AOAC. Official Methods of Analysis. 17th edn. Association of Official Analytical Chemists. Inc. Virginia, USA 2000.

[45] James CS. Analytical Chemistry of Foods, 1st edn. Chapman and Hall, New York 1995.

[46] Food and agriculture organization of the United Nations. Food energy-methods of analysis and conversion factors. FAO Food and Nutrition paper 77. Rome, Italy 2003.

[47] Saha J, Biswal AK, Deka SC. Chemical composition of some underutilized green leafy vegetables of Sonitpur district of Assam, India. *Inter. Food Res. J.* 2015; 22(4): 1466–1473.

[48] Gupta S, Lakshmi AJ, Manjunath MN, Prakash J. Analysis of nutrient and anti-nutrient content of underutilized green leafy vegetables. *Food Sci. Technol.* 2005; 38: 339–345.

[49] Badau MH, Abba HZ, Agbara GI, Yusuf AA. Proximate composition, mineral content and acceptability of granulated maize dumpling (*Dambu masara*) with varying proportions of ingredients. *Global Adv. Res. J. Agric. Sci.* 2013; 2(1): 320–329.

[50] Food and Nutrition Board. Dietary reference intakes for water, potassium, sodium, chloride, and sulfate. Washington DC: The National Academies Press 2005; 77–185.

[51] Odhav B, Beekrumb S, Akula U, Baijnath H. Preliminary assessment of nutritional value of traditional leafy vegetables in KwaZulu-Natal, South Africa. *J. Food Comp. Anal.* 2007; 20: 430–435.

[52] Phillips KM, Pehrsson PR, Agnew WW, Scheett AG, Follett JR, Lukaski HC, Patterson KY. Nutrient composition of selected traditional United States Northern Plains Native American plant foods. *J. Food Comp. Anal.* 2014; 34: 136–152.

[53] Garcia HP, Sanchez MMC, Camara M, Fernandez RV, Diez-MC, Molina M, Tardio J. Nutrient composition of six wild edible Mediterranean Asteraceae plants of dietary interest. *J. Food Compost. Anal.* 2014; 34: 163–170.

[54] Vincentea AR, Manganarisb GA, Ortiza CM, Sozzic GO, Crisostod CH. Nutritional quality of fruits and vegetables. *Postharvest Handling* 2014; 69–122.

[55] Rehman NU, Hussain J, Ali L, Khan AL, Mabood F, Gillani SA, Harrasi AA. Nutritional assessment and mineral composition of some selected edible vegetables. *European J. Med. Plants* 2014; 4(4): 444–457.

[56] Vadivel V, Janardhanan K. Nutritional and anti-nutritional characteristics of seven South Indian wild legumes. *Plant Foods Hum. Nutr*. 2005; 60: 69–75.

[57] Ishida H, Suzuno H, Sugiyama N, Innami S, Todokoro T, Maekawa A. Nutritional evaluation of chemical component of leaves stalks and stems of sweet potatoes (*Ipomoea batatas*). *Food Chem.* 2000; 68: 359–367.

[58] Vishwakarma KL, Dubey V. Nutritional analysis of indigenous wild edible herbs used in Eastern Chattisgarh, India. *Emir. J. Food Agric.* 2011; 23(6): 554–560.

[59] Yisa J, Egila JN, Darlinton AO. Chemical composition of *Annona senegalensis* from Nupe land, Nigeria. *Afr. J. Biotechnol.* 2010; 9(26): 4106–4109.

[60] Ullah Z, Baloch MK, Baloch IB, Bibi F. Proximate and nutrient analysis of selected medicinal plants of Tank and South Waziristan area of Pakistan. *Middle-East J. Sci.* 2013; 13(10): 1345-1350.

[61] Jaarsveld PV, Faber M, Heerden IV, Wenhold F, Rensburg WJV, Averbeke WV. Nutrient content of eight African leafy vegetables and their potential contribution to dietary reference intakes. *J. Food Comp. Anal.* 2014; 33: 77–84.

[62] Brahma J, Singh B, Rethy P, Gajurel P. Nutritional analysis of some selected wild edible species consumed by the Bodos Tribes of Kokrajhar district, BTC, Assam. *Asian J. Pharm. Clin. Res*. 2014; 7(3): 34–37.

[63] Satter MMA, Khan MMRL, Jabin SA, Abedin N, Islam MF, Shaha B. Nutritional quality and safety aspects of wild vegetables consume in Bangladesh. *Asian Pac. J. Trop. Biomed.* 2016; 6(2): 125–131.