INTRODUCTION

Food and medicine represent a continuum rather than artificial categories; Overlapping nature of traditional food system and medicine lead to the investigation of phytochemicals that explains the food culture and health outcomes [1]. Any of the edible wild plants that are included in local food baskets have both therapeutic and dietary functions and such medicinal foods have been part of Eastern Medicinal theories since ancient times; In Traditional Chinese Medicine also the concept of food as medicine is based on the same basic theories and they are vice-versa[2,3]. North Eastern States of Eastern Himalayas is rich in biodiversity [4,5], because of diverse ethnic groups, the region is equally rich in culture, traditional practices and customs. These people have rich knowledge on the utility of plant resources including herbal remedy; the region has many dimensions in food habits and flavour [6]. The shoot of Solanum spirale is used as food as well as medicine by the tribal people in Eastern Himalayan region; as a medicine, it is use to lower down high blood pressure, loose motion and stomach pain, tender shoot is steam cooked as vegetable and berry is use as appetizer. The present study was selected to discourse the phytochemicals and proximate composition of Solanum spirale. This herb also grows commonly in North East India, China and Thailand. It blooms with spirally arranged white flower and berries are orange on ripe. Bark, leaf and berry tastes bitter. S. spirale has been reported to be an antioxidant potential herb [7]. The herb is also use as anti-tussive and anti-inflammatory agent historically [8]. Primary metabolites like proximate composition and minerals in a diet play vital role in promoting health growth and development; Minerals regulate cell function in more than one way; they are constituents of skeletal structures, they maintain colloidal state of the body matter and regulate acid base equilibrium, diffusion, and osmotic pressure and they are components or an activator of enzymes. Proximate composition of a diet provides energy, protein and other requirements of a body for healthy growth and development; secondary metabolites help in the remedy of various health problems and work as a nutraceutical food. With

Proximate composition and GC-MS analysis of ethanol extract of Solanum spirale Roxb.

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ABSTRACT

Solanum spirale Roxb. is abundantly grown in eastern Himalayan regions. The shoot is used as a vegetable as well as medicine to control high blood pressure. The present study was carried out to profile the phytochemical compositions, mineral contents and proximate composition of the Solanum spirale shoot. GC-MS was used for the identification of phytochemicals and methods described in standard protocols were used to study minerals and proximate composition. A total of 40 phytochemicals were recorded from the ethanol extract. Mineral contents of the sample 0.115 (Fe), 0.07 (Mn), 0.015 (Cu), 0.040 (Zn), 2.25 (Mg), 3.08 (Na) and 16.7 (K) mg/g while proximate composition were 76.25± 0.093 % (moisture)3.82±0.26 % (Carbohydrate), 12.54±0.08% (Total ash), 0.39±0.98% (Crude protein), 6.12±1.07 % (Crude fibre), 0.37±0.07 % (Crude fat). (Z,Z)-6,9-Cis-3,4-epoxy-nonadecadiene occupied highest area percentage in TIC peak report with 24.55%, followed by Pentadecanoic acid with 18.81 percent, with Pentadecane with 9.99%, Hexadecanoic acid, Ethyl ester with 8.64%, (2E)(7R,11R)-3,7,11,15-Tetramethylhexadec-2-en-1-ol with 7.75%. Useful phytocompounds related to health problems including anticancer, anti-inflammatory, antioxidant, antitumor, cardioprotective, hypocholesterolemic, increase zinc bioavailability, inhibit uric acid formation, antibacterial, anti-inflammatory, antioxidant etc. are major components and such findings advocate Solanum spirale as a nutraceutical herb.

KEYWORDS: Medicinal food plant, Phytochemicals, High Blood Pressure, Proximate composition, Minerals
the above backdrops, the present research was taken up to study the proximate composition, phytoconstituents and minerals present in Solanum spirale shoot.

**MATERIAL AND METHODS**

**Sample Collection and Preparation**

Solanum spirale shoots were collected from Rening Village of Arunachal Pradesh, India. The herbarium was deposited in the Department of Botany, JN.College herbarium section with voucher number JNCTP/SOL/092019. The sample was washed thoroughly in distilled water and dried in shade till the weight did not change further; and pulverized into powder, using a mechanical grinder. 500g sample powder was subjected to Soxhlet apparatus in ethanol solvent, the slurry extract collected from rotary evaporator was used in the GC-MS analysis.

**Proximate and Minerals Studies**

For moisture study, fresh collected sample was used before drying. The following standard methods were followed in the proximate and minerals studies [9,10,11]. Ash content was determined in silica crucibles by incineration in a muffle furnace at 550°C for 5 hrs. Crude lipid was extracted by continuous Soxhlet extraction with petroleum ether (40-60°C). Crude fibre content was estimated by acid-base digestion with 1.25% H₂SO₄ and 1.25% NaOH solution. Nitrogen was estimated by KjeldelcMethod with steam distillation and titrated with standard 0.01 M HCl solution. Crude protein content was estimated by multiplying the sample per cent nitrogen content by a factor 6.25. (% protein = % nitrogen X 6.26). Carbohydrate was estimated by Anthrone Method with an ultraviolet-visible (UVVis) spectrophotometer (Lamda-25, Perkin Elmer, Cambridge UK). Minerals were analysed from solution obtained when 1.0g of the samples were digested with concentrated 10ml nitric acid and kept overnight and heated till fumes of HNO₃, soxhlet apparatus in ethanol solvent, the slurry extract collected from rotary evaporator was used in the GC-MS analysis.

**Phytochemicals Studies**

To study phytochemical compositions, All the solvents used were purchased from Merck Company analytical grade. GC-MS: Gas-Chromatography Mass Spectrometry (GC-MS) analyses of the each extract were carried out in Shimadzu GCMS-QP-2010 plus system. RTx-5 Sil MS column (30 m X 0.25 mm id X 0.25 film thickness) was used for the analysis. The operating conditions of the column were as follows: oven temperature program from 50°C to 210°C at 4°C/min with hold time of 2 min and from 210°C to 300°C at 15°C/min with hold time of 5 min, and the final temperature was kept for 20 min. The injector temperature was maintained at 270°C, the volume of injected sample was 0.3ul; pressure 85.4KPa, total flow 76.8mL/min, column flow 1.21 mL/min, linear velocity 40.5 cm/sec, purge flow 3.0 mL/min, split ratio: 60.0; ion source temperature 230°C, scan mass range of m/z 40-600 and interface line temperature 280°C. The identification of compounds was performed by comparing their mass spectra with data from NIST05 (National Institute of Standards and Technology, US) and WILEY 8.

**RESULTS**

A total of forty compounds (Figure 1) were identified (Table 1) from the ethanol extract and adequate mineral contents and proximate composition from Solanum spirale shoot was recorded; In the compound table, (Z,Z)-6,9-

| Peak  | RT   | Area % | Name of the compound                                                                 |
|-------|------|--------|--------------------------------------------------------------------------------------|
| 1     | 4.860| 1.05   | 2-Pyrrolidinone, 1-methyl-                                                             |
| 2     | 6.484| 0.62   | 2,3-Dihydro-3,5-dihydroxy-6-methyl-4h-pyran-4-one                                     |
| 3     | 7.124| 0.14   | 1-Tridecene                                                                           |
| 4     | 9.961| 0.35   | 1-Tetradecene                                                                        |
| 5     | 10.091| 0.38  | alpha-Tetradecene                                                                    |
| 6     | 11.876| 0.15  | 2(4H)-Benzo furanone, 5,6,7,7a-tetrahydro-4,4,7a-trimethyl-                           |
| 7     | 12.248| 0.17   | Fumaric acid, ethyl 2-isopropylphenyl ester                                          |
| 8     | 12.461| 0.52   | Phthalic acid                                                                         |
| 9     | 13.238| 0.49   | Piperidine, 1-(1-cyclopenten-1-YL)                                                   |
| 10    | 13.447| 0.33   | 5-Hydroxymethyl-1,3,3-trimethyl-2-(3-methyl-buta-1,3-dienyl)-cyclopentanol            |
| 11    | 13.578| 0.22   | Santalol, cis, alpha-                                                                |
| 12    | 13.647| 0.26   | Spiro-10-(2,11-dioxabicyclo[4.4.1]undeca-3,5-diene)-2’-(oxirane), 1,3,7,7-tetramethyl-|
| 13    | 14.307| 0.18   | 6-(1-Hydroxyethyl)-2-iodo-4-oxatri cyclo[4.2.1.0(3,7)]nonan-5-one                    |
| 14    | 14.597| 0.11   | Benzyl Benzoate                                                                      |
| 15    | 14.637| 0.22   | Calcin                                               |
| 16    | 15.223| 0.82   | 2,6,10-Trimethyl-14-ethylenec-14-pentadecane                                          |
| 17    | 15.479| 0.31   | Cyclopropanenonic acid, 2-(2-butylocyclopentyl)methyl)-, methyl ester                  |
| 18    | 15.674| 0.48   | 3,7,11,15-Tetramethylhexadec-2-en-1-ol                                                |
| 19    | 16.543| 0.81   | Pentadecanonic acid                                                                  |
| 20    | 16.714| 0.16   | Ethyl 9-hexadecanoate                                                                 |
| 21    | 16.797| 8.64   | Hexadecanonic acid, ethyl ester                                                      |
| 22    | 17.746| 0.17   | Heptadecanonic acid, ethyl ester                                                     |
| 23    | 17.938| 7.75   | (2E)(7R,11R)-3,7,11,15-Tetramethylhexadec-2-en-1-ol                                   |
| 24    | 18.240| 24.55  | (Z,Z)-6,9-CIS-3,4-Epoxy-monodecadiene                                                  |
| 25    | 18.381| 3.75   | Ethyl (9z,12z)-9,12-octadecadienoate                                                  |
| 26    | 18.435| 0.99   | Dichloroacetic acid, tridec-2-ynyl ester                                              |
| 27    | 18.489| 0.38   | 9-Octadecanonic Acid (Z)-                                                            |
| 28    | 18.669| 4.56   | Octadecanonic acid, ethyl ester                                                      |
| 29    | 18.961| 0.44   | 1,3,3-tricarbocatriene                                                                |
| 30    | 20.295| 0.79   | 9-Octadecanonic acid (Z)-                                                            |
| 31    | 20.465| 0.96   | 1,3-Cyclopentanediene, 4-hydroxy-2-pentyl-                                           |
| 32    | 20.611| 0.79   | Heptadecanonic acid, ethyl ester                                                     |
| 33    | 23.457| 0.51   | Ethy l                                                                 |
| 34    | 25.158| 0.22   | Octadecanonic acid, ethyl ester                                                      |
| 35    | 26.357| 0.22   | Heptadecanone                                                                      |
| 36    | 26.567| 2.07   | Squaleine                                                                             |
| 37    | 29.844| 3.39   | gamma-Tocopherol                                                                      |
| 38    | 31.249| 2.13   | dl-alpha-Tocopherol                                                                   |
| 39    | 33.896| 1.07   | Stigmaster-5,22-dien-3-ol                                                             |
| 40    | 35.436| 1.89   | Stigmaster-5-en-3-ol, (3.beta.).-                                                   |

**Table 1: Chemical composition of ethanol extract of Solanum spirale**
Table 2: Biological activity of the identified compounds

| Name of the compounds | Biological activity                                                                 |
|-----------------------|-------------------------------------------------------------------------------------|
| 2-Pyrrolidinone, 1-methyl- |                                                                                      |
| 2,3-DIHYDRO-3,5-DIHYDROXY-6-METHYL-4H-PYRAN-4-ONE alpha.-Tetradecene             |
| 2(4H)-BENZOFURANONE, 5,6,7,7A-TETRAHYDRO-4,4,7A-TRIMETHYLCYCLOPENTANE ESTER     |
| Fumaric acid, ethyl 2-isopropylphenyl ester                                    |
| PHTHALIC ACID                                                               |
| Santalol, cis-alpha.-             |                                                                                      |
| PENTADECANOIC ACID                                                             |
| HEXADECANOIC ACID, ETHYL ESTER (2E)(7R,11R)-3,7,11,15-TETRAMETHYLCYCLOPENTANE-2-EN-1-OL (Z,Z)-6,9-CIS-3,4-EPOXY-NONADECADECANE |
| ETHYL (9Z,12Z)-9,12-OCTADECADIENOATE                                         |
| Dichloroacetic acid, tridec-2-ynyl ester                                       |
| 9-OCTADECENOIC ACID (Z)-                                                      |
| OCTADECANOIC ACID, ETHYL ESTER                                                |
| 9-OCTADECENOIC ACID (Z)-                                                      |
| 1,3-Cyclopentanediene, 4-hydroxy-2-pentyl-                                  |
| Heptadecanoic acid, ethyl ester                                               |
| Ethyl L margarate                                                             |
| Squalene                                                                        |
| gamma.-Tocopherol                                                             |
| dl.-alpha.-Tocopherol                                                        |
| Stigmasta-5,22-dien-3-ol                                                      |
| Stigmast-5-en-3-ol, (3.beta.-)                                                 |
| Catechol-O-Methyl- transferase –inhibitor (12).                               |
| Methyl-guinidone –inhibitor (12).                                             |
| 5-alpha-reductase inhibitor (12).                                              |
| Antidote, anti HIV integrase, HIF1 alpha inhibitor (12).                      |
| Smart drug, 11B-HSD inhibitor, 5 HETE inhibitor (12).                          |
| Inhibit uric acid formation (12).                                              |
| 5-alpha-reductase inhibitor (12).                                              |
| Inhibit uric acid formation (12).                                              |
| Inhibit uric acid formation (12).                                              |
| Endocrinprotective (12).                                                      |
| Increase zinc bioavailability (12).                                            |
| Increase zinc bioavailability (12).                                            |
| Inhibit uric acid formation (12).                                              |
| Acidifier (12).                                                               |
| Inhibit uric acid formation (12).                                              |
| Inhibit uric acid formation (12).                                              |
| 17-beta-hydroxysteroid dehydrogenase-inhibitor (12).                          |
| Inhibit uric acid formation (12).                                              |
| Antioxidant, antioxidant, antitumour (13).                                    |
| Antioxidant, Tocopherol synergist, PPAR-Gamma-Antagonist (12).                 |
| Antioxidant,TNF-alpha inhibitor (12).                                          |
| Antimicrobial (14).                                                           |
| Anti-diabetic, apart from its existing cholesterol lowering efficacy (15).      |

CIS-3,4-epoxy-nonadecadiene was recorded to occupy the highest area percentage with 24.55% followed by Pentadecanoic acid with 18.81%; then Dichloroacetic acid, tridec-2-ynyl ester with 9.99%, while Hexadecanoic acid, ethyl ester was in 8.64%, Hexadecanoic acid, (2E) (7R,11R)-3,7,11,15-Tetramethylylhexadec-2- en-1-ol with 7.75%, and other phytocompounds are gamma-Tocopherol, 2-Pyrrolidinone, 1-methyl-, 2,3-dihydro-3,5-dihydroxy-6-methyl-4-phenyl-4-ol, 1,2- tridec-2-enecyclopentane, alpha.-Tetradecane, 2(4H)-benzofuranone, 5,6,7,7A-tetrahydro-4,4,7A-trimethyl-, Fumaric acid, ethyl 2-isopropylphenyl ester, Phthalicacid, piperidine, 1-(1-cyclopenten-1-yl)-, Santalol, cis-alpha.-, 5-Hydroxymethyl-1,3,3-trimethyl-2-(3-methyl-buta-1,3-dienyl)-cyclopentanol, Spirio-10-(2,11-dioxabicyclo[4.4.1]undeca-3,5-diene)-2’-(oxirane), 1,3,7,7-tetramethyl-, Benzyl Benzanoate, 6-(1-Hydroxylethyl)-2-i odio-4-oxa-tricyclo[4.2.1.0(3,7)]nonan-5-one,CALENDIN, 2,6,10-Trimethyl,14-Ethylene-14-Pentadecane, Cyclopropanononanoic acid, 2-[(2-butylcyclopropyl) methyl]-, methyl ester, 3,7,11,15-tetramethylylhexadec-2-en-1-ol, ethyl 9-hexadecenoate, Heptadecanoic acid, ethyl ester, (2E)(7R,11R)-3,7,11,15-tetramethylylhexadec-2-en-1-ol, ethyl (9Z,12Z)-9,12-octadecadienoate, 9-octadecenoic acid (Z)-, Octadecanoic acid, ethyl ester, 1-e-11z-octadecatriene, 9-octadecenoic acid (Z)-, ethyl margarate, Heptadecanoic acid, ethyl ester, 1,3-cyclopentanediene, 4-hydroxy-2-pentyl-, octadecanoic acid, ethyl ester, Heptadecanoate. Mineral contents of the sample was recorded in mg/g as Fe 0.115,Mn 0.07, Cu 0.015, Zn 0.040, Mg 2.25, Na 3.08 and K 16.7 and proximate composition was recorded as 76.25± 0.093 % (moisture), 3.82±0.26 % (Carbohydrate), 12.54±0.08% (Total ash), 0.39±0.98% (Crude protein), 6.12±1.07 % (Crude fibre), 0.37±0.07 % (Crude fat).

DISCUSSION

The Solanum spirale shoot contains useful primary as well as secondary metabolites. The ethanol extract of Solanum spirale shoot contain as many as twenty three useful phytocompounds (Table 2) in addition to proximate and minerals composition for healthy growth and development of body. (Z,Z)-6,9-cis-3,4,4-epoxy-nonadecadiene increase zinc bioavailability and availability of zinc boost immune system in body, PENTADECANOIC ACID stop uric acid formation and uric acid is one of the major problems with non-vegetarian food habit people, Pentadecane is antibacterial, anti-inflammatory, anticancer; Dichloroacetic acid, tridec-2-ynyl ester and hexadecanoic acid, ethyl ester also inhibit uric acid formation; Hexadecanoic acid is hypocholesterolemic, and antioxidant, (2E) (7R,11R)-3,7,11,15-tetramethylylhexadec-2-en-1-ol is Endoanesthetic, endocrinprotective, gamma-Tocopherol is anticancer, anti-inflammatory, antioxidant, antitumor, cardioprotective, hypocholesterolemic, natriuretic. Presence of adequate amount of potassium, magnesium, iron, Carbohydrate, Crude protein and Crude fibre is important for a healthy diet. Minerals and Proximate compositions in a food is vital for the proper growth and development of a healthy body and secondary metabolites included in diet act as a nutraceuticals thus help in fighting various health problems. The findings of Kawsa-ard et. al., [16]: also support the results and finding present study in which the essential oil of Solanum spirale Roxb. unripe fruits is reported to exhibit anticancer activities against MCF-7 (breast cancer) and NCI-H187 (small cell lung cancer), antituberculosis activity against Mycobacterium tuberculosis H37Ra and also showed moderately antibacterial activity against Escherichia coli and Staphylococcus aureus. Likewise, Sukanya et. al., [17] also
reported the *Solanum spirale* leaf essential oil also reported to showed significant antibacterial activity against both Gram-negative *Escherichia coli* and Gram-positive *Staphylococcus aureus* and also showed significant cytotoxicity against KB (oral cancer), MCF-7 (breast cancer) and NCI-H187 (small cell lung cancer) and recently Payum et al.,[18] have studied the Pharmacognostic characteristic of *Solanum spirale* shoot. In conclusion, *Solanum spirale* is a nutraceutical plant that provides energy, minerals including various useful phytocompounds. Presence of anti stroke and cardioprotective compounds validate the traditional knowledge and practices. The present study suggests the need of further studies on this nutraceutical plant.

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