

AN ACCOUNT OF *SAGITTARIA SAGITTIFOLIA* WITH SPECIAL REFERENCE TO PHYTOCHEMICAL STUDIES AND ITS SOCIO-ECONOMIC RELEVANCE

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Manipur, a north-eastern state of India is known for its rich ethnic accounts and traditional knowledge of plants and animals. Diverse plants obtained in wild are used as food which initially started through hit and trial method. Many lives have also lost due to wrong selection, and those selected ones are cultivated either on large scale in the field or on a small scale in the kitchen gardens. In spite of the risk of selection the diverse food plants provide the required nutrient supplement and as such the case of deficiency (malnutrition) related diseases were earlier uncommon with the Manipuris. Many of the plants while consumed as food also help to prevent from many diseases, as most of them possess the medicinal properties. Today with the changing life style the food habit is also changing and depends mostly on ready made packed foods with low nutritional value and the health of the people are deteriorating, and simultaneously the food plants are neglected at large. Some of such plants are still supporting families and are socio-economically relevant. *Sagittaria sagittifolia* Linn. is one such indigenous plant where the tubers and young shoots (crown buds) are used as a seasonal vegetable in many recipes by the various communities, and also as medicine by traditional healers, who are locally known as Meitei maibas (traditional male local healers) and maibis (traditional female healers) in Manipur. Nutritional values of the edible parts viz. tuber and shoot of this seasonal food are analyzed in terms of biochemical estimates. The analysis shows the presence of various nutritional components with differences in their concentrations, significant at $p=0.05$ between the tubers and shoots (crown bud). The utility of this vegetable as a source of starch, protein, amino acids, sugar, fat, soluble and insoluble nitrogen and vitamin C etc. confirmed through chemical analysis and information on its medicinal properties clearly indicate the significance of *Sagittaria sagittifolia* as a food supplement to the people. The market demand of *Sagittaria sagittifolia* is worked out through market survey and found to be highly relevant with the socio-economy of the rural people.

Keywords : Market-survey; Nutrition; Rural; Socio-economy.

Introduction

In developing countries lesser known plant species are used as food; many of which are not cultivated but gathered from natural habitats. Several of these plants are reported to have medicinal properties¹. Diversified food habits comprising of wild and indigenous foods are very common in the North Eastern states of India, especially in Manipur. The ethnic communities inhabiting the state use wide varieties of wild plants, about 400 species, ranging from algae to angiosperms as food². *Sagittaria sagittifolia* Linn., of the family Alismataceae, commonly called as arrow-head or duck potato and locally as

"koukha", is a wild semi-aquatic herb or grows in the soil that remains near saturation. At stolon tips, 20-30 tubers are formed during December to April in which various chemical constituents are stored. Each tuber has a crown bud (a young shoot) (Fig. 1), from which a plant can develop. The tubers are used as a food or medicine and eaten raw or cooked.

The information collected on socio-economic life of Manipuris clearly suggests the significant role of many unknown or less known plant species as food supplements in their daily diet and in supporting the economy of the family. The present study helps to introduce arrow-head

as one of the supplementary food which will partly help in solving food crisis. Traditional food plants have numerous advantages, especially in terms of household food security. In addition to broadening the food base, they increase the food supply and add variety to the diet³. Arrow-head is grown in abundance from tropical to warm temperate zones of the world as a perennial weed in paddy fields and marshy areas. Though the plants were grown in other places in India and abroad in plenty they were treated as weeds as their utilization know-how were not known to them, which otherwise were socio-economically important. For the authenticity and fitness of introducing arrowhead as a supplementary food, the detailed analyses of the nutritional parameters of the edible parts i.e. tuber and young shoots were carried out in terms of biochemical estimates viz. quantitative estimation of starch, total soluble sugar, reducing and non reducing sugars, total phenol, phytosterols, total protein, total amino acids, amounts of different types of amino acids, total fat, vit.c, total nitrogen, soluble and insoluble nitrogen, moisture and dry matter percentage. Since arrow-head play a major role in providing food security, and supporting families financially, the analysis of its market potential is considered essential and the survey of local markets and villages are also conducted (Fig.2).

Material and Methods

Information on the use and utility of *Sagittaria sagittifolia* Linn. as food vegetable and medicine were generated through survey and interaction with the local people (Manipuris) residing in different rural and urban areas of Manipur.

The details of indigenous food preparation methods used in different recipes are recorded and described in (Table 1). The recipes used by the Manipuris are unique and this know-how information so generated and documented could be of great significance in exploring such knowledge for the common people. Plants are collected from the natural habitat. Tubers and young shoots which are the edible parts are used for the analyses. Carbohydrates were determined using: i) Anthrone method⁴ for the estimation of total soluble sugars (TSS), ii) Nelson's method for estimation of reducing sugars⁵(RS), iii) non-reducing sugars according to methods of Malhotra and Sarkar⁶ and iv) the Anthrone method derived from i) for the estimation of total starch (TS). Total fat (TF) was determined with the method of Leslie and Fisher⁷. Total protein (TP) was determined with the method of Lowry *et al.*⁸, the Ninhydrin method of Moore and Stein,⁹ was used for estimation of total amino acids (TAA), qualitative analysis of the individual amino acids was with the TLC

method of Stahl¹⁰, and the elution technique for quantitative estimation of individual amino acids. Total nitrogen (TN) was determined with the micro-Kjeldahl method and soluble and insoluble nitrogen (SNF, INTF) using the method of Lang¹¹. Ascorbic acid content was determined with the indophenol reduction method of Roe¹². Total phenol was determined with the Foli-Ciocalteu's method of Bray and Thorp¹³, and total phytosterol (TPS) with the Libermann-Burchard reaction method of Grunwald¹⁴. Moisture content was determined with the methods of (AOAC), Association of Agricultural Chemist methods¹⁵. Means were separated with standard deviation of Biswas¹⁶. The market potential of *S. sagittifolia* was determined after a survey of wholesalers, retailers and sub-retailers (vendors) in different markets of the plain and hill districts of the state during the production season (i.e. December to April), in 2001-2003. The result of the survey was conducted on a broader scale covering a total of 30 markets of the plain and 11 markets of the Hill districts for determining the socio-economic relevance of the plant (Table 6-7).

Result and Discussion

Table 1 shows the type of popular recipes of *Sagittaria sagittifolia*. In this table the term frequency signifies the utilization percentage of the plant in different recipes based on the number of respondents that cited a particular recipe, out of the 450 households that are interviewed in the 9 districts of Manipur. Only those recipes which are cited by more than 50% of the respondents are tabulated. From the table, the parts utilized are known to be underground tuber and the associated young shoots. The table also shows the traditional use of the plant in different indigenous modes of preparations as cited by the respondent households.

Table 2 shows the information on the frequency of consumption of the plant in various recipes among the respondent households during the production season i.e. November to April. The frequencies of consumption is grouped in to three broad categories, viz. rarely consumed (consumed less than 2 times a month), often consumed (consumed 2 to 8 times a month) and very often consumed (consumed more than 8 times a month). In order to compare the frequencies of consumption of the different recipes, a weight of 1, 2 and 3 was applied to the frequencies obtained for "rarely", "often" and "very often" respectively, to obtain the composite score, which is used to compute a mean score. None of the respondents have cited about the preservation of the plant and waits for the arrival of the production season.

Table 3 shows the quantitative nutritional



Fig.1. *Sagittaria sagittifolia* Linn. (Alismataceae) Shoot (crown bud) and Tubers



Fig.2. *Sagittaria ssagittifolia* sold in the markets of Manipur

Table1. Some of the popular recipes of *Sagittaria sagittifolia* recorded and documented.

Name of the Recipes	Frequency (n=450)	Plant parts Used	Ingredients	Mode of preparation.
Ironba	429	Tubers with young shoots	Boiled or roasted tuber, boiled potato, boiled chili, boiled inflorescence of <i>Wendlandia glabrata</i> . DC., boiled or roasted fermented fish (ngari), roasted or steam cooked fish like <i>Labeo rohita</i> , chopped leaves and rhizome of <i>Houttuynia cordata</i> . Thunb., <i>Coriandrum sativum</i> L. dried inflorescence of Lavender plant, <i>Allium fistulosum</i> , adequate salt and water.	Firstly, roasted or boiled chilli, fish (fresh and fermented), are pasted together along with adequate salt. Secondly, boiled <i>Sagittaria sagittifolia</i> tubers with the attached young shoots and potato are then pasted. The two pastes are then mixed in water. Finally, fresh or dry inflorescence of <i>Lavendula</i> sp., chopped <i>Houttuynia cordata</i> Thunb., <i>Coriandrum sativum</i> L. and green centric leaves of <i>Allium fistulosum</i> Linn. are added to impart flavour.
Bora	325	Tubers with young shoots	Tuber with young shoot, chopped potato, sliced onion, grinded <i>Zingiber officinale</i> Rose., powdered red chili or chopped green chili, spices, pulse powder, oil, salt and water.	Gram/pea flour, spices, chopped or powdered chili, salt and grinded gingers are thoroughly mixed together with water to form a good paste. Then the tuber with the attached young shoots are dipped in the paste and fried in the oil. Onions and potatoes slices could also be added in the above paste.
Kanghou	375	Tubers with young shoots	Tubers, the attached young shoots, chopped potatoes and onion.	Tubers with shoots are sliced in to halves and are fried, together with chopped potatoes and onion in the oil.

Table2. Frequency of consumption of the various types of recipes of *Sagittaria sagittifolia*.

Name of the Receipts	Frequency percentage	Rarely (x1)	Often (x2)	Very often (x3)	Composite score	Mean score
Ironba	429	4	110	315	1169	2.72
Kanghou	375	5	110	260	1005	2.68
Bora	325	14	120	191	827	2.54

contents, viz. total sugar, reducing sugar, non-reducing sugar, starch, fat, phenol, phytosterols, vitamin C and moisture percentage of tuber and young shoots of *Sagittaria sagittifolia*, obtained by the different biochemical analysis methods.

Table 4 shows the presence of different amounts of the various nitrogen fractions i.e. total protein, total amino acids, total nitrogen soluble nitrogen, and insoluble

nitrogen in the tuber and associated young shoots of the plant with the differences significant at $p=0.05$.

Table 5 shows the difference in the composition of the amino acids in the tubers and young shoots. It was noticed that the amino acids found in both the edible parts, they occur in different quantities and the differences are significant at $p>0.05$. It is found that amino acid Arginine is present only in shoots, while glycine and aspartic acid

Table 3. Total, reducing, and non-reducing sugars, starch, fat, phenol, phytosterol, vitamin C, and moisture content in tubers and young shoots of *S. sagittifolia*, means of 6 replicates.

Part	Mean ± standard deviation in mg·g ⁻¹ dry wt.							VitaminC (mg·g ⁻¹)	Moisture (%)
	Total Sugar	Reducing Sugar	Non-reducing Sugar	Starch	Fat	Phenol	Phytosterol		
Tuber	106.28 ±0.01	44.76 ±0.01	65.53 ±0.03	79.50 ±0.04	64 ±3.70	8.20* ±0.35	0.50 ±0.01	0.01 ±0.004	60
Young Shoot	203* ±0.04	65.31* ±0.03	134.15* ±0.01	150.04* ±0.04	74* ±4.20	6.60 ±0.30	4.00* ±0.20	0.02* ±0.006	72

* Significant at P=0.05.

Table 4. Total protein, total nitrogen, soluble nitrogen, insoluble nitrogen, and total amino acid contents in tubers and young shoot of *Sagittaria sagittifolia*, mean of 6 replicates.

Part	Mean± standard deviation in mg·g ⁻¹ dry wt.				Total amino acid content (mg 10 g ⁻¹ dry wt.)
	Total Protein	Total Nitrogen	Soluble Nitrogen	Insoluble Nitrogen	
Tuber	17.77 ±0.04	7.89 ±0.02	6.70 ±0.003	0.78 ±0.003	2.17 ±0.02
Young Shoot	53.33* ±0.22	23.70* ±0.18	18.17* ±0.04	1.58* ±0.003	5.33* ±0.02

* Significant at P=0.05.

are present only in tubers while aminobutyric acid, lysine, Alanine and Glutamic acid are found in both.

Table 6 shows the survey report conducted at the markets of the plain districts of Manipur which comprises of a total of 30 markets. The farmers gathered the plants from the wild and sold it to the agents in the main markets, who act as the whole sellers to the retailers, who in turn act as the retailers to the sub-retailers and consumers. The table show the names of the markets along with their categories viz. the wholesalers (W), retailers (R) and sub-retailers/vendors (SR), quantities of the *Sagittaria sagittifolia* sold in each market per day, cost and selling prices in Rs. Kg⁻¹ for the respective categories of markets, total cost and selling prices of the plant in each of the markets in Rs. per day along with the total income (profit) in Rs. per day in the respective market categories. The table also shows the mean ± standard deviation values of the daily total income/profit of the plant gatherers (suppliers), wholesalers, retailers, sub-retailers (vendors) of the plain districts of Manipur during the production

Table 5. Content of amino acids in tubers and young shoots of *S. sagittifolia*, (mean ± standard deviation in mg/100g) mean of 6 replicates.

Part	Aminobutyric Acid	Arginine	Lysine	Alanine	Glycine
Tuber	0.10 ±0.04	ND ^z	0.40 ±0.03	0.08 ±0.02	1.00 ±0.03
Young Shoot	3.00* ±0.07	0.50* ±0.03	0.70* ±0.03	0.20* ±0.06	ND

* Differences significant at P=0.05.

^zND = not detected.

season (Dec.-April). The prices shown are the mean of 10 separate days of observation during the initial, peak and late seasons of the markets during 2003-04. The table as a whole shows the generation of income in the households from this plant.

Table 7 shows the market survey report of the Hill districts of Manipur which comprises of 11 markets. The markets of the hill districts are categorised as retailers and sub-retailers (vendors). The table shows the quantities of *Sagittaria sagittifolia* sold per day, cost and selling prices per kg, total cost and selling prices per day and the profit earned in the respective market categories. The table also shows the daily total profits earned by the retailers and sub-retailers in the hill districts of Manipur.

Figure 3 and 4 are the chromatograms (TLC) with the characteristic spots of the different amino acids from the young shoots and tubers of *Sagittaria sagittifolia*, respectively.

A list of recipes of *Sagittaria sagittifolia*, with the required ingredients and the methods of preparation

Table 6. Market scenario of *Sagittaria sagittifolia* of the wholesale, retail and sub-retail markets of the Valley (plain) districts of Manipur during the production season (December to April), showing the mean \pm standard deviation of 10 separate days of observation during the initial, peak and late seasons.

Name of the market	Category of the Markets	Quantity Sold day ⁻¹	Cost price in Rs.Kg ⁻¹	Sale price in Rs.Kg ⁻¹	Total cost price in Rs. day ⁻¹	Total sale Price in Rs. day ⁻¹	Total Income (profit) in Rs. day ⁻¹
Khwai keithel/ Khwairambad Bazaar	W.	13400 \pm 610	70 \pm 3	75 \pm 4	939830 \pm 82900	1007440 \pm 99350	67610 \pm 16450
	R	1855 \pm 100	75 \pm 4	85 \pm 5	139525 \pm 14920	158175 \pm 17775	18650 \pm 2855
Bisnupur Bazaar	R	1200 \pm 50	75 \pm 4	90 \pm 5	90200 \pm 8550	108250 \pm 10500	18050 \pm 1950
	SR	100 \pm 10	92 \pm 5	97 \pm 5	9250 \pm 1420	9750 \pm 1470	500 \pm 50
Kakching Bazaar	R	1200 \pm 50	75 \pm 4	90 \pm 5	90200 \pm 8550	108250 \pm 10500	18050 \pm 1950
	SR	80 \pm 8	90 \pm 5	95 \pm 5	7240 \pm 1120	7640 \pm 1160	400 \pm 40
Thoubal Bazaar	R	1280 \pm 50	75 \pm 4	90 \pm 7	96200 \pm 8870	115550 \pm 13460	19350 \pm 4590
	SR	75 \pm 7	90 \pm 7	95 \pm 8	6799 \pm 1155	7790 \pm 656	991 \pm 499
Khurai Bazaar	R	1200 \pm 50	75 \pm 4	92 \pm 5	86250 \pm 4600	110150 \pm 1400	23900 \pm 3200
	SR	70 \pm 7	92 \pm 5	97 \pm 7	6475 \pm 994	6839 \pm 1169	364 \pm 175
Singjamei Keithel	R	1250 \pm 50	75 \pm 4	90 \pm 5	93950 \pm 8750	112750 \pm 10750	18800 \pm 2000
	SR	65 \pm 6	90 \pm 5	96 \pm 8	5880 \pm 865	6288 \pm 1096	408 \pm 213
Lilong Bazaar	R	1225 \pm 50	75 \pm 4	85 \pm 5	92075 \pm 8650	104375 \pm 10375	12300.5 \pm 1725.5
	SR	55 \pm 5	85 \pm 5	96 \pm 5	4700 \pm 700	5305 \pm 755	605 \pm 55
Nongmeibung Keithel	R	750 \pm 40	75 \pm 4	90 \pm 7	56410 \pm 6000	67780 \pm 8850	11370 \pm 2850
	SR	65 \pm 6	90 \pm 7	97 \pm 7	5892 \pm 995	6347 \pm 1037	455 \pm 42
Kongba Bazaar	R	1245 \pm 50	75 \pm 4	92 \pm 5	93575 \pm 8730	114790 \pm 10825	21215 \pm 2095
	SR	64 \pm 6	92 \pm 5	96 \pm 6	5918 \pm 872	6180 \pm 960	262 \pm 88
Pisum Keithel	R	750 \pm 40	75 \pm 4	92 \pm 6	56410 \pm 6000	69240 \pm 8180	12830 \pm 2180
	SR	69 \pm 7	93 \pm 6	97 \pm 7	6459 \pm 1065	6742 \pm 1162	238 \pm 97
Jiri Bazaar	R	525 \pm 30	75 \pm 4	92 \pm 5	39495 \pm 4350	48450 \pm 5385	8959.5 \pm 1039.5

Name of the market	Category of the Markets	Quantity Sold day ⁻¹	Cost price in Rs.Kg ⁻¹	Sale price in Rs.Kg ⁻¹	Total cost price in Rs. day ⁻¹	Total sale Price in Rs. day ⁻¹	Total Income (profit) in Rs. day ⁻¹
	SR	57±5	92±5	96±6	5269±745	5502±822	233±77
Sekmai Bazaar	R	400±20	75±4	94±6	30080±3100	37720±4280	7640±1180
	SR	50±5	94±6	98±7	5294±806	5523±882	229±76
Sugnu Bazaar	R	520±30	75±4	93±5	39120±4330	48510±5390	9390±1060
	SR	53±5	93±5	98±6	4954±730	5224±808	270±78
Moirang Bazaar	SR	325±20	90±5	100±10	29350±3425	32700±5250	3350±1825
	SR	320±20	90±5	103±10	29375±3875	33160±5260	3785±1385
Keisamthong Keithel	SR	209±15	90±5	100±10	18885±2395	21050±3590	2165±1195
	SR	200±15	90±5	100±10	18075±2350	20150±3500	2075±1150
Kwakeithel Bazaar	SR	104±10	90±5	104±10	9410±1420	10916±2080	1506±660
	SR	113±10	90±5	105±10	10220±1465	11965±2180	1745±715
Koirenggei Keithel	SR	105±10	90±5	104±10	9500±1425	11020±2090	1520±665
	SR	75±7	93±6	106±10	7017±1101	8020±6528	1003±391
Pangei Bazaar Lamsang	SR	50±5	93±6	105±10	4680±765	5300±1025	620±260
Keithel Singda Bazaar Keisampat	SR	45±4	93±6	100±10	4209±642	4540±850	331±208
	SR	47±5	93±6	100±10	4401±747	4750±970	349±223
Tera bazaar Lamlai Bazaar Saitu	SR	25±3	93±6	105±10	2343±429	2655±565	312±136
	SR	5±1	93±6	105±10	471±123	535±155	64±32
gampbrajol Keithel	SR	7±2	93±6	105±10	663±228	755±280	92±52
	SR	5±1	93±6	100±10	471±123	510±150	39±27
Potfam Leimakhong Bazaar	SR	4±1	93±6	105±10	378±117	430±145	52±28
	SR	4±1	93±6	105±10	378±117	430±145	52±28
Serou Keithel	SR	4±1	93±6	105±10	378±117	430±145	52±28

Note: W= wholesalers, R=Retailers, SR=Sub retailers. Interest (profit) day⁻¹ = Sales Price (S.P.) - Cost Price C.P.)

Table 7. Market scenario of *Sagittaria sagittifolia* of the retail and sub-retail markets of the Hill districts of Manipur during the production season (December to April), showing the mean of 10 separate days of observation during the initial, peak and late seasons.

Name of the market	Category of the Markets	Quantity Sold day ⁻¹	Cost price in Rs.Kg ⁻¹	Sale price in Rs.Kg ⁻¹	Total cost price in Rs. day ⁻¹	Total sale Price in Rs. day ⁻¹	Total Income (profit) in Rs. day ⁻¹
Churachandpur Bazaar	R	1000±100 40±5	75±4	90±5	75400± 11500	90500± 14000	15100± 2500
	SR	1110±	90±5	97±5	3625± 650	3905± 685	280± 35
Wino bazaar	R	100	75±4	90±5	83650± 11940	100400± 14550	16750± 2610
	SR	60±5	90±5	97±5	5425± 750	5845± 785	420± 35
Senapati Bazaar	SR	50±5	90±5	98±5	4525± 700	4925± 740	400± 40
	SR	20±3	90±5	97±5	1815	1955± 391	140± 21
Tamenglong Bazaar	SR	15±2	90±5	98±5	1360± 255	1480± 271	120± 16
	SR	25±3	90±5	97±5	2265± 395	2440± 416	175± 21
Maram Bazaar	SR	100±10	93±6	105±10	9360± 1530	10600± 2050	1240± 520
Sapermina Keithel	SR	85±8	93±6	105±10	7953± 1254	9005± 1690	1052± 436
None Bazaar	SR	50±5	93±6	105±10	4680± 765	5300± 1025	620± 260
Yaingungpokpi Keithel	SR	80±6	90±5	97±5	7230± 940	7790± 982	560± 42
Chandel Bazaar	SR	12±2	90±6	97±6	1092± 252	1176± 266	84± 14
Kangpokpi Keithrl	SR						

Note: W= wholesalers, R=Retailers, SR=Sub retailers. Interest (profit) day⁻¹ = Sales Price (S.P.) - Cost Price (C.P.)

popularly used in Manipur was prepared in the year 2003 based on a survey carried out in the 450 households covering the nine districts of Manipur (Table1). The recipes recorded are so popular that even the non-Manipuri's who have visited or migrated to Manipur relish the recipes very frequently during the production season. People anxiously wait for the season to come as there is no practice of storing the plant for the off season. The recipes tabulated are popular in grand feasts and traditional ceremonial feasts and parties. Among the recipes "Koukha bora" is popularly sold in big hotels, restaurants in the urban areas and also in small local hotels in rural areas and supports many of the household income.

"Koukha Ironba" is not so popularly sold as koukha bora but is another favourite item in rice hotels

and is the most popular cuisine in the households. Thus, this indigenous vegetable helps to generate income in one form or the other. There are similar reports on the ability to generate minimal income from indigenous /traditional fruits and vegetables in Asia, Africa and Italy etc. ¹⁷⁻¹⁹. Indigenous/traditional food plants are used to fill in the relish gaps and in so doing they contribute to the food security and also provide dietary diversity for the people. The frequencies of consumption of the recipes show the importance of the plant as a household food security (Table1, 2).

Methods of preparation: Generally the recipes are prepared by roasting, frying, boiling and mashing. Over 90% households consume by boiling and mashing (koukha ironba), more than 80% consume by frying itself or with

Table 8. Daily Profit of wholesalers, retailers and sub-retailers(vendors) for *Sagittaria sagittifolia* in the plain and Hill districts of Manipur.

Mean ± standard deviation				
Profits of the Markets of the plain districts of Manipur			Profits of the Markets of the Hill districts of Manipur	
Wholesalers	Retailes	Sub-retailers/vendors	Retailers	Sub-retailers/vendors
Amount of <i>Sagittaria sagittifolia</i> sold day-1 = (13400±610) kg	Amount of <i>Sagittaria sagittifolia</i> sold in day-1 = (14150±610) kg	Amount of <i>Sagittaria sagittifolia</i> sold in (kg·day-1) = (2452±207) kg	Amount of <i>Sagittaria sagittifolia</i> sold day = (2110±200) kg	Amount of <i>Sagittaria sagittifolia</i> sold in (kg·day ⁻¹) = (537±54) kg
Cost price of Wholesalers Kg-1=Rs.70±3	Cost price of retailers Kg-1 = Rs.75±4	Cost price of sub-retailers Kg-1 = Rs.91.48±5.55	Cost price of retailers Kg-1 = Rs.75±4	Cost price of sub-retailers Kg-1 = Rs.90.80±5.40
Total cost price of wholesalers = Rs. 939830± 82900	Total cost price of the retailers = Rs. 1003490± 82901	Total cost price of subretailers/vendors = Rs.223953± 36544	Total cost price of the retailers = Rs. 159050 ± 23440	Total cost price of subretailers/vendors = Rs.49330 ± 7861
Wholesale price Kg-1 = Rs. 75±4	Retail price Kg-1 =Rs.(90.40±5.50)	Sub-Retailers' price Kg-1 =Rs.(100.35±8.50)	Retail price in Rs.Kg-1 = Rs.(90 ± 5)	Sub-Retailers' price Kg-1 = Rs.(99.35± 6.45)
Total wholesale price day-1 = Rs.1007440± 99350	Total sale price of the retailers day-1 = Rs.1203990± 117670	Total sale price of the sub-retailers = Rs. 253316± 41430	Total sale price of the retailers day-1 = Rs.190900 ± 28550	Total sale price of the sub-retailers day-1 = Rs 54276 + 9301
Total profit of the wholesalers day-1 = Rs.67610± 16450	Total profit of the retailers day-1 = 200504.5± 28675	Total profit of the sub-retailers day-1 = 24015±10470	Total profit of the retailers day-1 = 31850 ± 5110	Total profit of the sub-retailers day-1 = 5091 ± 1440

potato (kukha kanghou) and over 70% consume after dipping in a thick watery paste of gram or pea flour followed by a deep frying in mustard oil (kukha bora) and less than 50% of the population consume by roasting or steam cooked. Fried foods are more common in the urban than the rural dwellers. But exceptionally, preparation of kukha bora is equally popular in the urban and village dwellers and is an important item used to serve the guest as snacks in the households.

The plant is rich in many important nutritional components viz. starch, total sugar, reducing sugar and non-reducing sugars, total nitrogen, soluble and insoluble nitrogen, total protein, total amino acids, phenol, phytosterols, moisture, vitamin C, fat, and amino acids like Aminobutyric Acid, Arginine, Lysine, Aspartic Acid,

Alanine, Glutamic Acid and Glycine (Table3-5). Phenols and phytosterols content are very high in the plant. Phenol and phytosterol foods are of high demand and have high price in the global market for its medicinal and anticancer properties and in reducing total cholesterol in the body. Saturated phytosterols are more efficient in reducing cholesterol absorption than unsaturated phytosterol and has antitumor properties, inhibit colon cancer development and has no side effect except in individuals with phytosterolemia, an inherited lipid disorder and also reduces atherosclerosis²⁰. According to C.P. Wu *et al.* plant flavonoids are polyphenolic compounds and at nontoxic concentration, it could influence bio-availability of anticancer and antiviral drugs *in vivo* and thus, should be considered for increasing efficacy in drug therapies²¹.

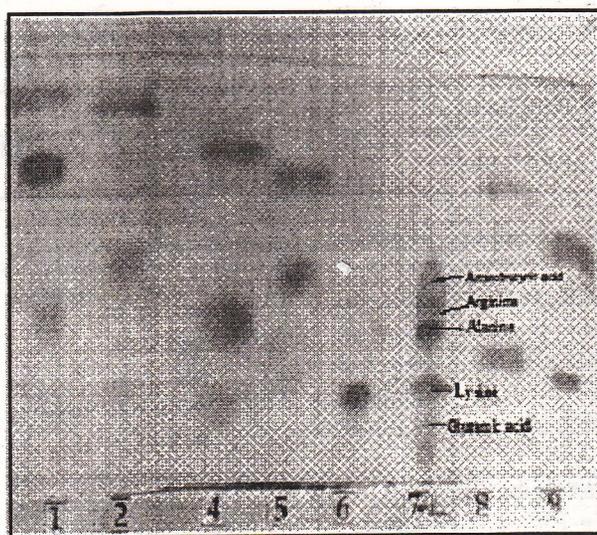


PHOTO2: TLC of amino acids of *Sagittaria sagittifolia* (shoot)

Fig 3. Detection of amino acids in *Sagittaria sagittifolia* (shoot) by TLC method.

Epidemiological studies carried out in Netherlands, correlated a higher flavonoid (polyphenolics) intake with a lower incidence of coronary heart disease (CHD)²². Phenolics such as (-)-epicatechin confer resistance to peroxidation and have antioxidant capacity and immunoregulatory effects²³. The plant also contain a good amount of carbohydrates in the form of starch, reducing and non reducing sugars. Deficiency in dietary fibre may cause diseases viz. appendicitis, constipation, diverticulosis and colon cancer while at the same time increase faecal bulk will dilute the concentration of potential carcinogens and reduces the contact time of carcinogens with the colonic epithelium²⁴. In addition to non-starch polysaccharides (NSP), the major component of dietary fibre, the undigested starch also called resistant starch (RS) helps significantly in colonic function²⁵. Arrowhead is also known for their medical properties, the tubers are used for the treatment of skin diseases. Powdered leaves are applied to get relief from itching. The leaves after mashing with molasses are used in curing of sore throat and inflammation of breast²⁶. Many active compounds like Trifolines A, B, C, D, biologically active Dipterpins and Sagittariol are also found in the tubers and may be responsible for its anticancer activity²⁷. Therefore, while consuming *Sagittaria sagittifolia* as food it could also prevent from certain diseases as the plant have medicinal properties. Through the result of analysis it is known that arrowhead have the potential as a consumer product. As many as 13400±610 kg·day⁻¹ are sold by farmers (plant gatherers/plant collectors) to the agents

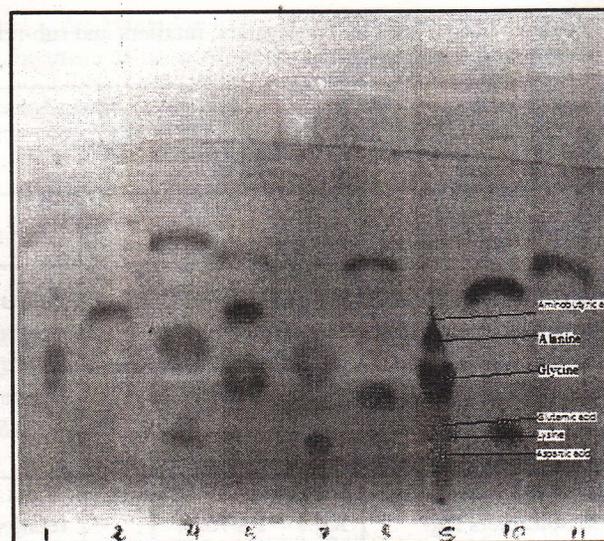


PHOTO3: - TLC of amino acids of tuber of *Sagittaria sagittifolia*

Fig 4. Detection of amino acids in *Sagittaria sagittifolia* (tuber) by TLC method.

(wholesalers) at an average cost of Rs. 70±3 kg⁻¹, who in turn sold at the wholesale price of 75±4 Kg⁻¹ to the retailers in the plain districts of Manipur. Out of the total amount of *Sagittaria sagittifolia* sold per day in the plain districts of the state 14150±610 kg are sold by retailers with the average retail rate of Rs.90.40±5.50 kg⁻¹, while an amount of 2452±207 kg are sold by sub-retailers/vendors per day at an average rate of Rs. 100.35±8.50 Kg⁻¹ (Table 6). In the markets of the hill districts of the state, an amount of 2110±200 kg and 537±54 kg of *Sagittaria sagittifolia* are sold daily in the retail and sub-retail markets at the respective prices of Rs. 90 ± 5 and Rs.99.35± 6.45 Kg⁻¹ (Table7).

Daily profits of retailers and sub-retailers of the plain districts during peak season are Rs.200504.5± 28675 and Rs.24015±10470, respectively. The wholesalers are only in the khwairamband bazaar and earned with a daily profit of Rs.67610±16450, while the farmers (gatherers) earned a profit of Rs.939830± 82900 per day. Retailers and sub-retailers of the hill districts earn a daily profit of Rs.31850 ± 5110 and Rs.5091 ± 1440, respectively (Table 8).

From this survey conducted in the households, markets and villages it was found that the plant is be used as a vegetable and is an alternative source of income for the gatherers and vegetable sellers and is socio-economically relevant.

Conclusion

Realizing the requirement of research knowledge on the nutritional and health values of indigenous food plants, in

changing the attitude of agricultural workers and the rural communities, for saving the indigenous food plants from a possible extinction, the present study is conducted. Research analyses prove its worth for consumption and to be categorized as healthy food. The presence of high amount of phenol, phytosterols, proves to be very significant, as increasing the aggregate amount of phytosterols consumption in a variety of foods may be an important way of reducing population cholesterol levels and preventing coronary heart disease²⁸. Phenolics in Olive oil not only have the antioxidant potency but also potentiate the immune response²⁹. Starch, sugar and fat acts as a source of dietary fibre, energy and as a form of stored food, respectively.

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