Content list available at http://epubs.icar.org.in, www.kiran.nic.in; ISSN: 0970-6429

Indian Journal of Hill Farming

June 2019, Volume 32, Issue 1, Page 71-78

Proximate constituents of some homegarden food crops and household food security in Mizoram, northeast India

Uttam Kumar Sahoo[1*] • Pebam Rocky[2]

[1]Department of Forestry, Mizoram University, Aizawl-796004, Mizoram

[2]North Eastern Space Application Centre, Shillong-793103, Meghalaya

ARTICLE INFO

Article history:
Received 25 July 2018
Revision Received 12 January 2019
Accepted 8 March 2019

Key words:
Chemical constituents, homegarden food crops, nutritional security

ABSTRACT

We analyzed 14 important homegarden food crops for their proximate constituents and household food security involving 22 villages and 92 homegardens spread over 40m-1200 m above msl in Aizawl district of Mizoram. Among the food crops, *Parkia timoriana* had highest moisture content (82.6%) while the rest were having below 50% moisture content. *P.timoriana* had highest carbohydrate content while highest protein content was found in *Acacia pennata*. The energy content was highest in P. timoriana (483 Kcal/100g) followed by *Discorea esculenta* (386 Kcal/100g) and *A.pennata* (332 Kcal/100g). Out of the 351 plant species encountered in home gardens, 133 were plants supplying vegetables and fruits with higher diversity of food plants in high altitude (104), followed by low altitude (95) and mid altitude (85). Homegarden food crops nevertheless helped not only in supplementing the dietary requirements but also the ensuring household food security in Mizoram.

1. Introduction

Food and Agriculture Organization (FAO) defines food security as a condition that "exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life". Individuals who are food secure do not live in hunger or fear of starvation. Food security at household level takes place when there is food availability as well as access to food by a household (Labadarious *et al.,* 2009). Home gardens are known as the best method of supplementary food production system for a household and homegardening is one of the strategies that have the potential of enhancing food security for the poor (Mutotsi *et al.,* 2008; Marsh, 1998, Sahoo, 2009, Barbhuiya and Sahoo, 2014, Barbhuiya *et al.,* 2016; Sahoo *et al*., 2011; Sahoo, 2017). One of the easiest ways of ensuring access to a healthy diet that contains adequate macro- and micronutrients is to produce many different kinds of foods in the home garden (Singh *et al.,* 2009, 2010). This is especially important in rural areas where people have limited income-earning opportunities and poor access to markets and an important source of food and income for poor households in peri-urban and urban areas. They have multiple potential benefits and are vital such as a direct increased access to nutritious food by food insecure households on a daily basis and a source of medicinal plants. Home gardening can be done using only the available local planting material, green manures, fencing and indigenous pest control methods without any virtually economic resources (Marsh, 1998, Rocky and Sahoo, 2018). Vegetables being the rich source of carbohydrates, fats and proteins, which form the major portion of the human diet, are the cheapest source of energy. Proximate and nutrient analysis of edible fruit and vegetables plays a crucial role in assessing their nutritional significance (Pandey and Srivastava, 2009). Traditional Mizo ethnic food comprises of plenty of uncommon leafy vegetables, fresh as well as preserved through smoking, such as mustard leaves, pumpkin leaves, beans leaves, varieties of bamboo shoot, apart from meat. Mizo meals are mildly spicy and simple in taste with high nutritive value. The dishes are cooked with the least amount of oil and boiling, steaming and sautéing are the most preferred cooking methods, probably to retain the maximum possible nutritive value of the ingredients.

*Corresponding author: uksahoo_2003@rediffmail.com

The considerable use of uncommon vegetable species by the local people in their diet motivated the present study to carry out the proximate analysis of few common food plants of Mizoram, and to understand whether the vegetables constituents of the home gardens are able to meet some of the nutritional requirements as a locally available dietary component and household food security in a rural landscape.

2. Materials and Methods

The study was carried out in 92 homegardens spread over 22 villages in Aizawl district of Mizoram ranging from 40 m above msl to 1200 m above msl. The study villages were grouped into three altitudinal range *viz.* high altitude (>1200 m above msl), mid altitude (300-1200 m above msl) and low altitude (<300 m above msl). Various attributes of vegetation in the home gardens such as density, frequency and abundance were estimated using standard methods. In the present study a total of fourteen common vegetable species identified from the homegardens were procured from the local market of Aizawl, Mizoram. The plant samples were air dried for two weeks and ground into uniform powder using a blender.

The samples were oven dried at 60°C until constant weight (AOAC, 1990; AOAC, 2000). The dried matter obtained was ground to a fine powder using a mixer/blender, sieved, and transferred to airtight plastic bottles and were stored in a refrigerator at 4°C until required for analysis. The cold stored samples were allowed to attain room temperature and mixed thoroughly with a spatula before withdrawing samples for further proximate constituent analysis. Proximate analysis was done on ground samples for each sample to yield result from which the compositions were computed.

The proximate analyses (moisture, ash, crude fats, proteins and carbohydrates) of all the samples were determined according to the procedure of Association of Official Analytical Chemist (AOAC, 1990). The moisture content was determined using weight difference method. Nitrogen and total crude protein content were determined on a dry weight basis according to the Micro- Kjeldahl distillation method (AOAC, 1990) involving the process of digestions, distillation and finally titration of the samples. Total carbohydrate content was determined by the anthrone method as described by Sadasivam and Manickam (1996). Total fats were determined by gravimetric method (Phillips *et al.,* 1997). A dry ashing method was used to determine the ash content by incinerating the sample in a furnace at 550ºC. All the proximate values are reported in percentage. The results for chemical composition were expressed in percentage of dry weight. The caloric value was calculated by summing up the percentages of crude-protein and carbohydrate multiplied by a factor of 4 (kcal/100g) and total crude fat multiplied by a factor of 9 (kcal/100g).

3. Results

Proximate analysis of food plants

The result of proximate analysis showed variation in concentration/proportions of bio-chemicals (carbohydrate, fats and protein) and other contents (ash, fiber, moisture). The result of proximate analysis shows variant concentration of proximate composition of the 14 vegetables plant species, details is as shown in table 1. Overall the samples showed higher proportion of moisture, carbohydrate, followed by crude protein, ash and crude fat, respectively. The moisture content of each species revealed different values ranging from 18.9 to 86.2, giving a wide variation, of the 14 vegetables, *Parkia timoriana* had the lowest moisture content of 18.9, and *Solanum anguivi* had the highest moisture content (86.2), remaining 4 and 10 plant species had moisture content of below and above 50% respectively. The content of carbohydrates was relatively high, ranging from 7.5 to 46.2 % DW in comparison to other chemical constituents. Among the vegetables samples, *P. timoriana* contained the highest carbohydrate content (46.2%), followed by *Musa paradisica, S. nigrum, Colocasia* sp. and the remaining vegetables revealed below 20% carbohydrate content (Table 1). The protein content of the 14 vegetables species range from 1.8 to 33.1% with *Acacia pennata* the maximum followed by *Clerodendron colebrookianum, Dysoxylum gobara* and *P. timoriana*. Plant species *viz. Colocasia* sp., *Cucurbita maxima, Dioscorea escullenta, Eurya cerasifolia, Hibiscus sabdariffa, S. anguivi, S. nigrum, S. acmella* and *Zanthoxylum rhetsa* had lower amount of protein content of below 10 %. The ash content ranged from very low 1.2% to the highest of 22.1. Vegetable species of *S. acmella, D. gobara, C. colebrookianum, Z. rhetsa* showed above 10% ash content. The crude fat content in 11 samples was relatively low ranging from 0.1 to 3.8 % DW. The highest content of crude fat was found in *P. timoriana* (12.4%), followed by *S. nigrum* (9.3%) and *E. cerasifolia* (5.7%). The energy content in Kcal/100g as per the proximate principles of the 14 traditional food plants prevalent in homegardens of Mizoram showed the maximum energy content in *P. timoriana* (483 Kcal/100g) followed by *D. escullenta* (386 Kcal/100g), *A. pennata* (332 Kcal/100g), *H. sabdariffa* (289 Kcal/100g), *C. colebrookianum* (274Kcal/100g), *S. anguivi* (251 Kcal/100g) and *Cucurbita maxima* (231 Kcal/100g). The other vegetables had less than 184 Kcal/100g and minimum energy level of 38 Kcal/100g was recorded in *S. nigrum*.

Table 1. Proximate principal of prominent traditional food plants prevalent in homegardens of Mizoram

Plant Species	Local names	Carbohydrate %	Crude Protein %	Fats (Lipids) %	Ash content %	Moisture %	Energy k Cal/100g
Acacia pennata	Khanghu	17.9±0.8	33.1±2.8	2.0±0.2	7.9±1.1	39.1±2.7	332±16
Clerodendron colebrookianum	Phuinam	9.0±1.2	19.6±2.5	1.6±0.3	11.5±0.8	58.3±3.7	274±9
Colocasia sp.	Dawl	23.4±2.2	1.8±0.1	0.3±0.0	0.9±0.0	73.6±3.2	64±2
Cucurbita maxima	Maien	11.3±2.0	3.9±0.3	0.8±0.1	2.8±0.3	81.2±4.1	231±7
Dioscorea esculenta	Baibing	19.3±1.7	1.5±0.2	0.3±0.0	1.70.5	78.2±4.3	386±11
Dysoxylum gobara	Thing thu pui	11.9±1.1	16.3±0.9	2.6±0.2	12.3±1.5	56.9±2.6	162±8
Eurya cerasifolia	Sineh	7.5±0.5	5.8±0.2	5.7±0.3	6.4±0.7	74.7±2.1	125±5
Hibiscus sabdariffa	Anthur	9.5±0.9	2.2±0.1	1.3±0.0	1.5±0.1	85.5±3.2	289±7
Musa paradisica	Changel	30.6±3.3	0.9±0.1	0.1±0.0	1.3±0.2	67.1±2.7	84±2
Parkia timoriana	Zawngtha	46.2±2.4	16.4±1.3	12.4±0.8	6.1±0.9	18.9±2.2	483±8
Solanum anguivi	Samtawk	10.6±1.7	1.4±0.2	0.6±0.0	1.2±0.0	86.2±3.7	251±6
Solanum nigrum	Tawkte	25.5±1.8	7.6±0.3	9.3±0.8	3.2±0.1	54.4±2.2	38±3
Spilanthes acmella	Ankasa	16.4±0.9	16.1±1.4	3.4±0.2	18.3±1.4	45.9±2.3	184±7
Zanthoxylum rhetsa	Chingit	7.5±1.2	8.6±0.9	2.0±0.2	10.4±0.8	71.5±6.5	107±4

Table 2. Food plants in the homegardens at different altitudes

Altitude	Trees	Shrubs	Herbs	Climbers	Total food plants	Total Species*
High	29	15	46	14	104	206
Mid	30	11	33	11	85	206
Low	28	15	35	16	95	227

*altogether 351 plant species encountered of which 133 were food plants in all atitudes

Table 3. Food plant varieties which are more than 30% of occurrence among the homegardens

Altitude	Trees	Shrubs	Herbs	Climbers	Total
High	15	5	15	3	38
Mid	13	4	8	3	27
Low	10	1	5	1	17

Homegarden plants for nutritional needs and household food security

Homegardens are an important source of vegetable for household consumption and animal food. The number of crops that a household had in its homegarden varied across the altitudes. In the present study 133 out of 351 plants were food plants supplying numerous vegetables and fruits (Sahoo and Rocky, 2015), with higher diversity of food plants in high altitudes (104) followed by low altitude (95) and mid altitude (85). Out of all the food plants herbaceous vegetables were a major constituent (Table 2). In the high altitude gardens occurrence of guava fruit was very high followed by the small tree *C. colebrookianum* (phuinam) followed by *Colocasia esculenta* (dawl) and *Cucurbita maxima* (maien) whose leaves are used as vegetables. Passion fruit, mustard and sweet potato were recorded in 72% of the gardens. *P. timoriana* occurred in 79% of the gardens whose pods are delicacy during winter. Herbs recorded maximum number and proportion (44%) in high altitude and least proportion in low altitude (37%). Trees (usually fruits trees) were the second major contributor to the food plants in all the altitudes. Although good number of herbal food plants were also recorded in the low altitude those with high frequency of occurrence among the gardens were very low (Table 3), represented by only five herbs. In the high altitude more variety of seasonal vegetables were recorded with high frequency of occurrence among the garden. Thus, in high altitudes not only were there variety of seasonal vegetables throughout the year but also were cultivated in most of the gardens. In the mid altitude mangoes were recorded in more than 93% of the gardens and fruits of different *Citrus* species were observed (Table 4). Guava and *C. colebrookianum* were also common similar to high altitudes. *Acacia pennata* a prickly leguminous woody climber whose stinky leaves are a favourite vegetable was recorded in many of the gardens. *Trevesia palmata* whose flower buds are a costly vegetable was also found frequently in the gardens in mid altitudes.

4. Discussions

Proximate analysis of common food plants

Edible vegetables are a vital component of human diet comprising essential biochemicals important for human metabolism (Aliyu, 2006). The result of proximate analysis of the fourteen common vegetables selected from the homegardens of Mizoram showed a varied concentration of nutrients (carbohydrate, fats, protein, ash, fiber, moisture). The moisture content of the 14 plants species showed a maximum of 86.2% in *S. anguivi* and as low as 18.9% in *P. timoriana,* lower moisture content will ensure lower rate of spoilage with longer shelf-life and less susceptibility to microbes and vice-versa (Adepoju, 2009, Adeyeye and Ayejuyo, 1994). Other species showed relatively high moisture content of above 30% *viz. H. sabdariffa* (85.5%), *C. maxima* (81.2%), *D. escullenta* (78.2%), *E. cerasifolia* (74.7%), *C.* (73.6%), *Z. rhetsa* (71.5%), *M. paradisica* (67.1%), *C. colebrookianum* (58.3%), *D. gobara* (56.9%), *S. nigrum* (54.4%), *S. acmella* (45.9%) and *A. pennata* (39.1%). This result is however similar to those obtained by other workers (FAO, 1990; Abidemi *et al.,* 2009; Chimma and Igyor, 2007). As the Mizoram weather condition range from maximum average temperature rarely exceeding 26°C, thus shelf life will be comparatively better to other hot regions despite the higher moisture content.

Carbohydrates has been categorized a good and essential cheap source of energy, constituting a major portion of a balanced diet. In our study, *P. timoriana* contained the highest carbohydrate content (46.2%), followed by *Musa paradisica* (30.6%), and the remaining vegetables showed below 20% carbohydrate content. The carbohydrate content of these vegetables is very high as compared to the values obtained in the studies of Agbaire *et al.* (2012). On the contrary Asibey-Berko and Tayie (1999) revealed vegetables with higher carbohydrate content ranging from 75% to 82.8%. Protein content of the 14 vegetables species ranged from 1.8 to 33.1% with highest in *A. pennata* followed by *colebrookianum* (19.6%), *D. gobara* (16.3%), *P. timoriana* (16.4%), *S. acmella* (16.1%). According to Pearson (1976) plant food that provide more than 12% of its calorific value from protein are considered good source of protein. Furthermore, adults, pregnant and lactating mothers required 34-56 g, 13-19 g and 71 g of protein daily respectively (Anon., 2002). The results of this investigation showed that adequate amount of protein are present in these vegetables. Therefore, as these plants can be utilized as a good source of non-conventional proteins. Remaining vegetables species had lower amount of protein content of below 10 %, however some of this has a fairly good protein content and can very well blend with other food items with average content so as to make-up the required amount. The ash content which is a measure of the mineral content of food was highest of in *S. acmella* (18.3%), and 3 other vegetables also showed a very high value of above 10% ash content *i.e. D. gobara* (12.3%), *C. colebrookianum* (11.5%) and *Z. rhetsa* (10.4%). The result therefore suggests a high deposit of mineral elements in these leaves (Antia *et al.,* 2006). Other species had relatively lower value but can definitively serve a fair source of mineral. The values were comparatively higher except for *M. paradisica* (1.3%), *S. anguivi* (1.2%) and *Colocasia* sp. (0.9%), compared to the reported value by Agbaire *et al.* (2012) and Abidemi *et al.* (2009) who reported of ash content ranging from 1.52 to 2.0%, which was also the acceptable range for edible vegetables in Nigeria, according to Lucas (1988).

The crude fat content in majority of the samples were relatively low ranging from 0.1 to 12.4% DW which shows that the vegetables will be beneficial for maintenance of good health. The highest content of crude fat was found in *P. timoriana* (12.4%), *S. nigrum* (9.3%) and *Eurya cerasifolia* (5.7%), suggesting them to be a good sources of lipids. The study by Rumeza *et al.* (2006) reported low percentage of fat in vegetables ranging 0.1% to 0.38%, however the present findings had wide variation in the results ranging from low, intermediate to high fat content.

Energy in terms of calorific value was found to vary from very good value of 483 Kcal/100g the lowest of 38kcal/100g. Some of these results are in agreement with the studies of Kanchan *et al.* (2011) and found to be in the normal range of 134.6 kcal/100gm to 431.6 kcal/100g. The highest value was found in *P. timoriana* (483 Kcal/100g) which is higher than the reported value of energy in vegetables by other workers (Isong *et al.,* 1999; Kulkarni *et al.,* 2003; Hussain *et al.*, 2009; Kanchan *et al.,* 2011) but are well within the reported value of energy content in different parts of *P. timoriana* pods by Elangbam and Singh (2012). Thus this study could identify some very good source of energy singly or in combinations as most of the vegetables gave relatively good values of nutrients and can serve as a component of a well-balanced diet.

Table 4. Important food plants recorded (% frequency, - not found) in different altitudes based on frequency of occurrence

Botanical names	High altitude	Mid altitude	Low altitude
Psidium guajava	88.37	42.42	54.55
Clerodendrum colebrookianum	86.05	62.50	48.48
Colocasia esculenta	83.72	62.50	48.48
Colocasia affinis	-	-	54.55
Cucurbita maxima	79.07	50.00	50.00
Parkia timoriana	79.07	50.00	42.42
Hibiscus sabdariffa	76.74	63.64	63.64
Mangifera indica	74.42	93.75	87.88
Passiflora edulis	74.42		
Brassica juncea	72.09		
Ipomea batatas	72.09		
Citrus reticulata		81.25	
Trevesia palmata		81.25	
Psidium guajava		75.00	69.70
Citrus grandis		62.50	
Acacia pennata		56.25	
Citrus macroptera car anamensis		56.25	48.48
Citrus medica var acidus			48.48
Carica papaya	44.19	50.00	69.70
Musa paradisiaca			78.79
Cocus nucifera	-	-	63.64
Tamarindus indica	-	-	63.64
Ananas comosus			60.61

Homegarden plants for nutritional needs and household food security

People all over the world grow gardens. In the tropics, anyone with any land can grow something all year round. Most rural tropical families have gardens around their houses fundamentally; home gardening provides a supplemental source of foodstuff for the family (Sahoo, 2007, Sahoo *et al.,* 2010, Sahoo and Rocky, 2015). But their importance goes beyond that. In many developing countries, home gardening becomes a survival strategy when food security is threatened by limited food availability and access. At other times, it is a resilience strategy to mitigate risk and vulnerability due to different natural and man-made stresses.

Among the homegardens in Mizoram the high altitude gardens tend to be more secure with sufficiency of household food supply as evident from the varieties of leafy vegetables and tubers like mustard, pumpkin, sweet potatoes, chilly, chayote (*Schium edule*, Iskut), brinjal, roselle, garden pea, lablab, lady's finger, winged beans, and other varieties of bean *etc.* apart from varieties of the fruits. The fewer occurrences of vegetables among the food plants in the low altitude might be attributed to the fact that as the gardens were dominated with dense canopy of areca nut trees the gardeners might not have enough space to grown seasonal vegetables to supply all year round. And since the areca nuts from these gardens could fetch direct cash income at the farm itself without taking them to the market (since traders come to the farm to collect the nuts), they have more liquid cash to but vegetables from the market. In the mid altitudes the status of food plants was intermediary in nature in between the high and low altitude. More varieties of vegetables in high altitude might also be due to the favourable climatic conditions and also the age of the garden which were comparatively older (Sahoo and Rocky, 2015). Over the years the farmers might have tried varieties of wild and domesticated plants and with long trail they might have stabilized certain plants in the garden as compared to the mid and low altitudes which are younger. Overall, the occurrence to numerous varieties of traditional food plants other than staple crops in the homegarden of Mizoram shows a picture of household food security and meeting the nutritional requirements of the rural poor. Dietary diversity, *i.e.* the number of foods consumed across and within food groups over a reference period, is widely recognized as a key indicator of nutrient adequacy (Cummings and Bingham, 1998; Ruel, 2003; Mirmiran *et al.,* 2004, Sahoo, 2009).

Studies show that the overall nutritional quality of the diet improves with increasing number of food groups (Torheim *et al.,* 2003; Steyn *et al.,* 2006; Kennedy *et al.,* 2007). Foods from the homegarden supplements the staple foods from the paddy fields or jhum fields, which are usually high in calories, but not very high in vitamin and mineral nutrients and since homegarden usually produce crops extremely high in nutrients and they tend to possess a high '*nutrient density'.* Humans need carbohydrates, protein, and fats, which are problem enough, but more critical in much of the tropics are vitamin and mineral nutrients. Roots and tubers are rich in energy and legumes are important sources of protein, fat, iron and vitamins. Green leafy vegetables and yellow- or orange-coloured fruits provide essential vitamins and minerals, particularly foliate, and vitamins A, E and C. Vitamin A which is necessary for good eyes are made by the body from carotenes and green leafy vegetables are good sources of ß–carotene, the precursor of vitamin A. Vegetables like cauliflower, mustard greens, *etc.* are good source of vitamin B1, and it's common in most green vegetables, as well as most of the vitamin A sources. Oranges, greens chilies, and guavas are good source of vitamin C which is to be consumed frequently as the body cannot store vitamin C for more than a week. Chilies are also rich in iron.

Maize, corm of 'iskut' (*S. edule*), sweet potato, *Manihot esculenta* (pangbal), *Ipomea batatas, etc.* which are the starchy crops provide additional carbohydrates to the household. Beans are excellent sources of protein. Tree beans (*P. timoriana*), winged bean, pegion pea (Behlawi) *etc.* are good sources of protein but being consumed fresh are also rich in vitamin C. *Acacia pennata* shoots are also a good source of protein. Mangoes are extremely high vitamin A and C values. Bananas are good carbohydrate, but there is some vitamin C value, and some minerals, notably potassium. The coconut water are rich in vitamins and minerals.

The homegarden also provide lots of needed protein (and some fat), especially in the form of small livestock (Rocky and Sahoo, 2018). For protein and iron, and for getting rid of weeds and garbage, livestock like pigs and poultry are a valuable part of the garden world. Homegardens in all the altitudes in Mizoram possess some livestock which provide meat and eggs. Their wastes also provide manure for the garden. Rearing honey bees were also common in the homegardens (Rocky and Sahoo, 2018).

Furthermore, consuming diverse diets offers protection against chronic diseases (Cummings and Bingham, 1998). Although not mentioned as medicinal plants, almost all plants found in the homegardens such as fruit trees, tubers, vegetables, beans or spices have a potential medicinal use and helps in maintaining a sound health (Sahoo, 2009, Jeeceelee and Sahoo, 2015). For example consumption of boiled *Clerodendrum colebrookianum* leaves is popular among Mizos and it has been reported to minimize high blood pressure, and consequently incidence of high blood pressure is very low among Mizo (Sharma *et al.,* 2001). In general, homegardens in Mizoram produce food year round, unlike the seasonal harvest in paddy field and jhum lands. Although yields are normally low, it is compensated by the diversity and nutritious nature of the products obtained.

Conclusion

The proximate analyses results showed that the homegarden vegetables are fairly endowed with energy content, moisture, and carbohydrate, followed by crude protein, ash and crude fat, respectively. Carbohydrate constituted the highest constituent in the plants followed by protein percentage and ash content while most of the plants showed low fat content. *Parkia timoriana* possessed highest value of carbohydrate, fat and energy value while highest protein was recorded in *Acacia pennata*. Unconventional food plants like *Spilanthes acmella*, *Dysoxylum gobara, Clerodendron colebrookianum, Zanthoxylum rhetsa* showed a very high ash content. Overall, these vegetables had a good proportion of nutritional attributes. The diverse food plants by increasing availability, accessibility, and utilization of food products. Household food supply was higher in high altitude homegarden with diverse vegetables and food crops than mid and low altitude gardens. Integration of livestock, poultry and apiculture activities into home gardening reinforced food and nutritional security for the rural poor. Since homegarden produce crops extremely high in nutrients, they supplement the staple foods from the paddy fields or jhum fields, which are usually high in calories, but not very high in vitamin and mineral nutrients. Most of the traditional food plants also have good medicinal value. Because of the homegarden the rural farmers with limited sustainable livelihood options have access to healthy diet. Thus home gardens can be an alternative source for balanced nutritional diets serving the perennial needs of the poor rural and the sub-urban societies.

Acknowledgement

This research was supported financially by Council of Scientific & Industrial Research, New Delhi (Grant No. 38(1149)/07/EMR-II).

References

Abidemi, T. A., Adebayo, O. J., Idowu, O. and Agbotoba, M. O. 2009. Nutrient content and anti-nuritional factors in Shea butter (*Butryospermum Parkii*) leaves. *African Journal of Biotechnology*, 8(21): 5888-5890.

Adepoju, O. T. 2009. Proximate composition and micronutrient potentials of three locally available wild fruits in Nigeria. *African Journal of Agricultural Research*, 4: 887-892.

Adeyeye, E. I. and Ayejuyo, O. O. 1994. Chemical composition of *Cola accuminata* and *Garcina* Kola seeds grown in Nigeria. *International Journal Food Science Nutrition*, 45: 223-230.

Agbaire, P. O. and Emoyan, O. O. 2012. Nutritional and antinutritional levels of some local vegetables from Delta State, Nigeria. *African Journal of Food Science*, 6(1): 8-11.

Aliyu, H. M. 2006. Proximate analysis of some leafy vegetables (Roselle, Jute and Bitterleaf). *International Journal of Food Agriculture Research*, 3(1): 11-14.

Anonymous. 2002. *Food and Nutrition Board, Institute of Medicine*. National Academy of Sciences. Dietary Reference Intake for Energy, Carbohydrate, Fibre, Fat, Fatty Acids, Cholesterol, Protein and Amino Acid (Micronutrients). www.nap.edu (Retrieved on 26/10/2013).

AOAC. 1990. *Official Methods of Analysis* (15 Ed.). The Association of Official Analytical Chemists, Washington DC, USA.

AOAC. 2000. *Official methods of analysis*. 17th Ed. Gaithersburg, MD, USA.

Asibey-Berko, E. and Tayie, F. A. K. 1999. Proximate analysis of some underutilized Ghanaian Vegetables. *Ghana Journal of Science*., 39: 91-92.

Barbhuiya, A., Sahoo, U.K. and Upadhyaya, K. 2016. Plant diversity in the indigenous homegardens in the eastern Himalyan region of Mizoram, Northeast India. *Economic Botany (Springer)*, 70(2): 115-131.

Barbhuiya, A. and Sahoo, U.K. 2014. Traditional homegarden Agroforestry: Structural diversity and functional dynamics in Aizawl district of Mizoram, North-East India. In: Pandey, C.B. & Chaturvedi, O.P (eds). *Agroforestry Systems and Prospects*, New India Publishing Agency, New Delhi, pp.1-25.

Chimma, C.E., and Igyor, M. A. 2007. Micronutrients and anti-nutritional contents of selected tropical vegetables grown in Southeast Nigeria. *Nigerian Food Journal*, 25(1): 111-116.

Cummings, J. H. and Bingham, S. A. 1998. Diet and the prevention of cancer. *British Medical Journal*, 317: 1636-1640.

Elangbam, P. and Singh, S.G. 2012. Composition of nutritional and antinutritional substance of a tree legume, *Parkia timoriana* (DC.) Merr. *The Ecoscan*, 6: 125-128.

FAO, 1990. *Traditional Food Plants*. FAO paper, 42:593.

Hussain, J., Khan, A. L., Rehman, N., Zainullah, Hussain, S.T., Khan, F. and Shinwari Z. K. 2009. Proximate and nutrient analysis of selected medicinal plant species of Pakistan. *Pakistan Journal of Nutrition*, 8(1): 620-624.

Isong, E. U., Nkanga, E. U., Umoh, E. E. and Offong, E. E. 1999. Nutritional and phytogeriatological studies of three varieties of *Gnetum africanum* ("afang"). *Food Chemistry*, 64: 489-493.

Jeeceelee, L. and Sahoo, U.K. 2015. Plant diversity and vegetation structure in differently sized homegardens of Mizoram, India. *International Journal of Research in Agricultural Sciences*, 2(5): 229-235

Kanchan, L. V. and Veenapani, D. 2011. Nutritional analysis of indigenous wild edible herbs used in eastern Chhattisgarh, India. *Emirates Journal of Food and Agriculture,* 23(6): 554-560.

Kennedy, G. L., Pedro, M. R., Seghieri, C., Nantel, G. and Brouwer, I. 2007. Dietary diversity score is a useful indicator of micronutrient intake in non-breast-feeding Filipino Children. *Journal of Nutrition*, 137: 472-477.

Kulkarni, D. K., Agte, V. V. and Kumbhojkar, M. S. 2003. Leafy vegetables consumed by Mahaadeokoli tribe in Western Maharastra with their nutritional Potential. *Ethnobotany*, 15: 34-38

Labadarios, D., Davids, Y. D., Mchaza, Z. and Weir-Smith, G. 2009. *The Assessment of Food Insecurity in South Africa.*

Lucas, E. O. 1998. The potential of leaf vegetable in Nigeria. *Outlook on Agriculture*, 17(4): 163-163.

Marsh, R. 1998. Building on traditional gardening to improve household food security. *Food, Nutrition and Agriculture*, 22:4.

Mirmiran, P., Azadbakht, L., Esmaillzadeh, A. and Azizi, F. 2004. Dietary diversity score in adolescents-a good indicator of the nutritional adequacy of diets: Tehran lipid and glucose study. *Asia Pacific Journal of Clinical Nutrition*, 3: 56-60.

Musotsi, A.A., Sigot, A.J., and Onyango, M.O.A. 2008. The role of home gardening in household food security in Butere division of Western Kenya. *African Journal of food Agriculture, Nutrition and Development*, 8(4): 375-390.

Pandey, C.V. and Srivastava, R.C. 2009. Soil nitrogen mineralization and microbial biomass relation, and nitrogen conservation in humid-tropics. *Soil Biology and Biochemistry*, 73(4): 1142-1149.

Pearson, D. 1976. *The Chemical Analysis of Foods*. 7th ed. Churchill Living stone, London.

Philips, K.M, Tarrago-trani, M.T., Grive, T.M, Grun, I., Lugogo, R., harris, R.F. and Stewart, K.F. (1997). Simplified gravimetric determination of total fat in food composites after chloroform-methanol extraction. Journal of the American Oil Chemists' Society, 74(2): 137-142.

Rocky, P. and Sahoo, U.K. 2018. Traditional Homegardens of Mizoram and Their Socio-Economic Development. In: *Forests, climate change and biodiversity* (Eds. Sood K.K. and Mahajan, V.), pp. 102-126. Kalyani Publisher, Ludhiana, India.

Ruel, M.T. 2003. Operationalizing dietary diversity: a review of measurement issues and research priorities. *Journal of Nutrition*, 133: 3911S-3926S.

Rumeza, H., Zafar, I., Mudassar, I., Shaheena, H. and Masooma, R. 2006. Use of vegetables as nutritional food: role in human health. *Journal of Agricultural and Biological Science*, 1(1): 18-22.

Sadavisam, S. and Macickam, A. (1996). Biochemical methods, 2nd Edition, A new Age International (P) Limited, 185-196.

Sahoo, U.K. 2007. Agroforestry Systems and Practices prevailing in Mizoram. In: Puri, S. and Panwar, P. (eds.) *Agroforestry Systems and Practices*, New India Publishing Agency, New Delhi, Pp. 367-384.

Sahoo, U.K. 2009. Traditional home gardens and livelihood security in North-East India. 665-670. *Journal of Food, Agriculture and Environment* (Finland), 9: 7(2): 665-670.

Sahoo, U.K. 2017. Homegardens: Traditional systems for maintenance of biodiversity in Kolashib district of Mizoram, Northeast India. In: *Natural Resource Management for Sustainable Development and Rural Livelihoods* (Eds: Sati VP & Lalmalsawmzuava, K.C), Vol. 1, pp. 219-245. Today & tomorrow's Printers and Publishers, New Delhi-110002, India.

Sahoo, U. K. and Rocky, P. 2015. Species composition and plant diversity as influenced by altitude and size of homegardens in Mizoram, North-East India. *International Journal of Ecology and Environmental Sciences*, 41(3-4): 195-215.

Sahoo, U.K., Rocky, P., Vanlalhriatpuia, K. and Upadhaya, K. 2010. Structural diversity and functional dynamism of traditional home gardens of north-east India. *The Bioscan*, special volume.1: 159-171.

Sahoo, U.K., Rocky,P. Vanlalhriatpuia, K. and Upadhaya, K. 2011. Species composition, production and energetic sustainability of homegardens in the highlands of eastern Mizoram, India. *Tree and Forest Science and Biotechnology,*5 *(special issue)*: 1-13.

Sharma, H. K., Changte, L. and Dolui, A. K. 2001. Traditional medicinal plants in Mizoram, India. *Fitoterapia*, 72(2):146-161.

Singh, J.S., Singh, P.K., Dutta, B.K. and Sahoo, U.K. 2009. Chemical composition and nutritive indices in *Parkia roxburghii* G.Don, A leguminous plant of India. *Indian Journal of Agricultural Biochemistry*, 22(2): 87-93.

Singh, J.S., Singh,. Singh, P.K., Dutta, B.K. and Sahoo, U.K. 2010. Effect of processing and cooking methods on some anti-nutritive, toxic components and nutritional composition in *Parkia roxburghii* G. Don seeds. *Indian Journal of Agricultural Biochemistry*, 23(2): 97-102.

Steyn, N. P., Nel, J. H., Nantel, G., Kennedy, G. and Labadarios, D. 2006. Food variety and dietary diversity scores in children: are they good indicators of dietary adequacy? *Public Health Nutrition*, 9: 644-650.

Torheim, L. E., Barikmo, I., Parr, C. L., Hatløy, A., Ouattara, F. and Oshaug, A. 2003. Validation of food variety as an indicator of diet quality assessed with a food frequency questionnaire for Western Mali. *European Journal of Clinical Nutrition*, 57: 283-1291.