TRADITIONAL KNOWLEDGE AND CONSUMPTION OF FOREST PLANT FOODS IN GHANA

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ABSTRACT

Promoting the consumption of forest plant foods is a sustainable way of ensuring good nutrition and food security. This study assessed traditional knowledge on and use of forest plant foods in three administrative districts of Ghana and evaluated their potentials for domestication and processing. A total of 606 households were randomly selected and interviewed using enumerator-administered questionnaires. Validation workshops with 30 participants were held in each district to help identify the species mentioned. In all, 83 species belonging to 45 families were documented. Knowledge of forest plant foods was found to be higher among older respondents than younger ones, indicating an urgent need to document traditional knowledge on forest plant foods before it disappears along with the older generation. ***Artocarpus altilis*** *(Parkinson) Fosberg and* ***Tetrapleura tetraptera*** *(Schumach. & Thonn.) Taub. were identified as potential species for domestication and processing. Domestication and processing of forest plant foods on a larger scale presents opportunity for economic development, sustainability benefits and food security.*

Keywords: ***Artocarpus altilis; domestication; food security; indigenous knowledge; Tetrapleura tetraptera***

Introduction

Traditional knowledge (TK) refers to a body of knowledge built by a group of people living in close contact with nature. It includes a system of classification, a set of empirical observations about the local environment and a system of self-management that governs resource use (Quinn, 2001). Over the years traditional knowledge has played and continues to play an important role not only for those who depend on it in their daily lives, but to industry and agriculture as well (Gopalam and Reddy, 2006). Through TK, people have learnt about the consumption and preservation of forest plant foods, plants that can cure certain ailments, plants that are poisonous and the seasons in which these plants are available. For generations, the shamans of indigenous tribes throughout the Amazon basin for example, have processed the bark of *Banisteriopsis caapi* (Spruce ex Griseb.) Morton to produce a ceremonial drink used in religious and healing ceremonies to diagnose and treat illness, meet with spirits and divine the future (Alikhan and Mashelkar, 2004). The indigenous San people of South Africa are also the holders of the TK on the use of the *Hoodia gordonii (Masson) Sweet ex Decne* plant to suppress hunger and thirst (Vermaak *et al.,* 2011). Several authors have used TK to document information on medicinal, veterinary, food and pest control uses of numerous woody plants in West Africa (Dalziel, 1937; Irvine, 1961; Ayensu, 1978; Abbiw, 1990). Despite, the importance of TK on plants, it is widely disappearing due to globalization that promotes intensive agriculture, changes in

lifestyle and the modern food industry (Signorini *et al*., 2009; Turreira-García *et al*., 2015).

The loss of traditional knowledge particularly on forest plant foods constitutes a major challenge to achieving food security (Warren, 1991; Ineke *et al*., 2007). Forest plant foods come in different forms such as vegetables, roots and tubers, fruits, seeds and nuts. These foods could help achieve food security due to their contribution to diets and nutrition. A number of studies have indicated the high nutritional and health benefits of forest plant foods (Mavengahama *et al*., 2013; Powell *et al*., 2013; Fungo *et al*., 2015; Ghosh-Jerath *et al*., 2015, 2016). According to Vinceti *et al.* (2008) and Msuya *et al*. (2016) forest plant foods are good sources of vitamins, minerals, carbohydrates, fats and proteins. For example the leaves of *Adansonia digitata* (baobab) and *Tamarindus indica* (tamarind) are high in calcium and are sources of protein and iron (Acquah, 2010; Kehlenbeck and Jamnadass, 2014). Studies conducted in Botswana indicated that most indigenous plant foods are comparable or have higher nutrient content than their exotic counter parts (Legwaila *et al*., 2011).

Harvesting and trading of forest plant foods could create employment and generate income for rural people (Akinnifesi *et al*., 2006; Legwaila *et al*., 2011). In times of food shortages, especially during lean seasons, forest plant foods can act as safety nets in many communities (Kehlenbeck *et al*., 2013; Boedecker *et al*., 2014). However, consumption of foreign foods is gradually replacing that of traditional foods (FAO *et al*., 2014). Indeed, the consumption of forest plant foods is declining with the erosion of traditional knowledge on forest foods, the influx of western culture and practices and the rapid depletion and degradation of forest resources (Banana and Turiho-Habwe, 1997; Arnold, 2008).

Few studies have been done to document indigenous knowledge on forest plant foods in Ghana (Irvine, 1961; Abbiw, 1990; Asiedu-Darko, 2010; Sraku-Lartey *et al*., 2017). These studies have focused on only few plant species. For example, Irvine (1961), documented the uses and nutritional value of certain food plants whiles Abbiw (1990) documented information on useful plants of Ghana which included forest plant species used as food. Within the decade, Asiedu-Darko (2010) conducted a survey to gather indigenous knowledge of *Solanum torvum* in the East Akim District of the Eastern Region of Ghana. Thus, there is an urgent need to document the traditional knowledge of plant uses before it disappears along with the knowledgeable people who have upheld it over time.

Domestication of forest plant foods offers an option for food security and incomes of people living in rural communities (Legwaila *et al*., 2011). Although, domestication of indigenous plant foods has received significant attention in sub-Saharan Africa in recent years, there are only a few documented examples on domestication of indigenous plant foods (Ofori *et al*., 2014). Schreckenberg *et al.* (2006) provide evidence of how the domestication of *Dacryodes edulis* and *Irvingia gabonensis* in Cameroon and Nigeria have contributed to raising incomes, providing potential for better nutrition and maintenance of biodiversity and environmentally sustainable agricultural systems.

The objective of this paper is to determine available traditional knowledge on forest plant foods in the selected communities in Ghana, and in consultation with local communities evaluate their potentials for domestication and processing.

Methodology

Study area

The study was conducted in three administrative districts of Ghana, one of which is officially referred to as Municipality. They are Offinso Municipality/ Municipal ($7^o15'$-$6^o95'$N, $1^o35'$-$1^o50'$E), Asante Akim South District (6°34′N, 1°7′W) and Assin South District (5°30′N,1°2′W) (Figure 1). The municipality and districts are located in the dry semi-deciduous, moist semi-deciduous and moist evergreen vegetation zones of the country, respectively. Asante Akim South and Offinso Municipal have six major forest reserves each, whiles Assin South has five major forest reserves. All the study areas experience a bi-modal rainfall pattern with major rainy season occurring from April to July, and the minor season from September to November. The population in the study areas according to the 2010 Population and Housing Census was 76,895 for Offinso Municipal, 117,245 for Asante Akim South and 104,244 for Assin South (Ghana Statistical Service, 2010).

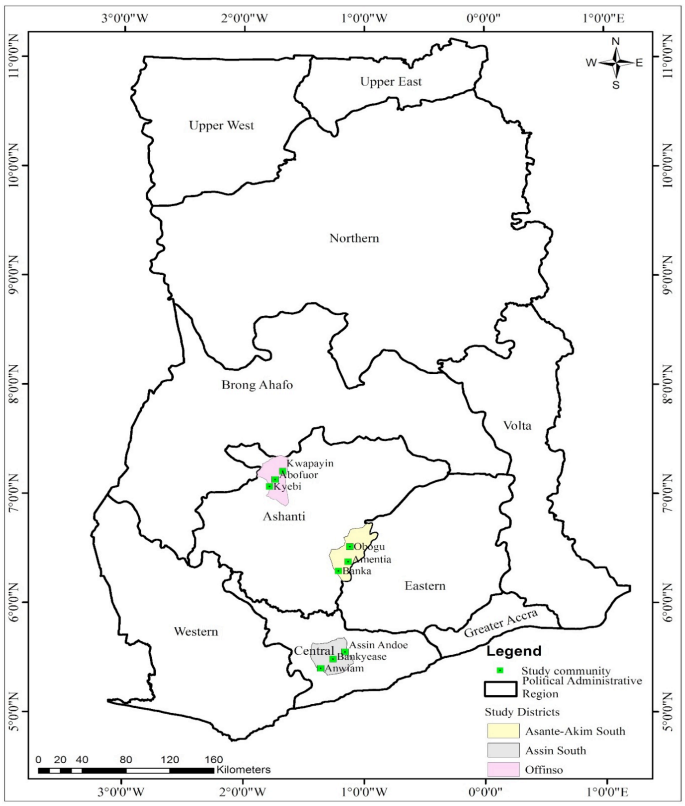

Figure 1: Map of the study locations in Offinso Municipal, Asante Akim South and Assin South districts of Ghana.

Study design

Two sampling techniques involving two stages of purposeful selection and one stage of randomization were used in the selection of municipality, districts, communities and households. First, one municipality and two districts were purposefully selected on the basis of accessibility and existence of major forest reserves within the municipality and districts. In the second stage, three communities each were purposefully selected from the municipality and two districts. Community selection was based on proximity to a forest reserve and willingness of community members to participate in the study. In the last stage, a total of 606 households were randomly selected from the municipality and two districts with 207 households in the Asante Akim District, 169 households in Assin South District and 230 households in Offinso Municipal. For this study, household was defined as a person or a group of persons, living together in the same house or compound and sharing the same house-keeping arrangements (Randall *et al.*, 2015). The study was approved by the District and Municipal Chief Executives of the selected areas. The Chiefs of the selected communities also approved the research protocol. Informed oral consent was obtained from the participating respondents.

Data Collection

Enumerator-administered questionnaires were used to collect information on socio-demographics which included questions on gender, age, marital status, household size, educational level, occupation and origin of respondent. Respondents were asked if they had any knowledge about traditional forest plant foods, and if so, how they acquired the knowledge. They were also asked to indicate the mode of transmission of the knowledge acquired. To determine the respondents' knowledge of traditional forest plant foods, each person listed the forest plant foods they had knowledge of. Respondents were also asked to indicate the forest plant foods they consume from the list mentioned, the part consumed, mode of consumption, seasonal availability and the level of availability (abundant, scarce or extinct). Respondents selected three forest plant foods they would want to be cultivated and processed in order of importance and the reasons for their choices from the list mentioned. For the purpose of this study, traditional forest plant foods was defined as plant species that grow naturally in a particular geographic area or forest and are consumed as food. The questionnaires were first pre-tested in the communities and adapted to suit the local context. Interviews took place in the homes of respondents. A validation workshop with 30 participants was held in each of the three districts to help identify the species mentioned**.** Respondents who were knowledgeable and had used more than 10 species were selected to participate in the workshop. They were asked to bring specimens (fruits, leaves, stem and bark) of the species mentioned. The plant species were identified through consensus at the validation workshop and by comparing specimens of the species to pictures in published literature.

Data analysis

Data was analysed using SPSS version 20. Descriptive statistics such as means, percentages and frequencies were computed and used to describe the data. The forest plant foods were categorized into seven groups based on folk perceptions (Pardo-de-Santayana *et al*., 2007), namely (1) "vegetables" i.e. plants of which leaves, stems or unripe fruits or seeds are consumed as vegetable; (2) "fruits" i.e. plants of which fruits or seeds are consumed when ripe; (3) "spices" i.e. plants used for seasoning (4) "vegetable oils" i.e. plants used as oils; (5) "stimulants" i.e. plants of which leaves, sap and seeds are used as stimulating drinks or beverages; (6) "drink" i.e. plants of which sap

can be consumed as a drink and (7) "carbohydrates" i.e. plants of which roots and tubers are starchy, which may be cooked or roasted before consumption. A one-way ANOVA (Analysis of Variance) was performed to compare the differences in mean age and household size between the three study areas. The Generalized Linear Model (GLM) based on Poisson distribution with a log link was carried out to identify which demographic variables influence the knowledge of forest plant foods. The response variable for the GLM was the number of forest plant foods respondents had knowledge of.

Results

Respondent characteristics

Six hundred and six (606) respondents from nine communities in the three districts were interviewed (Table 1). Average age of all respondents was 48.6 years. There was no significant difference in mean age between the respondents from the three study areas ($F = 2.90$, $df = 2$, $p > 0.05$). However, there was a statistically significant difference in the mean household size of the respondents ($F = 6.38$, $df = 2$, $p < 0.05$). A Tukey post-hoc test revealed that the mean household size for Asante Akim South (5.82 ± 0.25, $p < 0.05$) was significantly lower compared to Assin South (6.92 ± 0.29) and Offinso Municipal (7.03 ± 0.27). There was no significant difference between the mean household sizes of Assin South and Offinso Municipal ($p = 0.953$).

The level of education of the respondents varied across the study area, but in general, 19% of respondents had no formal education whilst more than half (55%) had completed Middle or Junior High School (JHS) (Table 2). Majority (80%) of the respondents were farmers, with others being traders, government workers, hunters, artisans and herbalists (Table 2). Majority (73%) of the respondents from Asante Akim South and more than half (53%) of the respondents from Offinso Municipal were natives. However, more than half (69%) of the respondents from Assin South were migrants (respondents who were presently living in the community but were not born there).

Table 1: Number of respondents from the three districts.

Districts/Municipality	Communities	Respondents
Asante Akim South	Amantia	77
	Banka	68
	Obogu	62
Assin South	Assin Andoe	50
	Breman Anwiam	61
	Bankyease	58
Offinso Municipal	Abofour	67
	Kyebi	76
	Kwapayin	87

Table 2: Socio-demographic characteristics of households in the Asante Akim South District, Assin South District and the Offinso Municipality in Ghana.

Characteristics		Asante Akim South (n=207)	Assin South (n=169)	Offinso Municipal (n=230)	Total (n=606)
Age of respondents (years)		49.9 ± 1.1	46.2 ± 1.0	49.01 ± 1.0	48.6 ± 0.6
Household size		5.8 ± 0.3	6.9 ± 0.3	7.03 ± 0.3	6.6 ± 0.2
Gender (%)	Male	63.3	54.4	46.5	54.5
	Female	36.7	45.6	53.5	45.5
Marital status (%)	Single	7.7	7.1	7.0	7.3
	Married	70.0	78.1	68.6	71.7
	Divorced	12.6	3.6	10.9	9.4
	Widowed	9.7	11.2	13.5	11.6
Educational Level (%)	No formal education	11.1	16.6	27.8	19.0
	Primary	13.5	21.9	13.9	16.0
	Middle/JHS	67.1	51.5	48.3	55.6
	Secondary	6.3	7.7	7.8	7.3
	Tertiary	1.9	2.4	2.2	2.1
Major Occupation (%)	Farmer	73.8	78.0	85.8	79.5
	Trader	10.4	14.6	9.6	11.3
	Government worker	8.9	1.8	1.8	4.3
	Hunter	0.5	0.0	0.0	0.2
	Artisan	5.9	4.3	2.3	4.1
	Herbalist	0.5	1.2	0.5	0.7
Origin (%)	Native	73.0	31.3	53.3	54.0
	Migrant	27.0	68.7	46.7	46.0

Modes of transmission and method of communication of traditional knowledge on forest plant foods

Respondents mentioned different modes of transmission of TK on forest plant foods they have learnt since childhood. Parents were the main transmitters of TK in the study areas (Table 3). Knowledge on forest plant foods was also acquired from grandparents, friends and school. However, respondents from Offinso Municipal did not receive any TK on forest plant foods in schools and fewer than 4% in Asante Akim South and Assin South had received TK on forest plant foods in schools. A considerable proportion of TK on forest plant foods was communicated orally, followed by observations, participation and experimenting in the preparation or eating of the forest plant foods across the three districts. There was virtually no documentation on the local knowledge of forest plant foods in the study areas (Table 3).

Effects of demographic characteristics on the knowledge of forest plant foods

The median number of forest plant foods mentioned by the respondents did not differ across districts (Figure 2).

Table 3: Mode of transmission and communication methods of TK in the Asante Akim South, Assin South districts and Offinso Municipal.

Mode of transmission	Asante Akim (n=201)	Assin South (n=162)	Offinso Municipal (n=215)
Grandparents (%)	60	56	38
Parents (%)	81	87	84
School (%)	1	3	0
Friends (%)	27	39	26
Method of communication	**Asante Akim (n=204)**	**Assin South (n=162)**	**Offinso Municipal (n=216)**
Oral (%)	67	85	88
Observation (%)	62	76	79
Experimenting (%)	43	28	50
Participation (%)	53	58	44
Documentation (%)	1	2	0

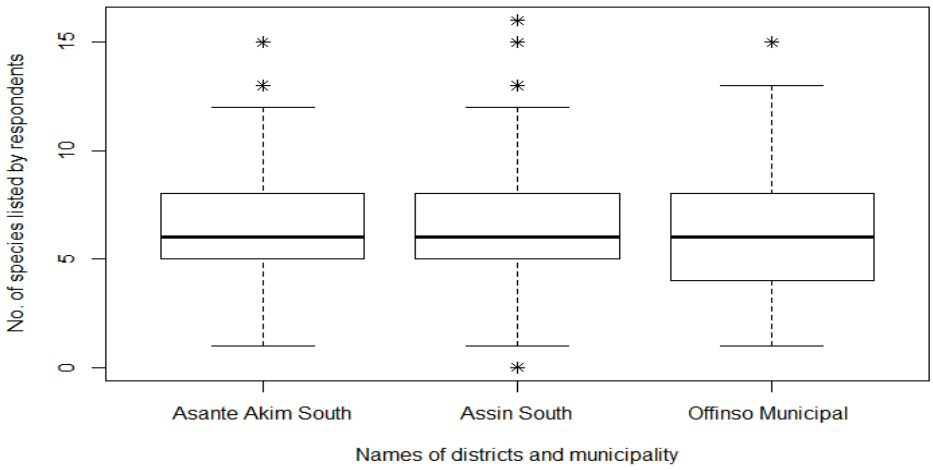

Figure 2: Box plot showing the number of species mentioned by respondents from Asante Akim South, Assin South and Offinso Municipal

Age, household size and origin were significant predictors for the number of forest plant foods known by the respondents. For a one-year increase in age, the knowledge on forest plant foods by respondents was likely to increase by 1.003. Furthermore, an additional member in the household was likely to increase the knowledge on forest plant foods by 1.009 (Table 4) given other variables in the model. Our results also indicate that natives were 1.1 times more likely to know about forest plant foods than migrants. Gender, education and occupation were not significantly associated with knowledge of forest plant foods.

Table 4: Generalized Linear Model showing the effect of socio demographic factors on the number of forest plant foods mentioned by respondents.

Socio demographic characteristics		Estimate	Odds ratio	Confidence Interval (odds ratio)
Gender	Male	-0.054	0.948	0.866-1.037
	Female	0	1 (reference)	
Age		0.003**	1.003	1.000-1.006
Household size		0.009**	1.009	0.999-1.019
Education	No formal education	0.315**	1.371	0.933-2.014
	Primary	0.188	1.207	0.819-1.778
	Middle/JHS	0.312	1.366	0.942-1.981
	Secondary/SHS	0.238	1.269	0.854-1.885
	Tertiary	0	1 (reference)	
Major Occupation	Farmer	-0.096	0.909	0.580-1.423
	Trader	-0.193	0.825	0.518-1.313
	Government worker	0.091	1.095	0.668-1.797
	Hunter	0.150	1.161	0.424-3.179
	Artisan	0.027	1.027	0.630-1.675
	Herbalist	0	1(reference)	
Origin	Native	0.118*	1.126	1.001-1.266
	Migrant	0	1(reference)	
Dispersion parameter		1.028		

* 5% significance level
** 10% significance level

Traditional knowledge and use of forest plant foods

Respondents had knowledge of 90 forest plant foods in the study areas. However, 83 of the forest plant food species are used in this study because we were not able to establish proper identification and scientific names of seven of the 90 species. The 83 forest plant foods belong to 45 families (Table 5). Respondents from Asante Akim South mentioned the highest number (73) of species followed by Offinso Municipal (63) species and Assin South District (61) species.

Of the 83 forest plant foods, 74% of them were mentioned and used by respondents from all the study areas. Two species, *Hypselodelphys poggeana* and *Combretum racemosum* were used by only respondents from Offinso Municipal whiles *Combretum smeathmannii* and *Ficus sycomorus* were used by only respondents from Assin South District. Five species namely *Memecylon blakeoides*, *Musanga cecropioides*, *Entada pursaetha*, *Taraxacum officinale* and *Ficus spp.* were used by only respondents from Asante Akim South District. In addition, they had knowledge of *Allanblackia floribunda* but had not consumed it before. The primary reason for collection of forest plant foods was for consumption in all the study areas. About 46%

of the respondents from the Asante Akim South District indicated that forest plant foods are mixed with other food sources and eaten daily, whilst 22% and 5% reported eating forest plant foods as part of their daily diets in the Offinso Municipal and Assin South District, respectively. About three quarters (75%) of the respondents eat forest plant foods less regularly in the Assin South district whilst 26% and 8% eat it less regularly in the Offinso Municipal and Akim South District, respectively. Some respondents from Asante Akim South (45%), Offinso Municipal (52%) and Assin South (20%) also eat these forest plant foods occasionally.

About a fifth (20%) of the respondents in the Offinso Municipal sell forest plant foods to earn income whereas less than a tenth of respondents from Asante Akim South (8%) and Assin South (2%) sell forest plant foods. Almost all the respondents who sell forest plant foods in the study areas sell the fruits of *Solanum torvum* (Turkey berry).

Table 5: List of forest plant foods mentioned by respondents from the Asante Akim South District, Assin South District and Offinso Municipality.

Scientific name	Local name	Family	Part (s) consumed	Categorization	Species mentioned (P), not mentioned (A)		
					Asante Akim	Assin South	Offinso Municipal
Xanthosoma spp	Ntwebu	Araceae	Tuber	Carbohydrate	A	P	P
Dioscorea prehensilis Baker Var. minutiflora	Ahabayere	Dioscoreaceae	Tuber	Carbohydrate	P	P	P
Dioscorea bulbifera L.	Akam	Dioscoreaceae	Tuber	Carbohydrate	P	P	A
Artocarpus altilis (Parkinson) Fosberg	Deeball	Moraceae	Fruit	Carbohydrate	P	P	P
Solanum tuberosum L.	Abrodwomaa, Asantom	Solanaceae	Tuber, Leaves	Carbohydrate	P	P	A
Byttneria catalpifolia Jacq.	Sukurowa	Sterculiaceae	Sap	Drink	P	A	P
Spondias mombin L.	Ataaba, Atoa, Ataawa	Anacardiaceae	Fruit	Fruit	P	P	P
Mangifera indica L.	Mango, Amango	Anacardiaceae	Fruit	Fruit	P	P	P
Annona squamosa L.	Apre	Annonaceae	Fruit	Fruit	P	P	P
Borassus aethiopum Mart.	Omankube	Arecaceae,	Fruit, Seed	Fruit	P	A	P
Ananas comosus (L.) Merr.	Abrobe	Bromeliaceae	Fruit	Fruit	A	P	P
Dacryodes klaineana (Pierre) H. J. Lam	Adwea	Burseraceae	Fruit	Fruit	P	P	P
Carica papaya L.	Brofere	Caricaceae	Fruit	Fruit	P	P	P
Myrianthus arboreus P. Beauv.	Nyankoma	Cecropiaceae	Fruit, pulp	Fruit	P	P	P
Terminalia Catappa L.	Aborofonkatie	Combretaceae	Seed	Fruit	P	P	A

Dialium indum L.	Akosua tuntum, Yooyi	Fabaceae	Seed	Fruit	P	P	P
Persea Americana Mill.	Paya	Lauraceae	Fruit	Fruit	P	P	P
Napoleonaea leonensis Hutch. & Dalziel	Obua	Lecythidaceae	Fruit	Fruit	P	P	A
Thaumatococcus daniellii (Benn.) Benth.	Anwonomosen	Marantaceae	Fruit	Fruit	P	A	P
Hypselodelphys poggeana (K Schum.) Milne-Redh.	Babadua	Marantaceae	Seed	Fruit	A	A	P
Ficus sycomorus L.	Osina	Moraceae	Seed	Fruit	A	P	A
Musa acuminata Colla	Kwadu	Musaceae	Fruit	Fruit	P	P	P
Psidium guajava Linn.	Guava	Myrtaceae	Fruit	Fruit	P	P	P
Carpolobia lutea G. Don	Ofiaw	Polygalaceae	Fruit	Fruit	A	P	A
Citrus sinensis (L.) Osbeck	Ankaa, akutu	Rutaceae	Fruit	Fruit	P	P	P
Deinbollia grandifolia Hook.f.	Aberewatoma, Mmaatam	Sapindaceae	Fruit	Fruit	P	A	P
Chrysophyllum africanum A. DC.	Adasama, Alasa, Adasa	Sapotaceae	Fruit	Fruit	P	P	P
Synsepalum dulcificum (Schumach. & Thonn.) Baill.	Asaa, Asaaba	Sapotaceae	Fruit	Fruit	P	P	P
Chrysophyllum perpulchrum Mildbr.	Atabene	Sapotaceae	Fruit	Fruit	P	A	P
Vitex doniana Sweet	Afoa	Verbenaceae	Fruit	Fruit	P	P	P
Syzygium aromaticum (L.) Merr. & L.M. Perry	Pepre	Myrtaceae	Seed	Spice	P	P	A
Monodora myristica (Gaertn.) Dunal.)	Aremma, Wediaba	Annonaceae	Seed	Spice	P	P	P
Parkia biglobosa (Jacq.) R.Br. ex G.Don	Dawadawa	Fabaceae	Seed	Spice	A	P	P
Tetrapleura tetraptera (Schumach. & Thonn.) Taub.	Prekese	Fabaceae	Fruit	Spice	P	P	P
Ocimum basilicum L.	Akokomesa	Lamiaceae	Leaves	Spice	P	P	A
Capsicum frutescens L.	Mesewa	Solanaceae	Fruit	Spice	P	P	P
Aframomum spp	Ateagyaa	Zingiberaceae	Leaves	Spice	P	P	P
Xylopia aethiopica (Dunal) A.Rich	Hwentia	Annonaceae	Fruit, Seed	Spice	P	P	P
Ocimum gratissimum L.	Nunum	Lamiaceae	Leaves	Spice	P	P	P
Piper guineense Schumach. & Thonn.	Esorowisa	Piperaceae	Seed	Spice	P	P	P
Aframomum melegueta K. Schum.	Efomwisa	Zingiberaceae	Fruit	Spice	P	P	A

Raphia hookeri G. Mann & H.Wendl.	Adobe	Arecaceae	Sap	Stimulant	P	A	P
Combretum smeathmannii G. Don	Ohwirem	Combretaceae	Leaves	Vegetable	A	P	A
Justicia flava (Vahl) Vahl	Afama	Acanthaceae	Leaves	Vegetable	P	A	P
Dracaena mannii Baker	Akosenakosene	Dracaenaceae	Leaves	Vegetable	A	P	P
Amaranthus hybridus L.	Efan	Amaranthaceae	Leaves	Vegetable	P	P	P
Xanthosoma robustum Schott	Bosomurudwera	Araceae	Leaves	Vegetable	P	A	P
Colocasia esculenta (L.) Schott	Brobe, kooko	Araceae	Leaves	Vegetable	P	P	P
Newbouldia laevis Seem. ex Bureau	Sesemasa	Bignoniaceae	Bark, Leaves	Vegetable	P	P	P
Bombax buonopozense P.Beauv.	Akata, Akokondie, Okuw	Bombaceae	Receptor, Bark, Flower	Vegetable	P	P	P
Ceiba pentandra (L.) Gaertn.)	Ceiba, Onyina	Bombaceae	Leaves	Vegetable	P	P	P
Combretum racemosum P. Beauv.	Kanfodua	Combretaceae	Leaves	Vegetable	A	A	P
Vernonia amygdalina Delile	Awonwono	Asteraceae	Leaves	Vegetable	P	A	P
Taraxacum officinale Weber ex Wiggers	Dandelon	Asteraceae	Leaves	Vegetable	P	A	A
Trichosanthes cucumerina L.	Akaton	Cucurbitaceae	Fruit	Vegetable	P	P	A
Cucurbita maxima Duchesne	Efere	Cucurbitaceae	Fruit, Leaves	Vegetable	P	P	P
Alchornea cordifolia (Schumach. & Thonn.) Müll.Arg.	Agyaaman	Euphorbiaceae	Bark	Vegetable	P	A	P
Phyllanthus capillaries Schumach. & Thonn.	Awobe	Euphorbiaceae	Whole Vine	Vegetable	A	P	P
Euphorbia hirta L.	Kakaweadwe	Euphorbiaceae	Leaves	Vegetable	P	A	P
Ricinodendron heudelotii (Baill.) Pierre ex Heckel	Wama, Nwama	Euphorbiaceae	Fruit, Bark	Vegetable	P	P	P
Griffonia simplicifolia (*Vahl ex DC*) Baill.	Kagya	Caesalpinaceae	Leaves	Vegetable	P	P	A
Oplismenus burmannii (Retz.) P.Beauv.	Nankakete	Poaceae	Leaves	Vegetable	P	P	A
Entada pursaetha DC.	Dufee	Mimosaceae	Leaves	Vegetable	P	A	A
Talinum triangulare (Jacq.) Willd.	Kotubete, Bokoboko	Portulacaceae	Leaves	Vegetable	P	P	P
Ficus spp.	Amangyedua	Moraceae	Leaves	Vegetable	P	A	A
Ficus sur Forsssk.	Odoma	Moraceae	Leaves, Bark	Vegetable	P	P	A

Piper umbellatum L.	Momohahan, Mumuaha	Piperaceae	Leaves	Vegetable	p	P	P
Geophila afzelii Hiern	Akura aso	Rubiaceae	Leaves	Vegetable	P	A	P
Blighia sapida K.D.Koenig	Akye, Ankye	Sapindaceae	Fruit Pulp	Vegetable	P	P	P
Solanum torvum Sw.	Abeduro, Kwahunsusuaa,Yaa Asantewaa, Abedwiridi	Solanaceae	Fruit	Vegetable	P	P	P
Solanum lycopersicum L.	Adjoa deede, Faadebegye, adwoba	Solanaceae	Fruit	Vegetable	P	P	P
Solanum pauperum C.H.Wright	Nsuasua	Solanaceae	Fruit	Vegetable	P	P	P
Memecylon blakeoides G. Don	Otweese	Melastomataceae	Fruit, Seed	Vegetable	P	A	A
Triplochiton scleroxylon K. Schum.	Wawa	Sterculiaceae	Leaves	Vegetable	P	P	P
Cyclosorus afer Ching	Aya	Thelypteridaceae	Leaves	Vegetable	P	A	P
Corchorus olitorius L.	Ayoyo	Tiliaceae	Leaves	Vegetable	P	P	P
Laportea aestuans (L.) Chew.	Honhon	Urticaceae	Leaves	Vegetable	P	P	P
Musanga cecropioides R.Br.	Odwuma	Cecropiaceae	Leaves	Vegetable	P	A	A
Lantana camara L.	Anansedokono	Verbenaceae	Flower, Leaves	Vegetable	P	A	P
Elaeis guineensis Jacq.	Abe	Arecaceae	Seed	Vegetable oil	P	P	P
Telfairia occidentalis Hook.f.	Akokorabonko, krobonko	Cucurbitaceae	Seed	Vegetable oil	P	P	P
Allanblackia floribunda Oliv.	Allanblakia, Sonkyi	Clusiacea	Seed	Vegetable oil	P	A	A
Tieghemella heckelii (A.Chev.) Roberty	Abako	Sapotaceae	Seed	Vegetable oil	P	P	P

Thirty-seven species belonging to 26 families are used as vegetables. This formed majority of the forest plant foods mentioned by the respondents from the study areas (Figure 3). Different parts of these vegetables such as leaves, fruit pulp, seed and flowers are consumed. These parts are either eaten raw, boiled or stir-fried with other vegetables. The second highest category was fruits representing 24 species and belonging to 20 families. In addition, five species are used as roots and tubers (carbohydrates). Also, 11 species belonging to eight families are used for seasoning (spices) whiles four species belonging to four families are used as vegetable oils. One species (*Raphia hookeri*) was said to be used as stimulant by respondents from Offinso Municipal and Assin South District. In addition, respondents from Offinso Municipal and Assin South District indicated that the sap that exudes from cut stems of one species (*Byttneria catalpifolia*) can be drunk to quench thirst (Figure 3).

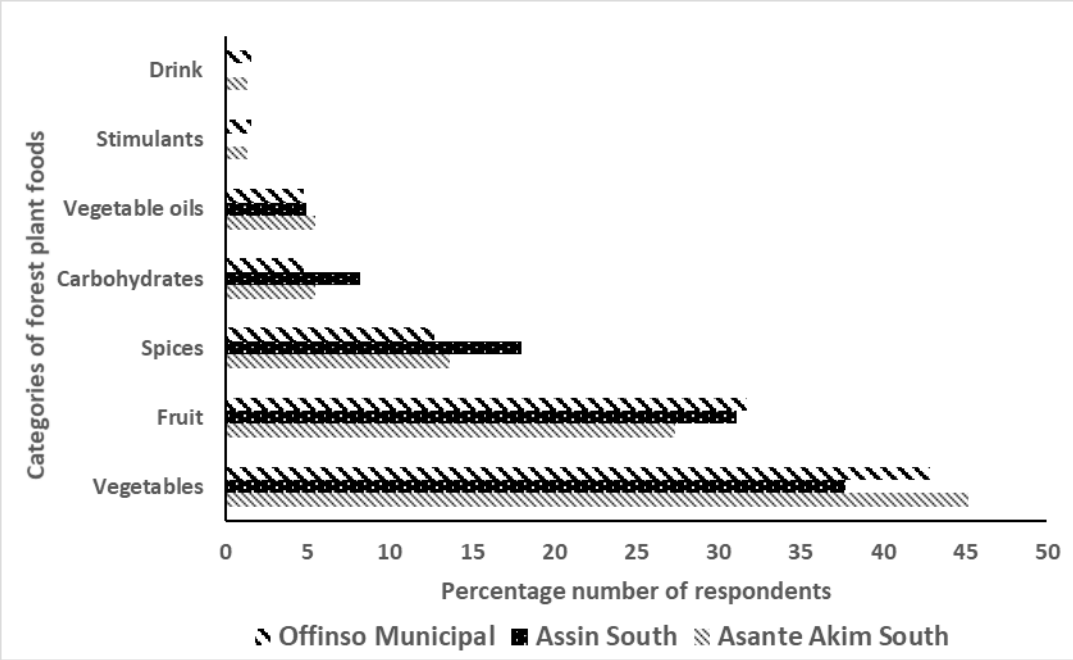

Figure 3: Categories of forest plant foods mentioned in the Asante Akim South, Assin South districts and Offinso Municipal in Ghana.

In terms of categories, the top 10 species mentioned by respondents, based on the frequency of use, are fruits (*Spondias mombin, Synsepalum dulcificum, Carica papaya*) spices (*Tetrapleura tetraptera*, *Capsicum frutescens*), vegetables (*Solanum torvum, Ceiba pentandra*) carbohydrates (*Artocarpus altilis*, *Dioscorea prehensilis*) and vegetable oil (*Telfairia occidentalis*). However, the top five most common species mentioned by respondents are *T. tetraptera, A. altilis, S. mombin, S. dulcificum* (miracle berry), *S. torvum* (turkey berry). *S. mombin* was said to be mostly appreciated by children because of their nutritious yellow pulp. Almost all of the species mentioned were autochthonous (i.e. native or originating from the same place). However, some of the species such as *Carica papaya (pawpaw), Persea americana, Mangifera indica, Psidium guajava, Elaeis guineensis* and *Citrus sinensis* have already been domesticated and can be cultivated in gardens.

Respondents from the three districts indicated that although majority of the forest plant foods are freely available and abundant, some are becoming scarce with some on the brink of local extinction. They indicated that human activities (illegal logging, indiscriminate bush fires) are the main causes for the near extinction of *A. altilis* and *T. heckelii.* They were also of the view that *Dioscorea praehensilis* was becoming rarer because of the application of herbicides on farmlands. Respondents from the study areas complained that some species such as *Telfairia occidentalis*, *T. tetraptera, Synsepalum dulcificum, Aframomum spp., Capsicum*

frutescens are also becoming scarce. *Memecylon blakeoides,* which was only present in the Asante Akim South District was also reported as becoming scarce.

Identification of potential forest plant foods for domestication and processing

Majority of respondents from the three study areas namely Asante Akim (83%), Assin South (81%) and Offinso Municipal (84%) indicated the potential for the cultivation of some of the forest plant foods. The need for processing some of the forest plant foods were also indicated by more than half of the respondents from the Asante Akim (60%), Offinso (55%) and Assin South (40%). All the respondents from the three study areas mentioned *T. tetraptera* and *A. altilis* (breadfruit) as the top two species to be domesticated and processed. The third species differed across the study areas with Asante Akim South indicating *T. heckelii (*Cherry Mahogany), Assin South *S. dulcificum* (Miracle berry) and Offinso Municipal *S. torvum* (Turkey berry). Factors that influenced the choice of *A. altilis* were that the species is becoming scarce and it is of high nutritional value. The respondents cook, roast or fry the mature fruit of *A. altilis* before eating. *T. tetraptera* was reported to be used in soups of nursing mothers to prevent postpartum contractions. Respondents also use *T. tetraptera* as a spice/seasoning in soups and it has high market value. Respondents indicated that *T. heckelii* is a multipurpose tree that can be used as timber as well as for the extraction of oil for export to boost income and improve livelihoods. *S. torvum* was said to be used for stews and soups. It is available almost all year round and has been planted in backyard gardens. The fruits and leaves are believed by the respondents to treat anaemia and asthma.

Both adults and children eat the fruit pulp of *S. dulcificum* (miracle berry) which serves as a sweetener. Its unique characteristic of modifying sour flavours to sweet enables the respondents to eat it before eating sour fruits. Miracle berry also serves as a substitute for sugar in some diets such as porridges. There was no evidence of commercial processing of any of the forest plant foods in the communities. Drying is the predominant method for preserving most of the forest plant foods in the study areas.

Discussion

Effects of demographic characteristics on the knowledge of forest plant foods

The results of the GLM (Table 4) indicate that a year's increase in age of the respondents positively influenced their knowledge on forest plant foods. Older respondents were more knowledgeable of forest plant foods than the younger ones. Poor documentation negatively affects parental transmission of traditional knowledge of forest plant foods to younger ones. In addition, the low level of knowledge about forest plant foods among the younger generation could be attributed to changes in lifestyles associated with changes in dietary habits and preferences (Ladio and Lozada, 2004; Turreira-García *et al*., 2015). For example, Ladio and Lozada (2004) reported that, lack of access to forests, drought and soil deterioration were some of the factors inhibiting the preservation of knowledge of plants among the younger generations in the Mapuche community of Patagonia in Argentina. In Guatemala, there are suggestions that knowledge of wild edible plants is decreasing due to the lack of interest among younger generations (Turreira-García *et al*., 2015).

In our study, gender had no effect on the knowledge of forest plant foods. However, the literature is not conclusive on the effect of gender on the knowledge of forest plant foods. Some studies report that women have more knowledge of forest plant foods (Somnasang *et al*., 1998; Panyaphu *et al*., 2011; Junsongduang *et al*., 2014) whiles others also report that men

are more knowledgeable of forest plant foods (Kang *et al*., 2014; Kujawska and Łuczaj, 2015). Education was also not associated with the knowledge on forest plant foods. Conversely, other studies have shown that longer period of formal education removes people from their natural, cultural, and physical environment, hence limiting the opportunity to learn about and participate in activities related to the transmission of knowledge from their transmitters (Somnasang and Moreno-Black, 2000; Zarger, 2002; Ladio and Lozada, 2004). Our results show that the natives are more knowledgeable of forest plant foods than the migrants. This is likely due to the fact that more time is needed for migrants to pick up traditional knowledge in their new environment.

Use of forest plant foods

Vegetables and fruits were found to be the largest food category of the 83 forest plant foods reported in this study. Consumption of vegetables and fruits gives diversity in daily food intake, adding flavour and taste to the diets. Several studies have also reported that vegetables and fruits are the highest category of plant foods (Legwaila *et al*., 2011; Uprety *et al*., 2012; Powell *et al*., 2013). For example, in Uganda, 34 plant species were known as traditional vegetables and fruits by rural residents of south western Rukungiri district (Musinguzi *et al*., 2006). Majority of the vegetables and fruits used in Uganda differ from the vegetables and fruits used by the respondents from this present study. According to Mavengahama *et al*. (2013) although vegetables may be eaten in small quantities they manage hunger and play an essential role in household food security. The top five species *T. tetraptera, A. altilis, S. mombin, S. torvum* (turkey berry*) and S. dulcificum* (miracle berry)*,* based on frequency of use mentioned by half (50%) of the respondents is attributed to their nutritional value and medicinal properties. The dry fruit of *T. tetraptera* has medicinal properties and a pleasant aroma and flavour which makes it a popular condiment in foods. Similarly, Okwu (2004) indicated that *T. tetraptera* helps to eliminate pungent odour and inhibit fungal growth in cassava fufu in Nigeria. In addition, different parts of the plants are used in the management of an array of ailments such as diabetes, hypertension, leprosy, convulsions, epilepsy and arthritis (Irvine, 1961; Abbiw, 1990; Enwere, 1998; Ojewole and Adewunmi, 2004).

The mature fruit of *A. altilis* was said to be cooked, roasted or fried before eating in the study areas, however, according to Ragone (2004), ripe *A. altilis* can be eaten raw or used to make beverages, desserts and other sweet dishes. In addition, the immature green fruit can be cooked entirely or cut into thin slices and boiled. Although, *S. mombin* was said to be mostly appreciated by children, not much use has been made with the fruit in Ghana. It is an important ingredient in the food industry such as in the preparation of ice cream, juices, yogurts, popsicles and jelly in Costa Rica and Brazil (Ayoka *et al*., 2008; Tiburski *et al*., 2011). It is also used in Panama, Peru and Mexico in fairly large quantities as jams. In the Amazon, the fruit is used mainly to produce wine and is also made into a cider-like drink in Guatemala *(*Ayoka *et al*., 2008). *S. torvum* (Turkey berry) is used as food in Ghana but it is also recognised for its medicinal properties. Similarly, it is widely used in the rural areas of India as traditional herbal medicine (Mahapatra and Panda, 2012) and in soups and sauces in Ivory Coast and Indonesia (Lim, 2013). On the other hand, Lim (2013) reports that the green fruit is eaten fresh in Thailand. *S. dulcificum* commonly known as the miracle berry was said to be used as a substitute for sugar. In Japan, the miracle berry has been reported to be popular among patients with diabetes and dieters. The miracle berry has been processed into tablets to enable diabetics

enjoy sweets without eating sugar (Shimamura n.d).

Potential forest plant foods for domestication and processing

Domestication of traditional forest plant foods has received attention in sub-Saharan Africa in recent years (Akinnifesi *et al.,* 2006; Schreckenberg *et al,*. 2006; Jones *et al.*, 2013, Ofori, *et al*., 2014). Five species namely *T. tetraptera, A. altilis, T. heckelii, S. dulcificum and S. torvum* were identified as having potential for domestication and processing by respondents in the three study areas. The top two species *T. tetraptera, A. altilis* that cut across the three areas are discussed.

Artocarpus altilis (breadfruit) is a traditional staple crop that has been cultivated over thousands of years by the people of Oceania (Jones *et al*., 2011; Zerega *et al*., 2004). Breadfruit is a versatile fruit that can be prepared and eaten at all stages of its development and maturity. It has been reported that the yields are superior to other starchy staples such as cassava and yam (Appiah *et al*., 2011). Several studies (Jones *et al*., 2011; Famurewa *et al*., 2015; Liu, 2016) have shown that breadfruit has high carbohydrate and protein content and is an excellent source of vitamins A and B, minerals including potassium and calcium, amino acids, essential fatty acids and dietary fibre. Due to the high potential of this important staple crop to contribute to food security, it has been included in the International Treaty on Plant Genetic Resources for Food and Agriculture and also classified as a priority crop by the Global Crop Diversity Trust (FAO, 2009; Jones *et al*., 2013). In Ghana, breadfruit is consumed as a snack by some rural inhabitants and could be used as a food security crop (Appiah *et al*., 2011). But generally, it is regarded as an unimportant product resulting in its neglect and lack of or little attention despite its important benefits (Gamedoagbao and Bennett-Lartey, 2007). Over 200 cultivars exist for breadfruit (Jones *et al*., 2011). However, the number of cultivars in Ghana is not known (Gamedoagbao and Bennett-Lartey, 2007). Further research is needed to identify which varieties would be suitable for cultivation in Ghana.

Tetrapleura tetraptera is common in Ghana, and throughout tropical Africa (Hawthorne, 1995). According to Franzel *et al*. (2008), *T. tetraptera* is the fourth most preferred indigenous tree species in Ghana. The wealth of this species as a medicinal plant to cure a number of ailments such as hypertension, asthma, diabetes mellitus, arthritis is reported in a number of studies (Ojewole and Adewunmi, 2004; Kuate *et al*., 2015). It also has nutritional benefits and the fruit is used as a spice, which adds good flavour to foods. It is rich in protein, lipids, potassium, iron, magnesium, phosphorous, and vitamin C (Okwu, 2003; Abii and Amarachi, 2007; Aniedi *et al.*, 2013). However, according to the survey conducted, *T. Tetraptera* is becoming scarce in the study areas. Studies conducted by FORM Ghana (2014) in Tain II Forest Reserve in the Brong Ahafo region also indicated that *T. tetraptera* is rare. In Nigeria, the species is at the verge of extinction (Aniedi *et al.,* 2013; Akpan and William, 2016).

Traditional forest plant foods are processed using local traditional knowledge in the study areas at the household level. Processing is essential as it adds value, increases shelf life and palatability of some products. There is a high rate of perishability of most vegetables and fruits due to lack of cold storage facilities in local communities. Forest plant foods, like other exotic food species, experience losses between harvest and consumption. Breadfruit is gluten-free and has been dehydrated and processed successfully into flour in Samoa, Philippines and Jamaica (Avegalio n.d). The breadfruit flour could help those who suffer from gluten

allergies. According to Sharon and Usha (2006), breadfruit flour can be stored for months at room temperature with little loss in quality. In Nigeria, the flour is used to prepare stiff porridge and 'fufu' (Mayaki *et al*., 2003; Oladeji *et al.*, 2013). It can also be used for making bread and biscuit (Amusa *et al*., 2002), cakes and pancakes (Ayodele and Oginni, 2002) and infant formulas (Esparagoza and Tangonan, 1993).

The domestication and processing of *A. altilis and T. tetraptera* on a larger scale deserves greater attention in Ghana as it can play an important role in food security and create livelihoods for people. There is the need to develop appropriate conservation strategies for domestication and modern methods of processing of forest plant foods. Lessons could be learnt from the domestication and processing of *Allanblackia parviflora* by the Novella Project being implemented by Unilever, Forestry Research Institute of Ghana of the Council for Scientific and Industrial Research (CSIR-FORIG) and International Council for Research in Agroforestry (ICRAF) (Peprah *et al*., 2009).

Conclusion

There was virtually no documentation on the local knowledge of forest plant foods in the study areas. Older respondents were more knowledgeable of forest plant foods than the younger ones, indicating an urgent need to document the traditi

onal knowledge on forest plant foods before it disappears along with the older generation. A number of forest plant foods abound in Ghana however, some of these are becoming scarce and are on the brink of extinction as a result of illegal logging, indiscriminate bush fires and the application of herbicides. There is need for extensive education on the important role of forest plant foods in food security and livelihoods improvement for especially forest-dwelling communities. Additionally, the opportunity to domesticate and process these plant foods on a larger scale could improve the economic fortunes of these people. Lastly, efforts are needed to develop appropriate conservation measures for processing of many of these plant foods.

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