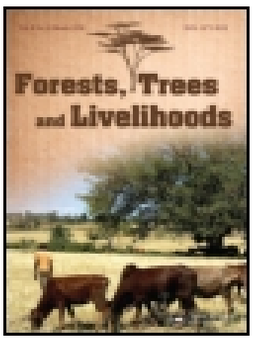

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Tetrapleura tetraptera in Ghana, Nigeria and Uganda: households uses and local market

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ABSTRACT

Tetrapleura tetraptera is an indigenous fruit tree in Tropical Africa. Scientific findings indicate its medicinal and nutritional properties, vital for rural livelihood sustainability. Despite this reported scientific potential, its uses in local communities have not received much attention. This study assessed *T. tetraptera* local uses in selected communities in Ghana, Nigeria and Uganda. Data were collected through semi-structured interviews with a total of 420 user households and 30 traders. Reported uses of *T. tetraptera* were medicine, food, timber, firewood, shade and cultural applications. When ranked by importance, medicinal uses emerged highest in Ghana, Nigeria and Uganda. Except for food uses that differed significantly ($p \leq 0.05$) between Uganda and Ghana, other *T. tetraptera* uses were not significantly different across the three countries. Household sales exclusively concerned the fruits, and were low, comprising only 16%, 15% and 6% of respondent households in Ghana, Nigeria and Uganda respectively. Our results reveal the importance of *T. tetraptera* for medicinal and food uses in local communities and its potential for improving local livelihoods through its domestication

KEYWORDS

Tetrapleura tetraptera; Fruit tree; Local market; Uganda; Ghana; Nigeria; Household use

Introduction

The use of wild fruit trees as food and medicine is a popular practice in developing economies like rural Africa (Kehlenbeck et al. 2013) and some parts of Asia (Joshi et al. 2018). This practice is further facilitated by cultural beliefs, rural poverty and high cost of conventional health care. For instance, several indigenous fruit trees such as *Tamarindus indica, Garcinia buchananii, Canarium schweinfurthii* and *Tetrapleura tetraptera* have been reported to be useful for food and medicine, especially in communities with limited health facilities (Katende et al. 1995; Okullo et al. 2014; Ranaivoson et al. 2015). However, *Tetrapleura tetraptera*, with its sweet tasty fruit pulp and pleasant aroma which makes it suitable for food and beverage flavouring (Ogbunugafor et al. 2017), seems to have received less attention in social economic research compared to other indigenous fruit tree species.

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Tetrapleura tetraptera (family Fabaceae) is a deciduous tree native to tropical Africa where it is distributed from Mauritania to Tanzania (Katende et al. 1995; Blay 1997). The tree grows up to 25 m high, with a diameter at breast height (DBH) of 1.5–3.0 m. Although its preferred habitats are savannah woodlands, dry forests and riverine forests, it is most common in dense rainforests and preserved forest patches around villages. The species is commonly known as "Prekese" in Ghana, "Aidan" in Nigeria and "Kikangabalimu" in Uganda. The meaning of these local names reflects the knowledge and use of the species by local communities in each country. For instance, the word "Prekese" in Twi dialect in Ghana means "soup perfume"; "Aidan" in Yoruba dialect in Nigeria means "cast no spell"; and "Kikangabalimu" in Rwamba dialect in Uganda means "it scares ghosts".

In agreement with its local names, *T. tetraptera* is reported to have various medicinal and nutritional properties (Adesina et al. 2016). The species medicinal attributes are due to presence of bio-active compounds (alkaloids, flavonoids, saponins, tannins, phenols and glycosides) which are essential for health (Okwu 2003). For instance, *T. tetraptera* fruit is reported to have anti-arthritis, anti-inflammatory and anti-diabetic properties (Ojewole and Adewunmi 2004). Aladesanmi (2007) and Soladoye et al. (2014) also indicated *T. tetraptera*'s use in managing schistosomiasis, a chronic parasitic disease caused by blood flukes (trematode worms). The nutritional attributes of *T. tetraptera* are due to essential food micronutrients, including iron and zinc found in the dry fruit (Akin-Idowu et al. 2011; Uyoh et al. 2013).

As said above, despite its medicinal and nutritional potential, *T. tetraptera* local use in the various communities where it is native has not been well documented. Most studies have focused on the chemical and pharmacological properties of *T. tetraptera* fruit (Abugri and Pritchett 2013; Lekana-Douki et al. 2011), with limited information on its local applications. To increase awareness of *T. tetraptera* potential uses, enhance its utilization and promote its domestication as a cash crop, we documented the various uses of *T. tetraptera* by local communities, and its local market in Ghana, Nigeria, and Uganda.

Materials and methods

Study area and selection of study villages

The study was conducted from September 2014 to January 2015, in selected districts/local government areas (LGAs) and villages/communities in Ghana, Nigeria and Uganda (Figure 1). The selection of countries was based on knowledge of occurrence and utilization of *T. tetraptera* and its geographical distribution following Blay (1997). Ghana and Nigeria were selected for the West-African range, and Uganda for the East-African range of *T. tetraptera* distribution. Country selection was further based on collaborative arrangements of researchers in Ghana, Nigeria and Uganda, facilitated by the International Foundation for Science (IFS).

Allocation of districts or LGAs within each country considered the country population, and the recorded or anecdotal knowledge of occurrence of *T. tetraptera* trees and their usage. The number of sampled districts or LGAs was six for Nigeria which has by far the highest human population size, and two in Ghana and two in Uganda, which have similar human population size.

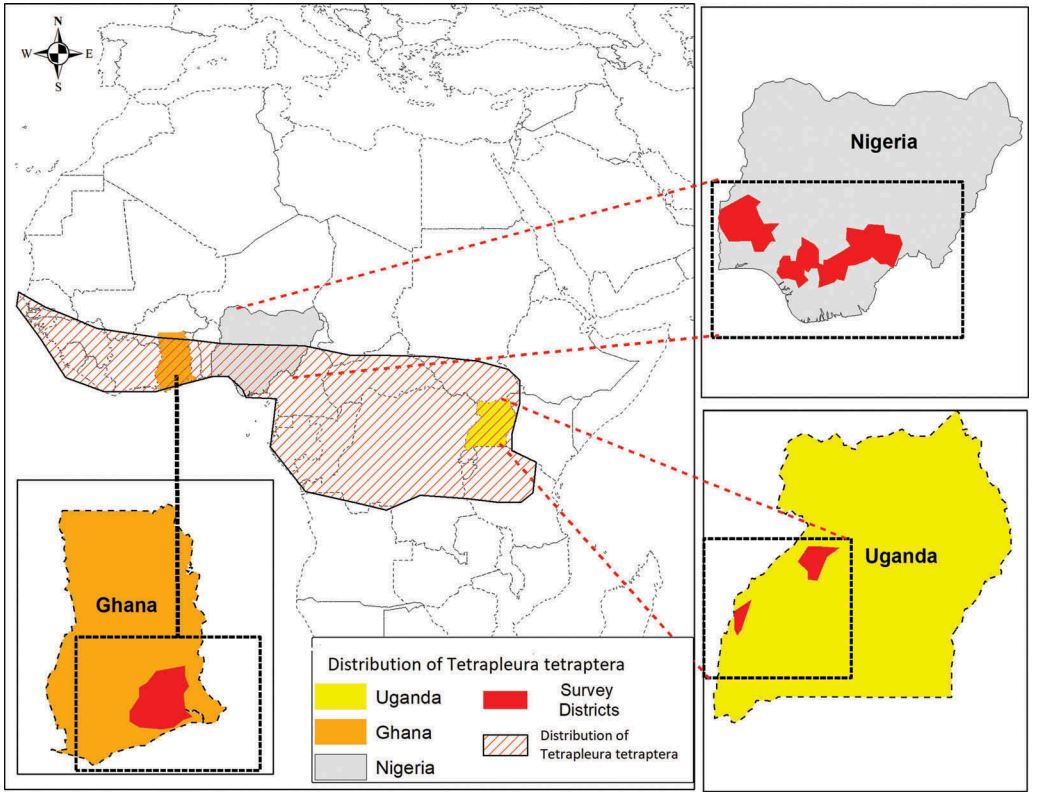

Figure 1. Location of study sites and distribution of Tetrapleura tetraptera.

In selecting individual districts for the study, we considered local markets and areas where the species was highly used or traded, using available district or LGA information obtained from the local government offices in each respective country. The selected districts or LGAs were Fanteakwa and Suhum Kraboa Coaltar in Eastern Ghana, Ife central, Ekpoma-Okha, Ibadan South West, Vandeikya, Nsukka and Njikoka in the Federal Republic of Nigeria, and Masindi and Bundibugyo in Western Uganda. Basic information for each of the selected districts and LGAs are presented in Table 1.

Communities living in all the selected districts are characterised by high poverty levels, with most households depending on subsistence farming and living on less than one dollar per day. The literacy levels range from 35–80%. However, land tenure systems differ. For instance, the selected districts of Ghana and Uganda are dominated by free-hold land tenure system, while those in Nigeria are characterised by government land ownership. The cropping systems are cross-cutting: whereas oil-palm (*Elaeis guineensis*) and cocoa (*Theobroma cacao*) are commonly grown in Nigeria and Ghana, maize, banana and beans are common in both Nigeria and Uganda.

After identifying districts and LGAs for the study, we surveyed all sub-counties or parishes where the species was highly used or traded, according to information obtained at local government district or LGA offices. We then ranked these sub-counties or parishes, according to their level of species use or trade in the market. In each district/LGA, we finally selected the sub-county with the highest ranking, and we then selected two villages[1] in each sub-county. We thus finally sampled four villages in Ghana, four in Uganda and twelve in Nigeria.

In Ghana and Uganda, the sampled villages comprised between 50 and 70 households, while in Nigeria, village population was higher, comprising between 11,000 and 50,000 households.

Household sample selection

We sampled a total of 420 households in the three countries for the survey. We then allocated the number of sampled households in each country according to its population size (i.e. 25, 35 and 160 million people in Ghana, Uganda and Nigeria respectively).

We thus allocated 70 households to Ghana and Uganda each, and 280 households to Nigeria. Proportional allocation of the sample households to each district was then employed. Finally, the district sample was distributed as evenly as possible among the selected two villages in each district/LGA (Table 2).

In each selected village, we generated a list of households that use the species, with the help of community leaders. From this village list, we randomly selected 8 to 38 households (Table 2). During household listing, we asked key questions to households to help us ascertain their knowledge of *T. tetraptera* tree. Furthermore, respondents were shown a tree picture and fruit of *T. tetraptera* and asked to identify it by local name, followed by an additional inquiry whether they have ever used the fruit. These preliminary questions ensured we only include *T. tetraptera* users in the survey.

Table 1. Basic information on the study areas in Ghana, Nigeria and Uganda.

Country	State	District/LGA	District size (SqKm)	Ethnic groups	Annual rainfall (mm)	Mean Annual Temperature (°C)	Vegetation and *T. tetraptera* habitat
Ghana	n/a	Fanteakwa[a]	1,150	Akan, Ga-dangme	1,500–2,000	24°C	Moist-semi deciduous forest vegetation for both districts.
	n/a	Suhum Kraboa Coaltar[a]	1,018	Akan, Ga-dangme	1,270–1,651	24–29	
Nigeria	Osun	Ife central[b]	111	Yoruba	1,000–1,500	30	Deciduous low land rain forest belt and savannah for all LGAs.
	Edo	Ikpoba-Okha[c]	862	Bini, Edos	1,000–1,500	30	
	Oyo	Ibadan South West[d]	40	Yoruba	1,205	28	
	Benue	Vandeikya[e]	1.8	Igbos, Igara	1,200 – 2,000	32.5	
	Anambra	Njikoka[a]	95	Igbos	2,000	23.5–32	
	Enugu	Nsukka	484		1,700	16–30	
Uganda	n/a	Masindi[h]	9,326	Banyoro	1,304	22.6	Tropical high forests around gazetted forest areas for both districts
	n/a	Bundibugyo [h]	2,338	Bamba	800 – 1,600	13–33	

Source: [a]Quaye et al. 2010; [b]Sanni (2010); [c]Izekor and Olumese 2010; [d]Adaramola and Oyewola 2011; [e]Agbidye et al. 2009; [a]Okoye et al. 2006; [g]Egbinola and Amanambu 2014; [h]Babel and Turyatunga 2015

Table 2. Number of household sampled in the districts/LGAs and villages.

District/LGA	Population of the district/LGA	Number of households sampled	Number of households/ respondents sampled per village
Ghana			
Fanteakwa	108,614	28	14[a], 14[b]
Suhum Kraboa Coaltar	167,551	42	21[c], 21[d]
Total 2 districts Ghana	*276,165*	*70*	
Nigeria			
Ife central	167,254	34	17[e], 17[f]
Ikpoba-Okha	371,106	76	38[g], 38[h]
Ibadan South West	282,585	58	30[i], 28[j]
Vandeikya	80,288	17	8[k], 9[l]
Nsukka	309,448	64	32[m], 32[n]
Njikoka	148,394	31	15[o], 16[p]
Total 6 LGAs Nigeria	*1,359,075*	*280*	
Uganda			
Bundibugyo	224,387	26	11[q], 15[r]
Masindi	370,000	44	20[s], 24[t]
Total 2 districts Uganda	*594,387*	*70*	
Total sample		**420**	**420**

Numbers of households sampled per village: a: Ahomahomasu and b: Ahenkwasis (**Fanteakwa District**); c: Okroase and d: Homea (**Suhum Kroboa District**); e: Iloro and f: Omitoto (**Ife LGA**); g: Ekpoma market area, and h: Iruekpen-Ichan (**Elkpoma-Okha LGA**); i: Egbeda and j: Molete (**Ibadan South West LGA**); k: Mbagra and l: New Market area (**Vandeikya LGA**); m: Unakashi and n: Lejja (**Nsukka LGA**); o: Nimo and p: Abagana (**Njikoka LGA**); q: Nyabyeya 1 and r: Kapeeka (**Masindi District**); s: Bumaga and t: Kyakatimba (**Bundibugyo district**).

Selection of markets and traders

We also conducted a market assessment in Ghana and Nigeria (we could not find any *T. tetraptera* selling point in Uganda). In each of the two countries, we carried out the assessment only in the district/LGA with the highest level of *T. tetraptera* commercialisation. In Ghana, this was Suhum Kraboa Coaltar district, while in Nigeria it was Vandeikya LGA. In each of these districts/LGAs, we undertook a reconnaissance survey, seeking information on the various *T. tetraptera* markets, the number of *T. tetraptera* traders in each market and the number of days each market opens per week. We then ranked markets according to the number of *T. tetraptera* traders and number of market days. We finally selected six local markets in each of the two selected districts/LGAs. In each of these markets, we employed snow-ball sampling techniques to select three to seven (3–7) *T. tetrapleura* traders, so that we finally interviewed 30 traders per country in Ghana and Nigeria.

Data collection techniques

In each household, we targeted the household head or the spouse as key respondents. Both quantitative and qualitative data were collected using a semi-structured questionnaire. The data focused on perceived local uses of *T. tetraptera* at community level, and commercial applications. Data on perceived local uses were obtained by asking respondents to list all useful *T. tetraptera* plant parts and their use in their communities. Further, we asked respondents whether they had sold any *T. tetraptera* products in the past year. Other information collected from the households were; sex, age and education of household head; and income and distance of the household to where T. *tetraptera* tree parts are collected.

In the local markets, quantitative data focused on obtaining information on *T. tetraptera* products sold around the area, selling points and respective product prices. Data on prices per kg in local currency at peak and off-peak seasons were collected, which were then converted to US dollars using prevailing rates at time of study (1 USD = 317 Nigerian Naira, 3.8 Ghana Cedis and 3500 Uganda Shillings).

Data analysis techniques

Household data on *T. tetraptera* local uses were summarized into frequency and percentage responses per district. Mean percentage responses of each local use per country were computed from the districts and then compared between countries using Analysis of Variance (ANOVA). The mean responses were then used to rank different *T. tetraptera* uses on a scale of one (*not important* at all) to five (*extremely important*), where: 1 = cited by 0–20% of the respondents (not important at all); 2 = cited by 21–40% (not important); 3 = cited by 41 – 60% (somewhat important); 4 = cited by 61–80% (very important) and 5 = cited by 81–100% (extremely important). The ranking was generated based on mean percentage responses of each *T. tetraptera* use per district, then computed per country and compared using ANOVA.

The local uses that scored mean ranking of somewhat important (41 – 60%) to extremely important (81–100%) were further analysed. Further analysis included identifying the different methods of *T. tetraptera* preparation for each individual application, mean percentage responses for different methods of *T. tetraptera* preparation and identifying the specific tree parts used. For instance, further analysis for different methods of medicinal uses included listing diseases treated by *T. tetraptera*, mean percentage responses for each disease and ANOVA to compare percentage responses of the different diseases reported across countries. After analysing data on *T. tetraptera* uses, *T. tetraptera* sale by individual households was also analysed.

The percentage of households that reported selling *T. tetraptera* products was calculated by country, and a binary logit model was applied to assess factors that influence households' sale of *T. tetraptera* products. In the logit model, the dependent variable was a binary choice for households that '*sell*' and '*do not sell*' *T. tetraptera*. Independent variables in the logit model included: sex, age, income, education and distance from homestead to where *T. tetraptera* is collected. The logit model was executed in two stages to compare the outcome with and without country dummies in the model. This analysis only considered *T. tetraptera* users in Ghana and Nigeria, where the species fruits were reported to be sold.

Further, market data from traders was analysed by synthesizing the qualitative information obtained per country regarding the selling points and market channels. The average fruit sales per trader were computed and mean *T. tetraptera* prices by country were compared across countries using ANOVA.

Results

Household characteristics

In this study, most sampled households were headed by individuals aged 22 to 82 years in Uganda; 27 to 85 years in Ghana and 21 to 90 years in Nigeria. Male headed households represented 52% and 56% of the respondents in Ghana and Nigeria respectively, but only

13% in Uganda (where 87% respondents were females). Most household heads (91% in Uganda; 78% in Ghana and 73% in Nigeria) had not attained education beyond primary level; and a majority of households (79% in Uganda, 48% in Ghana and 83% in Nigeria) earned between zero and fifty (0–50) USD per month.

Trader characteristics

Most of the interviewed traders were retailers both in Ghana (64%) and Nigeria (76%), with experience in *T. tetraptera* trade ranging from one to forty-eight years in Ghana, and one to twenty-five years in Nigeria.

Local uses of T. tetraptera

Local uses of *T. tetraptera* reported in our sample across Ghana, Nigeria and Uganda were: medicine, food, timber, and cultural rituals (Table 3). Shade and firewood uses were only reported in one and two countries respectively. The use of *T. tetraptera* for medicine was reported by most households in all the three countries with 82.5 % of the respondents in Ghana, 60.3% in Nigeria and 68.5 % in Uganda. Food was the second use reported in the two west-African countries with 72.0 % of the respondents in Ghana and 33.5% in Nigeria. In Uganda, cultural practices were the second use, cited by 53.5% of the respondents. There was a significant difference across countries for *T. tetraptera* use as food ($P \leq 0.05$), with more respondents reporting this use in Ghana than Uganda (Table 3). Other uses were not significantly different across the three countries.

As expected from the above results, when *T. tetraptera* uses were ranked, its medicine use was rated extremely *important in* Ghana, *very important* in Uganda and *some-what important* in Nigeria (Table 4). Food uses of *T. tetraptera* were ranked very *important* in Ghana, *some-what important* in Nigeria, and not *important at all* in Uganda.

Medicinal and food applications of T.tetraptera

Tetrapleura tetraptera was reported to treat a total of 20 diseases, with respondents reporting 14 diseases in Ghana, 15 in Uganda and 12 in Nigeria. Six diseases were collectively reported in Ghana, Nigeria and Uganda, while five were reported in either one or two of the three countries (Table 5).

Table 3. *Tetrapleura tetraptera* uses.

	Mean percentage respondents		
Local use	Ghana (n = 70)	Nigeria (n = 280)	Uganda (n = 70)
Medicine	82.5 ± 3.5[a]	60.3 ± 41.3 [a]	68.5 ± 36.1 [a]
Food	72.0 ± 16.9[a]	33.5 ± 34.4 [a]	09.5 ± 04.9 [b*]
Timber	00.5 ± 00.0 [a]	04.3 ± 08.0[a]	09.5 ± 09.2 [a]
Firewood	20.0 ± 28.2 [a]	00.0 ± 00.0 [a]	19.0 ± 14.1 [a]
Shade	00.0 ± 0.0 [a]	00.0 ± 00.0[a]	01.5 ± 02.1[a]
Rituals	01.0 ± 01.4 [a]	20.8 ± 34.1 [a]	53.5 ± 53.0 [b*]

Note: Similar letters in rows indicate no significant difference ($p \leq 0.05$) between countries; Different letters in rows indicate significant difference between countries ($p \leq 0.05$). Different letters in rows, denoted by * in rows indicate significant difference ($p \leq 0.1$) between countries.

Table 4. Ranking of *T. tetraptera* local uses.

	Mean rank scores		
Local use	Ghana (n = 70)	Nigeria (n = 280)	Uganda (n = 70)
Medicine	4.5 ± 0.7[a]	3.3 ± 1.9 [a]	4.0 ± 1.4 [a]
Food	4.0 ± 1.4 [a]	2.0 ± 1.6 [a]	1.0 ± 0.0 [a]
Timber	1.0 ± 0.0 [a]	1.0 ± 0.0 [a]	1.0 ± 0.0 [a]
Firewood	1.5 ± 0.7[a]	1.0 ± 0.0[a]	1.5 ± 0.7 [a]
Shade	1.0 ± 0.0 [a]	1.0 ± 0.0[a]	1.0 ± 0.0 [a]
Cultural practice	1.0 ± 0.0[a]	1.7 ± 1.6[a]	3.0 ± 2.8 [a]

Note: Similar letters in rows indicate no significant difference (p ≤ 0.05) between countries and local uses

Table 5. *T. tetraptera* applications for disease treatment

	Percentage of respondents		
Diseases	Uganda (n = 70)	Nigeria (n = 280)	Ghana (n = 70)
Gastro-intestinal disorders (pain and ulcers	36.8 ± 3.0[a]	10.2 ± 20.0[a]	04.4 ± 6.2[a]
Cardiovascular disorders	14.5 ± 4.8[a]	00.0 ± 0.0[b]	24.7 ± 00.4[c]
Hypertension	00.0 ± 0.0 [a]	10.7 ± 20.1 [a]	41.6 ± 11.8 [a]
Body cleansing	12.9 ± 13.1 [a]	00.0 ± 00.0 [a]	14.7 ± 14.6 [a]
Skin disorders	04.6 ± 1.4[a]	02.4 ± 05.8 [a]	00.0 ± 00.0 [a]
Reproductive disorders	10.1 ± 09.3 [a]	00.0 ± 00.0 [b]	00.0 ± 00.0 [a]
General body pains and weakness	15.3 ± 13.7 [a]	16.7 ± 40.8[a]	29.5 ± 28.9 [a]
Dental disorders	01.80 ± 02.5[a]	04.2 ± 06.7[a]	04.5 ± 06.3[a]
Cancer (Breast and uterine);	04.6 ± 01.4 [a]	02.4 ± 05.8 [a]	00.0 ± 00.0 [a]
Convulsions and epilepsy	09.6 ± 02.7 [a]	48.9 ± 36.7 [a]	00.0 ± 00.0 [a]
Anaemia	01.8 ± 02.5 [a]	00.0 ± 00.0 [a]	02.2 ± 03.1 [a]
Anti-natal and post-natal anaemic conditions	03.6 ± 05.0 [a]	10.2 ± 20.0 [a]	02.2 ± 03.1 [a]
Malaria and fever	37.1 ± 13.2 [a]	07.9 ± 13.7 [a]	48.4 ± 02.3[b]
Flu and colds	03.6 ± 5.1 [a]	04.8 ± 11.7 [a]	00.0 ± 00.0 [a]
Wounds, burns, snake bite and dislocation	09.9 ± 06.2 [a]	01.9 ± 04.5 [a]	01.1 ± 01.6 [a]
Low body immunity	00.0 ± 00.0 [a]	00.0 ± 00.0[a]	05.6 ± 07.9 [a]
Back pain	09.1 ± 02.8[b]	00.0 ± 00.0[a]	01.1 ± 01.6[a]
Diabetes	00.0 ± 00.0 [a]	00.0 ± 00.0 [a]	07.8 ± 11.0 [a]
Asthma and chest pain	00.0 ± 00.0 [a]	00.0 ± 00.0 [a]	02.2 ± 03.2 [a]
Measles	00.0 ± 00.0 [a]	03.4 ± 05.3[a]	00.0 ± 00.0 [a]

Note: Similar letters in a row indicate no significant difference (p≤0.05) between countries while different letter shows significant differences

Malaria and fever were reported as the condition most treated by *T. tetraptera* in Ghana (48.4%) and Uganda (37.1%); while convulsion and epilepsy was the most reported in Nigeria (48.9%). There was a significant difference (P ≤ 0.05) in percentage response of diseases treated by *T. tetraptera* in Ghana, Nigeria and Uganda; particularly for treating cardiovascular disorders, reproductive disorders, malaria and fever and back pain (Table 5).

The main *T. tetraptera* parts reported for disease treatment were fruit, stem-bark, root-bark, leaves and seed (Table 6). While the use of T. *tetraptera* fruit was reported in the three countries, the use of leaves and seed was only reported in Uganda. Across the three countries, the fruits of *T. tetraptera* were the main parts reported for treating 95% of the 20 diseases treated by *T. tetraptera* (Table 6). Other *T. tetraptera* parts reported in medicinal applications were stem bark (50%), leaves (20%), seed (15%) and root-bark (10%).

Concerning food applications, *T. tetraptera* fruit was reported to be used for different food uses, including food spicing in both Ghana and Nigeria, yam stew and porridge seasoning in Nigeria, fish seasoning in Ghana and direct eating as snack in Uganda.

Table 6. *T. tetraptera* parts used for medicinal applications.

Disease	Parts used	Country
Gastro-intestinal disorders	Fruit	Ghana, Nigeria and Uganda
	Stem bark; Root bark; seed	Uganda
Skin disorders for newly born babies	Fruit	Uganda
Cardiovascular disorders	Fruit	Ghana and Uganda
	Stem – bark	Ghana and Uganda
Hypertension	Fruit	Ghana and Nigeria
Back pain	Fruit	Ghana
General body pains and weakness	leaves; Fruit	Uganda
	Stem – bark	Ghana and Uganda
Malaria and fever	Fruit	Ghana, Nigeria and Uganda
	Stem – bark	Nigeria and Uganda
	Leaves; Seed	Uganda
	Root-bark	Ghana
Reproductive disorders	Leaves; Stem-bark	Uganda
	Fruit	Uganda
Snake bite	Seeds	Uganda
Wounds and burns	Fruit	Uganda
Cancer (Breast and uterine)	Stem – bark	Uganda
	Fruit	Nigeria
Flu and colds	Fruit	Nigeria and Uganda
Convulsions and epilepsy	Fruit	Nigeria and Uganda
	Leaves	Uganda
Asthma and chest pain	Fruit	Ghana
Dental disorders	Fruit	Ghana and Nigeria
	Stem – bark	Ghana
Diabetes	Fruit	Ghana
Low body immunity	Stem – bark	Uganda
	Fruit	Ghana
Body cleansing	Fruit	Ghana
Measles	Fruit	Ghana

Cultural applications of T.*tetraptera*

Cultural applications of *T. tetraptera* were reported in Uganda and Nigeria. They included: protection against evil spirits, thieves and witches and restoration of lost love relationships. While use of *T. tetraptera* in protection against evil spirits was reported in both Nigeria and Uganda, its use in protection from thieves, witches, and for the restoration of lost love relationships was exclusively reported in Uganda. The tree parts of *T. tetraptera* reported for cultural use were fruit, seeds, and stem bark. Planting *T. tetraptera* tree in the compound was also reported as a cultural practice in Uganda. The fruit was the commonest reported *T. tetraptera* part used for cultural applications in Uganda and Nigeria. The fruit constituted four out of five cultural applications of *T. tetraptera* reported in Uganda and two out of three applications in Nigeria.

T. tetraptera sale by households

In this study, households who reported selling *T. tetraptera* fruits made up 16%, 15% and 6% of the respondents in Ghana, Nigeria and Uganda respectively. Household sale of *T. tetraptera* was not significantly influenced ($p \leq 0.05$) by age, gender, education of household head, household size, income and distance from homestead to where *T. tetraptera* is collected (Table 7). However, the likelihood of *T. tetraptera* sale by households was significantly different

Table 7. Factors that influence households' sale of *T. tetraptera* (n = 420).

	With country included in the model as dummies		With country excluded from the model	
Explanatory variables	Coef.	P > z	Coef.	P > z
Country-Ghana	−.121	.782	-	-
Sex	−.132	.848	−0.209	0.739
Age	.024	.341	0.023	0.353
Education	.043	.285	0.040	0.300
Household size	.125	.131	0.126	0.129
Distance	.147	.127	0.147	0.125
Income	.000	.466	0.000	0.471
_cons/intercept	−4.087	1.721	−4.217	0.011

across countries ($p \leq 0.05$), and was 1.8 times higher in Nigeria and 0.1 times higher in Ghana than in Uganda[2] (Table 7).

Commercial applications of Tetrapleura tetraptera in local markets of Ghana and Nigeria

The fruit was reported by traders to be the only commercial part of *T. tetraptera* in the three countries. In both Ghana and Nigeria, traders reported *T. tetraptera* fruit selling points in retail shops and local markets, while selling points along the road side were only reported in Ghana. Average fruit sale per trader per market-day was estimated by traders to range from 1.0 to 22.0 kg in Nigeria and from 0.6 to 151.0 kg in Ghana; while mean prices of *T. tetraptera* fruits reported in Ghana and Nigeria were 2.6 ± 2.1 (USD/kg) and 0.4 ± 0.5 (USD/kg) respectively; a difference which was significant ($p \leq 0.05$) .

Discussion

T. tetraptera local uses found in this study are similar to other indigenous fruit trees e.g. *Tamarindus indica, Garcinia buchananii, Canarium schweinfurthii* (Okullo et al. 2014; Ranaivoson et al. 2015) which are commonly used by local communities across Africa. The uses reported in this study agree with previous reports on *T. tetraptera* medicinal and food properties (Adesina et al. 2016).

However, our study revealed some unexpected results, suggesting a need for more comparative studies across different countries. For instance the homogeneity of information regarding the different tree parts used and the medicinal use of *T. tetraptera* in the three countries was unexpected, given the differences in ethnicity and geographical disperse of the countries studied. Another unexpected result was that tree parts other than the fruit, such as stem bark, leaves and seeds, are used for treating several diseases, which differs from many other studies that emphasized the medicinal use of the fruit, hardly citing the other parts of the plant (Adesina et al. 2016). Further pharmacological evaluation is needed to explore the potential of tree parts other than the fruit, especially for medicinal uses. Further, our study revealed new insights regarding *T. tetraptera*'s most important uses in local communities. Particularly, *T. tetraptera* fruits have been conventionally known as food spices in Ghana and Nigeria ([FORIG] Forest Research Institute of Ghana 2005), yet in our study their use as medicine emerged as more prominent than food uses. Moreover, the use of *T. tetraptera* as food was only significant in Ghana and Nigeria, but not

in Uganda. These differences in preferences of *T. tetraptera* use need to be considered when promoting the species and during value addition process.

Irrespective of differences in preference, this study reveals *T. tetraptera's* potential to improve livelihoods of communities in Sub-Saharan Africa if the tree is domesticated. Since *T. tetraptera* trees fruit early (about two years and a half after planting), it could be planted in agroforestry systems (Addo-Danso et al. 2012). *T. tetraptera* domestication has already been attempted in some countries, though in crude forms. For instance, farmers in Ghana already manage *T. tetraptera* through natural regeneration on their farms (Blay 1997). Hence including *T. tetraptera* as an agroforestry tree in farms and planting it as shade tree in coffee, tea and cocoa plantations may play a role in livelihood improvement.

This study was done in purposively selected villages, sub-counties and districts/Local Government Areas, based on existence and availability of *T. tetraptera* users. This selection criterion could induce some bias on the uses of the species in the general population. However, we expect this bias not to significantly affect this study outcome, since our target was not the number of *T. tetraptera* tree users, but the knowledge of what it is used for. Similarly, our focus on users of *T. tetraptera* implies that we cannot assess the factors that affect the species use at household level. Future studies with inclusion of *T. tetraptera* non-users could help identify factors that determine the species use and barriers to its utilisation.

Conclusions

T. tetraptera is widely valued for medicinal, food and cultural applications in rural communities of Ghana, Nigeria and Uganda where it naturally grows. Most of the uses by households in Ghana and Nigeria are subsistence, with minimal sale, which may indicate untapped potential of the species for commercialization. Further research is however required to confirm the species' uses reported in our study and their distribution in the general population, better assess the balance between household subsistence and commercial uses, ensure sustainability of the species management, and pave the way for its domestication, seen as an essential prerequisite for promoting the species and its properties on the market in Africa and at global level.

Notes

1. In this study, the words "village" and "community" are interchangeably used to refer to the lowest administrative unit in Ghana, Nigeria and Uganda.
2. The reference country in the model is Uganda.

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