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Cocoa farming households in Ghana consider organic practices as climate smart and livelihoods enhancer

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Abstract

Background: Several state and non-state organizations are promoting organic agriculture as a climate smart option among cocoa farmers in the Ashanti region of Ghana. In this study, flora diversity and livelihoods position in organic and conventional farming were measured and compared. The experiment included 32 households with young plantations. Jaccard similarity, Shannon (H') and Simpson (D) diversity indices were measured to assess species similarity, abundance, evenness and dominance. The sustainable livelihoods indicators were food security, income, vulnerability and well-being.

Results: The results showed that the species are quite similar. The H' index for organic farms was slightly higher (0.808) than that of conventional farms (0.762); the D index (0.051) for organic was better than the conventional (0.084). The organic farmers studied had better sustainable livelihoods outcomes than the conventional farmers.

Conclusion: Since organic farming has more biodiversity, farmers should be encouraged to practise it to improve livelihoods outcomes and enhance climate change mitigation.

Background

Cocoa (*Theobroma cacao*) is a very important perennial crop in Ghana and serves as a major source of foreign exchange for the nation aside providing over 800,000 farmers with employment [22]. About two decades ago, the government of Ghana introduced a number of interventions including extension information dissemination, the Cocoa Disease and Pest Control (CODAPEC) programme, the Cocoa Hi-tech initiative programme, the payment of the remunerative producer prices and the bonus payment scheme as a means of rewarding farmers' effort in improving yields [28]. The Cocoa Hi-tech initiative programme was to boost the intensive use of fertilizers to replenish soil fertility, the application of pesticides on cocoa and the adoption of improved planting material to improve the productivity of cocoa farms [22, 23]. This conventional farming system, though a growth and output enhancer, is regarded as a form of green revolution with problems of biodiversity loss, pollution, environmental degradation and therefore lacks sustainability [25, 26]. The diversity of flora on arable and cultivated fields is at risk due to intensive use of mineral weedicides or herbicides [6, 12, 20]. Examples of weedicides or herbicides that are commonly used include the glyphosate brands such as *power*, sunphosate, sarosate, *adumawura* and *adwumaye.*

The sustainability concerns of conventional farming have been linked to the issues in global environmental change and impacts. There is declining rainfall and increasing temperature, and this usually results in reduction in agricultural production and food insecurity [24]. Hence, farming systems that are climate smart which can support climate change adaptation and mitigation and ensure food security concurrently have been perceived as a best practice option. Climate smart agriculture promotes use of weather, water, nitrogen, carbon, energy and knowledge smart practices [9]. Water smartness involves water conservation practices such as mulching; catch cropping fixesnitrogen and the application of organic

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manures and compost sequesters carbon and act as an energyresidue manager-considered energy smart; and when farmers are provided with weather information and they can share knowledge through association, then their practices are considered weather and knowledge smart.

In response to the call for the integration of climate smart agriculture into farming systems, several state and non-state agencies have supported households to practise organic farming in Ghana [11]. Traditionally, organic farming promotes the application of non-chemical-based fertilizers and pesticides; it integrates the use of mulches, compost, manures and catch cropping as well as agroforestry [4]. The farming system manages plant genetic resources, crop species and variety better and therefore strengthens farmers' resilience to changing climate as well as solves their food and livelihoods security problem [8]. The flora abundance provides diverse food sources and income diversification [21]. The issue of whether farmers who set aside their conventional practice to concentrate on organic farming appreciate the socio-economic gains is of interest.

In the Ashanti region of Ghana, a few (1000) households in the Atwima Mponua district have joined the Tanobiakoye Organic Cocoa Farmers' Cooperative Society Ltd to receive technical and managerial information on organic farming since 2010 [1]. Cocoa farmers in the community who continued their conventional practice are perceived as vulnerable in that they will experience higher biodiversity loss and be less able to cope with seasonality and climate change shocks. The capacity of conventional farmers to achieve sustainable livelihoods outcomes (increased food security, income and well-being, reduction in vulnerability and environmental soundness) is likely to be lower than that of their organic counterparts. The purpose of this paper is to describe flora diversity in organic and conventional cocoa farms and determine whether organic cocoa households have more sustainable livelihoods.

Methods

Study area

This study was carried out in the Atwima Mponua district of the Ashanti region of Ghana. The district is located in the south-western part of the Ashanti region and covers an area of approximately 894.15 square kilometres (http://www.ghanadistricts.gov.gh). The district is marked by double maxima rainfall seasons. The major rainfall period begins from March to July peaking in May. The average annual rainfall for the major season is about 170–185 cm per year. The minor rainfall period begins in August tapering off in November with an average minor annual rainfall of 100–125 cm per year. Mean annual temperatures of 27 °C are recorded in August and in March. The climate in the district is ideal for the cultivation of cash and food crops such as cocoa, kola, oil palm, maize, cocoyam, plantain, cassava, rice and all kinds of vegetables.

Even though the rainfall is adequate for agriculture, its erratic and unpredictable nature and concentration have adverse implications for rain-fed agriculture. The soil type in the district is the forest ochrosol. The vegetation is basically of the semi-deciduous type. The flora and fauna are diverse and composed of different species of both economic and ornamental tree species with varying heights and game and wildlife (http://www.mofa.gov.gh). The district has organic and conventional cocoa farmers located in several communities within the Tano Dumase Area Council. This study was conducted in two communities, namely Gyereso and Pasoro. The two communities have similar land forms, and so biases in comparison have been reduced.

Conceptual framework: linking flora abundance to income generation and food availability

There are state agencies/public sector institutions such as Cocoa Health and Extension Division (CHED), non-governmental organizations (NGOs) such as Agro Eco-Louis Bolk Institute (AE-LBI) and Rainforest Alliance (RA) and private cocoa beans buyers such as Armajaro Limited that are supporting the incorporation of organic cocoa farming. The organizations view organic farming practices as climate smart since it conserves biodiversity and also supports carbon sequestration. The expectation is that households that have adopted organic farming will have more diverse and abundant species. Therefore, the consumption and sale of such species will lead to increased food security, income and well-being as well as reduced vulnerability for organic farming households. The sustainable livelihoods framework (SLF) developed by the Department for International Development [5] captures the sense of the argument (Fig. 1). It is noted that the vulnerability context influences the level of livelihoods assets which include natural (N), human (H), financial (F), physical (P) and social (S) capital. The influence of transforming structures and processes leads to adoption of strategies that result in improved outcomes.

Method of data collection

Flora survey and farm selection

In August 2014, the ProEcoAfrica project randomly selected 150 households for farming systems' study in

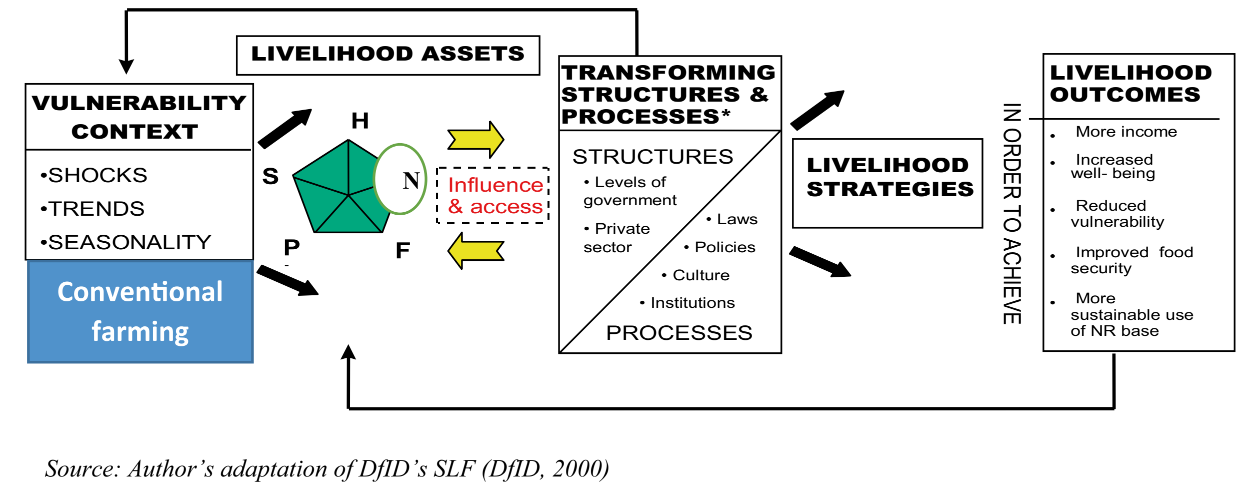

Fig. 1 Conceptual framework of study. *N* natural capital, *S* social capital, *F* financial capital, *P* physical capital, *H* human capital. *Source*: Author's adaptation of DfID's SLF [5]

Gyereso and Pasoro. The project is being implemented by the Research Institute of Organic Agriculture (FiBL), Switzerland, and University of Ghana to ascertain the profitability and productivity of organic and conventional cocoa farming systems. The ProEcoAfrica database was examined for relevance in January 2015. A total of 32 (32) cocoa farmers managing organic and conventional farms in the two communities were purposively selected from the database. Only farmers who managed cocoa farms that were aged between 2 and 3 years inclusive were selected. The canopies of these farms were not closed and therefore above-ground flora growth was in progress. After one month, those who were unwilling to participate in the experiment were replaced with willing farmers. For simplicity, there was an even distribution of the 32 farmers among the farming systems and among the communities: Eight each of organic and conventional cocoa farms were selected from Gyereso and Pasoro. Organic farms were selected and paired with conventional farms of similar size within 5 km where there were no adjoining fields between them. The pairing was done to minimize differences in landscape and elevation as well as soil types and characteristics [2].

Procedure for sampling the flora

In each cocoa farm, 25 m × 25 m main plots were marked out randomly. This plot was subdivided into five subplots of 5 m × 5 m out of which one was randomly selected to determine the quantitative abundance of herbaceous plants. The number of individual plant species in each plot was recorded. For each main plot, a species composition list was prepared to include trees, shrubs and herbs of the two farming systems. It was noted that the medicinal flora as well as crop flora like cocoyam (corm) and plantain (*musa spp*) were largely voluntary plants (that grow without cultivation). Species were identified as far as possible on site with the help of a professional (here, Taxonomist). Samples which could not be identified were collected and pressed for later identification at the herbarium in the Department of Botany, University of Ghana.

Household survey

Household heads of cocoa farms that were sampled were interviewed to assess the contribution of flora diversity on their cocoa farms to their livelihoods. Secondary data on the following variables were obtained from the ProEcoAfrica database: respondent's biodata, household composition, farming activities, agrochemical application information, membership of a farmer-based organization, health status of farmers' family and cost of production of farm produce. A face-to-face discussion was held with the individual farmers to validate the secondary data and collect new information through questionnaire administration (Additional file 1). The new data collected were on: frequency of consumption of identified flora species (as a measure of desirability or popularity of species), trends in sales, availability of flora species all year round (2014) and income from sale of flora. A focus group discussion was done to validate the information during the survey.

Methods of data analysis

The flora analysis to show biodiversity involved two steps:

1. Measuring species compositional similarity using Jaccard index [19] and
2. Measuring the diversity among species in the cocoa farm, using Shannon diversity index (H') and Simpson diversity index (D) [3, 19].

The Jaccard index of similarity is a ratio that is used to determine the similarity between two farming systems. Hence,

$$J = \frac{a}{(a + b + c)} \quad (1)$$

where J Jaccard index of similarity; a the number of species found in both organic and conventional farms; b the number of species in only organic cocoa farms; c the number of species in only conventional cocoa farms and $0 \leq J \geq 1$

Decision criteria: zero (0) denotes complete dissimilarity and one (1) for complete similarity.

The Shannon index is a ratio that is used to measure species abundance and evenness (see McCune and Grace [19] for formula). The Simpson index is a ratio used to measure species richness [19]. The calculation of ratios to obtain the *Shannon* (H') and *Simpson* (D) indices for each of the farming systems was guided by the Biodiversity Professional Software (free version). The Mann–Whitney U test was used to test the difference in the indices obtained for organic and conventional farms.

Hypothesis testing of Shannon and Simpson indices (Mann–Whitney U test)

H_o *1* There is no difference in Shannon index of diversity of flora in organic and conventional cocoa farms. Hence,

$$H'_{\mathrm{OF}} - H'_{\mathrm{CF}} = 0$$

H_a *1* The Shannon index of diversity of flora in organic cocoa farms is greater than that of conventional. Hence,

$$H'_{\mathrm{OF}} - H'_{\mathrm{CF}} > 0$$

H_o *2* There is no difference in Simpson diversity index of flora in organic and conventional cocoa farms. Hence,

$$D_{\mathrm{OF}} - D_{\mathrm{CF}} = 0$$

H_a *2* The Simpson diversity index of flora in organic cocoa farms is greater than that of conventional

$$D_{\mathrm{OF}} - D_{\mathrm{CF}} > 0.$$

Livelihoods outcome measurement

In the household survey analysis, farmers' livelihoods outcomes were measured:

Food security: This study assumed that edible flora species identified on the farms were nutritious and once available will be consumed by household members or sold. It was hypothesized that organic cocoa farmers will consume and sell more flora than their conventional counterparts. The t test of difference between means was used to ascertain the significance of the difference.
Well-being: The proportion of income from flora sale used to cover cost of health was measured.

Farmers who spent more than 40% of flora income to finance the cost of their health bills were considered to have better well-being (GSS 2015).

Income: The relative frequency of income ranges per annum of up to GHS400 was calculated. Any income (from sale of edible flora) above GHS150.00 was considered high; the difference in the proportion of organic versus conventional farmers who earned above GHS150 was measured, and the t test of difference between means was used to ascertain the significance of the difference.
Vulnerability reduction: This was considered as improved social inclusion. It was assumed that membership of farmer-based organization (FBO) improved a person's social status. FBO is a platform for improving one's voice in society, gaining and sharing knowledge and improving access to productive resources [15] A score of 1 was assigned to members and score of 0 was assigned to non-members. It was expected that organic cocoa farmers will have a higher mean score than the conventional; the organic farmers were considered more resilient than their conventional counterparts.

Results and discussion

Nature of flora sampled

Out of the 93 flora species sampled in organic cocoa farms, 20 (22%), 32 (34%) and 41 (44%) were herbs, shrubs and trees, respectively. Out of the 82 flora species sampled in conventional cocoa farms, 16 (19.5%), 31 (37.8%) and 35 (42.7%) were herbs, shrubs and trees, respectively. Also, organic cocoa farms had 53 species distributed randomly and 40 distributed aggregately compared to 47 and 35 species, respectively, of conventional farms. Findings from the current work agree with that of Kershaw (1973) who postulated that a farm has more random and aggregate distribution than the other, when more individual species variance mean ratio is 1 and greater than 1 for distribution patterns of species, respectively. The level of life-form abundance and the species distribution patterns of organic cocoa farms is higher than that of conventional farms.

Species compositional similarity

Overall, a total of 111 flora species were sampled in the 32 organic and conventional cocoa farms selected. Thirty-one of the species were found in only organic cocoa farms, while 18 species were found in only conventional cocoa farms; 62 species were found in both. The calculated Jaccard index of similarity in flora species in organic and conventional cocoa farms was 0.64, indicating moderate similarity. This deviates from the expectation of dissimilarity in species of organic and conventional farms [12]. The situation can be explained away: Some of the farms in the two communities were on the conversion state so there will be traces of chemical herbicides and fertilizers applied in the past. Some species are bound to be on both farms; those found on the study farms included *Alchornea cordifolia, Baphia nitida, Chromolaena odorata* and *Millettia zechiana.*

Extent of difference of flora diversity in organic and conventional cocoa farms

The Shannon index for organic farms (species abundance and evenness) was slightly higher (0.808) than that of conventional farms (0.762); the Simpson indices (species richness/dominance) were 0.051 and 0.084 for organic and conventional farms, respectively (Table 1). Based on the Mann–Whitney *U* test, the difference in Shannon index for the two farming systems was not statistically significant. Studies by Jastrzebska et al. [16] (Polielno, Peninsula) and Edesi et al. [7] (Olustvere, central Estonia) found that Shannon diversity index values for organic farms were higher than those of conventional farms.

The difference in Simpson index for the two farming systems was statistically significant at 1% level. The flora diversity and dominance on organic farms are higher than conventional, consistent with findings of Solomou et al. [27].

Contribution of flora to sustainable livelihoods

The indicators of sustainable livelihoods employed were food security, income, well-being and vulnerability.

Contribution of edible flora to food security

The contribution of flora species to food security will be much enhanced if there is high flora diversity (access to flora). This will lead to an increased consumption of flora species. A total of 26 flora species were used for food and medicine by the cocoa farmers interviewed. During focus group discussions it was learnt that about 90% of the 26 species identified were commonly known and utilized by majority of the local people, while the remaining 10% were only known and consumed by a few households in the study area. All the 26 flora species were available all year round. The survey results presented in Appendix 1 showed that there were slight differences with respect to availability of specific flora to organic and conventional farmers.

The results from a paired *t* test in terms of perceived availability of flora all season showed a significant mean difference in organic cocoa farms (63.96 ± 24.44) compared to conventional cocoa farms (60.11 ± 26.69) (Table 2).

Majority of the parts of species consumed were the leafy or vegetative parts. Thirty-one per cent of the species were consumed as medicine, while 50% were used as food. Fifteen per cent of the species were consumed for both food and medicinal purposes. The differences in

Table 1 Comparison of farming systems with diversity indices *Source:* Author (2014)

Community	Measure	Organic index	Conventional index	U
Gyereso	Shannon index	0.914	0.818	21
	Simpson index	0.048	0.101	14*
Pasoro	Shannon index	0.805	0.795	19
	Simpson index	0.062	0.078	11**
Atwima Mponua district	Shannon index	0.808	0.762	124.5
	Simpson index	0.051	0.084	56.5***

*, ** and *** denote 10, 5 and 1% significance, respectively

consumption of the flora species are due to the time of need and purpose for consumption (beverage for medicinal purposes (used in treating fever), as food or as a relish to accompany diets).

The mean difference between their consumption by organic and conventional cocoa farmers show that organic cocoa farmers consume more (63.0 ± 30.87) compared to conventional cocoa farmers (54.83 ± 33.82) (Table 2).

The mean difference between sales by organic and conventional cocoa farmers shows that there is no significant difference between organic and conventional cocoa farmers (25.0 ± 22.63 and 26.3 ± 25.8, respectively) (Table 2). However, the sale of the different species by both organic and conventional households suggests that there is market for flora. The following flora were among the one sold *Ananas comosus* (*AborƆbɛ*), *Cardiospermum halicacabum* (*FƆtƆ*), *Carica papaya* (*Boferi*), *Ceiba pentandra* (*Onyaa/Onyina*) and *Colocasia esculenta* (*Kooko*).

Flora income

The results show that more (25%) organic farmers earn higher income from flora sale than conventional cocoa farmers (Table 3). The difference in income categories of organic farmers according to Neudeck et al. [21] will diversify their diets and enhance food security, especially at the individual and household level.

Well-being

There is an indication that flora income was critical in improving the well-being of both organic and conventional farmers. The results show that organic farmers have a better well-being; thus, 6% more use above 40% proportion of flora income to cover health expenses. This is consistent with findings of Maroyi [18] that organic farmers have better well-being (Table 4).

Table 2 Food security measures used by organic and conventional cocoa farms ***Source:*** **Author (2014)**

Indicator	Mean		Standard error	*P* value
	Organic	Conventional		
Flora availability all season	63.96	60.11	1.443	0.0807
Flora consumption	63.0	54.83	2.65	0.007
Flora sale	25.0	26.3	0.45	0.67

Table 3 Range of income obtained from sale of flora by farming system ***Source:*** **Author computation (2015)**

Income range (GHS)	Per cent respondents	
	Organic	Conventional
10–50	18.8	6.3
51–100	18.8	31.3
101–150	37.5	31.3
151–200	18.8	12.5
201–250	6.3	6.3
251–300	18.8	12.5
301–400	18.8	6.3

Table 4 Proportion of yearly health expenses financed by flora income ***Source:*** **ProEco Africa database and Author (2015)**

Proportion by flora income (%)	Per cent of farmers	
	Organic	Conventional
0	31.3	43.8
1–20	18.8	12.5
21–40	18.8	18.8
41–60	25.0	18.8
61–80	0	0
81–100	6.3	6.3

Vulnerability reduction

Membership of a farmer-based organization (FBO) was used as a proxy to vulnerability measurement. All the studied organic cocoa farmers belonged to a FBO known as Tano Biakoye group. However, 75% of conventional cocoa farmers belonged to an FBO (Cocoa *Abrabopa*, a subsidiary of Wienco Ghana Ltd). The activities farmers engaged in as group members included farmer field day/schools, participation in fora, workshops and seminars as well as weekly meetings. During focus group discussion, the farmers from both groups admitted that meetings and training of organic farmers are more regular than those of the conventional farmers group. This suggests that organic cocoa farmers are more socially included and less vulnerable to climate change and other land-use changes compared to conventional cocoa farmers.

Conclusion and policy recommendation

The organic cocoa farmers studied had more flora available all season and consumed more flora; the income from flora sale, general well-being (covering health cost) and resilience (participation in farmer organization) of the organic farmers was better.

Since organic farms accommodate more species in a changing climate, thus for biodiversity conservation, organic farming should be encouraged as a climate smart option to improve livelihoods outcomes and enhance climate change mitigation.

Though there is no clear difference in species diversity with respect to evenness and since the species dominance in organic is higher, it should be the preferred farming system. It aids the mitigation of climate change shocks, and therefore, in order to increase adoption of organic farming in the face of climate change, more awareness should be created by public sector institutions such as Cocoa health and Extension Division (CHED), non-governmental organizations (NGOs) such as Agro Eco-Louis Bolk Institute (AE-LBI) and Rainforest Alliance (RA) and private cocoa beans buyers such as Armajaro Limited to encourage farmers to practise organic farming, especially when setting up new farms and adhere to standards set.

Additional file

Additional file 1.

Abbreviations

AE-LBI: Agro Eco-Louis Bolk Institute; CHED: Cocoa Health and Extension Division; CODAPEC: Cocoa Disease and Pest Control; DfID: Department for International Development; FBiL: Research Institute of Organic Agriculture; FBO: Farmer-based organization; NGO: Non-governmental organizations; RA: Rainforest Alliance; SLF: Sustainable livelihoods framework.

Authors' contributions

IA participated in the statistical analysis of data on flora diversity and edited the manuscript. ISE participated in the design of the study and helped to draft the manuscript. JB conceived of the study, participated in its design and coordination, performed the statistical analysis and helped to draft the manuscript. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

Availability of supporting data

Yes. Supporting data can be accessed on www.proecoafrica.net (miparkerjnr@gmail.com).

Declaration

The authors do hereby declare that, with the exception of references to past and current literatures consulted which have been duly acknowledged, the work presented was carried out from August 2013 to July 2015 at the Climate Change and Sustainable Development in the University of Ghana, Legon.

Ethical approval and consent to participate

This study did not require any ethical approval. However, the research will not publish any data in a way that enables others to link specific information to the farmer. All data will be analysed anonymously. There is no risk for the farmer to face negative consequences due to the information which they provide, and there are no "wrong" answers the farmer can give.

Appendix 1

See Table 5.

Table 5 Indicators used in measuring food security

Species	Per cent respondents on availability		Per cent respondents on consumption		Per cent respondents on sale	
	Organic	Conven	Organic	Conven	Organic	Conven
Ageratum conyzoides (Abrakyie abodwese)	62.5	50	0	6.3	0	0
Alchornea cordifolia (Ogyama)	62.5	68.8	43.8	37.5	0	0
Ananas comosus (AborƆbɛ)	68.8	81.3	93.8	93.8	6.3	25
Antiaris toxicaria (kyenkyen)	43.8	50	18.8	18.8	0	6.3
Baphia nitida (Odwene)	43.8	25	68.8	31.3	12.5	0
Blighia unijugata (Akye)	12.5	6.3	25	12.5	0	0
Boerhavia diffusa (NkokƆdwe)	31.3	43.8	43.8	31.3	0	0
Capsicum frutescens (Moko)	93.8	93.8	93.8	100	37.5	31.3
Cardiospermum halicacabum (FƆtƆ)	100	62.5	75	37.5	12.5	6.3
Carica papaya (Boferi)	87.5	87.5	93.8	100	0	25
Ceiba pentandra (Onyaa/Onyina)	87.5	81.3	56.3	31.3	25	6.3
Colocasia esculenta (Kooko)	50	43.8	75	81.3	25	18.8
Cyathula prostrata (Apupuaa)	37.5	18.8	25	6.3	12.5	0
Dioscorea bulbifera (Cocoa asi bayere)	75	93.8	25	6.3	56.3	50
Elaeis guineensis (Abɛ)	81.3	75	100	93.8	37.5	43.8
Emelia sonchifolia (Guakuro)	56.3	37.5	81.3	50	25	12.5
Lycopersicon esculentum (Nsusuwa)	56.3	75	75	87.5	43.8	50
Mangifera indica (Mango)	75	75	93.8	87.5	18.8	25
Manihot esculentum (Bankye)	87.5	93.8	81.3	93.8	50	75
Momordica charantia (Nyanya/Nyinya)	93.8	75	81.3	68.8	0	0
Musa paradisiaca (bode/mpusae)	100	100	100	100	87.5	93.8
Persea americana (pea/paya)	56.3	62.5	37.5	56.3	0	12.5
Phyllanthus amarus (abomaguwakyi)	68.8	62.5	87.5	68.8	12.5	12.5
Synedrella nodiflora (Kwadupo)	56.3	31.3	56.3	31.3	12.5	6.3
Talinum triangulare (ɛfan/bokoboko)	12.5	12.5	12.5	18.8	0	0
Vernonia amygdalina (awonwene)	62.5	56.3	93.8	75	0	0
Mean	63.96	60.11	63.0	54.83	25.0	26.3
T test	$P < 0.0807$ $t(25) = 1.443$		$P < 0.007$ $t(25) = 2.65$		$P < 0.67$ $t(18) = 0.45$	

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