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Wild plants, pregnancy, and the food-medicine continuum in the southern regions of Ghana and Benin

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ABSTRACT

Ethnopharmacological relevance: In West Africa, women utilize wild plant species to maintain and enhance their health throughout the duration of pregnancy. These plants are a culturally resilient and financially accessible form of nourishment for pregnant women in the region, many of whom are malnourished, yet studies that identify both the nutritional and medicinal properties of these plants are limited.

Aim of the study: The objective of this study was to analyze women's knowledge of plants consumed in pregnancy in the southern regions of Ghana and Benin from a food-medicine continuum perspective.

Materials and methods: We gathered data in two fieldwork periods in West Africa (Ghana 2010 and Benin 2011) through herbal market surveys and 56 questionnaires with women and then conducted a literature review on known properties of the plants.

Results: Ghanaian women reported consuming wild greens such as iron-rich *Nephrolepis biserrata* and tree barks such as protein-rich *Ricinodendron heudelotii* in a soup based on the African oil palm fruit (*Elaeis guineensis*), a source of fatty acids. In Benin, participants frequently reported ingesting plants during pregnancy in the form of herbal teas. Commonly cited species included *Securidaca longipedunculata, Dichapetalum madagascariense,* and *Schwenckia americana.* Several of the plants demonstrated antioxidant, anti-malarial and anti-inflammatory activity in pharmacological studies, yet the majority has incomplete nutritional and pharmacological profiles. In total, informants cited 105 species that were consumed during pregnancy. Although Ghanaian and Beninese women mentioned different species and different forms of consumption, in both countries women cited "strengthening" as the most common motivation to consume wild plants during pregnancy. Strengthening is a concept that resonates within the food-medicine continuum, bridging the local diet and herbal pharmacopoeia of women's plant use during pregnancy.

Conclusions: Ethnobotanical studies of this nature highlight the multidimensional use of plants and can improve health and nutritional programs in the region.

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1. Introduction

Many medicinal plants fall under the food-medicine continuum as resources that meet both medicinal and nutritional needs (Etkin, 1996; Pieroni and Price, 2006). However, research on their uses tends to focus exclusively on the dietary or pharmacological properties of the species, overlooking how plant consumption could influence or prevent illness (Etkin and Ross, 1991, 1982; Pieroni et al., 2006). By focusing on only one aspect of the health-promoting properties of a plant, ethnobotanical research on traditional pharmacopeias falls short of a full appreciation of the complex and multidimensional ways that plants influence health. Researching the nutritional properties of medicinal plants provides a more comprehensive foundation to assess dietary intakes (Etkin and Ross, 1991, 1982), and arrives at the heart of the food-medicine continuum discussion. Major international food and health organizations have recommended the documentation and evaluation of nutritional and medicinal properties of plants (Burlingame et al., 2009; WHO, 2013), yet all-inclusive studies that document both the pharmacological and nutritional properties of traditional pharmacopeias are largely lacking.

In Sub-Saharan Africa, medicinal plants are collected to maintain and enhance the general population's health and diet, as well as the well-being of more vulnerable populations such as pregnant women. Women from sub-Saharan Africa suffer from some of the poorest nutritional indicators worldwide: between 5% and 20% of

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women have a low body mass index (BMI) and anemia rates and vitamin A/zinc deficiency range from 21% to 80% (Lartey, 2008). Research from across the continent has highlighted the role of herbal medicine for women's health, ranging from sexual health to fertility and menstruation concerns, and throughout the duration of pregnancy, childbirth, and breastfeeding (Malan and Neuba, 2011; Steenkamp, 2003; Towns and Van Andel, 2014; Veale et al., 1992; Yemele et al., 2015). In spite of the results of a recent study in Cameroon showing that 75% of women interviewed were satisfied with herbal medicine during pregnancy (Yemele et al., 2015), research on the dietary contribution of wild edible plants has excluded pregnant women given their special nutritional needs and vulnerable health status (Boedecker et al., 2014). These plants contribute to a culturally resilient and financially accessible form of nourishment for pregnant women in the region, a population who has been prioritized by international health organizations due to poor health measures and malnourishment (Kinney et al., 2010). Local plants contribute micronutrients, fiber, and bioactive compounds, and in addition to being better adapted to local conditions and requiring less capital investments, they are also sometimes better nutritional sources than introduced vegetables (Yang and Keding, 2009). Stimulating the traditional practice of consuming indigenous plant species has the potential to be a culturally appropriate health initiative during pregnancy since they are affordable, accessible, and nutritious. Yet scientific research is sorely needed on their nutritional properties and therapeutic applications before government initiatives and development organizations can incorporate them into their programs.

This study focuses specifically on women's knowledge of plants consumed in pregnancy in the southern regions of Ghana and Benin. Previous studies by the same authors have highlighted the importance of plants in pregnancy, by demonstrating that pregnancy-related ailments are a salient health concern for women in western Africa (Towns and Van Andel, 2014), and that maternal health is a priority for urban herbal medicine consumers in both Benin and Ghana (Quiroz et al., 2014; van Andel et al., 2012). We sought to answer the following research questions: (1) What are the common plant species consumed as wild and semi-domesticated foods by pregnant women in the southern areas of Ghana and Benin?; (2) What are the most common motivations and forms of consuming these plants during pregnancy?; and (3) What is known about the nutritional and therapeutic properties of these plants?

2. Methodology

2.1. Research sites

In this study we combined data gathered during two different ethnobotanical fieldwork periods in West Africa with a literature review of the documented nutritional and medicinal properties of commonly cited wild food plants during our fieldwork. This study was part of a five-year study researching medicinal plants use for women's health, childcare, and ritual practices in Ghana, Benin, and Gabon. From June to September 2010, we worked in the southern regions of Ghana: Greater Accra, Central, Western, Volta, and Eastern with a team of Dutch and Ghanaian students. Fieldwork in Benin was carried out from April to October 2011 in the eight southern-most departments of Benin: Collines, Zou, Plateau, Kouffo, Mono, Atlantique, Littoral, and Ouémé with a second team of Beninese and Belgian students.

Southern Ghana was once covered with tropical rainforests, but has lost much of its forest during the past 50 years (FAO, 2015). The tropical climate has a distinct wet and dry season. The majority of the 26.3 million people in Ghana belong to Akan-speaking ethnic groups (CIA, 2015). Ghana is considered a county of "medium human development" according to the United Nations Development Program (UNDP, 2015a).

Benin is a country with a savannah-dominated landscape (50% of total area), characterized by its location in the Dahomey gap- a savanna corridor along the Guinean forest (FAO, 2015). It has a population just under 10.5 million people, which are composed of various ethnic groups including Fon (39%), Adja (15%), and Yoruba (12%) (CIA, 2015). Benin is considered a county of "low human development" according to the United Nations Development Program (UNDP, 2015a).

Throughout the research, we carefully followed the guidelines of the Code of Ethics of the International Society of Ethnobiology (International Society of Ethnobiology, 2006) and fully respected all research protocols with partner institutions in both Ghana and Benin. This included carefully explaining the nature of our research and obtaining prior informed consent from all participants, and obtaining official research permits and plant export permits. Upon acquiring all necessary permits, our formal partners indicated that no additional human subject review board was required.

2.2. Data collection and analysis

We began our data collection by purchasing medicinal plant foods from vendors on the major urban markets in southern Ghana and Benin. This initial activity enabled us to familiarize ourselves with the local populations' priorities and commonly utilized plant species. All market interactions were conducted in English in Ghana and French in Benin without the use of an interpreter. From our contacts at the marketplaces and our formal research partners in each country, we then utilized snowball sampling to identify additional female participants from nearby communities with whom we conducted our ethnobotanical questionnaires. The questionnaires were performed in English in Ghana and French in Benin and were facilitated by an interpreter who translated the questions into local languages. These questionnaires were designed using standard ethnobotanical methods (Alexiades and Sheldon, 1996), including free-listing exercises, specific questions on common plants consumed in pregnancy, and plant collection walks immediately following the completion of each questionnaire. We made botanical collections of all cited species following standard botanical collection methods, deposited vouchers of all plants at the Ghana Herbarium (GC) and the Herbier National du Bénin (BEN), and exported a complete set of duplicates to the Wageningen branch of National Herbarium of the Netherlands (WAG), now merged into Naturalis Biodiversity Center (L). During our fieldwork in Ghana, 14 women were involved as participants in our questionnaires from the Akyem, Ga, Fante, and Nzema ethnic groups. In Benin, we worked with 42 women from the Fon and Yoruba ethnic groups.

After calculating the most commonly cited wild plants consumed during pregnancy from market interviews and questionnaires, we conducted a literature review on the known nutritional and medicinal properties of these plants. Although most of the plants cited in our research were collected in the wild, we also identified several "semi-domesticated" species-defined as plants that were once cultivated but escaped to the wild, and/or partially managed wild edible plants (González et al., 2010), in addition to a few cultivated species. We used the term "medicinal food plants" to include the consumption of plant parts in sauces and soups, as well as the ingestion of beverages such as teas and decoctions. We searched for peer-reviewed scientific articles that documented the medicinal and nutritional properties of traditional plant use for each species and cited plant part in order to capture the duality of medicinal food plants. Literature reviews

were performed during June–July 2015, using Google Scholar and PubMed. We searched for the species and plant part in question, in combination with the keywords 'properties,' 'medicinal,' 'nutrition,' 'vitamin,' 'food,' and 'pregnancy.' We also checked for frequently used synonyms of target species. Additional literature was found in the plant use databases *Plant Resource of Tropical Africa* (PROTA) (http://www.prota4u.info/) and FAO/INFOODS (http://www.fao.org/infoods/infoods/tables-and-databases/faoinfoods-databases/en/). All scientific plant names were checked with The Plant List (www.theplantlist.org).

3. Results

The Ghanaian women involved in our study cited 32 plant species that were consumed during pregnancy. Most plants were used in combination with other species. The most commonly cited plants included the herbaceous weedy species *Ageratum conyzoides*, secondary forest trees *Ricinodendron heudelotii* and *Xylopia aethiopica*, and the cultivated African oil palm tree *Elaeis guineensis* (Table 1). The cultivated species *Manihot esculenta* is also included in the list since Ghanaian women reported to consume its leaves in contrast to the commonly consumed tuber (manioc). The women also reported the consumption of kaolin, a white clay, mostly as one of the ingredients in a multi-species mixture. The barks and fruits of the trees and leaves of the herbs were cited as herbal decoctions or as food additives in sauces or soups, most commonly in the oil palm fruit soup known as "abenkwan" (Twi). When leaves from wild plants were incorporated into the soup, it was called "abdendrú" or "ambemdró" (Twi)-likely a combination of the words "abe" (palm nut) and "aduro" (medicine).

The majority of these species were reported to be used to strengthen women during pregnancy. Ghanaian women said that the fetus would grow from such food and that delivery would be facilitated through consuming these plants. One woman stated that these plants were eaten "when the belly does not grow enough." They also noted that strengthening after birth is often done with the same species and soups. All species cited by Ghanaian informants as well as plant families, local plant names/languages, uses, forms of consumption, and voucher numbers are listed in Supplementary Table A.

The most frequently cited plants from our Ghana study have been documented to have a range of nutritional and medicinal properties (Table 1). The leaves of *Nephrolepis biserrata* have shown to be a good source of protein, calcium, iron, as well as having antioxidant and antimicrobial activity. *A. conyzoides* has been documented in studies to have anti-inflammatory, analgesic and antipyretic properties in addition to antifungal and antibacterial activity. Several species had incomplete profiles for both sets of properties, and the leaves of *Dracaena arborea* did not have any documented properties for human health.

In Benin, women from our study cited 81 total species that were consumed during pregnancy. All 81 species, as well as plant families, local plant names/languages, uses, forms of consumption, and voucher numbers are listed in Supplementary Table B. Like the Ghanaian women, most plants were a part of a multispecies recipe. The three most commonly cited species were *Securidaca longipedunculata*, *Dichapetalum madagascariense*, and *Schwenckia americana* (Table 2). Two women from Benin mentioned the fungus *Ganoderma* sp. in association with several plants for strengthening during pregnancy. The Beninese and Ghanaian participants cited eight of the same species: *Flueggea virosa*, *Heterotis rotundifolia*, *Khaya senegalensis, Newbouldia laevis*, *Secamone afzelii, Spathodea campanulata, Vernonia amygdalina*, and *Zanthoxylum zanthoxyloides*.

Beninese women most commonly reported consuming wild plants in the form of herbal decoctions. Women reported boiling the leaves and barks for hours and then sifting the plant parts from the liquid for consumption. The decoctions were reported to be ingested throughout the day. Participants noted that some plants were used for very early pregnancy and others closer to delivery. Only one informant mentioned wild species used as a sauce. Like the Ghanaian participants, strengthening plants were reported to be the most salient use category during pregnancy. The concept of strengthening included improved overall health to both the fetus and the mother.

The medicinal properties of the plants cited in Benin were better documented than the nutritional qualities; 6 out of the 10 top cited species had no associated nutritional studies (Table 2). Aside from the high vitamin C content of *Heterotis rotundifolia*, the only other nutritional quality documented for these species was antioxidant activity. Pharmacological studies demonstrated that several of the plants have antibacterial, anti-inflammatory, and antimicrobial activity. Four species demonstrated antimalarial activity in various studies (*D. madagascariense*, *Pavetta corymbosa*, *Sarcocephalus latifolius*, and *Chamaecrista rotundifolia*). We were unable to find any nutritional or medicinal properties for species such as *S. longipedunculata* and *Diodella sarmentosa.*

4. Discussion

4.1. The concept of "strengthening" and the food-medicine continuum

From the food-medicine continuum perspective, "strengthening" during pregnancy emerged as a salient concept of our participants, bridging food and medicine to ensure a strong and healthy pregnancy. The desire to be strong during pregnancy is likely closely linked to the high value placed on fertility in sub-Saharan countries (Caldwell and Caldwell, 1987); a women's ability to conceive and birth healthy children is associated with her social and psychological well-being (Cui, 2010; Dyer et al., 2002). In addition, strengthening may also be a reflection of the widespread state of undernourishment of pregnant women in the region, and the high rates of maternal and infant mortality (Kinney et al., 2010). The frequency of documented antimalarial activity in the cited plant species can be considered an additional component of maintaining strength in pregnancy; malaria is a major threat throughout a women's pregnancy (Huynh et al., 2011) as well as a salient reproductive health concern for women in the region (Towns and Van Andel, 2014). In this context, meeting a women's nutritional requirements and sustaining her physical health are key elements to the emic concept of strengthening and etic theories surrounding medicinal food plants and the food-medicine continuum (Etkin, 1996).

4.2. The untapped potential of local medicinal food plants

Several of the 105 species cited by our informants are documented as being good sources of vitamins, as well as demonstrating antioxidant, antimalarial, and antimicrobial activity. They should be considered real contenders in alleviating the nutritional and health burden on women in Benin and Ghana. Wild greens should not be systematically categorized as "emergency foods" or "famine foods" (Irvine, 1956) as they often have strong cultural and nutritional value to their communities even in times of abundance (Etkin, 1996). Additionally, these indigenous vegetables are underutilized economic resources, overlooked in their ability to contribute to improved economic well-being through sale at local markets.

After decades of anthropological and ethnobotanical research

Table 1
The most frequently cited medicinal food plants reported to be consumed during pregnancy from Ghana fieldwork in 2010.

Species	Use	Plant part	Form	Nutritional properties	Medicinal properties	Citation frequency (%)
***Ageratum conyzoides* (L.) L.**	Strengthening	Leaves	Decoction	Unknown	Anti-inflammatory, analgesic and antipyretic (Okunade, 2002); antifungal, antibacterial activity (Hoffman et al., 2004)	42
***Ricinodendron heudelotii* (Baill.) Heckel**	Strengthening	Bark, seed	Eat (soup)	Seed: rich in protein, crude fat, fatty acids (Tiki Manga et al., 2000)	Stem bark: antimicrobial (Momeni et al., 2005)	36
***Elaeis guineensis* Jacq.**	Strengthening	Seeds	Eat (soup)	Source of fatty acids, Vitamin E and carotenoids (Sundram et al., 2003)	Unknown	36
***Xylopia aethiopica* (Dunal) A.Rich.**	Strengthening	Fruits	Decoction, eat (spice in soup)	Antioxidant (Adaramoye et al., 2011)[a]	Antiallodynic, antihyperalgesic (Ameyaw et al., 2014); analgesic (Woode et al., 2012), anti-tumor, anti-asthmatic, anti-inflammatory, antimicrobial, hypotensive and coronary vasodilatory effects (Fleischer, 2003)	36
***Newbouldia laevis* (P. Beauv.) Seem.**	Strengthening	Leaves, bark	Decoction	Leaves: antioxidant (Habu and Ibeh, 2015)	Stem bark: antifungal activity (Hoffman et al., 2004)	21
***Spathodea campanulata* P. Beauv.**	Strengthening	Bark	Decoction	Contains tannins (Saleh et al., 1969)	Antimalarial (Amusan et al., 1996)	21
***Trichila monadelpha* (Thonn.) J.J.de Wilde**	Antiemetic	Bark	Decoction	Unknown	Analgesic, antitrypanosomal, and antimalarial (Woode et al., 2012)	21
***Nephrolepis biserrata* (Sw.) Schott**	Strengthening	Leaves	Eat (soup)	High in protein, calcium, iron (Maroyi, 2014);antioxidant (Shah et al., 2015)[a]	Antimicrobial (Rani et al., 2010)	14
***Dracaena arborea* (Willd.) Link**	Strengthening	Leaves	Eat (soup)	Unknown	Unknown	14
***Terminalia ivorensis* A.Chev.**	Strengtheninganemia	Bark	Decoction	Source of N,P,S,K,Ca,Mg, Al, Fe, Mn,Cu and B (Drechsel and Zech, 1991)[b]; antioxidant (Ponou et al., 2010)	Unknown	14
***Khaya senegalensis* (Desv.) A.Juss.**	Strengthening	Bark	Decoction	Anti-anemic activity (Sanni et al., 2005)[a]	Anti-proliferative, anti-inflammatory & pro-apoptotic effects (Androulakis et al., 2006)	14
***Manihot esculenta* Crantz**	Strengthening	Leaves	Eat (sauce)	Rich in essential amino acids and calcium (Ravindran and Ravindran, 1988)[c]	Unknown	14

[a] These studies were carried out in clinical studies on rats and do not directly associate with human health outcomes.
[b] These studies focused on analyzing the nutrients associated with plant health and do not guarantee bioavailability for humans.
[c] These studies were carried out for an analysis of ruminant feed. Further studies are needed to understand the bioavailability of the nutrients for humans.

Table 2
The most frequently cited medicinal food plants consumed during pregnancy from Benin fieldwork in 2011.

Species	Use	Plant part	Form	Nutritional Properties	Medicinal Properties	Citation frequency (%)
***Securidaca longipedunculata* Fresen.**	Strengthening	Leaves	Decoction	Unknown	Unknown	70
***Dichapetalum madagascariense* Poir.**	Strengthening	Leaves	Decoction	Unknown	Antiplasmodial activity (Yetein et al., 2013)	40
***Schwenckia americana* L.**	Strengthening	Whole plant	Decoction	Unknown	Analgesic and anti-inflammatory (Jimoh et al., 2011)	38
***Desmodium gangeticum* (L.) DC.**	Strengthening	Leaves, whole plant	Decoction	Antioxidant activity (Govindarajan et al., 2003)	Antileishmanial, immunomodulatory, antiasthmatic, smooth muscle relaxant, anti-inflammatory, anti-ulcer, cardio-protective, antidiabetic, antiamnesic, antiviral, hepatoprotective activities (Rastogi et al., 2011)	31
***Pavetta corymbosa* (DC.) F.N.Williams**	Strengthening	Leaves	Decoction	Unknown	Antimalarial (Koudouvo et al., 2011)	31
***Diodella sarmentosa* (Sw.) Bacigalupo & Cabral ex Borhidi**	Strengthening	Leaves, whole plant	Decoction	Unknown	Unknown	24
***Sarcocephalus latifolius* (Sm.) E.A. Bruce**	Stomachache strengthening	Root	Decoction	Antioxidant activity (Egbung et al., 2013)	Antiplasmodial activity (Yetein et al., 2013); antianemia (Hermans et al., 2004)	24
***Heterotis rotundifolia* (Sm.) Jacq.-Fél.**	Strengthening	Leaves	Decoction	High vitamin C content (Okeri and Alonge , 2006)	Antimicrobial activity (Abere et al., 2010)	21
***Chamaecrista rotundifolia* (Pers.) Greene**	Strengthening malaria	Leaves	Decoction	Unknown	Antiplasmodial activity (Yetein et al., 2013)	19
***Newbouldia laevis* (P.Beauv.) Seem.**	Strengthening	Leaves	Decoction	Antioxidant (Habu and Ibeh, 2015)	Antifungal activity (Hoffman et al., 2004); antibacterial activity (Akinpelu et al., 2009)	19

promoting indigenous vegetables and wild greens (Fleuret and Fleuret, 1980; Grivetti and Ogle, 2000; Schackleton et al., 2009), in a recent shift in policy for international agricultural research centers, researchers are now beginning to invest resources in researching African indigenous vegetables (AIV) and bioregional foods (Cernansky, 2015). Although the FAO/INFOODS Food Composition Databases include nutritional properties of traditional West African food such as yam, baobab leaves, amaranth leaves, and millet, it does not include many of the *wild* species cited by the women in this study nor underutilized species such as ferns (Maroyi, 2014). This new emphasis on AIVs not only excludes wild foods, it also does not capture the medicinal properties of these nutritious foods- once again diminishing multiuse plants to a single dimension. Particularly with the conclusion of the Millennium Development Goals and the emergence of the Post-2015 Sustainable Development Agenda (UNDP, 2015b), it is a very fertile time for ethnobotanists, development practitioners, ethnopharmacologists, agronomists, and the nutrition and medical fields to work together to recognize the value in these plants and promote their use and consumption as medicinal and nutritional resources.

4.3. Cultural components of medicinal food plants

The plant species, methods of preparation, and motivations for consumption identified in this research highlight not only the ethnic and floral diversity in the two countries where we worked, they also stress the deep-rooted cultural tradition of utilizing local plant resources. In Ghana, the consumption of the oil palm soup *ambemdró* with its associated wild greens is deeply engrained in the alimentary traditions of the Ghanaian ethnic groups with which we worked (Osseo-Asare, 2002). Similarly, an ethnobotanical study in neighboring Niger highlighted the value traditional cultures place on their local wild vegetable resources over the gardening crops promoted by development programs (Towns et al., 2013). The dedication to conserving and managing local plant species is also evident in the process of domestication (Harlan, 1976). Many of the herbaceous species cited by the women involved in this study, such as *Vernonia amygdalina* (see Supplementary Table A), still occur in the wild but are also widely cultivated for food by local populations (Ucheck Fomum, 2004). Our Ghanaian study also brought attention to geophagy, the consumption of clay (kaolin), in plant mixtures during pregnancy. Although little information is known about the safety of this practice and concerns exist around soil toxins and obstructing bioavailability of nutrients (Njiru et al., 2011), geophagy has been observed in pregnant women across sub-Sahara for relieving heartburn and nausea with the potentially positive effect of supplying nutrients and strengthening the immune system (Callahan, 2003).

In Benin, women most commonly reported the consumption of medicinal food plants in the form of herbal teas and decoctions. Their consumption as a beverage was largely inspired by the plants' preventative nature as a strengthening agent. Although consuming tea is popular worldwide and research efforts have been made to identify active components in common teas, little data is available on the bioactive composition for the diversity of herbal infusions or on differences in extraction methods (Horžić et al., 2009). The women's use and preparation of their local plant resources for pregnancy is different not only in their use of other plant parts but also in the form of processing-women from our study typically boiled the leaves and barks for hours before consuming. The differences in preparation and processing will likely result in varying degrees of nutrient bioavailability.

The strong commitment to traditional foods comes into question when populations move from rural to more urbanized areas.

Given the rapid annual rate of change in urbanization in African countries such as Ghana (3.4%) and Benin (3.7%) (CIA, 2014), there are potentially unhealthy consequences due to the "nutrition transition" to more contemporary diets (Yang and Keding, 2009). Although the access to plants may change as populations become more urbanized, plants are very likely to remain in demand by sub-Saharan populations, as evidenced by the presence of herbal remedies and African indigenous vegetables (both wild and cultivated species) on urban markets across the continent (Jusu and Sanchez, 2013; McMillen, 2008; Quiroz et al., 2014; Towns et al., 2014; van Andel et al., 2012; Williams et al., 2000). Research in South Africa has demonstrated the role of herbal medicine as a coping mechanism for socio-economic change brought on by urbanization (Varga and Veale, 1997). Therefore, although diets may change as populations leave rural areas, the demand for plants as medicinal and nutritional resources continues in urban settings and relocated populations.

4.4. Comparison of plants cited in Ghana and Benin

Out of the 105 total plant species cited in this study, only eight species were cited by both sets of women (*Flueggea virosa*, *Heterotis rotundifolia*, *Khaya senegalensis, Newbouldia laevis*, *Secamone afzelii, Spathodea campanulata, Vernonia amygdalina*, and *Zanthoxylum zanthoxyloides*); the majority of the plants were not repeated across datasets. While some of the variation may be a result of the uneven number of women involved in the research (14 in Ghana and 42 in Benin), the range of plants cited may also be reflective of the varied biodiversity of the two field sites. Due to the Dahomey Gap, one-half of Benin's vegetation is considered savannah, with only 2.5% gallery forest (FAO, 2015.) Ghana, by comparison has much more tropical forest (FAO, 2015), which is reflected by the use of tropical forest species like the canopy liana *Landophia owariensis*.

4.5. Strengths and weaknesses of our research

This research contributes to the ethnobotanical literature by linking both sides of the food-medicine continuum for pregnant women in West Africa by identifying both medicinal and nutritional properties of plant species. We overcame the theoretical shortcoming noted in some ethnobotanical studies in assuming that medicinal plant knowledge always equals use (Reyes-García et al., 2005) through our methodology of combining market surveys with questionnaires; the availability of these plants for sale on the market indicates that these resources are in demand by local consumers.

The knowledge generated in this study has direct implications for nutrition intervention programs, healthcare providers, conservation and agricultural development programs. However, additional studies are still needed: not only to fill the gaps in knowledge pinpointed in our research, but also to determine which quantities of plant resources women are consuming during pregnancy through dietary intake studies (Boedecker et al., 2014), as well as any seasonal variations in plant availability that may influence consumption patterns at different times throughout the year. Research in nearby Democratic Republic of the Congo has shown that overall consumption of wild greens by women was too low to meet dietary requirements or combat malnutrition in the Congo Basin (Termote et al., 2012). Research is also needed to analyze the potentially harmful and antinutrient properties of plants to fully understand their use and influence on human health. Several of the nutritional and pharmacological properties had only been studied on rats or for use in ruminant feed with no real understanding of the bioavailability of the nutrients for human health. Given their frequent consumption, particularly during the vulnerable period of pregnancy, research is sorely needed to fill in these research gaps. These research findings highlight not only the agricultural potential in sub-Saharan Africa, but also the necessity and urgency of nutritional and health intervention programs to recognize and promote the consumption of these health-promoting plant species.

5. Conclusion

The two groups of women involved in our study cited different species and different forms of consumption of plant species. Yet both Ghanaian and Beninese women cited "strengthening" as the most common motivation to consume wild plants during pregnancy, suggesting that it is a salient health concern across the region. This concept is positioned along the food-medicine continuum and manifested through the consumption of nutrient-rich and medicinally potent plant species. The consumed species, however, may vary from country to country, as they largely depend on natural vegetation patterns. The plant species mentioned in this study may therefore represent just the tip of the iceberg of wild vegetable species in Sub-Saharan Africa.

Some of the commonly cited species in Ghana, such as *Nephrolepis biserrata*, *Ricinodendron heudelotii*, and *Elaeis guineensis* are documented as being high in iron, protein and fatty acids (respectively). In Benin, frequently cited species such as *D. madagascariense*, *P. corymbosa*, and *S. latifolius* demonstrated antimalarial activity in various studies. However, several plants have incomplete profiles for both sets of properties and species such as *Dracaena arborea* in Ghana and *S. longipedunculata* and *D. sarmentosa* in Benin are not yet analyzed in nutritional or pharmacological studies. This gap is a timely and pertinent area for future research in understanding local plant resources' role in the health and well-being of pregnant women in Ghana and Benin, as well as elsewhere across West Africa. Ethnobotanical studies of this nature highlight the multidimensional use of plants and can improve health and nutritional programs in the region, but a commitment to identifying the plants, researching their nutritional and medicinal properties, and promoting their consumption is needed from healthcare providers, (ethno) pharmacologists, nutritionists, and agronomists alike.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.jep.2016.01.005.

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