FACTORS INFLUENCING THE SPECIFIC USES OF *MORINGA OLEIFERA* LAM. IN BENIN (WEST AFRICA)

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ABSTRACT

M. oleifera is widely cultivated and all its parts are used for several purposes. The present study determined factors which influence the most the specific uses of *Moringa oleifera* Lam. in Benin. An ethnobotanical survey ($n = 631$) was performed in forty-six localities across the three biogeographical zones of Benin. Fidelity levels were calculated for specific uses and the top ten ones were identified and included: salad and vegetable soup, mixed leaves with rice and couscous, forage, use for treating malaria, hypertension, stomachache, headache, tiredness, diabetes and indigestion. A multivariate probit model was estimated using simulated maximum likelihood to identify factors (socioeconomic factors and biogeographical zones) which influence the specific uses. Findings revealed that the use of Moringa for treating malaria, headache and diabetes were influenced (Prob. < 0.05) by only one factor (biogeographical zones for the first two and age for the last). Except for the use for treating stomachache which was not influenced by any factor, the other specific uses were jointly influenced (Prob. < 0.05) by at least two factors namely biogeographical zones and at least one of socioeconomic factors. Moringa public awareness projects should pay adequate attention to the influencing factors highlighted as they would be significant facilitators of adoption of *M. oleifera* use in various ways.

Keywords : Determining factors ; fidelity levels ; food security ; *Moringa oleifera* ; Probit.

FACTEURS INFLUENÇANT LES USAGES SPÉCIFIQUES DU *MORINGA OLEIFERA* LAM. AU BÉNIN (AFRIQUE DE L'OUEST)

RÉSUMÉ

M. oleifera est largement cultivé et toutes ses parties sont utilisées pour de multiples usages. La présente étude a déterminé les facteurs qui influencent les usages spécifiques du *Moringa oleifera* Lam. au Bénin. Une enquête ethnobotanique ($n = 631$) a été menée dans quarante-six localités réparties dans les trois zones biogéographiques du pays. Les indices de fidélités ont été calculés pour les usages spécifiques et les dix premiers usages suivant ont été identifiées comprenant: utilisation comme salade et sauce végétale, feuilles mélangées au riz et au couscous, utilisation comme fourrage, utilisation pour traiter le paludisme, l'hypertension, les maux de ventre, les maux de tête, la fatigue, le diabète et l'indigestion. Un model probit multivarié a été estimé utilisant la vraisemblance maximale simulée afin d'identifier les facteurs (facteurs socioéconomiques et zones biogéographiques) qui influencent ces usages spécifiques. Les résultats ont révélé que l'utilisation de l'espèce pour traiter le paludisme, les maux de tête et le diabète étaient influencée ($P < 0.05$) par un seul facteur (zone biogéographique pour les deux premiers et l'âge pour le dernier). A l'exception de l'utilisation de l'espèce pour traiter les maux de ventre qui n'était influencé par aucun facteur, les autres usages spécifiques étaient conjointement influencés (P < 0.05) par au moins deux facteurs notamment la zone biogéographique et au moins un des facteurs socioéconomiques. Les projets qui visent à promouvoir les divers usages de l'espèce devraient tenir compte des facteurs influençant identifiés car ils serraient des facilitateurs importants de l'adoption de l'espèce.

Mots clés : *Facteurs déterminants ; niveau de fidélité ; sécurité alimentaire ; Moringa oleifera ; Probit.*

INTRODUCTION

Moringa oleifera Lam., family Moringaceae, is an agroforestry species that has originated from Himalayan tract in north-western part of India (Pandey *et al.*, 2011 ; Mendieta-Araica *et al.*, 2012 ; Ganesan *et al.*, 2014). *M. oleifera* is widely cultivated in sub-Saharan Africa and all its parts are widely used for several purposes including medicine, food, fodder, domestic cleaning agent, green manure, rope, tanning hides and as water purifier (Muhl *et al.*, 2011 ; Popoola *et al.*, 2014). The species was gaining increasing interest in the last decades because of its nutritional and medicinal values. Since 1998, the World Health Organization is promoting *M. oleifera* based products (leaves, powder, oil, seed) as an alternative solution for combating malnutrition (Sreelatha & Padma, 2009). Moreover, Moringa seeds is also used in biofuel industries for biodiesel production (Rashid *et al.*, 2008 ; Muhl *et al.*, 2013).

Previous studies on Moringa focused on the various uses of the species and recorded seven use categories including medicine, food, fodder, fencing, firewood, coagulant and gum (Popoola & Obembe, 2013) with leaves being the most used part (Popoola & Obembe, 2013 ; Agoyi *et al.*, 2014). The nutritional values of the species have been recently investigated for functional food powder of leaves (Nouman *et al.*, 2013 ; Singh & Prasad, 2013). The application of processed seeds for organic farming have been demonstrated (Emmanuel *et al.*, 2011). Moringa was also cited to be of high socioeconomic importance generating profits (Diouf *et al.*, 2007 ; Torimiro *et al.*, 2009 ; Madi *et al.*, 2012 ; Azeez *et al.*, 2013). For instance, in northern Cameroon, the sale of *M. oleifera* leaves is two time more profitable than other leafy vegetables (Madi *et al.*, 2012). Beyond the nutritional and economic aspects, Moringa was also abundantly investigated regarding its morphological and growth patterns (Reyes Sánchez *et al.*, 2006 ; Dos Santos *et al.*, 2011 ; Patricio *et al.*, 2012 ; Gadzirayi *et al.*, 2013 ; Muhl *et al.*, 2013 ; Nouman *et al.*, 2013 ; Edward *et al.*, 2014), its physico-chemical and microbiological composition (Reyes Sánchez *et al.*, 2006 ; Anwar & Rashid, 2007 ; Rockwood *et al.*, 2013), genetic patterns (Muluvi *et al.*, 1999 ; Shahzad *et al.*, 2013 ; Ganesan *et al.*, 2014 ; Popoola *et al.*, 2014) and morphological traits (Diouf *et al.*, 2007 ; Ganesan *et al.*, 2014 ; Agoyi *et al.*, 2015 ; Dao & Kabore, 2015). In Benin, *M. oleifera* ranks among the national priority species based on the eating habits of populations (Dansi *et al.*, 2008a). The species is geographically well distributed with regard to the three biogeographical zones of Benin (Dansi *et al.*, 2008a). Ethnobotanical knowledge and uses of the species were investigated in southern Benin (Agoyi *et al.*, 2014) without exploration in the middle and northern part where food insecurity and poverty are more pronounced (PAM, 2014). In addition, many Non-Governmental Organizations (NGOs) promote *M. oleifera* nationwide, and some initiatives of its products commercialization even arose recently (Agoyi *et al.*, 2014).

Despite its high nutrient content, profit generating potential and research interest, *M. oleifera* is still not well and fully exploited (Pandey *et al.*, 2011) and therefore considered as an underutilized species (Singh & Prasad, 2013). Moreover, although the species is integrated into several programs of food assistance for preventing children and nursing mothers' malnutrition (Afuang *et al.*, 2003 ; Sreelatha & Padma, 2009), there is still some knowledge gaps of information. The relevance of these traditional ethnobotanical knowledge regarding the increasing of living standards of rural populations as well as decisions related to the sustainable use of plant resources, has frequently been noted (Benz *et al.*, 2000 ; Shackleton *et al.*, 2002). Most of the traditional knowledge about plants and their uses are fast disappearing as a consequence of socioeconomic and ecological changes (Signorini *et al.*, 2009). The use pattern of plants is associated to biological, ecological, socioeconomic and sociocultural factors (Wekerle *et al.*, 2006 ; Akerreta *et al.*, 2007 ; Turner *et al.*, 2009). Among these factors, age, gender, education level (Byg & Balslev, 2004 ; Ryan *et al.*, 2005 ; Beltrán-Rodríguez *et al.*, 2014), ethnicity, religion (Case *et al.*, 2005 ; Monteiro *et al.*, 2006) and socioprofessional (Martínez-Ballesté *et al.*, 2006 ; Beltrán-Rodríguez *et al.*, 2014), were found to have a stronger influence on shaping ethnobotanical knowledge and use patterns. Moreover, the ecological diversity influence traditional knowledge necessary for gathering and using plant species (Signorini *et al.*, 2009). As all parts of *M. oleifera* can be used in various ways, an important issue is which factors drive its specific uses. Eliciting factors driving the way the species is used is expected to play a key role in increasing its use and therefore contribute to its widely use.

The present study aims at assessing how socioeconomic factors and biogeographical zones influence the specific uses of *M. oleifera* in Benin. In long term, the findings may contribute to the improvement of the domestication strategies of the species which is expected to improve nutritional status, food security and income of rural low income households. Given previous findings, it was hypothesized that socioeconomic factors (ethnicity, gender, age, education level, religion, main socioprofessional activity) and biogeographical zones jointly influence the specific uses of *M. oleifera*.

MATERIALS AND METHODS

Study area

The study was conducted in Benin (West Africa) spanning the three biogeographical zones (Guineo-congolese zone, Sudano-guinean zone and Sudanian zone) (Figure 1). With a total area of 114 743 km², Benin is located within the tropics, between parallels 6°30'-12°30' N and 1°-3°40' E (INSAE, 2013).

In the guineo-congolese zone (6°25'-7°30' N), rainfall is bimodal with a mean annual rainfall of 1200 mm. Mean annual temperature varies between 25 °C and 29 °C and the relative humidity ranges from 69 % to 97 %. Soils are either deep ferrallitic or rich in clay. Adja, Sahouè, Fon, Aïzo, Mahi and relatives (belonging to the language family Kwa) are the main sociocultural groups (Judex *et al.*, 2009; Lewis, 2009). In the sudano-guinean zone (7°30'-9°45' N), rainfall is unimodal, from May to October, and lasts about 113 days with an annual total rainfall varying between 900 mm and 1110 mm. Mean annual temperature ranges from 25 °C to 29 °C, and the relative humidity from 31 % to 98 %. Soils in this zone are ferruginous. The main sociocultural groups in the sudano-guinean zone are Yoruba, Idaasha, Nagot and relatives (belonging to the language family Defoid) (Judex *et al.*, 2009; Lewis, 2009). The rainfall is also unimodal in the sudanian zone (9°45'-12°25' N), but mean annual rainfall is often less than 1000 mm, the relative humidity varies between 18 % and 99 % (highest in August) and temperature varies between 24 °C and 31 °C. The sudanian zone has hydromorphic soils, well-drained soils and lithosols. The main sociocultural groups are Ditammari, Berba, Waama, Gurma, Natimba and relatives (belonging to the Gur family language) (Judex *et al.*, 2009 ; Lewis, 2009).

The overall population of Benin is estimated at 10 008 749 inhabitants, and is fairly female-biased (51.2 %) (INSAE, 2013), with agriculture as major socioeconomic activity (INSAE, 2013). Overall, there are 29 main ethnic groups in Benin (Adam & Boko, 1993).

Sampling and data collection

The study localities were selected based on two criteria: the presence of the species and the ethnic groups of the main consumer/user. The presence of the species was assessed through literature review, exploratory survey, ethnoecological survey and investigation with the Moringa Association of Benin and National Agricultural Extension Services. Among the 29 ethnic groups of Benin (Adam & Boko, 1993), 23 consume and use *M. oleifera* (Dansi *et al.*, 2008b). Using the geographical distribution of sociocultural groups in Benin (Judex *et al.*, 2009), these consumer and user sociocultural groups were grouped into eleven major sociocultural groups (Table 1). Hence, 46 localities within 28 districts were selected nationwide across biogeographical zones (Figure 1).

To compute the sample size, a pre-survey of 30 persons per locality was carried out. The pre-surveyed interviewees answered whether they have used, at least once, a Moringa based product. The proportion of positive answers was considered and used to determine the number of respondents to be included in the survey. This number was determined through the Normal approximation of the Binomial distribution (Dagnelie, 1998) :

$$n = [(U_{1-\alpha/2})^2 \text{ x } p(1-p)]/d^2$$

Where, n is the sample size ; p is the proportion of respondents with a positive answer during the pre-survey ; $U_{1-\alpha/2}$ is the value of the normal random variable where, for a probability value of 1 - α/2, $U^2 \approx 4$ with $\alpha = 0.05$; d is the margin error of the estimation of any parameters to be computed from the survey and a value of 8 % was considered for a good precision.

Among the 801 respondents randomly selected and interviewed on a voluntary basis, only 631 who used the species were retained for the study. Data were collected during expeditions to the different sites through the application of participatory research appraisal tools and techniques, in this case individual interviews using a questionnaire. Socioeconomic data (gender, age, ethnicity, religion, education level, main socioprofessional activity) and ethnobotanical data (species use, main use category and specific uses) of respondents were collected.

Data analysis

Relative frequencies (%) were used to describe respondents according to their socioeconomic characteristics and biogeographical zones (see Table 1). From data collected, overall 82 specific uses were identified and fidelity levels were calculated for each use. The first ten specific uses with high value of fidelity level were retained (Figure 2 ; Table 2). Phi coefficients were estimated to measure associations between the specific uses.

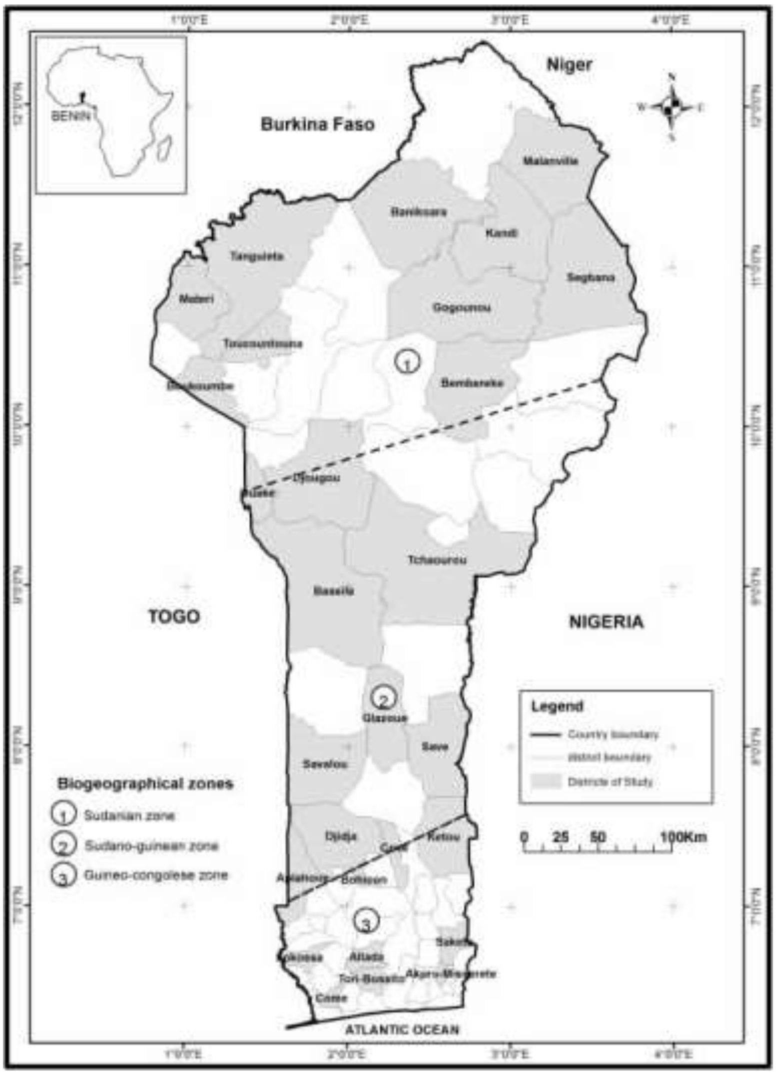

Figure1. Location of study districts

To identify factors (socioeconomic factors and biogeographical zones) which most influenced specific uses, a multivariate probit model (Cappellari & Jenkins, 2003) was estimated using simulated maximum likelihood. In the model, explanatory variables were socioeconomic data and biogeographical zones (see Table 1) while response variables were the ten specific uses. A multivariate probit model was used instead of several univariate probit models because the former can account for correlations between the response variables (Sodjinou & Henningsen, 2012). Actually, the multivariate probit model improves not only the precision of the estimation results and provides consistent standard errors of the estimates, but also enables to analyse the interrelations between the response variables (Sodjinou & Henningsen, 2012).

The package *psych* (Revelle, 2014) was used in R freeware (R Development Core Team) to estimate Phi coefficients. The program mvprobit (Cappellari & Jenkins, 2003) was used in STATA 13 statistical freeware to estimate the multivariate probit model. All statistical analyses were performed with significance level fixed to 5 %.

RESULTS

Socioeconomic characteristics of respondents

The majority of the respondents were men (61.01 %), while 47.86 %, 43.58 % and 51.8 % of them were young, adult and christians (Table 1). Approximately half (46.75 %) of the respondents had no formal education and more than half (68.62 %) were mainly not farmers. Among the eleven ethnic groups considered, the dominants were Fon and Mahi (15.53 %), Bariba (14.42 %), Aïzo and related (11.57 %) and Yoruba, Nagot and related (10.46 %). The majority (93.1 %) of the respondents claimed to know *M. oleifera* (Table 1). The Guineo-Congolese, Sudano-Guinean and Sudanian zones represent respectfully 38.19 %, 25.99 % and 35.82 % of respondents.

Specific uses of M. oleifera

The first ten specific uses have been identified based on their fidelity levels (Figure 2). The most cited specific uses were the use of leaves as salad and vegetable soup (75.44 %), the use of leaves against malaria (39.62 %) and the use of leaves and seeds for treating hypertension (19.65 %). 13.47 % of respondents cited the use of leaves as forage for animals, while 9.67 % and 9.51 % cited the use of leaves, seeds and roots respectively against stomachache and headache. The use of leaves, seeds, root and bark against tiredness was cited by 6.02 % of respondents. Also 6.02 % of respondents eat leaves mixed with rice and couscous. Leaves and seeds were used against diabetes (5.23 %) and to aid digestion (4.75 %).

Table 1. Distribution of the respondents according to their socioeconomic characteristics and biogeographical zones

Socioeconomic characteristics/ Biogeographical zones	Modality	Codes	Frequency	Percentage (%)
Gender	Woman	0	246	38.99
	Man	1	385	61.01
Age	Young	≤35 years	302	47.86
	Adult	35<years≤60	275	43.58
	Old	>60 years	54	8.56
Religion	Animism	0	89	14.10
	Islam	1	223	35.34
	Christianity	2	319	50.55
Education level	Uneducated	0	295	46.75
	Primary school	1	154	24.41
	Secondary school	2	129	20.44
	University	3	53	8.40
Main socioprofessionnal activity	Non-agriculture	0	433	68.62
	Agriculture	1	198	31.38
Ethnic groups	Adja and related		60	9.51
	Aïzo and related		73	11.57
	Bariba		91	14.42
	Boko, Peulh		36	5.71
	Dendi,Djerma		53	8.40
	Ditamari and related	-	51	8.08
	Fon,Mahi		98	15.53
	Goun and related		34	5.39
	Gourmantche and related		37	5.86
	Lopka and related		32	5.07
	Yoruba,Nagot and related		66	10.46
Biogeographical zones	Guineo-Congolese zone	1	241	38.19
	Sudano-Guinean zone	2	164	25.99
	Sudanian zone	3	226	35.82

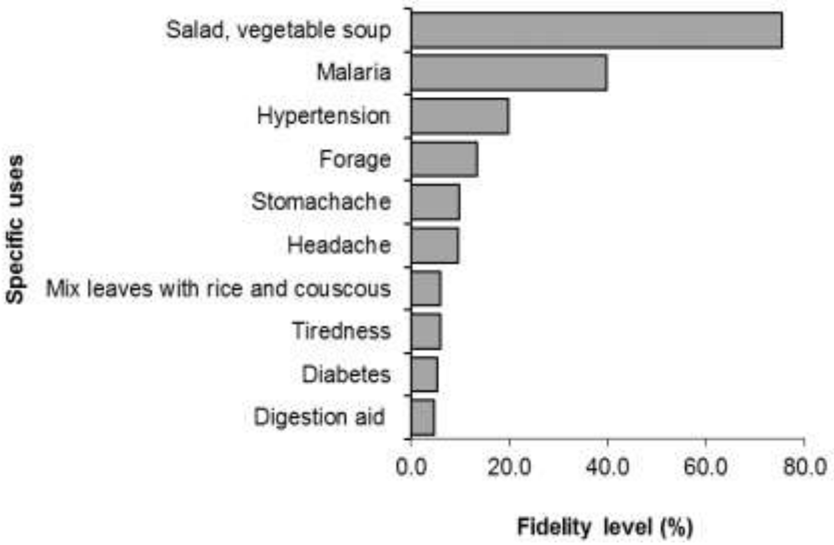

Figure 2. Fidelity levels of the first ten specific uses of *M. oleifera*.

There were not many statistically significant correlations ($P \le 0.05$) between the specific uses of *M. oleifera* (Table 2 ; Table 3). Actually, there was significant positive correlation between the use of species against malaria and its use against diabetes. There was also significant negative correlation between the use of species against malaria and its use as forage for animals. The use of species to fight hypertension was positively correlated with its use against diabetes. The use of species for digestion aid was positively correlated with its use against tiredness. Both food specific uses were only correlated between them.

Table 2. Phi coefficients matrix between the first ten specific uses of *M. oleifera*

	Mal	HPT	HDCH	DBTE	STCH	DGAid	TDne	SalVeg	MixL
HPT	-0.05								
HDCH	0.05	-0.05							
DBTE	**0.09**	**0.19**	0.06						
STCH	0.00	0.01	0.08	-0.03					
DGAid	0.08	-0.04	0.06	0.05	-0.07				
TDne	0.08	0.01	-0.01	0.00	0.03	**0.26**			
SalVeg	0.06	-0.01	-0.03	-0.04	0.02	-0.03	-0.06		
MixL	-0.08	-0.04	0.01	-0.03	-0.04	-0.06	-0.04	**-0.29**	
For	**-0.12**	0.06	-0.04	-0.01	-0.01	-0.05	-0.02	0.02	0.02

Values in bold are significant at $P \le 0.05$. Mal (Malaria), HPT (Hypertension), HDCH (Headache), DBTE (Diabetes), STCH (Stomachache), DGAid (Digestion aid), TDne (Tiredness), SalVeg (Salad, vegetable soup), MixL (Mixing leaves with rice and couscous), For (Forage)

Table 3. Plant parts used, mode of preparation, form of use and Relative Frequency Citation (RFC) of the first ten specific uses of *M. oleifera*

Use categories	Specific uses	Parts used	Mode of preparation	Form of use	RFC
Medicine	Malaria	Leaves	Fresh leaves boiled in water as infusion singly or with lemon or lemon grass	Drink the extract	0.30
			Fresh leaves soaked in alcohol	Drink the extract	0.05
			Leaves dried, crushed turn into powder	Added to prepared food or porridge	0.16
	Hypertension	Leaves	Fresh leaves boiled in water as infusion singly or with lemon or lemon grass	Drink the extract	0.13
			Fresh leaves soaked in alcohol	Drink the extract	0.02
			Leaves dried, crushed turn into powder	Added to prepared food or porridge	0.06
		Seeds	Seeds eaten raw or crushed as decoction	Eaten raw or as decoction	0.02
	Headache	Leaves	Leaves dried, crushed turn into powder	Added to prepared food or porridge	0.08
		Seeds	Seeds eaten raw or crushed as decoction	Eaten raw or as decoction	0.03
		Roots	Soak in water/alcohol or boiled with other herb	Drink the extract	0.05
	Diabetes	Leaves	Leaves dried, crushed turn into powder	Added to prepared food or porridge	0.04
		Seeds	Seeds eaten raw	Eaten raw	0.01
	Stomachache	Leaves	Fresh leaves boiled in water as infusion singly or with lemon grass	Drink the extract	0.05
			Fresh leaves soaked in alcohol	Drink the extract	0.03
		Roots	Boiled in water as infusion	Drink the extract	0.03
		Seeds	Seeds eaten raw	Eaten raw	0.02
	Digestion aid	Leaves	Fresh leaves soaked in alcohol	Drink the extract	0.02
		Seeds	Seeds eaten raw	Eaten raw	0.03
	Tiredness	Leaves	Fresh leaves soaked in alcohol	Drink the extract	0.01
		Leaves	Leaves dried, crushed turn into powder	Added to prepared food or porridge	0.02
		Seeds	Seeds eaten raw	Eaten raw	0.02
		Roots	Roots dried, crushed and turn into powder	Drink with water or porridge	0.01
		Bark	Bark boiled in water as infusion or ground and turn into powder	Drink extract or add powder to porridge	0.01
Food	Salad, vegetable soup	Leaves	Leaves prepared as vegetable soup	Eat as vegetable or soup	0.75
	Mix leaves with rice and couscous	Leaves	Leaves boiled with salt, pepper, onion	Eat mixed with rice and couscous	0.06
Fodder	Forage	Leaves	Harvest the leaves from the tree	Serve raw as forage for animal feed	0.13

Factors influencing the specific uses of M. oleifera

The multivariate probit model provides good and significant (Prob. = 0.000) estimates, not only for the regression coefficients (Table 4), but also for the correlation in the variance-covariance matrix of cross-equation error terms (Table 5). The analysis of regression coefficients showed that the species use to fight malaria and headache were negatively influenced by the biogeographical zones (level of use decreasing from south to north) which means their levels of use decrease from south to north. The use of the species against diabetes increases with age. The use of species against hypertension was positively influenced by ethnicity, age and biogeographical zones (level of use increasing from south to north). The use of species for treating indigestion was influenced positively by education level and negatively by biogeographical zones. The specific use of Moringa against tiredness was influenced positively by gender (better use by men than women) and negatively by main socio-professional activity (weak use by informants whose main activity is agriculture). Food use as salad and vegetable soup was significantly different between ethnic groups and was negatively influenced by biogeographical zones. As for mixing leaves with rice and couscous, it was influenced negatively by religion (weak use by muslim and christian informants) and positively by biogeographical zones. Finally, the use of Moringa for animal feed was influenced negatively by age and education level but positively by gender and biogeographical zones. In other words, the use of leaves for animal feed decreases from younger to older informants and education level, higher for men than women and increase from south to north.

The estimates of correlation between response variables in the variance-covariance matrix of cross-equation error terms (Likelihood ratio test of rhos = 0 ; chi2 (45) = 114.35 ; Prob. = 0.000) revealed that the use of the species to fight malaria increases the likelihood to use it against indigestion and tiredness (Table 5). On the other hand, the use of the species to fight malaria is done to the detriment of the use as forage for animal. The species use against hypertension increases the likelihood to use it against diabetes. The use of species against headache increases the likelihood to eat its leaves mixed with rice and couscous. More the species is used for digestion aid, more likely it is used against tiredness. Also, more the species is used against tiredness, more likely it is used as salad and vegetable soup. But, more the species leaves is eaten as salad and vegetable, less they are eaten mixed with rice and couscous.

Table 4. Estimates of multivariate probit model for specific uses of *M. oleifera*.

Variables	Malaria	Hyper-tension	Headache	Diabetes	Stomach-ache	Digestion aid	Tiredness	Salad, vegetable soup	Mixing leaves with rice and couscous	Forage
Constant	0.382	**-2.705**	-0.795	**-2.633**	**-1.354**	**-1.915**	**-2.449**	**1.185**	**-2.682**	**-2.443**
	(0.324)	**(0.397)**	(0.445)	**(0.554)**	**(0.443)**	**(0.631)**	**(0.561)**	**(0.357)**	**(0.667)**	**(0.463)**
Gender	-0.015	-0.141	0.016	-0.067	0.193	0.305	**0.575**	-0.087	0.346	**0.968**
	(0.115)	(0.135)	(0.158)	(0.187)	(0.159)	(0.216)	**(0.204)**	(0.124)	(0.199)	**(0.174)**
Age	-0.001	**0.015**	0.006	**0.017**	-0.003	0.006	0.010	-0.003	-0.002	**-0.012**
	(0.004)	**(0.004)**	(0.005)	**(0.006)**	(0.005)	(0.007)	(0.006)	(0.004)	(0.006)	**(0.005)**
Religion	-0.017	0.186	-0.045	0.006	-0.067	0.067	0.097	0.152	**-0.533**	-0.033
	(0.077)	(0.098)	(0.099)	(0.134)	(0.108)	(0.127)	(0.121)	(0.086)	**(0.183)**	(0.107)
Education level	0.044	0.047	0.031	0.109	-0.001	**0.198**	0.105	-0.064	0.175	**-0.162**
	(0.058)	(0.067)	(0.079)	(0.091)	(0.080)	**(0.101)**	(0.086)	(0.062)	(0.091)	**(0.077)**
Main socioprofes-sional activity	-0.056	-0.163	-0.057	-0.150	-0.121	-0.058	**-0.447**	0.180	-0.392	-0.111
	(0.134)	(0.160)	(0.192)	(0.224)	(0.180)	(0.263)	**(0.227)**	(0.143)	(0.205)	(0.167)
Ethnicity	-0.004	**0.086**	0.003	0.048	-0.016	0.015	-0.019	**-0.042**	-0.075	0.014
	(0.017)	**(0.020)**	(0.023)	(0.028)	(0.024)	(0.029)	(0.027)	**(0.019)**	(0.044)	(0.024)
Biogeographical zones	**-0.264**	**0.297**	**-0.379**	0.054	0.107	**-0.685**	-0.101	**-0.239**	**0.988**	**0.279**
	(0.065)	**(0.079)**	**(0.095)**	(0.111)	(0.099)	**(0.173)**	(0.115)	**(0.070)**	**(0.168)**	**(0.086)**
Multivariate probit (SML, # draws)	30									
Number of observations	631									
Wald chi2 (70)	242.66									
Log likelihood function	-2061.0753									
Prob > chi2	0.000									

( ): numbers in parentheses are standard errors. Values in bold indicates significant at P ≤ 0.05.

Table 5. Estimates of correlation between response variables in the variance-covariance matrix of cross-equation error terms

	Mal	HPT	HDCH	DBTE	STCH	DGAid	TDne	SalVeg	MixL
HPT	-0.093								
	(0.074)								
HDCH	0.081	-0.062							
	(0.088)	(0.094)							
DBTE	0.165	**0.324**	0.056						
	(0.103)	**(0.097)**	(0.112)						
STCH	-0.038	0.116	0.116	0.075					
	(0.085)	(0.090)	(0.105)	(0.104)					
DGAid	**0.277**	-0.076	0.045	0.142	-0.206				
	(0.115)	(0.132)	(0.134)	(0.132)	(0.140)				
TDne	**0.218**	0.077	0.007	-0.086	0.077	**0.370**			
	(0.095)	(0.107)	(0.114)	(0.126)	(0.116)	**(0.101)**			
SalVeg	0.074	0.028	-0.007	-0.025	-0.035	-0.100	**-0.182**		
	(0.067)	(0.072)	(0.080)	(0.081)	(0.081)	(0.089)	**(0.086)**		
MixL	-0.149	-0.178	**0.259**	0.092	-0.021	0.096	0.037	**-0.672**	
	(0.106)	(0.109)	**(0.128)**	(0.141)	(0.125)	(0.178)	(0.143)	**(0.075)**	
For	**-0.219**	0.042	-0.029	-0.045	0.014	-0.135	-0.015	0.032	-0.150
	(0.083)	(0.086)	(0.104)	(0.099)	(0.088)	(0.126)	(0.110)	(0.082)	(0.098)

Values in bold indicates significance at $P \leq 0.05$. ( ) : Numbers in parentheses are standard errors. Mal (Malaria), HPT (Hypertension), HDCH (Headache), DBTE (Diabetes), STCH (Stomachache), DGAid (Digestion aid), TDne (Tiredness), SalVeg (Salad, vegetable soup), MixL (Mixing leaves with rice and couscous), For (Forage).

DISCUSSION

This study identified the first ten specific uses of *M. oleifera* in Benin, and determined the factors which influenced them assuming joint effects of socioeconomic characteristics, and biogeographical zones. Findings revealed that the specific uses for treating malaria, headache and diabetes were influenced by only one factor (biogeographical zones for the first two and age for the last) while use of Moringa for treating hypertension, indigestion, tiredness, or as salad and vegetable soup, and mixing leaves with rice and couscous, and forage were jointly influenced by at least two factors.

The specific uses of Moringa most encountered were of medicinal and food use categories. Medicinal and food uses have been already observed as the first two use categories for the species in South Africa (Muhl *et al.*, 2011), in Nigeria (Popoola & Obembe, 2013), in Southern Benin (Agoyi *et al.*, 2014) and in India (Ganesan *et al.*, 2014). Among the first ten specific uses identified, the use of species as salad and vegetable soup and its use in fighting malaria were the most encountered as in Nigeria (Popoola & Obembe, 2013). They were followed by the species use against hypertension and for animal feed. The use of Moringa parts mostly in traditional medicine, human and animal nutrition have been confirmed by many authors (Popoola & Obembe, 2013 ;

Stevens *et al.*, 2013 ; Agoyi *et al.*, 2014). As observed by Gadzirayi *et al.* (2013), Popoola & Obembe (2013) and Agoyi *et al.* (2014), the most used plant parts were leaves followed by seed, root and bark. The massive use of leaves in traditional medicine, human and animal nutrition implies premature and continuing harvests, which constitutes a pressure on the foliar biomass and consequently on the species (Agoyi *et al.*, 2014). These authors argued that, as a result, populations do not give enough time to the species to flower which as result fail to produce seeds.

The specific uses for treating malaria and headache decrease from south (guineo-congolese zone) to north (sudanian zone). This highlighted the combined effects of sociocultural and agro-climatic differences (Sodjinou *et al.*, 2015) which can affect local populations' attitudes regarding the traditional medicine. Sociocultural differences could be related to ethnicity, standard of living and life style. Accordingly, significant differences were observed among ethnic groups and agro-ecological zones regarding the medicinal use of Moringa in Zimbabwe (Gadzirayi *et al.*, 2013) and in Nigeria (Popoola & Obembe, 2013). The positive influence of age on the use of Moringa against diabetes could be explained by the increasing of better knowledge on the species use with increasing age (Popoola & Obembe, 2013 ; Fadoyin *et al.*, 2014) especially for medicinal uses (Oyekale *et al.*, 2015) as also observed for other multipurpose species in Benin by Houehanou *et al.* (2011). In addition, age had positive influence on the willingness to pay for Moringa products because older people know the benefits of medicinal plants such as Moringa (Oyekale *et al.*, 2015). The species use against hypertension varied significantly according to the ethnicity and was positively influenced by age and biogeographical zones. Thereby, old people from ethnic groups within the sudano-guinean and sudanian zones are more likely to use leaves against hypertension. Actually, mostly older people suffer from hypertension. Moreover, like medicinal knowledge on the species, the medication compliance in hypertensive patients increases also with age as demonstrated in Iran (Hadi & Rostami-Gooran, 2004). Differences observed between ethnic groups regarding the use of Moringa against hypertension may be due to religion belief (Griffith *et al.*, 2005) and sociocultural perceptions on the species (Torimiro *et al.*, 2009). The higher the educational level, the higher the likelihood that people use the Moringa against indigestion. This is because education enhances the level of understanding of people (Fadoyin *et al.*, 2014) and is expected to improve access to various source of information on benefits of the species (Oyekale *et al.*, 2015). According to the later, educated people are also expected to earn more income, which will make them more willing to pay for Moringa products. Men who were not farmers were more likely to use Moringa against tiredness. This can be explained by the fact that men have more knowledge on medicinal uses of *M. oleifera* (Popoola & Obembe, 2013) and others multipurpose species (Houehanou *et* *al.*, 2011). The species use against stomachache was not influenced by any factor. This may be due to the fact that people tend to experience stomachache as a symptom of others illnesses such as indigestion. Overall, the medicinal uses of Moringa may be influenced by the preference for other vegetables which reduces the likelihood of willingness to pay for Moringa (Oyekale *et al.*, 2015) and to cultivate it. Authors explained that consumers do not perceive Moringa as a vegetable that has wide usage, like other vegetables. Therefore, more information should be made available and easily accessible on the benefits and the multiple uses of Moringa in human health and wellbeing, in order to increase preference for the species. On the other hand, oversimplifying the easy propagation and the biology of the species could contribute to the increasing of its level of cultivation compared to others vegetables.

The use of Moringa leaves as salad and vegetable decreases northwards but the use of leaves mixed with rice and couscous increases northwards. The significant differences observed among religions, ethnic groups and biogeographical zones indicate a strong link between these three factors and the uses of Moringa as food. The influence of ethnic groups and biogeographical zones regarding the use of Moringa as food has been observed in Nigeria (Popoola & Obembe, 2013) and in Zimbabwe (Gadzirayi *et al.*, 2013). This influence indicates an unequal distribution of indigenous knowledge on Moringa (Popoola & Obembe, 2013), and other plant species with strong cultural attachment (Ayantunde *et al.*, 2008 ; Houessou *et al.*, 2012 ; Omonhinmin, 2012). The observed difference between biogeographical zones can be also explained by differences in food processing practices between these zones (Sodjinou & Henningsen, 2012). Religion, ethnic groups and biogeographical zones are important factors to take into account in the species food utilization value assessment. Therefore, associations for the species uses promotion could be created within these sociocultural groups and then they can be used as relay points in projects promoting the species. This may contribute to increase the level of use of Moringa in various ways.

Adult, young and uneducated men from the sudanian zone are more likely to use Moringa leaves as forage for animal. Through biogeographical zones, ethnicity predicts significantly farmers' knowledge of livestock management (Segnon *et al.*, 2015). The high level of species use as forage is the north (sudanian zone) may drive the livestock based farming systems in this zone. Therefore, Moringa leaves could be an alternative source of fodder especially in drying season. As for age and gender, the way they influence the use of leaves as forage is contrary to the findings of Popoola & Obembe (2013). Actually, the later found that older use more leaves as forage than adults and young and that there is no difference according to gender. This can be explained by the pattern of study sample.

Correlations estimated between specific uses highlighted associated and non-associated uses, culinary behaviours' differences and healthcare behaviours' similarity. Actually, the use of Moringa for treating malaria is associated with its uses against tiredness, indigestion and as salad and vegetable soup. Therefore, promotion activities which aim at increasing the use level of species for treating malaria will also increase the use level of species against tiredness, indigestion and as salad and vegetable soup. On the other hand, the use of Moringa for treating malaria is non-associated with its use as forage obviously because of the high leaves consumption of forage. Increasing the cultivation level of the species will improve the availability of leaves. More the species leaves are eaten as salad and vegetable, less they are eaten mixed with rice and couscous. This is due to culinary behaviours' differences between ethnic groups and biogeographical zones. Moreover, correlations showed a healthcare behaviours' similarity between the use of species for treating hypertension and its use for treating diabetes. Actually, hypertension and diabetes frequently occur together (Cheung & Li, 2012) and are often found in the elderly (Attakpa *et al.*, 2017).

The utilization of a multivariate probit model was justified by the expectation that unobserved explanatory variables exist and affect more than one specific use and that the adoption of a specific use may drive the adoption of other specific uses and vice versa (Sodjinou & Henningsen, 2012). This expectation has been confirmed by the results indicating that analysing factors driving all specific uses simultaneously is much more efficient than analysing factors influencing each specific use separately. Therefore, the results of the multivariate probit model are more precise than the results from separate traditional univariate probit models (Sodjinou & Henningsen, 2012).

CONCLUSION

This study investigated factors influencing the specific uses of *M. oleifera* assuming joint effects of socioeconomic characteristics and biogeographical zones. The joint analysis of all specific uses allowed to get a deep insight into the inter-correlations between them. To increase the preference for *M. oleifera*, findings suggest to be made available and easily accessible information on the benefits and the multiple uses of Moringa in human health and wellbeing. Availability and accessibility of Moringa plant parts could be improved through the increasing of the level of cultivation of the species. Especially concerning food uses, religion, ethnic groups and biogeographical zones must be taken into account in the species food utilization value assessment. For the execution of public awareness projects activities, local associations for the species uses promotion must be created within ethnic groups and biogeographical zones. This association could be valuable contributing to increase the level of use of Moringa in various ways. Development and public awareness projects should pay adequate attention to the influencing factors highlighted as they would be significant facilitators of adoption of *M. oleifera* use in various ways. Extension agents should be trained to understand these influencing factors in order to get more sustainable positive impacts. In long term, these findings will contribute to the improvement of the domestication strategies of the species and therefore to the food security.

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CONFLICTS OF INTEREST

The authors report no conflicts of interest.

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