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Diversity and Traditional Consumption of Edible Insects in North Benin

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Authors' contributions

This work was carried out between both authors without any grant or financial aid from any source. Author FH designed the study and managed the literature researches, author JMK wrote the first draft of the manuscript and both authors collected the information, analysed, read through and approved the final manuscript.

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ABSTRACT

Shortage of protein from meat leads to the search for alternative protein source in order to meet up with the protein need by man. Edible Insects have been seen as a major alternative protein source in this regard. This study investigated the diversity of edible insect species and the proximate properties of some common insects used in traditional diet from three agro ecological zone in North Benin. In total 20 edible insects belonging to 4 orders *Orthoptera, Coleoptera, Isoptera* and *Hymenoptera* were identified to be consumed throughout the year. Thus it was also observed that each insect requires a special collection method. The quality attributes of consumption were distinguished according to the traditional technology processing of insects collected as boiling, sun drying, frying and smoking. These insects were rich in protein (25.2 – 64.4 g/100 g dry matter), fat (16.4-46.8 g/100 g dry matter) and minerals (1.0-4.8 g/100 g dry matter). Therefore effort should be geared toward developing improved preservation and processing methods of these edible insects since they can act as economic and nutritional sources to the inhabitants of these zones, thereby reducing rural poverty and malnutrition.

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Keywords: Edible insects; agro-ecological; proximate composition; quality attributes.

1. INTRODUCTION

The permanent availability and physical and economic access to sufficient, safe and nutritious food to satisfy the food needs and preferences, for an active and healthy life characterize food security [1,2]. But, when food contribution are deficient, or very unbalanced compared to world people dietary needs; it is food insecurity. This food insecurity leads to malnutrition and poverty. In Africa countries, most people are undernourished, due to lack of adequate food, high cost, drought, floods, pests or conflicts [3,4]. In Benin especially in north zone where certain food and meat that could act as major protein sources are scarce, insects are used as an alternative protein source to overcome the food insecurity. Also, edible insects have been used as foods based on cultural beliefs [5,6]. Some insects have been adopted as traditional food and are largely used in rural and urban areas of the northern part of the country. From the literature, insects are the largest animal group on earth [7], but few of them have played an important role in human nutrition history in the world [6,8-9]. Edible insects offer a considerable contribution to protein and mineral in human diets mostly for rural people [6,10]. A list of edible insects consumed in southern Benin was given by Tchibozo et al [5] who observed that edible insects contribute to the prevention and alleviation of malnutrition due to their protein content. Also a report on entomophagy in two Wama village in Northern Benin was done by Riggi et al. [11].

This study presents the results of a survey conducted across the three agro-ecological zone of Benin in order to compile an inventory of edible insect species, their time of availability, variation across socio-cultural groups, mode of preparation and consumption, quality attributes and nutritional value of mostly edible insects sold.

2. MATERIALS AND METHODS

2.1 Study Area and Selected Sites

The investigation was conducted in three agro-ecological zones of Benin from July to October 2016, namely the far Northern sudan zone (FNZ), the North sudan-sahelian zone (NSZ) and the Northwest and East central sudan zone (NEZ) (Fig. 1). These zones are endowed with an arid and semi-arid tropical climate, and characterized by two seasons oscillating between a wide dry season from mid October to April and rainy season from May to October within an annual rainfall varying from 800 and 950 mm [12]. These zones were chosen due to the importance attached to the consumption of edible insects. From each zone, one municipality was selected for their cosmopolitan aspect such as Malanville (11°12'N - 2°28' E) a municipality located within FNZ, Parakou (9°21' N - 2°30' E) a municipality located within NSZ and Natitingou (10°18' N - 1°23' E) a municipality located within NEZ.

2.2 Study Design and Sampling

The pilot study for this research focused on edible insects that the inhabitants of selected municipalities in North Benin consumed. All such species occur spontaneously in the woodlands within the Northern zones. In every municipality surveyed, the survey was conducted with the structured and semi structured questionnaire interviews with people only when prior informed consent was obtained. Since it was aimed identifying individuals with a detailed knowledge of insect species suitable for consumption, a non-probabilistic survey design was approved which involved the use of a snowball sampling approach. The sampling technique was used due to the fact that the interested to populations are unknown. The snowball sampling approach based on referrals made by people who share; know others who present the characteristics that are of research interest [13].

2.3 Data Collection

From different selected zones, a total of 181 edibles insects' consumers were interviewed from different socio-cultural groups (Table 1), and of both genders with a balanced mix of ages. In each municipality and prior to the survey, the particulars of the area (agro-ecological zone, name of location, name of village, socio-cultural group) were collected after detailed presentation of the research objectives to the actors. Through discussion, the following key information related to traditional cultural practices was recorded. These were: Consumption and use of insect species, use of insect products; seasonal availability and harvesting method, restriction of edible insect development, and commercialization of insect species and insect products.

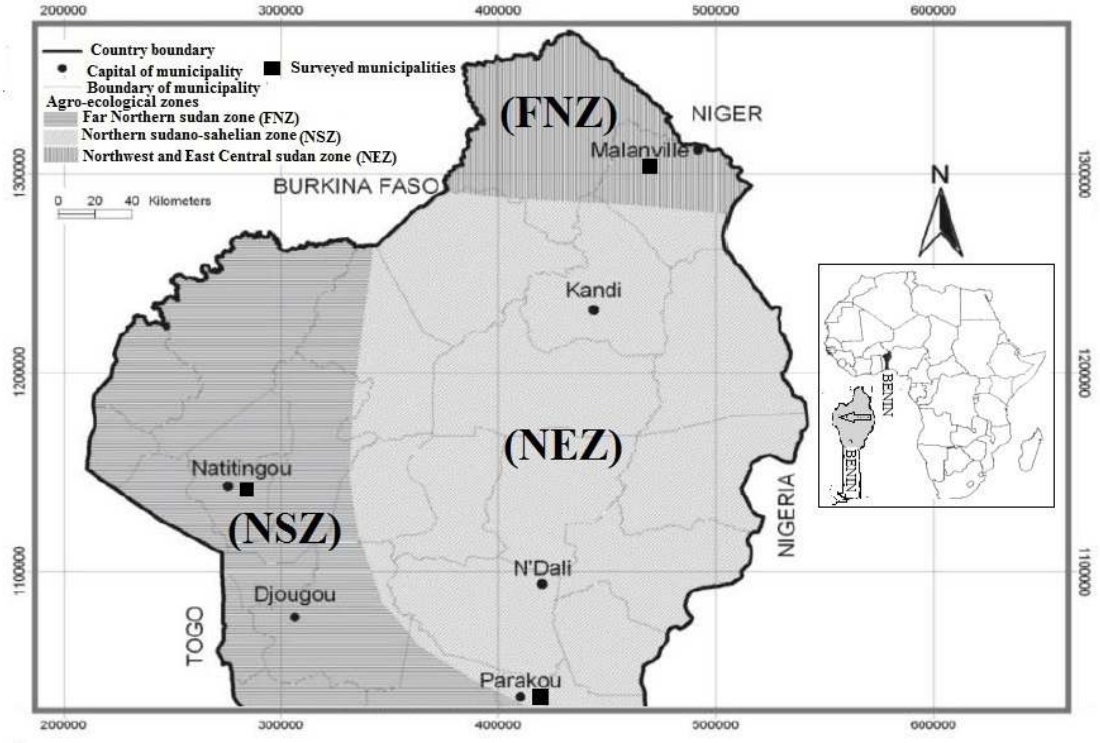

Fig. 1. Agro-ecological zones with surveyed municipalities

Table 1. List of socio-cultural groups met in the villages surveyed with their municipality

Villages	Municipality	Socio-cultural group
Monkassa	Malanville	Dendi, Djerma,
Bodjécali	Malanville	Dendi,
Goun-goun	Malanville	wama
Torozogou	Malanville	Dendi,
Fiarou	Parakou	Bariba, Dendi
Karobouarou	Parakou	Bariba,
Dabou	Parakou	Bariba, Dendi
Pam–Pam	Natitingou	Otamari, Wama,
Perpoyakou	Natitingou	Wama,
Pouya	Natitingou	Wama
Moupemou	Natitingou	Otamari,

2.4 Edible Insect Species Composition Analysis

2.4.1 Sampling

Five types of insects, the most available and sold such as Tobacco cricket (*Brachytrupes membranaceus*), two different types of scarabid beetles (*Pachnoda vossi* and *Gnathocera impressa*), a termite (*Macrotermes falciger*) and a grasshopper (*Ruspolia differens*) were bought from three different markets in the survey zones and each batch was taken for analysis.

2.4.2 Proximate composition

Dry matter was determined according to the ISO method [14]. Crude Protein was determined according to reference method of nitrogen content quantified [15]. Fat was determined according to Folch method [16]. Ash was determined according to ISO method [17].

2.5 Data Analysis

Raw data were stored using Microsoft excel 2007 and were later analysed using descriptive statistics (frequencies, percentages, means, etc.). The mean and standard error of means of the triplicate analyses related to proximate composition were calculated and the analysis of variance (ANOVA) was performed with Statistica (version 7.1, Stat Soft France, 2006) to determine significant differences between the species ($p < .05$).

3. RESULTS AND DISCUSSION

3.1 Socio-cultural Characteristics of the Informants

All the 181 informants interviewed during the survey were consumers of one of the edible insect species recorded from the three agro-ecological zones that belonged to the orders *Coleoptera* (66.9% of informants; n=121), *Isoptera* (55.8% of informants; n=101), *Orthoptera* (100% of informants; n=181) and *Hymenoptera* (50.8% of informants; n=92). The informants were aged between 18 and more than 61 years; 81.2% of them (n=147) were between 18-36 years, and 18.8% (n=34) between 37 and more than 61 years (Table 2). They were from both genders women (22.7 %) and men (77.3%). Most of them (54.1%) had no academic qualification, while 26.5%, 13.8% and 5.5% had attended primary school, secondary school and university respectively. They were farmers (44.2%), fishers/hunters (15.5%), craftsmen (19.3%), civil servants (3.9%), beekeepers (6.1 %) and trader (11.0%). In the survey zone, the main socio-cultural groups related to insect consumption were Bariba (22.7%), Dendi (15.5 %), Djerma (16.6%), Otamari (16.6 %) and Wama (28.7%). According to informants, the insects consumed were also used in traditional medicine (41.4%) that the *Isoptera* and the *Hymenoptera* were used for cooling of the memory (60.4%) and to treat headache (15.1%), the *Orthoptera* were exploited against cough (87.1%). In North Benin, edible insects constitute a source of income for insect seller's women. Similar results were observed in other regions where the consumption of insects is considerable as well as a protein source and traditional used as food [10,18-19].

3.2 Edible Insect Species Recorded Across Agro-ecological Zones

In total, four edible insect orders were recorded according to the agro-ecological zones in the North Benin (Fig. 2) representing 20 edible insects distributed among 8 insect families (Table 3). Though the list is not exhaustive, the *Orthoptera*, the *Isoptera* and the *Hymenoptera* were found everywhere in the three survey zones while the *Coleoptera* were present in two agro-ecological zones such as NSZ and NEZ. These results obtained on edible insect species according to agro-ecological zones in North Benin were not associated with cashew trees as reported by Agboton et al. [20] who recorded a large number of insect species but were not identified as edible.

Table 2. Demographic characteristic of edible insects' informants in the north Benin

Variables	Frequency (n=181)	Percentage
Ages (years)		
18 -25	60	33.1
26-30	57	31.5
31-36	30	16.6
37-40	9	5.0
41-45	10	5.5
46-50	8	4.4
≥ 51	7	3.9
Gender		
Females	41	22.7
Males	140	77.3
Educational status		
Illiterate (non-academic qualification)	98	54.1
Primary school	48	26.5
Secondary school	25	13.8
University	10	5.5
Main activities		
Agriculture	80	44.2
Fishing/hunting	28	15.5
Handicraft	35	19.3
Civil servants	7	3.9
Apiculture	11	6.1
Commerce	20	11.0
Socio cultural group		
Bariba	41	22.7
Dendi	28	15.5
Djerma	30	16.6
Otamari	30	16.6
Wama	52	28.7
Insects consumed		
Orthoptera	181	100.0
Coleoptera	121	66.9
Isoptera (3 species)	101	55.8
Hymenoptera	92	50.8

3.3 Overview of the Edible Insect Species with Collection Methods

Table 3 presents the list of edible insect species in North Benin. Locusts, grasshoppers, crickets were consumed in the order *Orthoptera*, beeltes in the order *Coleoptera* and winged and queen in the order *Isoptera* while egg, larva and pupa of bees were eaten in the order *Hymenoptera*. These edible insects are generally available for consumption for certain period of the year except *Hymenoptera*ns which were available year round (Table 3). For *Coleoptera*n and certain *Orthoptera*ns, a peak was recorded from April to

September which corresponds to the rainy seasons of the three agro-ecological zones; with Sacrabaeidae family being available between March and December while Buprestidae family were available from June up to December. Dytiscidae family were available from January up to April, Acrididae family were available from September to December. Gryllidae and Bradyporidae families were available from April up to December while termitidae family were available during the rainy season. These insect species have been reported eaten in Nigeria [18, 21-22] and in Sub-Saharan Africa [6,23].

According to informants, these insects involve some technique methods of gathering and collecting according to their characteristics.

Locust (*Cyrtacanthacris ruficornis*) grasshopper (*Gymnoproctus sculpturatus*, *Truxalis spp*, *Ruspolia differens*, *Ornithacris turbida cavroisi*) are commonly found in cropping area (millet, maize, and sorghum), grass, bush and shrubs. They are collected by hand and with stick very early in the morning before the sunrise.

Crickets (*Brachytrupes membranaceus*, *Gryllus bimaculatus*) live in the ground during the day. They are hunted by digging them out from their burrows.

Beetles, the edible beetles (*Pachnoda cordata*, *Gnathocera impressa*, *Rhabdotis buchardi*, *Gnathocera varians*, *Pachnoda vossi*, *Chondrorrhina abreviata*, *Sternocera interrupta*, *Steraspis castanea*) live in bush and shrub. They were collected by shaking the tree or moving the brush with stick to frighten them, where after they drop down. The water beetle (*Cybister sp.*) inhabit in water. They were collected with basket hung with stick.

Termites, the edible termites in the three agro-ecological zones are winged termites (*Macrotermes falciger*). According to informants, the winged termites swarm from termite mounds at the onset of rain. The informant called this swarm nuptial flight. In urban region, the suitable time for collecting is at night, the winged termites were trapped in large bowl of water close to source of light. In rural region, the winged termites were collected near the termite mounds; the people used the light to lure them into calabash. The winged termites are the future queens and kings and can be consumed but the soldier termites cannot be consumed (100% of informants).

The queen termites (*Syntermes aculeosus*) were collected during the rainy seasons when the termite mound can easily be destroyed. However, the removal of queen involved the destruction of termite mound causing death of whole colonies.

Honey, egg, larva and pupae of bees are collected from the beehive for eating after using the fire to chase away the adult bees.

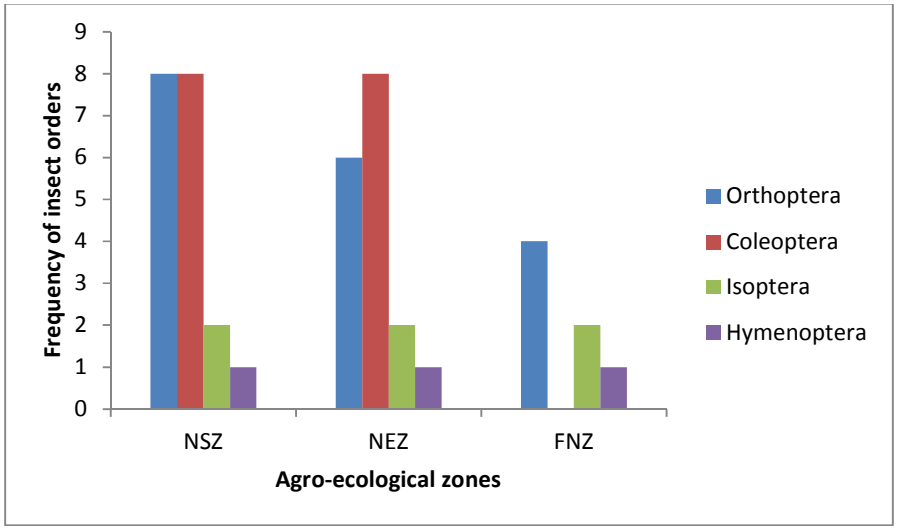

Fig. 2. Diversity of edible insect orders according to the three agro-ecological zones

NSZ: Northern sudan-sahelian zone; NEZ: Northwest and East-central sudan zone; FNZ: Far northern sudan zone

Table 3. List of insect species consumed by informants in North Benin

Insects	Common names	local names	Group socio-cultural	Collected area	Agro-ecological zone
Gymnoproctus sculpturatus (*Orthoptera*) (Bradyporidae)	Grasshoppers	Nagitasambi	Wama	Bush, Grass, shrub, millet	NSZ
Truxalis spp. (*Orthoptera*)(Acrididae)	Short horned grasshoppers	Chaubafranca	Wama	Bush, Grass, shrub	NSZ; NEZ; FNZ
Hieroglyphus africanus (*Orthoptera*) (Acrididae)	Grasshoppers	Sosore	Wama	Bush, Grass, shrub	NSZ; NEZ; FNZ
Ruspolia differens (*Orthoptera*)(Gryllidae)	Longhorn grasshoppers	Don Ditchadone Tchoubou Tchamtcham	Dendi Otamari Wama Djerma	Bush Grass, millet, shrub Bush Grass, millet, shrub Bush Grass, millet, shrub Bush Grass, millet, shrub	NSZ; FNZ
Cyrtacanthacris ruficornis (*Orthoptera*)(Acrididae)	Green tree locust	Manchougou	Wama	Bush, Grass, Okra, shrub	NSZ; NEZ
Ornithacris turbida cavroisi (*Orthoptera*) (Acrididae)	Grasshopper	Manchougou	Wama	Bush Grass, Okra, shrub	NSZ; NEZ
Brachytrupes membranaceus (*Orthoptera*) (Grillydae)	Short tail cricket	Baga	Wama	Under mango trees	NSZ; NEZ
Gryllus bimaculatus (*Orthoptera*)(Gryllidae)	Field Cricket	Gboo Quilili Tabatè Baha Doo	Bariba Dendi Otamari Wama Djerma	Bush Grass, millet	NSZ; NEZ; FNZ
Pachnoda cordata (*Coleoptera*) (Scarabaeidae)	Sun beetles	Pipiru	Wama	Bush Grass, Maize, Millet	NSZ; NEZ
Gnathocera impressa (*Coleoptera*) (Scarabaeidae)	Colorado beetle	Fapipiru	Wama	Bush Grass, Maize, Millet	NSZ; NEZ
Rhabdotis buchardi (*Coleoptera*) (Scarabaeidae)	Colorado beetle	Fapipiru	Wama	Bush Grass, Maize, Millet	NSZ; NEZ
Gnathocera varians (*Coleoptera*)(Scarabaeidae)	Rose beetle	Sopipiru	Wama	Bush Grass, Maize, Millet	NSZ; NEZ
Pachnoda vossi (*Coleoptera*)(Scarabaeidae)	Golden beetle	Pipisae	Wama	Bush Grass, Maize, Millet	NSZ; NEZ
Chondrorrhina abreviata (*Coleoptera*)(Scarabaeidae)	Beetles	Pipirundi	Wama	Bush Grass, Maize, Millet	NSZ; NEZ
Sternocera interrupta (*Coleoptera*)(Buprestidae)	Beetles	Kokouare	Wama	Acacia trees	NSZ; NEZ
Steraspis castanea (*Coleoptera*)(Buprestidae)	Beetles	Kokouare	Wama	Acacia trees	NSZ; NEZ
Cybister sp. (*Coleoptera*)(Dytiscidae)	True water beetle	Cotondousre	Wama	Water pool	NSZ; NEZ
Macrotermes falciger (*Isoptera*)(Termitidae)	Winged termites	Iiriiri, Yiri Gninbri Soungey Tchatchara	Wama Bariba Djerma Otamari	Termite mounds	NSZ; NEZ; FNZ

Insects	**Common names**	**local names**	**Group socio-cultural**	**Collected area**	**Agro-ecological zone**
Syntermes aculeosus (*Isoptera*)(Termitidae)	Queen termite	Gnonmi Toubou Sounnon Dousoukpé Touma Dolli	Dendi Bariba Dendi Wama Djerma	Termite mounds	NSZ; NEZ; FNZ
Apis mellifera (*Hymenoptera*) (Apidae)	Honey bee (egg, larva, pupa)	Tyan (bee, pupa), Tym (honey) Term (bee, pupa), Terfa (honey) Youh Iphiyé (bee, pupa) Thyphiyéti (honey)	Bariba; Wama Djerma, Dendi Otamari	Flowering plants	NSZ; NEZ; FNZ

Table 4. Edible insects' seasonal availability in North Benin

Group of insect	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Coleoptera												
Scarabaeidae			X	X	X	X	X	X	X	X	X	X
Buprestidae						X	X	X	X	X	X	X
Dytiscidae	X	X	X	X								
Orthoptera												
Acrididae									X	X	X	X
Gryllidae				X	X	X	X	X	X	X	X	X
Bradyporidae				X	X	X	X	X	X	X	X	X
Isoptera												
Termitidae				X	X	X	X	X	X			
Hymenoptera												
Apidae	X	X	X	X	X	X	X	X	X	X	X	X

X: available period

3.4 Traditional Consumption Forms of Edible Insects

The cooking methods of consumed insects are traditionally simple without constraint. In North Benin, before cooking the wings and guts of the large insects (crickets and locusts) were removed while beetles were cleaned in water overnight for living waste form their guts. All forms of consumed insects are used to cook dishes. The edible insects were sun dried, fried and smoked or roasted. They were used as condiment in slimy and vegetable sauces. Riggi et al. [11] reported that in the Northern Benin children between 5 and 15 of age chased in groups edible insects after collecting in a jar, cooked them in a pan with shea butter and chilli or grilled directly on charcoal.

3.5 Quality Attributes of Various Consumption Forms of Edible Insects

In the North Benin, the perception of quality of various consumption forms of edible insects by the informants was based on observations and consumption of quality attributes as colour, texture/consistency and taste (Table 5). The informants declared that the quality attributes of the consumption forms (boiled, fried, dried and smoked) were distinguished according to the traditional technology processing. Thus, the fried (91.8% of informants) and dried (97.1% of informants) edible insects were supposed to have brownish colour while the blackish colour was attributed to smoked forms (65.8%). Concerning the texture and consistency, the fried forms were considered to have crackle (85.1%), creamy (84.6%) and melting (75.8%) texture and the dried forms were mostly crackle (87.6%). For the taste, the informants claimed that the consumption forms of edible insects were recognized being deliciousness, salty taste and hazel tastes.

3.6 Proximate Compositions of Edible Insects

The proximate compositions of most available and sold edible insects in North Benin are shown in Table 6. There were significant differences ($p < .05$) in the means of the proximate compositions among the edible insect species. The highest dry matter content was obtained from *Brachytrupes membranaceus* (86.0 g/100 g) and *Ruspolia differens* (86.0 g/100 g) while the least value were in *Gnathocera impressa* (60.0 g/100 g) and *Pachnoda vossi* (60.0 g/100 g). The difference in dry matter content among the edible insect species was statistically significant with the $p < .05$. The level of ash content of *Macrotermes falciger* (4.8 g/100 g) was found to be higher than that of other species. There was a significant difference between the ash content of the edible insect species at $p < .05$. The high level of ash recorded proved that edible insects were rich in minerals. Minerals were recognized to play important metabolic and physiological roles in the living system [22,24]. The highest protein content was obtained in *Macrotermes falciger* (64.4 g/100 g DM) while the least content was in *Gnathocera impre*ssa (25.2 g/100 g DM). A significant difference of protein content was recorded at 5% of analysis of variance (ANOVA). The critical review of insects from a food safety and nutrition perspective presented by Belluco et al. [25] showed that insects form an excellent source of protein (many insect species above 60 g/100 g dry matter) and were safe for human

Table 5. Quality attributes of consumption forms of edible insects

Consumption forms	Colour		Texture/consistency			Taste		
	Brownish colour	Blackish colour	crackle	Creamy	Melting	Deliciousness	Salty taste	Hazel taste
Fried	91.8	11.1	85.1	84.6	75.8	87.9	85.6	74.1
Dried	97.1	35.1	87.6	10.2	0.0	84.1	55.8	24.4
Smoked	45.1	65.8	42.1	8.1	41.1	91.2	74.1	86.8

Table 6. Proximate composition of five edible insects (mean ± standard error)

Insect species	Dry matter (g/100g)	Ash (g/100g DM)	Crude protein (g/100g DM)	Fat (g/100 DM)
Brachytrupes membranaceus	86.0 ± 2.5^{c}	2.9 ± 0.4^{b}	39.7 ± 2.5^{b}	46.8 ± 2.2^{d}
Pachnoda vossi	60.0 ± 1.8^{a}	3.4 ± 0.1^{b}	64.2 ± 0.5^{d}	16.4 ± 1.0^{a}
Macrotermes falciger	69.2 ± 1.3^{b}	4.8 ± 0.4^{c}	64.4 ± 0.6^{d}	21.8 ± 1.2^{b}
Ruspolia differens	86.0 ± 0.8^{c}	3.3 ± 1.1^{bc}	46.1 ± 0.4^{c}	33.1 ± 1.0^{c}
Gnathocera impressa	60.0 ± 0.6^{a}	1.0 ± 0.2^{a}	25.2 ± 0.3^{a}	45.1 ± 0.2^{d}

DM: dry matter; ^{a,b,c,d,e}: Values on the same column followed by the same letter are not significantly different (p > .05)

consumption. Other authors showed that insects' protein is highly digestible [18]. The fat content of edible insect species varied from 16.4 to 46.8 g/100 g dry matter. The highest fat content was recorded in *Brachytrupes membranaceus* and the least content was in *Pachnoda vossi*. The difference in fat content among the edible insect species was statistically significant with the $p < .05$. Similar result on fat was obtained by Ramos-Elorduy et al. [26]. The fat content especially in the form of fatty acid from the studied insects compared favourably to those of meat [25].

4. CONCLUSION

This study revealed the large diversity of types of insects consumed in the Northern Benin. Edible insects play an important role in the diet of Northern Benin population. The three agro-ecological zones offered an evident environmental of insects' survival. The proximate composition of the studied insects revealed the presence of a high protein, fat and ash contents. However, more researches should be carried out on the microbiological properties of these insects in order to come up with a comprehensive attractive product based edible insects acceptable by consumers.

CONSENT AND ETHICAL APPROVAL

The study was approved by the Department of Nutrition and Agro Food Sciences, Faculty of Agronomy, University of Parakou. All authors declare that written, informed consent was obtained from all informants who received the survey and participation was completely voluntary.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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