Nutritionalpotentialofthecaterpillar*Imbrasia obscura*(Butler,1878)consumedintheKara region of Togo

ABSTRACT

Lepidopteranlarvae,which constituteunconventionalfoodresources in many parts ofthe world, are consumed by aboriginal populations in Togo without any study being carried out on their nutritional value. The aim of this study was to assess the nutritional compositionofthecaterpillar*Imbrasiaobscura*(Butler,1878)consumedbypopulationsin the Kara Region of Togo. To this end, 9 *I. obscura* samples were taken from three localities in this region.Ash, protein, vitamin and lipid contents were determined using AOAC (Association of Official Analytical Chemists) methods, and fiber content using the AFNOR (Association française de normalisation) method. Minerals were analyzed spectrophotometrically and colorimetrically. Fatty acid composition was determined by chromatography. This caterpillar is made up of 10.41 ± 0.33% moisture, 53.36 ± 0.05 % protein, 14.22 ± 0.62% lipids, 10.67 ± 0.62 % fiber and 1.04 ± 0.54 % carbohydrates. Lipidscontainmonounsaturated(oleic(30.57±0.03%)andelaidic(0.46±0.02%)acids) and polyunsaturated fatty acids (linoleic (4.82 ± 0.02 %), α-linolenic (1.872 ± 0.02 %), γ-linolenic (1.57 ± 0.01 %) and arachidonic (2.33 ± 0.01 %) acids). With regard to micronutrient composition, theaverage mineral content is 10.3%, andvaries according to the nature of each mineral. *I. obscura* also contains variable levels of fat-soluble vitamins (retinol: 0.02 ± 0.01 mg/100g and tocopherol 4.10 ± 0.07mg/100g) and water-soluble vitamins (thiamine: 1.35 ±0.16 mg/100g, riboflavin: 2.12 ±0.11mg/100g and niacin: 4.10 ±0.07mg/100g).Thesedatashowthequantitativeandqualitativerichnessof *I.obscura*in nutrients. This species could therefore contribute to the nutritional balance of consumers, and deserves to be given greater prominence on our plates.

Keywords:caterpillar,Imbrasiaobscura,nutritionalvalue,Kararegion,Togo.

1. INTRODUCTION

Forestsandtreesoutsideforests,withfreeaccesstoresources,attractaboriginalpopulations [1]. According to FAO [2], 60 million aboriginal peoples are almost entirely dependent on forests, and over 1.6 billion people worldwide depend to varying degrees on forests for their livelihoods.Householddependenceonforestresourcescanbedirect, throughtheharvesting of food and medicinal products, materials used for handicrafts and cultural ceremonies, as wellasfuelwoodortimber [3].Itcanalsobe indirect throughthemarketingoftheseproducts in order to obtain financial means for subsistence or even social fulfillment [4]. In developing countries, household dependence on forest resources has increased as a result of poverty andfoodinsecurity[5].Moreover,theoutlookfortheworld'spopulationisforcontinuedgrowth overthecomingdecades,especiallyindevelopingcountries,wherealmostallofthisincrease will occur [6]. Adding value to forest products, which have been exploited since time immemorial,isthereforeessentialforthesurvivaloftheseever-growingpopulations.Several studieshavebeen carried outin thisdirection[7, 8, 9]. According to thiswork, forests offer

interesting potential in terms of non-timber forest products (NTFPs) harvested to ensure the food and economic security ofdependentpopulations. Insects in particular are envisaged as a possible alternative or complementary food to conventional meat in order to mitigate the environmental impact of conventional livestock farming [10, 11]. However, to date, the nutritional value of many consumed insect species remains unknown. This knowledge is neededtoenhancethevalueofedibleinsectsandimprovethelivingconditionsofdependent populations. In Togo, very little work has been done on the nutritional value of this fauna. EthniccommunitiesKabyèandNawdbaintheKararegionofTogoconsumeandappreciate thecaterpillar*Imbrasiaobscura*(Butler,1878)(Lepidoptera:Saturniidae),butnostudieshave been carried out on its nutritional composition. This is justified by the lack of scientific knowledge of the latter. The aim of this study was to assess the nutritional potential of the *I. obscura* consumed by populations in the Kara region of Togo, with a view to improving its value.

2. MATERIALANDMETHODS

Biologicalmaterialstudiedandharvestingmethod

Thebiologicalmaterialusedinthisstudywasthe *I.obscura*caterpillar.Itisconsumedby the Kabyè and Nawdba ethnic groups in the Kara region of Togo. It is known by the following vernacularnames:KpankpatoulébyèandKpakpaïNawdba).Thecaterpillar'shostplant is *Parkia biglobosa* (Fabaceae) (figure 1).

Figure1:Imageof*I.obscura*caterpillarson*P.biglobosa*leavesinKpenzindé

Ninesamplesofabouttenlivecaterpillarspersamplingwerecollectedunderthehostplantin August 2021 in the three localities namely Kpenzindé, Kémérida and Siou (figure 2) in the Kara region (three sample sites per locality) where it is widely consumed.

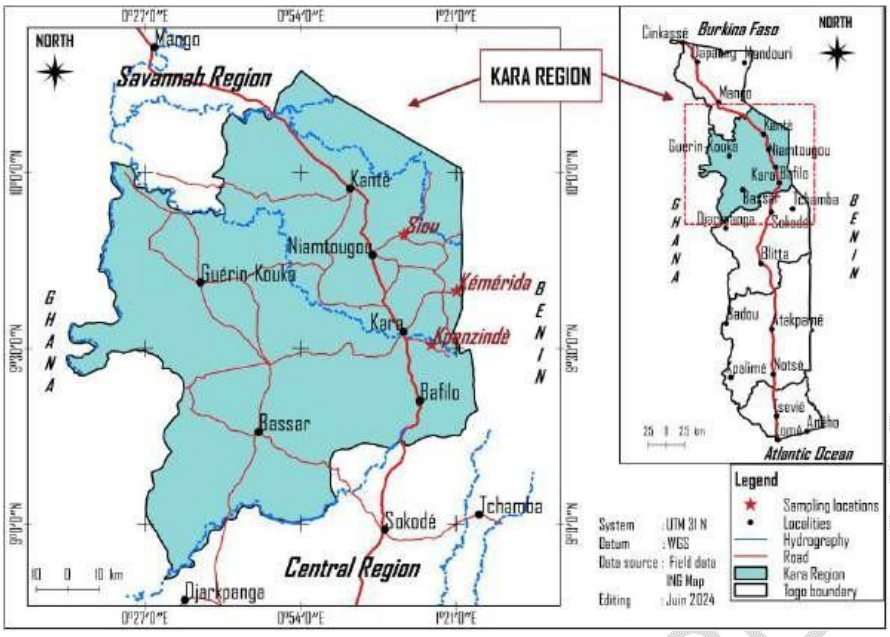

Figure2:Samplecollectionlocations

Sampleswerepreservedin70°alcoholandtransportedtotheAppliedEntomologyLaboratory intheUniversityofLoméforidentificationusing determinationkeys.Caterpillarsforchemical analysiswerecollectedateachsiteduringthesameperiod.Theselive-capturedinsectswere cold-killedandpreservedbyplacingtheminanicebox[12].Theywerethentransportedtothe Laboratory of Biochemistry Applied to Nutrition at the University of Lomé.

Chemicalanalysis

Determiningmoisturecontent

Itwasperformedonfresh*I.obscura*caterpillarsamplesusingtheSCALTECbranddesiccator (SM01 Instrument GmH, Germany) [12]. One gram of untreated wet insect sample is placed on a tared dish and introduced into tan electronic moisture analyzer (automatic analysis) according to the manufacturer's recommendations. A beep signals the end of dehydration, and the moisture content is displayed as a percentage on the instrument's screen.

Processingsamplesinthelaboratory

Five grams of fresh caterpillars from each sample site were weighed and mixed to obtain an average sample. The average samples from each locality were placed in an ISUZU type AS vacuum oven at 40° C for 7 days for dry. The dried caterpillars were ground in a General Electric Interlabs Moulinex. The ground samples were then sieved through a 1 mm mesh Fischer Scientific stainless-steel sieve for the different assays. Samples were analyzed in 2021 and 2022.

Determinationofproximatecompositionandenergy

Total fiber content was determined using the Weende method [13]. 200ml of 12.5g/l sulfuric acidwasintroducedinanErlenmeyerflaskcontaining3gofsample.Theresultingmixture

was boiled for 30 minutes. The mixture was then filtered through a 500 µm Fischer Scientific stainless-steelsieveandrinsed3timeswiththesamequantityofdistilledwater (200ml)while hot.TheresultinginsolubleswereaddedtoanotherErlenmeyerflaskcontaining200mlof 12.5g/l sodium hydroxide. The new mixture was treated in the same way as before. The residues contained in the sieve were transferred to a crucible of known mass. The contents were dried in a SCALTEC desiccator (SM01 Instrument GmH, Germany) at 150°C for one hour, weighed and then incinerated in a Nabertherm LE 14/11 muffle furnace at 550°C for 6 hours.Aftercoolinginadesiccator,thecruciblewasweighed.Thepercentageoftotalfiber (F)inthesamplewasobtainedusingthefollowingformula[13]:

$$F=\frac{\text{Massofresidueafterdrying}-\text{Massofashafterincineration}}{\text{massoftestsample}}\times 100 \quad (1)$$

Ashes were obtained by incinerating the samples in a Nabertherm LE 14/1 muffle furnace at 550°C for 6 hours [14].

Total protein in caterpillar samples was estimated by determining total nitrogen using the Kjeldahl method [15]. Total protein content was then calculated by multiplying total nitrogen by the conversion factor 6.25 [16].

Lipids from caterpillar samples were extracted continuously in a Soxhlet after hexane action on ground caterpillar samples. Weighed *I. obscura* was introduced into a lipid-free white cartridge.Thesewerethenpassedthroughacolumnofhexanetoextractthelipids.Extraction lasted 10 hours per day and was repeated over three successive days. The device was adjustedtoobtain5siphoningsperhour.Theextractobtainedattheendoftheoperationwas filtered and transferred to a dry flask, then evaporated under vacuum at 35°C using a Buchi R114 rotavapor. The lipids obtained after evaporation were weighed. The total carbohydrate contentofcaterpillarsampleswascalculatedby differencewiththepercentagesofothertotal constituents according to the following formula [16]:

$$\text{Carbohydrate}=100-(\text{Moisture}+\text{Protein}+\text{Fat}+\text{Ash}+\text{Fiber}) \quad (2)$$

The energy value of 100 grams of samples was determined by multiplying the percentage content of each of the macronutrients measured by its energy value, i.e. 17 kJ.g-1 , 38 kJ.g-1, 17 kJ.g-1 and 8 kJ.g-1 for proteins, lipids, carbohydrates and fibers respectively, then summing [16]:

$$EM=17X\text{Protein}+37X\text{Fat}+17X\text{Carbohydrate}+8X\text{Fiber} \quad (3)$$

Mineralanalysis

Themineralprofilewasdeterminedbysolubilizingthecrushedmaterialbyacidetching using two concentrated solutions (nitric acid and hydrogen peroxide). The product obtained after solubilization was assayed for calcium, magnesium, sodium, potassium, iron, copper and manganese.usingaflameionizationspectrophotometer,modelAASolaar (ThermoElectron Corporation), according to the wavelength of each mineral. Phosphorus content was determined using the phosphovanado molybdate method, and absorbance was assessed using a colorimeter (Jenway model 6300) [17].

Vitaminanalysis

The determination of vitamins in the samples was carried out according to the methods describedbyAOAC[14].Theprinciplesofthesemethodsarebasedonthestainingofvitamin molecules. The absorbance of colored solutions was measured using a colorimeter (Jenway model 6300).

Forretinol,onegramofsamplewasintroduced ina250mlflask.Aftertheadditionof5 mlof pyrogallol solution, 35 ml ethanol and 10 ml potassium hydroxide solution, the mixture was heatedfor30minat70-80°Cunderarefluxcondenserandthenlefttocoolunderastreamof water.Aftercooling,40mldistilledwaterand100mlpetroleum etherwereadded. Extraction wasperformedbystirringfor3min.Theresultingproductwasthenlefttosettle,andtheupper phasetransferredtoaseparatingfunnel.Theetherealphasewaswashed toneutralitywitha triple fraction of 50 ml water and filtered through filter paper. A 5 ml sample of the ethereal phase was introduced in a 50ml flask and made up with petroleum ether. The retinol concentration of this solution was determined by measuring its optical density at 325 nm.
Thethiaminecontentofthesampleswasdeterminedbyadding50mlof0.1Nsulfuricacid to onegramofeachsampleina100mlvolumetricflask.Themixturewasheatedinawaterbath at100°Cfor30min,withfrequentstirring.Fivemillilitersof2.5Nsodiumacetate solutionwas added to the contents of the flashand left to cool. After cooling, the flask was capped and placed in a water bath at 45-50°C for 2 hours. The resulting product was made up to 100 ml with distilled water and filtered through filter paper. 10 ml of the filtrate was added to 5 ml of potassium chloride solution. Absorbance was measured on this solution at a wavelength of 285 nm.

Forriboflavin,onegramofeachsamplewasweighedintoa250mlvolumetricflask,5mlof 0.1Nsulfuricacidand5mlofdichloroethenewereadded,followedby90mlofdistilledwater. Themixturewasstirredandheatedonasandbathfor30mintoextractalltheriboflavin. The mixturewasthencooledandmadeupto250mlwithdistilledwater.Itwasthenfilteredthrough filter paper. A 2 ml volume of the filtrate obtained was introduced into another 250 ml volumetric flask and topped up with distilled water. By measuring the absorbance of the colored solution at 460 nm, the riboflavin concentration of the solution could be determined. For niacin, five grams of sample were extracted with 50 ml of distilled water. Extraction was performed by repeated stirring for 30 min. The product was then left to settle and the upper phase was recovered and filtered. This operation was repeated 3 times each timewith the same quantity of distilled water (100 ml).Five milliliters of the mixed filtrates were introduced intoa100mlvolumetricflaskandtoppedupwithdistilledwater.Theabsorbanceofthecolored solution obtained, measured at a wavelength of 385nm, was used to determine the nicotinic acid content of the sample.

Fortocopherol,onegramofsamplewasweighedandplacedina250mlflat-bottomedflask. Solutionof10mlethanoland20mla1Nsulfuricacidwereadded.Theflaskwas wrappedin aluminum foil and heated with reflux for 45 min. The resulting solution was cooled for 5 min, followedbytheadditionof50mldistilledwaterandtransferredtoaseparatingfunnelcovered withaluminumfoil.Theunsaponifiablematterinthemixturewasextracted5 timeswith50ml dimethylethereachtime.Thecombinedextractwaswashedwith1Nsulfuricacidsolutionand driedoveranhydroussodiumsulfate.Theevaporatedextractwasimmediatelydissolvedin15 ml ethanol, 1 ml concentrated sulfuric acid and 1 ml concentrated nitric acid. The resulting product was placed in a water bath at 90°C for 30 min. After cooling, the tocopherol content of the extract was measured by ultraviolet absorption at 470 nm.

Lipidanalysis

The fatty acid composition of the caterpillar lipids studied was obtained by separating the methylestersfromthelipidsusinggaschromatography.Thetransformationoffattyacidsinto methyl esters by transesterification of the crude lipids using a methanolic solution of boron trifluoride (BF3-Methanol) in accordance with AOCS [18] was the preparatory step for chromatographic analysis.

Themethanolictrifluoridesolutionwaspreparedwith8%borontrifluoridereagentinmethanol priortothestartoftransesterification.Fortransesterification,100mgofsamplewasintroduced ina10mlscrew-tube.1.5mlofhexaneand1.5mlofmethanolicborontrifluoridesolutionwere added.Thetubewassealedundernitrogen,shakenvigorously,thenheatedto100°Cforone hour.Aftercoolingtoroomtemperature,1mlhexaneand2mldistilledwaterwereaddedand the mixture stirred under nitrogen. Two phases were obtained at rest. The upper phase was recovered and put in another tube under nitrogen. The lower phase was extracted twice with hexane. The collected phases (methyl esters) were washed with distilled water, then dried overanhydroussodiumsulfate.Thesolventwasevaporatedinvacuo.Hexanewasadded to concentrate methyl esters suitable for gas chromatography analysis. An HP 6890 series GC Systemgaschromatographwasusedfortheanalysis.Theinstrumentisequippedwithaflame ionizationdetectorandanHP-5(Crosslinked5%MESiloxane)capillarycolumn(length30m; filmthickness0.25µm;internal diameter0.32 mm).Theoven temperature isprogrammedto increasefrom-60to+325°Catarateof1°C/min.Theinjectortemperatureissetat275°Cand thedetectorat325°C.Theinletnitrogenpressureusedascarriergasvariesfrom6.90to47.6 kPa. The flow rate is maintained at 1 cm^3/mn and the dead time is 1 mn 15 s (hydrogen 40 cm/sec). Representative methyl ester peaks were identified using reference substances (methyl esters) by comparing the retention times of each chromatogram peak with those obtained for the standards. The percentages of saturated and unsaturated fatty acids (monounsaturated and polyunsaturated) in caterpillar lipids were obtained by summing the contents of the fatty acids concerned.

Statisticalanalysis

All trials were repeated three times. Averages were calculated on the basis of the three repetitions. Standard deviations (SD) were considered.

3. RESULTS

Proximatecompositionof*I.obscura*comparedwithotherproteinfoods

Theresultsobtainedinthisstudyshowthat100goffresh*I.obscura*caterpillarscontain10.41 ±0.33gofmoisture,53.36±0.05gofprotein,14.22 ±0.62goflipids,10.67±0.62goffiber, 1.04±0.54gofcarbohydrateand10.3±0.27gofashandanenergyvalueof1478.54 ±23.2 kJ/100g (table 1).

Table 1: Proximate composition (% of total weight) and energy content (kJ/100g) of *I. obscura* compared with other protein foods

Species or food	Moisture	Ash	Protein	Lipid	Fiber	Carbohydrate	Energy	Reference
I. obscura	10.41± 0.33	10.3 ± 0.27	53.36 ±0.05	14.22± 0.62	10.67± 0.62	1.04±0.54	1478.54± 23.2	
C.forda	10.06± 0.12	18.43± 1.25	51.43 ±3.8	9.25 ± 1.59	8.42 ± 0.45	2.39± 1.2	1324.72± 21.50	[12]
Beef	71.4	1.0	21.7	4.3	0	0	978	[16]
Chicken	72.8	1.0	20.4	5.9	0	0	563	[16]
Fish	78.7	1.2	17.1	1.2	0	0	335	[16]
Goatmeat	74.6	1.1	17.5	10.6	0	0	689	[16]
Pork	48	1.1	16.8	22.0	0	0	1100	[16]

Soybean	7.9	3.9	34.7	15.9	9.4	28.3	1730	[16]
Beans	8.9	3.9	22.1	1.5	10.3	53.2	1420	[16]

Mineralcompositionof*I.obscura*comparedwithotherproteinfoods

Themineralcompositionofthecaterpillarsstudiedshowsthattheyarerichinmacroelements likecalcium(132.03±0.37mg/100g),magnesium(84.42±2.40mg/100g),phosphorus (112.02 ± 2.1 mg/100g), potassium (130.50 ± 2.1mg/100g), sodium (26.96 ± 0.14mg/100g) and trace elements like iron (27.15 ± 0.61mg/100g), copper (0.17 ± 0.03mg/100g) and zinc (1.07 mg/100g ± 0.61) (table 2).

Table2:mineralcomposition(mg/100g)of*I.obscura*comparedwithotherproteinfoods

Species orfood	Ca	Mg	P	K	Na	Fe	Cu	Zn	Reference
I.obscura	132.03 ±0.37	84.42 ±2.40	112.02 ±2.1	130.50 ±0.63	26.96 ±0.14	27.15 ±0.61	0.17± 0.03	1.07± 0.61	
C.forda	206.19 ±4.74	97.3± 0.66	233.09 ±0.19	67.38 ±0.22	35.03 ±0.38	6.92± 0.12	3.55± 0.34	19.65± 0.16	[12]
Beef	5	22	170	327	50	2.1	0.09	3.6	[16]
Chicken	11	24	194	276	84	1.1	0.05	1.36	[16]
Fish	61	28	197	320	51	1.2	0.06	0.64	[16]
Goatmeat	11	27	150	385	82	2.4	0.16	3.45	[16]
Pork	10	20	170	301	47	1.4	0.10	3.6	[16]
Soybean	206	249	536	1770	5	6.5	1.5	4.8	[16]
Beans	50	185	309	1370	28	3.3	0.82	2.39	[16]

Vitamincompositionof*I.obscura*comparedwithotherproteinfoods

Theinsectspeciesstudiedhavevariablevitamin contents(100gofsampledryweight) (table 3):vitaminA(0.02±0.01mg),vitaminB_1(1.35±0.16mg),vitaminB_2(2.12±0.11mg),vitamin B_3(8.32 ± 0.15mg) and vitamin E (4.10 ± 0.07mg).

Table 3: Average vitamin content (mg/100g dry weight) of *I. obscura* compared with other protein foods

Species or food	Retinol(A)	Thiamine(B_1)	Riboflavin(B_2)	Niacin(B_3)	Tocopherol(E)	References
I.obscura	0.02±0	1.35±0.16	2.12±0.11	8.32±0.15	4.10±0.07	
C.forda	0.02±0	1.33±0.02	2.56±0.01	7.64±0.15	4.55±0.05	[27]
Beef	0	0.06	0.19	6.2	0.35	[16]
Chicken	17	0.09	0.16	7.0	0.26	[16]
Fish	2	0.06	0.19	6.2	0.23	[16]
Goatmeat	0	0.18	0.29	6.1	0.18	[16]
Pork	0	0.72	0.22	3.8	0.1	[16]
Soybean	0	0.72	0.28	2	0.68	[16]
Beans	0	0.39	0.12	1.9	0	[16]

Lipidcharacteristicsof*I. obscura*

Theresultsofthechemicalscreeningcarriedoutonthelipidsareshowninin Table4. Thelipids ofthisspeciescontainsaturatedfattyacidslikepalmiticacid(25.51±23.2%)andstearicacid

(32.37±0.06%).Lipidsaturationvaluesshowthatthespeciesstudiedcontain saturatedfatty acidsat58.88±0.01%(table4).Monounsaturatedfattyacidsarealsopresentinthisspecies. Theseareoleicacid(30.57±0.03%)andelaidicacid(0.46±0.02%),thetransisomerofoleic acid.Thepolyunsaturatedfatty acidscontainedinthelipidsofthiscaterpillar arelinoleicacid (4.82±0.02%),α-linolenicacid(1.87±0.02%)**,**γ-linolenicacid**(**1.57±0.01%)andarachidonic acid (2.33 ± 0.01%). The percentage of polyunsaturated fatty acids observed in the insect studied was 10.60 ± 0.02%.

Table4:Averagefattyacidcomposition(%)of *I.obscura*

Fattyacids	Pourcentage
Palmiticacid(C16:0)	25.51±0.04
Stearicacid(C18:0)	32.37±0.06
Totalsaturatedfattyacids	**58.88±0.01**
Oleicacidcis(C18:n-9)	30.57±0.03
Elaïdicacidtrans(18:n-9)	0.46±0.02
Totalmonounsaturatedfattyacids	**31.03±0.02**
Linoleicacid(C18:2n-12)	4.82±0.02
α-Linolenicacid(C18:2n-6)	1.87±0.02
γ-Linolenicacid(C18:2n-12)	1.57±0.01
Arachidonicacid(C20:4n-24)	2.33±0.01
Total unsaturated fatty acids	**10.60±0.02**
Omega6/Omega3	**4.66**

4. DISCUSSION

The water content of the *I. obscura* (10.41 ± 0.33%) is higher than that of the caterpillar *Imbrasia oyemensis* (Rougeot, 1955) (Lepidoptera: Saturniidae) which is 4.60 ± 0.58% [19] but similar to that of the caterpillar *Cirina forda* (Westwood, 1849) (Lepidoptera: Saturniidae) whichrangesfrom10.06±0.12%[12]and10.85±0.38%[20].andthatoflegumeseedssuch asbeans(10.5%)andsoybeans(9.3%)[16].Itislowcomparedtoconventionalmeatproducts commonly consumed in West Africa (beef :71.4%, chicken :73.8%, goat :74.6%, pork :48% and fish :78.7%) [16]. This low water content enables better physical preservation by simply drying the caterpillar, thus avoiding decomposition, and better conservation of most of the caterpillar's nutrients [21].

The results of this study show that the protein and lipid contents of this caterpillar are within the range of protein (14 and 68%) and lipid (5 and 49.5%) contents generally found in edible Lepidoptera[21]onafreshmassbasis.Comparingtheresultsofthis investigationwiththose obtained by Badanaro *et al* [12] on *C. forda* also consumed in Togo, *I. obsura* was found to bericherinprotein(53.36±0.05%vs51.43±3.8%)andlipids(14.22±0.62%vs9.25±0.62%) than *C. forda* (table 1). It was also richer in protein than beef (17.5%), chicken (17.6%), goat (19.2%), pork (12.5%), fish (16.5%), bean (21.3%) and soybean (31.3%) [16]. Protein levels (72%) obtained for the same caterpillar in Central Africa exceed those obtained in this study [21].Thisshows that*I.obsura*caterpillarsrankamongthe mostprotein-richfoods.Generally speaking,mostcaterpillarsconsumedhaveahighproteincontent(14and68%) [22].Forthis reason, the FAO [23] promotes their incorporation into low-protein flours to combat infant malnutrition.

Theenergyvalueper 100gof *I.obscura* ishigh(1478.54±23.2kJ).Thishighcalorific value could beexplainedbyitsrichnessinenergycomponents(proteins,carbohydrates,lipids and fibers).Thisvaluewashigherthanthatof*C.forda.*Consumptionof*I.obscura*couldtherefore reducetheeffectsofenergydeficienciesinconsumerpopulations.Comparedtoconventional

meat products such as beef, chicken, goat, pork and fish, which do not contain dietary fiber [16].*I.obscura* studied and *C.forda*[12]showed appreciable amountsoffiber(table 1).This caterpillarcould thereforecontributetobetterdietary digestionforpeopleofallages.Indeed, a lack of fiber in the diet can lead to gastric and intestinal disorders. Moreover, fiber has a positive effect on accelerating satiety, thus limiting the risk of overeating. This helps prevent obesity [23].

The ash from the incineration of *I. obscura* was used to quantify the mineral content of this species,which was found tobehigh(10.3 ±0.27%). This high mineral content suggests that this caterpillar provides the populations that consume them with sufficient quantities of minerals. The results obtained for calcium, magnesium, phosphorus, iron and copper during our work were similar to those obtained for *C. forda* [12, 21] and legumes (beans and soybeans),buthigherthanthoseforconventional meatproductscommonlyconsumedin West Africa [16], as shown in table 2. On the other hand, potassium levels were higher in meat products(beef(327mg/100g),chicken(276mg/100g),goat(385mg/100g),pork(301mg/100g) and fish (320mg/100g)) than in caterpillars (*I. obscura*: 130.50 ± 0.63mg/100g and *C. forda*67.38±0.22mg/100g)andlegumes(soybeans:1770mg/100gandbeans:1370mg/100g).Th e presence of minerals in insects is advantageous, as they are known to be involved in numerous biological functions. Calcium, potassium and magnesium are involved in the regulationofbloodpressure[25].Zincisessentialforcellularmetabolism.Itplaysanimportant role in cell renewal and protein synthesis [26].

All vitamin levels were higher in *I. obscura* (0.02 ± 0 mg/100g) than in conventional protein species. However, retinol levels in *I. obscura were* lower than those in chicken (5 mg/100g) andfish(141mg/100g)[16].Thesameappliestovitaminlevelsin*C.forda*(0.02±0mg/100g) [27]. Retinol could be supplemented in an insect diet by other sources of micronutrients like orangeand unrefinedpalm oil,generally known assourcesofretinol [28].Sincevitaminsare essential for the body to function properly, their presence in appreciable quantities in the caterpillars studied enhances their nutritional value.

Lipidsaturationvaluesshowthatthespeciesstudiedcontained58.88±0.01%saturated fatty acids. This is higher than recommended by the French Food Safety Agency (AFSSA), which recommendsamaximum dietaryintake of33%saturatedfattyacids [29].Indeed, highlevels ofsaturatedfattyacidsinthedietareconsideredtoberiskfactorsforcardiovasculardisease. Saturatedfattyacidsareexcellentenergynutrients,buttheirconsumptioninhighproportions can increase the risk of cardiovascular disease and promote the formation of thrombosis, leadingtocardiovasculardisease[30].Monounsaturatedfattyacidssuchasoleicandelaidic acids are also found in this species. With the exception of elaidic acid, which is trans- configured, all the other fatty acids in the lipids of the insect studied are cis-configured. Fortunately,thequantityfoundinthisinsectislow,as toohighanintakeoftransfattyacidsis likely to have a negative impact on health, as are saturated fatty acids [31]. This caterpillar's lipids also contained linoleic (4.82 ± 0.02%), α-linolenic (1.87 ± 0.02%), γ-linolenic (1.57 ± 0.01%) and arachidonic (2.33 ± 0.01%) acids, like polyunsaturated fatty acids. The level of polyunsaturatedfattyacidunsaturationobservedintheinsectstudiedislow(10.60±0.02%), sincetheircontentislessthan15%[29].Theirpresenceinfoodinhighquantitiesisbeneficial tohealth,astheyhavethepotentialtolowerLDL(LowDensityLipoprotein)cholesterollevels intheblood[32].However,thisspeciescontainsthetwoessentialfattyacids(linoleicacidand α-linolenicacid)thatarethepreсursorsofthetwofattyacidfamilies(Omega6andOmega3). The species studied had an Omega6/Omega3 ratio of less than 5, also attested by the work ofMabossy-Mobounaetal [21]onthiscaterpillar.This highlightsthe nutritionalqualityofthis insect's oils, as such a ratio reduces the risk of cardiovascular disease [33]. There are, however,somenotablelimitationstothisstudy.Becausetheanalyseswerenotcarriedouton a site-by-site basis, we were unable to carry out comparative statistical teststo confirm the

good nutritional qualities of this caterpillar, and to identify variations in the caterpillar's composition as a function of growing environment.

5. CONCLUSION

The aim of this study was to contribute to the development of a non-conventional food resource,the*I.obscura*caterpillar,bydeterminingitsnutritionalqualitiescomparedwithother conventional protein foods. The results of this study show that this caterpillar is rich in macronutrients, micronutrients and essential fatty acids. These parameters provide ample evidencethatintegrating *I.obscura*infoodrecipes in Togocouldsignificantly improve onthe prevalenceofmalnutritionamonglocalpopulationsingeneral,andparticularlyamongchildren and pregnant women in particular, who are the most vulnerable. It is important to consider appropriate management and conservation measures to ensure the sustainability of this resource. Proper management of this resource will involve regulating its exploitation, as well as protectingthe *P. biglobosa* hosttree,which is threatened by themanufactureof charcoal.

Dataavailability: Alldataareincludedinthedocumentcontent.

Disclaimer (Artificial intelligence): Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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